ARROWSMITH NORTH SILICA SAND PROJECT

ENVIRONMENTAL REVIEW DOCUMENT

VRX SILICA LIMITED

12 June 2023
Assessment Number: 2291
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PREPARED FOR VRX SILICA LIMITED
BY PRESTON CONSULTING PTY LTD

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Disclaimer:

ACKNOWLEDGEMENT OF COUNTRY

Preston Consulting acknowledges the Traditional Owners of the lands on which it works, in particular the Whadjuk people of the Noongar Nation and the Yamatji people, the Traditional Custodians of the land on which the activity is proposed. Preston Consulting pays its respects to Elders past and present, to emerging community leaders and to all Aboriginal and Torres Strait Islander peoples.

DOCUMENT CONTROL

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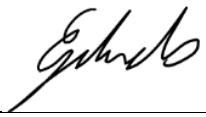
Checked	Gavin Edwards – Director Preston Consulting Pty Ltd		12/06/2023
Authorisation	Bruce Maluish – Managing Director VRX Silica Limited		12/06/2023

INVITATION TO MAKE A SUBMISSION

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal. VRX Silica Limited (VRX) seeks to develop a high-grade silica sand mine in the Geraldton Sandplain bioregion of Western Australia (WA), approximately 270 kilometres (km) north of Perth. The Proposal will produce a high-grade silica sand product via extraction and mechanical upgrading.

The Proposal includes the development of a mine feed plant, moveable surface conveyor, pipeline, processing plant, stockpiles, freshwater supply bore, access corridor, laydown, administration, water storage and associated infrastructure including gas fired power station, communications equipment, offices, workshop and laydown areas.

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 four weeks from 19 June 2023, closing on 16 July 2023.

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: 16 July 2023

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 potential flora and vegetation that may be present.	Section 5.3.1 Appendices 6 - 11
2	A flora and vegetation survey in accordance with Department of Agriculture, Water and the Environment (DAWE) and EPA guidance: I. A consolidated report including the integrated results of all surveys; II. All survey reports and data should be submitted via the Index of Biodiversity Surveys for Assessments (IBSA) Submissions with the IBSA number provided for verification. III. If previous studies are used for context, justification will be provided to demonstrate that they meet EPA Guidance and maps will be provided to show the location of previous surveys in relation to the Proposal.	Section 5.3.1 Appendix 6
3	Demonstrate how surveys are relevant, representative and demonstrate consistency with current EPA policy and guidance. Ensure database searches and taxonomic identifications are up to date.	Section 5.3.2 Appendices 5 - 11
4	Provide a figure depicting survey effort applied in relation to the study area and development envelopes, identifying the direct and indirect impact areas.	Section 5.3.1
5	Provide a comprehensive overview of Vegetation Direct Transfer (VDT) methods including detailed account of implementation across differing vegetation communities. Prior trials and evidence of the effectiveness of trials will be included.	Section 2.2.3 and 5.5.1
6	A comprehensive Dieback survey of all proposed disturbance areas.	Section 5.3.1 Appendix 10 and 11
7	Prepare and submit a Dieback Management Plan addressing dieback risks, impacts and management strategies.	Appendix 13
8	Determine whether any flora species recorded are significant (including those listed as Priority species under the *Biodiversity Conservation Act 2016* (BC Act) or listed as threatened under the EPBC Act or BC Act), and provide an analysis of local and regional context, including targeted surveys if required (refer to Environmental Factor Guideline – Flora and Vegetation for definition of significant flora). Discuss the regional and cumulative impacts of other existing or reasonably foreseeable development in the vicinity of the Proposal with the potential to impact the flora and vegetation values. These may include rehabilitation, projected climate change impacts, fire, mining, disease, weed invasion; impacts to biodiversity, recreation and water management.	Section 5.3.3 and 5.5.2 Appendix 6
9	Determine whether any vegetation identified is significant (including those listed as a Priority Ecological Community under the BC Act or Threatened Ecological Community under the EPBC Act or BC Act), and provide an analysis of local and regional context, (refer to Environmental Factor Guideline – Flora and Vegetation for definition of significant vegetation).	Section 5.3.4 and 5.5.1 Appendix 6
10	Provide maps showing the recorded locations of significant flora in relation to the Proposal and species distributions. Provide maps showing the extent of all vegetation, and significant vegetation, in the study area, the development envelopes, direct and indirect impact areas, and local and regional contexts.	Section 5.3.3 and 5.5.2 Appendix 6
11	Assess the potential direct and indirect impacts of the construction and operational elements of the Proposal on identified environmental values. Describe and assess the extent of cumulative impacts as appropriate. Include figures showing the predicted extent of loss and corresponding vegetation quality breakdown.	Section 5.5

Task No.	Required Work	Section and Page No.
12	Provide a quantitative assessment of impact: I. For significant flora, this includes; • Number of individuals and populations in a local and regional context; • Numbers and proportions of individuals and populations directly or potentially indirectly impacted; and • Numbers/proportions/populations currently protected within the conservation estate (where known). II. For all vegetation units (noting threatened and priority ecological communities and significant vegetation) this includes; • Area (in hectares) and proportions directly or potentially indirectly impacted; and • Proportions/hectares of the vegetation unit currently protected within conservation estate (where known).	Section 5.5
13	Describe the application of the mitigation hierarchy in the proposal design, construction, operation and closure. Specific, measurable, achievable, realistic and time-bound actions will be actioned to minimise and mitigate Proposal impacts. Include descriptions of management and/or monitoring plans to be implemented pre- and post-construction to demonstrate that residual impacts are not greater than predicted. Management and/or monitoring plans are to be presented in accordance with EPA instructions.	Section 5.6
14	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.	Section 5.5 and 14
15	Demonstrate that all practicable measures have been taken to reduce the area of the proposed disturbance footprint based on progress in the Proposal design and understanding of the environmental impacts.	Section 5.6
16	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.	Section 5.6 and Appendix 6
17	Discuss management measures, outcomes / objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 5.6
18	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (EPA, 2014a), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	Section 11.1
19	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy and offset principles in the EPBC Act Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	N/A
20	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	Section 5.7
21	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	Section 5.5 and 12

Task No.	Required Work	Section and Page No.
22	A chapter of the ERD will be dedicated to discussing the impacts of the proposal on MNES and make reference to all relevant standards, policies and other guidance material published by DAWE. Justification will be provided for any instances where published guidance is not followed. This chapter will include a discussion to demonstrate the Proposal is consistent with Australia's obligations under: I. the Biodiversity Convention; II. the Apia Convention; III. Convention on International Trade of Endangered Species (CITES); and IV. Each relevant recovery plan and threat abatement plan.	Section 12
Terrestrial Fauna		
23	In accordance with EPA Guidance conduct a desktop study to identify and characterise the vertebrate and short-range endemic (SRE) invertebrate fauna and fauna habitats in a local and regional context; and based on the results of the desktop study conduct: I. A Basic (Level 1) survey and fauna habitat assessment; and/or II. A Detailed (Level 2) survey including sampling inside and outside the impact areas that may be directly or indirectly impacted; and/or III. Targeted surveys for significant fauna that may be directly or indirectly impacted. If multiple surveys are conducted to support the assessment, a consolidated report will be provided including integrated results of the surveys. If previous studies are relied on for context, justification will be provided to demonstrate that they are relevant and consistent with EPA guidance. Maps will also be provided to illustrate the location of previous surveys in relation to the Proposal. A map of the survey effort applied in relation to the fauna habitats, the study area, development envelopes, identifying the direct and indirect impact areas.	Section 6.3.1 Appendices 14 - 16
24	Identify and describe the fauna assemblages present and likely to be present within the development envelopes that may be impacted by the proposal.	Section 6.3.4 Appendices 14 - 16
25	Identify and describe the fauna habitats identified by the studies and surveys. Describe significant fauna habitats, including but not limited to SRE invertebrate microhabitats, refugia, breeding areas, key foraging habitat, movement corridors and linkages.	Section 6.3.3 Appendix 14 - 16
26	Provide figure(s) and maps showing the extent of fauna habitats in relation to the Proposal and species distributions.	Section 6.3.3 Appendix 12 - 16
27	All survey reports and data should be submitted via IBSA Submissions with the IBSA number provided for verification.	Complete
28	Identify and describe the fauna assemblages present and likely to be present within the development envelopes that may be impacted by the Proposal.	Section 6.3.4
29	Identify significant and restricted fauna and describe in detail their known ecology, likelihood of occurrence, habitats and known threats.	Section 6.3.5 and 6.3.6
30	Assess the extent of direct and indirect disturbance in addition to known existing threats 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. Consider whether the remaining habitat has adequate carrying capacity.	Section 6.4
31	Map the locations of significant and restricted fauna records in relation to the fauna habitats, the study area, the development envelopes, and direct and indirect impact areas.	Section 6.5

Task No.	Required Work	Section and Page No.
32	Describe and quantify the extent of potential direct, indirect and cumulative impacts, including percentages, to habitats and significant species that may occur following implementation of the proposal during both construction and operations, in a local and regional context.	Section 6.4 and 6.5
33	Provide a table of the proportional extents of each habitat within the study area and development envelopes, and the predicted amount to be directly impacted and remaining. Consider any local or regional cumulative impacts.	Section 6.5.1
34	Outline the proposed avoidance and mitigation measures to reduce the potential impacts of the Proposal. Include descriptions of proposed management and/or monitoring plans that will be implemented pre- and post-construction to demonstrate and ensure residual impacts are not greater than predicted. Management and/or monitoring plans are to be presented in accordance with the EPAs Instructions.	Section 6.6
35	Predict the residual impacts from the proposal on terrestrial fauna after considering and applying the mitigation hierarchy.	Section 6.7
36	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	Section 6.6.3 Appendix 4
37	Perform a materials balance to determine the volumes of materials required for rehabilitation and materials available for rehabilitation.	Appendix 4
38	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (EPA, 2014a), the EPBC Act Environmental Offsets Policy and include reference to the Commonwealth Offset Assessment Guide for any MNES.	Section 11.1
39	Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines and the EPBC Act Environmental Offsets Policy. Any proposed offsets package will be assessed against the six offsets principles in the WA Environmental Offsets Policy and offset principles in the EPBC Act Environmental Offsets Policy. Spatial data defining the area of significant residual impacts will also be provided.	Section 11
40	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	Section 6.7
41	Demonstrate and document in the ERD information sufficient to allow the Commonwealth Minister to make an informed decision on whether or not to approve, under Part 9 of the EPBC Act, the taking of the action for the purposes of each controlling provision.	Section 6.5 and 12
42	A chapter of the ERD will be dedicated to discussing the impacts of the proposal on MNES and make reference to all relevant standards, policies and other guidance material published by the DAWE. Justification will be provided for any instances where published guidance is not followed. This chapter will include a discussion to demonstrate the Proposal is consistent with Australia's obligations under: I. the Biodiversity Convention; II. the Apia Convention; III. CITES; and IV. Each relevant recovery plan and threat abatement plan.	Section 12
Inland Waters		
43	Desktop water supply assessment to identify potential water supply sources for the Proposal and estimate potential yields based on available hydrogeological information.	Section 7.3.5 Appendix 20
44	Characterisation of the baseline hydrological and hydrogeological regimes in a local and regional context. Include regional and local hydrogeological description, including representative hydrogeological profiles across the site and contour maps of groundwater levels, flow directions, aquifer structure, seasonal and long-term trends, recharge/ discharge areas (vertical leakage) and identification of other groundwater users.	Section 7.3 Appendix 20 and 21

Task No.	Required Work	Section and Page No.
45	Hydrogeological investigations / modelling and analysis to identify sustainable water supply sources for the Proposal (in consultation with DWER) and predicted drawdown of the Yarragadee aquifer.	Section 7.3.5 Appendix 21 and 23
46	Provide a water balance for the mining operations.	Section 7.3.5
47	Sensitivity analysis to identify areas that may be impacted by changes in superficial groundwater levels within the mapped drawdown extent.	Section 7.3.5, 7.5.1 and 7.5.2 Appendix 21
48	Characterisation and assessment of the impacts of groundwater drawdown on other users, overlying aquifers, surface water expressions and other environmental values.	Section 7.3.5 Appendix 21 and 23
49	Hydrological investigations / modelling and analysis to characterise the surface water systems that may be directly or indirectly impacted by the Proposal.	Section 7.3.3 Appendix 20
50	Description of the design and location of any surface water diversions, with the potential to impact surface water or groundwater. Define whether the diversions will be permanent or temporary.	Section 7.3.3 and 7.5.3 Appendix 20
51	Characterisation and assessment of the resultant changes to surface water regimes as a result of the implementation of the Proposal.	Section 7.5.3 Appendix 20
52	Mapping and spatial data that shows and defines the extent of the predicted direct and indirect hydrogeological and hydrological impacts to environmental values.	Section 7.4
53	Physical and chemical waste characterisation studies to determine: I. The toxicity of any flocculants proposed to be used; II. If leaks and spills of slurry sands have the potential to contaminate inland waters and/or soils; and III. Identify potential residue impacts on post-closure rehabilitation.	Section 2.2.3, 7.3.6 and 7.5.1 Appendix 3 and 22
54	Desktop Acid Sulphate Soils (ASS) risk assessment to determine the risk of presence of ASS. Undertake an ASS survey if results from the desktop risk assessment identify this to be necessary.	Section 7.3.6 Appendix 22
55	Analyse, discuss and assess surface water and groundwater impacts. The analysis will include: I. Changes in groundwater levels and changes to surface water flows associated with the Proposal; II. Changes in groundwater and surface water quality associated with the Proposal; III. The nature, extent and duration of impacts; IV. Impacts to other water users; and V. Impacts on the environmental values of any sensitive receptors.	Section 7.4 and 7.5
56	Discuss the proposed management, monitoring and mitigation to avoid and minimise groundwater and surface water impacts, at local and catchment scale, as a result of implementing the Proposal.	Section 7.6
57	Demonstrate and document in the ERD how the EPA's objective for this factor will be met.	Section 7.7
58	Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (EPA, 2014a). Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided.	Section 12

Task No.	Required Work	Section and Page No.
Social Surroundings		
59	Undertake a heritage assessment (Aboriginal and European), utilising desktop information, and archaeological and ethnographic heritage surveys as required in order to: I. Make an assessment of listed heritage sites; II. Determine the importance of the site from an Aboriginal perspective (including heritage sites, and traditional uses such as bush tucker and medicine); and III. Assess the likelihood of significant European or Aboriginal heritage sites being present on site. Should unavoidable disturbances to Aboriginal heritage sites and/or places be proposed, approval under the *Aboriginal Heritage Act 1978* will sought.	Section 8.3 Appendix 24 – 27
60	Conduct consultation with traditional owners (Yamatji Marlpa Aboriginal Corporation; YMAC) during the assessment process to determine the heritage values of the development envelopes.	Section 3 and 8.3
61	Undertake consultation with traditional owners and knowledge holders in reference to the Arrowsmith River Registered Aboriginal Site (ID: 30068).	Section 3 and 8.3
62	Conduct a survey of the development envelopes to identify any Aboriginal Heritage Places that may exist.	Section 8.3 Appendix 24 – 27
63	Undertake an initial noise assessment based on predicted noise levels and distances to receptors to identify the risk of noise impacts. If noise impacts may be significant then complete a noise assessment including ambient baseline noise monitoring, identification of sensitive receptors, noise modelling based on typical worst-case meteorological conditions and an analysis of modelling results against Environmental Protection (Noise) Regulations 1997 and current ambient noise levels in the area.	Section 8.4.2
64	Discuss how the Proposal meets the principles of ecologically sustainable development, as defined in s. 3A of the EPBC Act.	Section 8.3.8 and 12.9
65	Characterise the values and significance of social surroundings in the vicinity of the Proposal.	Section 8.3
66	Identify the proposed activities and the potential scale and significance of direct and indirect impacts to social surroundings.	Section 8.3 and 8.4
67	Discuss the proposed management, monitoring and mitigation to prevent impacts to social surroundings as a result of implementing the proposal.	Section 8.4 and 8.5
68	Discuss how Part V of the EP Act will regulate nuisance noise and other emissions during construction and operation of the Proposal to ensure compliance with the Environmental Protection Regulations.	Section 8.6
69	To satisfy EPBC Act requirements, identify and describe potential positive and negative economic and social impacts of the Proposal, including: I. Estimates of any anticipated economic costs and/or benefits (in AUD); II. Explanations for any estimations of costs and/or benefits; III. Potential employment opportunities expected to be generated at each phase of the Proposal; and IV. Details of any public and stakeholder consultation activities, including the outcomes.	Section 8.4, 8.6.2 and 12.9
70	Discuss closure and rehabilitation management measures, outcomes / objectives to be implemented.	Appendix 4
71	Demonstrate how the EPA's objective for this factor will be met.	Section 8.6 and 8.7

Task No.	Required Work	Section and Page No.
Greenhouse Gas Emissions		
72	Estimate the expected Scope 1 (direct), Scope 2 (energy indirect) and Scope 3 greenhouse gas emissions over the life of the Proposal. The estimates will include: I. The detailed methods used to estimate emissions; II. A breakdown of annual and total of estimated Scope 1, Scope 2 and Scope 3 greenhouse gas emissions in tonnes of CO_2-e by all sources. Consider all proposed activities in determining the sources of emissions (e.g. mining, processing, clearing of land, etc.); III. Projected emissions intensity/intensities (emissions per unit of production) for the Proposal, including each calculation and calculation methodology; and IV. Benchmarking of the Proposal's annual emissions and emissions intensity against other comparable projects.	Section 9.4.2 and 9.4.3 Appendix 28
73	Demonstrate and document how the EPA's objective for this factor can be met.	Section 9.7
Air Quality		
74	Undertake a desktop assessment to evaluate potential air emissions from the Proposal and consider the significance of the potential impacts on the local airshed and nearest sensitive receptors. If the Proposal has the potential to impact ambient air quality at sensitive receptors then conduct an air quality assessment in accordance with EPA and contemporary guidance to predict air emissions and impacts on ambient air quality. The level of assessment will be informed by the results of the desktop assessment and based on the guidance of an air quality specialist, and may include: I. Atmospheric dispersion modelling; II. Operational dust analysis; III. Dust characteristics analysis; IV. A review of the location and distance to sensitive receptors; V. An analysis of existing levels of dust and other air pollutants; VI. Complaints data analysis; VII. Community surveys; and VIII. Comparison with similar operations.	Section 10.3, 10.4 and 10.5 Appendix 30
75	Demonstrate how the mitigation hierarchy of avoid, minimise, mitigate has been applied during the mine planning and design stages of the Proposal.	Section 10.6
76	Discuss the proposed management, monitoring and mitigation to prevent impacts to air quality as a result of implementing the Proposal.	Section 10.6
77	Discuss how Part V of the EP Act will regulate air emissions during construction and operation of the Proposal to ensure compliance with the Environmental Protection Regulations.	Section 10.6
78	Demonstrate and document how the EPA's objective for this factor can be met.	Section 10.7

EXECUTIVE SUMMARY

THE PROPOSAL

VRX Silica Limited (VRX) is seeking to develop the Arrowsmith North Silica Sand Project (the Proposal) located in the Mid-West region of Western Australia (WA), approximately 270 kilometres (km) north of Perth (Figure 1).

The development envelopes, disturbance footprint and indicative infrastructure footprint is provided in Figure 2.

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	Arrowsmith North Silica Sand Project
Proponent Name	VRX Silica Limited
Short Description	The Proposal is to develop a high-grade silica sand mine in the Geraldton Sandplain bioregion of WA, approximately 270 km north of Perth. The Proposal will produce a high-grade silica sand product via extraction and mechanical upgrading. The Proposal includes the sequential block mining of silica sand, development of a mine feed plant, moveable surface conveyor, pipeline, processing plant, stockpiles, freshwater supply bore, access corridor, laydown, administration, water storage and associated infrastructure including: gas fired power station, communications equipment, offices, workshop and additional laydown areas. Access to the site will be via an Access Road connecting the Mine to Brand Highway. A freshwater supply bore, water pipeline and Access Road will be located within the Access Development Envelope. All other infrastructure will be located within the Mine Development Envelope. Product will be hauled via road to Geraldton port where it is exported internationally.

Table ES2: Location and proposed extent of physical and operational elements

Proposal Element	Location / Description	Maximum extent, capacity or range
Physical Elements		
Mine and Associated Infrastructure • Mine feed plant (mobile) • Conveyor (mobile) • Surface slurry pipeline (mobile) • Processing plant and Stockpiles • Topsoil stockpiles • Water storage • Gas fired power station Associated infrastructure including administration, communications equipment, offices, workshop and laydown areas.	Figure 2	Clearing of 347.3 ha within the 347.3 ha Mine Development Envelope.
Access Corridor Access Road, water bore and water pipeline	Figure 2	Clearing of no more than 6.5 ha within the 60.4 ha Access Development Envelope.

Proposal Element	Location / Description	Maximum extent, capacity or range
Construction Elements		
Groundwater Abstraction	Figure 2	Abstraction of up to 0.9 GL/yr from the Yarragadee aquifer
Operational Elements		
Mining and Vegetation Direct Transfer (VDT)	Figure 2	Mining to be undertaken such that topsoil and vegetation is transferred directly to rehabilitation areas via VDT.
Silica Sand production	Figure 2	Production of up to 2 Mtpa of silica sand
Energy production	Figure 2	Up to 5 MW
Groundwater Abstraction	Figure 2	Abstraction of 0.9 GL/yr from the Yarragadee aquifer
Proposal elements with greenhouse gas emissions		
Construction Elements		
Scope 1	N/A	Land use change GHG emissions of 1,000 - 1,200 tCO_2-e
Scope 2	N/A	None
Scope 3	N/A	Annual Scope 3 emissions of up to approximately 30,416 tpa during the first three years.
Operational Elements		
Scope 1	N/A	Land use change Annual GHG emissions of 1,000 - 1,200 tCO_2-e Peak total GHG emissions of 33,160 tCO_2-e Energy Production Maximum annual GHG emissions of 17,121 tCO_2-e for the first 3 years and 30,743 tCO_2-e each year thereafter. Maximum 550,170 tCO_2-e GHG emissions over the life of the Proposal (conservatively assumes no renewable energy is utilised).
Scope 2	N/A	None
Scope 3	N/A	GHG emissions of 60,471 tCO2-e per year
Rehabilitation		
Areas temporarily cleared for laydown during the construction phase will be rehabilitated following construction. Final closure and rehabilitation to commence within 1 year of cessation of operations. Mined areas are to be progressively rehabilitated using VDT and infill planting.		
Commissioning		
N/A		
Decommissioning		
Removal of all above surface and buried infrastructure within 2 years of cessation of operations.		
Other elements which affect extent of effects on the environment		
Proposal Time	Construction Phase	Approximately 6 months.

Proposal Element	Location / Description	Maximum extent, capacity or range
	Operations Phase	30 years
	Decommissioning Phase	Approximately 2 years after operations

KEY ENVIRONMENTAL FACTORS

The EPA has identified Flora and Vegetation, Terrestrial Fauna, Inland Waters, Social Surroundings, Greenhouse Gas Emissions and Air Quality as Key Environmental Factors relevant to the Proposal.

Table ES3 summarises relevant information on the potential impacts, mitigation, residual impacts, outcomes and offsets for each of the relevant key environmental factors. The appendices provided include supporting studies and investigations undertaken to inform this Environmental Review Document (ERD), the key elements of which are included in this document.

Table ES3: Summary of potential impacts, proposed mitigation, residual impacts and outcomes

Flora and Vegetation	

Potential impacts	<u>General native flora and vegetation</u>
	• Up to 353.8 ha of native vegetation clearing and including:
	  ○ 14.5 ha of clearing to remain for the life of the Proposal
	  ○ 339.3 ha of clearing will be progressively rehabilitated via VDT
	• Reduction in vegetation health due to indirect impacts.
	<u>Priority Flora</u>
	• Clearing of known individuals of 7 different Priority Flora; and
	• Clearing of up to 353.8 ha of potential habitat including:
	  ○ 14.5 ha of habitat that will remain cleared for the life of the Proposal
	  ○ 339.3 ha of habitat that will be progressively rehabilitated via VDT
	• Cumulative impacts of clearing or translocation of known individuals of seven different Priority Flora species.
	<u>Threatened and other Priority Flora that may occur within the development envelopes:</u>
	• Clearing of 13 Threatened Flora and 44 other Priority Flora species were not recorded but could potentially occur;
	• Clearing of up to 353.8 ha of potential habitat including:
	  ○ 14.5 ha of habitat that will remain cleared for the life of the Proposal
	  ○ 339.3 ha of habitat that will be progressively rehabilitated via VDT
	• Reduction in habitat health due to indirect impacts.

Mitigation hierarchy	**Avoid**: • Multiple mine planning and access road design revisions were undertaken to avoid concentrations of Priority Flora; • Four of the eleven Priority Flora species recorded in the Survey Area will be avoided; and • The north-south drainage line and associated riparian vegetation along the western boundary of the Study Area will be avoided. **Minimise**: • Implement industry best-practice management measures for flora and vegetation; • Obtain and comply with approvals under the EP Act, *Mining Act 1978* (WA) (Mining Act) and *Dangerous Goods Safety Act 2004* (WA) (DG Act) if required;

	• Ensure impacts to Priority Flora within the Access and Mine Development Envelope do not exceed those predicted in Section 5.5.2; • Prepare a Significant Flora Management Plan; • Implement the Rehabilitation Strategy (Appendix 4); • Implement measures to minimise the risk and impact of slurry spills; • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills; • Comply with Water Quality Protection Guidelines and guidance notes; and • Implement Dieback Management Plan (DMP; Appendix 13). **Rehabilitate**: Progressive rehabilitation via VDT and targeted infill planting will occur during the mining process as described in Section 2.2.3 and in the Rehabilitation Strategy (Appendix 4). The Rehabilitation Strategy was developed in consideration of DMIRS Guidelines (2020a) and describes the rehabilitation of the Proposal, and associated management and monitoring proposed during the progressive and final rehabilitation phase including completion criteria, monitoring and reporting during closure. At the completion of the Proposal the site will be further rehabilitated to reinstate the flora and vegetation of areas that were disturbed for the life of the Proposal. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to flora and vegetation are summarised below: • All infrastructure will be removed from site; • All long-term disturbance areas 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 or dieback introduction; • Impacted Priority Flora will be included in the rehabilitation seed mix if they are not suitable for establishment via VDT; and • All depressions will be shaped to prevent the formation of new semi-permanent water sources. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years.
Residual impacts, including assessment of significance	<u>General Native Flora and Vegetation</u> The Proposal will result in clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of native vegetation that will be progressively rehabilitated via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. In the Iluka VDT trials it was reported by Mattiske (2020b) that the use of VDT vastly improved the establishment of sedge and rush (largely understory) species. These species are less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman, Koch and Morald, 2007), but often dominate local heath communities (Mattiske, 2020b). The ability to include those species in rehabilitation solves a significant problem for mine rehabilitation on Kwongan heath. Neil McMulkin, former Rehabilitation Superintendent for Iluka Resources, advised that if starting Eneabba mining again, VDT would be the preferred rehabilitation method, and for a small disturbance footprint operation like Arrowsmith North, it is even more suitable (due to the small distance between the clearing and rehabilitation areas) (N. McMulkin Pers. Comm. 2020). Infill planting of deeper-rooted species will be undertaken as required to target the original vegetation structure. There will be unavoidable impacts to the vegetation that is relocated during VDT, however the health of these areas are predicted to improve close to background over time. There may also be some changes to vegetation structure within mined areas as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers. Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general native flora and vegetation (refer to Section 5.6) 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 values that require further assessment in the following sections.

Priority Flora

VRX has made a considerable effort to avoid priority flora, the results of Mattiske (2022a) were used to revise the development envelopes to avoid concentrations of *Beyeria gardneri* (P3), *Hypocalymma gardneri* (P3), *Persoonia rudis* (P3) *and Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2). Seven Priority Flora species were recorded within the development envelopes (Figure 51). Of these, four are predicted to have more than 5 % of the recorded individuals (within the Mattiske survey areas) within the disturbance footprint, based on the known disturbance footprint of the Proposal within the Mine Development Envelope, and the indicative disturbance footprint within the Access Development Envelope (Figure 51):

1. *Banksia elegans* (P4);
2. *Comesperma rhadinocarpum* (P3);
3. *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3); and
4. *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2).

Banksia elegans (P4)

A total of 1,277 *Banksia elegans* (P4) individuals are predicted to be disturbed. This equates to 37.61% of the 3,395 individuals recorded within the survey areas. This percentage is however likely to be a conservative estimate, as the Mine Development Envelope aligns with the targeted flora survey area (which had intensive 20 m survey spacing), meaning that additional individuals may have been recorded elsewhere in the survey areas if intensive surveys were conducted in those areas also. As an indication of actual percentage impact (removing the statistical anomaly of the 20 m spacing intensive survey), calculations estimated that 274 of the 1,947 individuals (14.1%) recorded during the detailed survey would be impacted by the Proposal. It is likely that the percentage loss would be below this number if all of the survey areas were surveyed to the same intensity (as some intensive surveys were also completed for the detailed survey). Figure 52 also shows that this species was widespread throughout the survey areas, demonstrating that it is not restricted to the development envelopes.

Banksia elegans was recorded in five different vegetation communities (H3, H4, H7, S6 and W2), which collectively were mapped over an area of 940 ha, or 52% of the survey area, indicating widespread habitat. An estimated 118 ha of the local habitat for this species is predicted to be disturbed, equating to 12.6% of the local extent, which aligns with the proportion of individuals predicted to be disturbed above.

This species has also been recorded in another 44 locations in WA, ranging from Moore River to Geraldton (Figure 52), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 44 locations, it demonstrates that the number of impacted individuals are unlikely to be significant in a local or regional context. This species will be infill planted within VDT areas. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Comesperma rhadinocarpum (P3)

Thirty *Comesperma rhadinocarpum* (P3) individuals are predicted to be disturbed. This equates to 50.85% of the individuals recorded within the survey areas. A number of records of this species were the reason for amending the Mine Development Envelope boundary on the western edge (Figure 53). As with *Bankia elegans* above, this percentage is likely to be a conservative estimate, as more records are likely to occur west of the Mine Development Envelope boundary, based on the location of the records found.

Comesperma rhadinocarpum was recorded in one vegetation community (H1), which was mapped over an area of 326 ha, or 18% of the survey area. An estimated 109 ha of the local habitat for this species is predicted to be disturbed, equating to 33.5% of the local extent, which indicates that the proportion of individuals predicted to be disturbed above is likely to be conservative.

This species has also been recorded in another 16 locations in WA, ranging over 400 km from Perth to Utcha (near Northampton; Figure 53). While individual counts are not available for each of those 16 locations, it demonstrates that there are a number of populations across the region, and Mattiske (2022a) considered the species to be very wide-ranging in distribution, with adjunct populations at Koolyanobbing and Pinjin Homestead in the Great Victoria Desert. Mattiske (2019a) also identified this species in 2013 and 2019 in Iluka's VDT trial transects. This indicates that *Comesperma rhadinocarpum* has the potential to be successfully translocated using the VDT process. Regardless, infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Hemiandra sp. Eneabba (H. Demarz 3687) (P3)

Ninety eight *Hemiandra* sp. Eneabba (H. Demarz 3687) individuals are predicted to be disturbed. This equates to 42.4 % of the 231 individuals recorded within the survey areas. As with the species above this percentage is likely to be a conservative estimate. As an indication of actual

	percentage impact (removing the statistical anomaly of the intensive survey), calculations estimated that 46 of the 368 individuals (25.9%) recorded during the detailed survey would be impacted by the Proposal. It is likely that the percentage loss would be below this number if all of the survey areas were surveyed to the same intensity. This species was also recorded regularly throughout the Mine Development Envelope (Figure 54), indicating that more records were likely to occur in suitable surrounding habitat. *Hemiandra* sp. Eneabba (H. Demarz 3687) was recorded in four different vegetation communities (H2, H3, H4 and H7), which collectively were mapped over an area of 1,114 ha, or 62% of the survey area, indicating widespread local habitat. An estimated 205 ha of the local habitat for this species is predicted to be disturbed, equating to 18.4% of the local extent, which aligns with the proportion of individuals predicted to be disturbed above. This species has also been recorded in another 34 locations in WA, ranging from Eneabba to Yardanogo Nature Reserve (approximately 100 km; Figure 54), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 34 locations, it demonstrates that the number of impacted individuals is unlikely to be significant in a local or regional context. The majority of the impacted individuals lie within the VDT area, meaning that they may survive the VDT process and would not be lost. Mattiske (2019a) identified this species in 2019 in Iluka's VDT trial transects. This indicates *Hemiandra* sp. Eneabba (H. Demarz 3687) has the potential to be successfully translocated using the VDT process. Regardless, infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species. *Schoenus sp*. Eneabba (F. Obbens & C. Godden I154) (P2) A total of 167 *Schoenus sp*. Eneabba (F. Obbens & C. Godden I154) individuals are proposed to be disturbed. This equates to 35.67% of the 467 individuals recorded within the survey areas. As with the species above this percentage is likely to be a conservative estimate. *Schoenus sp*. Eneabba (F. Obbens & C. Godden I154) was recorded in two different vegetation communities (H1 and H5), which collectively were mapped over an area of 438 ha, or 24% of the survey area. An estimated 146 ha of the local habitat for this species is predicted to be disturbed, equating to 33.3% of the local extent, which indicates that the proportion of individuals predicted to be disturbed above is not as conservative as other species in this section. This species has also been recorded in another 13 locations in WA, ranging from Eneabba to Dongara (~100 km; Figure 55), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 13 locations, it demonstrates that there are a number of populations across the region. This species was generally recorded in a small number of locations, therefore there may be an opportunity to avoid some of these locations. The impacted individuals also lie within the VDT area, meaning that they may survive the VDT process and would not be lost. Infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species. <u>*Other Priority Flora*</u> Based on current mine planning, the Proposal is not expected to disturb any known individuals of the remaining Priority Flora (Figure 51) that were recorded within the development envelopes. Nevertheless, these Priority Flora are relatively widespread, with all having more than 22 other records throughout the region, therefore none are restricted to the development envelopes. ***Indirect Impacts*** Section 5.5.1 provides a detailed assessment of indirect impacts on native flora and vegetation, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact any known priority flora records if the mitigation measures listed in Section 5.6 are implemented.

Proposed environmental outcomes	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, 2016a). VRX conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes. A targeted significant flora survey was conducted over the development envelopes. VRX has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha that will be progressively rehabilitated via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper rooted species will be undertaken as required to target the original vegetation structure. There will be unavoidable impacts to vegetation within rehabilitated VDT areas, however based on VDT trials and studies conducted on the root structure of significant flora, the health of these areas are predicted to improve over time. There may also be some changes to vegetation structure within mined areas as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers. With the implementation of controls, the Proposal will not result in significant impacts to regional vegetation associations, locally significant vegetation communities, Threatened Flora or significant populations of Priority Flora. Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general native flora and vegetation (refer to Section 5.6). Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.
Assessment of offsets (if relevant)	Not relevant.
Terrestrial Fauna	

Potential impacts	<u>General Fauna Species and Habitat</u>
	• Up to 353.8 ha of fauna habitat clearing;
	  ○ 14.5 ha of clearing to remain for the life of the proposal;
	  ○ 339.3 ha of clearing will be progressively rehabilitated via VDT;
	• Potential death or injury of fauna from vehicle strike or entrapment; and
	• Indirect impacts to fauna habitat health and fauna behaviour.
	<u>SRE Fauna</u>
	• Disturbance to 9 potential SRE fauna found within (including one Priority 1 SRE *Idiosoma kwongan*) have been recorded within the development envelopes;
	• Up to 14.5 ha of habitat clearing to remain cleared for the life of the Proposal;
	• Up to 339.3 ha of habitat clearing to be rehabilitated progressively via VDT; and
	• Indirect impacts to fauna habitat health.
	<u>Malleefowl and potential habitat</u>
	• Up to 14.5 ha of habitat clearing to remain cleared for the life of the Proposal;
	• Up to 339.3 ha of habitat clearing to be rehabilitated progressively via VDT;
	• Disturbance of mounds (if developed in the future) or death or injury due to vehicle strike or earthmoving equipment;
	• Increased predation or competition from introduced fauna; and
	• Some indirect impacts to habitat health and behavioural impacts.
	<u>Carnaby's Cockatoo and habitat</u>
	• Up to 14.5 ha of medium to high value foraging habitat clearing to remain cleared for the life of the Proposal;

	• Clearing and progressive rehabilitation of up to 339.3 ha of moderate to high value foraging habitat; • Increased predation or competition from introduced fauna; and • Some indirect impacts to habitat health and behavioural impacts.
Mitigation hierarchy	**Avoid:** • Almost all of VSA2 (Dense Riparian Thickets) will be avoided; and • Key environmental features have been avoided. **Minimise:** • Implement industry best-practice management measures for terrestrial fauna; • Obtain and comply with approvals under the EP Act, Mining Act and DG Act if required; • Implement the Rehabilitation strategy (Appendix 4); • Ensure no confirmed SREs are restricted to the disturbance footprint; • Prepare and implement a Fauna Management Plan (FMP); • Conduct pre-clearance surveys for active Malleefowl mounds; • Implement measures to minimise risk and impact of slurry spills; • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills; and • Comply with Water Quality Protection Guidelines and guidance notes. **Rehabilitate**: Progressive rehabilitation via VDT and targeted infill planting will occur during the mining process as described in Section 2.2.2 and in the Rehabilitation Strategy (Appendix 4). The Rehabilitation Strategy was developed in consideration of DMIRS Guidelines (2020a & 2020b) and describes the rehabilitation of the Proposal, and associated management and monitoring proposed during the progressive and final rehabilitation phase including completion criteria, monitoring and reporting during closure. At the completion of the Proposal the site will be further rehabilitated to reinstate fauna habitat within areas that were disturbed for the life of the Proposal. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to terrestrial fauna are summarised below: 1. All infrastructure will be removed from site; 2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated; 3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction; 4. Carnaby's Cockatoo foraging species will be included in the rehabilitation seed mix if suitable; and 5. All depressions will be shaped to prevent the formation of new semi-permanent water sources. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years. **Offsets:** • Implement the offsets discussed in Section 11.
Residual impacts, including assessment of significance	<u>General Fauna Species and Habitat</u> The Proposal will result in clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of native vegetation will be progressively rehabilitated via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper-rooted species will be undertaken as required to target the re-establishment of the original habitat structure. There will be unavoidable impacts to fauna habitat health within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species (such as *Banksia* sp.) predicted to be able to become established in greater numbers.

	Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general fauna and their habitats (refer to Section 5.6 and 6.6). The assessment above identified that the Proposal was unlikely to result in significant impacts to general fauna species and their habitats, however there are potential impacts to specific fauna values that require further assessment. These assessments are provided in the following sections. <u>Short-range Endemic Fauna</u> Despite there being evidence of SREs within the development envelopes, the habitat that is to be disturbed and rehabilitated is not restricted and extends outside the development envelopes. This is reflected in the survey results, with all of the recorded species occurring outside the development envelopes. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Several SRE species may survive the VDT process and the reinstatement of SRE habitat is likely to be quicker than traditional rehabilitation methods. Based on the above, VRX considers that the Proposal is unlikely to have a significant impact on local SRE populations. <u>Malleefowl</u> Despite there being no evidence of Malleefowl individuals within the development envelopes, the Proposal will result in clearing of up to 353.8 ha of potential Malleefowl habitat, 14.5 ha of which will remain cleared for the life of the Proposal. Up to 339.3 ha of native vegetation will be progressively rehabilitated via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper-rooted species will be undertaken as required to target the original habitat structure. There will be unavoidable impacts to Malleefowl habitat within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers. Management and monitoring is proposed to prevent direct impacts to Malleefowl mounds and individuals, to improve the performance of VDT and minimise indirect impacts to Malleefowl habitats (refer to Section 6.6). <u>Carnaby's Cockatoo</u> Breeding or roosting habitat has not been recorded within the development envelopes. The Proposal will result in the progressive disturbance of up to 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of moderate to high value foraging habitat will be progressively rehabilitated via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success, however infill planting of deeper rooted species used for foraging by Carnaby's Cockatoo will be required to attempt to reinstate the original foraging habitat values. There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species such as Banksia predicted to be able to become established in greater numbers. Management and monitoring is proposed to improve the performance of VDT with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats (refer to Section 6.6). After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: 1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten-year period; and 2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable

	for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten-year period. This section has identified that there are large areas of similar potential foraging habitat in the region that will not be impacted by the Proposal. However, given the extent of the reduction in habitat for this species across its range the residual impacts described above are deemed to be significant and are proposed to be counterbalanced by offsets (refer to Section 6.6 and Section 11).
Proposed environmental outcomes	The EPA's environmental objective for this factor is to "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, 2016d). VRX has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in up to 353.8 ha of habitat clearing, 14.5 ha of which will remain cleared for the life of the Proposal, and 339.3 ha of which will undergo progressive rehabilitation via VDT. All of these habitats are well distributed throughout the region and species that potentially use the development envelopes generally have relatively wide-ranging distributions and/or will persist in adjoining unaffected areas given the presence of extensive areas of similar habitat nearby. Carnaby's Cockatoo was recorded in the survey area and is listed as Endangered under the EPBC Act and BC Act. It is primarily threatened by the loss and fragmentation of breeding and foraging habitat as a result of vegetation clearing (EPA, 2019). While no Carnaby's Cockatoo breeding trees were identified, the majority of the development envelopes was identified as containing moderate to high quality foraging habitat for this species. After the implementation of avoidance, minimisation and rehabilitation mitigation measures, there were residual impacts to Carnaby's Cockatoo foraging habitat, summarised as: 1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after a ten-year period; and 2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after a ten-year period. These residual impacts were deemed to be significant and are proposed to be counterbalanced by offsets to ensure that the EPA objective can be met. The proposed offset site takes advantage of the unique gradual mining method proposed by VRX, and the large long-term extent of the broader deposit. This has allowed VRX to set aside a large proportion of its Mining Lease as conservation for the life of the Proposal, allowing protection and conservation management to occur for a minimum of 30 years. If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DAWE and EPA Services to ensure they adequately counterbalance the residual impacts. Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor
Assessment of offsets (if relevant)	**Offsets** To counterbalance the residual impact of the Proposal, VRX proposes to designate a1,367.1 ha portion of their Arrowsmith North Mining Lease (M 70/1389) for use as an Offset Area. This area lies outside of and generally to the north of the Mine Development Envelope (Figure 88) and contains large areas of similar moderate to high foraging values, with Excellent to Pristine quality vegetation. A draft Offset Strategy has been developed and provided in Appendix 29 that provides details of the proposed offset. This section summarises the content provided in the draft Offset Strategy. <u>Values and Quality of Offset Site</u> *Vegetation condition* The condition of the vegetation within the Offset Area ranges from Pristine to Excellent, with the majority of the area considered Pristine (96.5 %) according to the Keighery (1994) scale. Some areas (3.5 %) on the western part of the Offset Area, near tracks, were downgraded to Excellent. Vegetation condition of the Offset Area is shown in Figure 33. *Foraging Value* The Offset Area is comprised entirely of native vegetation that represents foraging habitat for Carnaby's Cockatoo. BCE (2022) combined broad vegetation types, the soils or other substrates

	with which they are associated and the landform to define Vegetation and Substrate Associations (VSAs). The Offset Area is comprised of 1,152.2 ha of VSA1, 119.5 ha of VSA2 and 95.4 ha in VSA3. Both VSA1 and VSA3 (1,247.6 ha) are identified as Moderate to High value foraging habitat for Carnaby's Cockatoo, VSA2 is considered moderate value (foraging habitat is discussed further in Section 6.3.6). The extent of Carnaby's Cockatoo foraging habitat within the Offset Area is shown in Figure 88. <u>Management of Offset Site</u> VRX propose to protect and maintain Carnaby's Cockatoo foraging habitat as an offset for the residual impacts of the Proposal. Offsets include protection and maintenance activities to maintain (and potentially improve) the condition of the native vegetation and reduce the threats to Carnaby's Cockatoos within the Offset Area. Protection and maintenance activities include but are not limited to: 1. Demarcation of the Offset Area; 2. Access restrictions into the area to minimise damage from off-road vehicles; 3. Erection of signs to identify the boundaries of the Offset Area; 4. Regular monitoring for signs of weed propagation, spread of dieback and changes in vegetation condition and foraging value; 5. Removal / treatment of weeds and treatment of dieback affected areas (if present); 6. Regular monitoring for signs of feral animals (including Fox, Cat, Dog, Pig, Rabbit); 7. Feral animal trapping and management with a particular focus on Foxes and Cats; and 8. Consistent with Section 8.6.2, develop and implement a Ranger Program. Implementation of the management mechanisms listed above is expected to protect the Offset Area from any impacts that may lower the foraging value to Carnaby's Cockatoo and ensure that suitable extents of moderate and moderate to high foraging value habitat is available for a minimum of 30 years. The protection mechanisms listed above may have the added benefit of reducing predator numbers and improving the quality of foraging habitat. <u>Protection of Offset Site</u> The proposed offset site lies entirely within M 70/1389, a lease held by VRX under the Mining Act. The area has been drilled and confirmed to contain large deposits of silica sand, with predictions of nearly 100 years of available silica sand at Arrowsmith North. VRX intends to gradually mine the area after the completion of this Proposal (i.e., from approximately Year 30 onwards). Prior to this occurring however, the area is available for use as a long-term preservation area (i.e., for at least 30 years) and it is likely that some areas could remain relatively untouched for nearly 100 years. For the purposes of this assessment a 30-year timeframe has been assumed. The presence of silica sand in this portion of M 70/1389 means that VRX will have justification to hold and renew the tenement for the life of the Proposal. Exploration for other minerals within the tenement has not returned any results, therefore silica sand is likely to remain as the only marketable product within the tenement. There may be minor disturbances associated with linear infrastructure (powerlines, roads, pipelines etc.) that could occur in the 30-year timeframe however this has been accounted for in the offset calculations. <u>Suitability of Proposed Offsets</u> The proposed offsets listed above have been assessed against the WA Offset Calculator (DWER, 2021b; Section 11.4), the WA environmental offsets principles (EPA, 2011; Section 11.5), Commonwealth Environmental Offsets Guidelines (DSEWPaC, 2012a; Section 11.6.1) and the Commonwealth Offset Principles (11.6.3). Based on the assessments above, the proposed offsets were determined to be suitable to offset the significant residual impact of the Proposal on Carnaby's Cockatoo foraging habitat.
Inland Waters	
Potential impacts	<u>Superficial Aquifer</u> • Contamination of groundwater from hydrocarbon or chemical spills. <u>Yarragadee Aquifer</u> • Abstraction of 0.9 GL per year <u>Surface Waters</u> • 6 m wide crossing of a minor ephemeral drainage line; • Alteration to surface water flow regimes within mining areas; • Contamination from hydrocarbon or chemical spills; and • Sedimentation during earthmoving or as a result of slurry pipeline spills

Mitigation hierarchy	**Avoid**: VRX has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following: • Mining within drainage lines; • Arrowsmith River; and • Arrowsmith Lake. In addition to the above, the following avoidance mitigation measures have been incorporated: • Impacts associated with abstraction of the Superficial Aquifer have been avoided by mining above the groundwater table and targeting the Yarragadee Aquifer for water supply; and • Changes to soil infiltration regimes were avoided by finding a market for the tailings. **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 and comply with a 5C Licence for the abstraction of 0.9 GL/year from the Yarragadee Aquifer; • Obtain and comply with a DG Licence issued under the DG Act (if required); • Implement hydrocarbon storage and spill mitigation measures to minimise the risk and impact of hydrocarbon spills; • Design and install a suitable floodway crossing at the minor ephemeral drainage lines within the Access Development Envelope to maintain the natural hydrological regime; • Routinely inspect drainage infrastructure; • Incorporate gaps between VDT sod placements; • Inspect for erosion within the Mine Development Envelope and along the access corridor; • Comply with Water Quality Protection Guidelines and guidance notes; and • Develop and implement a Groundwater Operating Strategy. **Rehabilitate:** Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT and infill planting. This includes physically landforming the site and replanting vegetation sods to ensure surface water regimes are not significantly altered and erosion is managed. At the completion of the Proposal the remainder of the site will be rehabilitated. One of the planned outcomes of all rehabilitated areas will be to reinstate inland water regimes. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; 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 access corridor will be rehabilitated with watercourse crossing structures removed; 2. The mine will be progressively landformed, with post-mining drainage to align with current conditions; 3. The mine will be revegetated with local native species; and 4. All infrastructure will be removed. 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.
Residual impacts, including assessment of significance	<u>Superficial Aquifer</u> <u>*Yarragadee Aquifer Abstraction Impacts*</u> VRX has conducted a H3 hydrological assessment (Appendix 23) which includes modelling of drawdown from groundwater abstraction required for both the Arrowsmith North and Central projects. Modelling is based on the combined extraction of both Proposals (currently proposed to be 1.3 GL/annum) and therefore provides a conservative assessment of the potential impacts of

this Proposal. Existing abstraction allocations were considered up to 20 km from the proposals. Aquifer drawdown modelling was conducted for three operating scenarios for a 30 year mine life:

1. No Abstraction – steady state initial conditions, abstraction is set to zero;
2. Existing Allocations Abstracted (Base Case) – abstraction is set as the licensed allocation from 2015 - 2022, which is 6.283 GL/annum; and
3. VRX Proposed Abstraction (Arrowsmith North and Central Combined) – forward scenarios use the base case licenced allocation plus 1.30 GL/annum allocation to VRX, from their two productions bores, this is incremental to Scenario 2.

Scenario 2, where there is no VRX abstraction, show the drawdown for the Superficial aquifer at the Proposal as a maximum drawdown of up to 1m over 30 years. Scenario 3, where the 1.3 GL/annum combined VRX abstraction from the Yarragadee only is included, shows an additional drawdown of the Superficial Aquifer of less than 0.25 m over 30 years.

As there is no addition abstraction from the Superficial Aquifer in Scenario 3 the drawdown on this aquifer is due to leakage from the aquifer and the effects of climate change and subsequent reduction of rainfall. Modelling shows that abstraction of groundwater from the Yarragadee aquifer for the combined Arrowsmith North and Central Projects is likely to only contribute to a minor additional drawdown within the superficial aquifer (because of leakage) of 0 - 0.25 m over 30 years. This equates to an additional drawdown of 8 mm per year at the Proposal (assuming linear drawdown rates over 30 years). Review of the proposed superficial drawdown in the context of phreatophytic vegetation in the 0 – 3m depth to ground water category (the most groundwater dependant), drawdown would present a low risk as defined in Froend, et al., (2004). The modelling takes a conservative approach and results indicate abstraction presents a low risk to groundwater dependant vegetation, it is possible actual drawdown is less and subsequently the risk is lower. Based on this the proposed abstraction is not expected to have a significant impact on any ecosystems that may be dependent on the Superficial Aquifer.

Indirect Impacts

The Proposal will require the storage of various hydrocarbons and chemicals including fuel, oil, hydraulic fluid, flocculant, coolant, surfactants and degreasers. Spills and improper management / disposal of these hydrocarbons and chemicals present a contamination risk for the Surficial Aquifer. Furthermore, the Proposal includes the operation of light vehicles, FELs and other machinery which may pose a risk of hydrocarbon spillages.

The flocculant used in the process is Floerger AN900 series Anionic Polyacrylamide. Anionic polyacrylamide has no systemic toxicity to aquatic organisms or micro-organisms. The polymer is much too large to be absorbed into tissues and cells. The functional anionic groups do not interfere with the functioning of fish gills or daphnia respirators. Any adverse effects observed in laboratory tests are always seen at concentrations of over 100 mg/L and are probably due to the resulting viscosity of the test medium. The preparation of the test solutions at such concentrations requires high-energy stirring for long periods of time, sometimes several hours. Therefore, it can be concluded that these harmful concentrations will not exist in the natural environment (SNF Floerger, n.d.).

Anionic polyacrylamide has no potential to bioaccumulate, being completely soluble in water (solubility is only limited by viscosity) and insoluble in octanol. Additionally, being a flocculent, it adsorbs onto suspended matter and, in this way, is removed from the water phase. The sensitivity of polyacrylamide to ultra-violet light is well known and has been described in the scientific literature. Photolysis leads to the degradation of the polymer chain and the formation of much smaller molecules, or oligomers, which are accessible to microbial attack. A recent study financed by SNF-Floerger, has demonstrated that photolysis followed by aerobic or anaerobic treatment resulted in efficient mineralization of the polymer. This study provides evidence that acrylamide polymers have the potential to be naturally broken down and biodegraded and do not persist or accumulate in the environment (SNF Floerger, n. d.).

With the implementation of controls (Section 7.6), hydrocarbon and chemical storage and spills are expected to be able to be managed to prevent significant impacts on the Superficial Aquifer.

<u>Yarragadee Aquifer</u>

To enable the transport, processing and upgrading of mined sand, VRX will require up to 0.9 GL per annum of water. The area is constrained by areas of shallow water table that are likely to be impacted by groundwater abstraction from the Superficial aquifer (HydroConcept, 2019). Therefore, HydroConcept (2019) has identified the Yarragadee aquifer as the most prospective groundwater resource for the Proposal. There have been previous investigations that provide confidence that aquifer horizons are present in different units of the Yarragadee Formation. The aquifer can provide the required water supply from one production bore which would be capable of providing 5,000 kL per day (1.825 GL per annum). The production bore has been constructed and pump tested and is deemed suitable for the water requirements of the Proposal.

	Currently, there are four active groundwater licences provided by DWER under the *Rights in Water Irrigation Act 1914* (RIWI Act) that target the Yarragadee aquifer in the Dongara subarea, the cumulative potential abstraction rate of these licences and the proposed abstraction from VRX is 1.3872 GL per annum. The Yarragadee Aquifer within the Dongara subarea has a groundwater abstraction allocation limit of 4.5 GL, therefore a 0.9 GL increase in abstraction represents approximately 20 % of the total groundwater allocation. Climate projections (see Section 7.3.2) indicate less rainfall in winter and spring, increased intensity of heavy rainfall events, drought duration increases, increased average temperatures, increased evaporation rates and subsequently reduced soil moisture and surface runoff. Climate change is likely to change the way WA's utilise water, in the future it is anticipated that groundwater abstraction allocations will be revised from time to time. VRX will implement industry best practice to minimise the amount of water required for the Proposal. VRX has applied for licences for the construction of a bore and abstraction of groundwater under section 26D and 5C of the RIWI Act. These applications fall within the groundwater resources allocations for the Yarragadee aquifer. VRX will operate the Proposal in accordance with the licences, allocations and conditions issued by DWER under the RIWI Act and recognises that impacts of climate change may require change to future allocations. In consideration for WA's Climate Change Policy (DWER, 2020), alternative water sources (such as desalination) may be considered in the future if groundwater allocations at no longer available. VRX has conducted a H3 hydrological assessment (Appendix 23) which includes modelling of drawdown from groundwater abstraction required for both the Arrowsmith North and Central projects. Modelling is based on the combined extraction of both proposals (currently proposed to be 1.3 GL/annum) and therefore provides a conservative assessment of the potential impacts of this Proposal. Existing abstraction allocations were considered up to 20 km from the proposals. Aquifer drawdown modelling was conducted for three operating scenarios for a 30 year mine life: 1. No Abstraction – steady state initial conditions, abstraction is set to zero; 2. Existing Allocations Abstracted (Base Case) – abstraction is set as the licensed allocation from 2015 to 2022, which is 6.283 GL/annum; and 3. VRX Proposed Abstraction (Arrowsmith North and Central Combined) – forward scenarios use the base case licenced allocation plus 1.30 GL/annum allocation to VRX, from their two productions bores, this is incremental to Scenario 2. Scenario 2, where there is no VRX abstraction, show the drawdown for the Yarragadee Aquifer at the Proposal as a maximum drawdown of up to 1.25 m over 30 years. Scenario 3, where the 1.3 GL/annum VRX abstraction from the Yarragadee only is included, the incremental drawdown for the Yarragadee Aquifer is predicted to be an additional maximum drawdown of up to 1.25m over 30 years. Modelling shows that abstraction of groundwater from the Yarragadee Aquifer for the combined Arrowsmith North and Central Projects is likely to only contribute an additional 1.25 m of drawdown over 30 years at the Proposal. Drawdown within the Yarragadee aquifer is not predicted to directly impact any Groundwater Dependant Ecosystems due to physical isolation from these ecosystems. The proposed cumulative abstraction from the Yarragadee Aquifer is within the allocation limits set by DWER and will be managed under a 5C Licence issued under the RIWI Act. With the implementation of these controls VRX considers that the abstraction of 0.9 GL per annum can be undertaken without a significant impact on the Yarragadee Aquifer. <u>Surface Water</u> *Alteration of Surface Water Regimes within the Access Corridor* The access corridor will require a 6 m wide crossing of a minor ephemeral drainage line, southeast of Arrowsmith Lake (Figure 77). This crossing is to occur in close proximity to the Brand Highway's crossing with the Arrowsmith River. The crossing will be developed with a floodway given that is a high-point of the drainage line and significant flows are likely to only occur during flood events. The water pipeline will be buried through this section to prevent damage from flood flows. Given the narrow disturbance and the proposed location of the crossing it is considered unlikely that the Proposal will result in significant impacts to the surface water regimes of the drainage line. <u>*Alteration of Surface Water Regimes within the Mine*</u> The implementation of the Proposal has the potential to alter the direction and volume of surface water flows within and surrounding the Mine Development Envelope. These alterations are primarily a result of the changes to the soil characteristics and topography of the site. The

changes to these characteristics and their potential impact to internal and external flooding are discussed below.

Internal Flooding

The soils of the Mine Development Envelope are characterised as having a high infiltration rate that is slightly reduced by a humus surface layer. Therefore, if surface runoff is generated it is anticipated that it will infiltrate the sandplain relatively quickly. Runoff from the site is only anticipated in short intense rain bursts (RPS, 2020).

The Proposal will remove 8 – 15 m of sand from the soil profile which will decrease the vertical separation between the surface and the water table. The underlying geology is comprised of sand over uneven and sporadic sections of limestone with reduced permeability. The removal of sand from the soil profile will therefore result in the remaining sand horizon saturating more frequently, resulting in more run-off, however only in intense rainfall events. Given the unevenness of the underlying limestone, this effect would be somewhat erratic (RPS, 2020).

External flooding

The key surface water features in proximity to the development envelopes are the Arrowsmith River and Arrowsmith Lake. Arrowsmith River runs west before turning north and terminates in Arrowsmith Lake (a permanent pool), south of the Mine Development Envelope. The south-west corner of the Mine Development Envelope is located about 2.6 km north-east of the river and lake.

There is no survey data upon which to accurately estimate flood levels in the Arrowsmith River or produce a flood map. A rough cross-section of the river was developed based on Shuttle Radar Topography Mission data, this information was used to estimate flood levels (RPS, 2020).

The bed slope of the Arrowsmith River is about 0.2 %. The main channel appears to be a few metres wide with minimal capacity, this suggests that most flood flow is carried in the floodplain. A 100-year flood would be expected to flow about 1.4 m deep (on average) in the main channel, and up to 0.55 m deep in the floodplain footprint. A 10,000-year flood would be expected to flow about 2.3 m deep (on average in the main channel, and up to 1.1 m in the flood footprint).

The Mine Development Envelope represents a relatively insignificant extent (approximately 0.4 %) of the Arrowsmith River catchment area. Therefore, any alterations to the surface water flow volumes of the Mine Development Envelope are anticipated to have little to no impact to the key surface water features of the surrounding landscape. Furthermore, the Mine Development Envelope is not impacted by external concentrated flows due to its higher elevation within the surrounding terrain, and the sandy landscape around the site. Due to the sandy soils and lack of watercourses in the area, changes to external flooding from the site are anticipated to be minimal (RPS, 2020).

Surface Water Contamination

The implementation of the Proposal will require the development of supporting infrastructure and the maintenance and operation of machinery that has the potential to contaminate surface water with hydrocarbons and chemicals if spills were to occur.

The soils of the Mine Development Envelope have a high infiltration rate which limits the potential for runoff from the site, and therefore runoff is only anticipated to occur in rare, short, intense rain bursts. The Mine Development Envelope is disconnected from any key surface water features and concentrated surface water flows. Based on the above, any spills that occur within the Mine Development Envelope are unlikely to reach any surface water features, and mitigation measures are proposed (Section 7.6) to ensure spills are contained and cleaned up. Given this, and the low volumes of hydrocarbons and chemicals to be stored on site, the risk of a significant impact to surface water quality is considered unlikely.

Sedimentation and Erosion

The access corridor involves the clearing of a 6 m wide corridor (on average), which will include an access road and water pipeline. Sediment could be lost from this construction corridor during the construction period, while vegetation clearing or road construction is underway. Construction of this corridor would occur while the landscape is dry, and the construction period would be relatively short (weeks to months) given the minor scale of the infrastructure. The works are therefore unlikely to occur during periods of significant runoff which would limit the potential for sedimentation impacts to the minor drainage line. Mitigation measures are proposed (Section 7.6) to reduce this risk further to ensure sedimentation of the minor drainage line does not occur as a result of access corridor construction.

A water supply pipeline carrying groundwater abstracted from the Yarragadee aquifer will be constructed within the access corridor. A slurry pipeline will be constructed from the MFP to the Processing Plant (within the Mine Development Envelope). A rupture of either pipeline would result in water / sand slurry being deposited adjacent to the pipeline potentially resulting in sedimentation and / or erosion. Mitigation measures are proposed (Section 7.6) to reduce the likelihood of a rupture and to reduce the volumes that would be lost. In the event of a spill any spilt sand slurry would be cleaned up as soon as practicable. It is likely that the spilt sand slurry

	would settle quickly and the water would infiltrate the sand. Given the lack of fine material in the slurry and the infiltration characteristics of the sandy soil it is likely that any spills would not result in sedimentation or erosion over a large area, even during a flood event. Based on the above, it is considered unlikely that the Proposal would result in significant sedimentation or erosion impacts to any surrounding surface water features.
Proposed environmental outcomes	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, 2018). The Proposal has been designed to ensure that hydrological regimes are maintained. The Mine Development Envelope has no surface water drainage features due to high infiltration rates and these high infiltration rates are predicted to remain after mining. There is one crossing of a minor ephemeral drainage line that only contains flow during flood events. VRX will ensure that a floodway crossing is installed in this location to ensure flows are maintained with minimal restrictions. The Proposal is not expected to significantly impact the quality of groundwater or surface water. Processing requires the addition of a flocculant (discussed in Section 2.2.3) which is non-toxic, and no waste products will be produced, with a market available for the fine tailings material. Leaks and spills of slurry sand 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 MFP, slurry pipeline, water pipeline and Processing Plant. The design and operation of all of these items will be regulated under Part V of the EP Act and the Mining Act. Drawdown modelling indicates a minimal amount of drawdown may occur within the superficial and Yarragadee aquifers over the life of the Proposal. The small extent of drawdown is not expected to impact any groundwater dependant ecosystems. Construction of a bore and the abstraction of groundwater for the Proposal will be regulated under licences issued under Section 26D and 5C of the RIWI Act respectively. The implementation of design and operation mitigation measures, and regulation under Part V of the EP Act, Mining Act and RIWI Act, are expected to ensure that the Proposal does not significantly impact inland waters. The EPA objective for this factor is therefore able to be met.
Assessment of offsets (if relevant)	Not relevant.
Social Surroundings	

Potential impacts	<u>Local Residents and Community</u>
	• Noise emissions from construction or operations of the Proposal; and
	• The Access Corridor will be visible from the Brand Highway.
	• Restricted access to 408.5 ha of native vegetation within the development envelopes for the life of the Proposal.
	• 14.5 ha of native vegetation to be cleared for the life of the Proposal with remainder of disturbance area being progressively cleared.
	<u>Aboriginal Heritage Sites</u>
	• No direct or cumulative impacts to Aboriginal Heritage Sites; and
	• Indirect impacts to the Arrowsmith River and Arrowsmith Lake through alteration to hydrological regime including abstraction of up to 0.9 GL of water per annum from the Yarragadee Aquifer.
	<u>Land use for traditional purposes</u>
	• Up to 353.8 ha of native vegetation clearing and including:
	  ○ 14.5 ha of clearing to remain for the life of the Proposal;
	  ○ 339.3 ha of clearing will be progressively rehabilitated via VDT; and
	• Alteration of land from mining operations.
	• Altered access to land.
	• Reduction in amenity

Mitigation hierarchy	**Avoid** The key avoidance mechanism implemented by VRX was the design of the development envelopes to avoid key features relevant to this factor, including:

	• Aboriginal Heritage Sites; • Arrowsmith River; and • Arrowsmith Lake. There are no significant archaeological or ethnographic places identified within the development envelopes. **Minimise** The following mitigation measures are proposed to ensure that direct and indirect impacts to social surroundings are minimised: • Obtain Access Agreement with Southern Yamatji People; • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act; • Compliance with the Aboriginal Heritage protocol agreed upon by VRX and the Southern Yamatji people; • Implement industry best-practice management measures for Aboriginal Heritage; • If required, obtain and comply with approvals under the ACH Act for any Aboriginal Heritage sites (or Other Heritage Places that are likely to be sites) that are to be disturbed; • If required, ensure Aboriginal 'cultural salvage areas' are appropriately salvaged prior to disturbance; • Minimise clearing and access restrictions within areas used for traditional purposes; • Maintain and improve Traditional Owners' access to land for traditional uses; • Include bush tucker and medicine species in rehabilitation monitoring and infill planting if required; • Development of a Cultural Heritage Management Plan in consultation with Southern Yamatji People; and • Develop and implement a Ranger Program in consultation with the Southern Yamatji People. **Rehabilitate** Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT. This includes physically land forming the site and replanting vegetation to ensure surface safe site access and water regimes are not significantly altered. At the completion of the Proposal the site will be rehabilitated. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; and • Completion criteria, monitoring and reporting during closure. The key rehabilitation measures from the MCP that relate to social surroundings are summarised below: 1. Bush tucker and medicine species will be included in rehabilitation monitoring and infill planting will be conducted if required; 2. The access corridor will be rehabilitated with watercourse crossing structures removed; 3. The mine will be progressively landformed, with post-mining drainage to align with current conditions; 4. The mining area will be revegetated with local native species; and 5. All infrastructure (including land access barriers) will be removed. 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.

Residual impacts, including assessment of significance	Local Residents and Community Potential impacts to amenity for local residents and the community include noise from construction and operation, alterations to land access and visual impacts. The Proposal is located 2.2 km away from the nearest sensitive receptor and approximately 3.3 km away from the closest public road. The EPA Guidance Statement No. 3 (EPA, 2005) provides advice on the use of generic separation distances (buffers) between industrial and sensitive land uses to avoid conflicts between incompatible land uses. The generic separation distances are a tool to assist in the determination of suitable distances between industry and sensitive land uses where industry may have the potential to affect the amenity of a sensitive land use. Where the separation between the industrial and sensitive land uses is greater than the generic distance, there will not usually be a need to carry out site-specific technical analyses to determine the likely area of amenity impacts due to emissions from the industry. Consistent with the EPA (2005) definition for sensitive land use – land use sensitive to emissions from industry and infrastructure (sensitive receptor), have been identified in the vicinity of the Proposal. This includes residential development – any permanent structure whose primary use is as a dwelling place, and various other locations where people are residing either on a temporary or permanent basis. Under the separation distances guidance (EPA, 2005), the Proposal is best described as an 'Extractive Industry – sand and limestone extraction', involving no grinding or milling works. The corresponding generic buffer distance that is recommended is 300 m to 500 m, depending on size. The Processing Plant is 3.3 km and the haul road is 1.7 km from the nearest sensitive receptor (sensitive receptors are discussed in more detail in Section 8.4.1). The Proposal's setback distance to the nearest sensitive receptor far exceeds the EPA's recommended setback distances (EPA, 2005) for this industry. The Proposal also has a limited scope of noise emitting activities (construction, mining sand and processing), a relatively small operational footprint and vehicle movements have been restricted (speed and distance) where possible. The Proposal also has the potential to restrict access to 405.1 ha of Native Vegetation which comprises part of a much broader continuous landscape, this restriction represents 1.41 % of the remaining Native Vegetation within 10 km of the Proposal. Permission may be granted for access to areas that are not being actively mined or are under rehabilitation. Based on the above, the Proposal is not expected to significantly impact the amenity of the natural landscape (through noise emissions, visual impact or restricted land access) for local residents and the community. Aboriginal Heritage Sites No Aboriginal Heritage sites, Other Heritage Places (OHPs), isolated artefacts or previously unrecorded suspected Aboriginal archaeological sites were recorded during any of the field surveys conducted by YMAC (2018 and 2020) or SandS CRM (2021). There is one Registered Aboriginal Heritage Site located in close proximity to the Proposal; the Arrowsmith River (Horizon Heritage, 2021). The Arrowsmith River adjacent to the Access Development Envelope and will not be impacted directly by the Proposal. Site access and product haulage is not expected to indirectly impact the Registered Aboriginal Heritage Site as the access corridor terminates at the intersection with the Brand Highway. It was the conclusion of the survey team and archaeologists that these sites will not be impacted by the Proposal (Horizon Heritage, 2021). OHPs identified within proximity to the development envelopes include Arrowsmith Lake (1 km west of the Access Development Envelope), a common place of mythological and spiritual significance. Mungenooka Springs and Arramall Cave also reside close to the Proposal (9.5 km and 5 km northwest of the Mine Development Envelope, respectively), both sites will not be impacted directly by the Proposal. *Changes to the Hydrological Regime* Both Arrowsmith Lake and Arrowsmith River have the potential to be indirectly impacted by the Proposal through changes to the local hydrological regime. The Proposal includes the development of a crossing at a minor ephemeral drainage line within the access corridor and the abstraction of up to 0.9GL per annum of groundwater from the Yarragadee aquifer. The potential impacts of the Proposal on Arrowsmith Lake and Arrowsmith River have been assessed in Section 7.5. With the implementation of mitigation measures and controls described in Section 7.6, the Proposal is not expected to result in any significant hydrological impacts to Arrowsmith Lake and Arrowsmith River. Land used for Traditional Purposes *Clearing of native vegetation*

	It is likely some of the development envelopes were utilised by past Yamatji people as a resource area for food and dietary sustenance, however it is likely this would have been focussed on wetlands and watercourse areas outside the development envelopes. OHPs like Cliff Head and Eneabba West demonstrate that Yamatji people used their traditional country. The Proposal will result in clearing of up to 353.8 ha of native vegetation within the development envelopes, which would otherwise be available for traditional uses (such as bush tucker or medicine). 14.5 ha of clearing will be required for the life of the Proposal and 339.3 ha will be cleared and progressively rehabilitated using VDT and infill planting (described in detail in Section 2.2.3). The VDT method was chosen as it promotes a high level of live foliage cover, vegetation density and species richness, achieving results that are comparable to the natural vegetation in approximately eight years (Mattiske, 2019a). At a regional scale disturbance for the Proposal occurs entirely within vegetation association 378.1, which has 65.0 % of its pre-European extent remaining. The Proposal will disturb 0.44 % of the remaining vegetation association, or 0.28 % of the pre-European extent. This minor reduction is unlikely to significantly reduce the availability of similar land available for traditional uses in the region. At a local scale, mapped vegetation communities provide context about the types of vegetation that will be disturbed and what proportions will be retained. The Proposal will not disturb more than 46 % of the mapped extent of any vegetation communities within the survey area (Figure 50), with the greatest being 116.84 ha of the H3 vegetation community (45.3 % of extent mapped by Mattiske; 2022a). Given that more than 54 % of every vegetation community will remain, and the vegetation communities with the largest percentage loss are within the proposed VDT areas (i.e., the vegetation community is predicted to remain relatively intact), the Proposal disturbance is unlikely to have a significant impact on the availability of bush tucker and medicine species in the local area. Nevertheless VRX will consult with the Yamatji People to ensure bush tucker and medicine species are included in rehabilitation monitoring (and infill planting if required) to ensure these species are represented in VDT areas. Given the proposed progressive rehabilitation method (VDT and infill planting of bush tucker and medicine species if required), and the presence of similar habitat in the Survey Area the direct disturbance of the Proposal is therefore considered unlikely to have a significant impact on the availability of land used for traditional purposes. *Land Access* The development envelopes reside almost wholly on Unallocated Crown Land within the Yamatji Nation ILUA. The Proposal will include some restrictions to parts of land within the development envelopes that would otherwise be available for traditional purposes. Areas within the development envelopes that are being actively mined or are under rehabilitation will not be accessible by the public however, additional exceptions will be made for Traditional Owners where safe to do so. Overall, access to the land for Traditional Owners may be improved by the development of the access road for the Proposal (note the use of this road will be limited to Traditional Owners and not the general public). VRX has committed to maintaining and improving Traditional Owners' access to land for traditional purposes wherever possible and safe to do so. The Proposal is therefore unlikely to significantly restrict access to land for traditional purposes. *Amenity* The Proposal will affect the amenity of the area, through noise, dust and light emissions, however as discussed in Section 8.5.1 the scale of these emissions is likely to be minor and localised.
Proposed environmental outcomes	The EPA's environmental objective for this factor is to "protect social surroundings from significant harm" (EPA, 2016f). The Proposal has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that the social surroundings are protected from significant harm. The Proposal is expected to result in negligible impacts to Local Residents and Community given the setback distances of the Proposal to the nearest sensitive receptors and the lack of observed recreational or other use of the land. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value. VRX has conducted extensive Aboriginal Heritage, archaeological, ethnographic and work area clearance investigations on all proposed disturbance areas. Disturbance to all Aboriginal Heritage sites (including the Arrowsmith River registered heritage site) identified during those surveys have been avoided during Proposal design, eliminating direct impacts. Indirect impacts (i.e., those resulting from changes to the local hydrological regime) are possible; however, they are expected to be managed by licencing under the RIWI Act and the approval under the Mining Act. Based on the above, the Proposal is not expected to result in significant harm to Registered Aboriginal Heritage sites.

	The Proposal will result in clearing of up to 353.8 ha of native vegetation within the development envelopes. A significant portion of this clearing is to be progressively rehabilitated with VDT and infill planting. VDT is expected to return vegetation assemblage and health to a condition comparable with the natural vegetation. The extent of clearing is not considered significant at a regional scale. The Proposal will result in restrictions to the land use of parts of the development envelopes. Restricted areas are to be limited to areas that are under rehabilitation, are actively being mined or contain infrastructure, therefore the proposed restricted areas will be relatively small. VRX has also committed to maintaining and improving access to land for the Traditional Owners, and minimising disturbance within any areas that may be used for traditional purposes. As a result, the Proposal is not expected to significantly impact Land Used for Traditional Purposes. Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.
Assessment of offsets (if relevant)	Not relevant.
Greenhouse Gas Emissions	
Potential impacts	• Up to 30,743 t CO_2-e of Scope 1 GHG emissions per year • No Scope 2 GHG emissions. • Up to 48,827 t CO_2-e of Scope 3 emissions per year
Mitigation hierarchy	**Avoid** VRX has investigated several power supply options for the Proposal, including renewable sources including solar, wind and stored energy. Solar power could supplement a portion of the energy requirements of the Proposal, however landholder negotiations for a suitable solar farm site are unlikely to be completed prior to assessment. VRX will continue to investigate the development of a solar farm, with the intent to utilise existing cleared land. **Minimise** The following mitigation measures are proposed to avoid or minimise GHG emissions during the implementation of the Proposal; • Progressive rehabilitation; • Optimise efficiencies of product handling, haulage, pumping, etc., during operations; • Explore and implement low/no emission power options; • Utilise heavy haulage trucks along the haul road; • Maximise electrical efficiency; and • Maximise diesel efficiency. **Rehabilitate** Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT and infill planting. At the completion of the Proposal the site will be rehabilitated entirely. One of the planned outcomes will be to reinstate the native vegetation at all cleared areas. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; and • Completion criteria, monitoring and reporting during closure. The key rehabilitation measures from the MCP that relate to GHG emissions are summarised below: 1. Mining areas will be progressively rehabilitated via VDT; 2. Permanent disturbance areas at the mine and access corridor will be revegetated at closure; and 3. All GHG emissions-producing infrastructure will be decommissioned and removed.

	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.
Residual impacts, including assessment of significance	An estimate of the expected annual Scope 1 GHG emissions from the Proposal was calculated by KBPL (2021). An average of 30,743 t CO_2-e per annum is estimated to be produced over the life of the Proposal. The Proposal is predicted to increase WA's annual GHG emissions from Industrial Processes on average by approximately 0.45 % per annum, this represents an overall increase to WA's GHG emissions of 0.02 % when compared to the State's total GHG emissions of 91.85 Mt of CO_2-e for 2019 (DISER, 2021a). The Proposal is also predicted to increase Australia's annual GHG emissions from Industrial Processes on average by 0.06 %, this represents an overall increase to Australia's GHG emissions of 0.004 % when compared to the National total GHG emissions of 494.2 Mt CO_2-e for March 2021 (DISER, 2021b). Based on the information provided above, the Proposal will result in a small contribution to WA (and subsequently, Australia's) annual GHG emissions. Given the relatively small contribution, the impact resulting from the implementation of the Proposal is not considered significant.
Proposed environmental outcomes	The Proposal is estimated to produce an average of 30,743 t CO_2-e of Scope 1 GHG emissions per year over the 30 year mine life, which is not considered significant in comparison to EPA's assessable limit (100,000 t CO_2-e of Scope 1 GHG emissions) for the GHG Emissions Key Environmental Factor (EPA, 2020c). The Proposal GHG emissions equates to only 0.45 % of the predicted annual emissions from Industrial Processes and 0.02 % of the overall predicted annual GHG emissions in WA (DISER, 2021b). Nevertheless, VRX is committed to minimising GHG emissions from the Proposal through the implementation of the mitigation measures described in Section 9.6. The implementation of design and operational mitigation measures is expected to ensure that the Proposal does not significantly impact this factor. The EPA objective for this factor is therefore able to be met.
Assessment of offsets (if relevant)	Not relevant.
Air Quality	
Potential impacts	Local airshed Emissions of combustion products, including: • NO_x: 227,923 kg/year • SO_x: 392,193 kg/year • CO: 537 kg/year Emissions of dust consisting of 0.29 $\%_{wt}$ Respirable Crystalline Silica (RCS).
Mitigation hierarchy	**Avoid** No specific avoidance measures have been included as part of the Proposal, however VRX is committed to implementing renewable energy during the initial phase of the Proposal (from external sources). When implemented this will avoid or minimise the subsequent air emissions from the power station. VRX has designed the Proposal to avoid impacts to Air quality. The primary avoidance measure of the Proposal is the location of the Processing Plant and power station. The Processing Plant and Power Station are both significant contributors to the overall air emissions of the Proposal. VRX has designed the Proposal to ensure that buffers between the Processing Plant and Power Station, and the nearest sensitive receptors are maximised. As a result, the buffer distances are well beyond the EPA's recommended buffer distances for this industry type. Additionally, the relatively small size of the Proposal and limited operational footprint limits the limits the emissions. **Minimise** • Ensure buffers are incorporated into Proposal design; • Obtain and comply with Works Approval and Licence issued under Part V of the EP Act; • Obtain and comply with the other environmental approvals; • Implement progressive mining and VDT methods; • Implement industry best practice management measures for air quality;

	• Implement the Rehabilitation Strategy (Appendix 4); • Explore and implement low/no emission power options; • Utilise heavy haulage trucks along the haul road; • Maximise electrical efficiency; and • Maximise diesel efficiency. **Rehabilitate** Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT. This includes land-forming the site and replanting vegetation which will ensure wind-driven erosion is minimised. Once production has completed, emissions from product handling and processing will cease. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; and • Completion criteria, monitoring and reporting during closure. The key rehabilitation measures from the MCP that relate to air quality are summarised below: • The haul road will be rehabilitated with vegetation to reduce the potential for dust lift off; • The mining area will be progressively landformed and rehabilitated using VDT; • The mining area will be revegetated with local native species; and • All infrastructure will be decommissioned and removed. 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.
Residual impacts, including assessment of significance	<u>Particulate Matter</u> *Dust Characteristics* The potential dust emission sources from the Proposal fall into three categories: • Raw (in-situ) silica sand (mined material); • Commercial grade silica sand (product); and • Reject material (slimes) produced as the by-product of processing. Comprehensive testing has been undertaken by VRX to characterise the properties of the above-mentioned materials, including (but not limited to): • Dust Extinction Moisture (DEM); • Particle Size Distribution (PSD); and • Compositional analysis – elemental, trace metal leach testing, RCS The results of this material testing have been used to determine the likely characteristics of dust emitted (including particle size, composition, and colour) that influence the potential health or amenity impacts. *Dust Extinction Moisture* DEM testing in accordance with AS 4156.6-2000 has been conducted of commercial grade silica sand product (Microanalysis Australia, 2021a). The DEM test result of 3.7 % will be used as a guide for the moisture level required to minimise dust when storing and handling of the product. The graph of dust versus moisture level of the product is also useful as it illustrates the impact of adding moisture to the materials, for purposes of design and implementation of dust control measures Figure 87. The proposed use of water cannons for wetting down of the product stockpile and during product load out is a suitable dust control measure provided moisture levels are maintained below the DEM level. *Particle Size* PSD testing using laser diffraction size distribution analysis following ISO 13320-1:2009 has been conducted of bulk samples of commercial grade silica sand, raw (in-situ) silica sand and reject material, summarised in Table 54. These results are of the bulk material samples and should not be misinterpreted as the anticipated PSD of dust emissions from the Proposal.

	The very high percentages of the large particles that fall into the non-inhalable fraction (>100 µm), particularly in commercial grade silica sand product (99.8 %) and raw (in-situ) silica sand (97.1 %), indicates much of the material will not become readily airborne during material handling or due to wind erosion. The relatively higher percentage of thoracic (PM_{10}) and respirable (PM_4) particulate matter contained in the reject material indicates this material may become more readily airborne if allowed to dry out. The respirable fraction of the bulk samples is used to evaluate the potential health risk associated with exposure to RCS. *Composition* Analytical testing of the commercial grade silica sand product, raw (in-situ) silica sand and reject material has been conducted to characterise the RCS content of these materials, to evaluate the potential public health risk to sensitive receptors from exposure to RCS in ambient air (i.e., excludes consideration of occupational health risk). Bulk samples were collected by VRX and analysis for respirable (PM_4) silica content was undertaken by X-ray diffraction (XRD) and scanning electron microscope (SEM) using the modified size-weighted respirable fraction (SweRF) method (Pensis *et al,* 2014). Assuming that PM_4 concentrations associated with dust emissions from the Proposal approached the relevant national air quality standards for PM_{10} (NEPC, 2021) at the surrounding sensitive receptor locations, which is highly unlikely (overly conservative), a screening-level assessment can be conducted that compares the estimated concentrations of RCS derived from the results of the bulk material content, to relevant ambient air assessment criteria for RCS sourced from the DWER (2019) and the Californian Office of Environmental health Hazard Assessment (OEHHA) (2005). Despite the very conservative nature of such a screening assessment approach, the analysis shows that the estimated concentrations of RCS in ambient air at sensitive receptor locations is not expected to be equivalent to more than 2.3 % of the relevant assessment criteria. This confirms the in-situ content of RCS in the materials being handled is extremely low and does not present a potential public health risk to sensitive receptors from exposure to dust emissions from the Proposal. <u>Combustion Products</u> *Emissions* The primary emission sources of combustion products (NOx, CO and SO2) emitted from the Proposal include: • Natural gas fired power station – CAT G3520E or similar gas engine; and • Exhaust emissions from diesel industrial vehicles, comprised of: • Front end loader (FEL) (x3) – CAT 988K or similar; • Water truck; and • Road trains. Credible emission estimates have been derived for these emission sources, presented in Table 57. The manufacturer specification sheet for a representative gas engine (G3520E; Caterpillar, 2021) was used as the basis for the emission estimates for the power station. Projected diesel fuel consumption information was used as the basis for the emission estimates from vehicle exhausts. The methodology used to estimate emissions is outlined in further detail in Appendix 28. Emissions from the power station are the primary source of combustion products estimated for the Proposal, representing 70 % (NO_x), 94 % (CO) and 92 % (SO_2) of total emissions on an annual basis. The significance of the emissions of combustion products from the Proposal has been evaluated using a screening model. *Screening Analysis* The screening air dispersion model, SCREEN3, has been applied as a conservative approach to the assessment of the significance of emissions of combustion products estimated for the Proposal. SCREEN3 is a United States Environmental Protection Agency (USEPA) screening model, which provides maximum predicted concentrations for a range of 'worst case' meteorological conditions. Screening models are often applied to determine if the potential air quality impacts from a source warrants more detailed (refined) air dispersion modelling. The use of a screening model is preferred over the draft DWER (2019) screening analysis approach in this case to account for the distance to sensitive receptors, an important aspect of the Proposal. The maximum predicted 1-hour average concentrations of NO_2, CO and SO_2 expected to occur at sensitive receptors located more than 3 km downwind of the Proposal, are summarised in Table 58. The maximum predicted concentrations were compared to relevant assessment criteria to provide an objective evaluation of the potential air quality impact of the Proposal.

	Reduced Air Quality – Human Health *Respirable Crystalline Silica* The physical properties of silica sand (hardness, specific gravity) generally make it less susceptible to dust generation from particle attrition and wind erosion, however low porosity can act to reduce the effectiveness of wetting down of surfaces for dust abatement (ETA, 2021). Bulk materials testing of reject materials and raw and commercial grade silica sand, found that the PM_4 (respirable fraction) to be less than 0.29 % for any analyte (α-Quartz, Crystobalite or Tridymite). ETA (2021) predicted that RCS concentrations would be less than 2.3 % of the acute or chronic exposure limit criteria when compared to the relevant ambient air assessment criteria for RCS at sensitive receptors (using a conservative assumption that the concentrations approached the national air quality standards for PM_{10} (NEPC, 2021)). Based on ETA's (2021) conservative assessment, RCS emissions from the Proposal are not expected to have a significant impact on Air Quality. *Combustion Products* ETA (2021) applied the screening air dispersion model, SCREEN3, as a conservative approach to the assessment of the significance of emissions of estimated combustion products at the Proposal. ETA determined the maximum concentration of NO_x, CO or SO_x would be less than 20 % of the assessment criteria at any sensitive receptor. Combustion products from the Proposal are therefore considered unlikely to be significant in terms of their potential to cause adverse air quality impacts at the identified sensitive receptor locations. Detailed (refined) air dispersion modelling of combustion emissions from the Proposal was therefore not considered to be warranted. Based on ETA's (2021) assessment, combustion products from the Proposal are not expected to have a significant impact on Air Quality.
Proposed environmental outcomes	The EPA's environmental objective for this factor is "to maintain air quality and minimise emissions so that environmental values are protected" (EPA, 2020c). The Proposal has been designed to ensure that impacts arising from air emissions are avoided and minimised where possible. The location of the Proposal has been chosen so that a buffer, sufficient for the activities of the Proposal, is in place to ensure air quality at sensitive receptors is not significantly impacted. The Proposal activities have been optimised to keep product handling and energy requirements low, subsequently minimising emissions from combustion products. To minimise dust emissions, the Proposal design includes a small operational footprint and a relatively low annual area of disturbance. Furthermore, mined areas are rehabilitated progressively, limiting the total mined area at any given time. The silica sand upgrading process is predominately a wet process and the product is stored and hauls wet to minimise dust generation. VRX commissioned ETA (2021) to conduct an air emissions desktop assessment to support the Proposal. The assessment considered the factors that influence air quality, specifically in relation to: • Dust emissions from the various stages of Proposal development; • Combustion emissions from the power station; and • Vehicle exhaust emissions. Based on ETA's assessment it is considered unlikely that the Proposal will have a significant impact on air quality. The nature and scale of the Proposal, and the separation distance to surrounding sensitive receptors far exceeds the EPA's minimum recommended buffer and adverse impacts to Air Quality are not expected to occur. By implementing the controls detailed in the section above, airborne dust generation can be maintained within acceptable levels. Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.
Assessment of offsets (if relevant)	Not relevant.

HOLISTIC IMPACT ASSESSMENT

The Proposal is a long-term project that allows gradual small-scale annual impacts and progressive rehabilitation, in contrast to mining projects that require large areas to be cleared up-front and remain cleared for the entire mine-life.

The Proposal lies within the Geraldton Sandplains Bioregion, an area noted for its biological diversity, and in some areas, it is under pressure from land clearing. The Proposal also occurs within the range of the Carnaby's Cockatoo (Endangered; BC Act and EPBC Act), and several significant flora species were identified within the survey areas. The Proposal has unavoidable impacts associated with vegetation clearing and habitat loss, therefore it was imperative that these impacts were avoided and minimised as far as practicable, and rehabilitation methods were best-practice.

Given the above, VRX 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 up to 366.5 ha of native vegetation that was moderate to high value Carnaby's Cockatoo foraging habitat. VRX has since reduced the extent of the Mine Development Envelope to exclude Priority Flora populations as much as practicable, and as a result the extent of clearing of Carnaby's Cockatoo has been reduced by 12.7 ha to 353.8 ha.

In addition to the above, VRX has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, the key measures being:

- The adoption of a progressive mining and immediate rehabilitation approach;
- The use of VDT as a rehabilitation method;
- The mining of a raised dune system, to avoid leaving an excavation at closure;
- The avoidance of riparian and drainage areas to the west of the Mine Development Envelope;
- Revising the Mine Development Envelope to avoid Priority Flora populations;
- Revising the Access Development Envelope to avoid the Arrowsmith River Registered Heritage site; and
- The use of existing cleared areas where available (access corridor).

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:

- Slurry spills and leaks and process plant emissions will be regulated under Part V of the EP Act;
- Mine pit 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 permanent and temporary disturbance within each development envelope;
- A limit on groundwater abstraction volumes;
- The implementation of the Rehabilitation Strategy to ensure that VDT and other rehabilitation impacts on flora and vegetation and fauna habitat are minimised as far as practicable;
- The implementation of a FMP to ensure that impacts on terrestrial fauna habitats (in particular Carnaby's Cockatoo foraging habitat) are strictly monitored and managed to provide the best possible habitat quality during rehabilitation; and
- The implementation of an Offset Strategy.

Based on the above, and the assessment provided in Sections 5 -10, the Proposal is expected to be able to meet the EPA's objectives for all potential key environmental factors, with the exception of Terrestrial Fauna.

Residual impacts to Carnaby's Cockatoo foraging habitat are considered to remain significant once mitigation measures are implemented. Offset measures are required to counterbalance these residual impacts to ensure that the EPA objective for Terrestrial Fauna can be met. VRX has proposed offsets and assessed the suitability of the offset against the WA and EPBC offset guidance, provided in Section 11. Specifics of these offset measures will be reviewed and refined during the development of an Offsets Strategy (expected to be a Ministerial Condition) through discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they meet the required outcomes and adequately counterbalance the residual impacts.

VRX considers that the residual impacts to Carnaby's Cockatoo foraging habitat is able to be counterbalanced by the implementation of the offsets detailed in Section 11, such that the EPA's objectives are able to be met for all Key Environmental Factors.

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1 INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Environmental Review Document (ERD) is to provide a detailed description of the Arrowsmith North Silica Sand Project (the Proposal) and to enable assessment of the potential environmental impacts that may result, should the Proposal be implemented. The ERD also outlines the Proposal elements required for the construction and operation of the Proposal. The assessment will be completed by the Environmental Protection Authority (EPA) under the provisions of Part IV of the *Environmental Protection Act 1986* (Western Australia; WA) (EP Act).

The following EPA guidance has been considered in the preparation of this ERD:

- Environmental Impact Assessment (EIA) (Part IV divisions 1 and 2) Procedures Manual (EPA, 2021a);
- Statement of Environmental Principles, Factors and Objectives (EPA, 2021b);
- Instructions on how to prepare an Environmental Review Document (EPA, 2021c); and
- Instructions on how to identify the content of a proposal (EPA, 2021d).

This ERD focuses on the environmental factors that were deemed to be 'key' environmental factors by the EPA; 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. Therefore, this ERD describes the most relevant Proposal elements and impacts of the Proposal for Environmental Impact Assessment (EIA) and provides all relevant biological and technical reports and survey results as Appendices (Appendix 1 – 32).

1.2 PROPONENT

The Proponent for the Proposal is VRX Silica Limited (VRX) (ABN: 59 142 014 873).

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1.3 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

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 was 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 17 March 2021. The EPA released its decision to assess the Proposal as a Public Environmental Review (s. 40(2) (b) and s. 40(4)) on 24 May 2021. A proponent prepared Environmental Scoping Document (ESD) was then submitted to the EPA and formally approved on 15 March 2022.

1.3.2 Section 87 of the Environment Protection and Biodiversity Conservation Act 1999

The Proposal was referred to the Department of the Agriculture, Water and the Environment (DAWE) on 1 October 2020 (EPBC 2020/8788). DAWE determined that the Proposal was a 'controlled action' and required assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), due to potential impacts on the following relevant controlling provisions:

- Carnaby's Cockatoo (*Zanda latirostris*) – Endangered;
- Malleefowl (*Leipoa ocellata*) – Vulnerable; and
- Sandplain Duck Orchid *(Paracaleana dixonii)* – Endangered.

The Proposal will be assessed as an 'accredited assessment' under Part IV of the EP Act. Section 87 of the EPBC Act makes provisions for the EPA to undertake this accredited assessment of the potential impacts to Matters of National Environmental Significance (MNES) on behalf of DAWE.

Further information on the potential impacts of the Proposal on MNES is provided in Section 12.

1.4 Other Approvals and Regulation

1.4.1 Land Tenure

All Proposal aspects lie within mining tenement M 70/1389 and miscellaneous licence L 70/208 held by Ventnor Mining Pty Ltd (a wholly owned subsidiary of VRX).

Brand Highway intersection works will be conducted within the road corridor under the *Land Administration Act 1997* (WA) (LAA).

1.4.2 Other Decision-Making Authorities, Approvals and Regulation

Implementation of the Proposal is subject to other approvals in addition to Part IV of the EP Act and the EPBC Act. 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 and regulation

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	Relevant Key Environmental Factor and Objective	Can the DMA mitigate impacts and how will the EPA's factor be met
Minister for Environment DWER	EP Act Part V	**Works Approval** – required for the construction and commissioning of the Processing Plant and disposal of screened material back into the mine pits (during commissioning) **Licence** – required for the operation of the Processing Plant and disposal of screened material back into the mine pits	Noise emissions	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes While not expected to be significant, the primary source of noise emissions from the Proposal is the Processing Plant and Power Station. The design of the Processing Plant and Power Station will be assessed under Part V of the EP Act to ensure noise emissions are minimised and do not result in significant impacts to any sensitive receptors. Noise emissions from other aspects of the site are not expected to be significant and are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.
			Dust emissions	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes While not expected to be significant, a primary source of dust emissions from the Proposal is the Processing Plant and the design of the plant will be assessed under Part V of the EP Act to ensure dust emissions are minimised and do not result in significant impacts to any sensitive receptors. In addition to regulation under Part V of the EP Act, dust emissions from all aspects of the site are regulated under the *Mining Act 1978* (WA) (Mining Act; refer below) and are not expected to be significant. These emissions are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.
			Disposal of screened material back into mined areas and unintentional discharge of potentially contaminated	**Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.* **Terrestrial Environmental quality** EPA's objective: *To maintain the*	Yes The Works Approval and Licence will regulate pollution of land or waters from the disposal of screened material or any spills of slurry or hydrocarbons within the Processing Plant areas. Leaks and spills from all other aspects of the site are regulated under the Mining Act (refer below) and are not expected to be significant. These emissions are unlikely to require additional regulation under Part IV of the EP Act in order to meet the objective for this factor.

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
			water (stormwater), hydrocarbons, and/or sand slurry	*quality of land and soils so that environmental values are protected* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained*	
Minister for Mines and Petroleum Executive Director, Resource and Environmental Compliance Division (Department of Mines, Industry Regulation and Safety (DMIRS)) State Mining Engineer (DMIRS)	Mining Act *Work Health and Safety Act 2020* (WA) Work Health (Mines) Safety Regulations 2021	**Mining Proposal (MP) and Mine Closure Plan (MCP)** Required for any mining-related disturbance within tenements (i.e., all works apart from road intersection works)	Changes to the stability of the landscape	**Terrestrial Environmental Quality** EPA's objective: *To maintain the quality of land and soils so that environmental values are protected* **Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	Yes. A MP will be submitted to DMIRS prior to any disturbance at the Proposal and will include auditable outcomes for key DMIRS factors (Biodiversity, Water Resources, Land and Soils). These outcomes will be defined and approved by DMIRS to ensure that the impacts on the key DMIRS factors are mitigated to an acceptable level. In the context of landscape stability this will include an auditable outcome that the landscape will be safe and stable during mining to prevent slumps or collapsed walls which could have environmental impacts. A MCP will be submitted to DMIRS with the MP prior to any disturbance at the Proposal and will be revised every 3 years. It will include auditable closure and rehabilitation outcomes and criteria which will be defined and approved by DMIRS to ensure that impacts on key DMIRS factors are mitigated to an acceptable level. In the context of landscape stability, the Proposal is not expected to leave any open excavations at closure (mining includes removal of sand from the top of a dune). Regardless, a MCP will include an auditable outcome that the landscape will be safe and stable post-closure to prevent slumps or collapsed pits which could have environmental impacts. The implementation of the MP and MCP under the Mining Act is considered suitable to mitigate this impact such that the EPA's objectives can be met. By meeting DMIRS's Factors, the Proposal will also meet the EPA's objectives for the relevant factors. Additional regulation under Part

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
					IV of the EP Act is therefore unlikely to be required for this potential impact.
			Clearing of native vegetation	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	Partially. A MP will be submitted to DMIRS prior to any disturbance at the Proposal and will include auditable outcomes for the key DMIRS factor: Biodiversity. These outcomes will include requirements for best-practice topsoil stripping and storage, VDT, minimising the clearing footprint and taking accurate records. A MCP will be submitted to DMIRS with the MP prior to any disturbance at the Proposal and will be revised every 3 years. It will include auditable closure and rehabilitation outcomes and criteria which will be defined and approved by DMIRS to ensure that cleared areas are rehabilitated to an acceptable level. In the context of vegetation clearing this will include an auditable outcome that the rehabilitated areas will meet specific closure criteria designed to ensure flora, vegetation and fauna values are reinstated. The implementation of the MP and MCP under the Mining Act is considered suitable to mitigate rehabilitation and impacts during clearing however it is not considered suitable to mitigate impacts associated with the loss of vegetation. This is expected to require assessment under Part IV of the EP Act to ensure that the EPA's objectives can be met.
			Introduction and spread of weeds	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained*	Yes. The approved MP and MCP will define outcomes to ensure that the Factors defined in DMIRS's Environmental Objectives – Policy and Mining (DMIRS, 2020b) are met for the Proposal. The DMIRS Factor: Biodiversity, is relevant to this impact: DMIRS's objective for this factor is: *Maintain representation, diversity, viability and ecological function at the species, population and community level.* These outcomes will be defined and approved by DMIRS to ensure that impacts associated with weeds are mitigated to an acceptable

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
					level. This will include an auditable outcome to prevent the introduction or spread of any new weed species or populations during construction, operation or closure. By meeting these outcomes and the objective of DMIRS's Biodiversity Factor, the MP and MCP will ensure that the EPA's objective for flora and vegetation is met. Therefore, further regulation for the impact of the introduction and spread of weeds is not required to be assessed by the EPA.
			Alteration to the post mining land use	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes. Approval of a MP and MCP will ensure that the Factors defined in DMIRS's Environmental Objectives – Policy and Mining (DMIRS, 2020b) are met for the Proposal. The DMIRS Factor: Rehabilitation and Mine Closure, is relevant to this impact. DMIRS's objective for this factor is: *Mining activities are rehabilitated and closed in a manner to make them physically safe to humans and animals, geo-technically stable, geo-chemically non-polluting/non-contaminating, and capable of sustaining an agreed post-mining land use, and without unacceptable liability to the State.* By meeting the objective of DMIRS's Rehabilitation and Mine Closure Factor, the Proposal will also meet the EPA's objectives for social surroundings that are relevant to this impact. Additional regulation under Part IV of the EP Act is therefore unlikely to be required for this potential impact.
		Mine Safety Management System Required for the construction and operation of the Proposal	N/A – this approval is predominantly related to safety and therefore not expected to regulate impacts to the environment		

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
Minister for Mines and Petroleum Chief Dangerous Goods (DG) Officer (DMIRS)	*Dangerous Goods Safety Act 2004* (WA) (DG Act)	**DG Licence** May be required for the bulk storage of fuel if above specified limits (unlikely)	Contamination of soils, groundwater and surface water (hydrocarbon spills) Fire (combustion of stored fuel)	**Terrestrial Environmental Quality** EPA's objective: *To maintain the quality of land and soils so that environmental values are protected* **Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.* **Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	Yes. The storage and management of hydrocarbons will already be regulated under Part V of the EP Act and the MP / MCP however the DG Licence provides additional mitigation for the design and storage of larger volumes of DG (if large volumes of hydrocarbons (>100,000 L) are required to be stored on site). A DG Licence sets standards for the way in which DGs are stored on site. These standards are aimed at ensuring DGs are stored safely and in such a way that will not result in impacts to the environment. Having a DG Licence ensures potential spills and combustion risks from the Proposal are mitigated. A DG licence (in combination with the Part V and Mining Act approvals) will meet the objectives of the EPA for both factors by minimising the risk of contamination of soils and water, and protecting flora and vegetation, and terrestrial fauna by minimising the risk of fire. Regulation of the potential impacts on the environment from the storage of DG is therefore not expected to be required under Part IV of the EP Act.
Minister for Lands Minister for Planning Chief Executive Officer (Shire of Irwin)	*Local Government Act 1995* (WA) *Planning and Development Act 2006* (WA)	N/A – a development application is not required as this Proposal will be approved under the Mining Act			
Chief Executive Officer (DWER) Minister for Water	*Rights in Water and Irrigation Act 1914* (RIWI Act; WA)	**26D licence** Required for the construction of a bore to abstract groundwater	Abstraction of groundwater from the Yarragadee aquifer	**Inland Waters** EPA's objective: *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are*	Yes. A 26D Licence ensures that bores are drilled, constructed and maintained appropriately to ensure the aquifer and the groundwater resource is not compromised. A 5C Licence regulates the taking of water and assesses the impacts of the abstraction on the environment

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
		5C licence Required for the abstraction of groundwater		*protected.*	and other users. A 5C Licence is only granted if the impacts from the abstraction are shown to be sustainable with minimal environmental impacts or impacts to other users. A 26D licence for the Proposal has been issued and he bore has been drilled, constructed and tested. Licence holders are obligated to comply with their resource allocation and any conditions included in the licence. Licence holders are also required to use water efficiently and responsibly, minimising impacts on the water resource. These Licences will ensure the Proposal meets the EPA's objective for Inland Waters by maintaining the hydrological regime of groundwater. Regulation of the potential impacts on the environment from the drilling and abstraction of groundwater is therefore not expected to be required under Part IV of the EP Act.
Commissioner for Main Roads Western Australia	*Main Roads Act 1930* (WA)	**Application to 'Undertake Works within Road Reserve'** Intersection works within the Brand Highway road corridor	N/A – this approval is safety and planning based and therefore not expected to regulate impacts to the environment		
Minister for Aboriginal Affairs	*Aboriginal Heritage Act 1972* (AH Act) (WA); or *Aboriginal Cultural Heritage Act 2021* (WA) (ACH Act) *Note: A 12 month transitional period during which the regulations, statutory guidelines*	**Application for a permit under the ACH Act.** Required for consent to impact any Aboriginal Heritage sites (if not able to be avoided)	Disturbance of Aboriginal Heritage Sites	**Social Surroundings** EPA's objective: *To protect social surroundings from significant harm.*	Yes. Given the flexibility available to the Proposal the disturbance of Aboriginal Heritage sites is unlikely to be required. However, an application for a permit under the ACH Act will assess the significance of the proposed disturbance and determine what mitigation measures are required to obtain consent for any disturbance to an Aboriginal Heritage Sites. This consultation and assessment process will meet the EPA's objective for Social Surrounds by protecting registered Aboriginal Heritage sites from significant harm.
			Disturbance or indirect impacts	**Social Surroundings**	No (if avoidance is not possible).

DMA and department (if relevant)	Legislation or agreement regulating the activity	Approval required and relevant proposal element	Whether and how statutory decision-making process can mitigate impacts on the environment? (Yes/No and summary of reasons Include a separate line item for each relevant impact, and discuss how the EPA's factor objective will be met)		
			Relevant Impact	**Relevant Key Environmental Factor and Objective**	**Can the DMA mitigate impacts and how will the EPA's factor be met**
	and operational policies of the ACH Act will be developed. During this time the AH Act will remain in force to enable proponents to seek Section 18 consent if required.		to areas or artefacts of Aboriginal cultural value	EPA's objective: *To protect social surroundings from significant harm.*	Given the flexibility available to the Proposal, areas or artefacts of significant Aboriginal cultural value are expected to be able to be avoided. However, if disturbance or indirect impacts within these areas cannot be avoided then assessment and potential regulation under Part IV of the EP Act may be required (note that VRX has conducted extensive surveys, no areas or artefacts of significant Aboriginal cultural value have been recorded in the development envelopes).
Minister for the Environment (Cth)	EPBC Act	**s.133 Approval** – required for the assessment of the Proposal's impacts on MNES	Direct impacts to Threatened Fauna (Vehicle Strike)	**Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	No While there is likely to be significant overlap in regulation, the EPBC Act is a Commonwealth Act and as such cannot be relied upon to regulate impacts under WA legislation.
			Clearing of potential Threatened Flora or Fauna habitat	**Flora and Vegetation** EPA's objective: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained* **Terrestrial Fauna** EPA's objective: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*	

2 THE PROPOSAL

2.1 BACKGROUND

The Proposal was referred to the EPA on 17 March 2021. The level of assessment was set as Public Environmental Review (s.40(2)(b) and s.40(4)) on 18 May 2021. A proponent-prepared ESD was then submitted to the EPA and formally approved on 15 March 2022.

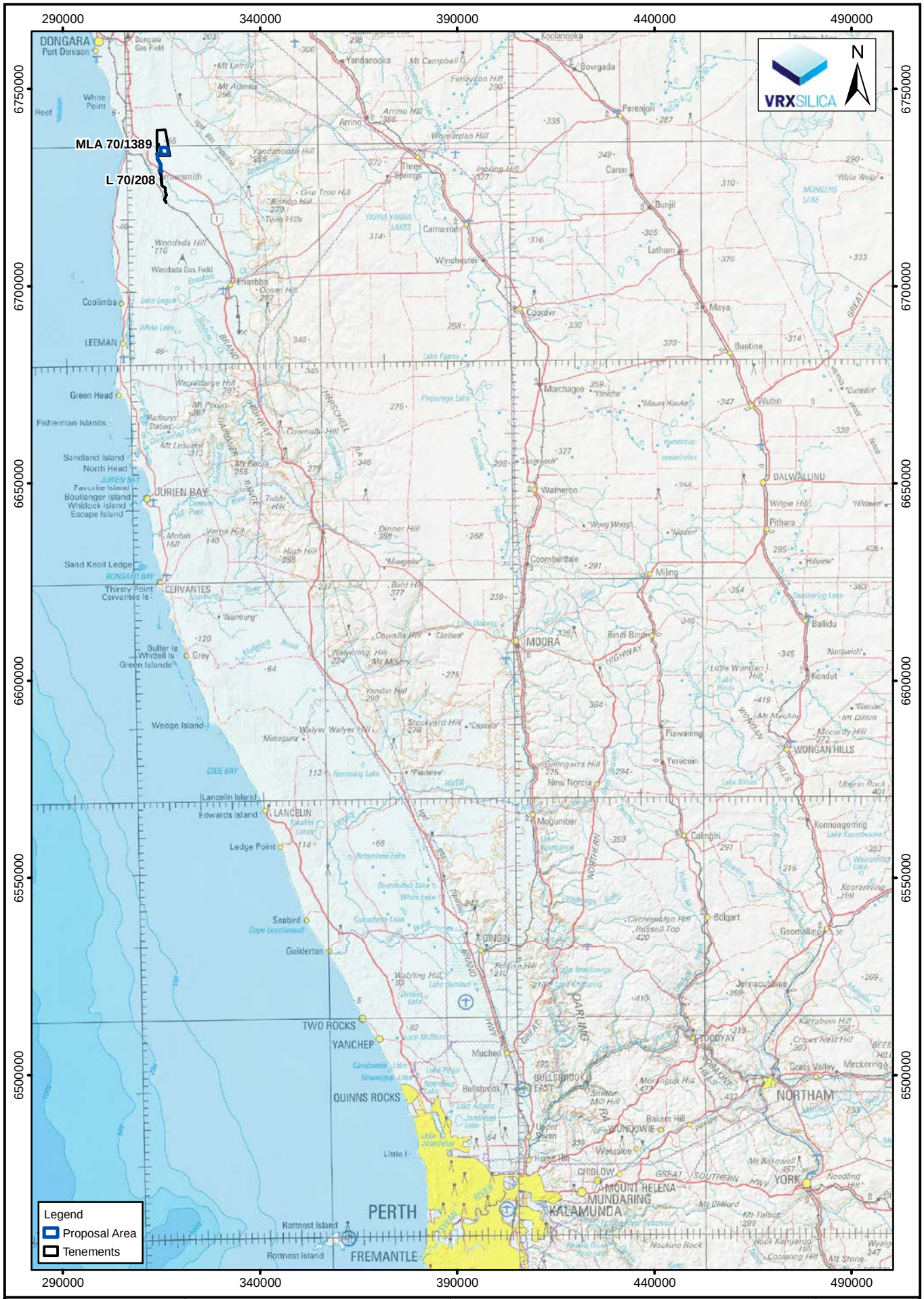
2.2 PROPOSAL DESCRIPTION

2.2.1 PROPOSAL LOCATION

VRX, an Australian Stock Exchange listed company (ASX: VRX), is seeking to develop the Arrowsmith Silica Sand Project, a series of high-grade silica sand mines in the Geraldton Sandplain bioregions of WA. There are two sites which make up the Arrowsmith Silica Sand Project, Arrowsmith North and Central. The Proposal defined in this ERD is the Arrowsmith North Silica Sand Project only.

The Proposal is located approximately 270 km north of Perth and lies primarily within mining lease M 70/1389 held by Ventnor Mining Pty Ltd, a wholly owned subsidiary of VRX. The regional location of the Proposal is shown in Figure 1.

Access to the site will be via a single access corridor within the Access Development Envelope which will connect the Mine Development Envelope to the Brand Highway.



0 20 km

Scale: 1:1,300,000
MGA94 (Zone 50)

CAD Ref: a2602_f56_01

Date: April 2022 | Rev: A | A4

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Arrowsmith North Project
Regional Location of the Proposal

Figure: 1

Figure 1: Regional setting of the Proposal

2.2.2 PROPOSAL CONTENT ELEMENTS

VRX has referred to the EPA's instructions 'How to Identify the Content of a Proposal' (EPA, 2021d) which focuses on how to define the Proposal elements for the purposes of an 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 Proposal elements (e.g., physical, construction and operational) which are likely to cause an impact on the environment are summarised in Table 3. Shapefiles for the development envelopes and indicative disturbance footprints are provided as Appendix 1.

Table 2: General Proposal content description

Proposal Title	Arrowsmith North Silica Sand Project
Proponent Name	VRX Silica Limited
Short Description	The Proposal is to develop a high-grade silica sand mine in the Geraldton Sandplain bioregion of WA, approximately 270 km north of Perth. The Proposal will produce a high-grade silica sand product via extraction and mechanical upgrading. The Proposal includes the sequential block mining of silica sand, development of a mine feed plant, moveable surface conveyor, pipeline, processing plant, stockpiles, freshwater supply bore, access corridor, laydown, administration, water storage and associated infrastructure including: gas fired power station, communications equipment, offices, workshop and additional laydown areas. Access to the site will be via an Access Road connecting the Mine to Brand Highway. A freshwater supply bore, water pipeline and Access Road will be located within the Access Development Envelope. All other infrastructure will be located within the Mine Development Envelope. Product will be hauled via road to Geraldton port where it is exported internationally.

Table 3: Location and proposed extent of physical and operational elements

Element	Location / Description	Maximum extent, capacity or range
Physical Elements		
Mine and Associated Infrastructure • Mine feed plant (mobile) • Conveyor (mobile) • Surface slurry pipeline (mobile) • Processing plant and Stockpiles • Topsoil stockpiles • Water storage • Gas fired power station Associated infrastructure including administration, communications equipment, offices, workshop and laydown areas.	Figure 2	Clearing of 347.3 ha within the 347.3 ha Mine Development Envelope.
Access Corridor Access Road, water bore and water pipeline	Figure 2	Clearing of no more than 6.5 ha within the 60.4 ha Access Development Envelope.
Construction Elements		
Groundwater Abstraction	Figure 2	Abstraction of up to 0.9 GL/yr from the Yarragadee aquifer
Operational Elements		
Mining and Vegetation Direct Transfer (VDT)	Figure 2	Mining to be undertaken such that topsoil and vegetation is transferred directly to rehabilitation areas via VDT.

Element	Location / Description	Maximum extent, capacity or range
Silica Sand production	Figure 2	Production of up to 2 Mtpa of silica sand
Energy production	Figure 2	Up to 5 MW
Groundwater Abstraction	Figure 2	Abstraction of 0.9 GL/yr from the Yarragadee aquifer
Greenhouse gas emissions		
Construction		
Scope 1	N/A	Land use change GHG emissions of 1,000 – 1,200 tCO_2-e
Scope 2	N/A	None
Scope 3	N/A	Annual Scope 3 emissions of up to approximately 30,416 tpa during the first three years.
Operation		
Scope 1	N/A	Land use change Annual GHG emissions of 1,000 – 1,200 tCO_2-e Peak total GHG emissions of 33,160 tCO_2-e Energy Production and Product Transport Maximum annual GHG emissions of 17,121 tCO_2-e for the first 3 years and 30,743 tCO_2-e each year thereafter. Maximum 550,170 tCO_2-e GHG emissions over the life of the Proposal (conservatively assumes no renewable energy is utilised).
Scope 2	N/A	None
Scope 3	N/A	GHG emissions of 60,471 tCO2-e per year
Rehabilitation and closure		
Areas temporarily cleared for laydown during the construction phase will be rehabilitated following construction. Final closure and rehabilitation to commence within 1 year of cessation of operations. Mined areas are to be progressively rehabilitated using VDT and infill planting.		
Commissioning		
N/A		
Decommissioning		
Removal of all above surface and buried infrastructure within 2 years of cessation of operations.		
Other elements which affect extent of effects on the environment		
Proposal Time	Construction phase	Approximately 6 months.
	Operations phase	30 years
	Decommissioning phase	Approximately 2 years after operations

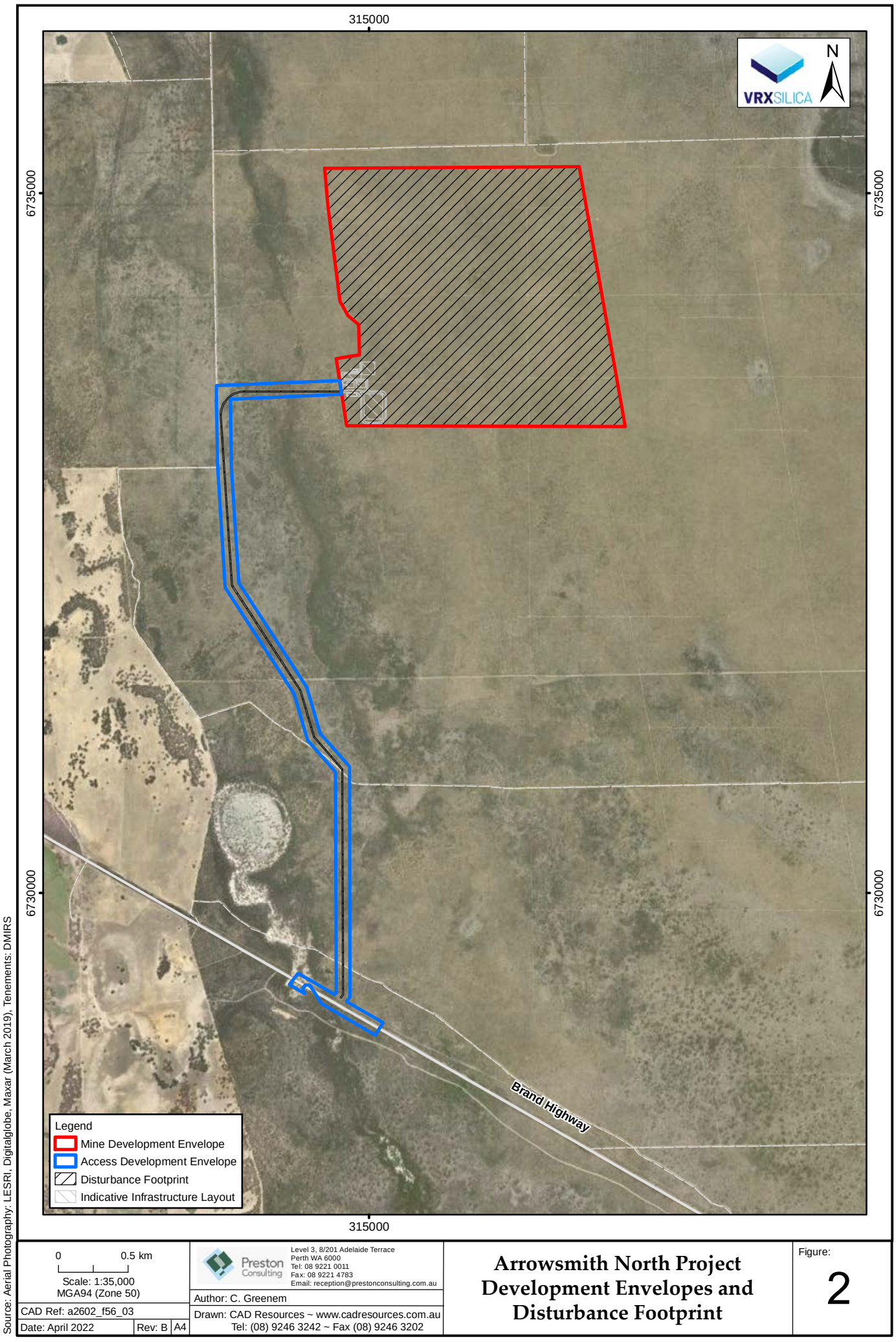


Figure 2: Development envelopes, Disturbance Footprint and indicative infrastructure layout

2.2.3 DETAILED DESCRIPTION

Overview

VRX is seeking to develop the Proposal, a high-grade silica sand mine located approximately 270 km north of Perth in the Geraldton Sandplain bioregion of WA.

The Proposal will involve sequentially mining 8 – 15 m of sand from below the surface of the soil profile, an indicative mining cross section is provided in Figure 3. Mining will be performed in sections by removing blocks (typically 150 m x 150 m), with an estimated five blocks being mined per year. Long-term infrastructure will include access / haul roads, pipelines, water storage dams, processing plant, power station, stockpiles and laydown area. The Proposal is based on a Probable Ore Reserve of 223 Mt comprising of 99.7 % SiO_2. The life of the Proposal is estimated to be 30 years, with additional reserves available that could extend this mine life (pending approval).

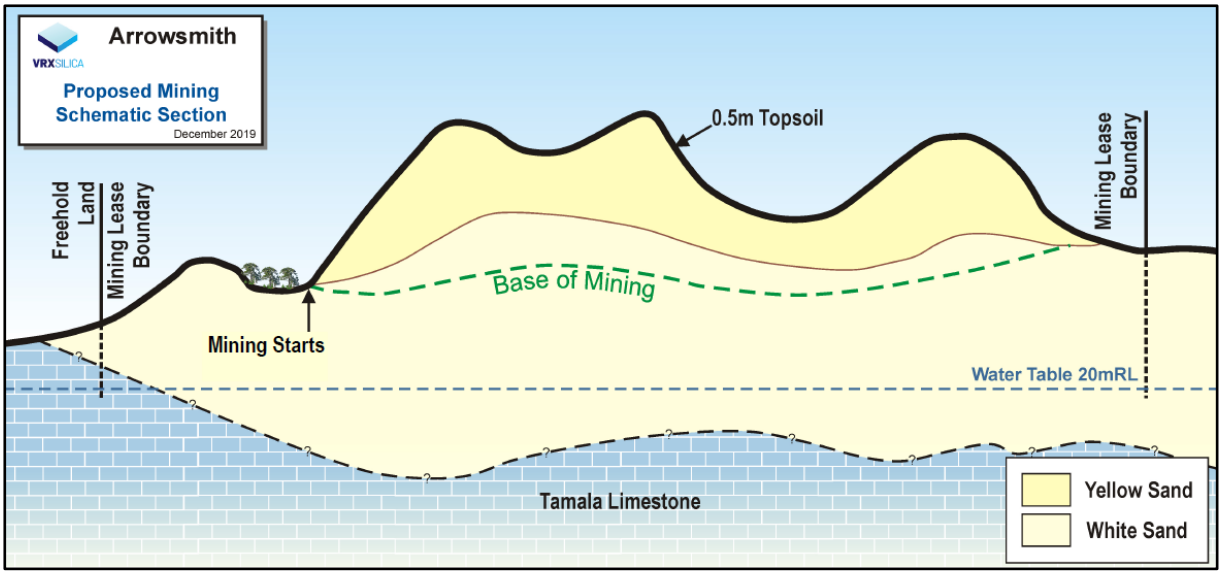


Figure 3: Indicative mining cross section

The Proposal consists of two distinct development envelopes; a Mine Development Envelope and an Access Development Envelope (Figure 2).

The Proposal will clear all native vegetation within the 347.3 ha Mine Development Envelope in order to develop the mine, processing plant and associated infrastructure (Figure 2). The access corridor / haul road, surface water pipeline and associated infrastructure will require disturbance of no more than 6.5 ha of native vegetation within the 60.4 ha Access Development Envelope (Figure 2).

Vegetation Direct Transfer

The rehabilitation technique VDT, or community translocation, is the practice of salvaging and replacing intact sods of vegetation with the underlying soil intact (Figure 4; Ross *et al*., 2000). Examples of utilising VDT in rehabilitation have shown rapid recovery of indigenous vegetation cover and conservation of the habitat. There are numerous advantages to utilising direct transfer as a rehabilitation technique, such as: recycling of plant and soil materials; faster re-vegetative process; restoration of the whole ecosystem; and erosion control (Ross *et al.,* 2000). Rehabilitation using this method allows for the retention of root stock, seed banks and soil micro-

organisms. These factors are particularly favourable when rehabilitating vegetation assemblages that have recalcitrant species, such as those found in the Mine Development Envelope (Rodgers *et al.,* 2011).

The deep sandy soil profiles within the Mine Development Envelope are ideally suited to the VDT rehabilitation method – the sandy soils are easy to handle, with little resistance to machinery and fewer problems with materials 'sticking' to machinery during handling, or rocky materials that cause additional fracturing and difficulty in handling. The placement of sods at the Proposal will be done in a staggered formation, allowing for a small gap between sods. This formation will provide better drainage and accumulation of organic material as well as providing a protected bed for seed and infill planted seedlings.

The Proposal has a relatively small annual mining footprint (a maximum of 12 ha per year) and does not need to follow long strandlines (as does mineral sand mining). These attributes make it ideally suited to the VDT method – where the soil blocks being harvested need only be transported tens to hundreds of metres to the pre-prepared rehabilitation area.

The complete VDT process is shown in a video prepared by VRX and is accessible via the following link: https://www.vrxsilica.com.au/miningandrehabilitationmethodology/

Historically, excavators with conventional bucket attachments have been used for VDT. This machinery has the potential to fragment the sod, exposing roots to the air and therefore requires a high degree of operator skill to ensure the structural integrity of sods are maintained. VRX intends to utilise a purpose-built wide-mouth Front End Loader (FEL) attachment (measuring 3 m x 3 m x 40 cm) as depicted in Figure 4. This is expected to reduce the scope of operator error and provide better control to increase the likelihood of successful VDT rehabilitation.

Figure 4: VDT excavation (sod removal) method

The efficacy of VDT as a rehabilitation method, particularly for the rehabilitation of the resprouting, rhizomatous and tuberous species that dominate the heath communities of the

Proposal, is discussed in a report on VDT Trials by Mattiske Consulting Pty Ltd (Mattiske; 2019a, Appendix 2). The most recent monitoring data highlighted the following advantages of VDT over conventional topsoil stripping, stockpiling and replacement for mine rehabilitation:

- Rootstock is mostly preserved allowing re-sprouting species survival (many recalcitrant);
- Seed bank preserved;
- Soil microbiology preserved;
- Soil compaction absent;
- Soil structure preserved; and
- Surface stability achieved.

Mattiske (2022b) provides a summary of the assessment of the root morphology of significant flora species likely to be present within the development envelopes against the VDT process. Mattiske determined that it is likely that the use of VDT will be successful for the establishment of the majority of significant flora species recorded within the development envelopes. The findings of this memo are discussed further in Section 5.3.4.

VDT provides a rehabilitation surface that is far less susceptible to erosion by wind or water, having a stable cover layer transferred from the harvested area. This significantly reduces the risk of rehabilitation failure due to sandblasting or poor establishment conditions. The transferred plants together with residual organic matter do not degrade in stockpile and provide an excellent retention of nutrients, soil mycorrhiza and micro flora and fauna.

The rootstock of dominant deep rooted or large rooted species (i.e., *Banksia, Xylomelum,* and *Eucalyptus*) is too deep or difficult to handle by VDT and is not able to be translocated, and it has not been proven up at a large scale. A review of the roots of the tree species common to the Mine Development Envelope is provided in Section 5.3.4. The inability to direct transfer deep rooted or large rooted species can be offset by infill planting with seedlings, or direct seeding in the gaps between soil blocks in the rehabilitation areas. Many of these species are re-sprouters however, all species are easily grown from seed at a nursery and have also been successfully established in mine rehabilitation. Combining these species with the ability of VDT to ensure recalcitrant species are largely retained (along with the other advantages listed above), makes VDT a logical choice for rehabilitation method.

Mining

VRX will employ a dry mining method that uses FELs to extract the upper 8 – 15 m of the soil profile. Mining will occur above the water table. A vertically exaggerated (20x) mine cross-section is provided in Figure 3.

Silica sand will be mined in 150 m x 150 m (2.25 ha) blocks in a linear pattern, as each block is mined, previously disturbed land will be rehabilitated using VDT. The complete mining sequence is illustrated in a video prepared by VRX, accessible via the following link:
https://www.vrxsilica.com.au/miningandrehabilitationmethodology/

Stage 1 – Initial Clearing

Stage 1 of the mining process includes clearing vegetation in the first 150 m x 150 m block (Figure 5). This first round of clearing will be achieved by a bulldozer; topsoil and vegetation will be removed and stockpiled for later use in conventional rehabilitation.

Stage 2 – Conveyor Clearing

Stage 2 involves the clearing of vegetation required for the development of a conveyor that runs parallel to the mining blocks (Figure 5). A 200 m long strip of vegetation is mulched and ripped in preparation for VDT. Sods are removed by a modified front-end loader and translocated to the area cleared during Stage 1. Vegetation clearing for the conveyor will occur in parallel to mining.

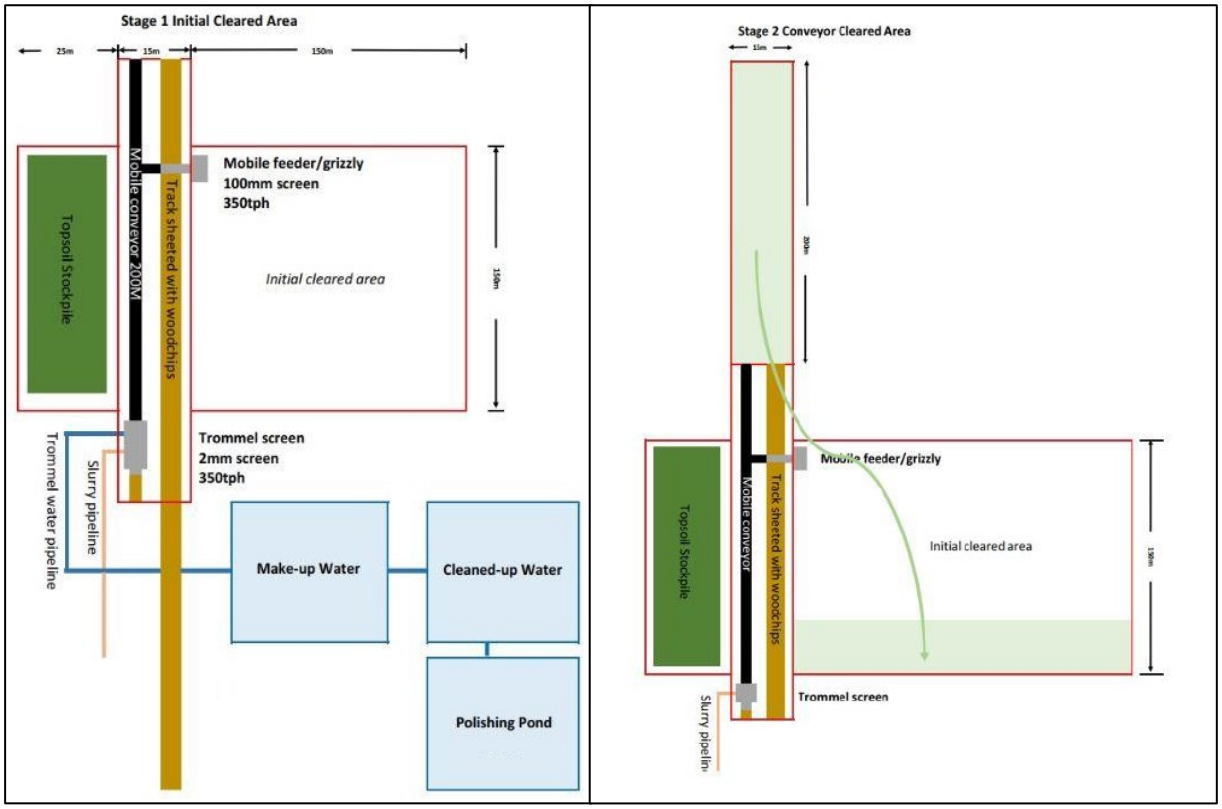


Figure 5: Stage 1 and 2 of the mining process

Stage 3 – Sod Relocation

The next block is prepared for mining using the same process described above (Figure 6). Sods are removed and translocated to the previously prepared area.

Stage 4 – Continuous Mining

The cleared block is mined using a conventional dry mining method. Silica sand is removed from the soil profile to a depth of 8 – 15 m using a front-end loader and deposited into the hopper of the Mine Feed Plant (MFP). Once mining has been complete, the next segment of vegetation required for the expansion of the conveyor is cleared using the same process described in Stage 2. Vegetation from the next block is then removed in preparation for mining.

This process is repeated in 150 m x 150 m blocks that span the width of the Mine Development Envelope (Figure 6).

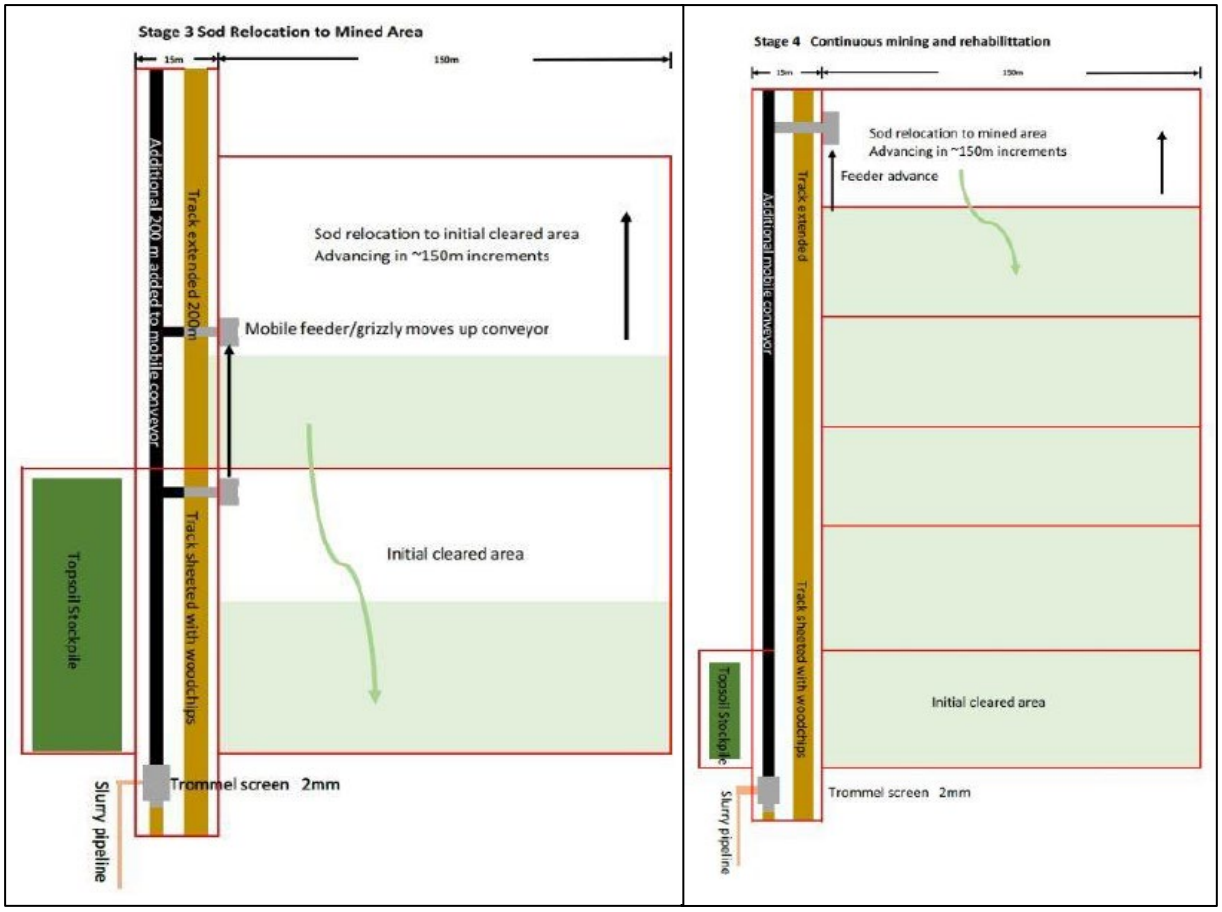


Figure 6: Stage 3 and 4 of the mining process

Stage 5 – Retreat

At this stage, mining has reached the furthest block in the mining area. To initiate the retreat to the first cleared area, a new block on the opposing side of the conveyor (Figure 7) is cleared and mined using the same process outlined in stage four.

Stage 6 – Completion

Stage six involves continuous mining to complete a full retreat, back to the first mining block whilst progressively removing and rehabilitating the conveyor (Figure 8). The last block will be rehabilitated with the topsoil that was stockpiled from the first block.

Stage 7 – Extension

Stage seven involves an extension of the conveyor and mine area (Figure 8). A new path will be established parallel to the previously mined areas and the mine sequence starts again.

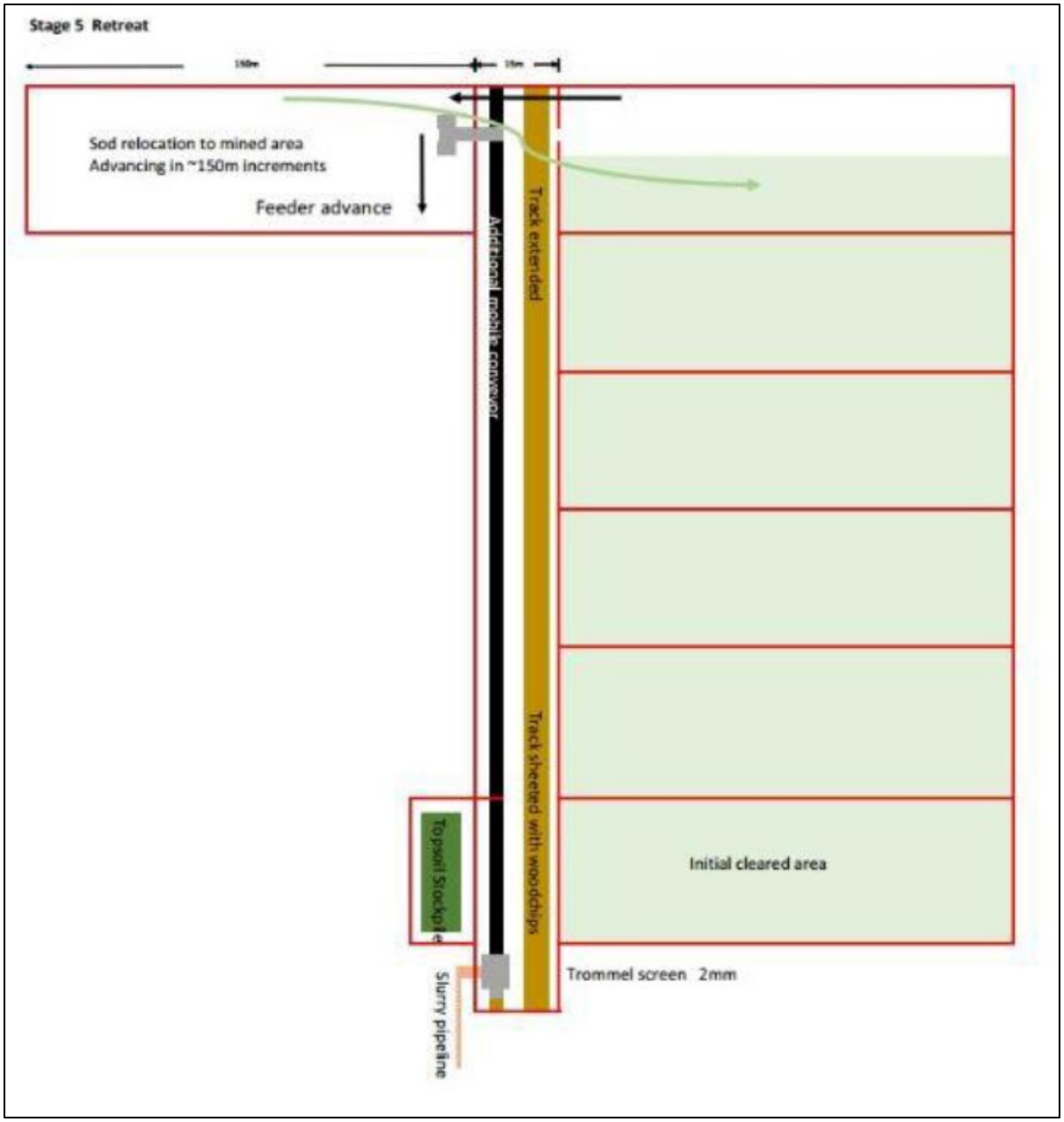


Figure 7: Stage 5 of the mining process

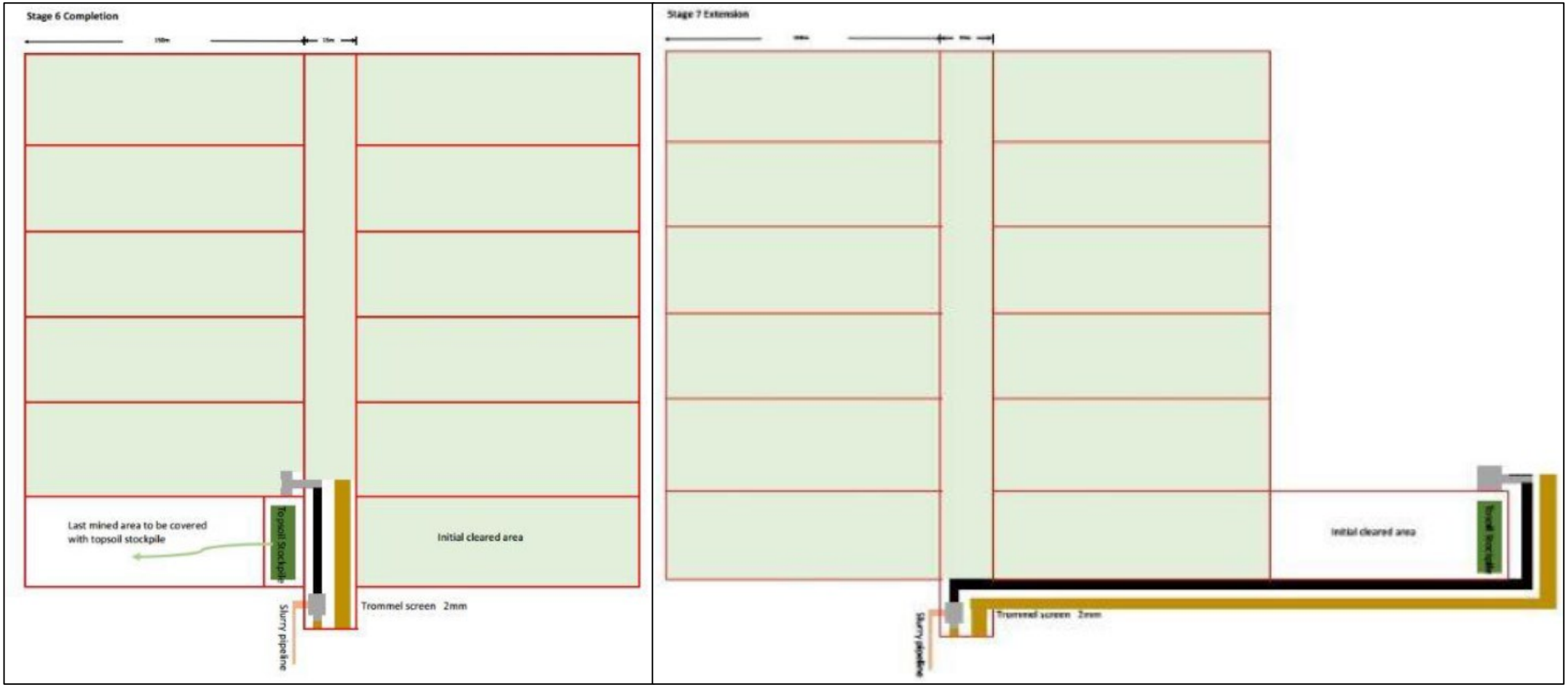


Figure 8: Stage 6 and stage 7 of the mining process

The proposed approach to mining will include transposing each block (one sod at a time) approximately 150 m in a single direction, with no blocks needing to be moved more than this distance. This mining sequence ensures that the block movements will generally retain the original vegetation community mosaic (discussed in Section 5.3.4). Further discussion on impacts of VDT on vegetation are discussed in Section 5.5.1.

Mine Feed Plant

Mined sand is processed through a MFP (Figure 9) that lies within the Mine Development Envelope (i.e., separate to the processing plant). The MFP is comprised of a hopper, conveyor and trommel screen.

Dry silica sand extracted from the mine face will be tipped across a dump hopper with static grizzly bars to remove oversize rocks and large organic material. The bin will meter feed out to a feed conveyor which will transfer feed to the mouth of a rotating trommel screen. The trommel screen will act to wash the sand and slurry the sand feed and remove +2 mm oversize sand, rocks and organic material. Water will be from the mine water storage tank. Undersize material from the trommel screen will gravitate to a bin and will be pumped to the processing plant via a slurry transfer system.

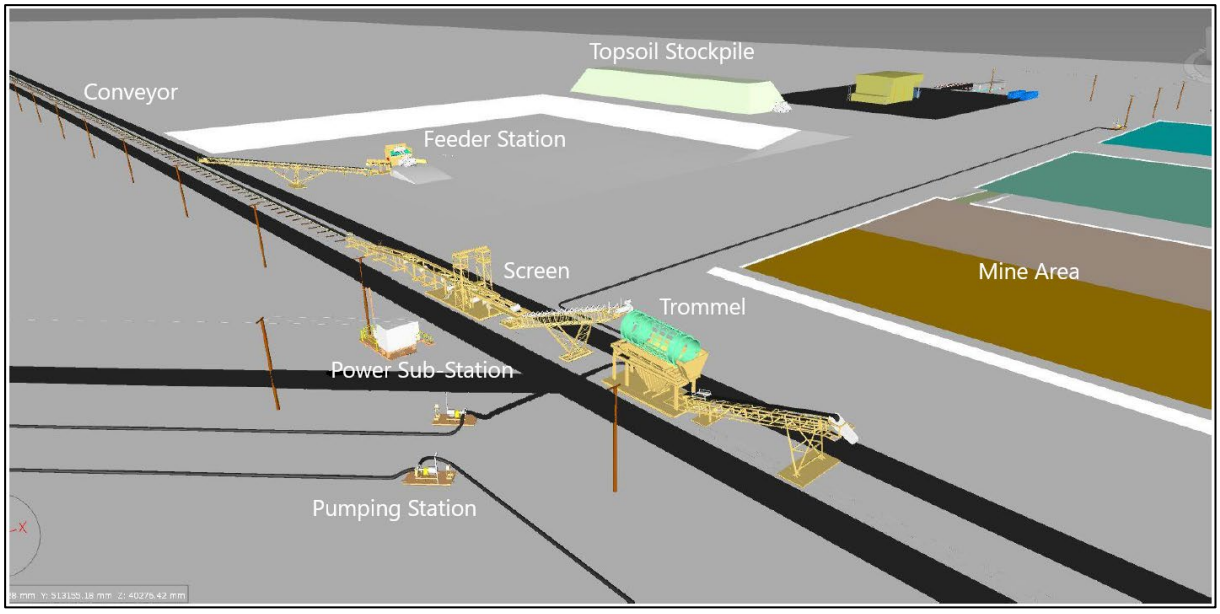


Figure 9: General arrangement of the Mine Feed Plant

Moveable Pipeline

Sand slurry will be piped to the processing plant via a moveable surface pipeline. The pipeline is manufactured from polyethylene and has a diameter of 280 mm. The pipeline will transfer approximately 8 m^3 of sand slurry (30% solids) per minute. The pipeline will be fitted with sensors and an alarm system with automatic shutdown. The sensors measure flow rates at the start and finish of the pipeline, and differences in the flow rates will trigger a shutdown of the system. Conservative estimates suggest that the shutdown of the system would occur within 1 minute (likely to be quicker) of a leak being detected, therefore a complete rupture is only expected to result in a spill of approximately 8 m^3 of slurry (2.4 m^3 of solids). The pipeline is proposed to be housed in a 'V' trench approximately 300 mm deep that will have the capacity to hold a complete rupture of the pipeline. Spills are expected to be localised within the trench, and

therefore any impacts to surrounding vegetation are unlikely. Infiltration rates are high, and it is anticipated the slurry will dry quickly. Spilled material will be recovered.

Processing Plant

Mined sand is pumped as a slurry to the processing plant (Figure 10) located in the southwest corner of the Mine Development Envelope (Figure 2). The sand is upgraded to a commercial grade using gravity and magnetic separation. A simplified sand processing flow chart is provided in Figure 11. Upgraded sand is pumped to a dewatering screen for drying, and clean dry product is stockpiled adjacent to the processing plant using a radial stacker conveyor in preparation for export.

Reject material (slimes) will report to a thickener tank with flocculant (discussed in the following section) addition to create a single plant tail. The thickener will utilise a pressure sensor activated underflow pump which will deposit densified tails into a dewatered tailings stack. The tails will then be taken offsite for sale in the local market.

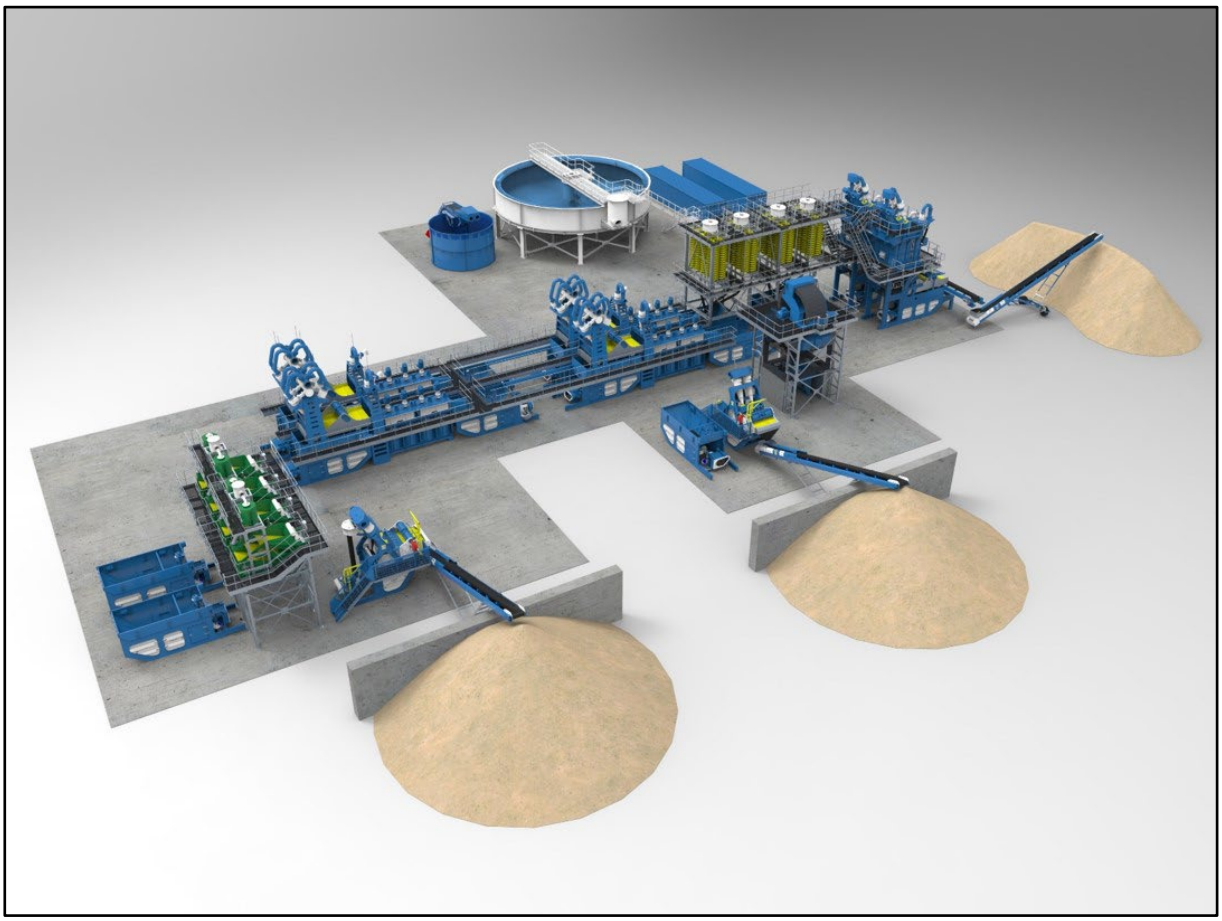


Figure 10: Process Plant indicative layout

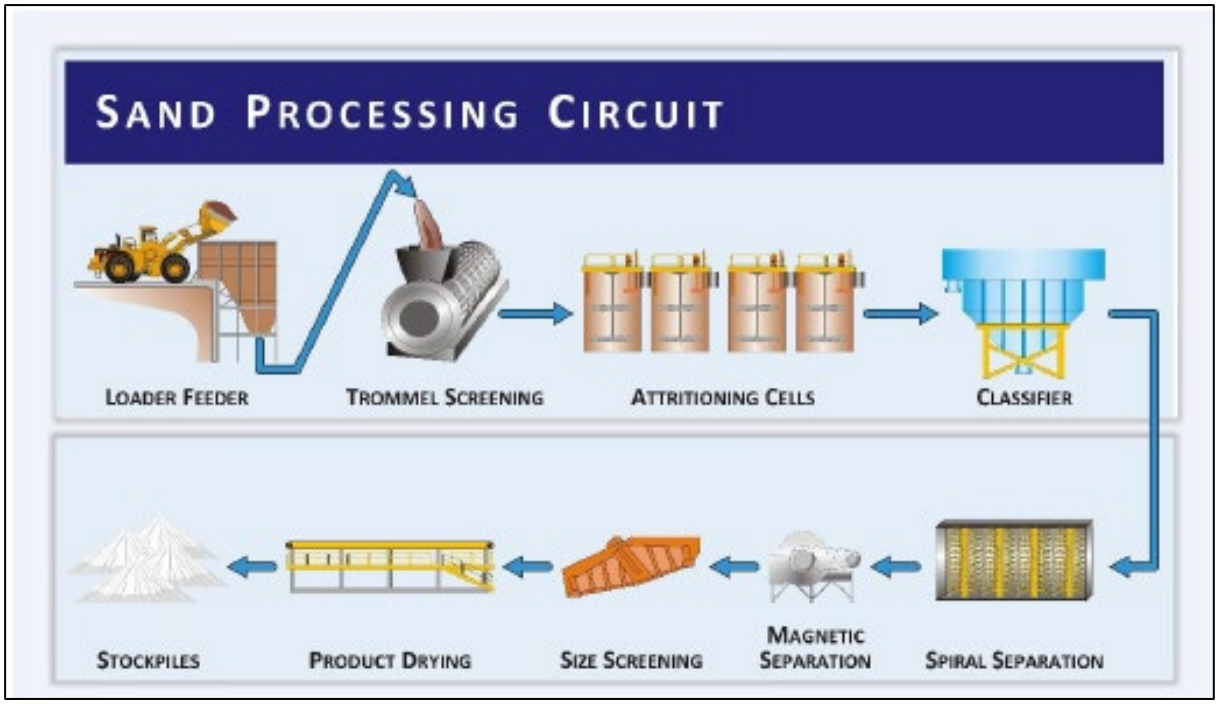


Figure 11: Silica sand processing flow chart

Flocculant

The flocculant used in the process is Floerger AN900 series Anionic Polyacrylamide. The following information is from the environmental data sheet for Floerger AN900 series Anionic Polyacrylamide (SNF Floerger, n.d.). The environmental datasheet is provided as Appendix 3.

Anionic polyacrylamide is the generic name for a group of very high molecular weight macromolecules produced by the free-radical polymerization of acrylamide and an anionically charged comonomer, mainly the sodium salt of acrylic acid, sodium acrylate. The combination of molecular weight and ionic charge results in extremely viscous aqueous solutions, one of the main properties of these polymers.

Access Corridor

Product will be hauled off site via the access corridor which connects the Proposal to the Brand Highway. The access corridor will be comprised of the following infrastructure:

- 5 m wide vehicle access / haul road;
- Power lines; and
- Process water pipeline.

The access corridor / haul road is within a Miscellaneous Licence (L 70/208, which overlies Unallocated Crown Land (UCL) and a Stock Route Reserve, R 19219) issued under the Mining Act.

There are a number of existing tracks within the Access Development Envelope which will be utilised and / or upgraded to minimise vegetation clearing.

Haulage and Product Export

Commercial grade silica sand will be reclaimed from the final product stockpile by front-end loaders, loaded onto haul trucks and transported to the Geraldton port for export (not part of this Proposal) via Brand Highway.

Power and Water Supply

Process water will be sourced from a groundwater bore that will target the Yarragadee aquifer at a rate of 0.9 GL/year. Potable water will be required for personnel, which will be trucked to site.

The Proposal will have minimal energy requirements. A power station (capable of 5 MW of electrical energy production) will be established at the processing plant site and reticulated using overhead powerlines. VRX is exploring the opportunities to develop a solar power farm with connected to batteries to provide supplementary power for the Proposal.

Supporting Infrastructure

To facilitate the Proposal, the following supporting infrastructure will also be developed:

- Administration building;
- Potable water storage;
- Communications;
- Workshop; and
- Laydown.

An indicative layout of site infrastructure is provided in Figure 2.

2.2.4 DEVELOPMENT ENVELOPES AND DISTURBANCE FOOTPRINTS

The development envelopes outline the boundaries for the Proposal (Figure 2), where all ground disturbance and key proposal elements listed below are proposed to occur. A total disturbance limit of 353.8 ha is proposed within a total development envelope area of 407.5 ha. Development envelopes and disturbance footprints for the access corridor and mine area are provided in Figure 2.

The Mine Development Envelope (same boundary as the Mine Disturbance Footprint) is located within VRX's mining lease application and covers an area of 347.3 ha. Up to 347.3 ha of native vegetation disturbance will be required within the Mine Development Envelope in order to develop the following:

- Mining areas;
- Mine Feed Plant;
- Processing Plant;
- Process water tanks;
- VDT initial stockpile area;
- Slurry and return water pipelines; and
- Ablutions area.

The Access Development Envelope covers an area of 60.4 ha. Up to 6.5 ha of native vegetation disturbance will be required within the Access Development Envelope (Figure 2) to develop the following:

- An access corridor approximately 5.5 km in length, running 800 m west then 4.7 km south from the southwest corner of the Mine Development Envelope to the Brand Highway;
- A groundwater bore that will supply water to the mine; and
- Water pipeline.

Shape files for the development envelopes have been provided in Appendix 1.

2.3 JUSTIFICATION

2.3.1 DO NOTHING APPROACH TO THE PROPOSAL

The Asia-Pacific region accounts for 47 % of the global demand for silica sand for glassmaking. In 2017, VRX identified a silica sand shortage in the Asia-Pacific region that is predicted to worsen with dwindling local supplies and increasing demand. This has provided a unique opportunity for WA to supply a niche, growing, silica sand market and meet this rising demand in the Asia-Pacific markets.

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.

VRX has completed a Bankable Feasibility Study to support the development of the Proposal.

Based on this outlook, VRX predicts a strong demand for its silica sand product. The 'do nothing' approach to the Proposal represents a lost commercial opportunity to VRX.

2.3.2 OTHER TECHNOLOGIES OR OPTIONS

VRX is planning to process the silica sand at the Mine to produce a beneficiated product. VRX has investigated the option of developing a glass manufacturing plant in proximity to the Proposal. This option is not being pursued at this stage due to the high capital cost, however VRX intends to continue investigations throughout the life of the Proposal.

2.3.3 ALTERNATIVE LOCATIONS AND DESIGNS CONSIDERED

During the initial planning phase of the Proposal VRX identified that environmental factors should have a significant influence on the design and location of the mine layout and infrastructure. Several baseline environmental surveys have been conducted, which have enabled VRX to incorporate avoidance and mitigation measures into the Proposal design. Since referral of the Proposal, VRX has improved their understanding of the local environment and has sought to make changes to the Proposal during assessment under Section 43A (S43A) of the EP Act (approved on 13 October 2021). Further modifications to the development envelopes and disturbance footprints (reductions) have been incorporated in this ERD to avoid impacts to significant flora and to align with the EPA's latest guidance: Instructions – How to identify the content of a Proposal (EPA, 2021d; published after referral of the original Proposal).

The key changes made to the Proposal are:

- Removal of the western access route and processing plant option;
- Removal of portion of the southern access route that is south of Brand Highway;

- Reduction in the extent of the Mine Development Envelope to exclude unique vegetation associations that contain higher concentrations of priority flora and to align with targeted flora search extents;
- Relocation of the silica sand processing plant to within the Mine Development Envelope;
- Restricting mining to above the water table only; and
- The VDT method has been refined and a rehabilitation strategy has been developed to mitigate the loss of vegetation during the mining process.

Changes made to the development envelopes and the disturbance footprints are illustrated in Figure 12.

2.4 LOCAL AND REGIONAL CONTEXT

The Proposal is located approximately 35 km northwest of Eneabba (3 km east of the Brand Hwy), in the Mid-West region of WA (Figure 1).

The following sections have been sourced from Mattiske (2022a) and State and Commonwealth Government reports describing the regional characteristics and values.

The Proposal lies within the Irwin Botanical District of the South-West Botanical Province (Beard 1990), and the Lesueur Sandplain (GES02) Interim Biogeographic Regionalisation for Australia (IBRA) subregion (DAWE, 2022a). This subregion is described as coastal Aeolian and limestones, Jurassic siltstones and sandstones (often heavily lateralised) of central Perth Basin.

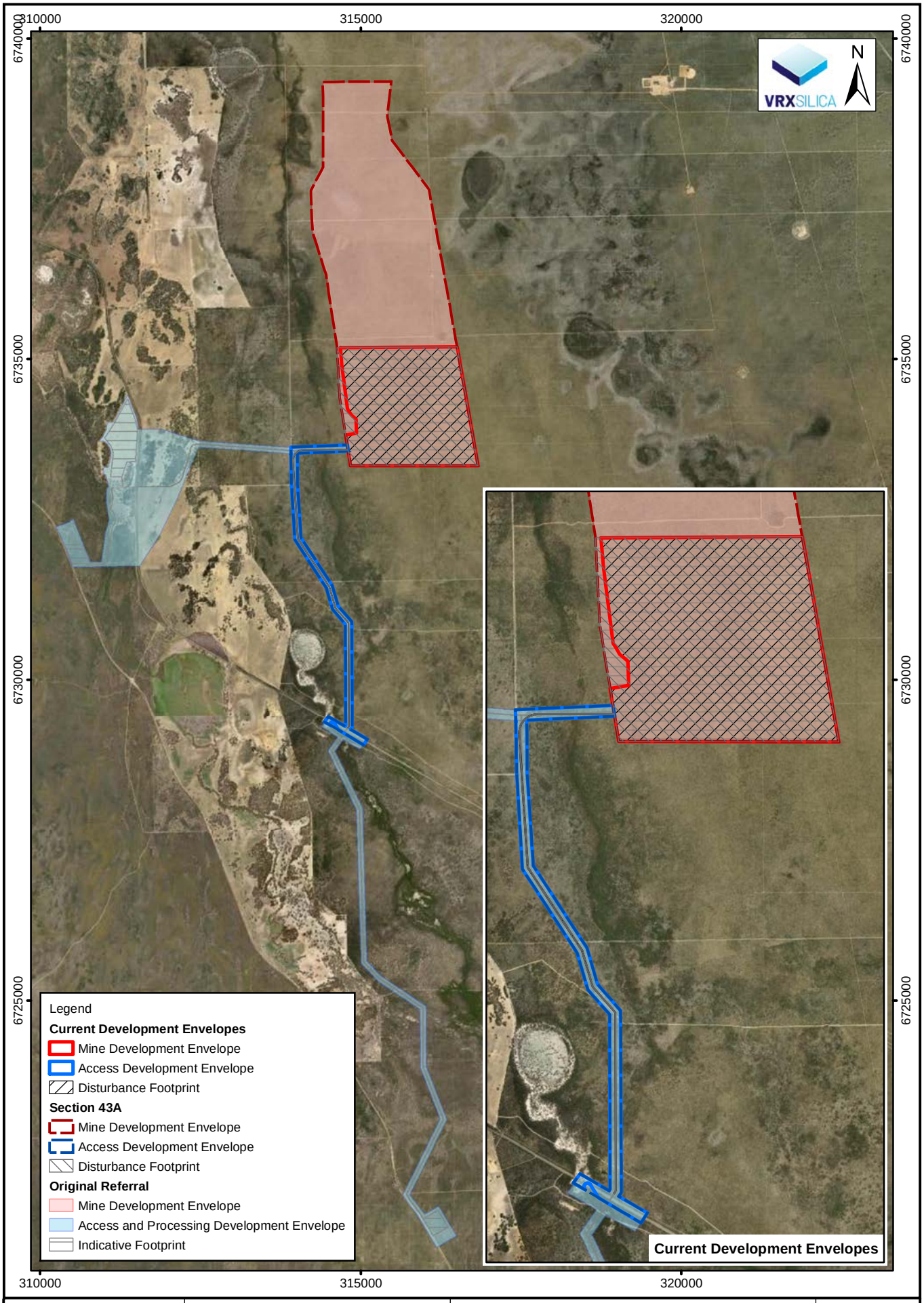
The underlying geology of the area is predominantly Permian to Cretaceous sedimentary basins, with horsts of Proterozoic rocks (Beard, 1990; Desmond and Chant, 2001). The area is characterised by undulating lateritic sandplains with leached sandy soils over laterite in coastal areas; earthy, yellow sand over laterite further inland; and hard-setting loams with red clay subsoils (Beard, 1990; Desmond and Chant, 2001).

The land comprising the mining tenement (M 70/1389) is mainly remnant bushland with a small portion utilised for grazing and agricultural purposes. The seasonal Arrowsmith River, south of the mining tenement, flows only during high rainfall events. Other notable landscape features nearby include; Arrowsmith Lake, Beharra Spring, Mungenooka Spring and Arramall Cave.

2.4.1 LAND USE

The Proposal lies within the Yamitji Nation native title determination. The Yamitji Nation is comprised of the Traditional Owner groups; Yamatji Nation, Hutt River, Southern Yamatji and Widi Mob native title claims and a portion of the Mullewa Wadjari native title claim. The Traditional Owners, who broadly identify as being Yamatji people, continue to hunt in the region, as well as practice their traditional culture, such as performing ceremonies and paying respects to ancestral spirits (Horizon Heritage, 2021).

The Access Development Envelope intersects land that is designated as File Notation Area (FNA) 14543 and 15090. FNA 14543 defines the Yamatji Nation Indigenous Land Use Agreement (ILUA) Area (formerly the Geraldton Alternative Settlement Agreement). FNA 15090 is a proposed Part IV reserve by the Yamatji Nation under the LAA. All leases held by VRX that intersect these FNAs will be compatible with the proposed land use.



Imagery: ESRI, Maxar (July 2018)

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Date: April 2022 | Rev: B | A4

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Arrowsmith North Project

Development Envelope Comparison

Figure: 12

Figure 12: Changes to development envelopes and disturbance footprints since referral

The dominant land use within the Lesueur Sandplain subregion is dry-land agriculture (69.34 %), with lesser areas of conservation and UCL and crown reserves (Desmond & Chant, 2001).

The current land use within the development envelopes is predominantly underlying UCL, Mining Act Leases and Licences. The Proposal also has minor intersections (all associated with the proposed access corridor) with:

- Road reserve (the Brand Highway, Land ID number: 3728866); and
- Stock route (reserve, R 19219).

Part of the Mine Development Envelope lies within a historical contaminated site mapped on DWER's Contaminated Sites Database (ID14216) and was classified as 'Contaminated – Restricted Land Use' under Section 13 of the *Contaminated Sites Act 2003* (WA) (CS Act) in June 2007. The nature of contamination is hydrocarbon contamination resulting from the development and operation of the Beharra Springs Gas Plant. The extent of contamination is believed to be limited to an area immediately surrounding the plant. The plant lies within two lots which, as a result of the above, have both been identified as a contaminated site in their entirety (restricted use – industrial/commercial). The Proposal meets the description of the restricted use therefore the listing is not expected to be impacted by the Proposal.

Tenure, land use and management for the Proposal and surrounds are shown in Figure 13.

2.4.2 Environmental Assets

Part of the Proposal lies within the Arrowsmith Lake Area defined under section 51B of the EP Act and mapped on DWER's clearing permit system (object ID 6561) as an Environmentally Sensitive Area. The Arrowsmith Lake Area was registered as a natural place in the Register of the National Estate (RNE) in March 1978 under the *Australian Heritage Council Act 2003*. Further information on the Arrowsmith Lake Area is held by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) on the Australian Heritage Database. The registered status means the place was entered in the RNE prior to its closure in 2007. The existence of an entry for a place in the RNE does not in itself create a requirement to protect the place under Commonwealth law. Nevertheless, information in the register may be current and may be relevant to statutory decisions about protection (DAWE, 2021).

No conservation reserves are located within the development envelopes. The closest conservation reserve is Beharra Springs Nature Reserve (Crown Reserve Number I 47436) located approximately 5.3 km southeast of the Mine Development Envelope and 5.6 km east of the Access Development Envelope. Other reserves surrounding the Proposal are the Beekeepers Nature Reserve (R 24496) located approximately 7 km to the west and Yardanogo Nature Reserve (R 36203) located 5 km to the north. The Lake Logue Nature Reserve (R 29073) and nature reserves R 39744 and R 25495 are located well to the south of the Proposal (Figure 13). These Nature Reserves are managed by the Department of Biodiversity, Conservation and Attractions (DBCA) for the conservation of flora and fauna.

The proposed access corridor traverses a small portion of Stock Route R19219 (shown in green in Figure 13). The Proposal does not overlap any listed or proposed wetlands of national or international importance.

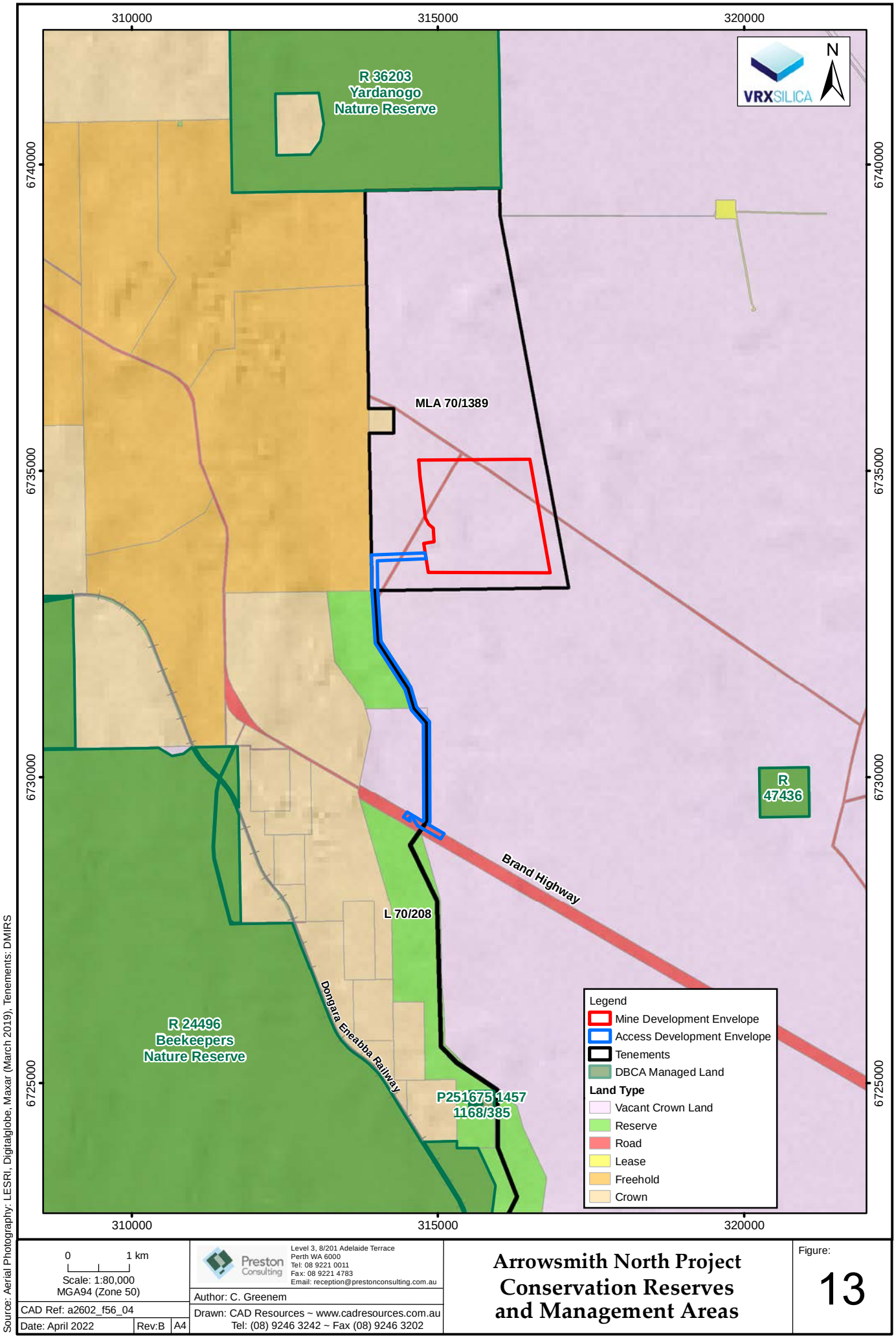


Figure 13: Conservation reserves and management areas

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 VRX. 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 have been consulted:

Commonwealth:

- DCCEEW.

State:

- DBCA;
- Department of Jobs, Tourism, Science and Innovation (DJTSI);
- Department of Planning, Lands and Heritage (DPLH);
- Department of the Premier and Cabinet (DPC);
- Department of Transport (DoT);
- DMIRS;
- DWER (EPA Services, Industry Regulation, Water);
- Main Roads WA;
- Mid-West Chamber of Commerce;
- Mid-West Development Commission (MWDC);
- Mid-West Ports Authority;
- Minister for Aboriginal Affairs;
- Minister for Energy;
- Minister for Mines and Petroleum;
- Minister for Ports;
- Minister for Regional Development;
- Minister for the Environment and Water;
- Minister for Transport; and
- The Treasurer.

Local:

- City of Greater Geraldton;
- Member of the Agricultural Region;
- Member of the Legislative Assembly (MLA) for Butler;
- MLA for Geraldton;
- MLA for Moore;
- Shire of Carnamah; and
- Shire of Irwin.

3.1.2 CORPORATE AND COMMUNITY STAKEHOLDERS

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

- Australian and New Zealand Environment and Conservation Council;
- Australian Nature Conservation Agency / Australian Wildlife Conservancy;
- Birdlife WA;
- Birds Australia;
- Conservation Council of WA;
- Greening Australia;
- Southern Yamatji People.
- Threatened Species Scientific Committee (TSSC; part of DCCEEW);
- Western Power; and
- Wildflower Society of WA.

3.2 STAKEHOLDER ENGAGEMENT PROCESS

VRX 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 such extensive 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;
- Commonwealth Government;
- Aboriginal groups with a connection to the Proposal lands; and
- Corporate and community stakeholders.

3.3 STAKEHOLDER CONSULTATION

VRX has a Stakeholder Consultation Register which maintains records of all consultations with stakeholders. The Register summarises key issues raised by stakeholders during the consultation process and describes how VRX has responded to those issues. A summarised version of the Stakeholder Consultation Register is provided in Table 4 to provide details of the stakeholder consultation undertaken to-date for the Proposal. A stakeholder consultation plan is also provided in Table 5 to demonstrate VRX's commitment to early and ongoing stakeholder consultation.

Table 4: Stakeholder consultation register

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Government Stakeholders			
DCCEEW	17 July 2019 (phone conference meeting)	Present the Proposal. EPBC Act referral and approval processes for the Proposal.	EPBC Referral has been submitted in parallel with the Section 38 Referral under the EP Act.
	2 November 2020 (email)	Email received from DCCEEW confirming that Proposal is a Controlled Action. This determination is based on the Proposal being likely to have a significant impact on the following MNES, including, but not limited to: • Carnaby's Cockatoo *(Zanda latirostris);* • Malleefowl *(Lieopa ocellata)*; and • Sandplain Duck Orchid *(Paracaleana dixonii).* A decision had not been made on the approach that must be used to assess the Proposal. DCCEEW has stopped the statutory assessment process to await a decision by the WA Government on whether an accredited assessment is an appropriate method.	VRX to proceed with referral of the Proposal to the EPA under Section 38 of the EP Act.
	15 March 2022	Review and acceptance of the ESD.	ESD studies completed and findings presented in this ERD.
	14 November 2022	Comments provided on draft ERD.	Draft ERD (this document) revised to address comments.
DBCA	1 July 2020	Present the Proposal. Potential offset options for reduction in Black Cockatoo foraging habitat.	VRX to liaise with DBCA through assessment process regarding suitable offset options.
DJTSI	2 September 2017, 2 April & 27 September 2019 (meetings)	Present the Proposal and host a discussion of the Arrowsmith North, Central and Muchea Silica Sand Projects.	VRX to keep DJTSI informed of progress.
DPLH	24 October 2019 (meeting)	Present the Proposal and discuss the requirements for rail and port services and infrastructure for the export of product.	VRX to keep DPLH informed of progress.
DPC	19 July 2019 (meeting)	Discussion of the Proposal and a confirmation of VRXs rights to tenements to be included in the Geraldton Alternative Settlement Agreement.	VRX to keep DPC informed of progress.
DoT	23 August 2019 (meeting)	Present the Proposal and discuss the requirements for rail and port services and infrastructure for the export of product.	VRX to keep DoT informed of progress.
DMIRS	2 August 2017, 26 November 2018, 22 March 2019, 13 February & 29 July 2020 (meetings)	Tenement requirements for the Proposal. Present the Proposal and discuss the requirements for EPA approvals.	VRX to keep DJTSI informed of progress. VRX to submit tenement applications as required. MP and MCP to be submitted.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
	8 March 2022	Presentation of the Proposal and planning for the preparation and submission of a MP and MCP.	VRX to keep DMIRS informed on progress.
DWER – EPA Services	1 August 2019 (meeting) 9 November 2019 (phone conference) 21 July 2020 (video conference)	Present the Proposal. Pre-referral meeting. Phone conference to discuss the Arrowsmith and Muchea Silica sand project requirements for water and EPA approvals. Update on Proposal referral timeframes.	Section 38 Referral and this SR prepared in accordance with EPA Services advice.
	28 August 2020 (email)	Submission of the Arrowsmith North Draft SR to DWER for review.	VRX to await DWERs comments on the SR.
	18 November 2020 (email)	DWER provided comments on the SR.	VRX to address comments and formally refer the Proposal to the EPA under Section 38 of the EP Act.
	15 March 2022	Review and acceptance of the ESD.	ESD studies completed and findings presented in this ERD.
	14 November 2022 (letter)	Comments provided on draft ERD	Comments addressed in this revision of the ERD
DWER – Industry Regulation	11 May 2020 (video conference)	Present the Proposal. Regulation under Part V of the EP Act. General advice.	Section 38 Referral and this SR prepared in accordance with Industry Regulation advice. Works Approval application to be submitted.
DWER – Water Licensing	11 May 2020 (video conference)	Present the Proposal. Groundwater investigations status. Regulation under the RIWI Act. General advice.	Section 38 Referral and this SR prepared in accordance with Industry Regulation advice. 5C Licence application to be submitted.
Mid-West Chamber of Commerce	22 July 2019 (meeting)	Discuss the Arrowsmith and Muchea Silica sand projects and long-term benefits for the Greater Geraldton Region.	VRX to keep Mid-West Chamber of Commerce informed of progress.
MWDC	22 July 2019 (meeting)	Discuss the Arrowsmith and Muchea Silica sand projects and requirements for rail and port services in the Greater Geraldton Region.	VRX to keep MWDC informed of progress.
Mid-West Ports Authority	22 July 2019 (meeting)	Discuss the Arrowsmith Silica sand projects and requirements for port services.	VRX to keep Mid-West Ports Authority informed of progress and port capacity requirements.
Minister for Regional Development; Agriculture and Food; Ports	23 August 2019 (meeting)	Present the Proposal and discuss the requirements for rail and port services and infrastructure for the export of product.	VRX to keep Minister informed of progress.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Minister for the Environment; Disability Services; Electoral Affairs	23 August 2019 (meeting)	Present the Proposal and discuss the requirements for EPA approvals.	VRX to keep Minister informed of progress.
State Treasurer and Minister for Aboriginal Affairs	3 December 2019 (meeting)	Present the Proposal and host a discussion of the Arrowsmith North, Central and Muchea Silica Sand Projects.	VRX to keep State Treasurer informed of progress.
City of Greater Geraldton	22 July 2019 (meeting)	Arrowsmith and Muchea Silica sand projects and long-term benefits for the state and the region.	VRX to keep City of Greater Geraldton informed of progress.
Member for the Agricultural Region	3 December 2019 meeting)	Discuss the Arrowsmith and Muchea Silica Sand projects and long-term benefits for the state and the region.	VRX to keep Member for the Agricultural Region informed of progress.
MLA for Butler	25 February 2019 (meeting)	Discuss the Arrowsmith and Muchea Silica Sand projects and long-term benefits for the state and the region.	VRX to keep Member informed of progress.
MLA for Geraldton	10 December 2019 (meeting)	Discuss the Arrowsmith Silica Sand project and long-term benefits for the state and the region.	VRX to keep Member informed of progress.
MLA for Moore	09 November 2018 (meeting)	Discuss the Arrowsmith and Muchea Silica Sand projects and long-term benefits for the state and the region.	VRX to keep Member informed of progress.
Shire of Carnamah	14 March 2020 (video conference meeting)	Discuss the Arrowsmith Silica Sand project and long-term benefits for the Irwin District.	VRX to keep Shire informed of progress.
Shire of Irwin	14 April 2020 (video conference meeting)	Discuss the Arrowsmith Silica Sand project and long-term benefits for the Irwin District.	VRX to keep Shire informed of progress.
Community and Corporate Stakeholders			
Australian and New Zealand Environment and Conservation Council	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Australian Nature Conservation Society / Australian Wildlife Conservancy	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Birdlife WA	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.

Stakeholder	Date/s	Relevant issues / topics raised	Proponent response / outcome
Birds Australia	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Conservation Council of WA	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Greening Australia	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Wildflower Society of WA	August 2020 (email)	Proposal introduction and environmental considerations / issues. Information Pack provided. Offer for meeting or further information. Notification of plan to submit Section 38 Referral.	Consideration of issues in Proposal design. VRX to meet with stakeholder and / or provide additional information upon request.
Southern Yamatji Claimants - Yamatji Marlpa Aboriginal Corporation (YMAC) Representative Body	10 December 2019, 20 February & 23 March 2020 (meetings and video conference)	Discuss the Arrowsmith Silica Sand project and long-term benefits and opportunities for the Southern Yamatji People. Native Title. Heritage surveys.	Mining Project Agreement negotiated. Aboriginal heritage surveys to be completed over disturbance areas.
	November 2020	Aboriginal Heritage and Ethnographic surveys on proposed mining and disturbance ground	Completed surveys. No Aboriginal Heritage issues raised.
Yamatji South elder	January 2021	Site meeting. Interview on fauna sightings by the Heritage Survey participants and historic sightings, particularly Carnaby's Cockatoo and Malleefowl sightings	Information included in this ERD.
ARC Resources	July 2019	Discuss rail requirements.	Rail access to be negotiated by rail owners and rolling stock contractors.

Table 5: Stakeholder consultation plan

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
2023 - 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 • Draft conditions • EPA Board meeting • Compliance
2023 - ongoing	DCCEEW	Telephone, letters, email and meetings	Correspondence during assessment under EPBC Act.	• Presentation of EIA • Review of draft ERD • Draft conditions • Management Plans • Compliance
2023 - 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
2023 - ongoing	DMIRS	Telephone, letters, email and meetings	Correspondence to obtain approval for Permit of Works, 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
2023 - ongoing	DBCA	Telephone, letters, email and meetings	Advice into ongoing management of Proposal within close proximity to Priority Flora. Offset sites and management.	• Priority Flora • Offsets • Black Cockatoo monitoring and management
2023 - ongoing	Main Roads WA	Telephone, letters, email and meetings	Discussions regarding under road pipeline construction.	• Future applications • Site access • Timing (i.e., construction & operation) • Operating hours

Timing	Stakeholder	Type	Purpose of planned engagement	Issues to be raised
				• Site access/routes
2023 - ongoing	DoT	Telephone, letters, email and meetings	Discussions regarding rail haulage.	• Future applications • Timing (i.e., construction & operation) • Site access/routes
2023 - ongoing	Mid-West Ports Authority	Telephone, letters, email and meetings	Correspondence to negotiate terms for the export of ore through Geraldton Port.	• Future applications • Export options • Path forward for the Proposal
2023	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
2023 - ongoing	Local Government Authorities	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 • Export through Geraldton Port
2023 - ongoing	Southern Yamatji 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
2023 - ongoing	Non-government organisations and community groups	Telephone, letters, email and meetings	Input and provision of information.	• Provision of ecological information • Invitation for comment • Priority Flora • Black Cockatoo

4 ENVIRONMENTAL PRINCIPLES

The EP Act identifies a series of principles for environmental management (Section 4a, EP Act, as amended). VRX has considered these principles in relation to the development and implementation of the Proposal. Table 6 outlines how the principles relate to the Proposal.

Table 6: 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 VRX has commissioned numerous ecological studies in order to inform the design of the Proposal, there are still several examples where a precautionary approach has been taken, such as: • Removal of areas of significant flora and vegetation from the development envelopes; • Transporting ore as a slurry through a pipeline to avoid potential impacts to the environment caused by manual transport; • Restricting mining to above the water table only; • Finding a market for the tailings to remove the requirement for onsite disposal; and • Limited requirement for chemicals in the processing of the ore (only an environmentally sensitive, biodegradable flocculant will be required).
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 specifically designed to ensure the best-possible rehabilitation quality is achieved, with VDT and infill planting proposed. Research collated on VDT during the study phase and to be conducted during the operational phase of the Proposal will build on the existing knowledge base and will allow more informed rehabilitation management 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 vicinity of the Proposal. Disturbance within areas of noted higher biological diversity (i.e., Carnaby's Roosting and Breeding Habitat, and area of concentrated priority flora) has been avoided by excluding them from the development envelopes. Priority has been given to maintaining natural ecological and landscape processes.
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	As discussed in Section 2.3.2, the Proposal mine plan, design and management controls have been revised to reduce potential impacts to environmental factors. VRX has proposed progressive rehabilitation via the VDT method and the costs of this have been included in the Proposal feasibility studies. VRX has confirmed that there is a market in the agriculture and brick-making industry for the only waste product from the Proposal (tailings).

Principle	How it will be addressed by the Proposal
minimise costs to develop their own solutions and responses to environmental problems.	
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	VRX has confirmed that there is a market in the agriculture and brick-making industry for the only waste product from the Proposal (tailings). General putrescible waste will be minimised by adopting the hierarchy of waste controls; avoid, minimise, re-use, recycle and safe disposal.

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 and Commonwealth Government guidance documents for flora and vegetation are summarised in Table 7 below.

Table 7: Policy and guidance relevant to the Flora and Vegetation key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was used as guidance to develop the Significant Flora Management Plan (SFMP; Appendix 5).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline - Flora and Vegetation (EPA, 2016a)	This document was considered in the preparation of this section (Section 5) of the ERD.
Relevant EPA Technical Guidance	
Technical Guidance – Flora and Vegetation Surveys for EIA (EPA, 2016b)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Flora and Vegetation report for Arrowsmith North.
Guidance Statement 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
Environmental Protection Bulletin 20 – Protection of naturally vegetated areas through planning and development (EPA, 2013)	This document has been considered in scoping the location and size of the Proposal, rehabilitation and EIA.
Checklist for documents submitted for EIA of proposals that have the potential to	This document was considered prior to submission of the ERD.

Policy and Guidance	How guidance has been considered
significantly impact on Sea and Land factors (EPA, 2016c)	
Other Policy and Guidance	
Biosecurity and Agriculture Management Act 2007	This document was considered during the assessment of weeds recorded in the survey area (Mattiske, 2022a).
DPaW Phytophthora Dieback Interpreters' Manual (FEM047; DPaW, 2015)	This document was used during Galvan's dieback assessments (Glevan, 2020 and 2021).
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Flora and Vegetation however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Flora and Vegetation however it was determined not relevant as offsets were not required.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Flora and Vegetation however it was determined not relevant as offsets were not required.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act Public Environment Report (PER)/Environmental Impact Statement (EIS; including the objects and principles of the EPBC Act, 1999; DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide	This document was considered when determining whether offsets were expected to be required for the Flora and Vegetation environmental factor.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered in the preparation of the Dieback Management Plan (DMP) and will be used for the preparation of the Significant Flora Management Plan (SFMP).
Environmental Management Plan Guidelines - template (DotE, 2018)	This document was used as guidance to develop the SFMP (Appendix 5).
EPBC Act Condition Setting Policy (DAWE, 2020)	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared at this stage of the assessment.
Relevant Technical Guidance	
Relevant EPBC Act listed species-specific survey guidelines and protocols.	This document was used as guidance when undertaking surveys of EPBC listed species and potential survey limitations.
Relevant EPBC Act listed species-specific Recovery plans, Threat Abatement Plans, Approved Conservation Advices (ACA's) and other documents.	This document was used as guidance to assess and manage EPBC listed species that may be impacted by the Proposal.

5.3 RECEIVING ENVIRONMENT

5.3.1 SURVEY EFFORT

A number of flora and vegetation desktop and field surveys and studies have been undertaken within and in close proximity to the development envelopes by Mattiske, Brian Morgan Consultant Botanist (BMCB) and Glevan Consulting (Glevan). These surveys include:

- Flora and Vegetation Assessment of Arrowsmith North Survey Area (Mattiske, 2022a; Appendix 6);
- *Paracaleana dixonii* Search Arrowsmith North Project – Initial Mine and Plant Area (BMCB, 2023; Appendix 7);
- Review of Roots and VDT (Mattiske, 2020a; Appendix 8);
- Investigation of Root Systems of the Priority Flora Species Recorded in the Arrowsmith North Mine Survey Area (Mattiske, 2022b; Appendix 9);
- Phytophthora Dieback Occurrence Assessment of Arrowsmith North (Glevan, 2020; Appendix 10); and
- Phytophthora Dieback Occurrence Assessment of Arrowsmith North Access (Glevan, 2021; Appendix 11).

The information contained within the following sections has been sourced from the reports listed above unless otherwise stated. The Mattiske (2022a) survey areas are defined in Figure 14, BMCB (2023) survey area in Figure 15 and the Glevan (2020 and 2021) survey areas are shown in Figure 16.

Flora and Vegetation Assessments

Mattiske was initially commissioned to conduct a desktop study of the flora and vegetation of the Survey Area. Extensive reconnaissance, Detailed and Targeted field surveys were then conducted to verify and build on the desktop assessment. A summary of these assessments is provided below. All information contained within the following sections is from Mattiske (2022a) unless otherwise referenced.

Desktop Assessment

A desktop assessment of relevant databases, literature and spatial data preceded the field assessments to:

- Produce a species list that represents the likely flora assembly of the Survey Area;
- Identify the possible occurrence of threatened and priority flora; and
- Identify the possible occurrence of Threatened and Priority Ecological Communities (TEC/PEC).

The databases and literature used to inform the objectives of the desktop assessment were:

- FloraBase;
- DBCA NatureMap;
- EPBC Act Protected Matters Search Tool; and
- Historical documentation and vegetation mapping of the region.

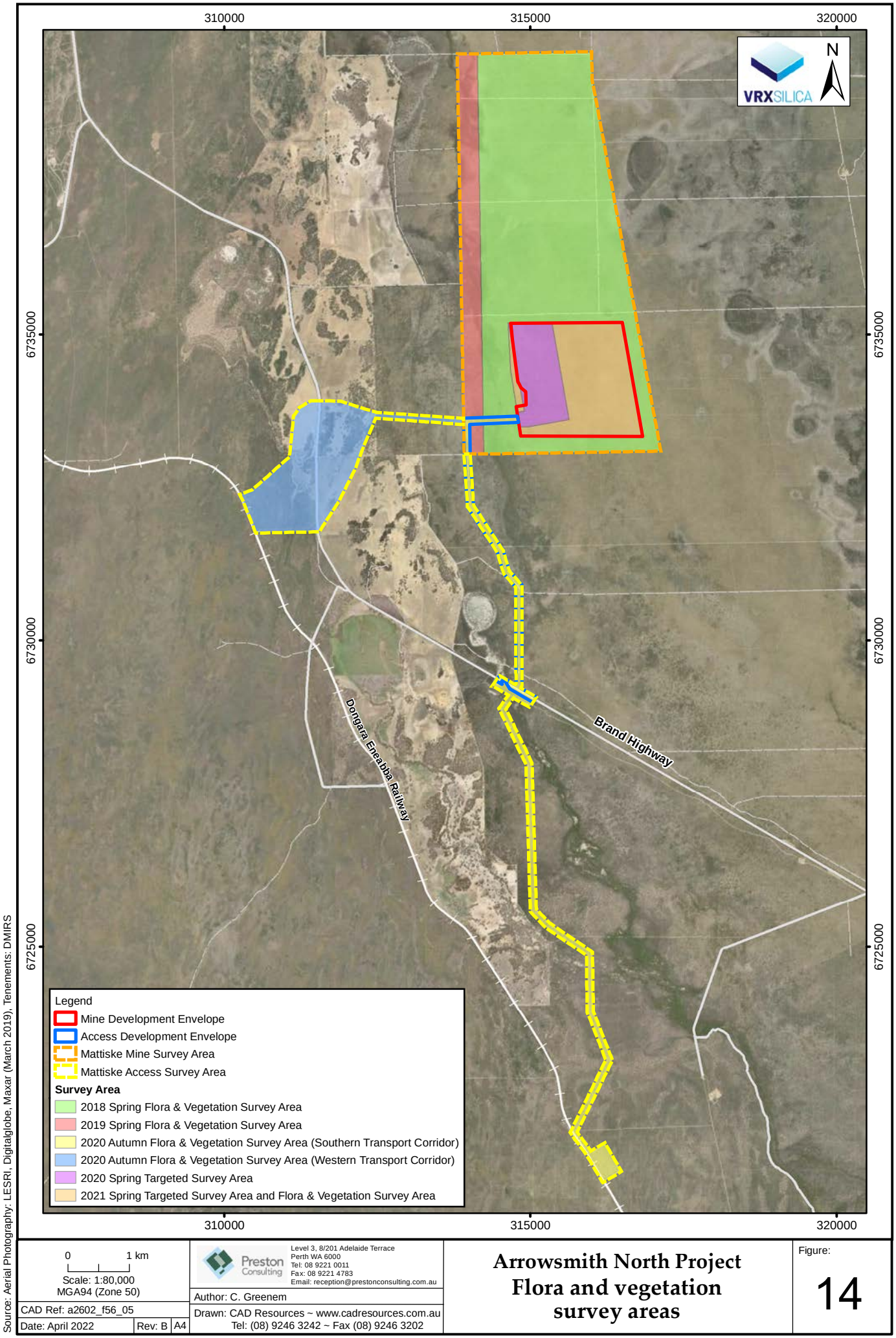


Figure 14: Flora and vegetation survey areas

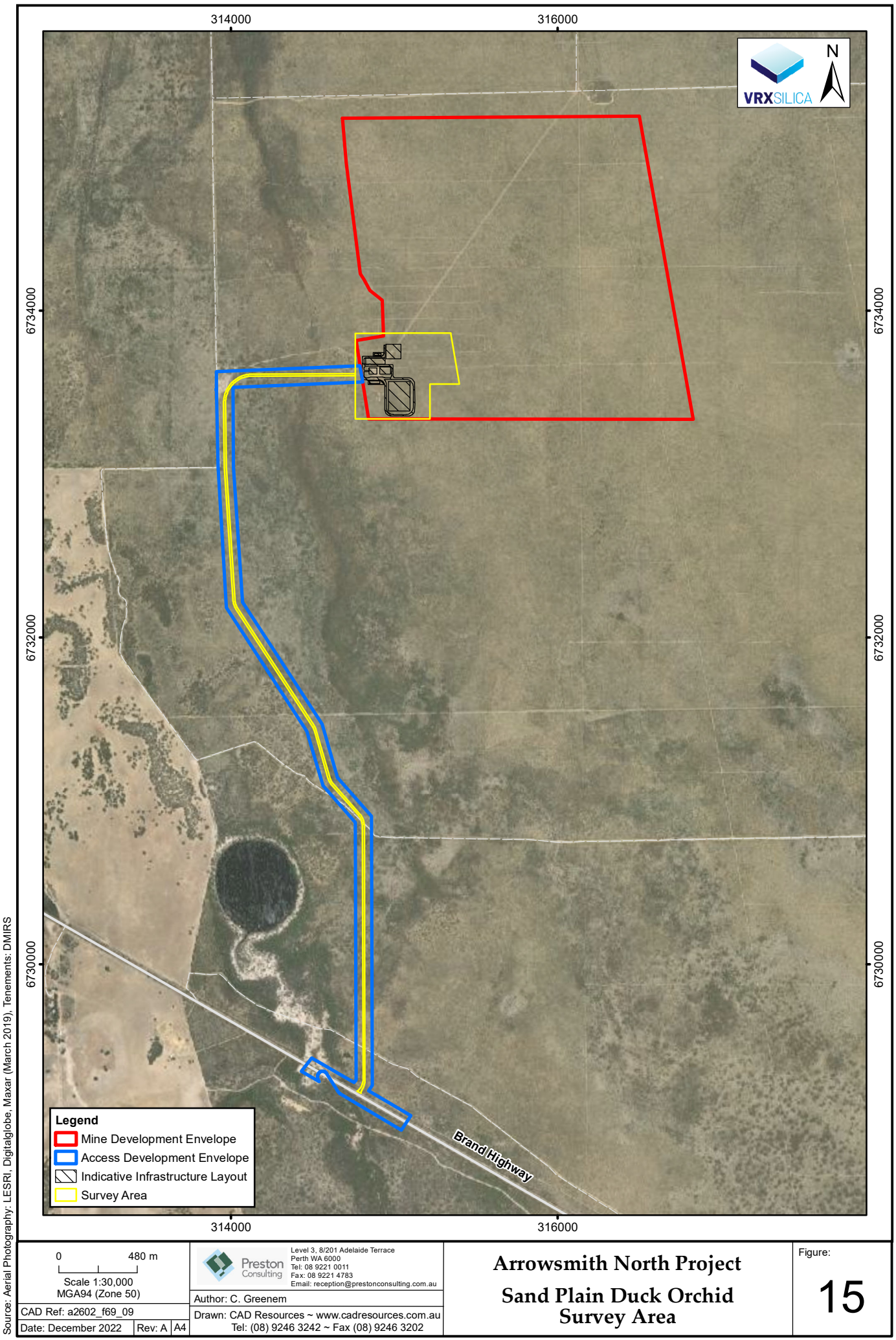


Figure 15: *P. dixonii* targeted flora survey area (BMCB, 2023)

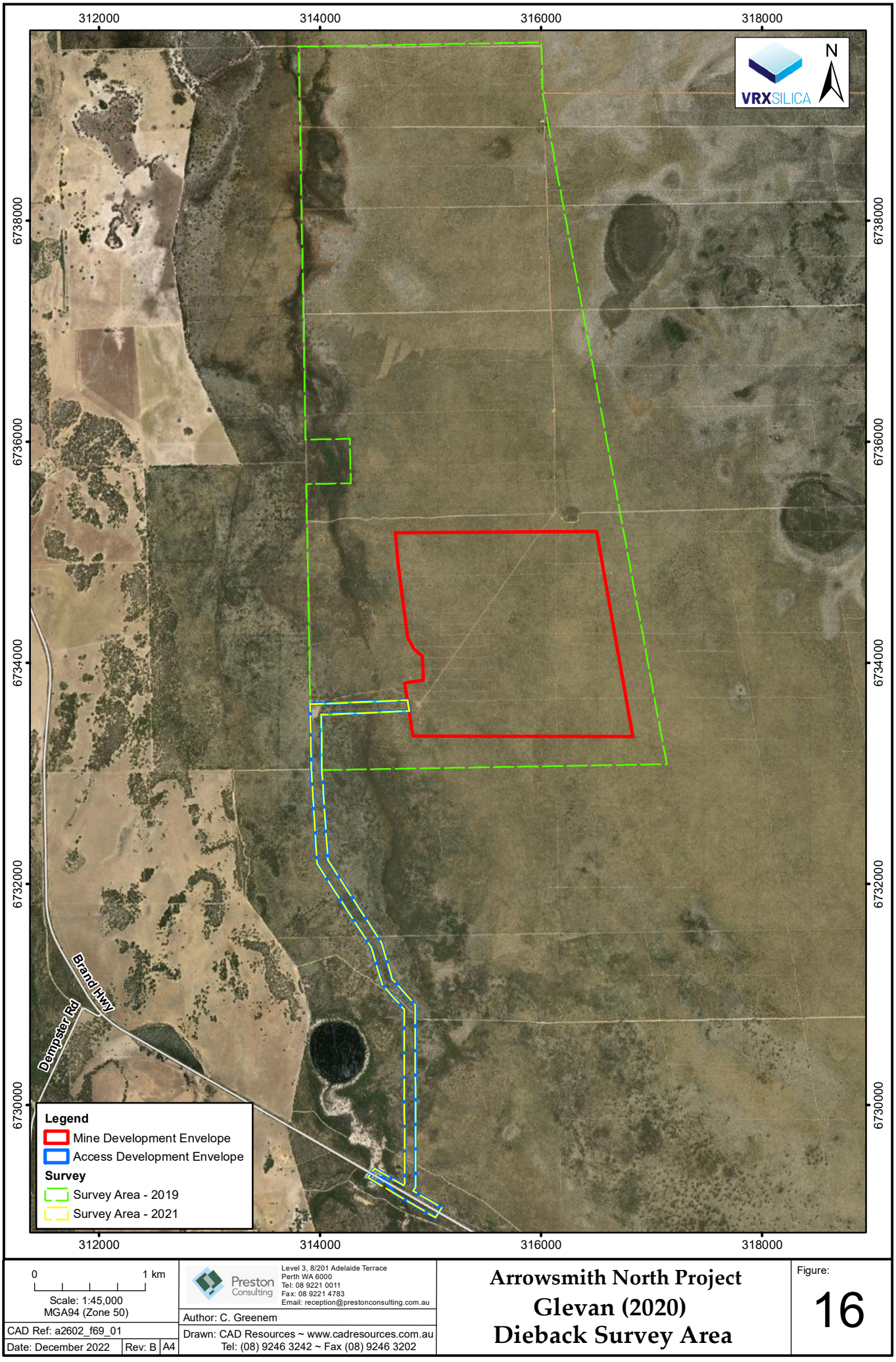


Figure 16: Glevan Dieback survey areas

Summary of Field Assessments

Detailed and Targeted field assessments of the flora and vegetation of the Survey Area were conducted by experienced botanists from Mattiske between 2018 and 2021, over six separate surveys; four detailed surveys and two targeted flora surveys for Threatened and Priority species. An additional targeted flora survey for the EPBC Act-listed threatened orchid, *Paracaleana dixonii* (named *Caleana dixonii* on the DCCEEW Species Profile and Threats Database (DCCEEW; 2023) but known in WA, and refered to in this document, as *Paracalena dixonii*) was conducted by BMCB (2023) in early December 2022. A total of 150 field person days were undertaken across these surveys. Of these 7 surveys, five were conducted in Spring, one conducted in Autumn and one in early Summer. The flora and vegetation field survey effort for the Proposal is summarised in Table 8.

Table 8: Summary of field surveys of the Survey Area, 2018 to 2021

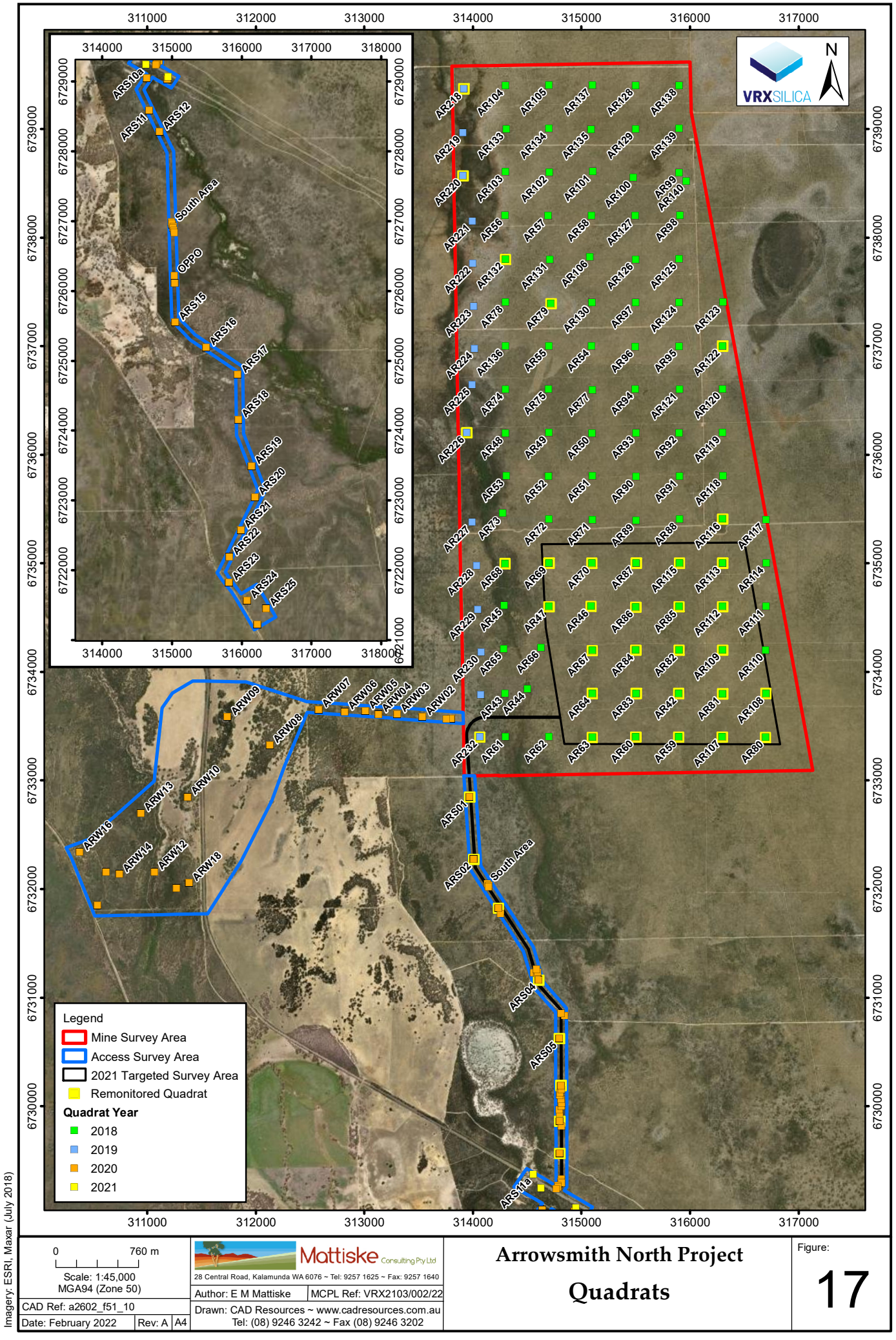
Survey	Year	Dates	Personnel	Area / Survey Type
1	2018	29 October - 2 November	4 botanists (20 days)	Mine Survey Area - Detailed Flora & Vegetation
	2018	5 November - 9 October	2 botanists (10 days)	
2	2019	21 - 25 October	4 botanists (20 days)	
	2019	11 - 14 November	3 botanists (12 days)	
3	2020	19 - 22 May	2 botanists (8 days)	Access Survey Area - Detailed Flora & Vegetation
4	2020	27 - 30 October	3 botanists (12 days)	Mine Survey Area - Targeted Threatened & Priority Flora
5	2021	13 - 17 September	4 botanists (20 days)	
	2021	20 - 24 September	4 botanists (20 days)	
6	2021	4 - 7 October	4 botanists (16 days)	Mine and Access Survey Area - Detailed Flora & Vegetation
7	2022	10 – 11 December	2 botanists, a member of the Orchid Society of WA and 3 Environmental Scientists (12 days)	Plant footprint, first year of mining and an area within the Access Development Envelope.

All surveys were conducted in accordance with methods outlined in *Technical Guidance – Flora and vegetation surveys for environmental impact assessment* (EPA, 2016b). All botanists held valid collection licences to collect flora for scientific purposes, issued under the *Biodiversity Conservation Act 2016* (WA) (BC Act).

Detailed Survey

Mine Survey Area

Survey sites for the Mine Survey Area were selected using aerial photographic maps and field observations. A total of 98 survey sites were established in the Mine Survey Area in 2018, and 15 additional survey sites were established in 2019. These 113 survey sites were selected to sample all vegetation types, with replication. Thirty-three of these 113 quadrats were re-surveyed in October 2021, this supplementary survey was undertaken to provide additional survey data on the range of flora that is likely to occur in the Survey Area. The quadrat locations within the Survey Area are shown in Figure 17, quadrats that lie within the development envelopes are shown in Figure 18.



0 760 m

Scale: 1:45,000
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Date: February 2022 | Rev: A | A4

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28 Central Road, Kalamunda WA 6076 ~ Tel: 9257 1625 ~ Fax: 9257 1640

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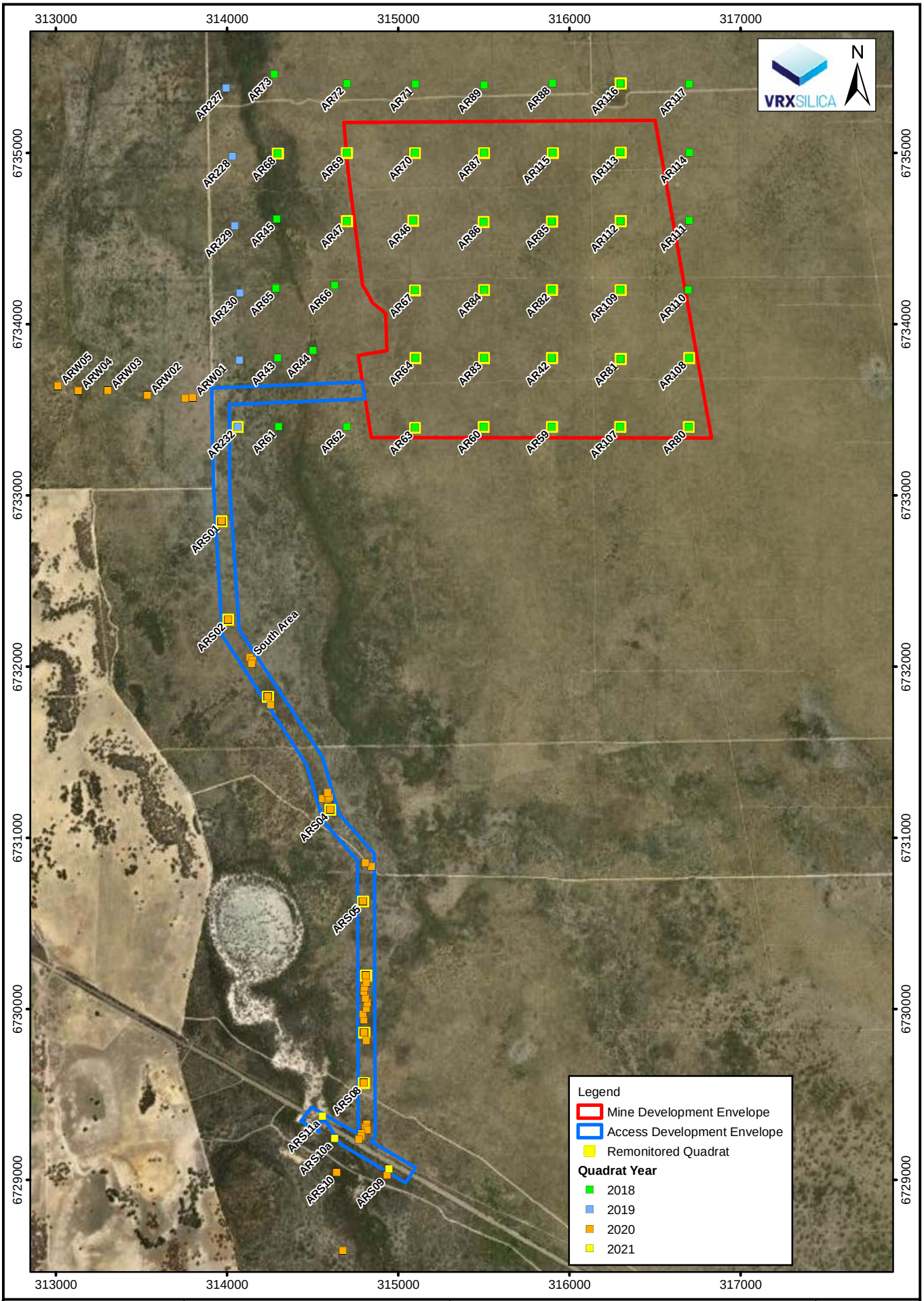
Arrowsmith North Project

Quadrats

Figure: 17

Imagery: ESRI, Maxar (July 2018)

Figure 17: Quadrat locations within the survey areas



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CAD Ref: a2602_f56_07

Date: April 2022 | Rev: B | A4

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Arrowsmith North Project

Quadrats Locations

Figure: 18

Figure 18: Quadrat locations within the development envelopes

Survey sites consisted of pegged 10 m x 10 m quadrats. Flora and vegetation were described and sampled systematically at each survey site, and additional opportunistic collections were undertaken wherever previously unrecorded plants were observed. At each quadrat, the following floristic and environmental parameters were recorded:

- GPS location;
- Local site topography;
- Soil type and colour;
- Outcropping rocks and their type;
- Percentage litter cover and percentage bare ground;
- Approximate time since fire;
- Vegetation condition (based on Keighery, 1994); and
- For each vascular plant species, the average height and the percentage cover (of both alive and dead material) over the survey site.

During field surveys botanists also had access to detailed taxonomic and ecological data on all potential significant species which may be encountered during the field survey. If suspected or known significant flora species were encountered, a specimen was collected for subsequent identification, and plant numbers were recorded for the population.

All plant specimens collected during the field surveys were dried and processed in accordance with the requirements of the Western Australian Herbarium (WAH). The plant species were identified based on taxonomic literature and through comparison with pressed specimens housed at the WAH. Where appropriate, plant taxonomists with specialist skills were consulted. All Priority flora species have been re-confirmed by WAH identification botanist Mike Hislop. Nomenclature of species recorded is in accordance with the WAH (1998-).

Access Survey Area

Survey sites for the Access Survey Area were selected using aerial photographic maps and field observations. A total of 44 survey sites were established in 2020, these survey sites were selected to sample all vegetation types, with replication, within the Access Survey Area. Eleven of the 44 quadrats were re-monitored in October 2021 to provide additional survey data on the range of flora that is likely to occur in the Access Survey Area. The location of survey sites for the Access Survey Area are shown in Figure 17.

Survey sites consisted of pegged 10 m x 10 m quadrats. Flora and vegetation were described and sampled systematically at each survey site, and additional opportunistic collections were undertaken wherever previously unrecorded plants were observed. At each quadrat the following floristic and environmental parameters were recorded:

- GPS location;
- Local site topography;
- Soil type and colour;
- Outcropping rocks and their type;
- Percentage litter cover and percentage bare ground;
- Approximate time since fire;
- Vegetation condition (based on Keighery, 1994); and
- For each vascular plant species, the average height and the percentage cover (of both alive and dead material) over the survey site.

The methodology for assessing threatened and priority flora consisted of foot traverses within the Access Survey Area. Botanists used handheld GPS units loaded with the survey polygons. Botanists walked between survey sites, recording significant flora species. If suspected or known significant flora species were encountered, a specimen was collected, and plant numbers were recorded for the population.

All plant specimens collected during the field surveys were dried and processed in accordance with the requirements of the WAH. The plant species were identified based on taxonomic literature and through comparison with pressed specimens housed at the WAH. Where appropriate, plant taxonomists with specialist skills were consulted.

Targeted Surveys

During the 2020 targeted survey, the methodology for assessing threatened and priority flora consisted of foot traverses within the Mine Survey Area. Botanists used handheld GPS units loaded with the survey polygons. Botanists walked between survey sites, recording significant flora species. In the targeted survey work, botanists used handheld Garmin GPS units loaded with the survey polygon and a 20 m wide grid overlayed (Figure 19). Within the grid, botanists walked in a zig-zag fashion recording significant flora species. A 20 m overlay grid was used to ensure an adequate level of detail was provided. This methodology was undertaken over the initial mining area only (the current Mine Development Envelope), due to the logistics of walking a 20 m grid over the 1,025 ha Mine Survey Area. If suspected or known significant flora species were encountered, a specimen was collected, and plant numbers were recorded for the population.

During 2021 Mattiske was commissioned to undertake a targeted survey of the area shown in Figure 14. Botanists had access to all relevant data in the ESRI iOS application, Collector for ArcGIS on Apple iPads (provided and maintained by CAD Resources). Data layers accessible in the field included the Mine Survey Area and the Access Survey Area, locations of all known significant flora from both historical and contemporary surveys and aerial imagery supplied by CAD Resources. The 2021 target survey area populated with a grid 20 m apart in a north-south and east-west orientation.

The transects were used as a guide for foot traverses (Figure 19). The locations of any significant flora were recorded with the Esri iOS application, Collector for ArcGIS. If there was more than one plant of the same species in the same location (within 10 m) the area of the population was recorded.

A targeted field survey for the EPBC Act listed threatened orchid, *Paracaleana dixonii* was conducted in December 2022 by Brian Morgan in collaboration with Daniel Marsh Botanical Consulting (Marsh); a member of the Orchid Society of WA with a special interest in *P. dixonii*. A total of six participants attended a known location of *P. dixonii* in the local area (approximately 40 km south of the Proposal) to determine if the species was detectable. Following this, the team carried handheld GPS units loaded with the survey polygon and walked the Survey Area at 10 m spacing to attempt to locate the species (Figure 20 and Figure 21). The Survey Area was traversed systematically, participants meandered in a zig-zag pattern along the traverse lines covering a greater area than would normally be covered in a straight line. Participants took a conservative approach to plant identification, notifying the botanists of any flora that resembled *P. dixonii* for confirmation.

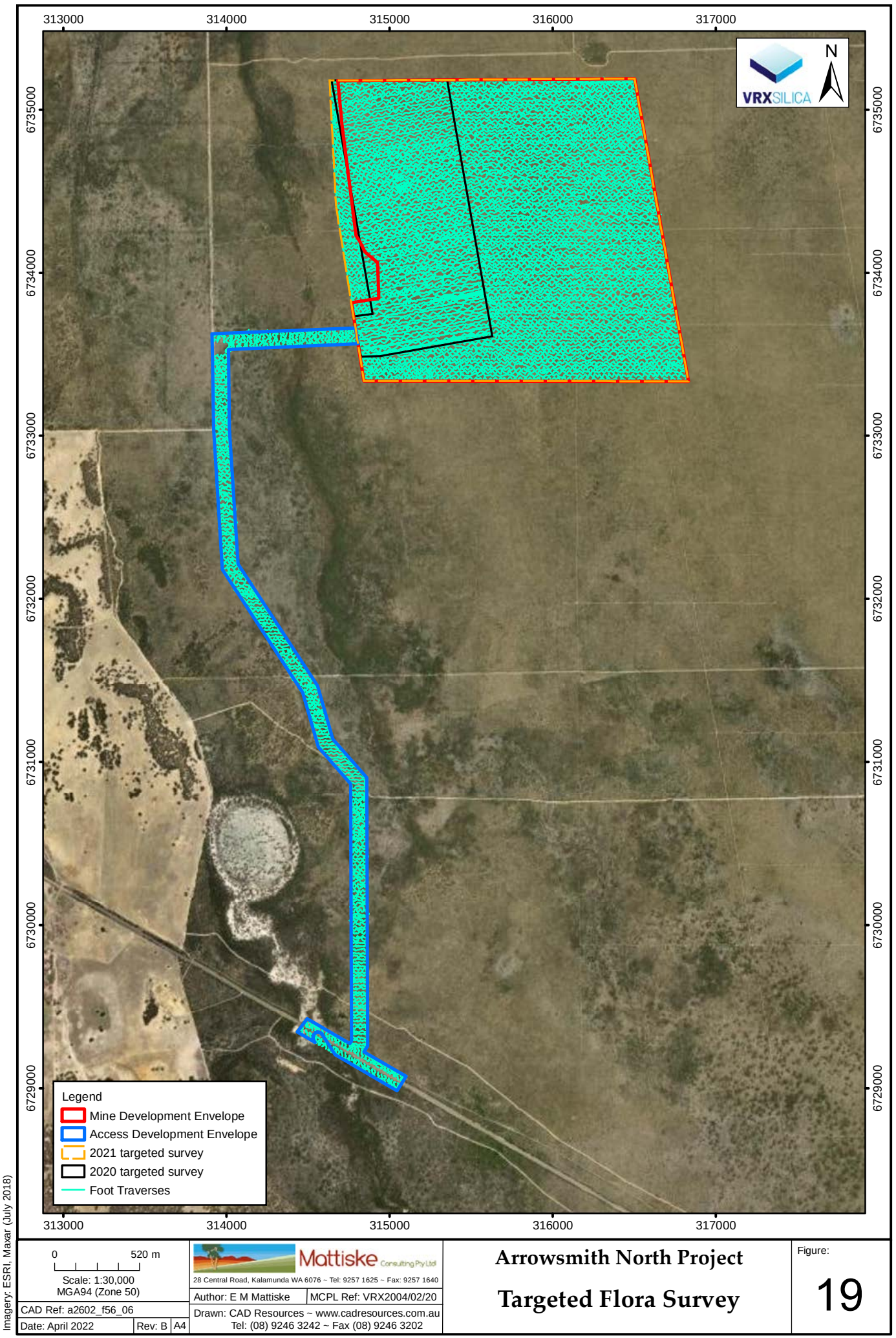
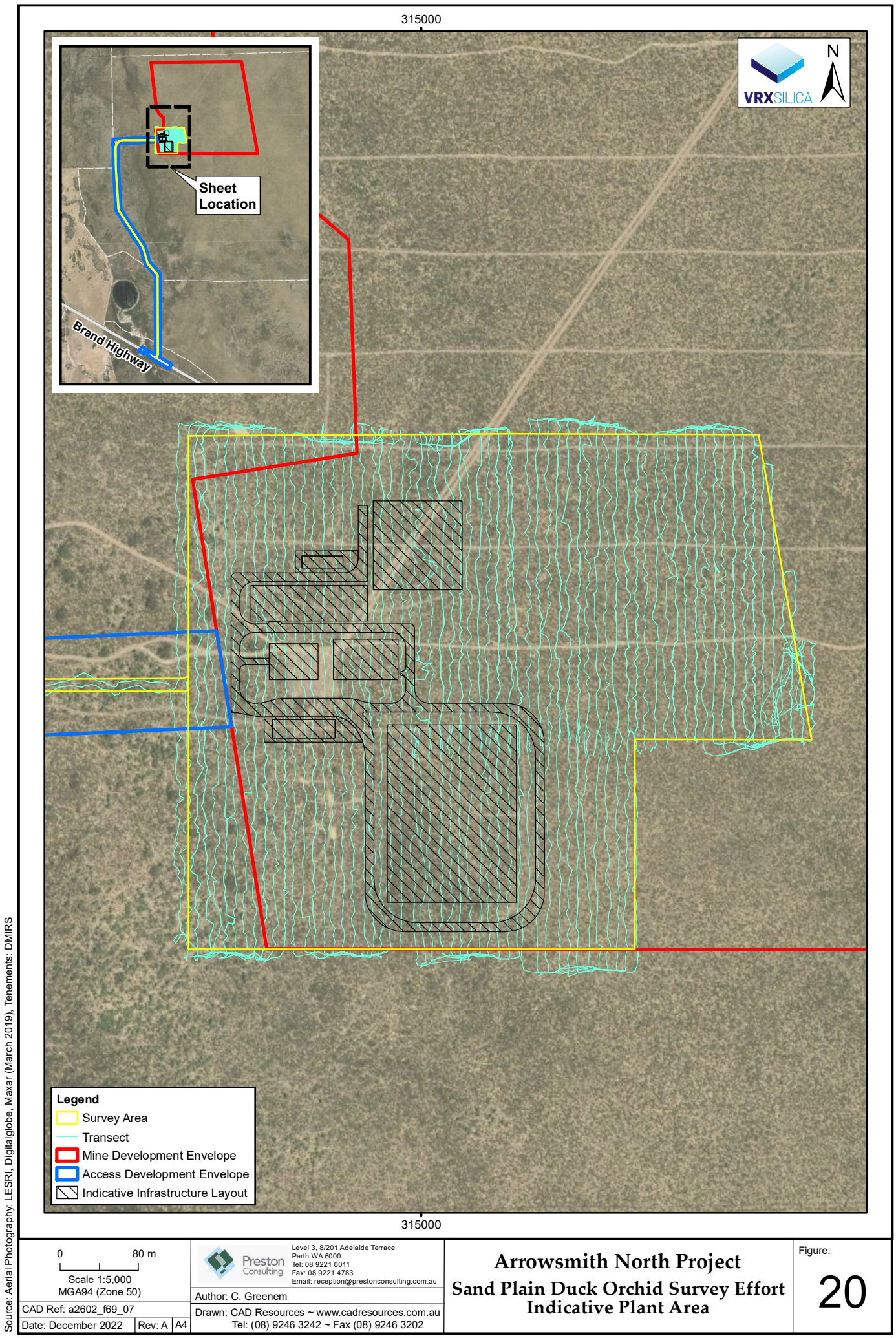


Figure 19: Targeted flora survey areas



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Arrowsmith North Project

Sand Plain Duck Orchid Survey Effort Indicative Plant Area

Figure: 20

Figure 20: Targeted survey effort for *P. dixonii* (1 of 2)

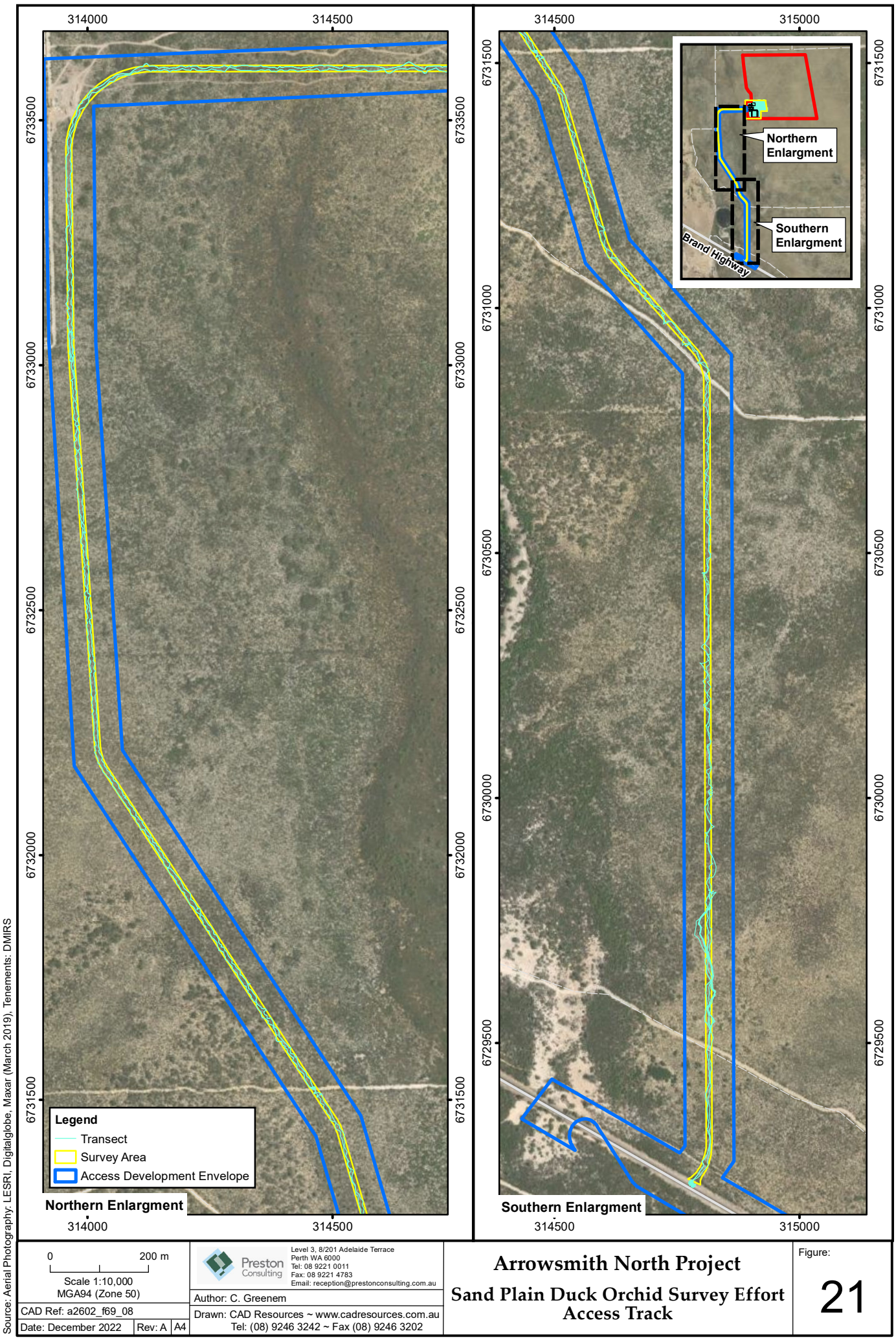


Figure 21: Targeted survey effort for *P. dixonii* (2 of 2)

Survey Timing

According to the *Technical guidance – Flora and vegetation surveys for EIA* (EPA, 2016b), the primary survey timing for the Irwin Botanical Province is Spring (September - November). The surveys were all undertaken between September and November within the primary survey timing excluding one survey within the Access Survey Area. This survey was originally completed in May 2020; however, a subset of quadrats was re-monitored during the October 2021 survey and a targeted Threatened and Priority Flora assessment was completed during September 2021. The surveys were timed, where possible, to align with peak flowering periods of significant flora with the potential to occur in the survey areas.

Above average rainfall was received in the three months prior to the 2018, May 2020 and 2021 surveys (Figure 22). The average rainfall for February - April 2020 was above average due to a large rainfall event in February, however the March and April rainfall was below average. In 2019, rainfall in the 3 months preceding the survey was well below average. The total rainfall recorded in 2019 was 288.2 mm, the long-term average yearly rainfall is 487.3 mm.

All surveys, except the May 2020 Access Corridor survey, have been undertaken to align with the peak flower periods of significant flora. Above average winter rainfalls were received prior to the October/November 2018 survey, October 2020 survey, September/October 2021 survey and December 2022 survey. In contrast rainfall preceding the October/November 2019 survey and September 2020 survey was below the long-term average rainfall for the area, based on Bureau of Meteorology (BoM) data for Green Grove. It is apparent that the area is prone to large seasonal fluctuations in rainfall. Overall, based on a range of factors including the proportion of potential flora recorded (estimated at 83 %), proportion of annual taxa recorded (13.1 %), and vegetation quadrat distribution within the Survey Area, the survey has not been constrained by factors which would adversely affect the survey outcomes nor the conclusions derived from the data used to support vegetation analysis.

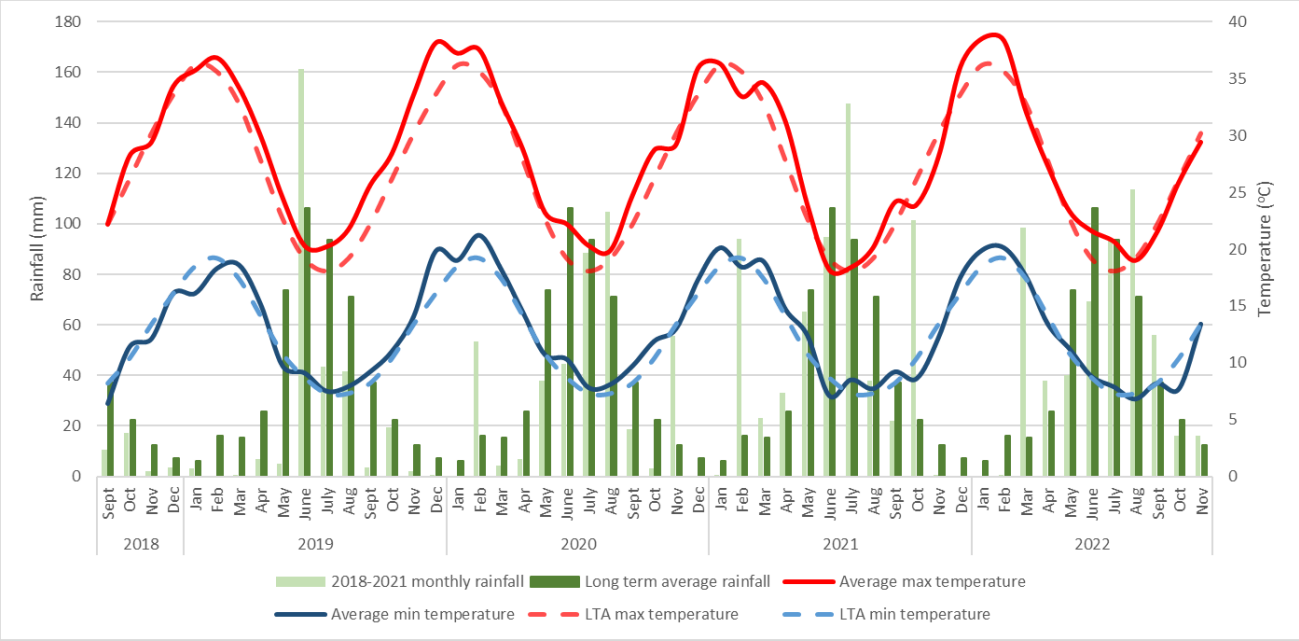


Figure 22: Average and 2018-2022 rainfall for Green Grove and average monthly and long-term temperature for Carnamah (BoM, 2022a)

Dieback Assessment

Mine Survey Area

Glevan was commissioned in 2019 to conduct a desktop and field assessment of the Mine Survey Area to:

- Inform the extent of dieback infection within the proposal area and surrounding landscape;
- Identify vegetation that can be protected and likely sources of dieback contamination; and
- Outline the potential impacts on the environment this Proposal may have in relation to dieback.

A desktop assessment was carried out prior to the assessment in the field, and all information relevant to the Proposal was assembled to assist the interpretation process as defined in Chapter 7 of the Phytophthora Dieback Interpreter's Manual for Lands Managed by the Department (FEM047; DPaW, 2015). The desktop assessment used previous assessments of the area, history of burning and other disturbances to inform the field assessment.

All in-field Phytophthora Dieback detection, diagnosis and mapping was performed to standards and procedures defined in Chapter 6 of FEM047 (DPaW, 2015). These procedures are grounded on the presence in the vegetation of indicator species, and the observance of deaths in these plants. An indicator species is a plant species that is reliably susceptible to *Phytophthora*. Indicator species deaths alone do not necessarily indicate disease presence and it was necessary to consider all environmental and ecological factors that were present. These other factors (as listed in DPaW (2015) include:

- Chronology of plant deaths;
- Pattern of plant deaths;
- Topographical position;
- Vectoring – causal agencies; and
- Biomass and biological diversity reduction.

During the assessment process, the collection of evidence to support the field diagnosis was recorded, and waypoints were mapped at locations to show evidence of:

- Where field diagnosis is certain or almost certain of Phytophthora Dieback infestation;
- Healthy indicator species where field diagnosis is almost certain of the site being uninfested;
- Sites with too few or devoid of indicator species, thus supporting uninterpretable classification; or
- Areas of disturbance, which are temporarily uninterpretable or excluded from assessment.

All soil and tissue samples taken during the assessment were to standards and prescriptions defined in Chapter 11 of FEM047 (DPaW, 2015). All samples are analysed in the Vegetation Health Services laboratory (DBCA) using best-practice techniques.

Access Survey Area

All Phytophthora Dieback detection, diagnosis and mapping were performed to standards and procedures defined in Chapter 6 of FEM047 (DPaW, 2015). These procedures are grounded on the presence in the vegetation of indicator species and the observance of deaths in these plants.

Other causes of plant deaths considered when determining the presence of Phytophthora Dieback included:

- Drought, wind scorch and frost;
- Fire and lightning;
- Senescence and competition; and
- Physical damage.

Before the assessment, all information relevant to the Proposal was assembled to assist the interpretation process. This information included previous assessments of the area and history of burning.

Review of Root Surveys and VDT

Mattiske was commissioned in February 2020 to assess the outcomes of the Iluka VDT trials (discussed further in Section 2.2.3 and 5.5.1) and how the roots of the vegetation within the Mine Development Envelope are likely to impact these outcomes (Appendix 2).

A review of root studies was conducted to identify typical root structures within the upper soil profile of the Mine Development Envelope. This review allowed Mattiske to identify individual flora species and clusters of vegetation likely to have large lignotubers, lateral roots and/or deeper roots that could present barriers to the proposed VDT rehabilitation method.

In March 2022, Mattiske also undertook a targeted assessment of the root systems of priority flora species previously recorded in the Survey Area (Mattiske, 2022b). Information from this assessment has been used in determining the viability of the VDT rehabilitation practice for specific priority flora species and to prioritise other rehabilitation methods for species that are unlikely to be successfully relocated by the VDT rehabilitation method.

5.3.2 ALIGNMENT WITH TECHNICAL GUIDANCE

Flora and Vegetation Assessments

Mattiske designed and implemented field assessments based on the relevant state and federal legislation and guidelines outlined in Section 5.2, as well as EPA technical guidance (EPA, 2016a; EPA, 2016b). All botanists held valid collection licences to collect flora for scientific purposes, issued under the BC Act. Assessment methods were deemed to align with the EPAs guidance however there were some unavoidable limitations due to the sterility and flowering behaviour of some plant species. These limitations are not deemed significant to the results of the surveys. Further detail on survey limitation is provided inTable 9.

Table 9: Potential limitations of the flora and vegetation surveys

Potential Survey Limitation	Impact on Survey
Availability of contextual information at a regional and local scale	**Not a limitation:** Reference resources such as Beard's mapping, together with online flora and vegetation information, has provided an appropriate level of information for the current survey. The vegetation of the Dongara area has previously been mapped by Beard (1976). Mattiske has completed previous flora and vegetation and surveys for the Proposal in recent years (Mattiske 2019b, 2020c, 2020d, 2021a, and 2021b). Regional threatened and priority flora localities were also sourced from tenement holders in close proximity to the Proposal, namely Iluka Resources Limited and Tronox Limited.

Potential Survey Limitation	Impact on Survey
Resources (i.e., were there adequate resources to complete the survey to the required standard)	**Not a limitation for either survey:** Adequate resources were made available by VRX to complete the survey.
Competency/ experience of team carrying out survey; experience in the bioregion surveyed	**Not a limitation:** Botanists had extensive experience working in a range of botanical districts across the state. Two of the botanists have consistently worked within this bioregion for more than 8 years. Botanists were familiar with flora in the area. Any unknown or potential threatened or priority flora species were collected and identified, utilising resources available at the WAH and consultation with expert taxonomists. A member of the Orchid Society of WA that has extensive experience in identification and mapping the extent and location of *P. dixonii* was involved in the targeted survey for this species (BMCB, 2023).
Proportion of flora collected and identification issues	**Potential limitation:** While many plants were in flower during the survey, a proportion of plants encountered during the survey were sterile and may impact the chance of identification of some specimens to species level. Orchid species may not emerge each year if conditions are not favourable. Although this may affect the completeness of the species list, it is not expected to have a significant effect on mapping reliability, nor on the identification of threatened and priority species in the area as the majority were perennial species. Surveys have taken place over multiple years and in different seasons maximising the opportunity to record the greatest number of taxa. In the case for *P. dixonii,* flowering and detectable individuals were observed at known locations in the area and it is reasonable to assume that this species would be detectable at the BMCB (2023) targeted survey area if they were present. Based on the survey quadrat data, it was estimated that approximately 83 % of the potential flora species that may be present were recorded.
Effort and extent of survey	**Minimal limitation:** The Survey Area was thoroughly covered. Survey quadrats were initially selected from high resolution aerial maps. Low replication of some vegetation communities was unavoidable given the low occurrences within the Survey Area. The threatened and priority flora survey (Mattiske, 2022a) was undertaken by botanists by means of a comprehensive meandering foot-traverse to ensure thorough coverage of the survey area. Flora that was unknown or resembled threatened or priority flora were collected, the location and habitat noted, and the number of plants estimated. The EPA (2016b) recommends a traverse width of 10 m in the South West, however states an effective search width will be determined by the distance over which a target species can be reasonably observed considering the general vegetation structure/density. It was determined that 20 m was an appropriate traverse width as the vegetation was mainly low Heath and botanists could readily observe the majority of the target species. No Thicket or Scrub communities were present in the targeted flora survey area. The 20 m traverse was also the maximum width surveyed, though, when target species were found a more intensive search in the immediate area was conducted, this was often within 1 – 3 m. In addition to the Mattiske (2022a) targeted survey, an additional targeted survey for *P. dixonii* was conducted at 10 m spacing to align with the EPA's guidance (BMCB, 2023).
Mapping reliability	**Not a limitation.** Handheld GPS units and *Collector for ArcGIS* software on Apple iPads were used for the survey. *Collector for ArcGIS* on Apple iPads was loaded with satellite imagery layered with the area boundary and traverse transects allowing the botanists location to be mapped in real time. Both devices for a majority of field conditions have an accuracy level of ± 5 m.
Access restrictions within Survey Area	**Not a limitation for either survey:** Vehicle access to the Survey Area and foot traverses were sufficient to allow access to the entirety of the Survey Areas. All Survey Areas were easily accessible for traversing on foot.
Survey timing, rainfall, season of survey	**Not a limitation:** The EPA (2016b) recommends that flora and vegetation surveys in the South – West Botanical Province be conducted in Spring (September - November). The majority of surveys were completed in October and November which falls within this period and also coincided with the peak flowering time of many of the threatened and priority flora species likely to be found in the area. One survey of the Arrowsmith North transport corridor, was conducted in May. However, the quadrats were re-monitored during October and targeted Threatened & Priority assessment of the whole area was

Potential Survey Limitation	Impact on Survey
	completed during September. Re-monitoring of vegetation quadrats and targeted Threatened & Priority assessment was also completed in the Survey Area in Spring, to provide supplementary survey data In addition to the Mattiske (2022a) targeted survey, an additional targeted survey for *P. dixonii*. Survey timing was just outside the peak flowering period for this species as defined by DotE (2013b; Peak flowering period: late October to late November. Dormant between December and late April) however mild temperatures and above average rainfall for the months preceding the survey effort coupled with positive records of flowering individuals (in good condition) in known locations confirmed that the survey timing was adequate to record this taxon.
Disturbances (fire/flood/clearing)	**Not a limitation for either survey:** The Survey Area exhibits minimal levels of disturbance, mainly from past fire events.
Data and statistical analysis	**Not a limitation for either survey:** Introduced species, annual species and singletons were excluded from the data set prior to analysis. Data collected was sufficient for delineation of vegetation communities based on statistical analysis.

Mattiske (2022a) determined that the surveys were not constrained by the limitations identified above.

Above average winter rainfalls were received prior to the October/November 2018 survey, October 2020 survey, September/October 2021 survey and December 2022 survey. In contrast rainfall preceding the October/November 2019 survey and September 2020 survey was below the long-term average rainfall for the area, based on BoM data for Green Grove. It is apparent that the area is prone to large seasonal fluctuations in rainfall. Overall, based on a range of factors including the proportion of potential flora recorded (estimated at 83 %), proportion of annual taxa recorded (13.1 %), and vegetation quadrat distribution within the Survey Area, the survey has not been constrained by factors which would adversely affect the survey outcomes nor the conclusions derived from the data used to support vegetation analysis.

While many taxa were in flower during the various surveys, a proportion of plants encountered during the surveys were sterile and may impact the identification of some specimens to species level. Botanists that undertook the survey are experienced in the flora of the Geraldton Sandplains and identification of some taxa are possible even with sterile plants. A review of the potential constraints associated with these surveys determined that they were not subject to constraints that would adversely affect the outcome nor the conclusions formed from the results. Consequently, it is reasonable to conclude that the Survey Area have been adequately surveyed (Mattiske, 2022a).

VRX notes that EPA (2016b) recommends a traverse width of 10 m in the South West region, however is also states an effective search width will be determined by the distance over which a target species can be reasonable observed considering the general vegetation structure/density. Mattiske (2022a) determined that 20 m was an appropriate traverse width as the vegetation was primarily low Heath. There were no Thicket or Scrub communities present in the targeted threatened and priority surveys. As seen in Figure 23, the dominant low heath vegetation is easy to observe target species at a width of 20 m.

The applied methodology of systematic meandering within a 20 m vegetation corridor width, results in a 50% increase in survey intensity compared to walking in a straight line. There were a number of small and cryptic priority species that were recorded during the targeted threatened and priority surveys which also indicates the survey intensity was adequate. *Comesperma*

rhadinocarpum (P3) and *Stawellia dimorphantha* (P4) both grow to a height of only 35 cm and 20 cm respectively and were observed frequently, while *Leschenaultia juncea* (P3), a grass-like herb, was also found. The survey design and intensity was considered adequate to observe *Paracaleana dixonii* (T) individuals, as its size is similar to other significant species found during targeted threatened and priority surveys.

Figure 23: Kwongan heath at the survey area with 20 m measuring tape

Targeted Paracaleana dixonii Survey

The targeted survey for threatened *P. dixonii* was prepared and conducted in consideration of the Australian Government's Survey Guidelines for Australia's Threatened Orchids - Guidelines for detecting orchids listed as 'threatened' under the *Environment Protection and Biodiversity Conservation Act 1999* (DotE, 2013b). The survey effort was determined to generally align with the guidance however, 10 m spacing for the transects was chosen (as opposed to the recommended 6 m spacing) due to the type of habitat (open heath) being surveyed. The open heath of the survey area is predominantly 0.5 - 1 m tall and well-spaced, such that observations can be made at a 5 m distance. A slow survey speed was adopted to allow enough time to look between ground covers and under small bushes despite the species favouring open sandy areas. Survey timing was just outside the peak flowering period for this species as defined by DotE (2013b; Peak flowering period: late October to late November. Dormant between December and late April) however mild temperatures and above average rainfall for the months preceding the survey effort coupled with positive records of flowering individuals (in good condition) in known locations in the area confirmed that the survey timing was adequate to record this taxon.

Dieback Assessment

Phytophthora Dieback detection, diagnosis and mapping was performed by Glevan to standards and procedures defined in FEM047 Chapters 6, 7, 8 and 11 (DPaW, 2015).

5.3.3 FLORA

General Flora

A total of 305 vascular plant taxa, representative of 136 genera and 52 families, were recorded within survey quadrats within the Survey Area between 2018 and 2021. The majority of taxa recorded were representative of the Myrtaceae (37 taxa), Proteaceae (33 taxa), and Fabaceae 30 taxa) families. Forty annual plant species were recorded within the Survey Area, representing 13.1 % of all taxa recorded, and 11 of these represent introduced annual species.

The 2021 re-surveyed vegetation quadrats in the Survey Areas recorded a total of 186 vascular plant taxa, representative of 100 genera and 43 families. This is compared to the same vegetation quadrats in 2018, 2019, 2020 resulting in 167 vascular plant taxa, representative of 86 genera and 36 families. Species richness increased by an average of 6.85 ± 0.77 taxa per vegetation quadrat in 2021. This increase is likely due to more favourable seasonal conditions in Spring 2021 compared to previous years. While it is acknowledged that higher numbers of recorded taxa were noted during the 2021 survey, initial surveys were not unduly impacted by below average rainfall. Below average rainfall preceding the Spring 2019 and 2020 surveys, did not influence the formulation of vegetation communities or significant flora recorded, and as such initial surveys still meet EPA guidance and are suitable for use in any impact assessment.

The majority of the taxa recorded were widespread both locally and more broadly within the Lesueur Sandplain subregion.

A species accumulation curve was used to evaluate the sampling adequacy within the Survey Areas and is presented in Figure 24. In the Survey Areas the incidence-based coverage estimator of species richness was 367.4. Based on this value and the total of 305 taxa recorded (in vegetation mapping sites only), approximately 83 % of the flora species potentially present within the Mine Survey Area and Access Survey Area were recorded.

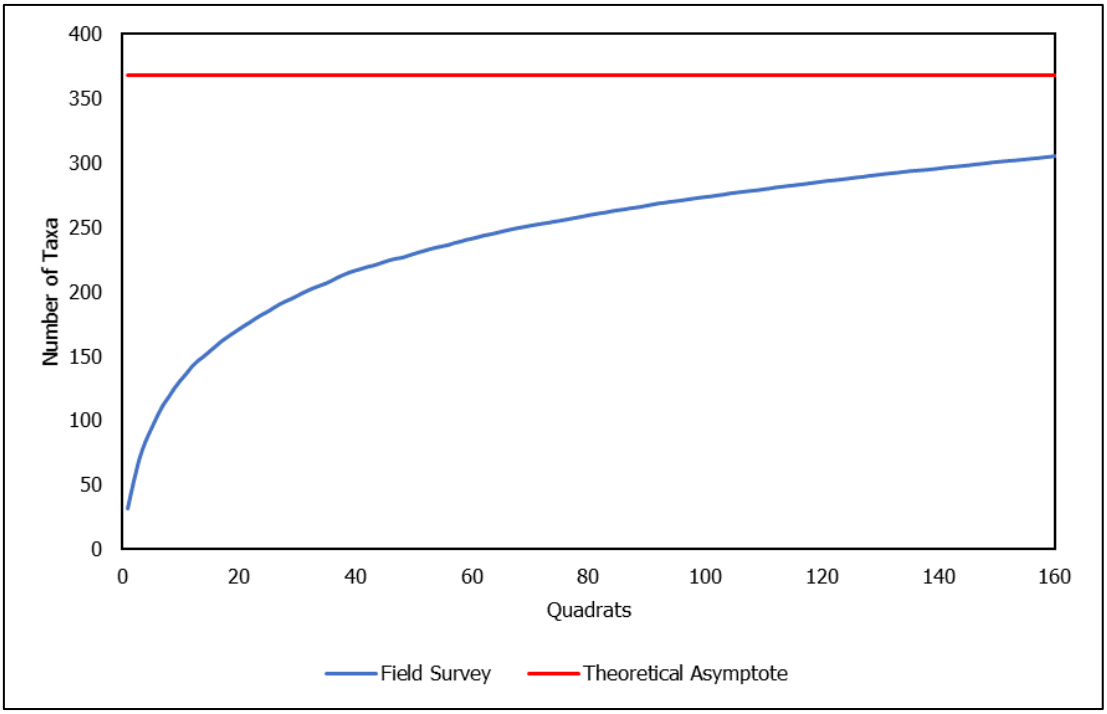


Figure 24: Average randomised species accumulation curve

Unidentified Flora

While many taxa were in flower during the various surveys, a proportion of plants encountered during the surveys were sterile and may impact the identification of some specimens to species level. None of the unidentified flora species are species of interest or likely to represent new species. Botanists that undertook the survey are experienced in the flora of the Geraldton Sandplains and identification of some taxa are possible even with sterile plants.

Several of the plant species collected could not be identified accurately to species level due to the absence of sufficient taxonomic characters to enable accurate identification. Eight taxa were identified to family level only, and 35 to genus level. No taxa were question-marked at a genus level, however, twelve were identified to genus level but were question-marked at species level. The principal reasons for not being able to fully identify some of the collected specimens to species level were:

- Plant material was sterile or lacked sufficient taxonomic features to permit accurate identification to species level. In these cases, the species is identified as, for example, *Thysanotus sp.* or *Drosera sp.*; and
- The plant material collected could not be determined to a known taxon. For example, *Lepidosperma* species are currently undergoing taxonomic revision, making accurate identification to species level difficult. Five Lepidosperma taxa were denoted *sens. lat*. (*Lepidosperma apricola sens. lat., Lepidosperma scabrum sens. lat., Lepidosperma squamatum sens. lat. and Lepidosperma tenue sens. lat.*), these species are in the broad sense related to the binomial name. One additional taxon of Lepidosperma, (*Lepidosperma aff. apricola*), shows affinities to *Lepidosperma apricola* but is not identical.

None of the unidentified flora species are species of interest or likely to represent new species (Mattiske, 2022a). Records of unidentified flora are summarised in Table 10 and shown in Figure 25.

No unidentified flora species were only recorded within the development envelopes.

Table 10: Records of unidentified flora

Unidentified Flora	Number of records within the Survey Area	Number of records within the development envelopes
Drosera sp.	13	4
Drosera sp (climbing)	16	7
Lepidosperma apricola sens. Lat.	3	0
Lepidosperma scabrum sens. Lat.	18	4
Lepidosperma squamatum sens. Lat.	1	0
Lepidosperma tenue sens. Lat.	7	2
Lepidosperma aff. Apricola	1	0
Thysanotus sp.	17	9
Thysanotus sp. (climbing)	22	1

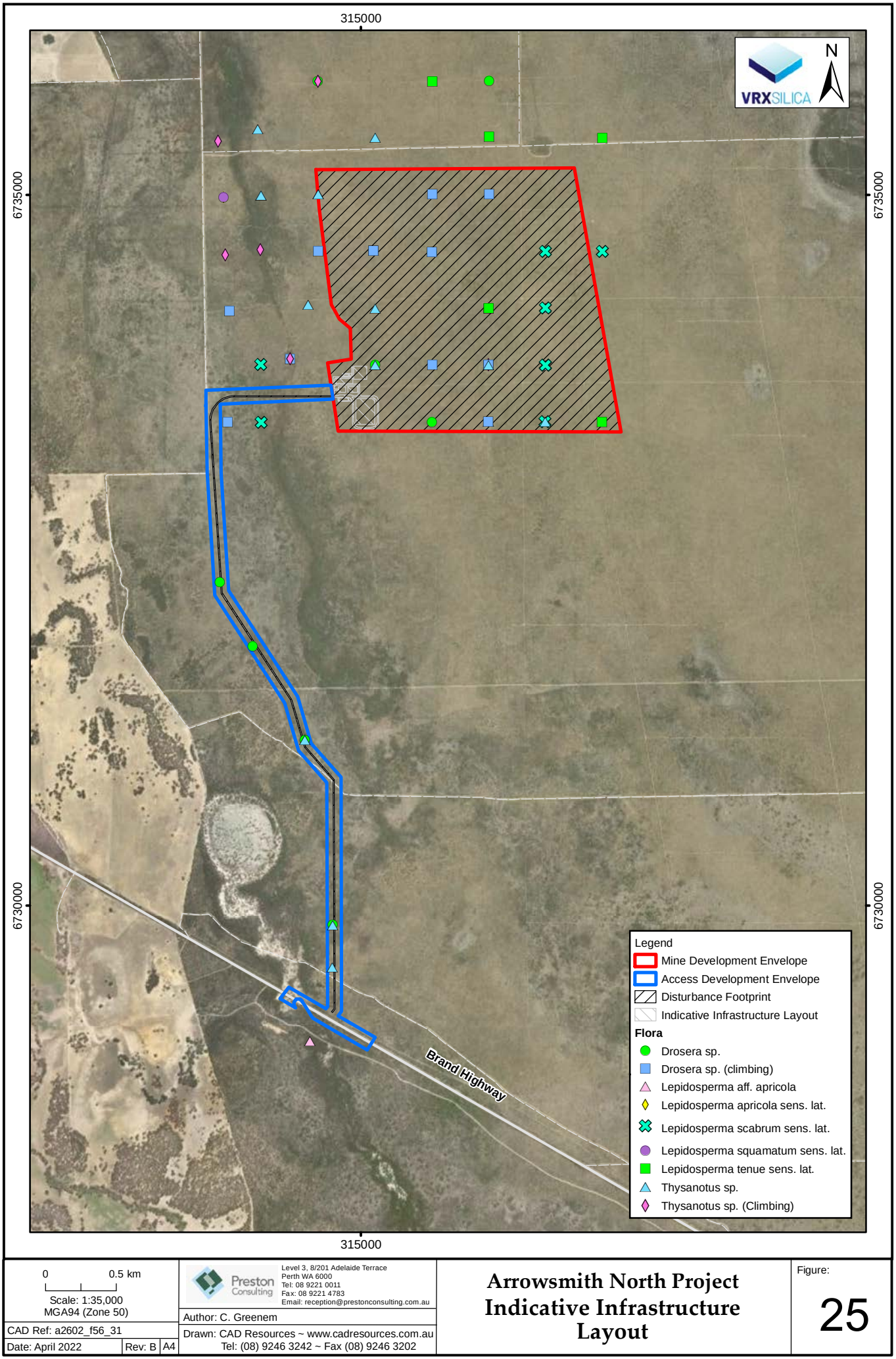


Figure 25: Location of plant species that could not be identified

Threatened and Priority Flora

Potential Taxa – Desktop Assessment

Thirteen Threatened Flora species listed by the DBCA (2018a) and DAWE (2022b), and 44 priority flora listed by WAH (1998 -) have the potential to occur within the development envelopes, 35 of these have the potential to occur in the Mine Survey Area and 20 in the Access Survey Area. Mattiske (2022a) assessed the likelihood of recording any listed Threatened and Priority taxa within the survey areas, based on factors including known soil type, topography and distribution. All Threatened Flora species with the potential to occur within the Survey Area were determined to have a low likelihood of occurrence.

Initially the Threatened *P. dixonii*, was deemed to have a high likelihood of occurrence within the survey areas. Based on subsequent data analyses, the likelihood of the presence of *P. dixonii* has been reduced to a low probability in view of the distance to previous locations and differing soil substrate. The closest *P. dixonii* records are at least 5 km to the east of the survey areas near the Parmelia gas pipeline. Mattiske has previously extensively surveyed between these records and the Mine Survey Area for Beach Energy at the Beharra Springs Gas facility, and no additional *P. dixonii* records have been found in this area.

The primary preferred soil type of *P. dixonii* is described as grey sand over laterite (Brundrett, 2014), while it has also been recorded less so on deep sandy soils (Brown, 2022). WAH (1998-) has described the preferred soil as grey sand over granite, this is evidently erroneous, and may refer to *P. brockmanii*, in which *P. dixonii* was grouped before 2006 (Hopper and Brown). In an analysis of the 20 *P. dixonii* records held at the WAH, the majority of records (60%) indicate plants have been collected on grey sand over laterite or grey sand, while four records are from white sand. The dominant soil type in the Arrowsmith North survey area comprises deep white to pale yellow sand, no grey sand is present.

The closest *P. dixonii* records are approximately 5 km to the east of the Arrowsmith North survey area near the Dampier to Bunbury Natural Gas Pipeline. Mattiske has previously surveyed extensively between these records and the Arrowsmith North survey area for Beach Energy at the Beharra Springs Gas facility, and no additional *P. dixonii* records have been found in this area. There is a clear north-south line these records form, evidently due to landform and soil characteristics.

Nine priority flora species had a high likelihood of occurrence, mainly due to previous records in the area and suitable habitat. Nineteen priority flora species had a moderate likelihood of occurring in the survey areas and 20 had a low likelihood.

The Threatened and Priority taxa with the potential of occurring within the survey areas are detailed in Table 11.

Table 11: Threatened and Priority flora potentially occurring within the Survey Area

Species	Conservation Status		Likelihood of Occurrence
	EPBC Act	BC Act	
Threatened Species			
Conostylis dielsii subsp. *teres*	Endangered	Threatened	Low
Conostylis micrantha	Endangered	Threatened	Low

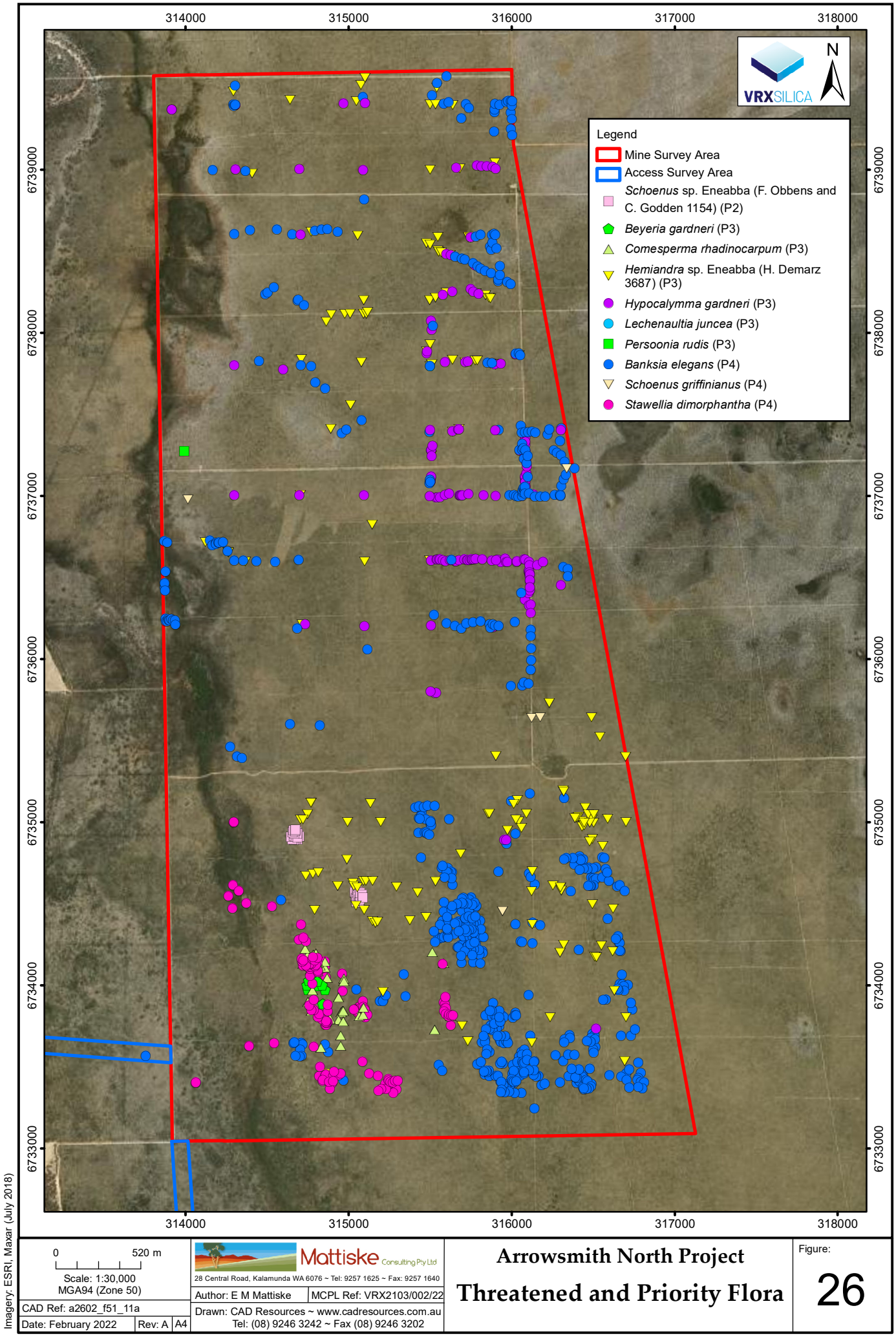
Species	Conservation Status		Likelihood of Occurrence
	EPBC Act	BC Act	
Daviesia speciosa	Endangered	Threatened	Low
Eucalyptus crispata	Vulnerable	Threatened	Low
Eucalyptus x impensa	Endangered	Threatened	Low
Eucalyptus leprophloia	Endangered	Threatened	Low
Eucalyptus x balanites	Endangered	Threatened	Low
Hemiandra gardneri	Endangered	Threatened	Low
Paracaleana dixonii[1]	Endangered	Threatened	Low
Styphelia obtecta	Endangered	Threatened	Low
Tetratheca nephelioides	Critically Endangered	Threatened	Low
Thelymitra stellata	Endangered	Threatened	Low
Wurmbea tubulosa	Endangered	Threatened	Low
Priority Species			
Acacia latipes subsp. *licina*	-	Priority 3	Moderate
Acacia vittata	-	Priority 2	Low
Banksia elegans	-	Priority 4	High
Banksia fraseri var. *crebra*	-	Priority 3	Moderate
Banksia scabrella	-	Priority 4	Moderate
Beyeria gardneri	-	Priority 3	Moderate
Caladenia denticulate subsp. *albicans*	-	Priority 1	Low
Calectasia palustris	-	Priority 2	Low
Calytrix chrysantha	-	Priority 4	Moderate
Calytrix eneabbensis	-	Priority 4	Moderate
Calytrix superba	-	Priority 4	Moderate
Centrolepis milleri	-	Priority 3	Moderate
Comesperma griffinii	-	Priority 2	Moderate
Comesperma rhadinocarpum	-	Priority 3	High
Dampiera tephrea	-	Priority 2	Low
Drosera pedicellaris	-	Priority 1	Moderate
Eucalyptus macrocarpa subsp. *elachantha*	-	Priority 4	Low
Eucalyptus macrocarpa x pyriformis	-	Priority 3	Low
Eucalytus zopherophloia	-	Priority 4	Low
Grevillea erinacea	-	Priority 3	Moderate
Guichenotia alba	-	Priority 3	Low
Guichenotia quasicalva	-	Priority 2	Low
Hemiandra sp. Eneabba (H. Demarz 3687)	-	Priority 3	High
Hopkinsia anoectocolea	-	Priority 3	Moderate

Species	Conservation Status		Likelihood of Occurrence
	EPBC Act	BC Act	
Hypocalymma gardneri	-	Priority 3	High
Hypocalymma tetrapterum	-	Priority 3	Low
Lasiopetalum ogilvieanum	-	Priority 1	Moderate
Leschenaultia juncea	-	Priority 3	High
Persoonia chapmaniana	-	Priority 3	Low
Persoonia filiformis	-	Priority 3	Low
Persoonia rudis	-	Priority 3	High
Poranthera asybosca	-	Priority 1	Moderate
Schoenus griffinianus	-	Priority 4	High
Schoenus sp. Eneabba (F. Obbens & C. Godden I154)	-	Priority 2	Moderate
Scholtzia calcicola	-	Priority 2	Moderate
Stawellia dimorphantha	-	Priority 4	High
Stylidium carnosum subsp. Narrow leaves (J.A. Wege 490)	-	Priority 1	Low
Stylidium longitubum	-	Priority 4	Low
Stylidium pseudocaespitosum	-	Priority 2	Low
Stylidium torticarpum	-	Priority 3	Low
Styphelia filifolia	-	Priority 3	Low
Synaphea oulopha	-	Priority 3	Low
Triglochin protuberans	-	Priority 3	Low
Verticordia argentea	-	Priority 2	Moderate
Verticordia dasystylis subsp. *oestopoia*	-	Priority 1	Low
Verticordia fragrans	-	Priority 3	Moderate
Verticordia luteola var. *luteola*	-	Priority 3	Moderate
Verticordia luteola var. *rosea*	-	Priority 1	Moderate

[1]Named *Caleana dixonii* on the DCCEEW Species Profile and Threats Database (DCCEEW; 2023) but known in WA, and refered to in this document, as *Paracalena dixonii*

Recorded Taxa - Field Assessment

No Threatened Flora listed under the EPBC Act or BC Act were recorded in the survey areas. Eleven priority flora taxa were recorded within the survey areas, one of which, *Hopkinsia anoectocolea* (Priority 3) was recorded only within the southern alignment of the Access Survey Area. Eight species were recorded only within the Mine Survey Area. Two species, *Banksia elegans* and *Stawellia dimorphantha* were recorded in both the Mine Survey Area and Access Survey Area. The location of the species is shown in Figure 26 and Figure 27. Significant flora recorded within the development envelopes are shown in Figure 28. The extent of these species and their conservation status are detailed in Table 12.



Imagery: ESRI, Maxar (July 2018)

0 520 m

Scale: 1:30,000
MGA94 (Zone 50)

CAD Ref: a2602_f51_11a

Date: February 2022 | Rev: A | A4

Mattiske Consulting Pty Ltd
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Arrowsmith North Project

Threatened and Priority Flora

Figure: 26

Figure 26: Significant flora recorded within the survey areas (Mine Survey Area)

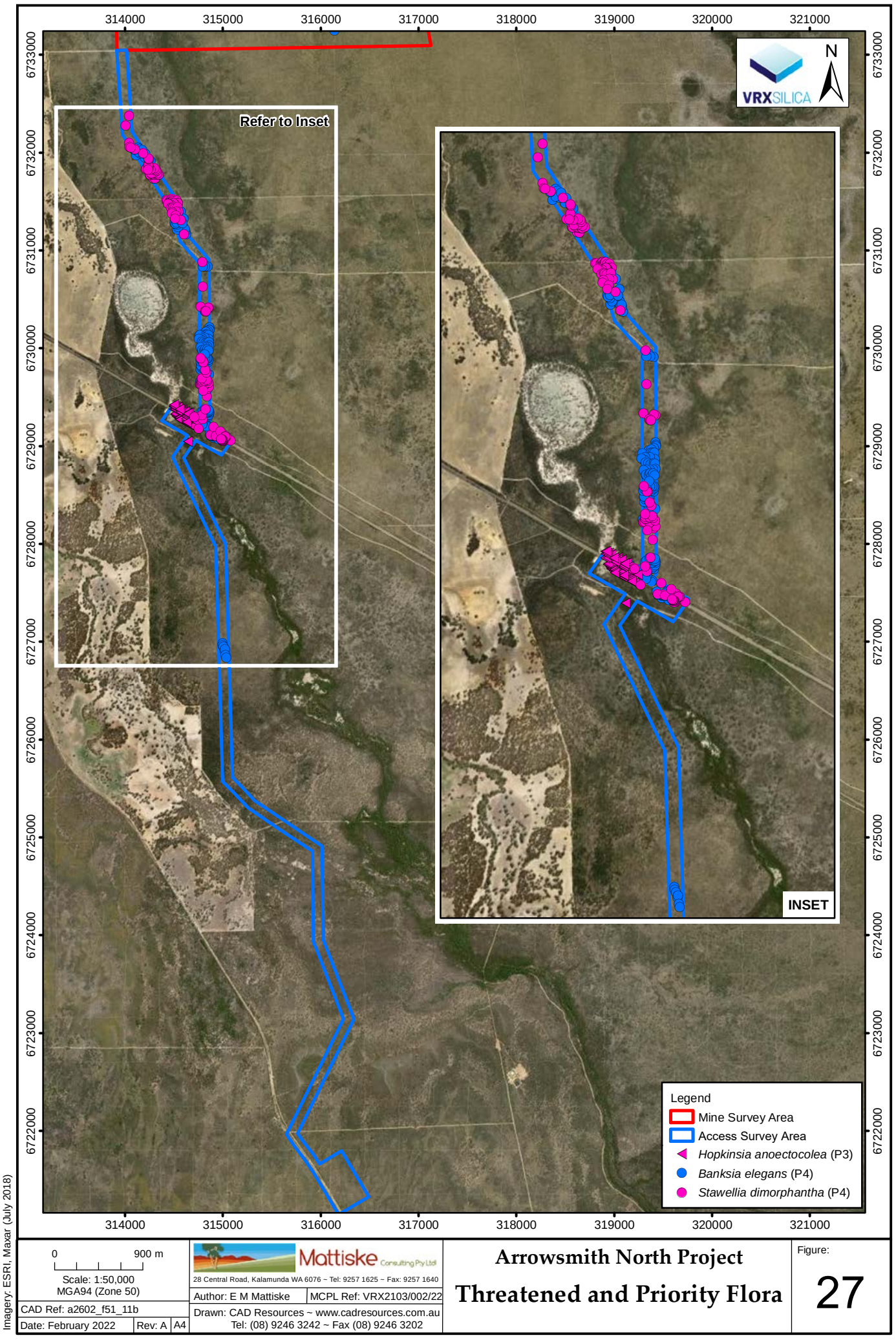


Figure 27: Significant flora recorded within the survey areas (Access Survey Area)

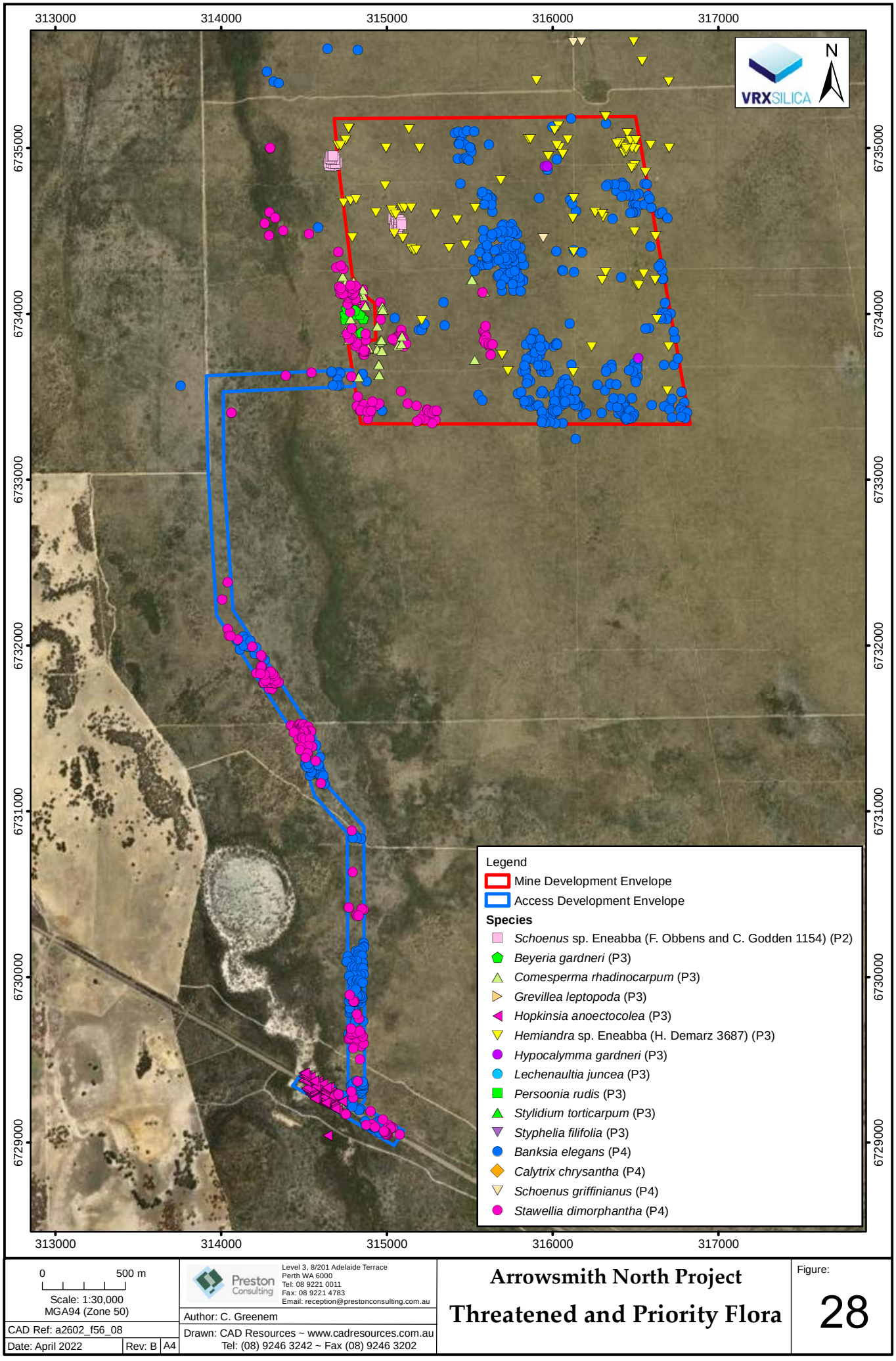


Figure 28: Significant Flora recorded in proximity to the development envelopes

Table 12: Priority flora recorded within the Survey Areas

Species and conservation status	Survey Area Record	Extent within Survey Areas
Banksia elegans (P4)	Mine, Targeted and Access	Recorded throughout the Mine Survey Area from 589 locations totalling 2,601 plants. This species was also recorded throughout the Access Survey Area from 152 locations totalling 794 plants. The 44 records held at the WAH indicates *Banksia elegans* ranges from Moore River to Geraldton. *Banksia elegans* occurs on white or red sands, on sandplains and low dunes. This species is not restricted to a unique set of ecological conditions and is present in various vegetation communities within the survey areas.
Beyeria gardneri (P3)	Mine and Targeted	Recorded from eight locations throughout the Mine Survey Area totalling 33 plants. The 37 records held at the WAH show *Beyeria gardneri's* distribution range from Cataby to Nerren Nerren, north of Kalbarri. This species often occurs on yellow sand (WAH 1998-). Observations from the survey areas indicated plants were located on yellow/grey/white sand over shallow limestone on top of rises.
Comesperma rhadinocarpum (P3)	Mine and Targeted	Recorded scattered in the southern section of the Mine Survey Area from 47 locations totalling 59 plants. The 17 records held at the WAH indicates *Comesperma rhadinocarpum* ranges from Perth to Utcha Well Nature Reserve. This species occurs on a wide range of habitats from sandy loams, sandy clay and sand, sometimes over laterite or limestone and appears to be associated with the H1 vegetation community.
Hemiandra sp. Eneabba (H. Demarz 3687) (P3)	Mine and Targeted	Recorded scattered throughout the Mine Survey Area from 161 locations totalling 231 plants. The 35 records held at the WAH indicates this species ranges from Eneabba to the Yardanogo Nature Reserve near Dongara with a preference for sandplain habitat. This species is not restricted to a unique set of ecological conditions and is present in various vegetation communities within the Mine Survey Area.
Hopkinsia anoectocolea (P3)	Access	Recorded from 85 locations totalling 657 plants in the Access Survey Area (Figure 27). The 50 records held at the WAH indicate *Hopkinsia anoectocolea* ranges from York to Carnamah. *Hopkinsia anoectocolea* occurs on white or grey sand in seasonally wet depressions, floodplains and salt lakes. This species has only been recorded within the T4 vegetation community and is most likely restricted to winter wet depressions.
Hypocalymma gardneri (P3)	Mine	Recorded scattered throughout the Mine Survey Area from 152 locations totalling 274 plants. The 22 records held at the WAH indicates this species ranges from Dandaragan to Dongara. This species occurs on a wide range of habitat from grey to brown sand, often over laterite. This species is not restricted to a unique set of ecological conditions and is present in various vegetation communities within the Mine Survey Area.
Leschenaultia juncea (P3)	Mine	Recorded in the Mine Survey Area from one location totalling one plant. The 22 records held at the WAH indicates *Leschenaultia juncea* ranges from Hill River to Mingenew. *Leschenaultia juncea* occurs on a wide range of habitat including white, grey or yellow sand or sandy gravel. This species has currently only been recorded once in the Mine Survey Area within the H6 vegetation community.

Species and conservation status	Survey Area Record	Extent within Survey Areas
Persoonia rudis (P3)	Mine	Recorded in the north-western part of the Mine Survey Area from one location totalling one plant. The 41 records held at the WAH indicates *Persoonia rudis* is a wide ranging species which occurs from the Bullsbrook Nature Reserve to Three Springs. *Persoonia rudis* occurs on a wide range of habitat from white, grey or yellow sand often over laterite. This species has currently only been recorded within the W2 vegetation community.
Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2)	Mine and Targeted	Recorded in the Targeted Survey Area from 30 locations, totalling 467 plants. The WAH houses 13 specimens of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2), distributed form Eneabba to Dongara. *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) occurs on grey, yellow or white sand (Plate 1a; WAH 1998-). This species has currently only been recorded in two main patches within different vegetation communities.
Schoenus griffinianus (P4)	Mine	Recorded scattered throughout the Mine Survey Area from five locations totalling nine plants. The 40 records held at the WAH indicates *Schoenus griffinianus* is a wide ranging species which occurs from Perth to Geraldton with a preference for sandplain habitat. This species is not restricted to a unique set of ecological conditions and is present in various vegetation communities within the Mine Survey Area.
Stawellia dimorphantha (P4)	Mine, Targeted and Access	Recorded scattered in the south-western part of the Mine Survey Area from 123 locations totalling 169 plants. This species was also recorded from 125 locations within the Access Survey Area totalling 229 plants (Figure 26; Figure 27). The 23 records held at the WAH indicates *Stawellia dimorphantha* ranges from Eneabba to Allanooka. This species occurs on a wide range of habitat from white, grey and yellow sand and was mostly recorded within the T1 vegetation community and once within the S3 community.

No *P. dixonii* individuals were recorded within the Survey Area during the 2022 targeted survey. This species was positively identified (approximately ten individuals) at a known location approximately 40 km south of the Proposal. The individuals identified were in good condition (Figure 29) which indicated the survey was conducted during the peak detectability period.

The larger number of threatened and priority flora species identified as having the potential to occur within the study areas (Table 11) can be attributed to the larger and more diverse desktop search area in which was used in both surveys. Many of these species are restricted to specific landscape features such as lateritic hills and outcrops that do not occur in the survey areas.

Range Extensions Flora

No species recorded within the survey areas represent extensions to their current known distributions.

Figure 29: *P. dixonii* recorded at the known location approximately 40 km south of the Proposal

Introduced Flora

The following 11 introduced (weed) species were recorded within the survey areas:

- *Aira caryophyllea*;
- *Brassicaceae* sp.;
- *Briza maxima*;
- *Eragrostis curvula;*
- *Hypochaeris glabra*;
- *Lysimachia arvensis*;
- *Sonchus oleraceus;*
- *Trifolium arvense* var. *arvense*;
- *Ursinia anthemoides*;
- *Vulpia myuros forma myuros;* and
- *Wahlenbergia capensis*.

None of these species are listed as Weeds of National Significance (WoNS; DotEE, 2019b). All species recorded are listed in the Midwest region impact and invasiveness ratings (DPaW, 2013b). Four were listed as having a high ecological impact (*Aira caryophyllea, Brassicaceae* sp, *Eragrostis curcula* and *Ursinia anthemoides*), including *Brassicaceae* sp. listed as having a medium/high ecological impact. Two were listed as being of low ecological impact (*Lysimachia arvensis* and *Hypochaeris glabra*) and the remaining five species were listed as having unknown ecological impacts (*Briza maxima, Sonchus oleraceus, Trifolium arvense* var. *arvense, Wahlenbergia capensis and Vulpia myuros forma myuros*) (DPaW, 2013b). All weed species recorded were described as having rapid invasiveness, with the exception of *Trifolium arvense* var. *arvense*, which has moderate invasiveness (DPaW, 2013b).

5.3.4 VEGETATION

The Proposal is located within the Irwin Botanical District, which is described as coastal scrub heath on sandplains, with *Acacia* and *Allocasuarina* thickets further inland, and hard-setting loams with *Acacia* scrub and scattered *Eucalyptus loxophleba* (Beard, 1990).

The Survey Areas are comprised of the Eridoon and Illyarrie Pre-European vegetation systems (Figure 30). The Eridoon system is defined as a flat coastal plain with various small rivers and creeks with numerous small lakes and swamps and some limited alluvial flats of heavier soil on the lower Arrowsmith River. Vegetation within this system is comprised of scattered small trees with an open layer of tall shrubs over a closed layer of small heath-like shrubs, which experiences frequent fires. The Illyarrie System consists of sandplains with scrub heath and the occasional thickets, scattered trees or woodland.

More recently, the vegetation of WA has been assigned to bioregions and subregions under the IBRA, with the Survey Area falling within the Lesueur Sandplain subregion of the Geraldton Sandplain Region (DAWE, 2022a). The Geraldton Sandplain 3 (GS3 – Lesueur Sandplain subregion) is described as having high floristic diversity and levels of endemism, with vegetation comprised mainly of proteaceous scrub heaths. Extensive York Gum (*Eucalyptus loxophleba*) and Jam (*Acacia acuminata*) woodlands occur on outwash plains associated with drainage (Desmond and Chant, 2001).

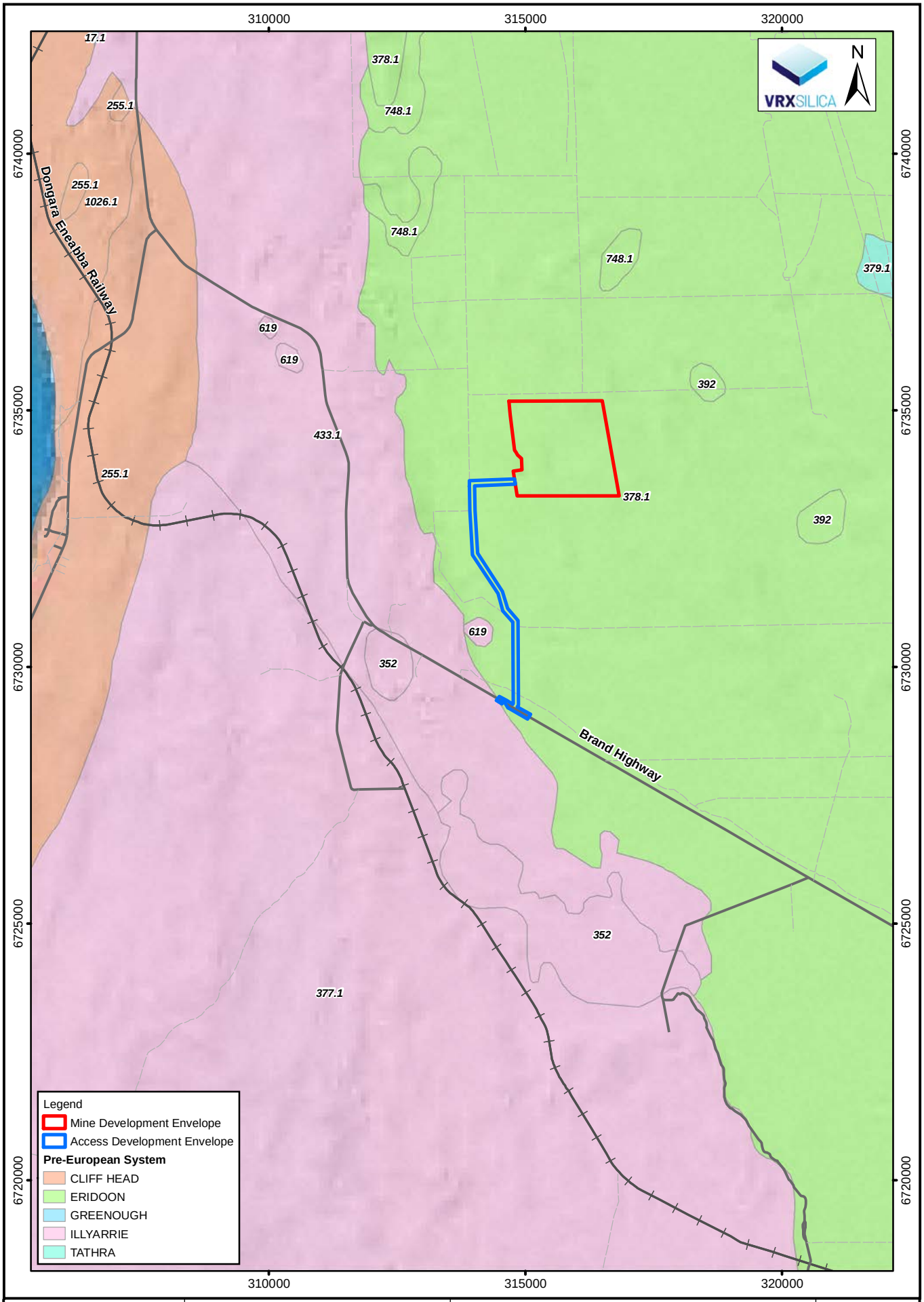
Land Systems

The underlying geology of the development envelopes is predominantly Permian to Cretaceous sedimentary basins, with horsts of Proterozoic rocks. The development envelopes are characterised by undulating lateritic sandplains with leached sandy soils over laterite in coastal areas; earthy, yellow sands over laterite further inland; and hard-setting loams with red clay subsoils (Beard, 1990; Desmond and Chant, 2001).

The survey areas are comprised of two land systems (Figure 31). The Department of Primary Industries and Regional Development (DPIRD) identifies the land systems within the Survey Area as the Tamala South System and Correy System.

The Tamala South System (221 Ta) has a state-wide extent of approximately 154,103 ha and is comprised of rises and low hills with relict dunes and some limestone outcrops on coastal limestone north of Jurien Bay. Yellow deep sands are common, with yellow/brown shallow sands and calcareous shallow and deep sands. Vegetation is comprised of *Banksia* woodlands and heathlands.

The Correy System (221 Cy) has a state-wide extent of 27,768 ha and is comprised of Broad sandy alluvial fan of the lower Arrowsmith River. Pale deep sands predominate, with grey shallow sandy duplexes, moderately deep sandy gravels and yellow deep sands less common. *Banksia* woodlands and heathlands (Mattiske, 2022a).



Source: Aerial Photography: LESRI, Digitalglobe, Maxar (March 2019), Tenements: DMIRS

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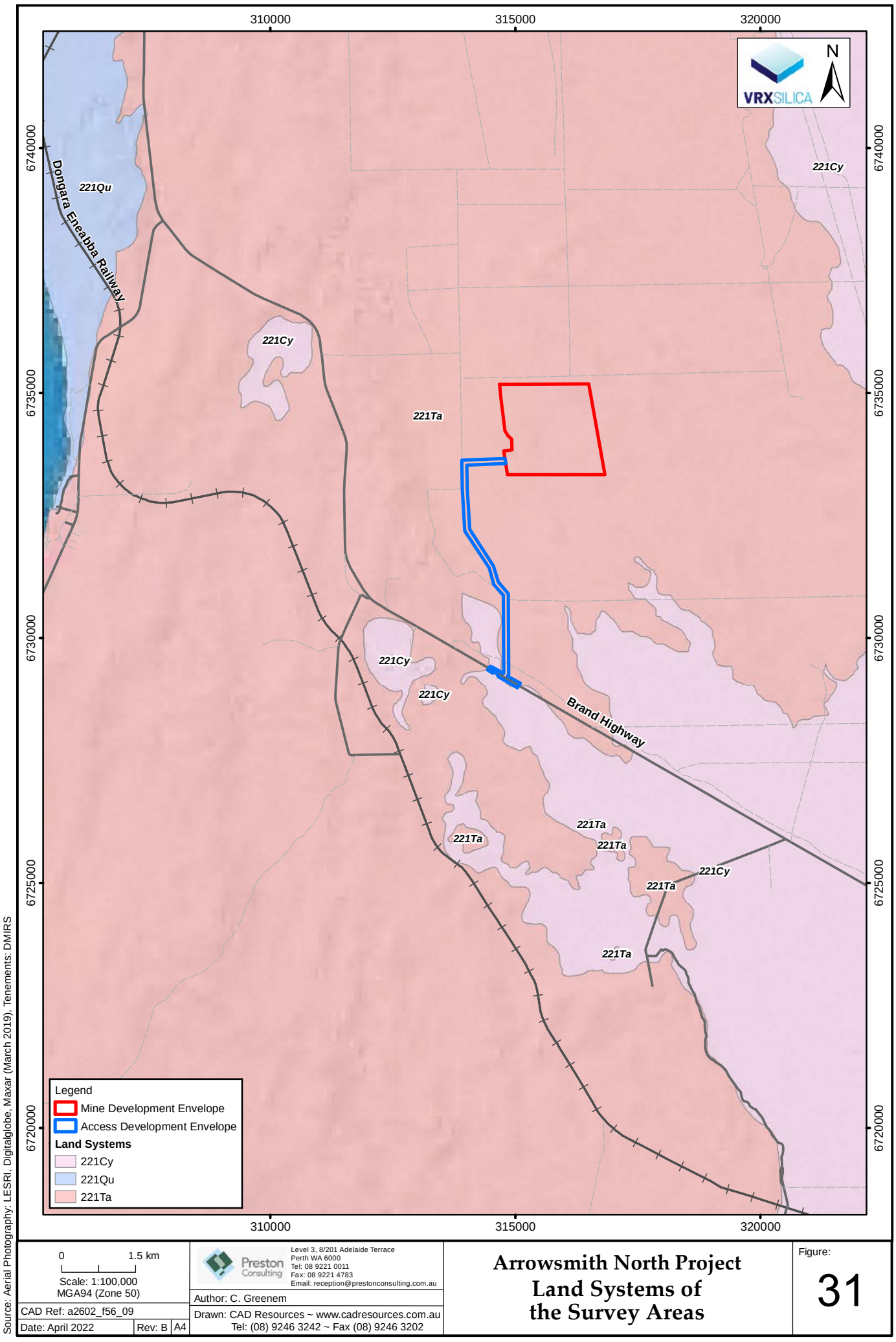
Arrowsmith North Project
Pre-European Vegetation of the Survey Areas

Figure: 30

Figure 30: Pre-European vegetation of the Survey Area



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Arrowsmith North Project
Land Systems of the Survey Areas

Figure: 31

Figure 31: Land Systems of the Proposal area

Regional Native Vegetation Extent

Native vegetation within 10, 15 and 20 km of the development envelopes was mapped using DPIRDs Native Vegetation Dataset and is shown in Figure 32. The extent of native vegetation surrounding the development envelopes is summarised in Table 13.

Table 13: Native vegetation surrounding the Proposal

Radius (km)	Area of native vegetation remaining (ha)	% of native vegetation remaining
Proposal Development Envelopes	405.1	99.20
10	28,657.5	91.66
15	58,621.2	91.60
20	90,125.7	85.87

Vegetation Associations

The extending Survey Area is comprised of four vegetation associations which are shown in Figure 30 however only one intersects with the development envelopes (Table 14)

Table 14: Vegetation associations within the development envelopes

Pre-European System	Vegetation Association	Description	State-wide Pre-European Extent (ha)	Extent remaining (ha)	Survey Area	
					Area of Intersection (ha)	Proportion of Extent remaining (%)
Eridoon	378.1	Mixed heath with scattered tall shrubs *Acacia* spp., *Proteaceae* and *Myrtaceae*	124,192.7	80,734.1 (65.0 %)	1,808.89	2.24

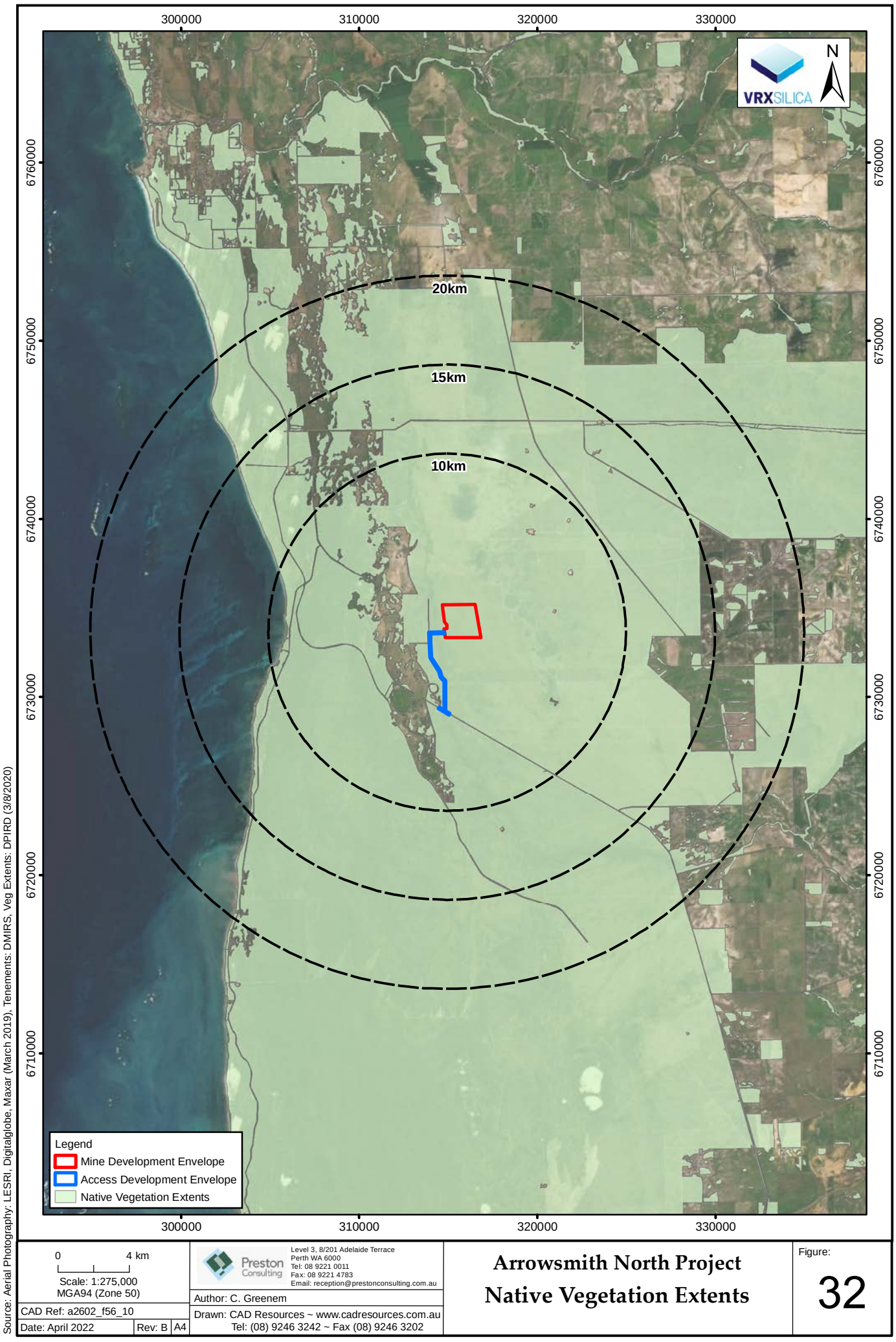


Figure 32: Extent of native vegetation surrounding the Proposal

Vegetation Condition

The condition of the vegetation within the Mine Survey Area ranged from Pristine to Excellent, with the majority of the area considered Pristine according to the Keighery (1994) scale. Some areas on the western part of the Mine Survey Area, near tracks, were downgraded to Excellent. The condition of the vegetation within the Access Survey Area was more variable, ranging from Completely Degraded to Pristine. The majority of the southern portion of the Access Survey Area was considered Pristine to Excellent according to the Keighery (1994) scale. Areas on the western portion of the Access Survey Area, varied in vegetation condition and contained large areas of Completely Degraded agricultural land. The vegetation condition of the Mine and Access Survey Areas are shown in Figure 33 and summarised in Table 15.

Table 15: Vegetation condition of the survey areas

Condition	Mine Survey Area		Access Survey Area	
	(ha)	(%)	(ha)	(%)
Pristine	1,666.389	96.50	159.50	35.58
Excellent	60.49	3.50	101.27	22.59
Very Good	0	0	40.43	9.02
Good	0	0	44.44	9.91
Degraded	0	0	0	0
Completely Degraded	0	0	102.59	22.90
TOTAL	**1,727.13**	**100**	**448.24**	**100**

Vegetation within the survey areas is comprised mostly of the Eridoon system which experiences frequent bushfires. The extent and timing of fires within 20 km of the Proposal are mapped in Figure 34.

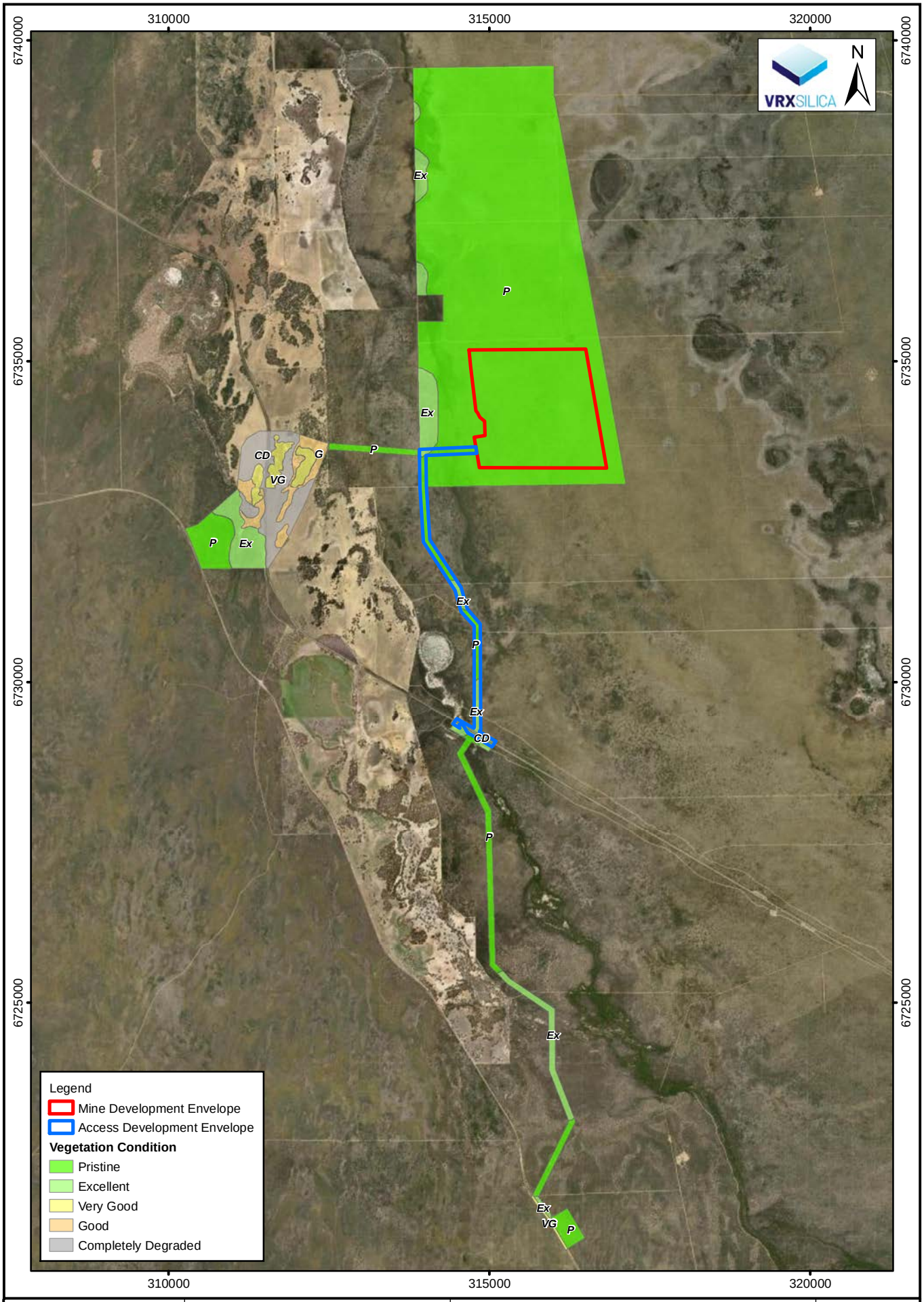


Figure 33: Vegetation condition of the Survey Area

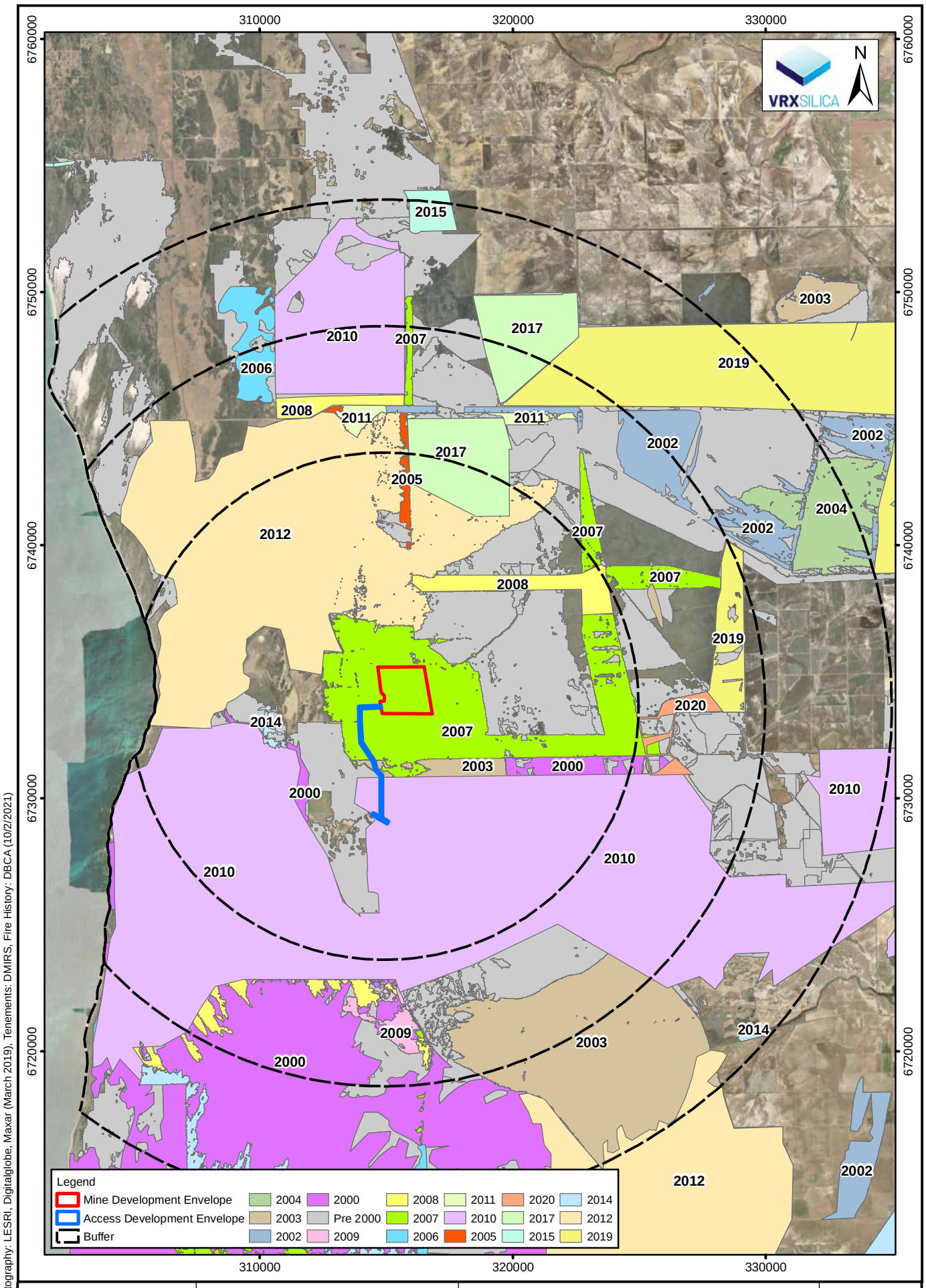


Figure 34: Extent of bushfires near the Proposal

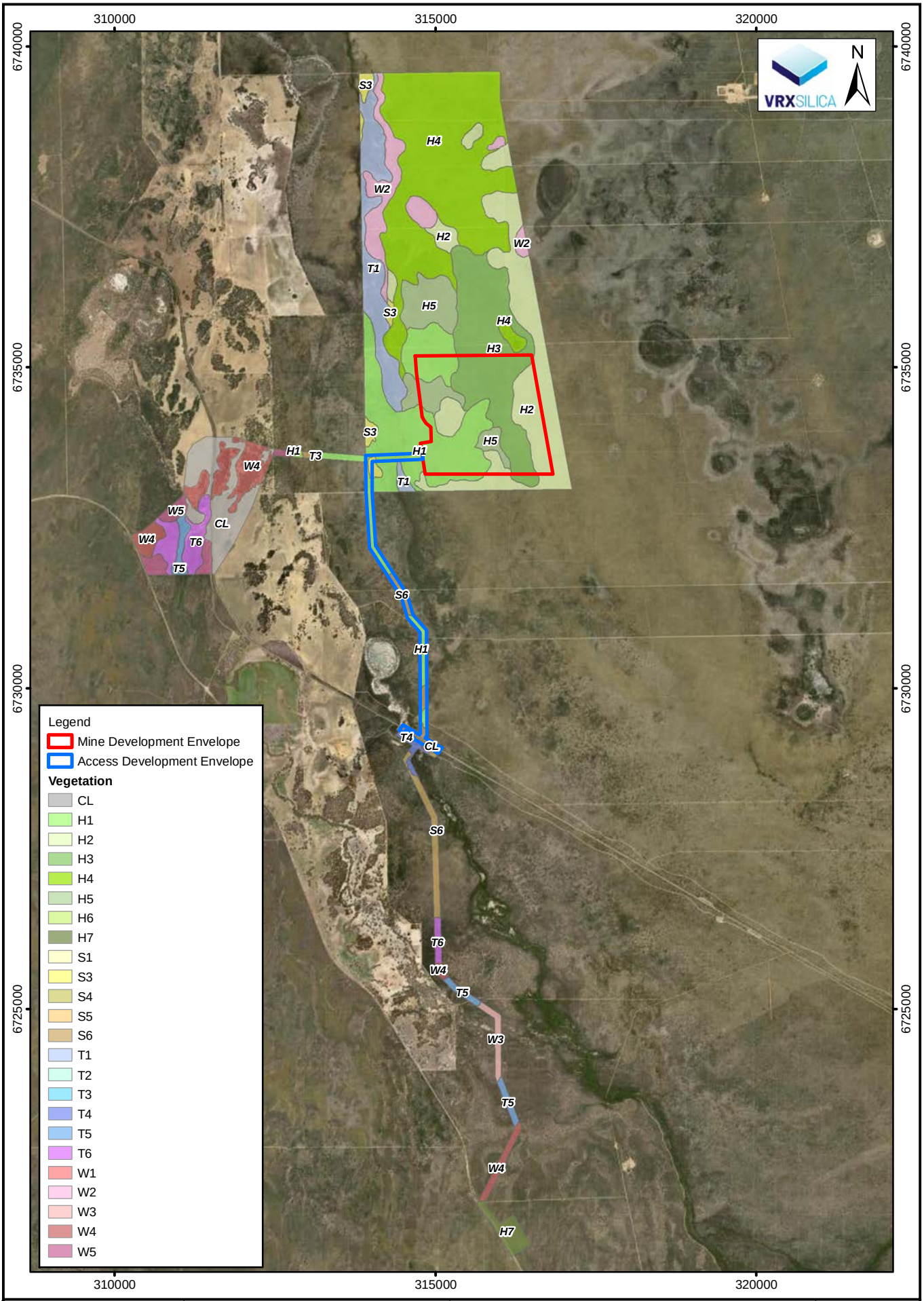
Vegetation Communities

Seventeen vegetation communities were defined and mapped across the survey areas. Survey quadrat physical data and aerial photographic maps were used to delineate the boundaries of the vegetation communities. The vegetation communities are presented in Figure 35. Vegetation community descriptions and their extent within the survey areas is presented in Table 16.

Table 16: Vegetation communities within the Survey Areas

Name	Vegetation Community Description	Extent			
		Mine Survey Area (ha)	Access Survey Area (ha)	Total Survey Area	
				ha	%
H1	Open Heath to Closed Heath of *Hakea polyanthema, Calothamnus blepharospermus, Conospermum triplinervium, Petrophile macrostachya* and *Melaleuca leuropoma* with emergent *Banksia attenuata* over *Acanthocarpus preissii* and *Ecdeiocolea monostachya* on cream and white surface sands.	288.98	36.57	325.55	14.85
H2	Open Heath to Closed Heath of *Banksia hookeriana, Banksia attenuata* with occasional *Banksia menziesii* over *Melaleuca leuropoma, Eremaea beaufortioides* var. *beaufortioides, Scholtzia laxiflora, Conospermum triplinervium, Eremaea violacea* subsp. *violacea* over *Mesomelaena pseudostygia* on white sands on plains.	314.39	0	314.39	14.34
H3	Open Heath of *Melaleuca leuropoma, Leptospermum oligandrum, Hakea polyanthema, Conospermum triplinervium, Beaufortia elegans* and *Pileanthus filifolius*, with isolated trees of *Banksia attenuata* and *Xylomelum angustifolium* over *Mesomelaena pseudostygia* and *Ecdeiocolea monostachya* on cream/grey sand on plains.	258.15	0	258.15	11.78
H4	Open Heath of *Conospermum triplinervium, Banksia attenuata, Banksia hookeriana, Melaleuca leuropoma, Daviesia divaricata subsp. divaricata* and *Eremaea beaufortioides* var. *beaufortioides* over *Mesomelaena pseudostygia* and *Dampiera spicigera* on yellow-cream/white sand on flats.	517.89	0	517.89	23.63
H5	Open Heath to Closed Heath of *Banksia shuttleworthiana, Banksia attenuata* with occasional *Banksia menziesii over Melaleuca leuropoma, Eremaea beaufortioides* var. *beaufortioides, Conospermum triplinervium, Scholtzia laxiflora and Verticordia grandis* over *Mesomelaena pseudostygia, Ecdeiocolea monostachya* and *Lepidobolus preissianus subsp. preissianus* on pale yellow sandy flats.	112.44	0	112.44	5.13
H7	Open Heath to Closed Heath of *Banksia leptophylla* var. *melletica, Melaleuca leuropoma* and *Hakea trifurcata* over *Ecdeiocolea monostachya, Lepidobolus preissianus* and *Stenanthemum notiale* subsp. *notiale* on cream sand on lower slopes.	0	24.09	24.09	1.10
S3	Scrub of *Banksia attenuata, Banksia leptophylla var. melletica, Hakea polyanthema* and *Melaleuca leuropoma* over *Scholtzia laxiflora, Petrophila macrostachya, Petrophile drummondii, Allocasuarina humilis, Hakea costata* and *Acacia spathulifolia over Scaevola repens* subsp. Northern Sandplains (R.J. Cranfield & P.J. Spencer 8445) and *Mesomelaena*	23.71	0	23.71	1.08

Name	Vegetation Community Description	Extent			
		Mine Survey Area (ha)	Access Survey Area (ha)	Total Survey Area	
				ha	%
	pseudostygia on white-yellow sand on flats and slopes.				
S6	Open shrubland of *Acacia blakelyi* and *Allocasuarina campestris*, over *Ecdeiocolea monostachya, Jacksonia hakeoides* and *Lepidobolus preissianus* on cream/grey sand on flats to lower slopes.	0	44.39	44.39	2.03
T1	Thicket to Scrub of *Allocasuarina campestris, Grevillea leucopteris, Guichenotia ledifolia, Acacia lineolata, Calothamnus quadrifidus subsp. quadrifidus* with occasional *Eucalyptus todtiana* and *Banksia attenuata* over *Dianella revoluta* and *Ecdeiocolea monostachya* on grey/cream/orange/red sand on flats and slopes.	132.54	0	132.54	6.05
T3	Thicket of *Allocasuarina campestris, Acacia spathulifolia, Melaleuca systena, Callitris arenaria* over *Ecdeiocolea monostachya, Lechenaultia linarioides* and *Acanthocarpus preissii* on cream sand on flats.	0	1.07	1.07	0.05
T4	Thicket to Scrub of *Acacia blakelyi* and *Acacia rostellifera* over *Lepidosperma* aff. *apricola, Scholtzia laxiflora, Hakea lissocarpha* and *Verticordia densiflora* on grey sand on flats.	0	9.88	9.88	0.45
T5	Thicket of *Acacia blakelyi* and *Acacia saligna* and *Macrozamia fraseri* over *Waitzia acuminata* and *Poaceae sp.* on sandy loam/clay on low lying flats.	0	26.74	26.74	1.22
T6	Thicket of *Acacia blakelyi, Macrozamia fraseri with occasional Grevillea leucopteris* over *Conostylis candicans, Waitzia acuminata* and *Aira caryophyllea* on cream/grey sand on flats.	0	55.38	55.38	2.53
W2	Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* over open shrubland of *Melaleuca leuropoma, Eremaea beaufortioides var. beaufortioides, Daviesia triflora, Styphelia xerophylla, Pileanthus filifolius* and *Stirlingia latifolia* over *Alexgeorgea nitens, Lyginia imberbis* and *Stylidium crossocephalum* on cream to white sands on plains.	95.47	0	95.47	4.36
W3	Open mallee woodland of *Eucalyptus drummondii*, over shrubland of *Acacia saligna*, over isolated *Solanum lasiophyllum* and *Poaceae sp.* on grey clay loam on flats.	0	13.28	13.28	0.61
W4	Woodland to isolated trees of *Eucalyptus erythrocorys*, over sparse to closed shrubland of *Acacia spathulifolia* and *Acacia rostellifera*, over *Melaleuca leuropoma, Conostylis candicans subsp. procumbens,* and *Ecdeiocolea monostachya* on cream sand with limestone outcropping on slopes.	0	98.23	98.23	4.48
W5	Isolated trees of *Eucalyptus erythrocorys*, over open shrubland of *Melaleuca systena, Banksia sessilis* and *Labichea cassioides*, over *Hibbertia hypericoides* subsp*. hypericoides* and *Desmocladus* asper on grey/brown sand with limestone outcropping on flats and slopes.	0	32.03	32.03	1.46
CL	Cleared land	0	106.59	106.59	4.86
	Total	**1,743.57**	**448.24**	**2,191.80**	**100**



Imagery: ESRI, Maxar (July 2018)

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Arrowsmith North Project

Vegetation Communities

Figure: 35

Figure 35: Vegetation communities of the Survey Area

Managed Lands

There are a number of Nature Reserves in the area surrounding the Proposal, presented in Figure 13. Beharra Springs Nature Reserve (R 47436) is located southwest of the Proposal, Beekeepers Nature Reserve (R 24496) is located to the west of the Proposal and the Yardanogo Nature Reserve (R 36203) is located to the north. The Lake Logue Nature Reserve (R 29073) and nature reserves R 39744 and R 25495 are located to the south of the Proposal (Figure 13).

The Access Survey Area overlaps with File Notation Areas FNA11507 and FNA2140 and as such are managed by DMIRS/LANDGATE and DBCA respectively. FNA2140 which is associated with Arrowsmith Lake, is an EPA recommendation for an "A" class Nature Reserve.

Threatened and Priority Ecological Communities

No Threatened Ecological Communities (TECs), pursuant to Part 2, Division 1, Subdivision 1 of the BC Act and as listed by the DBCA (2018a) or DAWE (2022b), or Priority Ecological Communities (PECs) as listed by DBCA (2019a) were recorded within the survey areas.

Locally Significant Vegetation Communities

None of the vegetation communities recorded within the survey areas were considered locally or regionally unique and all are well represented in the wider area (Mattiske, 2022a). Eleven of the 17 mapped vegetation communities contained Priority Flora records and therefore would be considered habitat for significant flora species.

Root Characteristics

The information contained in this section is from Mattiske (2020a & 2022b; Appendix 8 & 9) unless otherwise referenced.

Roots and VDT Assessment (Mattiske, 2020a)

Mattiske initially conducted a desktop assessment which identified that he majority of the roots, underground rhizomes and organs occur in the upper 40 cm of the soil profile within the Mine Development Envelope (Figure 36). The exceptions include some shrub species that send deeper roots to several metres below the surface.

In addition, some of the dominant shrubs and trees have large lignotubers, lateral roots and/or deeper roots. The larger lignotubers and roots pose some difficulties in designing mining and rehabilitation methods for the Proposal. Plants that have larger root or underground organs include species of *Banksia*, *Xylomelum, Eucalyptus* and *Macrozamia*. Of the latter, the absence of some of these species in the VDT trials (Section 5.3.1) reflects the difficulty of establishing these species from propagules. Note that *Macrozamia* species were not recorded within the development envelopes.

Roots of *Eucalyptus todtiana* (Figure 37) individuals within the Mine Development Envelope had large lignotubers near the soil surface (<30 cm) with lateral roots spanning 10 – 20 cm and droppers with a length of 10 – 20 cm.

Roots of *Banksia* sp. within the Mine Development Envelope (Figure 38) presented with both lateral and deeper roots extended to at least 3 - 4 m and although decreasing in size were still substantial within upper soil profiles.

Figure 36: Upper soil profile cross section typical of the Mine Development Envelope (Mattiske, 2020a)

Figure 37: Roots of *Eucalyptus todtiana* (Mattiske, 2020a)

Figure 38: Roots of *Banksia* species (Mattiske, 2020a)

Roots of the Woody Pear (*Xylomelum angustifolium*) were found to have large lignotubers near the surface (<30cm) with laterals extending 10 – 20 cm and droppers with a length of 10 - 20 cm (Figure 39).

Figure 39: Roots of Woody Pear species (*Xylomelum angustifolium*) (Mattiske, 2020a)

Priority Flora Root Assessment (Mattiske, 2022b)

In March 2022, an additional investigation was conducted by Mattiske (2022b) into root systems within the Survey Area that supported the investigation by Mattiske (2020a) with the majority of the priority species present recorded with shallow to moderate root systems. Five of the priority species were recorded with shallow root systems which increases the potential for successful VDT. Two species were recorded with moderate and one species was recorded with a moderate/deep root systems indicating there would be less chance of successful VDT (i.e., infill planting will be required).

The five species with shallow root systems were:

- *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2);

- *Hopkinsia anoectocolea* (P3);
- *Hypocalymma gardneri* (P3);
- *Schoenus griffinianus* (P4); and
- *Stawellia dimorphantha* (P4).

The two species with moderate to deep root systems were:

- *Beyeria gardneri* (P3); and
- *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3).

One species (*Banksia elegans;* P4) had a moderate to deep root system.

The priority flora and their root systems, assessed by Mattiske (2022b) are summarised in Table 17.

Table 17: Root system assessment summary and viability for VDT (Mattiske, 2022b)

Species	(SCC)	Number of Plants	Plant Height (cm)	Root Depth (cm)	Root System Type	Root Depth Rank
Schoenus sp. Eneabba (F. Obbens & C. Godden I154)	P2	2	55 – 57	30	Adventitious	Shallow
Beyeria gardneri	P3	1	55	>40	Adventitious, tap root	Moderate
Hemiandra sp. Eneabba (H. Demarz 3687)	P3	2	20 – 35	>60	Tap root	Moderate
Hopkinsia anoectocolea	P3	1	80	40	Adventitious, sand binding	Shallow
Hypocalymma gardneri	P3	3	30 – 40	15 – 30	Adventitious	Shallow
Banksia elegans	P4	1	80	>100	Tap root, lignotuber	Moderate/Deep
Schoenus griffinianus	P4	1	8	10	Adventitious	Shallow
Stawellia dimorphantha	P4	2	4 - 9	18 - 20	Stilt	Shallow

Note: SCC = State Conservation Code

Two plants of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) from the same population in deep yellow sand on a mid-slope were excavated (Figure 40). Previous collection of Schoenus sp. Eneabba (F. Obbens & C. Godden I154) showed that the rhizomes of this species are short with an ascending pattern of growth (Figure 40). The plants excavated were 570 mm and 550 mm tall with the culms forming tufts. Roots of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) were approximately 300 mm long with a diameter of 2 mm which was uniform along the length. Numerous and mostly uniform roots which also appeared to have some sand binding ability were found. The roots were oriented both laterally and vertically with root depths of 300 mm deep on both plants sampled.

One plant of *Beyeria gardneri* was excavated in yellow sand on a sandstone ridge (Figure 41). *Beyeria gardneri* was found to have a tap root reaching below 40 cm. The plant also had fine (<1 mm) adventitious roots originating from the tap root. The tap root had a 3 mm diameter at the base of the plant and 2 mm diameter at 20 cm depth. Other adventitious roots were 2 mm in diameter. The height of the plant was 55 cm.

Figure 40: Left and middle: Two different *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154 (P2) plants with roots exposed. Right: Rhizomes of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154 (P2).

Figure 41: *Beyeria gardneri* (P3) with roots exposed (Mattiske, 2022b)

Three plants of *Hypocalymma gardneri* were excavated in grey or grey-yellow sand (Figure 42). *Hypocalymma gardneri* had adventitious roots to a depth of 15 cm with a diameter of 2 mm. The plant heights were 30 cm to 40 cm. The roots spread more laterally than down and each root was covered in a loose bark like layer. The longest measured root was 38 cm; however, this root was broken and extended further.

Figure 42: Two plants of *Hypocalymma gardneri* (P3) with roots exposed (Mattiske, 2022b)

One plant *of Banksia elegans* was excavated in yellow sand on an upper slope (Figure 43). *Banksia elegans* has a deep root structure with a lignotuber and spreading adventitious roots. The lignotuber was 5 cm tall above the surface and 5 cm below. The total width was 25 cm. Adventitious roots extended well beyond the 30 cm of the excavation with diameters of 30 mm and 12 mm measured at the lignotuber and 15 mm and 5 mm 30 cm from the lignotuber. The majority of roots were aligned laterally.

Figure 43: *Banksia elegans* (P4) with roots exposed (Mattiske, 2022b)

Hopkinsia anoectocolea is a rhizomatous, tufted perennial herb that grows 0.5 m to 1 m tall with brown flowers from September to December. *Hopkinsia anoectocolea* often occurs in white or grey sand, winter wet depressions, floodplains and salt lakes (Figure 44).

Schoenus griffinianus is a small, tufted perennial sedge to 0.1 m high which flowers from September to October. *Schoenus griffinianus* occurs predominantly on white sand, often in disturbed areas (Figure 44).

Stawellia dimorphantha is a stilt-rooted perennial herb that grows 0.05 m to 0.2 m high with purple/cream flowers from June to November. *Stawellia dimorphantha* often occurs on white, grey and yellow sand (Figure 45).

Figure 44: Left: *Hopkinsia anoectocolea* (P3) with roots exposed; Right: *Schoenus griffinianus* (P4) with roots exposed

Figure 45: *Stawellia dimorphantha* (P4) with roots exposed

Dieback

The information contained in this section is from Glevan (2020 and 2021; Appendix 10 and 11) unless otherwise referenced.

Phytophthora is a microscopic, parasitic water mould that belongs to the class Oomycetes which behave largely as a necrotrophic pathogen causing damage to the host plant's root cell structure by invading and infecting the host at a cellular level. Phytophthora Dieback is the result of interaction between three physical components forming a 'disease triangle': the pathogen (Phytophthora species), the environment and the host. All three components are needed for the disease to develop over time. Host species found in the Mine Survey Area that will display Phytophthora Dieback symptoms include *Adenanthos cygnorum, Banksia candolleana, B. dallanneyi, B. menziesii, Isopogon tridens* and *Stirlingia latifolia*. These species are not the only species susceptible to dieback in the Mine Survey area, as approximately 40% of native species in WA's south-west bioregion are considered susceptible to this disease, including many from the Proteaceae (banksia's and hakeas), Ericaceae (snottygobble), Myrtaceae (eucalypts) and Xanthorrhoeaceae (grass-trees) families (DBCA, 2022).

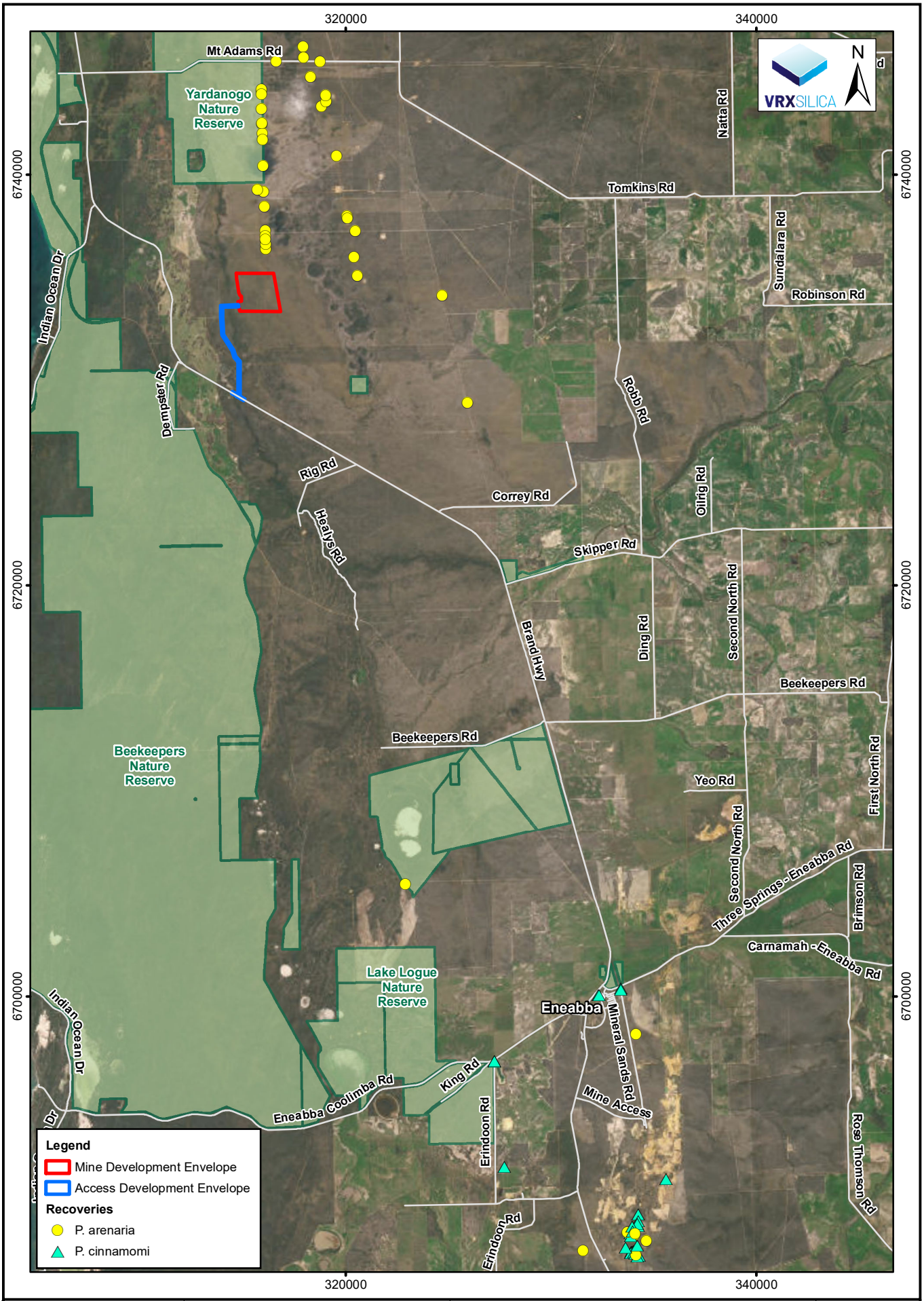
The development envelopes experience a long-term average annual rainfall of 492 mm which places the site as being marginally vulnerable to *Phytophthora cinnamomi* but still vulnerable to other Phytophthora species.

Desktop Assessment

A desktop assessment revealed that *Phytophthora arenaria* has been recovered within and around the development envelopes on numerous occasions. The development envelopes contain vegetation with moderate to high susceptibility to the Phytophthora pathogens. The northern portion of the Mine Survey Area was burnt in 2013 and has recovered to be interpretable to Phytophthora Dieback. The southern portion was burnt pre-2012 and is in similar condition. Scattered deaths of Phytophthora Dieback-indicating species, and species not expected to be susceptible were observed throughout the Mine Survey Area. These deaths, with no observed possible vector of pathogen introduction, have been attributed to the recent drier years of well below average rainfall.

Phytophthora arenaria has been recorded at numerous locations from within the Mine Survey Area. Whilst these infestations are not noted as having a significant impact on the vegetation, it is anticipated that the introduction of *Phytophthora cinnamomi* would cause significant vegetation decline. Phytophthora Dieback caused by *Phytophthora cinnamomi* is having a significant impact on vegetation in the Eneabba region (Figure 46). Although this area is nearly 40 km south of the Mine Survey Area, the Eneabba long-term average annual rainfall of 492 mm and the vegetation (Eridoon-378) at both sites suggests that the environmental conditions are very similar.

Assessments have been conducted by Glevan within the Mine Survey Area and the greater area since 2006. In that period, 56 sites displaying suspicious deaths have been sampled to determine if Phytophthora was the cause of the vegetation decline. Twenty-six sites have shown the presence of *P. Arenaria*; no other Phytophthora species have been recorded. Significantly, *Phytophthora cinnamomi* has not been recovered from the greater area. Due to the period and repetition of assessments in the area, and the spatial distribution of Phytophthora recoveries, it is considered highly unlikely that *Phytophthora cinnamomi* would present in the undisturbed vegetation.



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Arrowsmith North Project
Phytophthora Recoveries in the Region

Figure: 46

Figure 46: Phytophthora locations in the region

Field Assessments

A field assessment of the Survey Area (Figure 47)was conducted by Glevan in 2019 (M 70/1389) and 2021 (access corridor). A north-south access track was excluded as it represents an extension of the Beharra Springs facility access track and did not accurately represent the Survey Area.

Seven sites with deaths of Phytophthora Dieback-indicating species were sampled to determine the presence of the pathogen (Figure 47). Four of those sites did prove the presence of Phytophthora. It is known however that the pathogen is not *P. cinnamomi*. Despite the presence of Phytophthora in the Survey Area, no vegetation has been classified as Infested.

Scattered deaths were observed throughout the Survey Area in Phytophthora Dieback susceptible and non-susceptible plant species. These deaths were most likely resulting from the drier conditions in the Survey Area and are consistent with other heathland vegetation observed in adjacent areas.

The access corridor traverses remnant vegetation, with a small section following a firebreak adjacent to private property. The north-eastern section that traverses east from the private property has been developed with the vegetation cleared and a track installed. From Brand Highway to the parallel firebreak track (approximately 250 m linear distance), the southern section has been classified as Uninterpretable. The vegetation contained few Phytophthora Dieback indicating species. Therefore, no demarcation was installed as the track may be used to delineate the Uninterpretable from the uninfested section. The remaining area within the Access Survey Area was recorded as uninfested.

The Survey Area, aside from the excluded access track and uninterpretable area, is considered uninfested and should be managed as Protectable.

5.3.5 ENVIRONMENTAL VALUES

Based on the information provided in Section 5.3, the following environmental values were determined to require assessment for this factor:

- General native flora and vegetation, which covers all vegetation types listed in Mattiske (2022a) in order to assess broad local and regional impacts, and habitats for Priority flora;
- Priority flora species recorded within the development envelopes; and
- Threatened and priority flora species that have a moderate or high potential to occur within the development envelopes.

Unidentified flora were not considered an environmental value as none were restricted to the development envelopes.

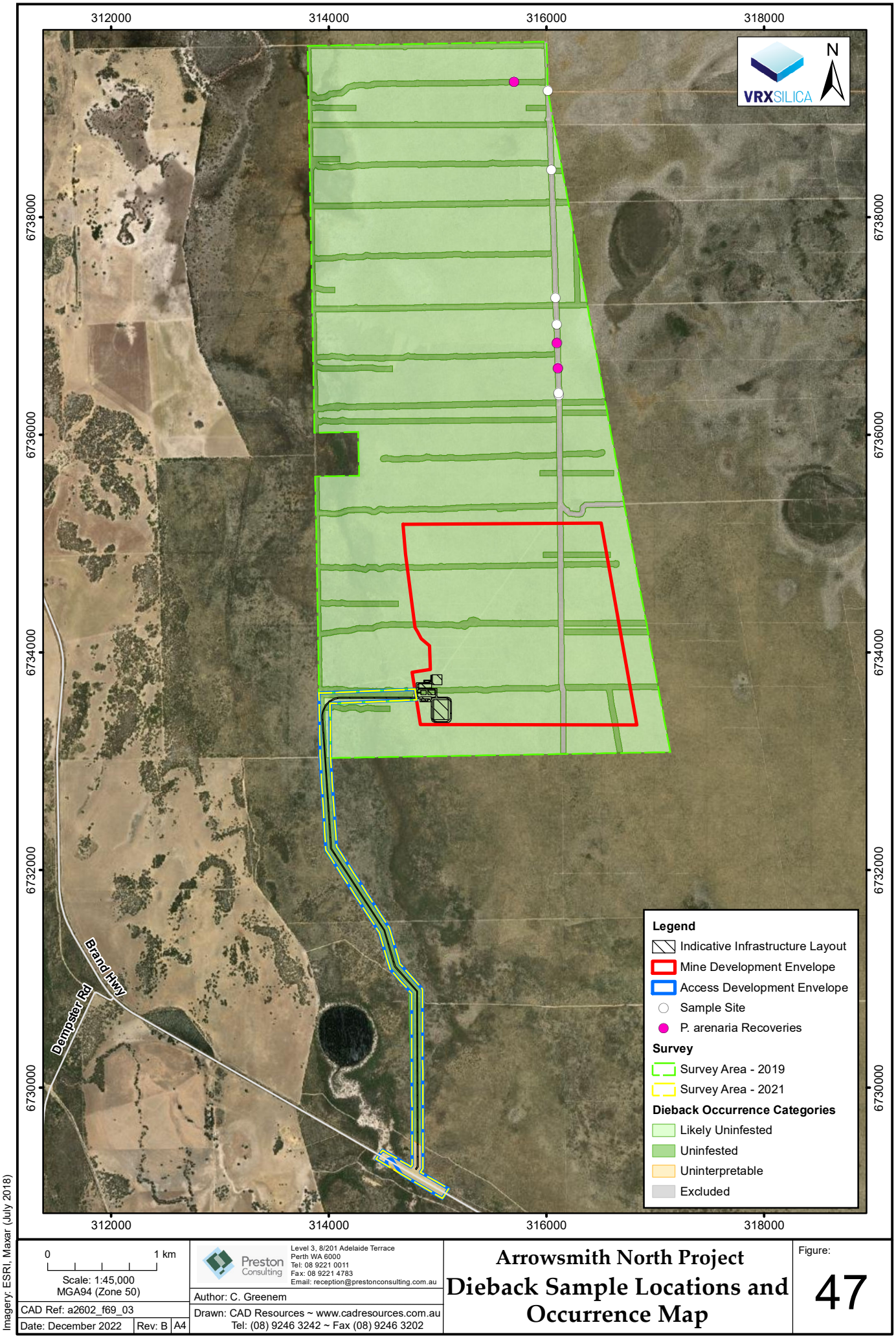


Figure 47: Dieback sample locations, recoveries and occurrence mapping within the Survey Area

5.4 POTENTIAL IMPACTS

Table 18 defines the potential impacts (direct, indirect and cumulative) on the environmental values listed above in a local and regional context. Assessment of the potential impacts is provided in the following sections.

Table 18: Potential impacts on flora and vegetation

Environmental value	Current Extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General native flora and vegetation	The pre-European vegetation associations within the survey area are partially cleared with a minimum of 45 % of each type remaining	Up to 14.5 ha of native vegetation clearing to remain cleared for the life of the Proposal Up to 339.3 ha of native vegetation clearing and progressive rehabilitation via VDT	Reduction in vegetation health as a result of: • Alterations to fire regimes • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback • Dust deposition affecting photosynthesis and transpiration rates of flora and vegetation.	Impacts to general native flora and vegetation from the following projects: • Arrowsmith Central Silica Sands (Proposed) • Beach Energy / AWE limited - Beharra Springs Gas (Operational) • Perpetual Resources limited - Beharra Silica, Beharra West and Arrowsmith West (Proposed) • Strike and Warrego Energy - West Erregulla Gas Field (Proposed) Impacts to local vegetation from agriculture, resources and road infrastructure	Up to 14.5 ha of native vegetation clearing and up to 339.3 ha of native vegetation clearing and progressive rehabilitation via VDT in addition to disturbance associated with other proposals. Reduction in vegetation health due to indirect impacts Vegetation in the Midwest region is expected to be reasonably tolerant to dust deposition and at minimal risk of physiological impacts.
Priority Flora	Seven significant species were recorded within the development envelopes	Clearing of: • 1,277 known *Banksia elegans* (P4) individuals • 30 known *Comesperma rhadinocarpum* (P3) individuals • 98 known *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) individuals • 11 known *Hypocalymma*	Reduction in vegetation health as a result of: • Alterations to fire regimes • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations	Impacts to priority flora from the proposals listed above. Impacts to local vegetation from agriculture, resources and road infrastructure	Clearing or translocation of known individuals of seven different Priority Flora Clearing of up to 14.5 ha of potential habitat for the life of the Proposal and up to 339.3 ha of potential habitat clearing and progressive

Environmental value	Current Extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
		gardneri (P3) individuals • 1 known *Schoenus griffinianus* (P4) individuals • 167 known *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) individuals • 6 known *Stawellia dimorphantha* (P4) individuals Clearing of up to 14.5 ha of potential habitat for the life of the Proposal and up to 339.3 ha of potential habitat clearing and progressive rehabilitation via VDT	• Reduction of groundwater depth		rehabilitation via VDT in addition to disturbance associated with other proposals. Reduction in habitat health due to indirect impacts
Threatened and other Priority Flora that may occur within the development envelopes	13 Threatened Flora and 44 other Priority Flora species were not recorded but could potentially occur	Clearing of up to 14.5 ha of potential habitat for the life of the Proposal and up to 339.3 ha of potential habitat clearing and progressive rehabilitation via VDT	Reduction in habitat health as a result of: • Alterations to fire regimes • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Introduction or spread of dieback	Impacts to Threatened and other Priority flora from the proposals listed above Impacts to local vegetation from agriculture, resources and road infrastructure	No direct impacts to known individuals Clearing of up to 14.5 ha of potential habitat for the life of the Proposal and up to 339.3 ha of potential habitat clearing and progressive rehabilitation via VDT Reduction in habitat health due to indirect impacts in addition to clearing of potential habitat form other proposals.

5.5 ASSESSMENT OF IMPACTS

The following sections assess the potential impacts on each environmental values identified in Section 5.3.5.

5.5.1 GENERAL NATIVE FLORA AND VEGETATION

Table 19 summarises the extent of the potential direct and indirect impacts on general native flora and vegetation. Additional assessment is provided in the following sections.

Table 19: Potential impacts on general flora and vegetation

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Area (ha)	Extent in development envelopes (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Regional Native Vegetation						
Extent within 10 km of Mine Development Envelope	28,657.5	N/A	405.14	353.8 (1.2 % of extent)	Negligible	2,960.1 (9.5 % of regional extent)
Extent within 15 km of Mine Development Envelope	58,621.2	N/A	405.14	353.8 (0.6 % of extent)	Negligible	5,723.2 (8.9 % of regional extent)
Extent within 20 km of Mine Development Envelope	90,125.7	N/A	405.14	353.8 (0.4 % of extent)	Negligible	15,176.9 (14.5 % of regional extent)
Vegetation associations						
378.1	80,734.1	1,808.9	408.15	353.8	Negligible	353.8 (0.44 % of regional extent)
Vegetation communities (Mattiske, 2022a)						
H1	N/A	325.55	144.46	109.11	Negligible	109.11 (33.51 % of mapped extent)
H2	N/A	314.39	88.39	88.39	Negligible	88.39 (28.11 %)
H3	N/A	258.15	116.84	116.84	Negligible	116.84 (45.26 %)
H4	N/A	517.89	0	0	Negligible	0
H5	N/A	112.44	36.90	36.90	Negligible	36.90 (32.81 %)
H7	N/A	24.07	0	0	Negligible	0
S3	N/A	23.71	2.21	0.18	Negligible	0.18 (0.75 %)
S6	N/A	44.39	15.93	1.24	Negligible	1.24 (2.79 %)
T1	N/A	132.54	0.02	0	Negligible	0
T3	N/A	1.07	0	0	Negligible	0
T4	N/A	9.88	1.66	0	Negligible	0
T5	N/A	26.74	0	0	Negligible	0
T6	N/A	55.38	0	0	Negligible	0
W2	N/A	95.47	0	0	Negligible	0
W3	N/A	13.28	0	0	Negligible	0
W4	N/A	98.22	0	0	Negligible	0
W5	N/A	32.03	0	0	Negligible	0

Flora / Vegetation / Feature	Regional extent (ha / numbers)	Extent in Survey Area (ha)	Extent in development envelopes (ha)	Extent in Indicative Disturbance Footprint (ha)	Indirect Impacts	Cumulative impacts (ha)
Priority Flora						
Banksia elegans (P4)	44 records ranging from Moore River to Geraldton	3,395 individuals	1,928 individuals	1,277 individuals	None predicted	1,277 individuals (37.6 % of local records)
Beyeria gardneri (P3)	37 records from Cataby to Nerren Nerren	33 individuals	0 individuals	0 individuals	None predicted	0
Comesperma rhadinocarpum (P3)	17 records from Perth to Utcha	59 individuals	30 individuals	30 individuals	None predicted	30 individuals (50.8 % of local records)
Hemiandra sp. Eneabba (H. Demarz 3687) (P3)	35 records from Eneabba to Yardanogo Nature Reserve	231 individuals	98 individuals	98 individuals	None predicted	98 individuals (42.4 % of local records)
Hopkinsia anoectocolea (P3)	50 records from York to Carnamah	657 individuals	0 individuals	0 individuals	None predicted	0
Hypocalymma gardneri (P3)	22 records from Dandaragan to Dongara	274 individuals	11 individuals	11 individuals	None predicted	11 individuals (4.0 % of local records)
Leschenaultia juncea (P3)	22 records from Hill River to Mingenew	1 individual	0 individuals	0 individuals	None predicted	0
Persoonia rudis (P3)	41 records from Bullsbrook Nature Reserve to Three Springs	1 individual	0 individuals	0 individuals	None predicted	0
Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2)	13 records from Eneabba to Dongara	467 individuals	167 individuals	167 individuals	None predicted	167 individuals (35.76 % of local records)
Schoenus griffinianus (P4)	40 records from Perth to Geraldton	9 individuals	1 individual	1 individual	None predicted	0
Stawellia dimorphantha (P4)	23 records from Eneabba to Allanooka	398 individuals	107 individuals	6 individuals	None predicted	6 individuals (1.50 % of local records)

VDT Study

Mattiske was commissioned in August 2019 by Iluka to conduct monitoring of 16 VDT trial transects that were established in October 2012. Iluka is required to undertake a continuous programme of investigation and research (including monitoring and the study of sample areas) to measure the effectiveness of environmental protection and management on site. The results of the investigations are to be reported annually and triennially.

The VDT rehabilitation technique was trialled to assess the survivorship of sedge, rush and herbaceous species. Specifically, the objectives included:

- Re-monitor the 16 transects within the trial VDT area;
- Record or collect and identify the vascular plant species present within the trial VDT area;
- Review the conservation status of the vascular plant species recorded by reference to current literature and current listings by the DBCA (2019a) and plant collections held at the WAH (WAH, 1998-), and listed by DAWE (DotEE, 2019a) under the EPBC Act;
- Collect quantitative data used to calculate plant density, foliage cover and species richness to compare the effects of the four treatments applied to the translocated vegetation;
- Assess the contribution of resprouter and seeder individuals in each treatment;
- Assess the proportional representation of growth forms in each treatment;
- Provide comments on the current status of the translocated vegetation;
- Provide any anecdotal observations recorded in the field;
- Provide recommendations in response to results of the 2019 monitoring; and
- Prepare a report summarising the findings.

Sixteen 12 m VDT transects were established within the allocated trial VDT rehabilitation area located within the former Jennings mining area during February 2012 (Figure 48). Twelve quadrats were sampled along the length of each transect. Four VDT treatments were applied to the translocated vegetation within the trial VDT area during 2012:

1. Slashed with the application of Envy transpiration blocker;
2. Slashed without the application of Envy transpiration blocker;
3. Control (no treatment); and
4. No slashing with the application of Envy transpiration blocker.

Vegetation that was slashed, was done so prior to transfer, whilst the Envy transpiration blocker (AgroBest, 2012) was applied in situ after translocation.

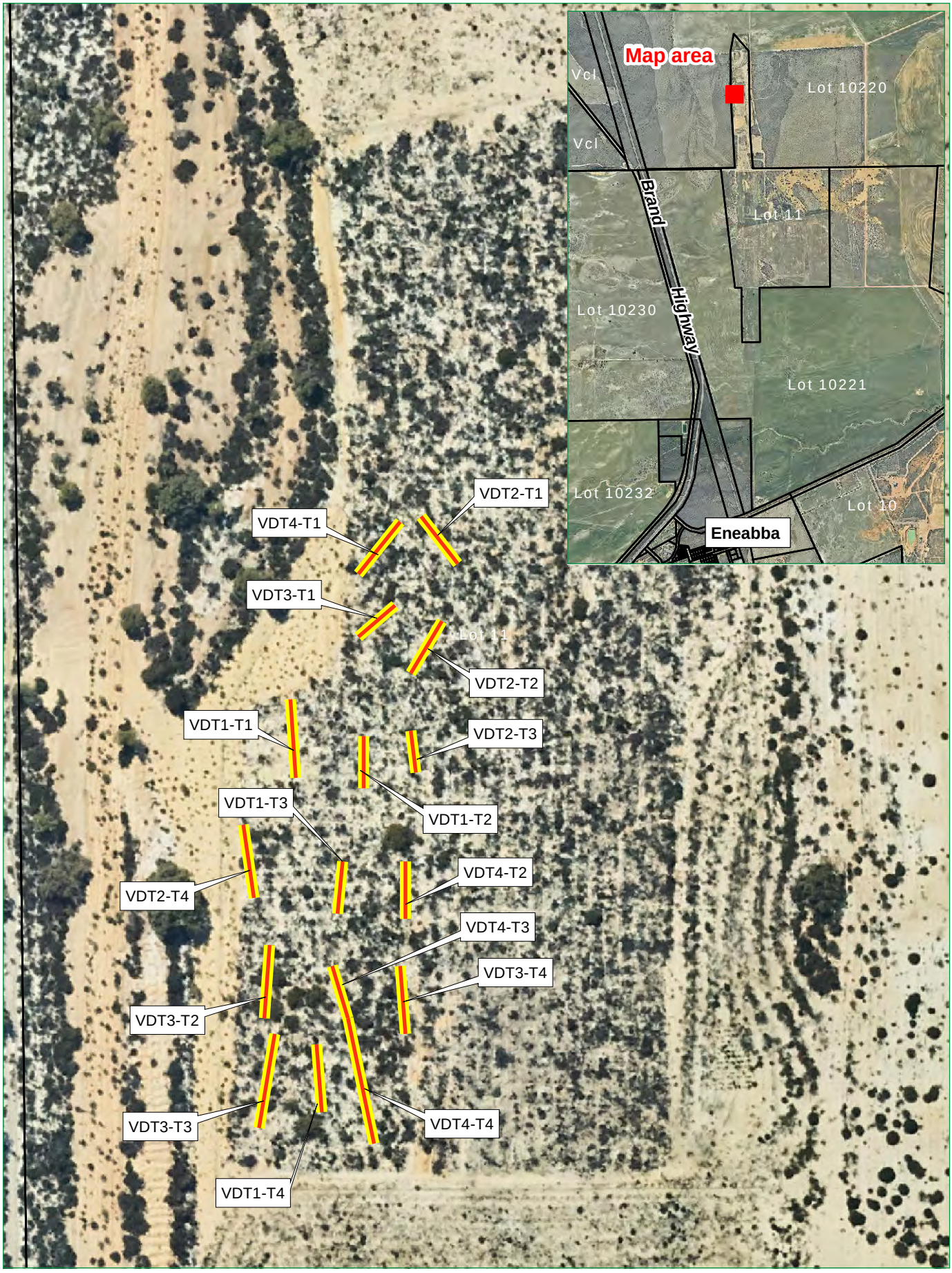
Monitoring of the 16 trial VDT transects was undertaken by four experienced botanists from Mattiske on 7 and 8 October 2019. The survey work was carried out in accordance with methods outlined in Technical Guidance – *Flora and vegetation surveys for EIA* (EPA, 2016b).

VRX has drawn on the results of these investigations as a basis for quantifying the benefits and efficacy of VDT as a rehabilitation technique for Kwongan heath vegetation representative of the Mine Development Envelope. The information contained within the following sections is from Mattiske (2019a; Appendix 2) unless otherwise referenced.

Flora

During the 2019 monitoring trial, Mattiske recorded a total of 130 vascular plant taxa which are representative of 66 plant genera and 28 plant families within the 16 trial VDT transects. The majority of the taxa recorded were representative of the Cyperaceae (17 taxa), Myrtaceae (15 taxa) and Fabaceae (12 taxa) families.

No Threatened Flora listed under the EPBC Act or BC Act were recorded. Five priority flora species were recorded, with seven individuals of *Comesperma rhadinocarpum* (P3), one individual of *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3), two individuals of *Hypocalymma gardneri* (P3), 11 individuals of *Desmocladus elongatus* (P4) and ten individuals of *Schoenus griffinianus* (P4) recorded across all four treatments.



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Aerial photo - 27 Aug. 2019

Legend

VDTs

ENEABBA

VDT trial transects layout

ILUKA

ORIG: S.Barron DRAWN: D.G.S. SCALE (A4): 1:1,000 DATE: 22 Nov. 2019 DWG No: 257654 ver.00

FIGURE: 48

Figure 48: VDT trial transects (Mattiske, 2019a)

Weeds

Five introduced plant species were recorded within the trial VDT transects, down from ten species recorded in 2015 (Mattiske, 2019a). The reduction in the numbers of introduced species across the trial irrespective of treatment may be due to the increase in plant density and foliage cover across the trial area combined with a decrease in rainfall in the three months preceding the survey, which may have impeded further establishment of introduced species within these areas. None of these species are declared pest organisms pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* (DPIRD, 2019) and none are WoNS (DotEE, 2019b).

All four VDT treatments contained introduced species, with the incidence of introduced species noticeably increasing over the years up to 2014, where a large increase in mean alive introduced species density was seen. However, there was a reduction in alive introduced species density recorded during the 2015 monitoring and the 2019 monitoring. Treatment 4 had the lowest incidence of introduced species (1 individual), with treatment 1 again having the highest incidence of introduced species (59 individual plants).

Plant Density

Mean alive plant densities decreased since the monitoring in 2015 in VDT treatments 1 and 3 and increased in treatments 2 and 4. Alive foliage had continually increased across the survey years and in the 2019 survey had more than doubled that of the 2015 survey in every treatment. This suggests that although alive density had decreased, combined with a concurrent increase in alive foliage cover, the vegetation within the trial was beginning to recover from the stresses imposed upon it due to the different trial treatments. The larger, more dominant plants appeared to have had a flush of growth, and the increase in size (as demonstrated by increased mean alive foliage cover) may have resulted in the death of smaller, less dominant plants due to competition, and hence an increase in mean dead plant densities.

Foliage Cover

Mean alive foliage cover increased in all treatments, following the same trajectory as previous monitoring years. Treatments which were not slashed (treatments 3 and 4) have the highest mean alive foliage cover. Overall, no strong conclusions can be drawn in relation to treatments and foliage cover as treatment 2, which was slashed also, had a mean alive foliage cover almost matching that of treatment 4. Mean dead foliage cover recorded in 2019 saw an overall increase in comparison to 2015 monitoring, however treatments 3 and 4 had less dead foliage cover than the survey years prior to the 2015 monitoring.

Species Diversity

The Shannon-Weiner diversity indices' (H') for density increased within all treatments between 2015 and 2019, with the exception of treatment 2 (2.40 and 2.01 respectively). The H' for foliage cover showed a reduction in all treatments between 2015 and 2019, with the exception of treatment 3, which increased. The increased H' value for density indicated a positive trend for species diversity in the VDT trial. A reduced H' value for foliage cover is most likely attributable to the increased growth of dominant shrub species, in particular, *Adenanthos cygnorum*, along with other species such as *Conospermum triplinervium* and *Leptospermum oligandrum*, which have a high percentage cover compared to other species.

Species Richness

Total species richness (excluding introduced species) decreased within all four treatments from 2015 - 2019, most likely due to a reduction in annual species in 2019. The reduction in annual species in the 2019 survey can be attributed to reduced rainfall and increased temperatures in the three months preceding the survey. Total species richness including introduced species also decreased within all four treatments for the same reasons, along with a reduction in introduced species seen in the 2019 monitoring. Overall, all four treatments were similar, however treatments 3 and 4 (non-slashed treatments) again had the highest total native species richness.

Growth Form

The proportion of alive plants by growth form varied throughout the survey years (2012 – 2019). In the 2019 monitoring, the proportion of perennial herbs and shrubs have increased compared to previous years, while annual grasses and annual herbs have decreased compared to previous years. This difference is largely due to the decrease in density of annual herbs such as *Gnephosis tenuissima* and *Levenhookia spp*. These species were recorded in 2018 in wetter areas between the translocated sods of vegetation, where micro-habitats have been created due to the excessive water content within the soil. As previously mentioned, the reduced rainfall in the 2019 season had likely resulted in less annual species being present. The increased proportion of shrubs and perennial herbs was a result of the increased growth of shrub species previously mentioned such as *Adenanthos cygnorum* and perennial herbs such as *Conostylis* species.

The proportions of dead growth forms within all treatments between 2012 and 2019 were highly variable. In the 2019 survey the most dominant dead growth form is shrubs, in all treatments aside from treatment 2, in which perennial herbs make up the dominant dead growth form. This correlated with the overall increase in alive shrub growth form in the survey area. Some plant death is beneficial, according to Ross *et al*. (2000), as it represents a recycling of nutrients and serves as habitat and a food source for invertebrates.

Seeder and Resprouter Species

Between 2012 and 2014 within all four treatments there was a noticeable increase in the proportions of alive seeder species and a reduction in the proportions of alive resprouter species. However, the 2015 and 2019 surveys saw an increasing trend within all four treatments, in the proportions of alive resprouter species, with a concurrent reduction in the proportions of alive seeder species. This is notable given that recalcitrant (cannot be propagated easily from seed or vegetatively) resprouter species from the families *Cyperaceae* and *Restionaceae* have often been absent in rehabilitated areas using other rehabilitation techniques (Dobrowolski, 2014).

The proportion of dead resprouter species had mostly decreased since the 2012 survey. The 2019 survey followed this trend, aside from a slight increase in dead resprouter species in treatments 1 and 4 since the 2015 survey. The overall decrease in dead resprouter species suggests these species are now stabilising after the stress from the initial translocation. There appears to be no significant difference between treatments and the success of resprouter species, although it may be noted that while treatment 1 has a lower proportion of resprouter species it is still following the same increasing trend seen with the other treatments.

Anecdotal Observations

A few notable anecdotal observations were recorded during the 2019 monitoring. There were generally high numbers of resprouting plants and additional regeneration across the majority of the trial VDT area. There was an overall increase in foliage cover, proteaceous and myrtaceaous shrubs were observed to be resprouting, in particular, *Adenanthos cygnorum* was noticeably larger, making up a higher percentage foliage cover than previous years. Furthermore, an increase in shrub growth and soil-binding sedges and rushes resulted in an increase in soil stabilisation, and a reduction in water and wind-driven soil erosion which was observed in previous monitoring years.

The Proteaceous species, which are a major component of Kwongan heath, were showing signs of regeneration. The regeneration of Proteaceous shrubs in particular appeared to be somewhat slower than other plant families, this may in part be due to the damage caused to lignotuberous shrub species during translocation, coupled with slow growth rates and the lack of ideal seed conditions. One possible reason for the high level of Proteaceous deaths may be the depth of the translocated soil, which at 300 – 400 mm is most likely too shallow to allow the full translocation of the deep roots of some larger shrubs. Roots of the some of the larger shrub species occurring in the area may go as deep as 2 m, with tap roots extending beyond 2 m (Dodd *et al*., 1984). However, large Proteaceous shrubs were still recorded throughout the VDT area. Numerous *Conospermum triplinervium* were recorded throughout the trial as large flowering plants, suggesting that the translocated soil seedbank holds viable seeds, and that this species is regenerating via topsoil stored seed. Current observations within the VDT area showed that some *Banksia* and *Petrophile* species were able to recover, such as:

- *Banksia nivea* subsp. *nivea*;
- *Banksia shuttleworthiana*;
- *Petrophile brevifolia*;
- *Petrophile macrostachya*; and
- *Petrophile scabriuscula*.

Conclusions

It appeared from quantitative results and anecdotal observations that there was a good level of regeneration of rush and sedge species in 2019, in addition to the large increase in foliage cover for shrub species.

As a whole, eight years since the vegetation has been translocated there appears to be little difference in the effect of treatment on the receiving vegetation. The vegetation in all of the treatments had undergone a high level of stress, but appeared to be regenerating, with significantly increased foliage cover and reduced levels of erosion observed in the 2019 survey. However, it must be noted that some key dominant species found in undisturbed Kwongan such as *Banksia* and *Petrophile* species were yet to become apparent in the vegetation structure.

The use of VDT vastly improved the establishment of sedge and rush (largely understory) species. These species are less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman, Koch and Morald, 2007), but often dominate local heath communities (Mattiske, 2020b). The ability to include those species in rehabilitation solves a significant problem for mine rehabilitation on Kwongan heath. Neil McMulkin, former Rehabilitation Superintendent for Iluka Resources, advised that if starting Eneabba mining again, that VDT would be the preferred rehabilitation method, and for a small disturbance footprint

operation like Arrowsmith North, it is even more suitable (due to the small distance between the clearing and rehabilitation areas) (N. McMulkin Pers. Comm. 2020).

It is acknowledged that the Iluka VDT trials (Mattiske, 2019a) do not provide a direct comparison of the VDT rehabilitation methodology against other conventional methods such as topsoil stockpiling and respreading, re-seeding and infill planting. These reports do however provide a valuable insight into the performance of VDT. With this information, VDT can be evaluated against some of the completion criteria that are outlined in the Rehabilitation Strategy (Appendix 4), particularly:

- General vegetation community composition;
- Vegetation Condition;
- Floristic diversity;
- Species richness;
- Priority flora; and
- Introduced species.

Despite these reports not offering a comparison against specific rehabilitation techniques, VDT still provides a rehabilitation advantage as it is shown to make significant progress towards meeting the completion criteria detailed above (discussed further in the Rehabilitation Strategy; Appendix 4). This highlights the advantage VDT provides over other rehabilitation techniques as it would be unlikely that they would be able to demonstrate satisfaction of the completion criteria.

Direct Disturbance

The Proposal will result in the clearing of up to 14.5 ha of native vegetation, which will remain cleared for the life of the Proposal, and up to 339.3 ha of native vegetation which will be cleared and progressively rehabilitated via VDT.

The Proposal includes the progressive translocation of 339.3 ha of vegetation within the Mine Development Envelope via VDT (the VDT process is described in detail in Section 2.2.3 with details of VDT trial success in the section above). The VDT method was chosen as it promotes a high level of live foliage cover, vegetation density and species richness, achieving results that are comparable to the natural vegetation in approximately eight years (Mattiske, 2019a; Appendix 2). There are some factors associated with the VDT method that require careful management to ensure it is effective such as:

- Ensuring adequate soil salvage depths;
- Ensuring there are no acidic leachates;
- Appropriate handling of stripped sods;
- Minimising environmental stressors post transfer;
- Avoiding over-compaction of soils from vehicle movement; and
- Minimising the exposure of vegetation roots during handling and planting.

The VDT method is not capable of returning the complete assemblage of flora species recorded in the Kwongan heath vegetation recording within the Mine Development Envelope. Observations made during previous VDT trials do not show many *Banksia* or *Petrophile* species to be regenerating (Mattiske, 2019a). Therefore, VRX has assumed that it will be necessary to infill plant these species from tube stock or seed where appropriate to ensure these species remain part of the vegetation structure.

As part of the assessment of the regional significance of the clearing, the extent of the proposed clearing has been compared with the mapped regional extent of native vegetation within a 10, 15 and 20 km radius of the Proposal. In contrast to other areas of the Geraldton Sandplains region the extent of remaining native vegetation remains high in the vicinity of the Proposal. 28,657.5 ha of native vegetation remains within 10 km of the Proposal (91.66 % of original extent), 58,621.2 ha of native vegetation remains within 15 km of the Proposal (91.60 % of the original extent) and 90,125.7 ha remains within 20 km of the Proposal (85.87 % of original extent). The Beekeeper Nature Reserve lies to the west of the Proposal and provides protection for an estimated 120,000 ha of native vegetation.

The proposed clearing represents a reduction of 1.24 % of the regional extent of native vegetation within 10 km of the Proposal, 0.60 % within 15 km and 0.39 % within 20 km. The cumulative impacts of the proposed and existing clearing will therefore not be significantly increased, and significant areas of native vegetation will remain after implementation of the Proposal, including large areas within the conservation estate. Given that 339.3 ha of the clearing will be progressively cleared and rehabilitated via VDT the clearing of vegetation for the Proposal is unlikely to represent a significant impact in a general regional context. This clearing is assessed further from an ecological context in the sections below.

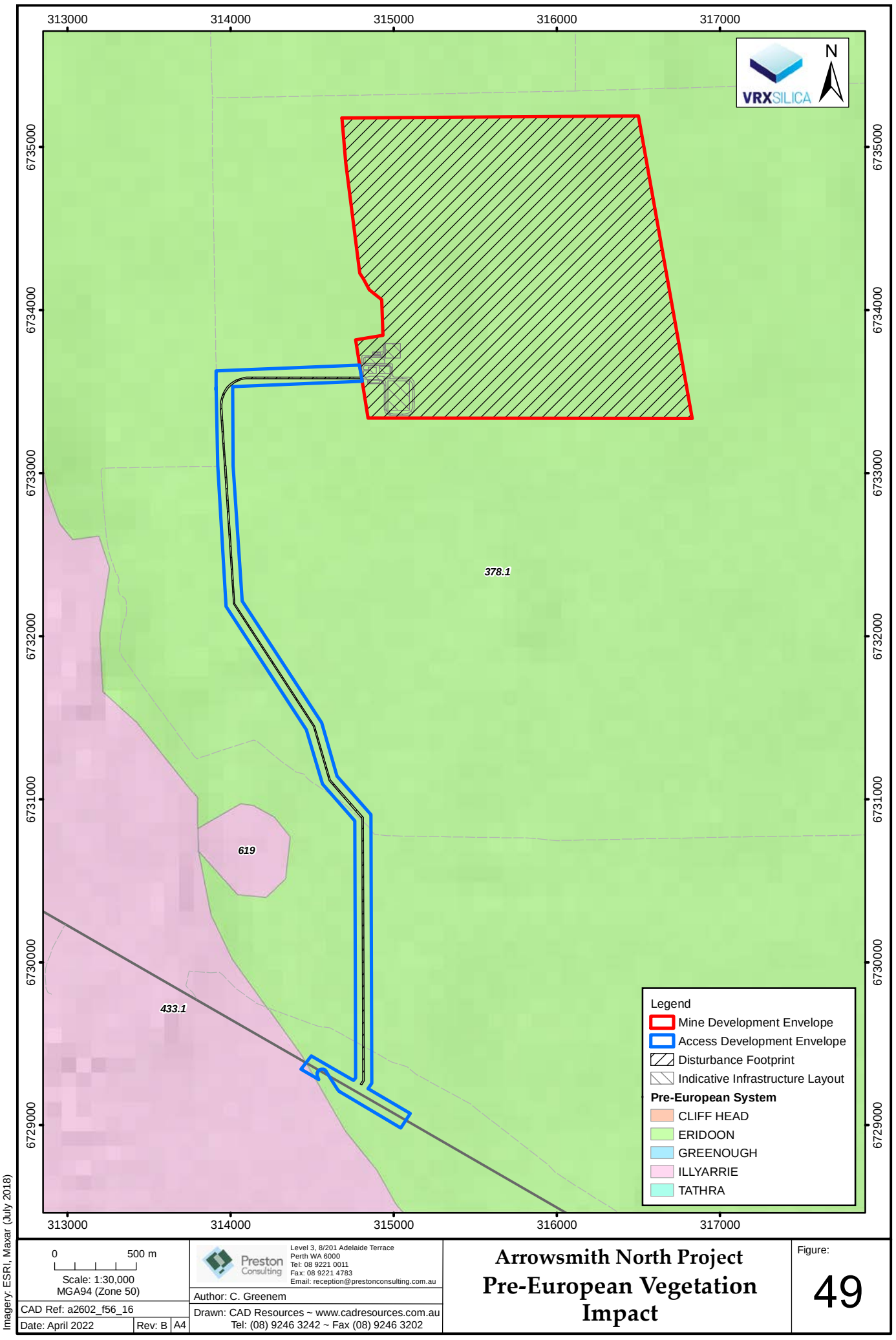
At a regional scale, the 353.8 ha of native vegetation clearing required for the Proposal will occur across a single vegetation association (378.1; Figure 49 and Figure 50). VRX has assessed the impacts of the Proposal against potential and existing cumulative impacts of other proposals in close proximity to the Proposal. VRX has identified six projects within 20 km of the Proposal that may have a cumulative impact on the extent of native vegetation. the majority of the projects are proposed and therefore the extent of clearing required for each has not yet been quantified. As most (four) projects are for silica sand mining, VRX assumes these projects will be similar in size and scope to the Proposal (with the exception of the Perpetual Resources Beharra Silica project that is proposed to clear approximately 600 ha; Perpetual Resources Limited, 2022) and will require approximately 450 ha of native vegetation clearing each. A green energy project has also been referred to the EPA (Infinite Green Energy Arrowsmith Hydrogen Project; Assessment Number: 2345) that will require clearing of approximately 140 ha of native vegetation. Based on this assumption, the cumulative native vegetation clearing of all projects is estimated to be:

- Up to 2,990 ha or only 3.3% of the remaining native vegetation extent within 20 km of the Proposal;
- Up to 2,540 ha or only 4.3% of the remaining native vegetation extent within 15 km of the Proposal; and
- Up to 2,540 ha or only 8.9% of the remaining native vegetation extent within 10 km of the Proposal.

This estimate is expected to be conservative due to the following reasons:

- Not all projects will be viable and proceed through to development; and
- The Beharra Springs Gas plant has only resulted in approximately 50 ha of clearing.

These projects are also expected to occur within the Eridoon (378.1) Vegetation Association which has 65% of its pre-European extent remaining (80,734.1 ha). No significant planned proposals have been identified within this vegetation association that would reduce the current extent by more than a few percent (the Proposal will result in only a 0.44% reduction in comparison).



Imagery: ESRI, Maxar (July 2018)

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CAD Ref: a2602_f56_16

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Arrowsmith North Project
Pre-European Vegetation Impact

Figure: 49

Figure 49: Vegetation associations disturbed by the Proposal

Vegetation association 378.1 has 65.0 % of its pre-European extent remaining and the Proposal will disturb 0.44 % of the remaining vegetation association, or 0.28 % of the pre-European extent. This minor reduction is unlikely to be significant as there will be 64.71 % of the pre-European extent remaining after the implementation of the Proposal and 339.3 ha of the vegetation will be progressively rehabilitated via VDT, resulting in high quality rehabilitation of this vegetation association.

At a local scale, the Proposal will not disturb more than 46% of the mapped extent of any vegetation communities mapped within the survey areas (Figure 50), with the greatest being 116.84 ha of the H3 vegetation community (45.3% of mapped extent). Given that no vegetation communities were noted as being locally unique, more than 54% of every vegetation community will remain, and the vegetation communities with the largest percentage loss are within the proposed VDT areas (i.e., the vegetation community is predicted to be progressively rehabilitated), the Proposal disturbance is unlikely to have a significant long-term impact on local vegetation communities.

The VDT process will relocate 150 m x 150 m blocks of native vegetation to previously mined areas located only 150 m from its source location. By limiting the relocation distance the vegetation community boundaries are more likely to reflect pre-mining boundaries (i.e., the maximum offset or change would be 150 m). In addition the movement of sods (which make up each block) will be in sequence so that the vegetation community mosaic is maintained within each block.

Despite its benefits with shallow-rooted species, VDT is unlikely to be able to maintain all flora taxa at pre-mining levels (i.e., loss of some deep rooted species and taller trees is predicted) therefore the flora composition of the vegetation will change as a result of mining. The Proposal targets the top of a dune, and the removal of sand will result in an overall decrease in depth to the water table. This change will favour some species if they are able to access the groundwater, and further changes to the composition of flora may occur through the competitive environment presented in rehabilitated areas (i.e., species that prefer disturbance may become established earlier).

The development envelopes contain several flora values that are considered significant. An assessment of the direct disturbance of those values is provided in Section 5.5.2.

Altered Fire Regimes

The Eridoon land system is characterised as experiencing frequent wildfires, this is reflected in the high proportions of reseeder and respouter species present within the vegetation assemblage. Generally, the vegetation is fire-dependant, with much of the Study Area already impacted by wildfire.

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 subsequent ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore expected to not be significant.

Burial as a Result of Slurry Spills

The slurry pipelines will run from the MFP to the Processing Plant, and will be fitted with automatic shutdown detection and will be located within a 'V' drain designed to capture the release of slurry from a complete pipeline rupture. A rupture of this pipeline therefore has limited potential to release sand slurry into the surrounding vegetation. Upon notification of a spill, VRX will mobilise to remediate the impacted area, dried sand slurry will be recovered and taken from the site and any impacted vegetation will be rehabilitated as required. The details of spill containment systems are generally planned and managed via a Works Approvals under Part V of the EP Act and a MP under the Mining Act. The mitigation measures are described in Section 5.6.2.

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.

Eight introduced species were identified during flora / vegetation surveys (Mattiske, 2022a). None of these taxa are listed as WoNS, however two were listed as having a high ecological impact (*Aira caryophyllea* and *Ursinia anthemoides*). Given the presence of these 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).

Reduction of Groundwater Depth

The removal of silica sand within the mining footprint will reduce the depth to groundwater in those areas (i.e., mining will remove 8 - 15m of sand). The reduction in distance between the ground surface and the underlying groundwater may result in a competitive advantage or disadvantage to some species. There is the potential that more deep-rooted species (such as *Banksia* sp.) become established over time as they will have improved access to the shallower groundwater table. Root surveys conducted by Mattiske (2020a) indicate the vast majority of species assessed within the survey area have root structures that do not access groundwater and therefore are unlikely to be groundwater dependant (excluding *Banksia* sp. which are known to have tap roots extending 3 – 4 m below the surface). Changes in the depth to groundwater are therefore unlikely to have a significant impact on the majority of flora species within the survey area, however there may be improved outcomes for deep-rooted species such as *Banksia* sp.

Abstraction of groundwater for the Proposal will result in drawdown within the superficial and Yarragadee aquifer. Drawdown within the superficial aquifer is expected to be minor (8 mm per annum) and only as a result of leakage from abstraction within the underlying Yarragadee aquifer. The drawdown rate is within the range of natural groundwater level variation and would present a low risk to phreatophytic vegetation in the 0 – 3 m depth to groundwater category (the most groundwater dependant; if present) based on drawdown risk tables by Froend, *et al.*, (2004). The extent of drawdown and the impacts on the water table are discussed further in Section 7.5.2.

Hydrocarbon Spills

Considering 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.

Dieback

The introduction of *P. cinnamomi* to the development envelopes could result in a significant vegetation decline, based on the observed impacts to vegetation at Eneabba that share similar environmental conditions. Given the risk of dieback, hygiene management measures will be implemented to prevent the introduction of dieback (Section 5.6).

P. arenaria is a pathogen that is native to the area (Rea *et al.*, 2011). This pathogen is expressed as single deaths and revisited sites generally do not show additional deaths. There is no requirement, using DBCA standards, to manage the area to prevent the spread of *P. arenaria*. Regardless, VRX has prepared and will implement a DMP (Section 5.6) for *P. cinnamomi* which includes management practices that will also manage the spread of *P. arenaria*.

Vegetation and Dust

The construction and operation of the Proposal will result in the generation of dust. Dust generation is discussed further in Section 10. There is the potential deposited dust to affect the health of susceptible vegetation by adversely affecting photosynthesis and transpiration rates. As the Proposal is in an area of high biodiversity, the potential for deposited dust to have an effect upon the health of vegetation has been considered.

The separation distance between the Proposal and the closest conservation reserves (at least 5 km away) far exceeds the recommended generic buffer distance (discussed further in Section 8.4.1) established for protection of amenity (EPA, 2005), considered in the context of this Proposal to be a suitable proxy for the assessment of potential effects upon vegetation from dust deposition.

More generally, native vegetation in the Midwest region is expected to be reasonably tolerant to dust deposition and at minimal risk of physiological impacts (Eco Logical Australia, 2016), being adapted to high dust levels that occur naturally in summer under the combination of high winds and low rainfall. Dust deposition will be mitigated to some extent by periodic high rainfall events, which would remove built-up materials on foliage.

Based on the above, dust emissions from the Proposal are not expected to have a significant impact on flora or vegetation health.

Summary

The Proposal will result in clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of native vegetation that will be progressively rehabilitated via VDT.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. In the Iluka VDT trials it was reported by Mattiske (2020b) that the use of VDT vastly improved the establishment of sedge and rush (largely understory) species. These species are less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman, Koch and Morald, 2007), but often dominate local

heath communities (Mattiske, 2020b). The ability to include those species in rehabilitation solves a significant problem for mine rehabilitation on Kwongan heath. Neil McMulkin, former Rehabilitation Superintendent for Iluka Resources, advised that if starting Eneabba mining again, VDT would be the preferred rehabilitation method, and for a small disturbance footprint operation like Arrowsmith North, it is even more suitable (due to the small distance between the clearing and rehabilitation areas) (N. McMulkin Pers. Comm. 2020). Infill planting of deeper-rooted species will be undertaken as required to target the original vegetation structure.

There will be unavoidable impacts to the vegetation that is relocated during VDT, however the health of these areas are predicted to improve close to background over time. There may also be some changes to vegetation structure within mined areas as a result of improved access to groundwater, with deeper rooted species (*Banksia* sp.) predicted to be able to become established in greater numbers.

Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general native flora and vegetation (refer to Section 5.6)

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 values that require further assessment in the following sections.

5.5.2 PRIORITY FLORA

Direct Disturbance and VDT

VRX has made a considerable effort to avoid priority flora, the results of Mattiske (2022a) were used to revise the development envelopes to avoid concentrations of *Beyeria gardneri* (P3), *Hypocalymma gardneri* (P3), *Persoonia rudis* (P3) *and Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2). Seven Priority Flora species were recorded within the development envelopes (Figure 51). Of these, four are predicted to have more than 5 % of the recorded individuals (within the Mattiske survey areas) within the disturbance footprint, based on the known disturbance footprint of the Proposal within the Mine Development Envelope, and the indicative disturbance footprint within the Access Development Envelope (Figure 51):

1. *Banksia elegans* (P4);
2. *Comesperma rhadinocarpum* (P3);
3. *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3); and
4. *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2).

Banksia elegans (P4)

A total of 1,277 *Banksia elegans* (P4) individuals are predicted to be disturbed. This equates to 37.61% of the 3,395 individuals recorded within the survey areas. This percentage is however likely to be a conservative estimate, as the Mine Development Envelope aligns with the targeted flora survey area (which had intensive 20 m survey spacing), meaning that additional individuals may have been recorded elsewhere in the survey areas if intensive surveys were conducted in those areas also. As an indication of actual percentage impact (removing the statistical anomaly of the 20 m spacing intensive survey), calculations estimated that 274 of the 1,947 individuals (14.1%) recorded during the detailed survey would be impacted by the Proposal. It is likely that the percentage loss would be below this number if all of the survey areas were surveyed to the

same intensity (as some intensive surveys were also completed for the detailed survey). Figure 52 also shows that this species was widespread throughout the survey areas, demonstrating that it is not restricted to the development envelopes.

Banksia elegans was recorded in five different vegetation communities (H3, H4, H7, S6 and W2), which collectively were mapped over an area of 940 ha, or 52% of the survey area, indicating widespread habitat. An estimated 118 ha of the local habitat for this species is predicted to be disturbed, equating to 12.6% of the local extent, which aligns with the proportion of individuals predicted to be disturbed above.

This species has also been recorded in another 44 locations in WA, ranging from Moore River to Geraldton (Figure 52), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 44 locations, it demonstrates that the number of impacted individuals are unlikely to be significant in a local or regional context. This species will be infill planted within VDT areas. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Comesperma rhadinocarpum (P3)

Thirty *Comesperma rhadinocarpum* (P3) individuals are predicted to be disturbed. This equates to 50.85% of the individuals recorded within the survey areas. A number of records of this species were the reason for amending the Mine Development Envelope boundary on the western edge (Figure 53). As with *Bankia elegans* above, this percentage is likely to be a conservative estimate, as more records are likely to occur west of the Mine Development Envelope boundary, based on the location of the records found.

Comesperma rhadinocarpum was recorded in one vegetation community (H1), which was mapped over an area of 326 ha, or 18% of the survey area. An estimated 109 ha of the local habitat for this species is predicted to be disturbed, equating to 33.5% of the local extent, which indicates that the proportion of individuals predicted to be disturbed above is likely to be conservative.

This species has also been recorded in another 16 locations in WA, ranging over 400 km from Perth to Utcha (near Northampton; Figure 53). While individual counts are not available for each of those 16 locations, it demonstrates that there are a number of populations across the region, and Mattiske (2022a) considered the species to be very wide-ranging in distribution, with adjunct populations at Koolyanobbing and Pinjin Homestead in the Great Victoria Desert. Mattiske (2019a) also identified this species in 2013 and 2019 in Iluka's VDT trial transects. This indicates that *Comesperma rhadinocarpum* has the potential to be successfully translocated using the VDT process. Regardless, infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Hemiandra sp. Eneabba (H. Demarz 3687) (P3)

Ninety eight *Hemiandra* sp. Eneabba (H. Demarz 3687) individuals are predicted to be disturbed. This equates to 42.4 % of the 231 individuals recorded within the survey areas. As with the species above this percentage is likely to be a conservative estimate. As an indication of actual percentage impact (removing the statistical anomaly of the intensive survey), calculations estimated that 46 of the 368 individuals (25.9%) recorded during the detailed survey would be

impacted by the Proposal. It is likely that the percentage loss would be below this number if all of the survey areas were surveyed to the same intensity. This species was also recorded regularly throughout the Mine Development Envelope (Figure 54), indicating that more records were likely to occur in suitable surrounding habitat.

Hemiandra sp. Eneabba (H. Demarz 3687) was recorded in four different vegetation communities (H2, H3, H4 and H7), which collectively were mapped over an area of 1,114 ha, or 62% of the survey area, indicating widespread local habitat. An estimated 205 ha of the local habitat for this species is predicted to be disturbed, equating to 18.4% of the local extent, which aligns with the proportion of individuals predicted to be disturbed above.

This species has also been recorded in another 34 locations in WA, ranging from Eneabba to Yardanogo Nature Reserve (approximately 100 km; Figure 54), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 34 locations, it demonstrates that the number of impacted individuals is unlikely to be significant in a local or regional context. The majority of the impacted individuals lie within the VDT area, meaning that they may survive the VDT process and would not be lost. Mattiske (2019a) identified this species in 2019 in Iluka's VDT trial transects. This indicates *Hemiandra* sp. Eneabba (H. Demarz 3687) has the potential to be successfully translocated using the VDT process. Regardless, infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Schoenus sp. Eneabba (F. Obbens & C. Godden I154) (P2)

A total of 167 *Schoenus sp*. Eneabba (F. Obbens & C. Godden I154) individuals are proposed to be disturbed. This equates to 35.67% of the 467 individuals recorded within the survey areas. As with the species above this percentage is likely to be a conservative estimate.

Schoenus sp. Eneabba (F. Obbens & C. Godden I154) was recorded in two different vegetation communities (H1 and H5), which collectively were mapped over an area of 438 ha, or 24% of the survey area. An estimated 146 ha of the local habitat for this species is predicted to be disturbed, equating to 33.3% of the local extent, which indicates that the proportion of individuals predicted to be disturbed above is not as conservative as other species in this section.

This species has also been recorded in another 13 locations in WA, ranging from Eneabba to Dongara (~100 km; Figure 55), and Mattiske (2022a) considered that this species was "well represented in distribution in the surrounding region", with "widespread records in the surrounding area". While individual counts are not available for each of those 13 locations, it demonstrates that there are a number of populations across the region. This species was generally recorded in a small number of locations, therefore there may be an opportunity to avoid some of these locations. The impacted individuals also lie within the VDT area, meaning that they may survive the VDT process and would not be lost. Infill planting of this species will occur if they do not survive the VDT process. Based on the above the Proposal is unlikely to significantly impact the local or regional extent of this species.

Other Priority Flora

Based on current mine planning, the Proposal is not expected to disturb any known individuals of the remaining Priority Flora (Figure 51) that were recorded within the development envelopes. Nevertheless, these Priority Flora are relatively widespread, with all having more than 22 other records throughout the region, therefore none are restricted to the development envelopes.

Indirect Impacts

Section 5.5.1 provides a detailed assessment of indirect impacts on native flora and vegetation, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact any known priority flora records if the mitigation measures listed in Section 5.6 are implemented.

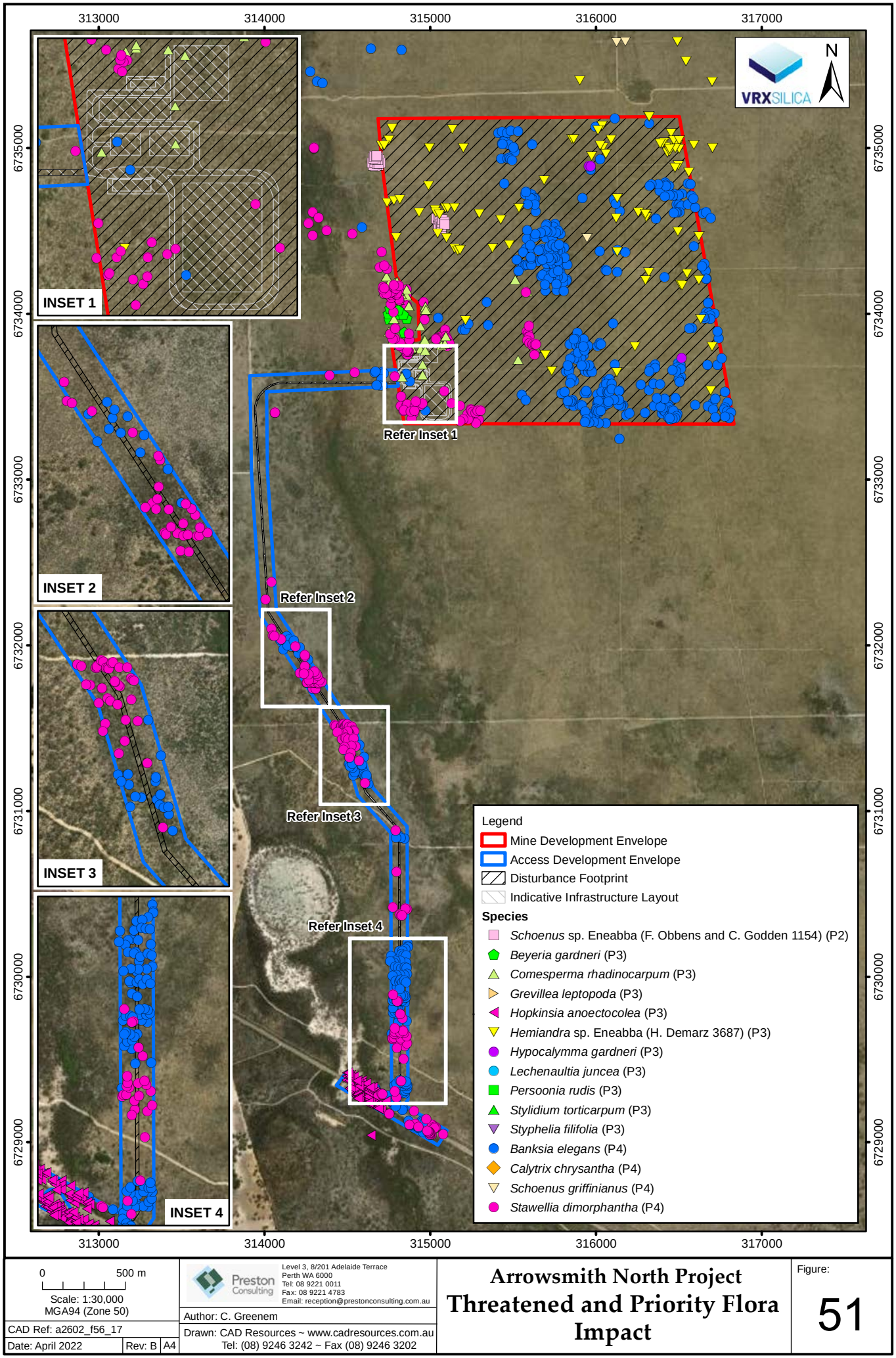


Figure 51: Priority Flora records impacted by the Proposal

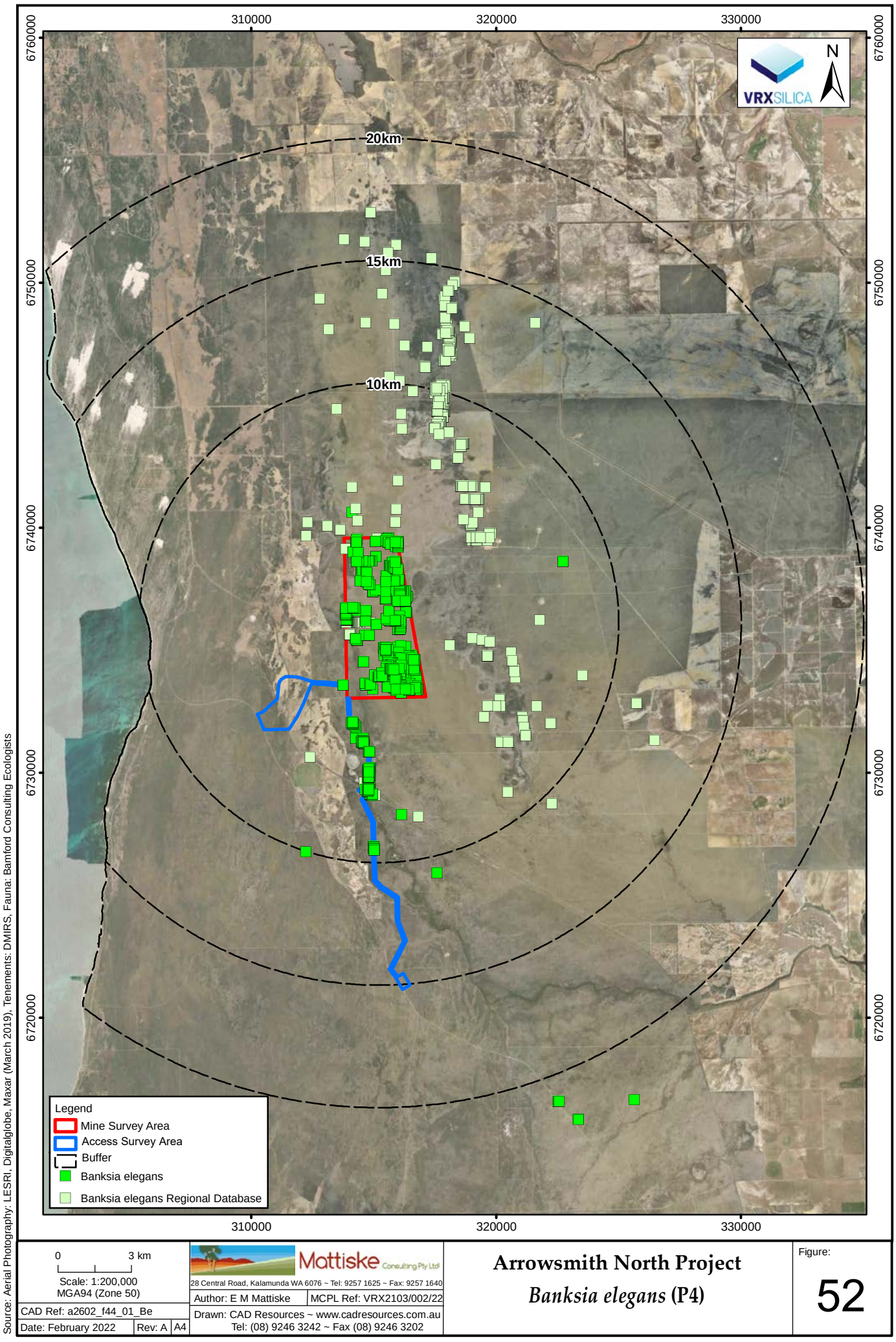


Figure 52: Known records of *Banksia elegans*

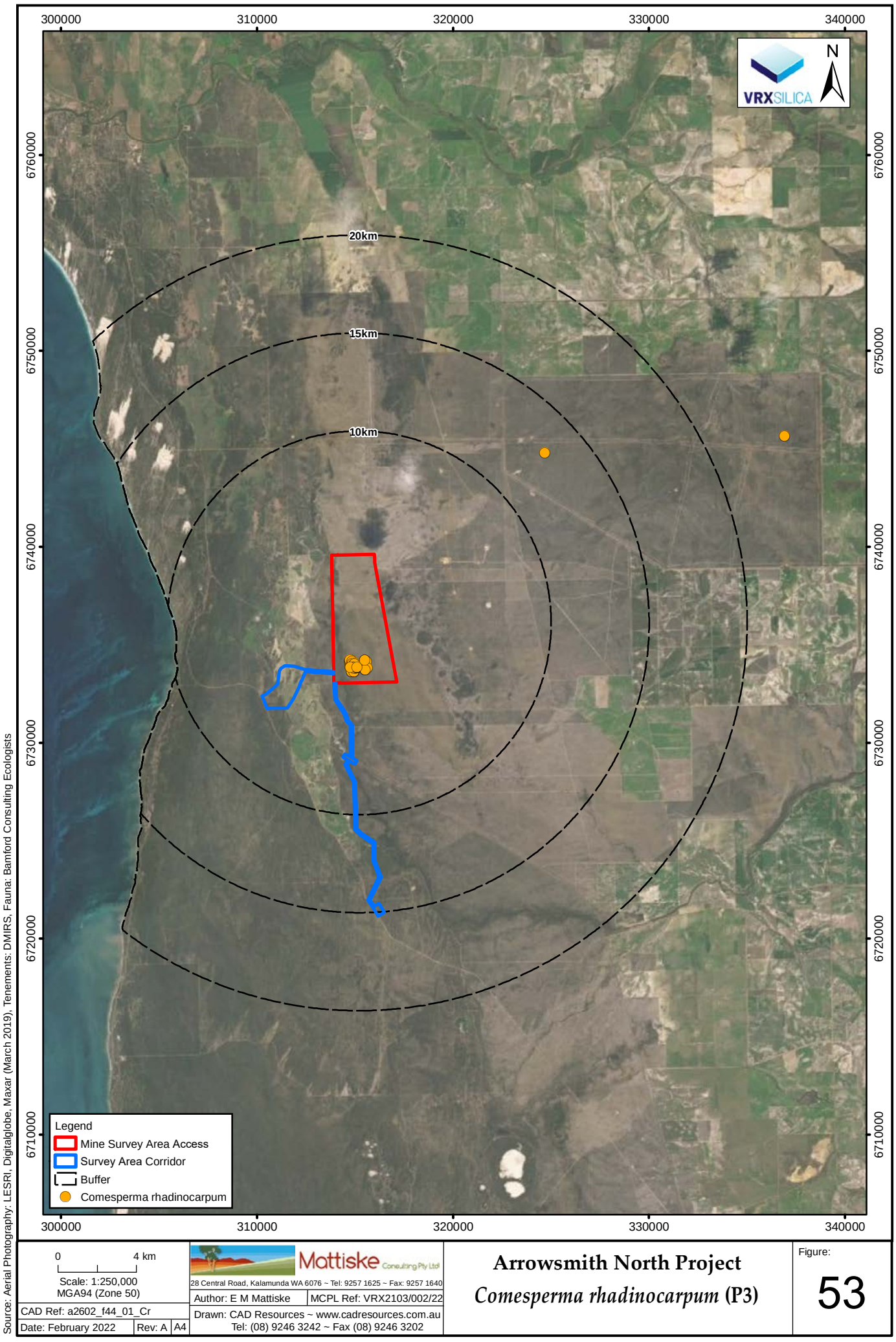


Figure 53: Known records of *Comesperma rhadinocarpum*

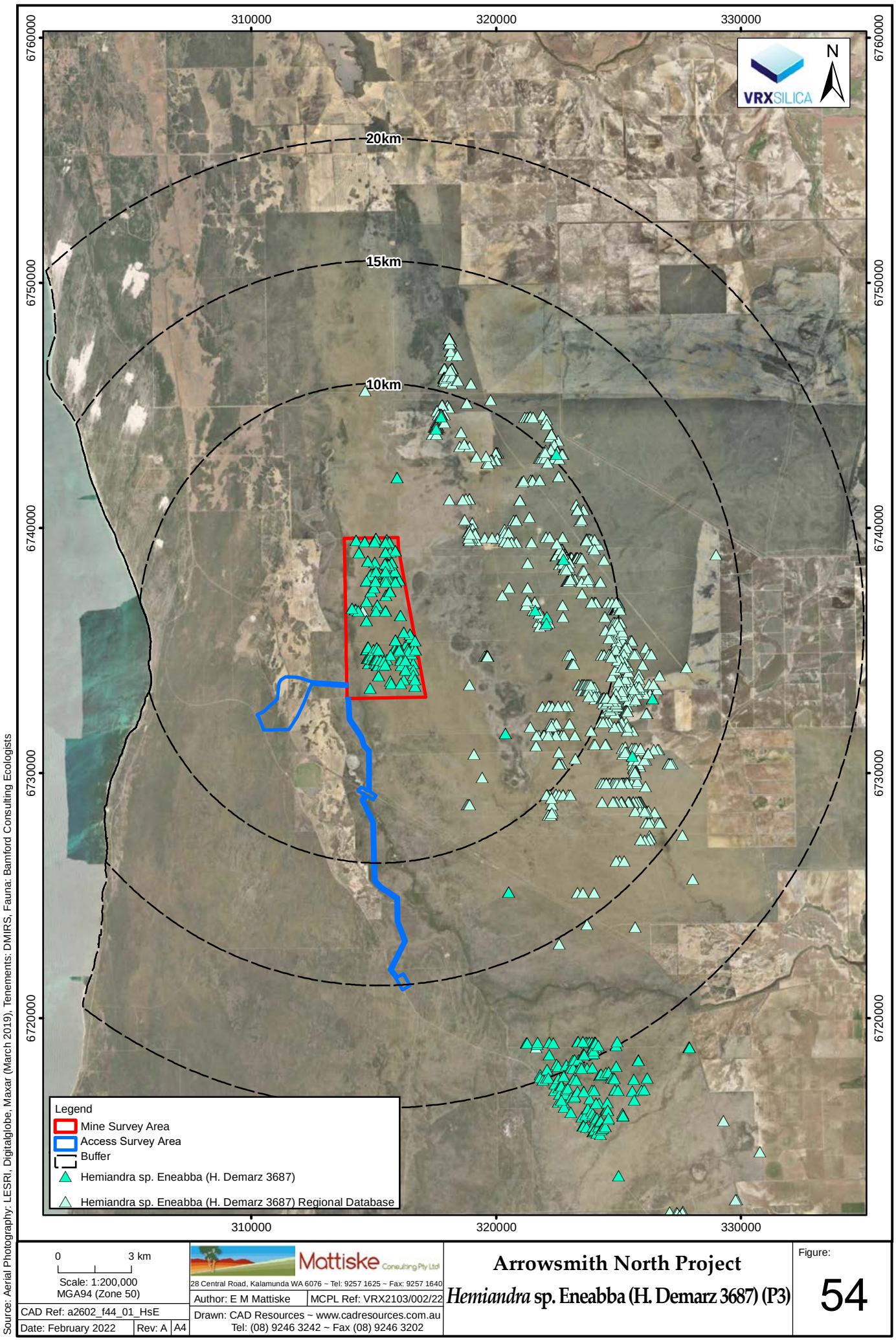
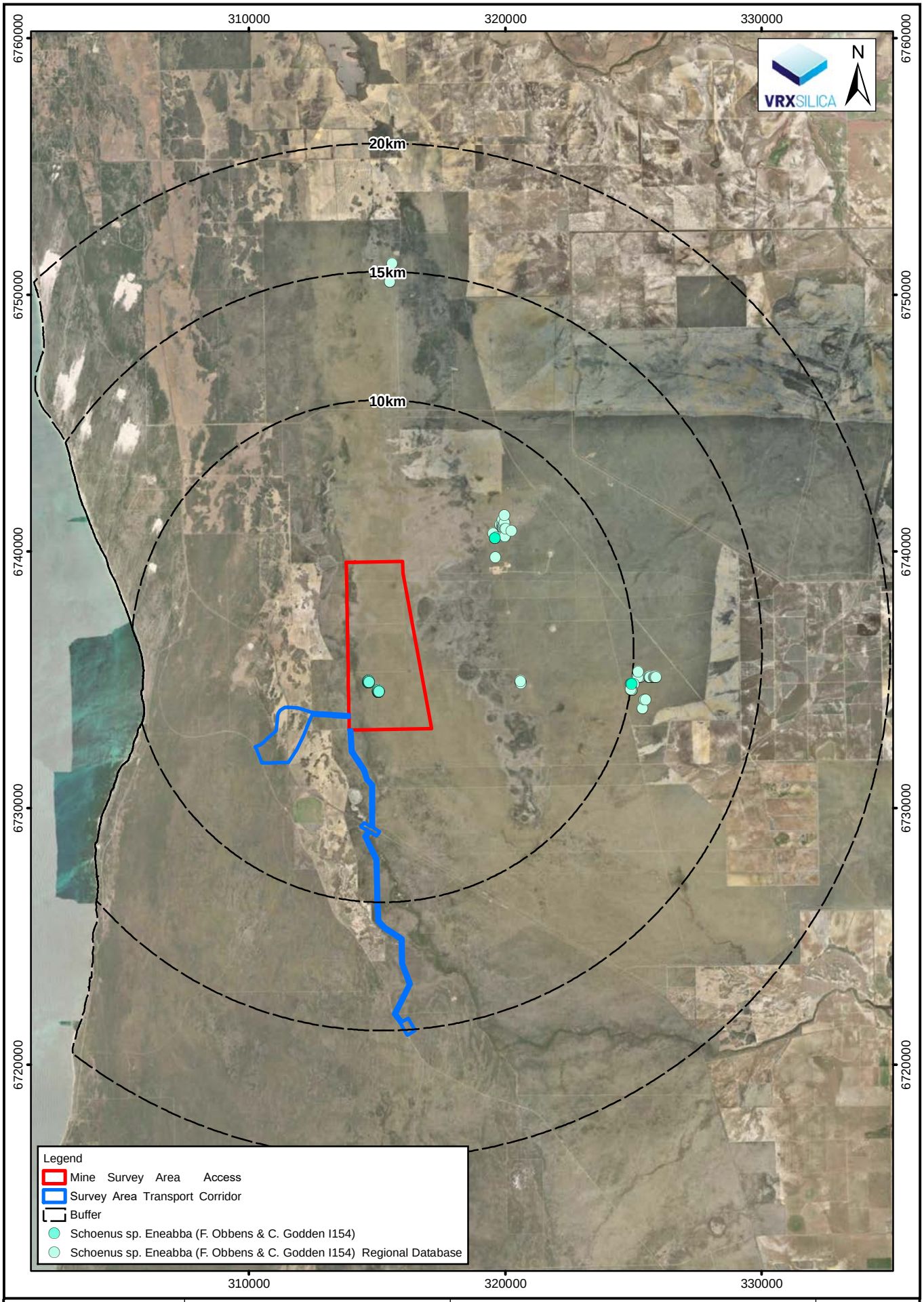


Figure 54: Known records of *Hemiandra* sp. Eneabba (H. Demarz 3687)



Source: Aerial Photography: LESRI, Digitalglobe, Maxar (March 2019), Tenements: DMIRS, Fauna: Bamford Consulting Ecologists

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Arrowsmith North Project
Schoenus sp. Eneabba (F. Obbens and C. Godden I154) (P2)

Figure: 55

Figure 55: Known records of *Schoenus* sp. Eneabba (F. Obbens and C. Godden I154)

5.6 MITIGATION

VRX 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.

5.6.1 AVOID

VRX conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes, and have utilised this information to conduct multiple mine planning and access road design revisions. This avoidance process resulted in the final boundaries of the development envelopes and disturbance footprint presented in this ERD, specifically modifications made to the western boundary of the Mine Development Envelope to avoid concentrations of Priority Flora (specifically *Beyeria gardneri, Hypocalymma gardneri, Persoonia rudis and Schoenus* sp. Eneabba (F. Obbens & C. Godden I154). The development envelopes now avoid the following values identified during the surveys:

1. Four of the 11 Priority Flora species recorded within the Survey Area (refer to Section 5.5.2); and
2. The north-south drainage line and associated riparian vegetation along the western boundary of the Survey Area.

5.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to flora and vegetation 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 the dozer operator to minimise clearing;
    c. Progressive clearing and rehabilitation (via VDT) will be undertaken;
    d. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    e. Water or dust suppressants will be applied to disturbed areas, mining areas and product transfer/storage areas as required to minimise dust generation;
    f. Emergency and fire response capabilities will be maintained to respond to fire outbreaks where possible;
    g. Weed and dieback hygiene and management measures / procedures will be implemented to prevent spread of weeds and dieback and the introduction of new weed species as a result of construction and operation;
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;
    d. DG Licence to be issued under the DG Act as required;
3. **Ensure impacts to Priority Flora within the Access and Mine Development Envelope do not exceed those predicted in Section 5.5.2;**

4. **Prepare a SFMP** prior to ground disturbance, which will provide further detail regarding the significant flora commitments in Item 3 and 4 above;
5. **Implement the Rehabilitation Strategy**. The Rehabilitation Strategy is provided in Appendix 4 and will be implemented during VDT;
6. **Implement the following measures to minimise the risk and impact of slurry spills:**
    a. Include leak detection and automatic shut-down systems on slurry pipelines;
    b. Develop and implement internal slurry spill clean-up procedure;
    c. Undertake routine maintenance on all plant equipment including pipeline, pumps, leak detection sensors and automatic shut-down systems;
    d. Environmental incident recording, investigation and reporting system;
7. **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;
8. **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, and the handling and storage of other waste materials, including contaminated soils; and
9. **Implement Dieback Management Plan (DMP; Appendix 13)** to mitigate dieback risks and impacts.

5.6.3 REHABILITATE

Progressive rehabilitation via VDT and targeted infill planting will occur during the mining process as described in Section 2.2.3 and in the Rehabilitation Strategy (Appendix 4). The Rehabilitation Strategy was developed in consideration of DMIRS Guidelines (2020a; 2020b) and describes the rehabilitation of the Proposal, and associated management and monitoring proposed during the progressive and final rehabilitation phase including completion criteria, monitoring and reporting during closure.

At the completion of the Proposal the site will be further rehabilitated to reinstate the flora and vegetation of areas that were disturbed for the life of the Proposal. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to flora and vegetation are summarised below:

1. All infrastructure will be removed from site;
2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction;
4. Impacted Priority Flora will be included in the rehabilitation seed mix if they are not suitable for establishment via VDT; and
5. All depressions will be shaped to prevent the formation of new semi-permanent water sources.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years.

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, 2016a).

VRX conducted extensive flora and vegetation surveys of the areas within and surrounding the development envelopes. A targeted significant flora survey was conducted over the development envelopes.

VRX has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, however direct impacts to flora and vegetation are unavoidable. The Proposal will result in the clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha that will be progressively rehabilitated via VDT.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper rooted species will be undertaken as required to target the original vegetation structure. There will be unavoidable impacts to vegetation within rehabilitated VDT areas, however based on VDT trials and studies conducted on the root structure of significant flora, the health of these areas are predicted to improve over time. There may also be some changes to vegetation structure within mined areas as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers.

With the implementation of controls, the Proposal will not result in significant impacts to regional vegetation associations, locally significant vegetation communities, Threatened Flora or significant populations of Priority Flora.

Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general native flora and vegetation (refer to Section 5.6).

Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.

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 and Commonwealth Government guidance documents for terrestrial fauna are summarised in Table 20.

Table 20: Policy and guidance relevant to the Terrestrial Fauna key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2021f).	This document was used as guidance to prepare a Fauna Management Plan (FMP; Appendix 12).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Terrestrial Fauna (EPA, 2016d);	This document was considered in the preparation of this section (Section 6) of the ERD.
Relevant EPA Technical Guidance	
Technical Guidance – Sampling methods for terrestrial vertebrate fauna (EPA, 2020a)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the terrestrial vertebrate fauna reports for the Proposal.
Technical Guidance – Terrestrial fauna surveys (EPA, 2020b)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the terrestrial fauna reports for the Proposal.
Technical Guidance – Sampling of short-range endemic invertebrate fauna (EPA, 2016e)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Short Range Endemic (SRE) invertebrate fauna reports for the Proposal.
Other Policy and Guidance	
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Terrestrial Fauna however it was determined not relevant as offsets were not required.

Policy and Guidance	How guidance has been considered
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Terrestrial Fauna however it was determined not relevant as offsets were not required.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Terrestrial Fauna however it was determined not relevant as offsets were not required.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016a)	This document was considered in the preparation of this ERD and while undertaking EIA.
EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide	This document was considered when determining whether offsets were expected to be required for the Terrestrial Fauna environmental factor.
Environmental Management Plan Guidelines (DotE, 2014a)	This document will be considered in the preparation of the FMP.
EPBC Act Condition Setting Policy (DAWE, 2020); an	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared at this stage of the assessment.
Relevant Technical Guidance	
Relevant EPBC Act listed species specific survey guidelines and protocols.	This document was used as guidance when undertaking surveys of EPBC listed species and potential survey limitations.
Relevant EPBC Act listed species specific Recovery plans, Threat Abatement Plans, ACA's and other documents.	This document was used as guidance to assess and manage EPBC listed species that may be impacted by the Proposal.

6.3 RECEIVING ENVIRONMENT

Information in this section has been sourced from the following reports:

- Fauna Assessment of Arrowsmith North (Bamford Consulting Ecologists (BCE), 2022; Appendix 14);
- Arrowsmith North Project Short-range Endemic (SRE) Invertebrate Desktop Assessment (Bennelongia, 2021a; Appendix 15); and
- Arrowsmith North Project SRE Invertebrate Survey (Bennelongia, 2021b; Appendix 16)

6.3.1 SURVEY EFFORT

A Basic (Level 1) fauna assessment, Detailed (Level 2) fauna assessment and targeted surveys for significant fauna were conducted by BCE in November 2018, September 2019 and October 2019. A desktop assessment was conducted by Bennelongia in December 2020 to determine the likelihood of significant SRE invertebrate fauna occurring within the Proposal Survey Area (Survey Area). Results of the desktop assessment were used to inform a Level 2 SRE fauna filed survey which comprised of foraging, wet pit trapping and soil-leaf litter collection. All information contained within the following sections is from BCE (2022) and Bennelongia (2021a; 2021b) unless otherwise referenced.

Desktop Assessments

Terrestrial Fauna

The Detailed fauna assessment by BCE (2022) preceded the field assessment and included a desktop assessment of relevant databases, literature and spatial data. The desktop assessment was undertaken to:

- Produce a species list that represents the likely vertebrate fauna assembly of the Survey Area; and
- Assess the potential presence of significant fauna, SRE species and habitats in the Survey Area.

Database searches of the Survey Area and surrounding environment produced a potential species list. Some species were excluded because their ecology, or the lack of habitat within the Survey Areas, meant that it is highly unlikely that these species will be present.

The databases and literature used to develop the species list are detailed below:

- Atlas of Living Australia;
- DBCA NatureMap (incorporating the WAM's FaunaBase and the DBCA Threatened and Priority Fauna Database);
- BirdLife Australia's Birdata Database;
- EPBC Protected Matters Search Tool; and
- BCE's Database;

A 20 km buffer was considered sufficient due to the extensive work BCE had conducted at this location previously. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler *et al.* (2000) and Anstis (2013);
- Reptiles: Storr *et al.* (1983, 1990, 1999 and 2002) and Wilson and Swan (2013);
- Birds: Blakers *et al.* (1984); Storr and Johnstone (1998, 2004), Barrett *et al.* (2003) and Menkhorst *et al.* (2017); and
- Mammals: Menkhorst & Knight (2004); Armstrong, 2011, Churchill (2008); and Van Dyck and Strahan (2008).

Previous Surveys

BCE has conducted multiple fauna surveys at Arrowsmith and nearby areas which have included several Basic (Level 1; EPA, 2020a) assessments, monitoring, targeted fauna assessments and a Detailed (Level 2; EPA, 2020a) fauna assessment. There have also been studies by other consultants in the region, particularly for the Eneabba mineral sands mine (results collated in BCE desktop reviews). Species records from these studies are contained in the NatureMap database which was consulted as part of the desktop assessment. In addition, BCE maintains a detailed database and annotated species lists for all its previous assessments (some of which pre-date NatureMap) and these were consulted for reference as part of the desktop assessment. Previous reports consulted for background information include Harris *et al.* (2008), Metcalf and Bamford (2008), Bamford (2009), Bamford (2012), Everard and Bamford (2014), Bamford *et al*. (2015), Bamford and Chuk (2015-17), Bamford and Chuk (2019), Bancroft and Bamford (2020), and Bamford (2020). Some of these studies (Metcalf and Bamford, 2008, Bamford, 2009 & 2012) were undertaken within or immediately adjacent to the Survey Area for Tronox (formerly Tiwest Joint

Venture) and included a two-season detailed fauna survey. A detailed survey was also undertaken at the Beharra Springs Silica Project area immediately to the north of the Survey Area and at the same time as the current investigations (i.e., in December 2021). Other studies occurred within 20 km. All species records used to inform the expected species list for the Survey Area and the source of the records are included in BCE (2022).

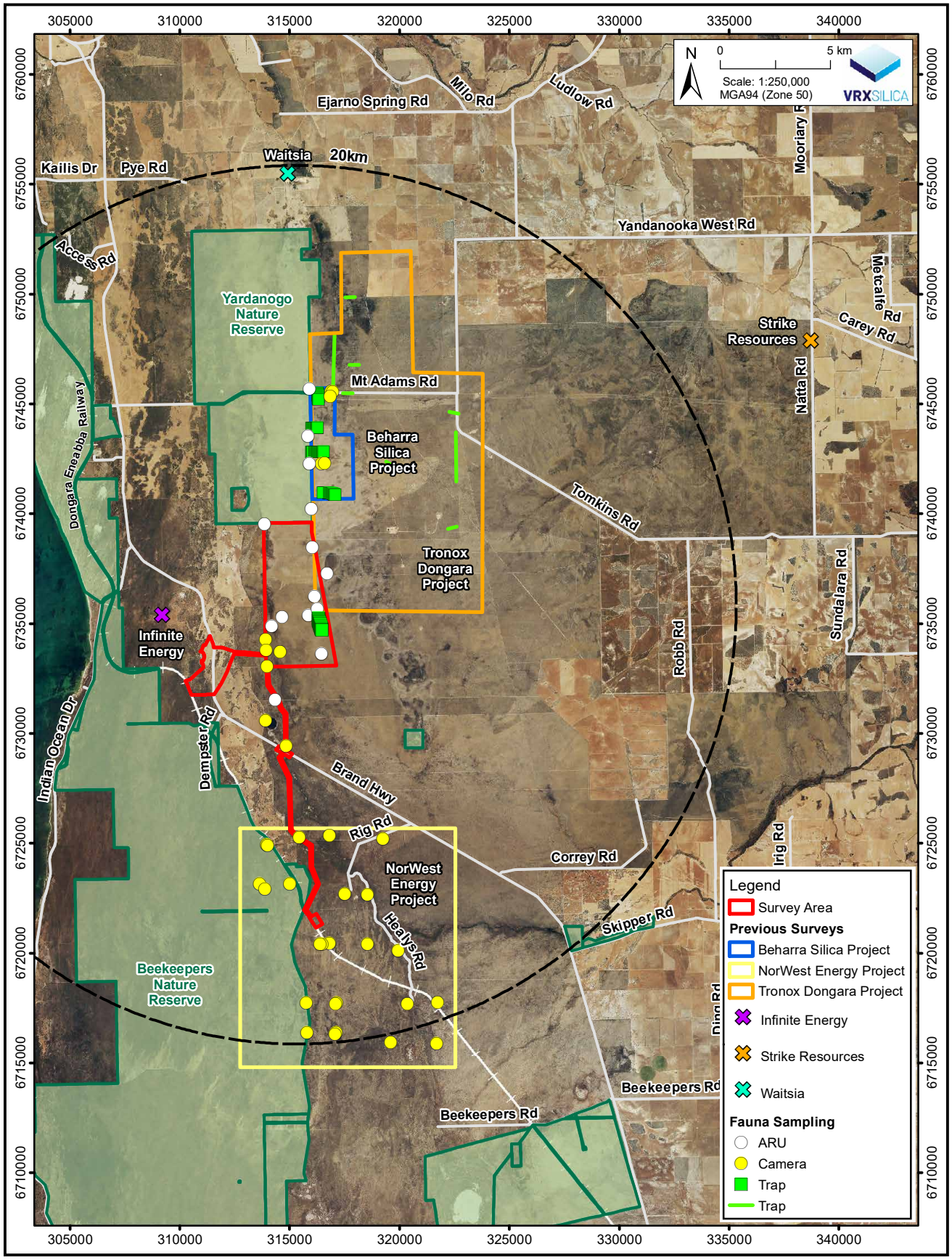
The details of previous studies are summarised in Table 21 and the extent is shown in Figure 56.

The previous studies used a range of techniques as they were carried out for different purposes but were consistent with EPA guidance at the time. In combination, they are consistent with current (EPA, 2020a) guidance in the range of techniques used; for example, motion-sensitive cameras were not used by Metcalf and Bamford (2008) but were used extensively at a nearby site by Bamford and Chuk (2015-2017). They were also used at the Beharra Spring site (Bamford and Bancroft, 2022). These two detailed surveys carried out within about 5 km of the Survey Area had two minor deviations from current guidance (EPA 2020a). These deviations are discussed further in BCE (2022; Appendix 14).

Table 21: Previous BCE surveys within c. 20 km of the Proposal

Authors	Description	Alignment with current guidance (EPA, 2020a)	Limitations
Harris *et al.* 2008	Survey for threatened fauna in the Tronox My Adams project area. Hand-searching and aural surveys targeting the Millipede *Antichiropus* 'Eneabba 1' (previously found in the Mt Adams project area (Metcalf and Bamford, 2008), the Phasmid-mimic Cricket *Phasmodes jeeba* (uncertainty about past records in the Mt Adams area) and Western Ground Parrot (unconfirmed but well-regarded sighting in Mt Adams area in 1992). Survey involved hand-searching and aural survey in spring 2008.	Targeted survey (*sensu* EPA, 2020a). Methods based on survey approaches described by Rentz (1996) for invertebrates, and based on advice from DBCA for Western Ground Parrot.	No limitations except uncertainly always surrounds surveys for rare species and absence can rarely be confirmed.
Metcalf and Bamford 2008	Basic, Detailed and Targeted surveys in the Tronox Mt Adams project area, including a site inspection (Sep 2002), and late winter and spring surveys (2007). Investigations included hand-searching for SRE invertebrates, aural surveys for Western Ground Parrot, pitfall trapping (900 trapnights), Elliott and cage trapping (240 trapnights each), bird censussing, harp-traps for bats and opportunistic observation.	A wide range of sampling techniques used as outlined by the EPA (2020b). Traps were run for five nights in each survey as was standard at the time.	No limitations. Motion-sensitive cameras were not used as is standard practice now, but were used at a nearby site by Bamford and Chuk (2015-2017).
Bamford 2009	A desktop review and site inspection carried out for Iluka from ca. Beekeepers' Road to Arrowsmith River, west of Brand Highway. Included some aural survey work for Western Ground Parrot.	Basic survey.	No limitations.
Everard and Bamford 2014	A desktop review and site inspection around and south of Eneabba for Iluka. Over 20 km south of Arrowsmith North project area, but a comprehensive review of multiple fauna surveys around Eneabba across similar landscapes.	Basic survey	No limitations.

Authors	Description	Alignment with current guidance (EPA, 2020a)	Limitations
Bamford 2012	Targeted surveys for the Western Ground Parrot in the Tronox Mt Adams Project area and nearby Beekeepers' Nature Reserve. Surveys carried out in May 2008 and June 2012 with up to eight observers over up to five evenings and mornings.	Targeted survey. Methods based on advice from DBCA for Western Ground Parrot.	No limitations except uncertainty always surrounds surveys for rare species and absence can rarely be confirmed. Possible calls were heard in June 2012 but this was not followed up.
Bamford *et al.* 2015	Desktop review and site inspection of Waitsia project area for AWE; northern edge of Yardanogo Nature Reserve. Included targeted surveys for Western Ground Parrot and observations on roosting Carnaby's Cockatoo.	Basic and targeted survey.	No limitations.
Bamford and Chuk 2015-2017	Use of motion-sensitive cameras (baited) to detect fauna activity along drill-lines just west of Arrowsmith, targeting feral species but also appropriate for detecting significant species such as Malleefowl, Chuditch, Western Ground Parrot and Quenda. Total effort was 904 camera-nights over three years (about 10 days each autumn in 2015, 2016 and 2017). Opportunistic observations on other fauna made.	Targeted survey. Methods complement Metcalf and Bamford (2008).	No limitations.
Bamford and Chuk 2019	Desktop review and site inspection of the VRX Arrowsmith South project area.	Basic survey.	No limitations.
Bancroft and Bamford 2020	Desktop review, site inspection and some targeted survey across a broad area from just east of the Arrowsmith North Proposal area to south of Eneabba; for Beach Energy. Included an update of previous desktop reviews across this area and field investigations to confirm black-cockatoo roosts and black-cockatoo foraging habitat.	Basic and some targeted survey	No limitations.
Bamford 2020	Desktop review, site inspection and some targeted survey of the Beharra Spring Silica Project (Adams Road immediately west of Tronox project area). Targeted survey included searching for SRE invertebrates and assessing habitat for Carnaby's Cockatoo.	Basic and some targeted survey	No limitations.



Source: Aerial Photography: Landgate (Nov 2016), Tenements: DMIRS
Author: Bamford Consulting Ecologists, Drawn: CAD Resources (08 9246 3242), Date: Aug 2022, CAD Ref: a2602_f61_01, Rev: A

Figure 56: Locations of previous fauna studies undertaken around the Survey Area (Referred to as Project Area) by BCE. Sampling locations and types are also shown

Short-Range Endemic Invertebrates

BCE (2022) also included a desktop assessment of SRE fauna. Records of listed invertebrates from the entire Mid-West region (DBCA, 2018b) were accessed from the DBCA threatened and priority fauna list (DBCA, 2019a) to produce a broad list that was then interpreted on the basis of the environments within the Survey Area and the distance to the nearest records.

An additional desktop assessment was conducted by Bennelongia in December 2020 and 2021 to better understand the SRE invertebrates that have the potential of occurring within the Survey Area. The specific aims of the assessment were to determine:

- The occurrence of potential SRE species from invertebrate records in the vicinity of the Proposal;
- The occurrences of any listed species from invertebrate records in the vicinity of the Proposal (BC Act and EPBC Act); and
- Determine the likelihood that SRE and listed invertebrate species occur in the Survey Areas, based on the types of habitat present.

Previous records of terrestrial invertebrate species were collated from Bennelongia and WAM databases, along with published taxonomic literature, from a search area that extended 50 km north, east and south of the Proposal, bordered on the west by the Indian Ocean. The search area is shown in Figure 57.

Field Assessment

Terrestrial Fauna

The Survey Area (Figure 58) has been visited by BCE on three occasions as part of investigations for VRX (November 2018, October 2019 and December 2021). It was first visited on 18 November 2018 to conduct a site inspection, but adjacent areas had previously been visited multiple times over the period 2002 - 2012 by BCE personnel for studies undertaken for Tronox. The nearby Beharra Springs Silica project area was also visited in August 2020 and December 2021, the latter in conjunction with studies at Arrowsmith North. The purpose of the site inspection was to gain a better understanding of the fauna values of the Survey Area, and to place the expected species list generated from the desktop assessment into the context of the environment of the Survey Area. This involved traversing the Survey Areas to examine vegetation and substrate present (and consequent habitat available for fauna), and to record opportunistic observations of fauna.

A further visit was undertaken between 23 - 25 October 2019 specifically for Carnaby's Cockatoo and the Western Ground Parrot which are Endangered and Critically Endangered respectively under State and Commonwealth legislation. A walkover survey was undertaken to search for evidence of Black-Cockatoo foraging and to assess the foraging value of the vegetation, and a search of the surrounding landscape was carried out for features that could support roosting and breeding Carnaby's Cockatoos. A vantage point survey on one evening took place to watch for any evening movements of Carnaby's Cockatoos, which can reveal roosting and nesting sites.

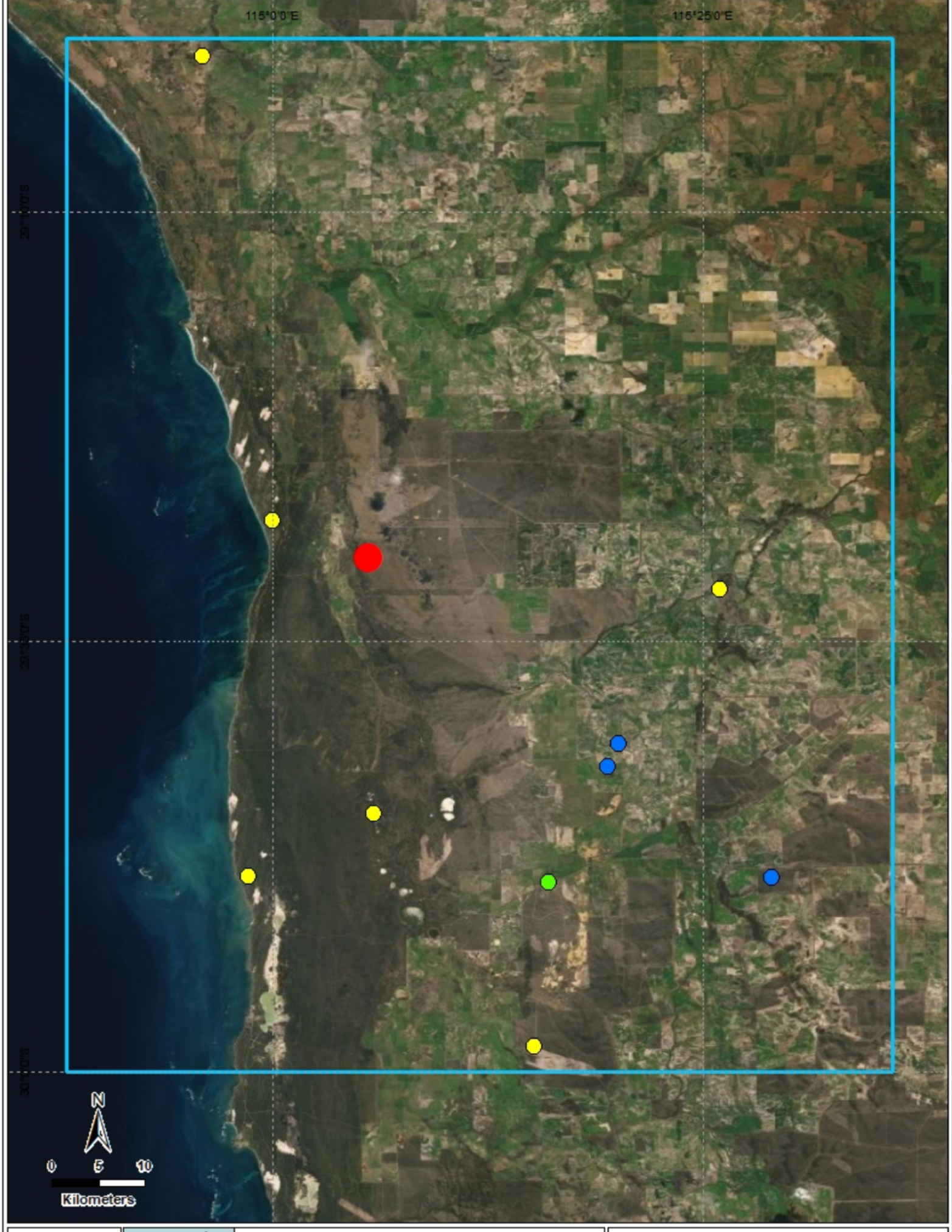


Figure 57: Bennelongia (2021a) SRE desktop assessment search area

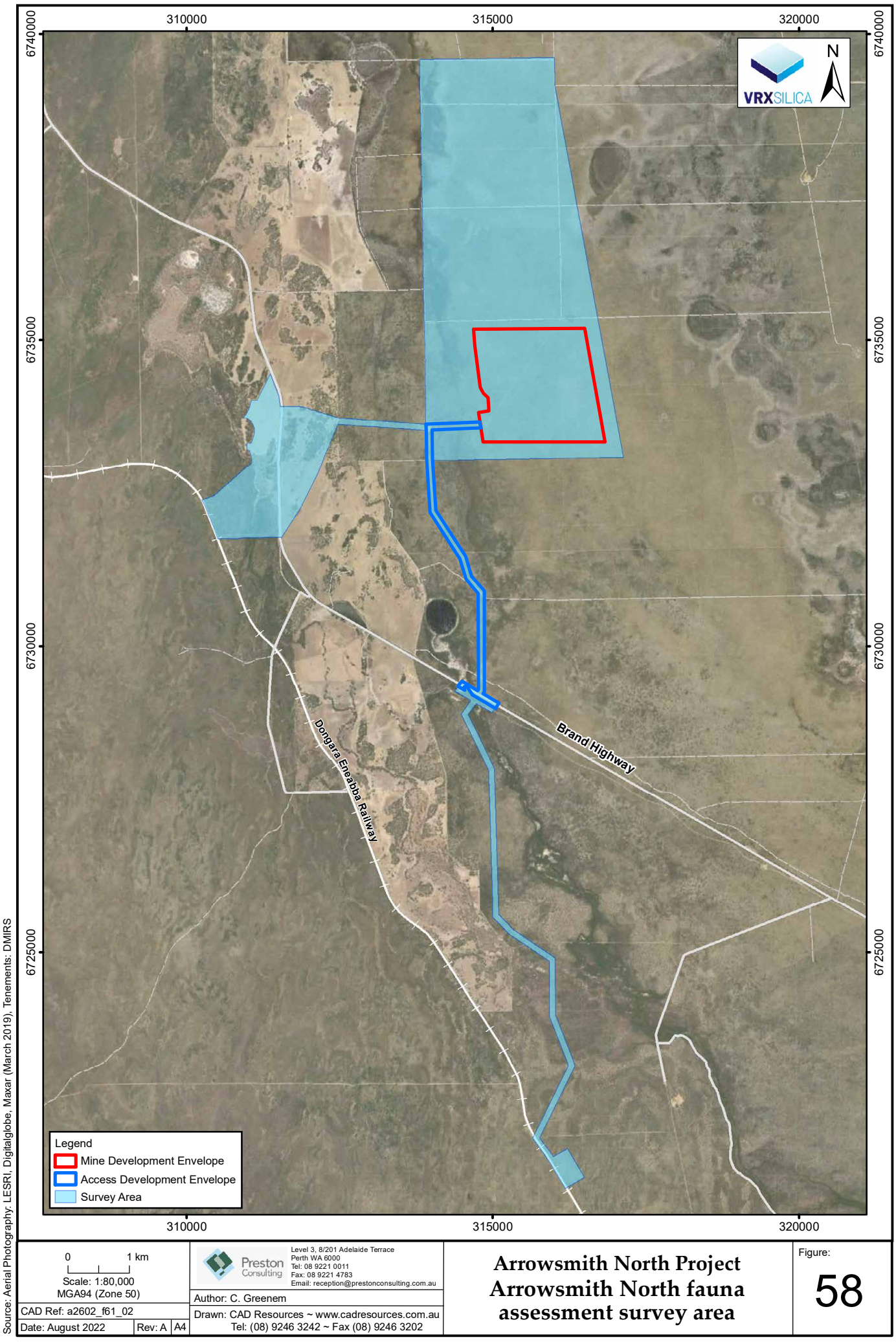


Figure 58: Arrowsmith North fauna assessment Survey Area (BCE, 2022)

The third survey took place from 1 - 9 December 2021 and occurred in conjunction with a detailed survey in the Beharra Springs Silica project area. Key activities during this survey were:

- Inspection of the southern transport corridor to generally familiarise the consultant with this area and verify Vegetation and Substrate Associations (VSAs);
- Install and operate one systematic sampling transect;
    - Pitfall trapping;
    - Funnel traps;
    - Bird censusing;
- Black-Cockatoo foraging habitat assessment;
- Motion sensitive cameras;
- Audio recording units (ARUs) primarily for the Western Ground Parrot;
- Opportunistic invertebrate collection; and
- Opportunistic observations

In addition to the BCE investigations, botanists from Mattiske (2022a) had undertaken detailed flora and vegetation surveys which included personnel walking transects spaced at 20 m intervals across the entire Mine Development Envelope. While searching for rare plants, the personnel are very familiar with features such as Malleefowl mounds and were asked to report any observations that made (none were recorded).

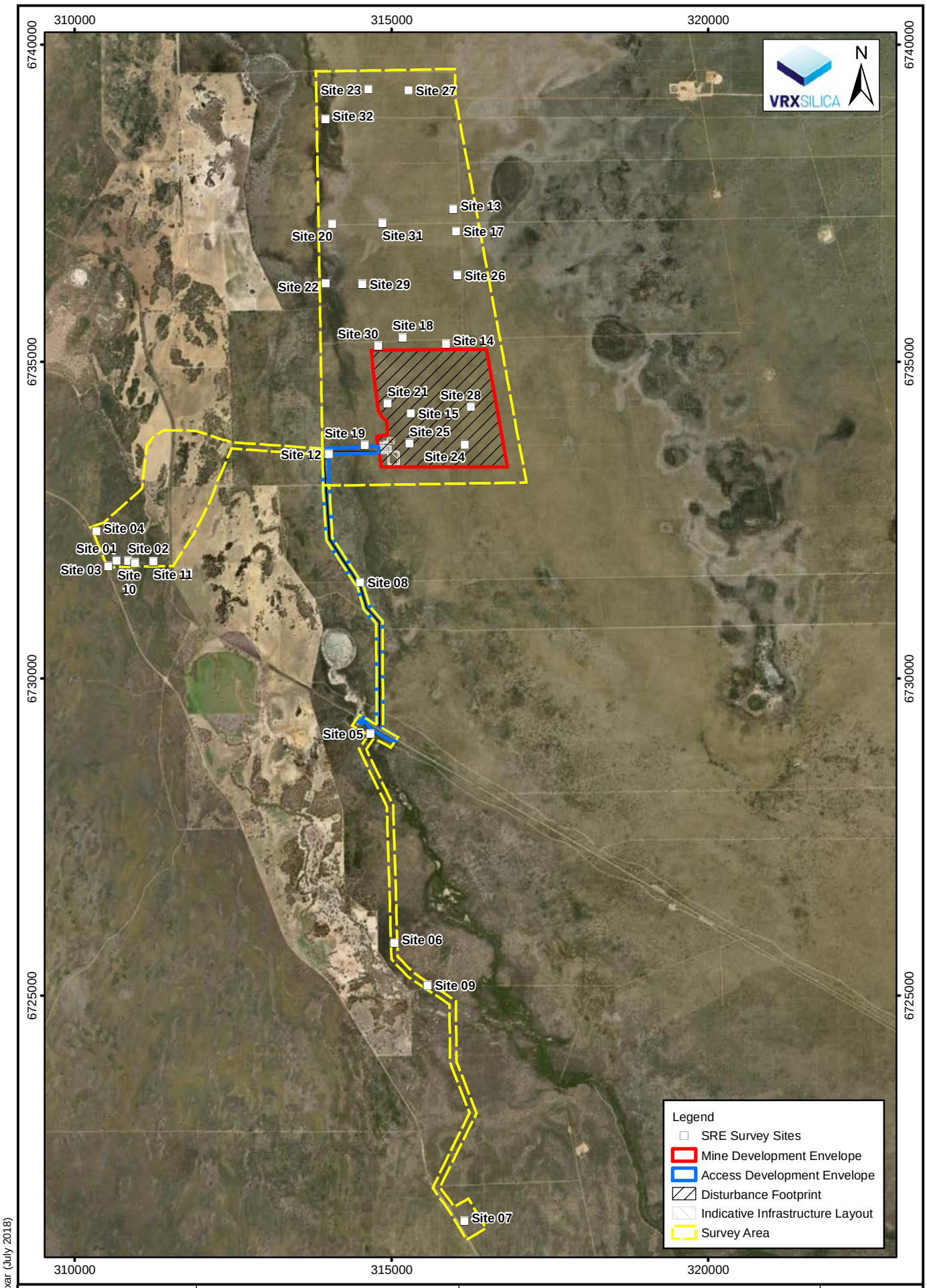
Short-Range Endemic Invertebrates

Bennelongia was engaged by VRX to determine the presence of significant SRE invertebrate fauna occurring in the Survey Area. The assessment was based on the habitat types present within the Survey Area, previous records of terrestrial invertebrates within a search area around the Proposal (50 km buffer) and a single-season survey. A single season Level 2 field survey of SRE invertebrate fauna was undertaken between 15 - 21 June 2021 and between 19 - 21 July 2021. The specific aims of the surveys were to:

- Characterise SRE invertebrates in the Survey Area;
- Provide further information on the potential SRE habitats of the Survey Area and its surrounds; and
- Assess the SRE status of species and the likelihood of their confinement to disturbance areas at the Proposal.

The survey approach and methods used were based on *Technical Guidance: Sampling of Short-Range Endemic Invertebrate Fauna* (EPA, 2016e). The survey was designed to target species from invertebrate groups known to contain a high proportion of range-restricted species: land snails (Gastropoda), millipedes (Diplopoda), centipedes (Chilopoda), pseudoscorpions (Pseudoscorpiones), scorpions (Scorpiones), spiders (Mygalomorphae and Selenopidae), harvestmen (Opiliones) and slaters (Isopoda). Earthworms (Megadrilacea) and velvet worms (Onychophora) were not targeted because they are restricted to high-rainfall areas (Blakemore, 2000; Reid, 2002).

The survey was conducted primarily within the Survey Area defined in Figure 59, with a small portion of sites located in representative habitats outside the Survey Area in order to validate the extent of habitats beyond the Survey Area and provide some regional context.



Imagery: ESRI, Maxar (July 2018)

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CAD Ref: a2602_f56_30

Date: April 2022 | Rev: B | A4

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Arrowsmith North Project

SRE Survey Sites

Figure: 59

Figure 59: SRE Field Survey Area and sampling site locations

Sampling Effort

A total of 32 sites were sampled using a range of active search methods that varied at each site according to habitat, knowledge of the biology of certain taxa and visual observations of burrows or other signs of target species. These sites were distributed across each of the habitats present, and the distribution of sampling sites is shown in Figure 59. In general, up to three methods were applied to each site – wet trapping (Tr), foraging (F) and litter collection (L) (Table 22). At 15 sites all three methods were employed, whereas at 17 sites there was no trapping. The following sections contain detailed descriptions of each different methodologies. Sites where three methods were employed are viewed as comprehensively surveyed, whilst those without trapping are partially surveyed. All sites were sampled once.

Table 22: Numbers of sampling sites for each combination of collection methods

Sample Method	Total
Wet Trapping + Foraging + Litter Collection	15
Foraging + Litter Collection	17
Total	**32**

Foraging

Thorough active searches were performed at all sites and invertebrates from target groups were collected. Searches were conducted at all prospective microhabitats present, including leaf litter, under logs, in the soil and bark at the base of large trees, under large debris, in rock piles and foliated rock across a 1 to 2-hour time period by two staff. Collection notes were taken to document the microhabitats where important specimens were found. While searching across all sites, detecting the presence of burrows was prioritised. Twenty-seven sites comprised of areas of moderate to heavy leaf litter which were searched for burrows by using a leaf blower to reveal any burrow lids or entrances. At 21 sites, 29 representative burrows (scorpions and mygalomorphs) were excavated. Scorpion burrows were observed at twelve sites where a total of 23 cup traps were left over several nights at the entrance of scorpion burrows in an attempt to catch them upon leaving the burrow.

Comprehensive light and UV spotlighting was undertaken at 11 sites by four persons at night to collect nocturnally active species, e.g., night hunting spiders of the family Selenopidae, or animals that fluoresce under ultraviolet light making them easily detectable (scorpions and opilionids).

Animals collected in the field were preserved directly in 100 % ethanol and identified morphologically using dissecting and compound microscopes and the available taxonomic literature, unpublished keys, and reference collections by Bruno Buzatto, Huon Clark and Jane McRae at the Bennelongia laboratory.

At all sites detailed site habitat assessments were undertaken. These metrics comprise shade and litter cover, fire and stock impact, soil types, landscape forms and dominant vegetation.

Wet Pit Traps

'Wet' pit traps were deployed at 15 sites to capture wandering or foraging invertebrates. A total of 45 traps were deployed with variations in the number of traps able to be deployed within each habitat (between one and six traps depending on the ease of digging traps). Each trap consisted of a 0.5 L plastic jar, half-filled with a mixture of 70 % pure ethanol and 30 % propylene glycol as

a preservative, buried with the opening flush with the ground surface. Trap holes were excavated by trowel and shovel. A circular lid mounted on brackets was attached to the traps and kept 2 cm above the opening, in order to reduce vertebrate bycatch and collection of rain and excess debris. Lead netting was not used, also in an effort to further reduce vertebrate bycatch. Finally, a plastic mesh (with 1 cm x 1 cm square holes) was added to the entrance of the traps, once again to further reduce vertebrate bycatch. The traps were left in situ for approximately four weeks, after which time they were retrieved and transported back to the laboratory.

Soil-Leaf Litter Collection

Two composite samples of approximately 1 L of leaf litter and underlying soil were collected from all 32 sites and placed in calico bags. The samples were kept cool and out of direct light, transported back to the laboratory and placed in Tullgren funnels to collect invertebrates using absolute ethanol as a preservative. Subsequently, the substrate was also sorted under dissecting microscopes to collect any remaining specimens.

Other Surveys and Investigations

Several other surveys and investigations have been conducted to support development of the ERD. Exploration investigations by VRX, Flora and Vegetation surveys by Mattiske (2022a) and BMCB (2023), Aboriginal heritage investigations by YMAC (2018 and 2020) and SandS CRM (2022), and interviews with Traditional Owners (Barry Dodd, pers. Comms) were also considered for their incidental observations of significant fauna (such as Malleefowl).

6.3.2 ALIGNMENT WITH TECHNICAL GUIDANCE

Terrestrial Fauna

EPA Guidance Statement 56 (EPA, 2020b) and technical guidance (EPA, 2020a) outlines a number of limitations that may arise during surveying. No limitations to the BCE fauna assessment were identified. Further detail on survey limitation is provided in Table 23.

Table 23: Potential limitations of the Terrestrial Fauna surveys

EPA Limitation	BCE Comment
Availability of data and information.	**Not a Limitation:** Abundant information from databases and previous studies.
Competency/experience of the survey team, including experience in the bioregion surveyed.	**Not a Limitation:** The ecologists have had extensive experience in conducting desktop reviews and reconnaissance surveys for EIA fauna studies, and have undertaken a number of studies within the immediate region.
Scope of the survey (e.g., were faunal groups were excluded from the survey).	**Not a Limitation**: The survey focused on terrestrial vertebrate fauna and fauna values. Some information on invertebrates was available from databases and some invertebrate collection undertaken. Detailed invertebrate survey was carried out by Bennelongia (2021b).
Timing, weather and season.	**Not a Limitation:** Not a limitation, except maxima were very high in the December 2021 survey period. Rainfall in the previous few years had been low and may have suppressed the abundance of some species.

EPA Limitation	BCE Comment
Disturbance that may have affected results	**Not a Limitation:** None. There had been no recent fires that could have affected fauna populations; aerial imagery indicated that the northern half of the Survey Area was last burnt in 2012 whilst the southern half was last burnt in 2007. Nearby locations where other studies had bene carried out had not been affected by recent fire at the time of those studies.
The proportion of fauna identified, recorded or collected.	**Not a Limitation:** All observed fauna were able to be identified.
Adequacy of the survey intensity and proportion of survey achieved (e.g., the extent to which the area was surveyed).	**Not a Limitation:** The site was adequately surveyed to the level appropriate for a Basic level assessment. Fauna database searches covered a 25 km radius beyond the centroid of the Survey Area. The level of sampling, with a single season trapping survey and a multi-season targeted approach, is not considered a limitation as this assemblage is well-understood in the area due to multiple previous field investigations, including detailed, concurrent survey nearby (within 5 km) (refer to BCE (2022; Appendix 14) for more detail).
Access problems.	**Not a Limitation:** There were no access problems encountered.
Problems with data and analysis, including sampling biases	**Not a limitation:** There were no data problems.

Short-Range Endemic Invertebrates

Bennelongia's (2021a) SRE desktop assessment was developed with reference to guidelines and recommendations set out in EPA (2016e). EPA (2016e) proposes that an initial assessment with a risk-based approach is typically required to determine the likelihood of SRE fauna occurring within the Survey Area. The likelihood of SRE fauna occurring within the Survey Area can be inferred from the occurrence or otherwise of geographic boundaries, landform changes or habitat isolates, the results of previous surveys, and advice from the WAM and DBCA. In the context of most assessments, habitat isolates can be identified from vegetation type mapping (assuming this is available at sufficient scale of resolution early in the assessment), as this represents the smallest thematic unit. Vegetation types reflect changes in geology, landform, soil type and hydrology – all of which are likely factors in governing the distribution of SRE taxa. Other habitat mapping, such as detailed geomorphological mapping or soil surveys, may also be informative, provided these are also of suitable resolution (EPA, 2016e).

Based on the EPA's guidance, an initial SRE assessment with a risk-based approach was determined to be a suitable level of assessment for the Proposal. Bennelongia's (2021a) assessment satisfies the EPA's guidance on the level of assessment for SRE's as it considers historical records surrounding the Proposal and recently mapped vegetation communities and soil types within the Survey Area to determine the suitability of the area as SRE habitat and determine the likelihood of recording SRE's within the Survey Area.

The survey approach and methods used in the field assessment by Bennelongia (2021b) were based on the guidelines and recommendations outlined by the EPA (2016d; 2020b). The SRE status of each species recorded in the search and Survey Area was determined using a modified version of the WAMs SRE classification system. The modifications used by Bennelongia (2021b) aim to account for the fact that many recorded species have limited available data on their taxonomy, range, habitat preferences, and/or natural history. The survey was designed to target species from invertebrate groups known to contain a high proportion of range-restricted species.

Many SRE Groups are most active and therefore likely to be collected during and immediately following substantial rainfall. All the foraging in the survey was done in June 2021, which recorded a total of 47.9 mm of rain (in the nearby Carnamah weather station). There was a combined 3.5 mm rainfall during the survey dates (15 – 21 June), and the traps were in place until 21 July 2021, covering approximately four weeks during which another combined 114.1 mm of rain was recorded. This significant amount of rain in the area, combined with the high capture rate of SRE groups reported here, indicates that the timing of the survey was adequate and allowed the collection of the target fauna.

6.3.3 FAUNA HABITAT

General Fauna

The IBRA has identified 26 bioregions in WA which are further divided into subregions. The Survey Area lies in the GS3 sub-region, comprising coastal Aeolian and limestones of the central Perth basin overlain with shrub-heaths and rich in endemics (BCE, 2022). The broader Geraldton Sandplains Bioregion is composed mainly of proteaceous scrub-heaths, rich in endemics, on the sandy earths of an extensive, undulating, lateritic sandplain. Extensive York Gum and Jam woodlands occur on outwash plains associated drainage (Thackway and Cresswell, 1995). The dominant land uses in this bioregion are agriculture, conservation reserves and crown reserves (BCE, 2022). The Survey Area exhibits extremely high floristic endemism, with over 250 species of sandplain flora endemic to the subregion. The area is known Australia-wide and internationally as having particularly high floristic diversity and levels of endemism (Desmond and Chant, 2001).

The Survey Area reflects major components of the Lesueur Sandplain Subregion and the vegetation has been described by Mattiske (2022a). The mine area consists largely of Kwongan heath and associated shrublands typical of the subregion, with small low-lying areas subject to seasonally damp conditions. There is no clearing except for exploration tracks and firebreaks. These environments are also represented along the transport corridor, but the corridor traverses close to a linear riparian feature which lies in some cases <100 m to the east. It also passes close to woodland of *Eucalyptus erythrocorys* over shrubs on sand with outcropping limestone (Mattiske vegetation types W4 and W5; as close as 50 m to the west), and close to Arrowsmith Lake (c. 500 m to the west). The vegetation and soils along the access corridor therefore tend to be more complex than in the mine area, with more shrubby elements. There are large wetlands lying east (outside) of the Survey Area that include tall woodland of eucalypts (Plate 7). Although outside the Survey Area, they may be relevant to some fauna using the development envelopes. There is also a wetland (Arrowsmith Lake) c. 500 m of the access corridor. This contained water at the time of the September 2019 and December 2021 site visits.

Broadly, the Survey Area is part of a 25 km wide corridor along the coast connecting nature reserves and crown land. The corridor extends over 150 km south, however only 13 km north until agriculture becomes the dominant land use. Directly surrounding the site consists of similar bushland except for a partly cleared agricultural property to the west. The Survey Area is thus currently more or less intact and continuous except for this property in the west, although the Riparian Thickets (VSA 2) are linear in nature and thus represent a natural corridor for the movement of some fauna. VSA 1 is broadly-distributed across the landscape, and therefore species such as Carnaby's Cockatoo is very unlikely to be following defined movement corridors, but will rather disperse to source food supplies.

VSAs combine broad vegetation types, the soils or other substrates with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. BCE (2022) identified six VSAs within the Survey Area. However, only three VSAs (1, 2 and 3) are considered relevant to the Proposal due to their proximity and extent within the development envelopes. The descriptions and extents of these VSAs are detailed in Table 24. All VSAs identified by BCE (2022) are shown in Figure 60.

Table 24: VSAs within the Survey Area

VSA	Description	Extent within Survey Area (ha)
VSA1 Kwongan Heath	 Low, dense, proteaceous/myrtaceous shrubland on yellow and pale sands. This VSA contained several *Banksia* species that were in flower during September 2019. Occurs across majority of the Survey Area and varies with landscape position from high to low on stabilised dunes. Vegetation types H1, H2, H3, H4, H5, H7, S3 and S6 (Mattiske, 2022a) Occurs across majority of the mine portion of the Survey Area and varies with landscape position from high to low on stabilised dunes. Occurs along the eastern end of the western corridor and along much of the southern corridor.	1,621.2

VSA	Description	Extent within Survey Area (ha)
VSA2 Dense Riparian Thickets (and seasonal watercourse and swamps)	 Dense thickets mostly of Acacia, in some areas *Allocasuarina campestris*, growing on peaty-sand low in the landscape but extending onto slopes. These thickets are limited in the Survey Area to a small drainage line in the west, but are extensive along the southern transport corridor where this passes close to the Arrowsmith River. There are large wetlands lying east (outside) of the Survey Area that include tall woodland of eucalypts. While outside the Survey Area, they may be relevant to some fauna using the Survey Area. There is also a wetland (Arrowsmith Lake) just west of the Access Development Envelope. This contained water at the time of the September 2019 site inspection. Occurs along the southern corridor where this crosses damplands and the upper reaches of the Arrowsmith River. Vegetation types T1, T3, T4, T5 and T6 (Mattiske, 2022a).	225.6
VSA3 Open Woodland	 Open, low woodland of Banksia sp. with scattered *Eucalyptus todtiana* and *Xylomelum angustifolium* over shrubs on sand. Vegetation type W2 (Mattiske, 2022a). Present in small patches in the mine portion of the Survey Area but tends to merge with VSA 1.	95.5

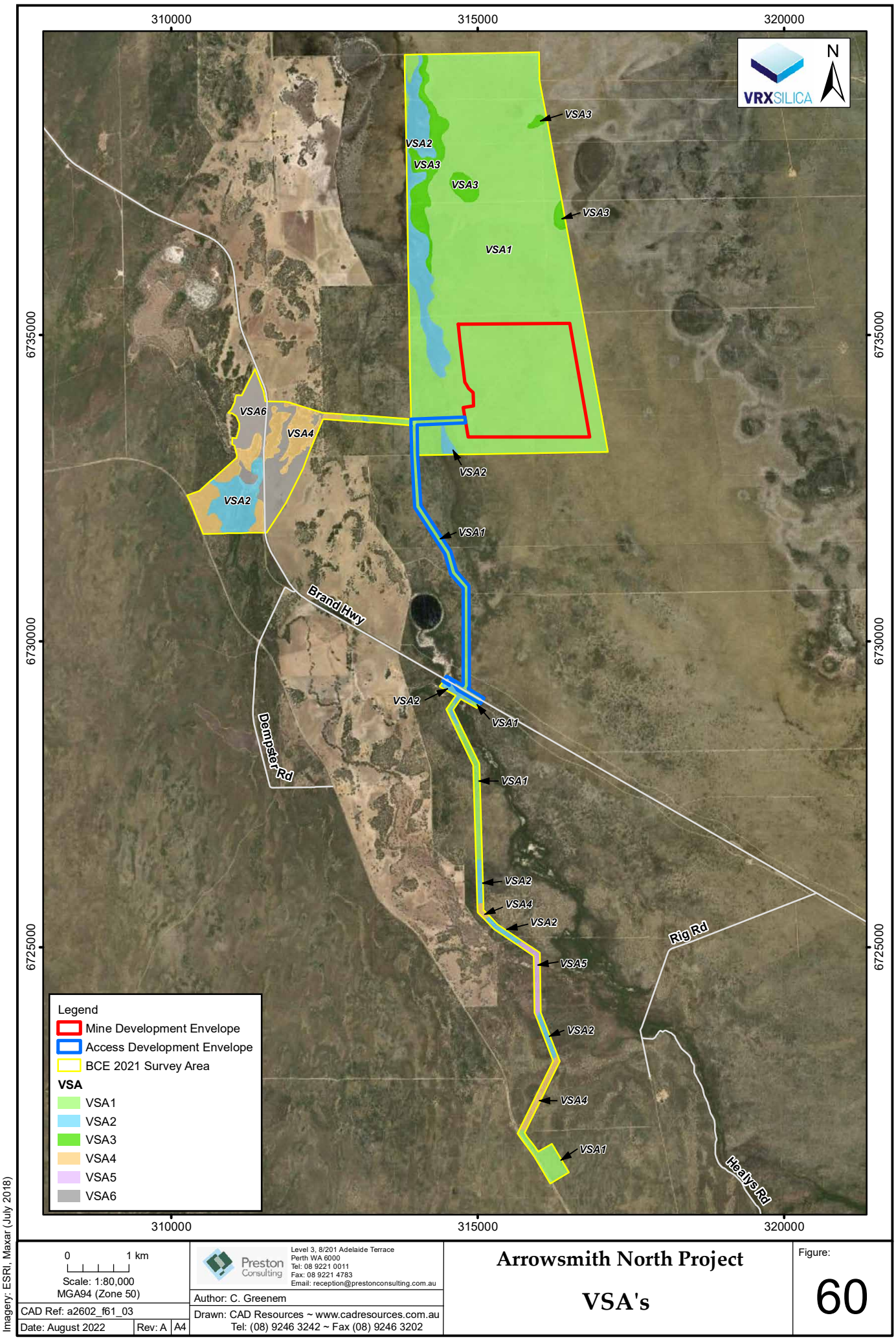


Figure 60: VSAs within the Survey Area

Invertebrate Fauna

Vegetation communities in the Survey Area were mapped by Mattiske (2022a), including the proposed mine site and Western and Southern transport corridor options. Vegetation communities are discussed in Section 5.3.4.

The vegetation communities within the Survey Area have the potential to harbour SRE species, particularly in microhabitats that have higher local moisture content than surrounding areas, such as bark, leaf litter beds, soil humus, large debris and south-facing slopes. Such microhabitats within remnant vegetation on the Geraldton Sandplains are likely to have provided refuges for many relictual invertebrate taxa, as the region has undergone long-term aridification and historical clearing for pastoral land use (Ecologia, 2010). It is possible that the taller and/or thicker vegetation communities, such as woodlands, shrubs and closed heaths, are likely to contain a higher proportion of prospective microhabitats than more open communities within the Survey Area. However, such microhabitats could be found within any of the vegetation communities identified within the Survey Area. Despite a lack of dedicated sampling effort in the Geraldton Sandplains, species from numerous SRE Groups have been recorded from habitats in the bioregion that resemble the Survey Area, including mygalomorph spiders, scorpions, pseudoscorpions, isopods, millipedes and snails (Harvey *et al.,* 2000; Ecologia, 2010). Mygalomorph spiders are particularly well-known to inhabit coastal sandplains of the bioregion; for example, many species of the family Idiopidae are endemic to the Geraldton Sandplains (Rix *et al*., 2018a; Rix *et al*., 2018b; Rix *et al.,* 2019).

6.3.4 General Fauna

The desktop survey (BCE, 2022) identified 203 vertebrate fauna species as potentially occurring in the Survey Area including ten frogs, 51 reptiles, 114 birds and 25 mammals. The assemblage includes 14 vertebrate species of conservation significance, these species discussed further in Section 6.3.6. It is expected that at least 13 mammals, one bird and one reptile identified in the desktop survey have become locally extinct. Excluded species include waterbirds that may overfly the Survey Area and visit nearby wetlands, but which would not use it due to the lack of habitat. Several waterbird species were observed nearby in September 2019 and December 2021, and are included in Appendix 10 of BCE, 2022 which provides an annotated list of species observed in and around the Survey Area.

Frogs

The ten frog species consist mostly of burrowing frogs which rely on seasonal flooding for breeding, and all of these have been recorded in previous BCE surveys within about 15 km of the Survey Area. Three of these previously recorded species were detected in the Survey Area: the Moaning Frog was recorded during pitfall sampling and the Turtle Frog was recorded on ARUs in December 2021, and the Banjo Frog was calling at Arrowsmith Lake just outside the access corridor in September 2020. A fifth species, the Crawling Toadlet, was recorded along Mt Adams road to the north in August 2020. Such burrowing species are likely to breed in seasonal wetlands but disperse widely through upland vegetation for the rest of the year, except for the Turtle Frog that breeds terrestrially and has no need of free water. The drainage line and damplands within the Survey Area, Arrowsmith Lake, and the wetland system to the east, are thus likely to be important for frogs. Three of the frog species (Motorbike Frog, Slender Tree-Frog and Squelching Froglet) do not burrow and are often confined to permanent or near-permanent wetlands. They

have been recorded by BCE at Ejarno Spring (c. 20 km north of the Survey Area) and are expected as residents only along the Arrowsmith River and its tributaries and associated wetlands. They may be present at Arrowsmith Lake.

Reptiles

The majority of the 51 reptile species expected are considered resident in the Survey Area except for the Long-necked Tortoise (expected only as an Irregular visitor in the vicinity of the drainage line and Arrowsmith Lake near Brand Highway) and the Woma (probably locally extinct). The Woma is discussed below as it is of conservation significance and there is a very slight possibility that it is still present. Another reptile of conservation significance returned from databases, the Western Spiny-tailed Skink, is considered not to be present due to lack of suitable habitat (large trees). The Lesueur Sandplains Subregion and more broadly the mid-west coast of WA is recognised for high reptile richness and a large number of species that are at their distributional limits (Maryan, 2005). Species close to their distributional limits includes the gecko *Diplodactylus ornatus*, which was caught in the VRX Arrowsmith North and nearby Beharra Springs project areas in the December 2021 sampling. Previous BCE surveys in the general area have recorded 40 reptile species, with 15 confirmed in Survey Area. Due to the sandy substrate, scarcity of rocky areas (limestone lies just outside the access corridor) and geographic location of the Survey Area, the expected assemblage would be a mix of sand specialists, fossorial and coastal species along with widespread, generalist species.

Birds

The bird assemblage of 114 species included 39 classed as residents, 40 as regular visitors or migrants, 27 considered to be irregular visitors and seven vagrants, and of these, three are introduced species. One species, the Western Ground Parrot, is probably locally extinct but there are occasional reports that it persists in the area. Some other bird species, such as the Western Whipbird (*Psophodes nigrogularis*) and Bush Stone-curlew (*Burhinius grallarius*), may be locally extinct, but there are no confirmed historical records of these in the Survey Area, so these were not included. A total of 106 bird species have been confirmed in the general region by Metcalf and Bamford (2008), including 68 bird species in the Tronox Dongara project area in a two-season survey in 2007. The current series of surveys recorded only 35 species, but this doesn't include the 11 waterbird species recorded around Arrowsmith Lake.

There is likely to be a high seasonal abundance of nectivorous birds present in the Survey Area when vegetation is in flower. The Survey Area are subject to incursions of arid zone bird species in some years. For example, in a 30-year study between Cataby and Badgingarra, the Black Honeyeater was absent most years, but approximately one year in 10 it was among the most abundant of nectarivores (M. Bamford unpubl. Data). Similarly, the White-fronted Honeyeater, Pied Honeyeater, Red-backed Kingfisher, Masked Woodswallow, Ground Cuckoo-shrike and Budgerigar have each been recorded on fewer than five occasions in the 30 year study north of Cataby. It is possible that a sub-species of Red-tailed Black-Cockatoo, the Inland Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksia samueli*), may visit the Survey Area occasionally (note that this sub-species is not of conservation significance). The Survey Area is also expected to be rich in resident birds utilising the dense Kwongan heaths (VSA 1) and thickets (VSA 2), in particular those that prefer to keep low in the vegetation strata such as White-browed Scrubwren, White-breasted Robin and three Fairy-wren species. The riparian thickets (VSA 2) may support some birds through drier periods. Several waterbird species were observed on Arrowsmith Lake

in September 2019; notes on these species are include in Appendix 8 of BCE (2022) but these species are not included in the fauna assemblage of the Survey Area as they all rely on at least moderately large water bodies outside the Survey Area.

Mammals

The mammal assemblage is depauperate, with 28 species known generally from the area, but 13 of these being locally extinct due to predation by introduced predators, habitat destruction and changing fire regimes. An additional nine introduced species may be present. The extant native mammal assemblage includes 12 residents, one irregular visitor (Rakali) and two regular visitors (both bats). Three Dunnart species may occur in the area, including the Grey-bellied Dunnart which is at the northern edge of its range, and the White-tailed Dunnart (confirmed by Metcalf and Bamford, 2008) which also has a limited range along the west-coast extending from Kalbarri to Mooliabeenee (near Gingin). The 'Little Dunnart' (confirmed by Metcalf and Bamford, 2008) is a currently unrecognised taxon similar to *Sminthopsis dolichura* (but with a shorter tail being same length as head and body rather than noticeably longer) and known from the Survey Area, north of Cataby, Mooliabeenee and just north of Muchea (M. Bamford unpubl. Records). Specimens have been lodged with the WAM (1984 from Mooliabeenee and 2018 from near Cataby) and have been DNA tested. They are virtually identical to *S. dolichura* on DNA but morphologically distinct based on tail length, and the Western Australia Museum (WAM) noted that DNA tests are not conclusive (K. Travouillon, pers. Comm.). Apparently, there are no immediate plans to review the taxonomy of *Sminthopsis* but BCE considers it important that the 'Little Dunnart' should be recognised as a distinct taxon even while undescribed. The Survey Area may be an important foraging habitat for bats, although it lacks major roosting sites such as caves (but caves are located in Beekeepers NR).

Nine introduced mammal species are expected to occur in the Survey Area, including the feral predators, Fox and Cat.

A total of 13 native and nine introduced species have been confirmed in the general region by BCE; with 11 native and five introduced species confirmed in the Survey Area in recent surveys.

Fauna Assemblages

Key features of the fauna assemblage expected in the Survey Area are:

- Uniqueness: The assemblage is broadly typical of the Lesueur Sandplain subregion. It is of note because it is substantially intact (except for nearly half the native mammals), has good connectivity to nearby conservation reserves and is rich in reptiles, many of which are limited to sandplains. It has a high proportion of seasonally abundant nectivorous birds;
- Completeness: The assemblage of species from the Survey Area is relatively complete, except for locally extinct critical weight range mammals, and the probable loss of one reptile and one birds; and
- Richness: The Lesueur Sandplain subregion is recognised as being rich in reptile (Maryan, 2005). Other vertebrate fauna groups are not especially rich, but the bird assemblage is notable for high levels of seasonal variation due to the movements of nectar-dependent birds. The mammal assemblage has suffered a high level of species loss.

As a fauna value, the most important features of the Survey Area's assemblage are that it is rich in reptiles and seasonally rich in nectar-dependent birds. It is also important because the assemblage occurs in a region with a high level of habitat loss.

6.3.5 SHORT-RANGE ENDEMIC INVERTEBRATES

Possible or known SREs with the potential to occur within the Survey Area

Using the WAM and Bennelongia databases, Bennelongia (2021a) identified 25 species within the search area that have known or potential ranges of <10,000 km^2. These species included modern and trapdoor spiders, pseudoscorpions, scorpions, centipedes, millipedes and slaters. None of the species had sufficient taxonomic certainty and representation in collections to categorise as 'confirmed SREs'. However, based on available information regarding habitat specialisation, biology and ecology of the species or their close relatives, 14 of the species are considered 'likely potential SREs'. A further ten species were data deficient and assigned as 'likely potential SREs' by default. One species with uncertain identification, the barychelid trapdoor spider *Synothele* `*howi*?' is considered an 'unlikely potential SRE'.

Based on historical records in the BCE database a millipede (*Antichiropus* Eneabba 1) had been previously recorded in the general area (Metcalf & Bamford, 2008; BCE, 2022) and was therefore considered likely to be a resident of the Mine Development Envelope (BCE, 2022). The millipede *Antichiropus* Eneabba 1 is a SRE which is found in Eneabba but has also been recorded at Mt Adams, where it is associated with Acacia thickets close to wetlands (Metcalf & Bamford, 2008). It should be noted that the ecology and distribution of SRE invertebrates is often poorly understood or documented, and the Proposal occurs in a region that is likely to be poorly-surveyed for these groups. Thus, there may be undetected SRE species present, although the development envelopes lack the distinctive geological features (such as isolated rocky hills, outcropping limestone and mesic refugia) with which SRE species are sometimes associated. Seasonal and isolated wetlands are however present close to the access corridor and may support undetected SRE species.

Potential SREs recorded within the Survey Area

The field survey (Bennelongia, 2021b) collected 185 specimens of at least 36 different species from SRE Groups. Groups represented include spiders (at least ten species), pseudoscorpions (at least six species), scorpions (three species), centipedes (five species), millipedes (four species), isopods (five species) and snails (three species). Table 25 provides a list of species from SRE groups collected during the single season survey that are potential SREs. Several records (two records of *Olpiidae* sp., one *Urodacus* sp. and one *Antichiropus* sp.) are of unconfirmed species that are likely to be potential SRE species. For this EIA, these species have been considered as Potential SRE species. Locations of the records are referenced to the sampling site locations in Figure 59.

The SRE status of two species could not be assessed as they were either juveniles (Hersiliidae sp.) or females (Anamidae sp.) and were not investigated genetically because they were only collected in reference sites (outside the impact footprint of the Proposal), and were hence considered not under threat from development.

Table 25: Potential SREs recorded by Bennelongia (2021b)

Higher Classification	Lowest Identification	Specimens	Sites (Bold = within development envelopes)	Known only from the Survey Area	Distribution and SRE status
ARTHROPODA					
ARACHNIDA					
Araneae					
Araneomorphae					
Hersiliidae	Hersiliidae sp.	1	4	?	**Potential SRE**
Mygalomorphae					
Anamidae	Anamidae sp.	1	2	?	**Potential SRE**; DNA required for species level identification
Barychelidae	Barychelidae `BMYG185'*	1	17	**Yes**	**Potential SRE**; singleton
	Barychelidae `BMYG186'*	1	23	**Yes**	**Potential SRE**; singleton
Idiopidae	*Euoplos* sp.*	1	19	?	**Potential SRE**; failed to return a sequence
	*Idiosoma kwongan**	1	**15**	No	**P1 listed; Potential SRE;** also known from Arrowsmith Central (21 km SSE) and Mt Lesueur, 83 km to the south.
	Idiosoma `BMYG189`*	3	7, 30, 32	No	**Potential SRE**; also known from Arrowsmith Central (21 km SSE)
	Idiosoma `BMYG188`*	3	29,13	No	**Potential SRE**; also known from Arrowsmith Central (21 km SSE)
	Idiosoma sp.*	1	26	?	**Potential SRE**; failed to return a sequence
	Idiopidae sp. `BMYG190`*	1	22	No	**Potential SRE**; also known from Arrowsmith Central (23 km SSE)
Pseudoscorpiones					
Chthoniidae	*Austrochthonius* `BPS368`	8	3, 11, 12, 26	No	**Potential SRE**; also known from Arrowsmith Central (21 km SSE)
Chernetidae	Chernetidae `BPS377`*	1	11	No	**Potential SRE**; also known from Arrowsmith Central (17 km SSE)
	Chernetidae `BPS378`	1	22	**Yes**	**Potential SRE**; singleton
Olpiidae	*Beierolpium* 8/4 `BPS370`*	8	18, 20, **24**, **28**, 30, 32	**Yes**	**Potential SRE**; known from six sites up to 5.7 km apart
	Beierolpium 8/4 `BPS374`*	2	1, 26	**Yes**	**Potential SRE**; known from two sites up to 7 km apart
	Beierolpium 8/4 `BPS375`*	1	29	**Yes**	**Potential SRE**; singleton

Higher Classification	Lowest Identification	Specimens	Sites (Bold = within development envelopes)	Known only from the Survey Area	Distribution and SRE status
	Olpiidae sp.*	3	**12**, 26	?	The specimens from site 26 are potentially one of the species above, whereas the specimen from site 12 could not be genetically or morphologically assigned to a genus
Scorpiones					
Urodacidae	*Urodacus* `BSCO071`*	8	1, **8**, 14, 18, **25**, 31, 32	No	**Potential SRE**; also known from Arrowsmith Central (SSE) and Beharra; known linear range of 30 km
	Urodacus `BSCO072`*	1	1	**Yes**	**Potential SRE**; singleton
	Urodacus sp.*	5	1, 19, **24**, 26	**?**	Most likely one of the species above
CHILOPODA					
Geophilida					
Mecistocephalidae	*Mecistocephalus* `BGE060`	7	7, **12**, 22, **25**, 29, 30, 32	No	**Potential SRE**; also known from Arrowsmith Central (23 km SSE)
Schendylidae	*Australoschendyla* `BGE054`	4	3, 9, **12**, 30	No	**Potential SRE**; also known from Arrowsmith Central (SSE) and Beharra; known linear range of 30 km
Scolopendrida					
Scolopendridae	Scolopendrinae `BSCOL079`	1	3	**Yes**	**Potential SRE**; singleton
DIPLOPODA					
Polydesmida					
Paradoxosomatidae	*Antichiropus* `BDI074`*	12	11, **21**	**Yes**	**Potential SRE**; known from two sites 4.46 km apart
	Antichiropus sp.	3	6, 11, **12**	**?**	Likely represents the species above
Spirostreptida					
Iulomorphidae	*Podykipus* sp.	6	**5**, 7, 26, 29	?	**Potential SRE**; also known from Arrowsmith Central (SSE); known linear range of 22 km
MALACOSTRACA					
Isopoda					
Armadillidae	*Buddelundia* `BIS449`*	11	**12**, **25**, 29, 30	No	**Potential SRE**; also known from Arrowsmith Central (SSE) and Beharra; known linear range of 28 km

Higher Classification	Lowest Identification	Specimens	Sites (Bold = within development envelopes)	Known only from the Survey Area	Distribution and SRE status
	Buddelundia `BIS451`	1	3	No	**Potential SRE**; also known from Beharra, 15 km NNE
Philosciidae	*Laevophiloscia* `BIS445`*	13	2, 4, **5**, **21**, **25**	No	**Potential SRE**; also known from Arrowsmith Central (SSE) and Beharra; known linear range of 30 km
	Laevophiloscia `BIS448`	2	4	**Yes**	**Potential SRE**; singleton
	Philosciidae `BIS446`*	19	2, **5**, 9, 10, 11, **12**, 13, **24**, 26, 27, 30, 31	No	**Potential SRE**; also known from Arrowsmith Central (SSE) and Beharra; known linear range of 29 km
Totals		**120**	**8 sites within the development envelopes**	**10 are known only from the Survey Area**	**31 potential SRE invertebrates have potential to occur in the Survey Area (3 of which are unconfirmed species but are likely to be species that are potentially SREs).**

*Indicates species for which molecular work was used to confirm morphological identification and delimitate species boundaries for cryptic species or species represented by females, juveniles or fragmented individuals that could not be morphologically identified to species level, and yet had the potential to represent SRE groups.

6.3.6 SIGNIFICANT FAUNA

For the purposes of this assessment the term 'significant fauna' refers to fauna listed under the EPBC Act or BC Act, DBCA Priority Fauna, species that have declined extensively across the region, or some species that occur at the edge of their range. The potential fauna assemblage of the Survey Area includes 24 significant fauna species (Table 26).

BCE (2022) uses the following rationale for identifying significant fauna species:

- Species classed as CS1 are those listed under WA State and/or Commonwealth legislation;
- Species classed as CS2 are listed as Priority by the DBCA; and
- The CS3 class is subjective and is assigned by BCE (no regulatory listing).

CS3 includes species that have declined extensively across the region, and some species that occur at the edge of their range. This makes their presence in the Survey Area significant as populations on the edge of a species' range are often less abundant and more vulnerable to local extinction than populations at the centre of the range (Curnutt *et al.*, 1996).

Table 26: Significant fauna potentially occurring within the Survey Area

Species	Conservation listing	Presence within Study Area	Expected Status
Invertebrates			
Millipede (*Antichiropus* Eneabba 1)*	Locally Significant	Unconfirmed	Uncertain Records within 12 km of the Survey Area
Bothriembryontid Land Snail (*Bothriembryon perobesus*)	P1	Confirmed	Resident Recorded by Bennelongia (2021b).
Kwongan Heath Shield-Backed Trapdoor Spider (*Idiosoma kwongan*)	P1	Confirmed	Resident Records within 20 km of Survey Area Recorded by Bennelongia (2021b) and BCE (2022).
Springtime Corroboree Stick Katydid (Eneabba) (*Phasmodes jeeba)*	P3	Unconfirmed	Uncertain Records within 50 km of Survey Area
Thorny Bush Katydid (Moora) (*Hemisaga vepreculae*)	P2	Unconfirmed	Uncertain Records within 50 km of Survey Area
Woollybush Bee (*Hylaeus globuliferus*)	P3	Unconfirmed	Uncertain Records within 50 km of Survey Area
Reptiles			
Woma (*Aspidites ramsayi*)	P1	Unconfirmed	Locally extinct?
Carpet Python (*Morelia spilota imbricate*)	Locally Significant	Unconfirmed	Resident
Black-striped Snake (*Neelaps calonotos*)	P3	Confirmed	Resident
Birds			
Malleefowl (*Leipoa ocellata*)	V, S3	Unconfirmed	Irregular visitor
Fork-Tailed Swift (*Apus pacificus*)	M, S5	Unconfirmed	Irregular visitor

Species	Conservation listing	Presence within Study Area	Expected Status
Peregrine Falcon (*Falco peregrinus*)	S7	Unconfirmed	Irregular visitor
Rainbow Bee-eater (*Merops ornatus*)	Locally Significant	Confirmed	Regular migrant
Carnaby's Cockatoo (*Zanda latirostris*)	E, S2	Confirmed	Regular visitor
Western Ground Parrot (*Zanda latirostris*)	E, S2	Unconfirmed	Locally extinct?
Rufous Fieldwren (*Calamanthus campestris*)	Locally Significant	Confirmed	Resident
Shy Heathwren (*Calamanthus cautus*)	Locally Significant	Confirmed	Irregular visitor
White-browed Babbler (*Pomatostomus superciliosus*)	Locally Significant	Unconfirmed	Vagrant
Crested Bellbird (*Oreoica gutturalis*)	Locally Significant	Unconfirmed	Resident
Mammals			
Brushtail Possum (*Trichosurus valpecula*)	Locally Significant	Unconfirmed	Locally Extinct?
Brush Wallaby (*Notamacropus Irma*)	P4	Confirmed	Resident
Rakali (*Hydromys chrysogaster*)	P4	Unconfirmed	Irregular visitor
Fish			
Western Minnow (*Galaxias occidentalis*)	Locally Significant	Unconfirmed	Irregular Visitor
Western Pygmy-perch (*Nonnoperca vittata*)	Locally Significant	Unconfirmed	Irregular Visitor

EPBC Act listed species: V = Vulnerable, E = Endangered, C = Critically Endangered, M = Migratory.
BC Act listed species: S1 – S7 = Schedule 1 – 7;
*DBCA Priority Species: P1 – P5 = Priority 1 – 5. * SRE*

Invertebrate Fauna

Potential Significant Invertebrate Fauna

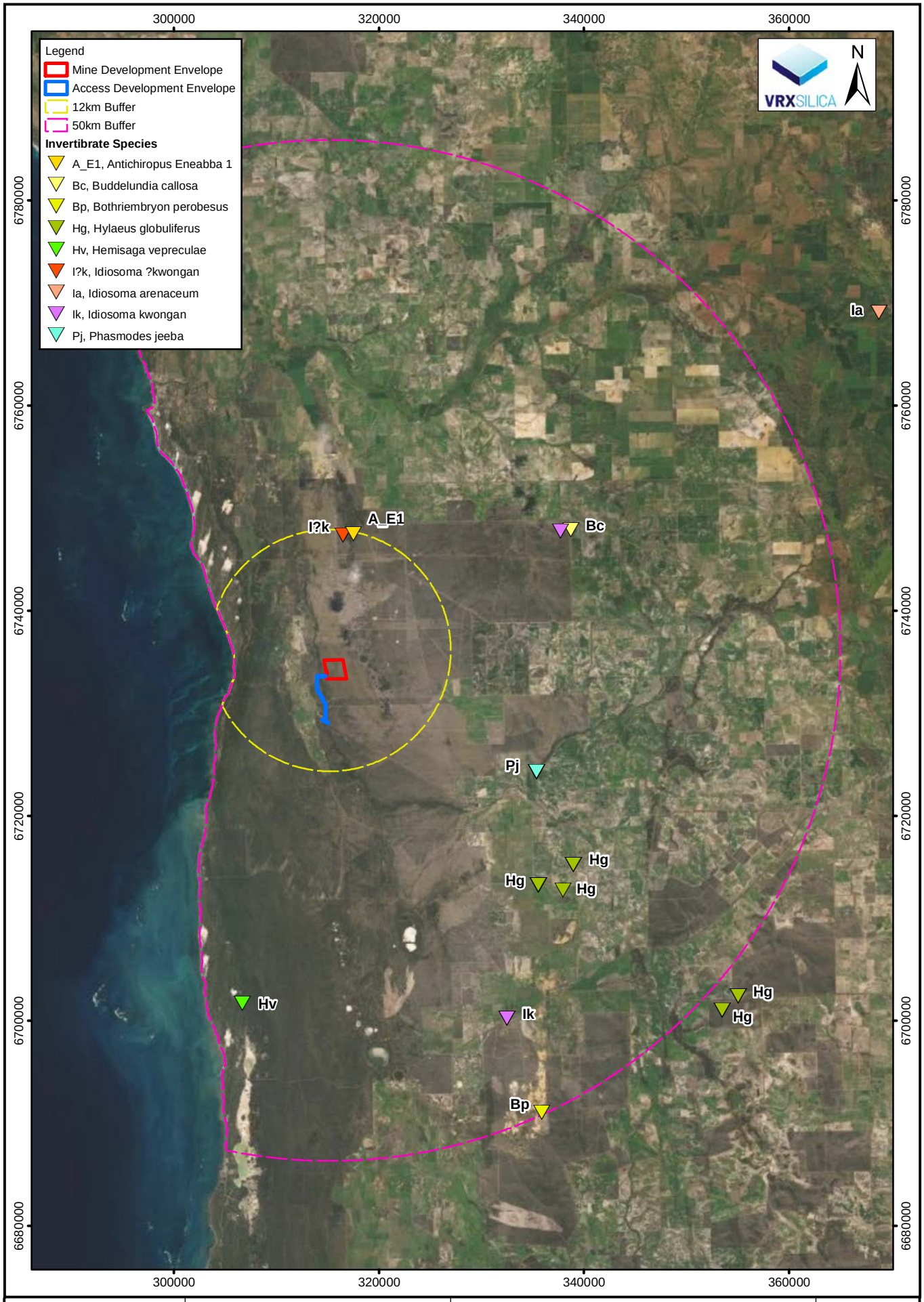
Assessments of the Survey Area by BCE (2022) and Bennelongia (2021a; 2021b) identified three invertebrate fauna species that are or may be of conservation significance that have the potential to occur within the development envelopes, these species include: a Bothriembryontid Land Snail (*Bothriembryon perobesus*), Woollybush Bee (*Hylaeus globuliferus*) and Kwongan Heath Shield-Backed Trapdoor Spider (*Idiosoma kwongan*).

BCE (2022) also identified four additional species as having the potential of occurring within the Survey Area:

- Springtime Katydid (*Hemisaga vepreculae*) (P2);
- The locally significant Millipede (*Antichiropus* Eneabba 1; an SRE discussed in the following section) (CS3);
- The slater *Buddelundia callosa* (CS3); and
- Springtime Corroboree Stick Katydid (*Phasmodes jeeba*) (P3).

There is a cluster of records of Springtime Corroboree Stick Katydid (*Phasmodes jeeba*) (P3) approximately 25 km south-east of the Survey Area, likely in Kwongan Heath similar to that present within the Survey Area. However, this species was not found by Bennelongia (2021b).

Confirmed records of significant invertebrate fauna within 50 km of the BCE (2022) Survey Area are provided are provided in Figure 61.



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Arrowsmith North Project
DBCA Listed Threatened & Priority Invertibrate Species

Figure: 61

Figure 61: Locations of DBCA-listed (Threatened and Priority) invertebrate species within 50 km of the Survey Area

Recorded Significant Invertebrate Fauna

Of the potential significant invertebrate fauna listed above, two species (*Bothriembryon perobesus* (P1) and *Idiosoma kwongan* (P1)) were recorded, both during the Bennelongia (2021b) field survey. One record of *Idiosoma kwongan* was recorded by BCE (2022) in a survey for Strike energy 20 km east of the Proposal. These species are discussed further in the following sections and their locations are shown in Figure 62.

Bothriembryontid Land Snail (Bothriembryon perobesus)

The Priority 1 snail *Bothriembryon perobesus* is listed as poorly known under the BC Act. It has previously been recorded as far south as Gingin (approximately 200 km south of the Proposal) and as far north as Geraldton (approximately 90 km north of the Proposal). Within the desktop search area, it has been collected from locations surrounding the Proposal, with the nearest collection approximately 5 km west on the coast (Figure 61). Many of the previous collections are associated with Banksia woodlands and low shrubland on white sandy soils, similar to the vegetation within the development envelopes (Whisson, 2019). While most species in the genus are typically only collected among leaf litter, *B. perobesus* has been found on bare sand and the branches of shrubs (Whisson, 2019).

Bennelongia (2021b) collected shells of dead *Bothriembryon perobesus* individuals that are perfectly consistent with the morphology of this Priority 1 listed species (confirming its presence; Figure 62). The site where this species was found is a sand plain with *Banksia* shrubland, where the vegetation community has been described as type "H1". This habitat is locally widespread and connected to habitat outside the Survey Area towards the Southwest. It is therefore likely that this species is not restricted to any habitats in the Survey Area.

Shield-Backed Trapdoor Spider (Idiosoma kwongan)

The Priority 1 shield-backed trapdoor spider, *Idiosoma kwongan*, is currently considered data deficient in terms of biology and ecology, but it appears to be restricted to the southern Geraldton Sandplains bioregion (i.e., the Lesueur Sandplains) (Rix *et al.,* 2018a). The collection within the search area is among the most northerly known records of the species and is approximately 30 km south-east of the Proposal (Figure 61). However, the collection was from Kwongan vegetation at the Eneabba Mineral Sands mine site, which is similar to the Proposal (Iluka, 2012).

A single record of *Idiosoma kwongan* was recorded by Bennelongia (2021b; Figure 62). The individual was sequenced, and genetically matched the specimens T27117 (GenBank accession code MH144661) and T139468 (accession code MH144660) at only 3.5-3.8 % Mt-COI divergence, confirming the morphological identification. The detection of this species in the Survey Area represents an important range extension for a Priority 1 listed species (Rix *et al.,* 2018a), changing the known linear range from 36 km (if you only consider previous WAM records) to 83 km. The site where this species was found is on a flat white sand plain with small *Banksia* shrubland, where the vegetation community has been described as type "H2". This habitat is locally widespread and connected to habitat outside the Survey Area towards the East and Southeast.

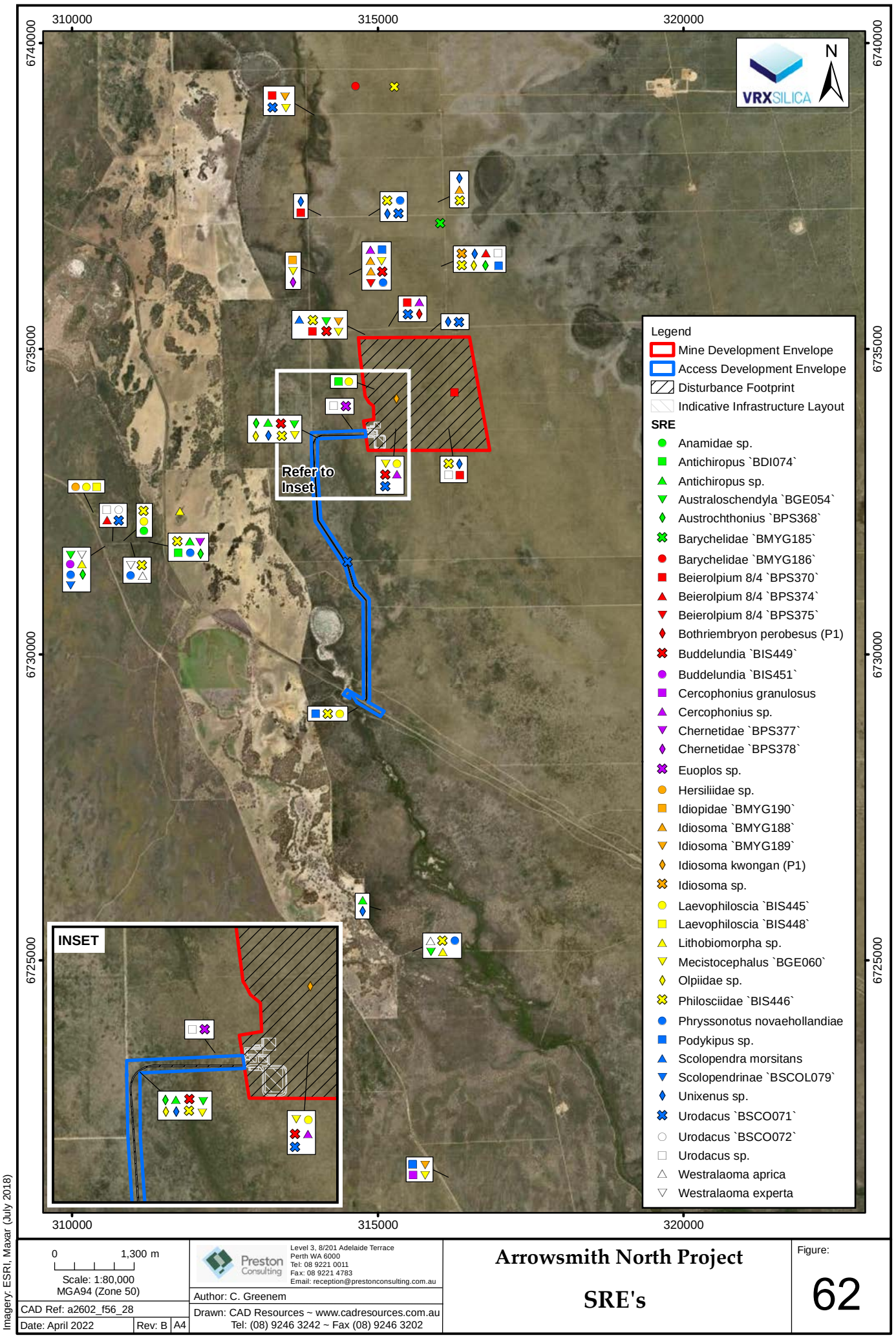


Figure 62: Significant Invertebrate Fauna Records (Bennelongia, 2021b)

It has also been noted in the field that the burrows of this species are usually under *Allocasuarina* or *Casuarina* trees, which is associated with the fact that the species uses leaves of these trees to make a 'moustache-like' arrangement of twiglines around the door of their burrows (Rix *et al.,* 2018a). The vegetation community described as type "H2" does not specifically mention these trees, but they still occurred in small numbers in the collection site of this species. It seems that *Idiosoma kwongan* might not be restricted to any habitats in the Survey Area, and might occur in areas where at least a few *Allocasuarina* or *Casuarina* trees are present, even if these trees are not the dominant vegetation type.

Idiosoma kwongan was also recorded by BCE in 2021 in the Beharra project area to the north and from the Strike Energy project area c. 20 km to the east (BCE, 2022).

Vertebrate Fauna

Expected Vertebrate Fauna Assemblage

The expected vertebrate assemblage include 18 significant vertebrate species (note three of these species may be locally extinct) comprising five CS1, four CS2 and nine CS3 species (Table 27). Thirteen additional significant species are considered to be locally extinct; these are also discussed below.

Species Likely to be Locally Extinct

Thirteen mammal species that formally occurred in the surrounding area, some likely well into the 20th Century, are now considered locally extinct. These species are mostly of high significance and in some cases are now represented only by island sub-species, with the mainland subspecies that would have been present in the Survey Area being extinct. Their local extinction is likely due to a combination of factors including habitat degradation, changed fire regime and feral predators. Some of these locally extinct species do still occur in the south-west (Chuditch, Tammar, Quenda and Woylie) but there is no evidence they persist in the general region. All would almost certainly have been detected in the multiple previous surveys in the region, particularly surveys with high use of cameras (Figure 56).

Woma

The south-west population of the Woma is listed as Priority 1 because of severe population decline, probably due to habitat clearing and predation by Foxes. It was not returned from databases for the region of the survey areas, but there are records from Kwongan heath on sand at Badgingarra. It was almost certainly a former resident in the survey areas and while probably locally extinct, there is a slight chance it persists. If present at very low densities, the species would be almost undetectable.

Table 27: Conservation significance vertebrate fauna that may occur within the Proposal Area (BCE, 2022)

CS1 – Listed under WA State and/or Commonwealth legislation	
Malleefowl (*Leipoa ocellata*)	
Conservation status	Vulnerable; Schedule 3. Has declined in range due to habitat clearing and fragmentation, and probably impacts of feral predators.
Distribution and habitat	Semi-arid woodlands and shrublands across southern Australia.
Ecology	Occurs single or in pairs with an unusual breeding system based upon incubation of eggs in a mound. Terrestrial but can fly strongly, and feeds on a range of plant and animal materials. Males maintain breeding mounds and do almost all work on the mound. They have several mounds in their home range of up to 4.6 km^2 and change mounds at intervals of several years as litter reserves become depleted, but are generally sedentary within their home range (Marchant and Higgins, 1993).
Expected occurrence	Irregular Visitor. Occasionally recorded in the general area. The Storr-Johnstone Bird Databank (R. Johnstone, pers comm.) has records of disused mounds of the Malleefowl 10 km south of Eneabba (c.50 km south of the Survey Area) and at a location along the Arrowsmith River about 10 km south of the Survey Area (Figure 63). The latter was of two mounds found in 2008, with one described as 'fairly new'. The two disused mounds were in *Acacia* shrubland and such vegetation associated with the Arrowsmith River is the most likely environment in the broader region to provide habitat for the Malleefowl. There is a recent (2022) unconfirmed report of an active mound in the same general area (R. Johnstone pers comm.). This suggests there may be a breeding population to the south. However, there is no indication that there is a resident, breeding population in the Survey Area, with no evidence of the species found during the site visits to the Survey Area or nearby despite the tracks and mounds being distinctive and conspicuous. Similarly, across multiple surveys in the broader region carried out by BCE the species has not been encountered. The Survey Area was subject to an intensive search for rare flora, with personnel at a 20m spacing across the entire area, and no mounds were encountered (the botanists were familiar with mounds of the species and this transect search approach is consistent with current guidance on searching for Malleefowl (NHT 2004, McGrath et al. 2010)). Much of the vegetation may be too low as the Malleefowl usually occurs in woodlands and tall shrublands. Acacia shrubland (VSA 2; see Figure 63) does occur in the west of the Proposal, but the lack of records suggests no Malleefowl are present and impacted areas do not support this environment. If present, the birds would occur at a low density of <1 bird/km2 based on information provided by Marchant and Higgins (1993). In WA Malleefowl are also found in some shrublands dominated by *Acacia*, and occasionally in woodlands dominated by eucalypts such as Wandoo *E. wandoo*, Marri *Corymbia calophylla* and Mallet *E. astringens* (Storr, 1985, 1986, 1987; Storr & Johnstone, 1988; Benshemesh & Malleefowl Preservation Group, 2001; Sanders et al., 2003). The habitat requirements of Malleefowl anywhere in Australia are poorly understood and have as yet received limited study due to the difficulty of efficiently assessing the abundance of the birds at different sites. A sandy substrate and abundance of leaf litter are clear requirements for the construction of the birds' incubator-nests (Frith, 1959, 1962). Densities of the birds are generally greatest in areas of higher rainfall and on more fertile soils (Frith, 1962; Benshemesh, 1992; Copley & Williams, 1995) and where shrub diversity is greatest (Woinarski, 1989). However, the floristic and structural requirements of the species are not well understood and have been examined in only two studies of limited scope. In an interview with Barry Dodd, an Elder of the Amangu People (Traditional Owners of the Proposal) and Custodian of the country surrounding the Proposal, it was recorded that Mr. Dodd had never witnessed any Malleefowl within the Aboriginal Heritage Survey area conducted by YMAC (2020), Mr. Dodd mentioned "…I've never seen a Malleefowl out there (referring to the Proposal). It really is the wrong country for them." (Pers. Comm. Barry Dodd, 2021, Appendix 18). Ethnozoological investigations were conducted in collaboration with the Southern Yamatji Community to better understand their connection to Country and to understand the Southern Yamatji Peoples experience with specific fauna species. Discussion were held with Southern Yamatji People over the presence of select significant fauna, particularly Malleefowl. Survey participants were asked about their prior knowledge of the area particularly in relation to the presence of Malleefowl. VRX received consistent responses stating that Malleefowl had not been recorded in the area (SandS CRM, 2022).

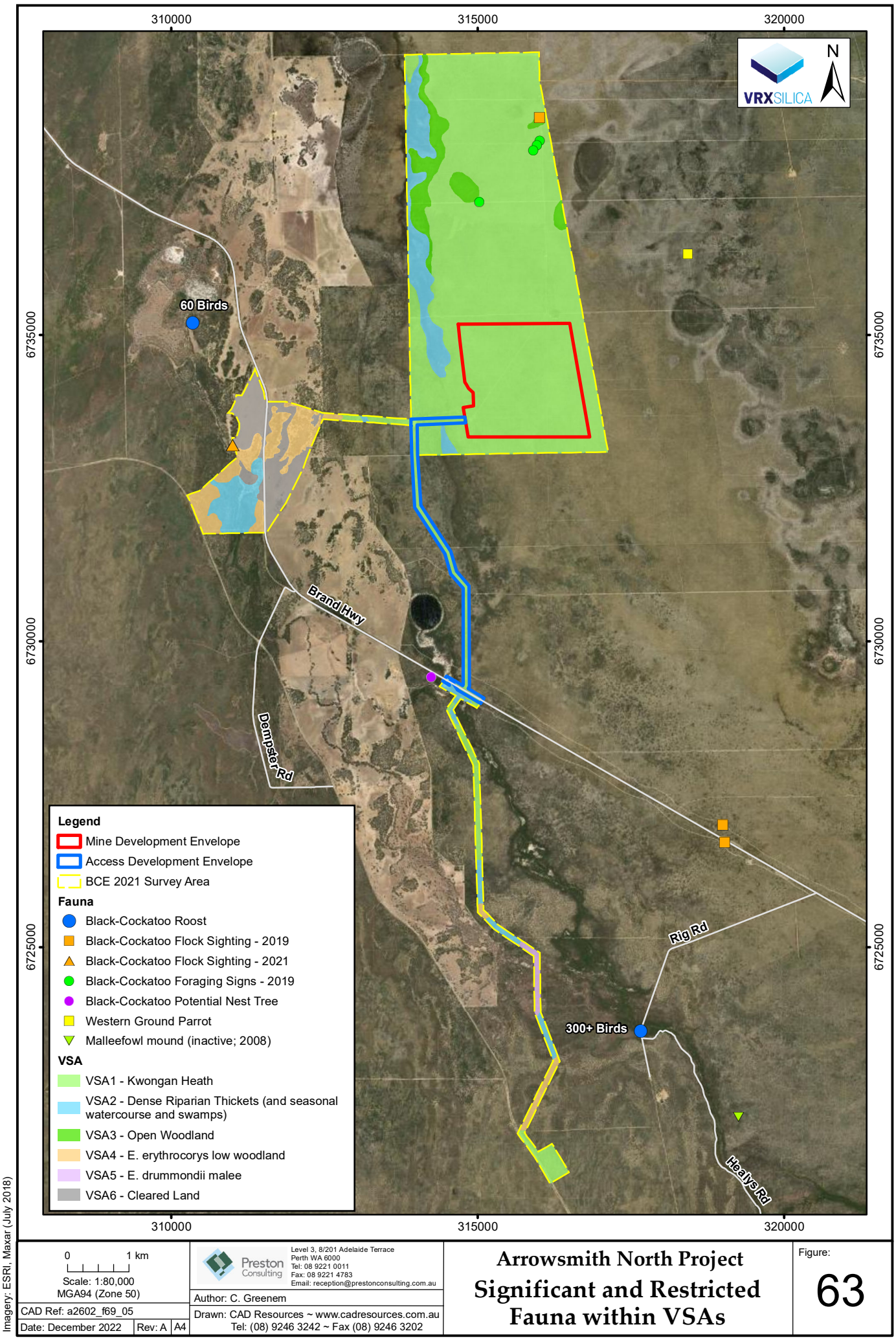
	No Malleefowl mounds were observed during VRX's exploration activities, Aboriginal Heritage, fauna and flora and vegetation surveys (including foot traverses and targeted surveys) for the development envelopes.
Fork-tailed Swift (*Apus pacificus*)	
Conservation status:	Migratory; Schedule 5. Considered to be significant because it is migratory and subject to international conservation agreements.
Distribution and habitat:	The swift is a largely aerial species of unpredictable occurrence in WA. There are scattered records from the south coast, widespread in coastal and subcoastal areas between Augusta and Carnarvon, scattered along the coast from south-west Pilbara to the north and east Kimberley region. Sparsely scattered inland records, especially in the Wheatbelt, but more common in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (Higgins, 1999; DAWE, 2022a). Aerial, usually flying from as low as one metre to in excess of 300 m above the ground.
Ecology:	A diurnal, aerial insectivore, this species often forages along the edge of low pressure systems in flocks of 10 - 1000 birds (Higgins, 1999; DAWE, 2022a). Breeds in Siberia (April to July) and spends the non-breeding season (October to mid-April) in Australia. Being aerial, it is effectively independent of terrestrial ecosystems when in Australia.
Expected occurrence:	Irregular visitor. Flocks may pass over the Survey Area briefly at intervals of a year or more. A flock of about ten birds was observed high (several hundred metres) over Dongara on 7 December 2021, during the field trip, and was possibly part of a much larger group of birds moving across the landscape. The birds were present for about five minutes and then moved on, which is typical of observations of this species.
Peregrine Falcon (*Falco peregrinus*)	
Conservation status:	Schedule 7. Only listed under the BC Act.
Distribution and habitat:	More or less cosmopolitan throughout Australia (Menkhorst *et al.,* 2017). This species occurs in a variety of habitats but is usually reliant on cliff faces or tall trees for nesting (Debus, 2019).
Ecology:	A highly adept aerial predator that predominantly forages on birds, although will also occasionally take invertebrates, fish, reptiles and mammals Debus (2019). Mostly diurnal or crepuscular.
Expected occurrence:	Irregular visitor. The Survey Area may be part of the foraging range of a pair. It is unlikely to breed in the Survey Area due to the lack of suitable nesting sites such as cliff faces, large tree hollows and large nests of other birds, although there are large trees around the drainage systems to the east and south, and shallow rivers in the broader region.
Western Ground Parrot (*Pezoporous flaviventris*)	
Conservation status:	Critically Endangered; Schedule 1. Of very high significance and has suffered a catastrophic decline in range and abundance with the only confirmed population numbering about 50 - 100 birds in the Cape Arid region east of Esperance. The decline in range is due to a combination of factors, but broad-scale fire (as opposed to patchy fires that provide a range of fire-age vegetation) and feral predators (possibly feral Cats in particular) are of key concern.
Distribution and habitat:	Formerly widespread in near-coastal shrublands of the south-west, including in the Kwongan heaths north of Perth. Thus, a species primarily of VSA 1.
Ecology:	A terrestrial and ground-nesting parrot that feeds on a range of plant materials; however, can fly well. Calls before dawn and after sunset, and activity correspondingly often crepuscular. Favours long-unburnt vegetation but will forage in recently-burnt areas.
Expected occurrence:	Possibly locally extinct with no recent confirmed records north of Perth. However, there are accounts of the Western Ground Parrot persisting in this region, including a fairly reliable sighting in 1992 of an adult male and an immature bird. The sighting was very close to the Survey Area, less than 2 km from the eastern boundary (Figure 63). In 2008 and 2012, targeted Ground Parrot surveys were undertaken in the areas surrounding the Survey Area in the former Tronox leases to the east and Beekeepers NR to the west and south (Bamford, 2008; Bamford, 2012). The surveys involved several people listening for calls of the Parrot during the times before sunrise and after sunset, when the species is

	most vocal. In 2012, one and two note calls were heard from two individuals that were possibly from the Western Ground Parrot. However, given the full song was not heard, the species could not be confirmed. Whilst not confirmed, it is a possibility that the species does persist in the area. The aural record was in close proximity to the Survey Area – 6 km east of the south-eastern boundary. Both 1992 and 2012 records were in areas of Kwongan shrubland. Based on the above information, ARUs were set within the Survey Area in October 2019 and 2021 however the species was not detected.
Carnaby's Cockatoo (*Zanda latirostris*)	
Conservation status:	Endangered; Schedule 2. Of significance because of population decline due largely to clearing of breeding habitat in the Wheatbelt and foraging habitat in the non-breeding range near the coast.
Distribution and habitat:	Endemic to the South-West, roughly south of a line Kalbarri to west of Esperance, but the range has contracted from the Wheatbelt in the last 50 years. Breeds in eucalypt woodlands but forages in eucalypt woodlands and proteaceous woodlands and heaths.
Ecology:	A granivore that also feeds on insect larvae, the species is migratory with inland breeding habitat (c. July to December) and more coastal non-breeding habitat, but movements are incomplete and some birds are beginning to breed in the former non-breeding range near the coast. The Survey Area is in a region where the breeding and non-breeding ranges overlap. Often forms large flocks in the non-breeding season and roosts in traditional locations; usually locally large trees close to water. Proteaceous woodlands and heaths are important during the breeding and non-breeding seasons.
Expected occurrence:	A regular visitor to the Survey Area with records from September 2019; also regularly recorded during other work in the broader region including 14 birds observed just south of Mt Adams Road in August 2020, and a flock of about 70 birds observed about 5 km to the west in December 2021. The Survey Area provides foraging habitat of proteaceous and myrtaceous shrubland in VSA 1 and VSA 3, however roosting and breeding are unlikely due to the lack of suitable trees. There is potential nesting habitat approximately 2 km east of the Survey Area in River Gums along a drainage line, and roosting locations are known to the north, west and south-west. This species is discussed in detail below.
CS2 – Listed as Priority by the DBCA	
Woma (*Aspidites ramsayi*)	
Conservation status:	Priority 1 (southern population). Cogger *et al*. (1993) classified the south-western population as Endangered, whilst Maryan (2005) suggested it may be critically endangered given the rarity of recent sightings. The southern population of the Woma has declined across much of its range, probably due to clearing and predation by feral predators. It is this South-West population that is listed as Priority 1. The northern (western deserts) population appears to be secure.
Distribution and habitat:	Formerly found across the dry heathlands and woodlands of the South-West, from Shark Bay to the Great Victoria Desert, but now greatly reduced in this region. Still widespread in the Great Sandy and Little Sandy Deserts. Usually associated with sandy soils.
Ecology:	A terrestrial predator of small to medium-sized vertebrates in heathlands, woodlands and spinifex hummock grasslands on sand. Often nocturnal but occasionally encountered during daylight hours.
Expected occurrence:	Possibly locally extinct. It was not returned from databases for the region of the Survey Area, but there are records from Kwongan heath on sand at Badgingarra. It was almost certainly a former resident in the Survey Area and while probably locally extinct, there is a slight chance it persists in the surrounding region. If present at very low densities, the species would be almost undetectable.
Black-striped Snake (*Neelaps calonotos*)	
Conservation status:	Priority 3. The Black-striped Snake has a naturally limited distribution and a large part of its range lies within areas affected by agricultural and/or urban development.
Distribution and habitat:	Confined to the coastal plain between Mandurah and Dongara; sandy soils of heaths and woodlands. Bush *et al.* (2007) suggest that the Dongara population is isolated as at the time there was only a single record from that area, but the Metcalf and Bamford (2008) record of the species from the Tronox Lease suggests it is more widespread in the north of its range. The possibility that the northern population is isolated is supported by the lack of records in the Eneabba area, where extensive fauna surveys have been undertaken. This is despite there being suitable environments between Cooljarloo ((about 120 km south of Arrowsmith and where the species has been recorded by BCE) and

	the Dongara/Arrowsmith region. The Metcalf and Bamford (2008) specimen was found at (50J) 317862mE, 6749842mN. It was in kwongan shrubland on sand like much of that in the current Survey Area.
Ecology:	A fossorial species that probably feeds on small lizards. Often found by hand-searching through loose, sandy soil.
Expected occurrence:	Resident and presumably widespread in the Survey Area in VSAs 1 and 3.
Brush-Wallaby (*Notamacropus irma*)	
Conservation status:	Priority 4. The Brush Wallaby is widespread in the South-West but has declined due to habitat loss (clearing for agriculture and urban development) and may also be affected by Fox predation.
Distribution and habitat:	Endemic to the South-West more or less south of line from Geraldton to Esperance, although it has disappeared from much of the Wheatbelt due to clearing. Occurs in a wide range of vegetation types from Eucalypt Woodland to Banksia Woodland, Shrublands and Kwongan. The Brush Wallaby is encountered consistently in Kwongan heath and low woodlands from Cataby to Dongara (M. Bamford pers. obs.). Metcalf and Bamford (2008) saw one animal in the Tronox Dongara project at (50J) 322500mE, 6744600mN.
Ecology:	Based on detailed radio-tracking study in Banksia Woodland in Whiteman Park (Bamford and Bamford, 1999): a largely solitary species that browses on shrubs and bushes; rarely on grass. Rarely drinks free-standing water and rarely ventures from dense vegetation. Individuals occupy home ranges of up to c. 10 ha; larger in males than females and those of females overlap.
Expected occurrence:	Resident and presumably widespread in the Survey Area; may favour taller vegetation of VSAs 2 and 3 than the low heath of VSA 1.
Rakali (*Hydromys chrysogaster*)	
Conservation status:	Priority 4. In the South-West the Rakali has declined due to wetland degradation (clearing and salination).
Distribution and habitat:	The Rakali is semi-aquatic and occurs in permanent and reliably seasonal waterways around Australia. In some areas it also occurs along marine coastlines. In the South-West it occurs along major rivers and in large wetland systems where the native riparian vegetation is more or less intact.
Ecology:	A semi-aquatic predator of freshwater crustaceans and other large aquatic invertebrates, fish, ducklings and probably young tortoises. It favours permanent water (lakes, streams and rivers) but will move into seasonal wetlands.
Expected occurrence:	Irregular visitor. The species may occur occasionally along the Arrowsmith River and other rivers in the region, so individuals may at times move through the drainage systems from the Arrowsmith River to Arrowsmith Lake, but they are too seasonal and intermittent to support the species regularly.
CS3 – Locally Significant	
Western Minnow (*Galaxias occidentalis*)	
Conservation status:	Considered of local significance (CS3) because the Arrowsmith River is the northern limit of the species' range. Has probably suffered some range contraction due to wetland loss and degradation, and declining rainfall.
Distribution and habitat:	Endemic to permanent wetlands of the South-West from the Arrowsmith River to 100 km east of Albany. Occurs in fresh and brackish water.
Ecology:	A fast-moving predator that moves upstream to breed in winter, so will spread into usually dry sections of watercourses on a seasonal basis.

Expected occurrence:	Irregular visitor. Likely to occur seasonally in the upper reaches of the Arrowsmith River and small numbers may occasionally disperse into the drainage system crossed by the access route.
Western Pygmy-perch (*Nonnoperca vittata*)	
Conservation status:	Considered of local significance (CS3) because the Arrowsmith River is the northern limit of the species' range. Has probably suffered some range contraction due to wetland loss and degradation, and declining rainfall.
Distribution and habitat:	Endemic to permanent wetlands of the South-West from the Arrowsmith River to near Hopetoun (east of Albany). Occurs in fresh and slightly brackish water. Considered by Allen *et al.* (2002) to be the most widespread and abundant native freshwater fish in the South-West.
Ecology:	A predator but able to take only small items due to small mouth. Will disperse during high water levels.
Expected occurrence:	Irregular visitor. Likely to occur seasonally in the upper reaches of the Arrowsmith River and small numbers may occasionally disperse into the drainage system crossed by the access route.
South-West Carpet Python (*Morelia spilota imbricata*)	
Conservation status:	Previously considered Priority 4 but has since been delisted. The sub-species has declined due to land-clearing and predation by feral species. It is considered CS3 as these threatening processes remain, and where Fox control is implemented the pythons becomes noticeably more abundant (M. Bamford pers. obs.)
Distribution and habitat:	Occurs across southern WA from near Shark Bay to the southern edge of the Nullarbor Plain; in a wide range of environments from forest to woodlands and coastal shrublands. Often in areas with rocks or logs that provide shelter.
Ecology:	A usually nocturnal predator of vertebrates and in particular mammals.
Expected occurrence:	Resident. While a difficult species to detect, it is seen regularly in Woodlands and Kwongan between Cataby and Badgingarra (Brand Highway) and along Indian Ocean Drive north of Jurien (M. Bamford pers. obs.). It probably occurs in all VSAs in the Survey Area.
Rainbow Bee-eater (*Merops ornatus*)	
Conservation status:	This species was recently removed from the Migratory list of the EPBC Act and Schedule 5 of the WA Act. Despite this, it is a migrant in the South-West. Part of its conservation interest is related to its selection of breeding sites, as it is likely to breed along the edges of clearings and tracks, and thus may place itself at risk of mortality. It has been recorded regularly in the Survey Area and nearby.
Distribution and habitat:	Occurs across mainland Australia and parts of Indonesia; a summer-breeding migrant in the south. In the South-West it arrives in October and departs in January/February. Favours fairly open vegetation types including parkland clearing and constructs nesting burrows in sandy to sandy-loam soils, often in the open.
Ecology:	An aerial insectivore that forages by 'sallying' from a perch. Eats a wide range of insects and not just bees. Often seen in loose flocks on migration and may breed in loose colonies or singly. Tends to be faithful to breeding sites but will also move if a site gets too overgrown or is destroyed. Will also colonise new areas and has been known to nest in piles of earth on construction sites.
Expected occurrence:	Regular visitor. Can be expected to arrive in October and depart in February. Will breed where there are areas of suitable sparse vegetation on sand. The species may be particularly abundant during migration periods as birds pass through.
Rufous Fieldwren (*Calamanthus campestris*), Shy Heathwren (*Calamanthus cautus*), White-browed Babbler (*Pomatostomus superciliosus*) and Crested Bellbird (*Oreoica gutturalis*)	
Conservation status:	These species were formerly listed as Priority (thus CS2) due to massive declines as a result of habitat loss across the Wheatbelt. Considered of local conservation significance as these declines have happened and are probably ongoing in some cases as remnant vegetation degrades, and the Survey Area is on the edge of the Wheatbelt. The Rufous

	Fieldwren and Shy Heathwren were observed in September 2019, the latter just outside and to the south of the Survey Area. The Rufous Fieldwren was also observed in December 2021, and the Crested Bellbird was recorded in the Beharra Project area just to the north, also in December 2021.
Distribution and habitat:	These four species occur broadly across southern Australia and in the South-West are found in semi-arid heaths and woodlands, hence their susceptibility to clearing in the Wheatbelt. The Rufous Fieldwren occurs in very low heath (VSA 1) and will also move into areas following fire and during mine site rehabilitation, moving out as the vegetation gets dense and tall (M. Bamford pers. obs.). The Shy Heathwren favours denser, taller vegetation, such as VSA 2 and dense areas of VSA 3, while the White-browed Babbler usually occurs in tall and moderately open shrubland with scattered thickets. The babbler is a conspicuous species and has not been recorded despite multiple visits to the general area, hence it is considered likely only as a vagrant. The Crested Bellbird is the most Catholic in environmental preference, occurring in low heaths and Kwongan to open tall shrublands and scattered trees over spinifex.
Ecology:	Insectivores that forage over the ground and low vegetation; the babbler will also search under loose bark. Mostly sedentary but will move if the environment changes, such as the Fieldwren moving as vegetation structure alters with time since fire or rehabilitation.
Expected occurrence:	The Rufous Fieldwren, Shy Heathwren and Crested Bellbird are expected as residents and have been recorded in the Survey Area or nearby. The Babbler is expected only as a vagrant as it is readily detected so would have been recorded if present. Most of the vegetation may be too low and dense for it. However, with records from databases, there would appear to be resident birds nearby. The Rufous Fieldwren readily colonises early stage rehabilitation (M. Bamford pers. obs.) so may be temporarily abundant in young rehabilitation.
Brushtail-Possum (*Trichosurus vulpecula*)	
Conservation status:	Although widespread in the South-West, the Brushtail Possum has disappeared from parts of its range due to habitat loss and feral predators. It would formerly have occurred in the Survey Area and, while it may be locally extinct, it may persist in areas of large trees around the drainage system to the east. Scats that might have been of this species were found in this area of large trees in November 2018, but identity was uncertain. Relictual populations are known from locations such as Dandaragan and Goomalling, and such populations are of local significance.
Distribution and habitat:	Patchily distributed (formerly widespread) across the South-West. Usually in woodland and forest with large trees.
Ecology:	An arboreal omnivore, nocturnal and shelters in tree hollows during the day.
Expected occurrence:	May be locally extinct, but the species does persist in some areas of the South-West despite extensive clearing, and scats possibly of this species were found in November 2018, amongst large trees east of the Survey Area. Much of the Survey Area, however, is probably not suitable due to the general absence of large trees.



Imagery: ESRI, Maxar (July 2018)

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Arrowsmith North Project

Significant and Restricted Fauna within VSAs

Figure: 63

Figure 63: Significant and restricted fauna within VSAs

Western Ground Parrot

Given there was a possibility that this species could occur within the survey area, targeted surveys were conducted. Four ARUs were deployed in and around the survey areas on 23 and 24 September 2019 and collected on 18 October 2019. They were set up to sample for calling Western Ground Parrots and make further assessment of their potential presence. One ARU was an AudioMoth (Hill *et al*., 2018 & 2019) running firmware version 1.2.2, while the other three were SOLO biological recorders (Whytock and Christie, 2017) running SOSI-2019-09-20.img.zip. These ARUs were chosen for their cost effectiveness and compatible audio response with that of commercial ARUs. Both recorders were placed in low-lying, dense heath (maximum of 1 m high), set to record during peak calling periods of the Western Ground Parrot; a minimum of one hour after sunset and a minimum of one hour before sunrise. Recorders recorded over 70 nights in total. The software for the SOLO was customised by James Christie and Barry Shepherd for the particular timing. The location of the ARUs are shown in (Figure 56).

None of the ARU recordings identified any evidence of this species.

Brushtail Possum

Although widespread in the South-West, the Brushtail Possum has disappeared from parts of its range due to habitat loss and feral predators. It would formally have occurred in the survey areas and, while it may be locally extinct, it may persist in areas of large trees around the drainage system to the east. Relictual populations are known from locations such as Dandaragan and Goomalling, and such populations are of local significance.

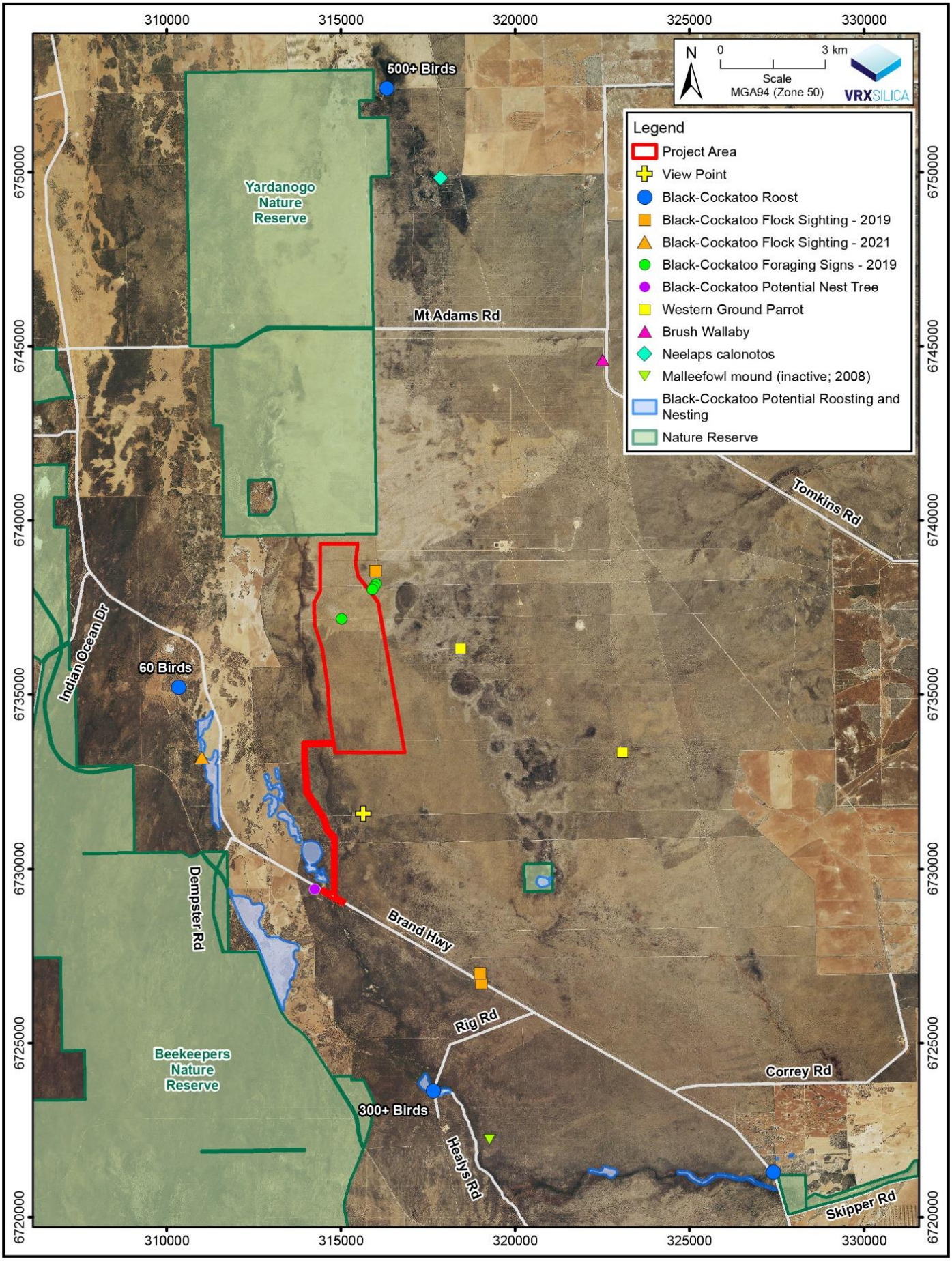
Carnaby's Cockatoo

One species of Black-Cockatoo of conservation significance has been confirmed in the general area, Carnaby's Cockatoo. The other two significant black-cockatoos in the South-West, Baudin's and the Forest Red-tailed, do not occur on the northern Swan Coastal Plain. Red-tailed Black-Cockatoos in the general region of the Proposal are a different and widespread (inland) sub-species (*Calyptorhynchus banksia escondidus*). Carnaby's Cockatoo may forage on proteaceous and myrtaceous vegetation in the Survey Area and roost in large trees near water courses. Foraging and roosting by Carnaby's Cockatoos have been confirmed adjacent to the Survey Area and is discussed below. Locations of foraging signs and sightings of Carnaby's Cockatoo collected in September 2019 and December 2021 are shown in Figure 64. Breeding nearby is also a possibility but is unconfirmed.

Overall, Carnaby's Cockatoo is likely to be present in the region for much of the year with the Survey Area representing foraging habitat used by non-breeding birds. There is no roosting or breeding habitat in the development envelopes and no regular surface (drinking) water.

Breeding habitat

The Survey Area is unlikely to support breeding by Carnaby's Cockatoos. There are no large trees (trees of sufficient size to provide nesting hollows) in the Mine Survey Area, while just one large tree with two potential (but unused) hollows was found in the access corridor (Figure 65). These potential hollows were examined from the ground so cannot be confirmed as actually being hollows of sufficient depth. They had no evidence of use (i.e., no chew marks or other marks) and even if they were found to be too shallow for current use, they are still potential hollows.



Source: Aerial Photography: Landgate (Nov 2016), Tenements: DMIRS
Author: Bamford Consulting Ecologists, Drawn: CAD Resources (08 9246 3242), Date: Dec 2022, CAD Ref: a2602_f55_06, Rev: C

Figure 64: Carnaby's Cockatoo roosts, sightings and ARU locations

Figure 65: Large tree with potential breeding hollows in the Access Development Envelope

A search of the wider landscape for suitable roosting and breeding trees was conducted in September 2019; this identified several locations with trees (River Gums *Eucalyptus camaldulensis*) of possibly suitable stature along the Arrowsmith River and around wetlands to the south and south-east of the Proposal. A few trees in these areas may contain hollows of suitable size for nesting by black-cockatoos. Ron Johnstone (pers comm.) noted that he has checked some large trees along the Arrowsmith River for nesting black-cockatoos but found no evidence. The nearest known breeding by Carnaby's Cockatoo is at Coomallo Creek, about 100 km south of the Arrowsmith area (DBCA, 2019b; Saunders and Dawson, 2017).

Roosting habitat

Three Carnaby's Cockatoo roost sites have been confirmed and one is suspected within proximity of the Survey Area. Bamford and Chuk (2015 – 2017) recorded a flock of 300+ individuals roosting 10 km south of the Mine Survey Area, 2 km east of the southern alignment along the Arrowsmith River (Figure 64). In April 2015, Bamford (pers. Obs.) recorded a roost of 500+ individuals approximately 13 km north, near the north-eastern boundary of Yardanogo Nature Reserve. Two groups of Carnaby's Cockatoos of ten or so individuals were seen flying very directionally and at speed across the Brand Highway (one group flying west, the other east) approximately 5 km south of the Mine Survey Area on 23 September 2019 just after dusk. This timing and flight pattern suggest they were travelling to roost sites. Additionally, approximately 45 minutes before sunrise on 24 and 25 September 2019, Carnaby's Cockatoos could be heard calling from the Western Flora Caravan Park where the surveyors were staying; this lies just over 18 km south-east of the Survey Area. Static calls at this time of the day strongly suggest the presence of a roost. On 6 December 2021, a roost of at least 60 birds was found just west of Brand Highway and about 4 km east of the Survey Area. These birds flew in from the south in the evening, crossed Brand Highway and may have visited a stock watering point to drink, then flew west back to the roost site. Roosting activity

at these sites occurs across the year (April, June, September and December), suggesting that some birds are present almost year-round.

Data retrieved from the Great Cocky Count coordinator, Adam Peck (pers. comm) confirmed the absence of any other known Carnaby's Cockatoo roosts within 12 km of the Mine Survey Area. While there are no large trees within the Survey Area that are likely to be used for roosting, there are large trees nearby, particularly along drainage lines that may be suitable. The presence of the roosts 4 km west, 10 km south and 13 km north to the south means that the Survey Area may regularly be visited by foraging Carnaby's Cockatoos.

While watching and listening at dusk on the evening of 24 September 2019 from a vantage-point located 1.7 km south of the site no Carnaby's Cockatoo were seen or heard. This suggests low activity of the species in the area during the breeding season, but observations made in August 2020 in the Beharra Project area to the north (a small flock of mostly male Carnaby's Cockatoos) suggests that some breeding may be occurring in the region. A search of the wider landscape for suitable roosting and breeding trees was conducted in September 2019 identified several areas where large trees that might be suitable for roosting are present along the Arrowsmith River and around wetlands to the south and east of the Survey Area (Figure 64).

Black-cockatoos are likely to move regularly to and from roosting sites, departing in the morning and returning in the evening. Flight paths around roosting sites and across the landscape will be determined by the availability of water resources and foraging habitat. The Survey Area lies within a broad swathe of continuous foraging habitat so the birds are likely to move across the landscape in search of seasonal and annual changes in foraging resources. Patterns of movement will thus vary seasonally and even annually. Movement pathways can therefore not be predicted except very close to roost sites.

Foraging habitat

Banksias, hakeas, eucalypt trees, acacias and Woody Pears (*Xylomelum*) provide foraging habitat for Carnaby's Cockatoos, Acacias and Banksias in particular are widespread throughout the Survey Area. Furthermore, a large number of scattered and chewed Banksia inflorescences consistent with Carnaby's were found across the Mine Survey Area in September 2019. Two flocks (one of 50 individuals) were also spotted flying over the Mine Survey Area in the mid-afternoon during the September 2019 survey. Flocks have occasionally been recorded in the general area, foraging in Kwongan heath and Banksia low woodland, including approximately 500 individuals north of Yardanogo Nature Reserve (April 2015; Bamford *et al.,* 2015) and flocks of over 300 individuals near the Arrowsmith River west of Brand Highway (Bamford and Chuk 2015-2017).

BCE (2022) assigned a foraging value score to the VSAs in the Survey Area for Carnaby's Cockatoo. The vegetation characteristics score (out of 6) were assigned as follows:

- VSA 1 (Kwongan Heath). Vegetation characteristics score of 4 out of 6. Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40 % projected foliage cover;
- VSA 2 (Riparian Thicket). Vegetation characteristics score of 2 out of 6. Shrubland in which species of foraging value, such as shrubby banksias, have <10 % projected foliage cover. However, some patches of Riparian Thicket supported a wide range of other foraging species such as *Hakea*, *Acacia* and Myrtaceae such as *Calothamnus*, and therefore the score was adjusted slightly by assigning a context score of 1 out of 3; and

- VSA 3 (Open Woodland): Vegetation characteristics score of 4 out of 6. This score is based on the vegetation being a blend of 'Woodland with tree banksias 5-20 % projected foliage cover' (score of 3 out of 6) and 'Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40 % projected foliage cover'.

The context score was the same (2) for VSAs 1 and 3, but this is based upon the total survey area and could be lowered to a context score of 1 if impact areas and rehabilitation effectiveness are taken into account. VSA 2 had a context score of 1 as while it received a vegetation characteristics score of only 2, it is limited in area and has some secondary foraging species. Site Context is a function of site size, availability of nearby habitat and the availability of nearby breeding areas. The Survey Area lies in a landscape with extensive similar vegetation in two nature reserves, which lowers the context value, but the total impact area is uncertain so the assessment is based on the total survey area. If breeding were confirmed nearby then a higher context score could be applied. The species density score of 1 is used for VSAs 1, 2 and 3, as Carnaby's Cockatoos were seen regularly in the area.

Overall, the Kwongan heath (VSA 1) and the low, open woodland (VSA 3) have a high foraging value for the species (7 out of 10). This is on the basis of having high proportions of key food plants, notably banksias. The Kwongan Heath (VSA 1), however, is much more extensive. The Riparian Thicket (VSA 2) is also extensive and has a moderate foraging value with few banksias but high densities of acacias and some hakeas. The foraging value of VSAs for Carnaby's Cockatoo is summarised in Table 28.

Table 28: Foraging value of VSAs for Carnaby's Cockatoo

VSA	Area (ha)	Vegetation Characteristics	Context	Species Density	Total Foraging Value
VSA1 – Kwongan Heath	1,621.2	4	2	1	7
VSA2 – Dense Riparian Thickets	225.6	2	1	1	4
VSA3 – Open Woodland	95.5	4	2	1	7

Drinking Habitat

The Survey Area has no permanent surface water for drinking. The nearest sources of water are Arrowsmith Lake and stock watering points on farmland to the west of the Proposal.

6.3.7 Environmental Values

The information provided in Section 6.3 was utilised to determine the environmental values that require assessment for this factor. Environmental 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 survey areas;
- Species with 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
- Habitat types 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.

Section 6.3.6 identified eight significant fauna species (two invertebrates and five vertebrates) that were recorded within the survey areas and 24 that may occur. No fauna habitats were identified as being restricted to the development envelopes, however historical records indicate that many of these species will utilise Kwongan Heath as a general habitat. The species that were not recorded are expected to be widespread throughout the extent of Kwongan Heath therefore 'General Fauna Species and Habitats' is considered a suitable environmental value to enable an assessment of impacts to the habitats utilised by these species.

Section 6.3.5 identified 28 potential SRE species recorded within the Survey Area including one Priority 1 SREs, and a Priority 1 invertebrate was recorded (not a SRE); Bothriembryontid Land Snail *(Bothriembryon perobesus)*. No habitats were identified as being restricted to the development envelopes and all SRE species were found in locations outside the development envelopes. Regardless, SRE species warrant further assessment as a separate environmental value. The Bothriembryontid Land Snail *(Bothriembryon perobesus)* was not recorded within the development envelopes and therefore is not considered to be a separate environmental value that requires assessment. The assessment of general fauna species and habitat is sufficient for this species.

Malleefowl is listed as Vulnerable under the EPBC Act and Schedule 3 under the BC Act. While no evidence of this species was recorded during the field surveys, its conservation listing warrants a specific assessment as a separate environmental value.

Carnaby's Cockatoo is listed as Endangered under the EPBC Act and Schedule 2 under the BC Act. This species was recorded during the field surveys, and its conservation listing also warrants a specific assessment as a separate environmental value.

Table 29 assesses each habitat type against the significance criteria.

Table 29: Fauna habitats of the survey areas

Habitat	Habitat type that is important to the life history of a significant species
VSA1 – Kwongan Heath	Yes – moderate (VSA2) and moderate to high (VSA1 and 3) Carnaby's Cockatoo foraging habitat
VSA2 – Dense Riparian Thickets	
VSA3 – Open Woodland	

The following Environmental Values were therefore determined to require assessment for this factor:

- General Fauna Species and Habitat;
- SRE Fauna;
- Malleefowl; and
- Carnaby's Cockatoo.

6.4 POTENTIAL IMPACTS

Table 30 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context. Assessment of the potential impacts is provided in the following sections.

Table 30: Potential impacts on terrestrial fauna

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
General fauna species and habitat Currently all vegetation associations have more than 65 % of their pre-European extent remaining.	Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal Up to 339.3 ha of fauna habitat clearing to be rehabilitated progressively via VDT Death or injury of fauna due to vehicle strike or earthmoving equipment	Increased predation or competition from introduced fauna Alterations to fauna behaviour (including feeding or breeding characteristics) as a result of elevated dust, light or noise emissions Reduction in habitat health as a result of: • Alterations to fire regimes • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback	Clearing of fauna habitat associated with other Proposals including: • Arrowsmith Central Silica Sands (Proposed) • Beach Energy / AWE limited – Beharra Springs Gas (Operational) • Perpetual Resources limited – Beharra Silica, Beharra West and Arrowsmith West (Proposed) • Strike and Warrego Energy – West Erregulla Gas Field (Proposed)	Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal and up to 339.3 ha of fauna habitat clearing to be rehabilitated progressively via VDT, in addition to clearing associated with other Proposals. Potential death or injury of fauna from vehicle strike Some indirect impacts to fauna habitat health and fauna behavioural impacts.
SRE Fauna 9 potential SRE fauna found within (including one Priority 1 SRE *Idiosoma kwongan*) have been recorded within the development envelopes.	Up to 14.5 ha of habitat clearing to remain cleared for the life of the Proposal. Up to 339.3 ha of habitat clearing to be rehabilitated progressively via VDT.	Reduction in habitat health as a result of: • Alterations to fire regimes • Vehicle vibrations causing habitat collapse • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback	Clearing of habitat associated with other Proposals listed above.	Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal and up to 339.3 ha of fauna habitat clearing to be rehabilitated progressively via VDT, in addition to clearing associated with other Proposals. Some indirect impacts to habitat health.
Malleefowl and potential habitat No evidence recorded however may be an occasional visitor	Up to 14.5 ha of habitat clearing to remain cleared for the life of the Proposal Up to 339.3 ha of habitat clearing to be rehabilitated	Increased predation or competition from introduced fauna Alterations to behaviour (including feeding or breeding characteristics) as a result of elevated dust, light or noise emissions Reduction in habitat health as a result of: • Alterations to fire regimes	Clearing of habitat associated with other Proposals listed above.	Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal and up to 339.3 ha of fauna habitat clearing to be rehabilitated progressively via VDT, in addition to clearing associated with other Proposals.

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
	progressively via VDT Disturbance of mounds (if developed in the future) or death or injury due to vehicle strike or earthmoving equipment	• Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback		Disturbance of mounds (if developed in the future) Potential death or injury from vehicle strike or entrapment Some indirect impacts to habitat health and behavioural impacts
Carnaby's Cockatoo and potential habitat Kwongan Heath, Dense Riparian Thickets and Low Woodlands that provide moderate to high value foraging habitat for Carnaby's Cockatoo.	Up to 14.5 ha of medium to high value foraging habitat clearing to remain cleared for the life of the Proposal Clearing and progressive rehabilitation of up to 339.3 ha of moderate to high value foraging habitat.	Increased predation or competition from introduced fauna Alterations to behaviour (including feeding or breeding characteristics) as a result of elevated dust, light or noise emissions Reduction in habitat health as a result of: • Alterations to fire regimes • Burying as a result of unintentional discharge of sand slurry from surface pipelines • Establishment or spread of weed species / populations • Reduction of groundwater depth • Hydrocarbon spills • Introduction or spread of dieback	Clearing of habitat associated with other Proposals listed above.	Up to 14.5 ha of medium to high value foraging habitat clearing to remain cleared for the life of the Proposal, and clearing and progressive rehabilitation of up to 339.3 ha of moderate to high value foraging habitat. In addition to habitat loss associated with other Proposals. Some indirect impacts to habitat health and behavioural impacts

6.5 ASSESSMENT OF IMPACTS

The following sections assess the potential impacts on each environmental value identified in Section 6.3.7.

6.5.1 GENERAL FAUNA SPECIES AND HABITAT

Direct Disturbance and VDT

The Proposal will result in the clearing of up to 353.8 ha of fauna habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of fauna habitat that will be progressively rehabilitated via VDT (described in detail in Section 2.2.3). The VDT method was chosen as it promotes a high level of live foliage cover, vegetation density and species richness, achieving results that are comparable to the natural vegetation in approximately eight years (Mattiske, 2019a). There are however some factors associated with the VDT method that require careful management to ensure it is effective such as:

- Ensuring adequate soil salvage depths;
- Ensuring there are no acidic leachates;
- Appropriate handling of stripped sods;
- Minimising environmental stressors post transfer;
- Avoiding over-compaction of soils from vehicle movement; and
- Minimising the exposure of vegetation roots during handling and planting.

The VDT method is not capable of returning the complete assemblage of flora species recorded in the Kwongan heath vegetation recorded within the Mine Development Envelope. Observations made during previous VDT trials do not show many *Banksia* or *Petrophile* species to be regenerating (Mattiske, 2019a). Therefore, it may be necessary to infill plant this species from tube stock or seed where appropriate to ensure these species remain part of the vegetation structure.

At a regional scale disturbance for the Proposal occurs entirely within vegetation association 378.1, which has 65.0 % of its pre-European extent remaining. The Proposal will disturb 0.44 % of the remaining vegetation association, or 0.28 % of the pre-European extent. This minor reduction is unlikely to be regionally significant given there will be 64.7 % of the pre-European extent remaining after the implementation of the Proposal and 339.3 ha of the vegetation will immediately undergo VDT, resulting in high quality rehabilitation of this vegetation association and the fauna habitats it contains.

As part of the assessment of the regional significance of the clearing, the extent of the proposed clearing has been compared with the mapped regional extent of remaining remnant native fauna habitat within a 10, 15 and 20 km radius of the Proposal (Figure 32). In contrast to other areas of the Geraldton Sandplains region the extent of remaining native fauna habitat remains high in the vicinity of the Proposal. 28,657.5 ha of native fauna habitat remains within 10 km of the Proposal (91.66 % of original extent), 58,621.2 remains within 15 km (91.6 % of original extent) and 90,125.7 ha remains within 20 km of the Proposal (85.87 % of original extent). The Beekeeper Nature Reserve also lies to the west of the Proposal and provides protection for an estimated 120,000 ha of similar native fauna habitat.

The proposed clearing represents a reduction of 1.24 % of the regional extent of remaining native fauna habitat within 10 km of the Proposal, 0.60 % within 15 km and 0.39 % within 20 km. The cumulative impacts of the proposed and existing clearing will therefore not be significantly increased, and significant areas of native fauna habitat will remain after implementation of the Proposal, including large areas within conservation reserves. Given that 339.3 ha of the clearing will be progressively cleared and rehabilitated via VDT the clearing of fauna habitat for the Proposal is unlikely to represent a significant impact to fauna habitats in a general regional context. This clearing is assessed in more detail from an ecological context in the sections below.

The Proposal is situated in an extensive, continuous landscape comprised primarily of Kwongan heath. The extent of disturbance required for the Proposal is relatively small in comparison to the surrounding environment and the disturbance footprint does not does intercept, isolate or fragment any unique habitat. The Proposal will also be implemented in a progressive manner with disturbed areas being rehabilitated via VDT and infill planting. This methodology is anticipated to result in areas of mining being rehabilitated fully prior to the completion of mining (vegetation is expected to reach maturity within ten years), re-establishing fauna habitats. Considering the factors described above, the Proposal is not expected to fragment or isolate any

fauna habitats for general fauna. If any local fragmentation were to occur, it is not expected to persist, with mining areas only anticipated to be open for months at a time.

VRX has assessed the impacts of the Proposal against potential and existing cumulative impacts of other proposals in close proximity to the Proposal. VRX has identified six projects within 20 km of the Proposal that may have a cumulative impact on the extent of native vegetation. The majority of the projects are proposed and therefore the extent of clearing required for each has not yet been quantified. As most (four) projects are for silica sand mining, VRX assumes these projects will be similar in size and scope to the Proposal (with the exception of the Perpetual Resources Beharra Silica project that is proposed to clear approximately 600 ha; Perpetual Resources Limited, 2022) and will require approximately 450 ha of native vegetation clearing each. A green energy project has also been referred to the EPA (Infinite Green Energy Arrowsmith Hydrogen Project; Assessment Number: 2345) that will require clearing of approximately 140 ha of native vegetation. Based on this assumption, the cumulative native vegetation clearing of all projects is estimated to be:

- Up to 2,990 ha or only 3.3% of the remaining native vegetation extent within 20 km of the Proposal;
- Up to 2,540 ha or only 4.3% of the remaining native vegetation extent within 15 km of the Proposal; and
- Up to 2,540 ha or only 8.9% of the remaining native vegetation extent within 10 km of the Proposal.

This estimate is expected to be conservative due to the following reasons:

- Not all projects will be viable and proceed through to development; and
- The Beharra Springs Gas plant has only resulted in approximately 50 ha of clearing.

These projects are also expected to occur within the Eridoon (378.1) Vegetation Association which has 65 % of its pre-European extent remaining (80,734.1 ha). No significant planned proposals have been identified within this vegetation association that would reduce the current extent by more than a few percent (the Proposal will result in only a 0.44 % reduction in comparison).

At a local scale, the Proposal will result in clearing of 353.8 ha of VSA1 (Kwongan heath) which represents 21.8 % of its mapped extent (Figure 66). The extent of recorded VSAs, their extent within the development envelopes and the extent of Proposed clearing is summarised in Table 31 (excludes cleared land).

Table 31: VSAs, extent and indicative disturbance

VSAs	Extent within survey areas (ha)	Extent in development envelopes (ha)	Extent in indicative disturbance footprint (ha)
VSA1 – Kwongan Heath	1,621.2	404.7	353.8 (21.8 % of mapped extent)
VSA2 – Dense Riparian Thickets	225.6	1.2	0
VSA3 – Open Woodland	95.5	0	0

Table 31 provides the following findings:

- All disturbance occurs within VSA1;

- None of the VSAs are restricted to the development envelopes; and
- More than 78 % of the extent of VSA1 is located outside the Mine Development Envelope and indicative disturbance footprint of the access road.

Based on the above, the direct disturbance of the Proposal will not result in the significant reduction in the extent of VSA1 and will not impact any other VSA. Given the proposed progressive rehabilitation method (VDT and infill planting), and the presence of similar habitat in the Survey Area the direct disturbance of the Proposal is therefore considered unlikely to have a significant impact on the availability of habitat for general fauna populations in the area.

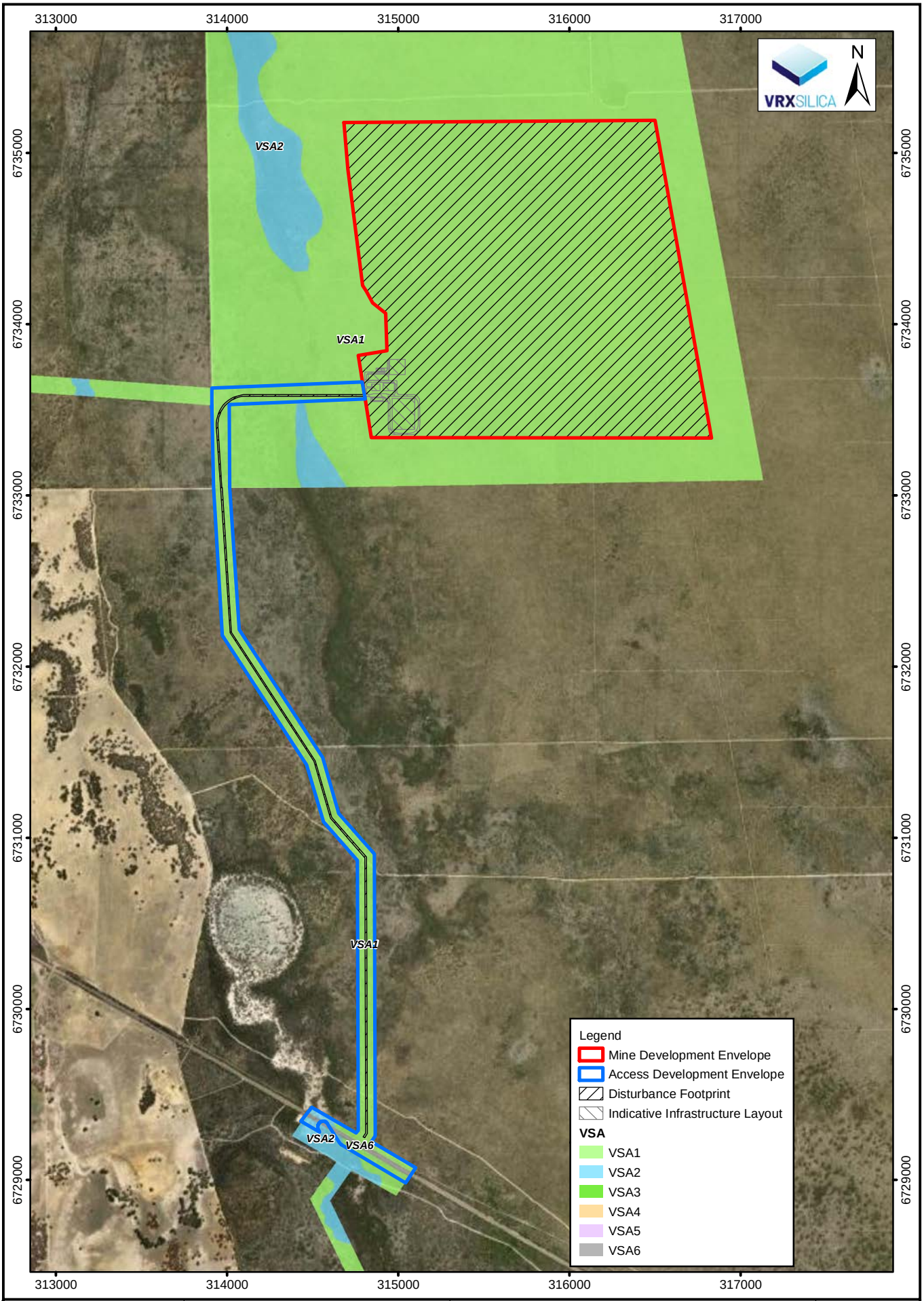
The development envelopes contain several habitat values that may be considered significant in the context of individual species. An assessment of the direct disturbance of those values is provided in Sections 6.5.1 - 6.5.4.

Vehicle / Earthmoving Equipment Strike

There is a risk of fauna death or injury if fauna are struck by earthmoving equipment during clearing, VDT or mining. The majority of larger 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 careful use of the VDT method. It is likely however that there will be some fauna injuries or deaths during these activities. VRX will implement management measures to minimise this likelihood (refer to Section 6.6).

Vehicle strike may lead to fauna injuries or fatalities as light vehicles and trucks will regularly use the access road. Vehicle movements have been avoided where possible, for example a slurry pipeline is proposed between the MFP and the processing plant (avoiding the need to transport ore via truck). Furthermore, vehicle will be speed restricted along the access road to reduce the likelihood of vehicle strike.

Based on the above, any fauna strike impacts are likely to be rare and not significant on a local or regional scale.



Imagery: ESRI, Maxar (July 2018)

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Scale: 1:30,000
MGA94 (Zone 50)

CAD Ref: a2602_f56_20

Date: April 2022 | Rev: B | A4

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Arrowsmith North Project

VSA's Impact

Figure: 66

Figure 66: VSAs to be disturbed by the Proposal

Introduced Fauna

Introduced species were recorded in fauna surveys within the study areas including cats and foxes (BCE, 2022). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at work areas; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The workforce will be relatively small, and 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 access 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 and the Southern Yamatji People (refer to Section 6.6 and 8.6).

With the implementation of controls (refer to Section 6.6 and 8.6) 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 Behaviour

The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the Processing Plant (24-hour operations), which covers only several hectares. Equipment moving within the mining area will produce noise emissions however this will be limited to a small area given the progressive mining footprint. Nevertheless, it is expected that some fauna will keep their distance from the mining area while operating. With the implementation of controls (refer to Section 6.6 and 8.6) potential increased risks to fauna from 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.

Altered Fire Regimes

The Eridoon land system is characterised as experiencing frequent wildfires, this is reflected in the high proportions of reseeder and resprouter species present within the vegetation assemblage. Generally, the vegetation is fire-dependant, with much of the Study Area already impacted by wildfire.

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 6.6), the development of the Proposal will provide improved access to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk is therefore not expected to be significant.

Habitat Burial as a Result of Slurry Spills

The slurry pipelines will run from the MFP to the Processing Plant, and will be fitted with automatic shutdown detection and will be located within a 'V' drain designed to capture the

release of slurry from a complete pipeline rupture. A rupture of this pipeline therefore has limited potential to release sand slurry into the surrounding vegetation. Upon notification of a spill, VRX will mobilise to remediate the impacted area, dried sand slurry will be recovered and taken from the site and any impacted vegetation will be rehabilitated as required. The details of spill containment systems are generally planned and managed via a Works Approvals under Part V of the EP Act and a MP under the Mining Act. The mitigation measures are described in Section 5.6.2

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.

Eleven introduced species were identified during flora / vegetation surveys (Mattiske, 2022b). Four were listed as having a high ecological impact (*Aira caryophyllea, Brassicaceae* sp, *Eragrostis curcula* and *Ursinia anthemoides*), including *Brassicaceae* sp. listed as having a medium/high ecological impact. Given the presence of these weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species (Section 6.6).

Reduction of Groundwater Depth

The removal of silica sand within the mining footprint will reduce the depth to groundwater in those areas (i.e., mining will remove 8 - 15m of sand). The reduction in distance between the ground surface and the underlying groundwater may result in a competitive advantage or disadvantage to some flora species. There is the potential that more deep-rooted species (such as *Banksia* sp.) become established over time as they will have improved access to the shallower groundwater table. Root surveys conducted by Mattiske (2020a) indicate the vast majority of flora species assessed within the survey area have root structures that do not access groundwater and therefore are unlikely to be groundwater dependant (excluding *Banksia* sp. which are known to have tap roots extending 3 – 4 m below the surface). Changes in the depth to groundwater are therefore unlikely to have a significant impact on the majority of flora species (and therefore the fauna habitat) within the survey area, however there may be improved outcomes for deep-rooted species such as *Banksia* sp. This may lead to an increase in foraging habitat coverage for Carnaby's Cockatoo once rehabilitation has become established.

Abstraction of groundwater for the Proposal will result in drawdown within the superficial and Yarragadee aquifer. Drawdown within the superficial aquifer is expected to be minor (8 mm per annum) and only as a result of leakage from abstraction within the underlying Yarragadee aquifer. The drawdown rate is within the range of natural groundwater level variation and would present a low risk to phreatophytic vegetation in the 0 – 3 m depth to groundwater category (the most groundwater dependant; if present) based on drawdown risk tables by Froend, *et al.*, (2004). The extent of drawdown and the impacts on the water table are discussed further in Section 7.5.2.

Hydrocarbon Spills

Considering 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 6.6 and are designed to further reduce the risk of fauna habitat impacts from hydrocarbon spillage.

Dieback

The introduction of *P. cinnamomi* to the development envelopes could result in a significant vegetation decline, based on the observed impacts to vegetation at Eneabba that share similar environmental conditions. Given the risk of dieback, hygiene management measures will be implemented to prevent the introduction of dieback (Section 5.6 and 6.6).

Summary

The Proposal will result in clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of native vegetation will be progressively rehabilitated via VDT.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper-rooted species will be undertaken as required to target the re-establishment of the original habitat structure.

There will be unavoidable impacts to fauna habitat health within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers.

Management and monitoring is proposed during the operational phase to improve the performance of VDT and minimise indirect impacts to general fauna and their habitats (refer to Section 5.6 and 6.6).

The assessment above identified that the Proposal was unlikely to result in significant impacts to general fauna species and their habitats, however there are potential impacts to specific fauna values that require further assessment. These assessments are provided in the following sections.

6.5.2 SHORT-RANGE ENDEMIC FAUNA

Direct Disturbance

Section 6.3.5 identified 31 potential SRE species recorded within the Survey Area including one Priority 1 SRE (Kwongan Heath Shield-Backed Trapdoor Spider (*Idiosoma kwongan*) (P1)). As discussed in Section 6.4, the Proposal will result in the clearing of up to 353.8 ha of fauna habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of fauna habitat will be rehabilitated via VDT. The Proposal has been designed to avoid the majority of potential SRE records. As a result VRX will disturb habitat where 9 of the 31 potential SRE species (including *Idiosoma kwongan*) were recorded. All 9 species are also recorded locally outside of the indicative disturbance footprint. Local populations of these species are therefore not restricted to the disturbance area and are expected to continue to occupy the local area. Potential SRE species recorded impacted by the Proposal are summarised in Table 32 and shown in Figure 62.

Table 32: Potential SRE fauna impacted by the Proposal

SRE fauna	Number of Species Recorded			Records that are restricted to the disturbance footprint
	Within Survey Area	Within the development envelopes	Within indicative Disturbance Footprint	
Potential SRE Fauna (inclusive of species below)	31	13	9	0
Kwongan Heath Shield-Backed Trapdoor Spider (*Idiosoma kwongan*) (P1)	1 (additional records found directly to the north-east at Strike Energy site (BCE, 2022))	1	1	0

14.5 ha of potential SRE habitat will remain cleared for the life of the Proposal. Clearing required for the life of the Proposal is required for the development of the MFP, access roads, processing plant and power station. This infrastructure is proposed to be developed over a relatively small area which is unlikely to contain significant portions of any single SRE habitat. The clearing for the access road is typically 4 m in width, and will not result in the complete clearing of any single vegetation community. It is therefore unlikely that any SREs would be restricted to the narrow access road clearing footprint.

The majority of the clearing footprint (339.3 ha of 353.8 ha, or 95.9 %) will be progressively cleared and rehabilitated via VDT, with less than 10 ha cleared at any time. The VDT method (described in detail in Section 2.2.3) includes moving large sods of soil directly to rehabilitation areas, keeping the soil and groundcover intact. Past research has demonstrated that VDT allows for the maintenance of sensitive plant species that would otherwise be lost during traditional rehabilitation methods (Rodgers *et al.,* 2011) and preliminary assessments for some invertebrate species, including earthworms and snails, has also shown positive results (Rodgers *et al.,* 2011). The survivorship of burrowing animals such as scorpions, millipedes and mygalomorph spiders after VDT has not been extensively studied (Bennelongia, 2021b), however it is expected that these species would have a greater chance of survival than traditional rehabilitation methods due to the reduced disturbance of the soil structure. Many SRE species inhabit leaf litter or habitats on or near the surface of the soil, and could be successfully translocated during VDT. Pseudoscorpions, slaters and centipedes for example, are known to inhabit surface environments such as leaf litter, beneath rocks and logs (Beier, 1966; Edgecombe and Giribet, 2007; Judd, 2004; Weygoldt, 1969), while some pseudoscorpions are also found under the bark of both living and dead trees (Weygoldt 1969; Bennelongia, 2021b). SRE species that burrow below the depth of the VDT sods may however remain in the soil after the VDT sod has been removed, and would therefore the level of impact on those species would be greater.

The Proposal is situated in an extensive, continuous landscape comprised primarily of Kwongan heath. The extent of disturbance required for the Proposal is relatively small in comparison to the surrounding environment and the disturbance footprint does not does intercept, isolate or fragment any unique habitat. The Proposal will also be implemented in a progressive manner with disturbed areas being rehabilitated via VDT and infill planting. This methodology is anticipated to result in areas of mining being rehabilitated fully prior to the completion of mining (vegetation is expected to reach maturity within ten years), re-establishing fauna habitats. Considering the factors described above, the Proposal is not expected to fragment or isolate any

fauna habitats for general fauna. If any local fragmentation were to occur, it is not expected to persist, with mining areas only anticipated to be open for months at a time.

All of the SREs that were recorded within the disturbance footprint of the Proposal were also recorded outside of the development envelopes. The development envelopes also do not contain restricted habitats for SREs. The recorded species are also potentially widespread in the broader environment but have either not been recorded or the survey data has not been made available to VRX.

Indirect Impacts to Habitat

Section 6.4 provides a detailed assessment of indirect impacts on fauna and their habitat, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for SREs also, with the Proposal considered unlikely to indirectly impact SRE habitat if the mitigation measures listed in Section 6.6 are implemented.

Summary

Despite there being evidence of SREs within the development envelopes, the habitat that is to be disturbed and rehabilitated is not restricted and extends outside the development envelopes. This is reflected in the survey results, with all of the recorded species occurring outside the development envelopes.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Several SRE species may survive the VDT process and the reinstatement of SRE habitat is likely to be quicker than traditional rehabilitation methods.

Based on the above, VRX considers that the Proposal is unlikely to have a significant impact on local SRE populations.

6.5.3 MALLEEFOWL

Direct Disturbance and VDT

Malleefowl were identified as potentially occurring within the development envelopes, however no sightings or evidence of its presence was observed during VRXs exploration activities, Aboriginal Heritage surveys, fauna surveys or flora and vegetation surveys (including foot traverses and targeted surveys). This species may occur across the habitats within the development envelopes, however only on occasion.

In the wheatbelt region of WA, Malleefowl distribution is associated with landscapes comprised of mallee/shrubland and thicket vegetation (Parsons, 2008). BCE (2022) describes the likely habitat for this species, if it were to be present, as *Acacia* shrubland. The VSAs within the Mine Development Envelope are primarily VSA 1 (Kwongan Heath), whereas the habitat types described above are representative of VSA2 (Dense Riparian Thickets) which represents 1.2 ha of the development envelopes (0.53% of VSA2 recorded in the Survey Area). No disturbance is proposed within VSA 2.

Malleefowl occur in a wide range of habitat types and habitat critical to the survival of the species is known only in broad terms. No particular populations or general areas can be described as

being of greater importance for the long-term survival of Malleefowl than any other at this stage (Benshemesh, 2007). This impact assessment takes a conservative approach, in the absence of a definition of habitat critical to the survival of this species and any formal records, VSA1 has been considered to be habitat (possibly foraging; as much of the vegetation may be too low as the Malleefowl usually occurs in woodlands and tall shrublands, BCE 2022).

Malleefowl chicks receive not parental assistance and are self-sufficient almost immediately after hatching. Adults reach sexual maturity at around 3 - 4 years. As specific habitats for Malleefowl are not clearly defined it is unclear when during their lifecycle the habitats will be used. For the purposes of this assessment it has been assumed that the potential habitat (VSA1 and VSA2) will be utilised throughout the lifecycle of this species. There may be a preference for taller shrubs and thickets for breeding (BCE, 2022). Although there is no evidence to suggest a resident breeding population exists within the development envelopes (BCE, 2022) or that VSA1 is a suitable breeding habitat, there is a chance that breeding could occur (this conservative determination is made in the absence of information on habitat specificity for this species). If this is the case, implementation of the Proposal may result in disturbance to breeding habitat for the Malleefowl. Malleefowl are known to be wide ranging and in some instance will have multiple breeding mounds within an area of up to 4.5 km^2. If a breeding population were to exist, and VSA1 was suitable habitat, the Proposal will only result in disturbance to a relatively small area (approximately 30 ha from mining and development at any one time; previously mined areas will be at varying stages of rehabilitation), and the nature of the mining method would allow active mounds to be avoided.

As discussed in Section 6.4, the Proposal will result in the clearing of up to 353.8 ha of fauna habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of fauna habitat will be rehabilitated via VDT.

Significance of Disturbance

The clearing of habitat will be progressive, therefore there will be areas of foraging habitat that will be retained for up to 30 years as mining progresses. A conservative assumption would be that 200 ha would be retained for at least ten years before it is cleared, and half of this area would be retained for over 20 years.

As part of the assessment of the regional significance of this clearing, the extent of the proposed clearing has been compared with the mapped regional extent of native vegetation within a 10, 15 and 20 km radius of the Proposal (Figure 32). In contrast to other areas of the Geraldton Sandplains region the extent of remaining native vegetation remains high in the vicinity of the Proposal. 28,657.5 ha of native fauna habitat remains within 10 km of the Proposal (91.66% of original extent), 58,621.2 remains within 15 km (91.6% of original extent) and 90,125.7 ha remains within 20 km of the Proposal (85.9% of original extent). The Beekeeper Nature Reserve lies to the west of the Proposal and provides protection for an estimated 120,000 ha of native vegetation. The proportion of this native vegetation that constitutes potential Malleefowl habitat is unknown, however a large proportion occurs within the same vegetation associations as the Proposal, which indicates similar habitat. Furthermore, Malleefowl are known to inhabit a broad range of habitat types.

The proposed total clearing (at the end of the mine life) represents a reduction of 1.24% of the regional extent of native fauna habitat within 10 km of the Proposal, 0.60% within 15 km and 0.39% within 20 km. The cumulative impacts of the proposed and existing clearing will therefore

not be significantly increased, and significant areas of native fauna habitat will remain (90.5% within 10 km, 91% within 15 km and 85.48% within 20 km of the Proposal) after implementation of the Proposal.

The Proposal is situated in an extensive, continuous landscape comprised primarily of Kwongan heath. For the purpose of this impact assessment VRX has assumed this is representative of Malleefowl habitat despite there being no evidence to suggest there is a resident breeding population. Malleefowl may use this area for foraging and to move between areas of suitable (foraging or breeding). The extent of disturbance required for the Proposal is relatively small in comparison to the surrounding environment and the disturbance footprint does not does intercept, isolate or fragment any unique habitat. The Proposal will also be implemented in a progressive manner with disturbed areas being rehabilitated via VDT and infill planting. This methodology is anticipated to result in areas of mining being rehabilitated fully prior to the completion of mining (vegetation is expected to reach maturity within ten years), re-establishing fauna habitats. It is expected, that with the implementation of the Proposal, sufficient habitat of the same type and quality will remain to maintain connectivity with the surrounding habitats. Considering the factors described above, the Proposal is not expected to fragment or isolate any fauna habitats for Malleefowl. If any local fragmentation were to occur, it is not expected to persist, with mining areas only anticipated to be open for months at a time.

VRX has also assessed the impacts of the Proposal in a cumulative context. Five projects have been identified within 12 km of the Proposal. Using the following assumed disturbance areas, 450 ha of clearing required for three projects, 600 ha for the Beharra silica project and 140 ha for the Arrowsmith Hydrogen Project, it is assumed there could be a cumulative impact of up to 2,090 ha of native vegetation clearing (assuming all proposals proceed). It is impossible to determine what percentage of the remaining vegetation would be considered foraging habitat, however it is reasonable to assume that the percentage within the potential impact areas is similar to that elsewhere. Based on this assumption, the cumulative impact is expected to result in a reduction of available potential Malleefowl habitat by approximately 4.7%.

Based on the information provided above, it is likely that the Proposal will progressively remove infrequently used potential Malleefowl habitat, and there will be some time before potential habitat regrows to maturity. This loss is unlikely to result in significant impacts to local and regional populations.

Section 6.5.1 determined that the direct disturbance of the Proposal will not result in the significant reduction in the extent of any VSA that may be utilised by Malleefowl on occasion. Given the proposed VDT method, and the extent of similar habitat in the area, the direct disturbance of the Proposal is considered unlikely to have a significant impact on the availability of potential habitat for any Malleefowl individuals or populations in the area.

Introduced Fauna

Introduced species were recorded in fauna surveys within the study areas including cats and foxes (BCE, 2022). Without mitigation, the Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at work areas; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The workforce will be relatively small, and 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 access 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 and the Southern Yamatji People (refer to Section 6.6 and 8.6).

With the implementation of controls (refer to Section 6.6 and 8.6) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts to Malleefowl individuals or populations are not significant on a local or regional scale.

Altered Behaviour

The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the Processing Plant (24-hour operations), which covers only several hectares. Equipment moving within the mining area will produce noise emissions however this will be limited to a small area given the progressive mining footprint. Nevertheless, Malleefowl (if present) may keep some distance from the mining area while operating. With the implementation of controls (refer to Section 6.6 and 8.6) potential increased risks to Malleefowl from 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.

Indirect Impacts to Fauna and Habitat

Section 6.5.1 provides a detailed assessment of indirect impacts on fauna and their habitat, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact Malleefowl habitat if the mitigation measures listed in Section 6.6 are implemented.

Summary

Despite there being no evidence of Malleefowl individuals within the development envelopes, the Proposal will result in clearing of up to 353.8 ha of potential Malleefowl habitat, 14.5 ha of which will remain cleared for the life of the Proposal. Up to 339.3 ha of native vegetation will be progressively rehabilitated via VDT.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper-rooted species will be undertaken as required to target the original habitat structure.

There will be unavoidable impacts to Malleefowl habitat within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers.

Management and monitoring is proposed to prevent direct impacts to Malleefowl mounds and individuals, to improve the performance of VDT and minimise indirect impacts to Malleefowl habitats (refer to Section 6.6).

6.5.4 CARNABY'S COCKATOO

Direct Disturbance and VDT

Carnaby's Cockatoo were identified as occurring within the development envelopes, with moderate – high quality foraging habitat recorded throughout the development envelopes, particularly within VSA1, VSA2 and VSA3. No roosting or breeding habitat was recorded within the development envelopes.

The Proposal will result in the progressive clearing of up to 353.8 ha of moderate to high value foraging habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of moderate to high value foraging habitat will be progressively rehabilitated via VDT.

Foraging Value after VDT

BCE (2020; Appendix 19) uses a scoring system that provides a very simple measure of the effectiveness of the proposed VDT and infill planting method of rehabilitation. Primarily, it is a question of projected foliage cover of shrubby *Banksia* species. Projected foliage cover is a more relevant measure than stem density, as the cover of the *Banksia* canopy affects the number of *Banksia* cones that will be available to the birds. Stem density may not relate directly to foliage cover however, it is a useful measure, particularly when plants are young (thus small) and have not achieved mature cover. The number of cones will vary annually with rainfall or cyclically (Copland and Whelan, 1989), and with time since fire (Valentine *et al.,* 2014), but these are short-term perturbations and it is the underlying potential productivity of the vegetation, based upon the 'volume' of foliage, that ultimately determines the food resource.

For the original purpose of assessing foraging value, projected foliage cover was estimated in the course of a rapid ecosystem assessment by BCE (2022). For the purpose of evaluating the effectiveness of the Rehabilitation Strategy, the opportunity exists to accurately measure foliage cover in both reference (existing Kwongan Heath) and rehabilitation areas. Further detail can be gained by determining species composition with the aim of achieving a similar composition between reference and rehabilitation sites. Studying the foraging preferences of Carnaby's Cockatoo in the area would be useful to develop an understanding of which plant species they actually rely upon most, as these may not be the most abundant species.

The actual Carnaby's Cockatoo foraging value of revegetation created through VDT and infill planting will depend largely on the density / projected foliage cover of key food plants (shrubby *Banksias*). As *Banksias* have been found to be underrepresented in trial VDT (Mattiske, 2019a), it is almost certain that direct seeding and/or infill planting of *Banksias* will be required, and the effectiveness of this is uncertain. *Banksias* can be difficult to establish in conventional rehabilitation but it is not known how they will respond in VDT. After ten years, it can probably be assumed that some establishment of *Banksias* can be achieved, perhaps with a site condition score of 2 or even 3 (out of 6 using the BCE scoring system). A site condition score of 3 would receive additional scores for context and species density therefore, resulting in a total score of 6 (out of 10), but a site condition score of just 2 would receive no additional scores. This is a limitation of the BCE scoring system, but it does recognise that vegetation of low condition may

not be used by birds at all, especially when the surrounding vegetation has a high foraging value (BCE, 2022). Using the value system (out of ten) generally adopted for foraging value, for the purpose of this impact assessment, VRX will use a conservative score of 5 out of 10 as the post VDT Carnaby's Cockatoo foraging value. This value may be increased with monitoring results if VDT and infill planting is shown to be successful.

Significance of Disturbance and VDT

Carnaby's Cockatoo are known to be present in the surrounding region, and the Proposal disturbance will reduce the availability of foraging habitat. While breeding, black cockatoos will generally forage within a 6 – 12 km radius of their nesting site. Following breeding, birds assemble into flocks and move through the landscape searching for food, usually foraging within 6 km of a night roost. Because of this mobility, potential for reduced seed set and flowering due to drought, and the irregular or infrequent flowering and fruiting patterns of many of their food sources, large areas of foraging habitat are required to support black cockatoo populations (DSEWPaC, 2012b).

As part of the assessment of the regional significance of this clearing, the extent of the proposed clearing has been compared with the mapped regional extent of native vegetation within a 10, 15 and 20 km radius of the Proposal. In contrast to other areas of the Geraldton Sandplains region the extent of remaining native vegetation remains high in the vicinity of the Proposal. 28,657.5 ha of native fauna habitat remains within 10 km of the Proposal (91.66 % of original extent), 58,621.2 remains within 15 km (91.6 % of original extent) and 90,125.7 ha remains within 20 km of the Proposal (85.9 % of original extent). The Beekeeper Nature Reserve lies to the west of the Proposal and provides protection for an estimated 120,000 ha of native vegetation. The proportion of this native vegetation that constitutes Carnaby's Cockatoo foraging habitat is unknown, however a large proportion occurs within the same vegetation associations as the Proposal, which indicates similar habitat.

The proposed total clearing (at the end of the mine life) represents a reduction of 1.24 % of the regional extent of native fauna habitat within 10 km of the Proposal, 0.60 % within 15 km and 0.39 % within 20 km. The cumulative impacts of the proposed and existing clearing will therefore not be significantly increased, and significant areas of native fauna habitat will remain (90.5 % within 10 km, 91 % within 15 km and 85.48 % within 20 km of the Proposal) after implementation of the Proposal.

The Proposal is situated in an extensive, continuous landscape comprised primarily of high quality Kwongan heath. The extent of disturbance required for the Proposal is relatively small in comparison to the surrounding environment and the disturbance footprint does not does intercept, isolate or fragment any unique habitat (i.e., habitat found nearby). The Proposal will also be implemented in a progressive manner with disturbed areas being rehabilitated via VDT and infill planting. This methodology is anticipated to rehabilitate some mined areas fully prior to the completion of mining (vegetation is expected to reach maturity within 10 years), re-establishing fauna habitats. The Proposal targets foraging habitat for the Carnaby's Cockatoo and will not impact breeding or roosting habitat. Furthermore, Carnaby's Cockatoo is likely to move through the landscape with little restriction having preference for areas with water, roosting habitat or foraging habitat. The Proposal is not expected to restrict any movement of this species. Considering the factors described above, the Proposal is not expected to fragment or isolate any

fauna habitats for Carnaby's Cockatoo. If any local fragmentation were to occur, it is not expected to persist, with mining areas only anticipated to be open for months at a time.

VRX has also assessed the impacts of the Proposal in a cumulative context. Five projects have been identified within 12 km (the expected foraging range of local Carnaby's Cockatoo) of the Proposal. Using the same methodology above (450 ha of clearing required for three projects, 600 ha for the Beharra silica project and 140 ha for the Arrowsmith Hydrogen Project) it is assumed there could be a cumulative impact of up to 2,090 ha of native vegetation clearing (assuming all proposals proceed). It is impossible to determine what percentage of the remaining vegetation would be considered foraging habitat, however it is reasonable to assume that the percentage within the potential impact areas is similar to that elsewhere. Based on this assumption, the cumulative impact is expected to result in a reduction of available Carnaby's Cockatoo foraging habitat by approximately 4.7%.

The clearing of habitat will be progressive, therefore there will be areas of foraging habitat that will be retained for up to 30 years as mining progresses. A conservative assumption would be that 200 ha would be retained for at least ten years before it is cleared, and half of this area would be retained for over 20 years.

Based on the information provided above, it is likely that the Proposal will progressively remove foraging habitat, and there will be some time before suitable foraging species grow to a maturity level that is suitable to once again support foraging by this species. While this loss is unlikely to result in significant impacts to local and regional populations (given the large areas of remaining foraging habitat in the area), VRX is aware that habitat loss is a key contributor to the decline of this species in WA. Taking this into consideration, the loss of any foraging habitat is considered to be significant.

Introduced Fauna

Introduced species were recorded in fauna surveys within the study areas including cats and foxes (BCE, 2022). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors:

- Food wastes at work areas; or
- Presence of cleared corridors that may be utilised by introduced fauna for access or predation.

The workforce will be relatively small, and 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 access 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 and the Southern Yamatji People (refer to Section 6.6 and 8.6).

With the implementation of controls (refer to Section 6.6 and 8.6) potential introduced fauna impacts described above are expected to be able to be appropriately mitigated such that impacts to Carnaby's Cockatoo individuals or populations are not significant on a local or regional scale.

Altered Behaviour

The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the Processing Plant (24-hour operations), which covers only several hectares. Equipment moving within the mining area will produce noise emissions however this will be limited to a small area given the progressive mining footprint. Nevertheless, Carnaby's Cockatoo may keep some distance from the mining area while operating. With the implementation of controls (refer to Section 6.6 and 8.6) potential increased risks to Carnaby's Cockatoo from 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.

Indirect Habitat Impacts

Section 6.5.1 provides a detailed assessment of indirect impacts on fauna habitat, which showed that indirect impacts would be minimal outside the area of direct disturbance. This assessment is suitable for this value also, with the Proposal considered unlikely to indirectly impact Carnaby's Cockatoo habitat if the mitigation measures listed in Section 6.6 are implemented.

Summary

Breeding or roosting habitat has not been recorded within the development envelopes. The Proposal will result in the progressive disturbance of up to 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of moderate to high value foraging habitat will be progressively rehabilitated via VDT.

VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success, however infill planting of deeper rooted species used for foraging by Carnaby's Cockatoo will be required to attempt to reinstate the original foraging habitat values.

There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species such as Banksia predicted to be able to become established in greater numbers.

Management and monitoring is proposed to improve the performance of VDT with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats (refer to Section 6.6).

After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as:

1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year period; and

2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year period.

This section has identified that there are large areas of similar potential foraging habitat in the region that will not be impacted by the Proposal. However, given the extent of the reduction in habitat for this species across its range the residual impacts described above are deemed to be significant and are proposed to be counterbalanced by offsets (refer to Section 6.6 and Section 11).

6.6 MITIGATION

VRX has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate and offset.

6.6.1 AVOID

The key avoidance mechanism implemented by VRX was the design of the development envelopes to avoid key environmental features. VRX has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid almost all of the constrained VSA2 (Dense riparian thickets).

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. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
    e. Water or dust suppressants will be applied to disturbed areas and product transfer/storage areas as required to minimise dust generation;
    f. Emergency response capabilities will be maintained to prevent fire outbreaks where possible;
    g. Weed and dieback hygiene and management measures / procedures will be implemented to prevent spread of weeds / dieback and the introduction of new weed species as a result of construction and operation;
    h. Any trenches will be dug with shallow interior slope angles or exit points to allow fauna escape;
    i. Any trenches will be progressively opened and closed;
    j. Fauna egress mechanisms will be installed at all trenches and turkeys nests / water ponds;

k. Any open trenches (if required) will be inspected less than two hours after sunrise for the presence of trapped fauna;
l. Training will be provided to ensure that fauna are not fed by site personnel;
m. Food wastes will be stored in bins that are not easily accessible to fauna;
n. Low noise equipment will be used where practicable;
o. All incidents resulting in fauna injury or death will be reported internally;
p. 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;
   d. DG Licence issued under the DG Act if required;
3. **Implement the Rehabilitation Strategy**. The Rehabilitation Strategy is provided in Appendix 4 and will be implemented during VDT;
4. **Ensure no confirmed SREs are restricted to the disturbance footprint**. For any potential SRE species recorded only within the proposed disturbance footprint, one of two actions will be undertaken:
   a. The disturbance footprint will be revised to ensure the potential SRE species are no longer recorded only within the disturbance footprint; or
   b. Additional studies will be completed to confirm whether the species are confirmed SREs. If they are not confirmed SREs then the disturbance footprint will remain unchanged. If the species are confirmed as SREs, either:
      i. The disturbance footprint will be revised to ensure the SRE species are no longer recorded only within the disturbance footprint; or
      ii. Additional targeted SRE Fauna assessments will be commissioned to identify records outside of the disturbance footprint.
5. **Prepare and implement a FMP.** The FMP will include commitments to minimise impacts to fauna habitat, and in particular Carnaby's Cockatoo foraging habitat, including:
   a. Commitments to minimise habitat disturbance during construction and operations;
   b. Minimum infill planting or seeding requirements for species utilised for Carnaby's Cockatoo foraging in VDT rehabilitation areas;
   c. Annual monitoring of the rehabilitation success of VDT areas, in particular the species utilised for Carnaby's Cockatoo foraging;
   d. Reporting and recording of Carnaby's Cockatoo and other significant fauna sightings;
   e. Reporting of introduced fauna sightings within VDT areas;
   f. Annual targeted fauna survey of VDT rehabilitation areas to assess the usage characteristics of these areas against baseline sites;
6. **Conduct pre-clearance surveys for active Malleefowl mounds**. Pre-clearance surveys will be conducted prior to disturbance for the mine plant and access road (during construction) and of each block (during mining). Pre-clearance surveys will include walking transects of the area to be cleared at 20 m spacing to identify any mounds. If an active mound is located it will either be avoided or will only be disturbed when no longer in use;
7. **Implement the following measures to minimise the risk and impact of slurry spills:**
   a. Include leak detection and automatic shut-down systems on slurry pipelines;
   b. Develop and implement internal slurry spill clean-up procedure;

   c. Undertake routine maintenance on all plant equipment including pipeline, pumps, leak detection sensors and automatic shut-down systems;
   d. Environmental incident recording, investigation and reporting system;
8. **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;
9. **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, and the handling and storage of other waste materials, including contaminated soils.

6.6.3 REHABILITATE

Progressive rehabilitation via VDT and targeted infill planting will occur during the mining process as described in Section 2.2.3 and in the Rehabilitation Strategy (Appendix 4). The Rehabilitation Strategy was developed in consideration of DMIRS Guidelines (2020a & 2020b) and describes the rehabilitation of the Proposal, and associated management and monitoring proposed during the progressive and final rehabilitation phase including completion criteria, monitoring and reporting during closure.

At the completion of the Proposal the site will be further rehabilitated to reinstate fauna habitat within areas that were disturbed for the life of the Proposal. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to terrestrial fauna are summarised below:

1. All infrastructure will be removed from site;
2. All long-term disturbance areas will be respread with topsoil (or ripped and seeded if topsoil is no longer viable) and rehabilitated;
3. All earthmoving equipment will be cleaned free of any soil material to minimise the risk of weed or dieback introduction;
4. Carnaby's Cockatoo foraging species will be included in the rehabilitation seed mix if suitable; and
5. All depressions will be shaped to prevent the formation of new semi-permanent water sources.

The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years.

6.6.4 OFFSETS

After the implementation of the mitigation measures described above, it is predicted that the Proposal will have an unavoidable residual impact on moderate to high value Carnaby's Cockatoo foraging habitat.

Proposed offsets for the unavoidable residual impacts on Carnaby's Cockatoo foraging habitat are discussed in Section 11.

6.7 PREDICTED OUTCOME

The EPA's environmental objective for this factor is to "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, 2016d).

VRX has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes, however some direct and indirect impacts to terrestrial fauna are unavoidable. The Proposal will result in up to 353.8 ha of habitat clearing, 14.5 ha of which will remain cleared for the life of the Proposal, and 339.3 ha of which will undergo progressive rehabilitation via VDT. All of these habitats are well distributed throughout the region and species that potentially use the development envelopes generally have relatively wide-ranging distributions and/or will persist in adjoining unaffected areas given the presence of extensive areas of similar habitat nearby.

Carnaby's Cockatoo was recorded in the survey area and is listed as Endangered under the EPBC Act and BC Act. It is primarily threatened by the loss and fragmentation of breeding and foraging habitat as a result of vegetation clearing (EPA, 2019). While no Carnaby's Cockatoo breeding trees were identified, the majority of the development envelopes was identified as containing moderate to high quality foraging habitat for this species. After the implementation of avoidance, minimisation and rehabilitation mitigation measures, there were residual impacts to Carnaby's Cockatoo foraging habitat, summarised as:

1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year period; and
2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo). The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year period.

These residual impacts were deemed to be significant and are proposed to be counterbalanced by offsets to ensure that the EPA objective can be met. The proposed offset site takes advantage of the unique gradual mining method proposed by VRX, and the large long-term extent of the broader deposit. This has allowed VRX to set aside a large proportion of its Mining Lease as conservation for the life of the Proposal, allowing protection and conservation management to occur for a minimum of 30 years.

If the Proposal is approved, the Ministerial Statement is likely to contain a condition requiring the development and implementation of an Offset Strategy. The offset measures will be reviewed and refined in the Offset Strategy and will be informed by discussions with DMIRS, DBCA, DCCEEW and EPA Services to ensure they adequately counterbalance the residual impacts.

Based on the above the Proposal is expected to be able to meet the EPA's objective for this factor.

7 INLAND WATERS

7.1 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.

7.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for inland waters are summarised in Table 33.

Table 33: Policy and guidance relevant to the Inland Waters key environmental factor.

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare *EP Act* Part IV Environmental Management Plans (EPA, 2021f)	This document was considered, although not deemed to be relevant to the Groundwater Operating Strategy (GOS; Appendix 17) as this document was prepared in accordance with the RIWI Act.
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Inland Waters (EPA, 2018)	This document was considered in the preparation of this section (Section 7) of the ERD.
Other Policy and Guidance	
WA Water in Mining Guideline. Water licensing delivery report series. Report No. 12. (Department of Water (DoW), 2013)	This document provides guidance when developing a groundwater management plan, it was not considered in the preparation of this section (Section 7) of the ERD, as no management plans are required.
Operational Policy 5.12 – Hydrogeological reporting associated with a groundwater well licence (DoW, 2009)	This document was considered in the preparation of this section (Section 7) of the ERD.
WA Environmental Offsets Policy (EPA, 2011);	This document was considered during EIA for Inland Waters however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Guidelines (EPA, 2014a); an	This document was considered during EIA for Inland Waters however it was determined not relevant as offsets were not required.

Policy and Guidance	How guidance has been considered
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Flora and Vegetation however it was determined not relevant as offsets were not required.
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act 1999) (DotEE, 2016a)	Other Minister of the Environment (Cth) approval decision making considerations
EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide;	This document was determined to not be required as offsets for the Inland Waters environmental factor are not required.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered, although not deemed to be relevant to the GOS as this document was prepared in accordance with the RIWI Act.
EPBC Act Condition Setting Policy (DAWE, 2020)	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared.
Relevant Technical Guidance	
Relevant EPBC Act listed species specific survey guidelines and protocols.	This document was used as guidance when undertaking surveys of EPBC listed species and potential survey limitations.
Relevant EPBC Act listed species specific Recovery plans, Threat Abatement Plans, ACA's and other documents	This document was used as guidance to assess and manage EPBC listed species that may be impacted by the Proposal.

7.3 RECEIVING ENVIRONMENT

7.3.1 SURVEY EFFORT

Baseline data relevant to this section has been sourced from the following:

- Climate data from the BoM (2022b; 2022c), in particular the Carnamah weather station (008025);
- Estimated flows in the Arrowsmith River were calculated based on data obtained from stream gauge monitoring station (701005: Arrowsmith River – Robb Crossing; RPS, 2020);
- VRX provided Particle Size Determination (PSD) data; and
- Detailed hydrogeological logs were sourced from Leeman Shallow monitoring bores near the Proposal, (Nidagal; 1991a, 1991b and Kern, 1994).

The collected data was used to inform the following Surface Water, Hydrogeological and Acid Base Accounting (ABA) assessments used to inform Proposal design and this ERD:

- RPS Group (RPS, 2020; Appendix 20) conducted a surface water assessment to illustrate the surface water characteristics of the Proposal and predict the effect of the Proposal on surface water systems. The scope of the assessment included:
    - Review of relevant historical surface water data for the survey area;
    - Characterise and describe the existing surface water environment from a regional and local perspective;
    - Investigate soil characteristics to determine run-off / infiltration characteristics;

- Flood estimation, delineation of catchments, and flood extents;
- Surface water management including assessment of potential environmental impacts of the Proposal on natural drainage systems; and
- Assessment of post-mining surface water characteristics including a discussion on final slopes / terrain profiles, trapped low points, drainage issues and rehabilitation;

- HydroConcept Pty Ltd (HydroConcept, 2019; Appendix 21) conducted a Hydrogeological Feasibility Assessment on the VRX Silica Arrowsmith tenements, including the development envelopes. The assessment included a review of the regional hydrology, development constraints, potential borefield layout, design considerations and the likely approval process under the RIWI Act;
- Mine Waste Management (MWM, 2020; Appendix 22) conducted an ABA analysis on composited samples taken from the Mine Development Envelope; and
- Water Direct Pty Ltd (Water Direct, 2022; Appendix 23) conducted a H3 Hydrogeological Assessment for the VRX Silica Arrowsmith North and Central proposals. The assessment considered pump testing data in the context of existing groundwater allocations and climate change to model and determine the impact of the proposals.

7.3.2 CLIMATE

The Mid West of WA has a Mediterranean climate with a mean maximum temperature of 19.2 – 36.2°C in summer and 7.3 – 18°C in winter. The average annual rainfall at this location (Carnamah; ID: 008025) is about 375.9 mm, and variable (300 – 850 mm per annum or about 60 – 175 % of average). Most rainfall occurs from May – August (winter) and September – April is dry (summer) (BoM, 2022b). Average annual pan evaporation (recorded at Green Grove) is approximately 2,200 mm (~3 mm/day in winter, and ~9 mm/day in summer) (BoM, 2022c).

The Carnamah weather station was identified as the closest active weather station with monthly records for both rainfall and temperature, data from 2021 is illustrated in Figure 67 (BoM, 2022b).

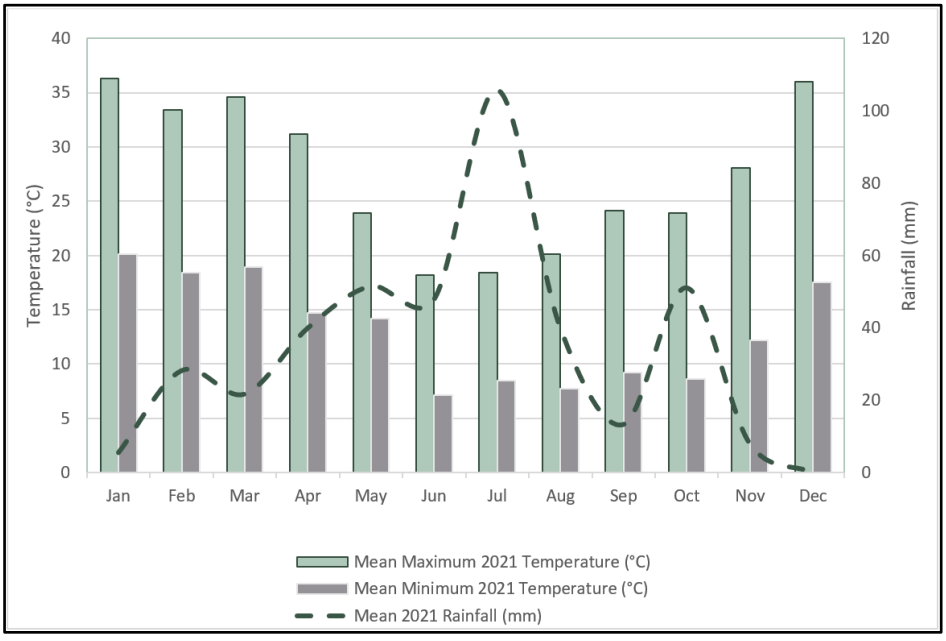


Figure 67: Rainfall and temperature data for Carnamah

Rainfall Intensity-Frequency-Depth

Intensity-Frequency-Depth data is required to characterise storm rainfall intensities and is provided by the BoM. Information is provided for various Average Exceedance Probabilities (AEP), and the equivalent Average Recurrence Intervals (ARI), up to the 2,000-year ARI.

Mine closure requires consideration of rare storms that could occur in time undefined after closure. For example, the 10,000-year rainfalls can be used as the basis for extreme rainfalls, taken as 24 % greater than the 2,000-year rainfalls (based on extrapolation of actual statistical rainfall data); or approximately two times the 100 year rainfalls (RPS, 2020).

On this basis, rainfall intensity data for the Proposal is shown in Table 34.

Table 34: Intensity-frequency-depth data (rainfall depth in mm)

AEP/ARI Duration	63 % 1 Yr	50 % 1.44 Yr	20 % 4.5 Yr	10 % 9.5 Yr	5 % 20 Yr	2 % 50 Yr	1 % 100 Yr	2,000 Yr	10,000 Yr
1-Hour	16	18	24	29	34	41	47	76	94
2-Hour	20	22	30	36	43	52	59	96	119
6-Hour	28	31	43	53	62	88	97	139	172
12-Hour	34	39	62	66	78	96	111	176	218
24-Hour	42	47	78	79	94	116	135	217	269
30-Hour	44	50	69	83	99	122	146	241	298
72-Hour	55	61	83	99	116	141	161	278	344

Climate Projections

Temperature

Based on the WA Climate Predictions (DWER, 2021c), climate change projections relating to temperature in the Southwestern Flatlands, an area that covers the Northern Agricultural, Wheatbelt South Coast, South West and Perth-Peel regions are as follows:

- By 2030, mean annual temperature is projected to increase by 0.5 – 0.9°C under an intermediate emissions scenario and by 0.5 – 1.1°C under a high emissions scenario, compared to mean conditions from 1986 – 2005.
- By 2019, mean annual temperature is projected to increase by 1.2 - 2°C under an intermediate emission scenario and 2.6 - 4°C under a high emissions scenario.
- The temperature and frequency of very hot days (>35°C) is expected to increase from 28 days (current) to 36 days by 2030 and 63 days by 2090, an increase of 125%.
- Each individual season is projected to warm by approximately the same amount as the annual mean.

Rainfall

The southwest region of WA, where the Proposal resides, has experienced a widely reported decline in rainfall over the last several decades (DoW, 2015). The reduced rainfall is a result of weakened and less frequent frontal systems, attributed to large-scale changes in southern hemisphere circulations patterns resulting from changes in global heat distribution. The trend in rainfall decline is expected to continue, based on the climate projections from the general

circulation models results analysed as part of the South-west WA Sustainable Yields (SWWASY) project (DoW, 2015).

Statistical analyses of rainfall trends were completed from 32 meteorological stations throughout WA, with data from seven stations in the southwest climate region used for analysis of trend and assessment of climate scenarios. The gridded change in average annual rainfall for the southwest region is shown in Figure 68, the results of which indicate drying trends across dry, median and wet scenarios, including greater rainfall reductions along the coastline (DoW, 2015).

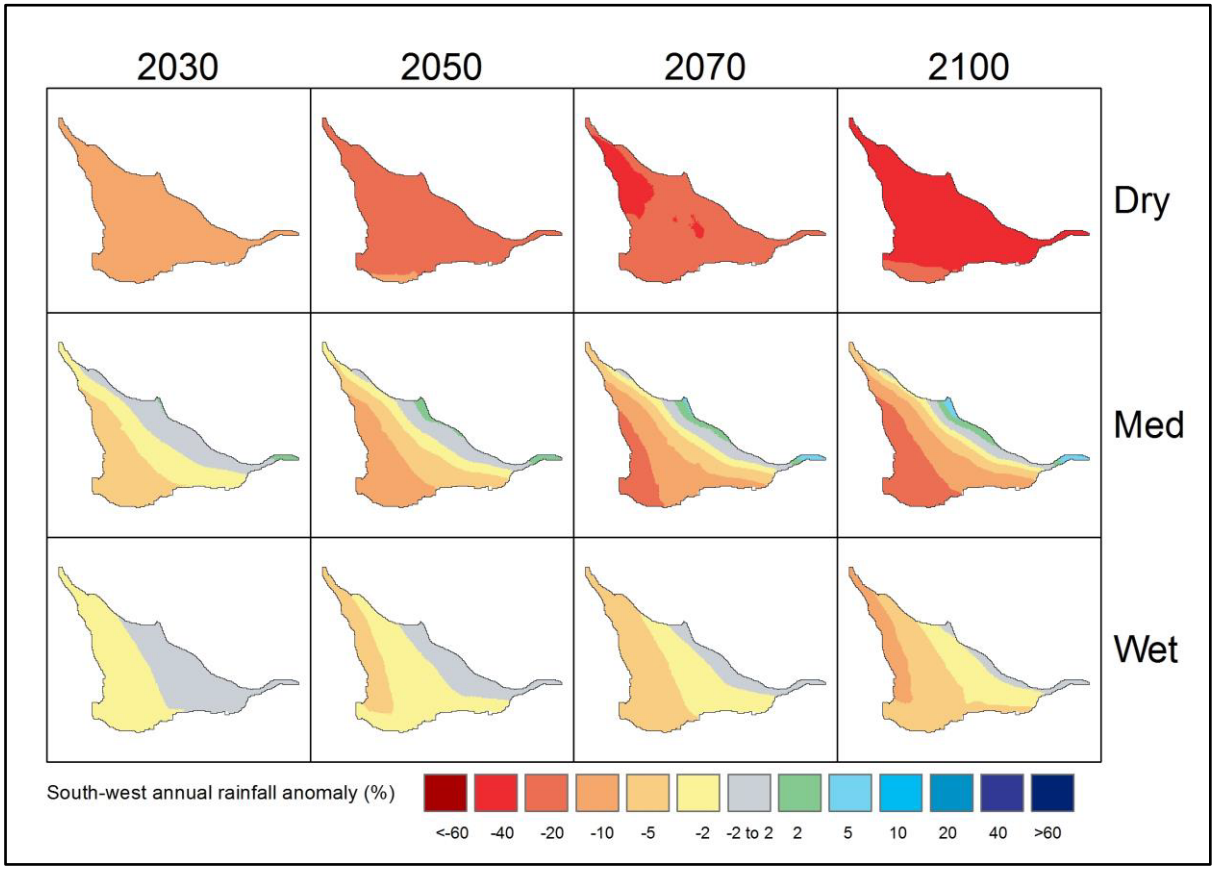


Figure 68: Change in average annual rainfall relative to the baseline period for the southwest region for representative wet, median and dry scenarios to 2100 (DoW, 2015)

Projected rainfall differences for the southwest region compared with 1986 – 2005 rainfall statistics (DWER, 2021c) are summarised in Table 35.

Table 35: Changes in projected rainfall as a result of climate change (DWER, 2021c)

Timing	2030	2090	
	Intermediate Emissions Scenario (% rainfall change)	Intermediate Emissions Scenario (% rainfall change)	High Emissions Scenario (% rainfall change)
Summer	-22 to +14	-22 to +25	-26 to +28
Autumn	-18 to +9	-22 to +10	-33 to +14
Winter	-16 to +2	-26 to -3	-44 to -13
Spring	-20 to +3	-33 to +3	-52 to -5
Annual	-13 to 0	-22 to -1	-36 to -2

Under all emission scenarios, the time spent in drought is projected to increase and although total annual rainfall is expected to reduce, the intensity of heavy rainfall events will likely increase (DWER, 2021c). Climate change projections indicate an overall decrease in rainfall, particularly in winter and spring, increased intensity of heavy rainfall events, increases in the duration of drought, increased average temperatures, increased evaporation rates and subsequently reduced soil moisture and surface runoff.

7.3.3 SURFACE WATER

The information contained within this section is from RPS (2020; Appendix 20) unless otherwise stated. The RPS (2020) desktop surface water assessment was conducted on the Mine Development Envelope and surrounds as defined in Figure 69.

Catchment Characteristics

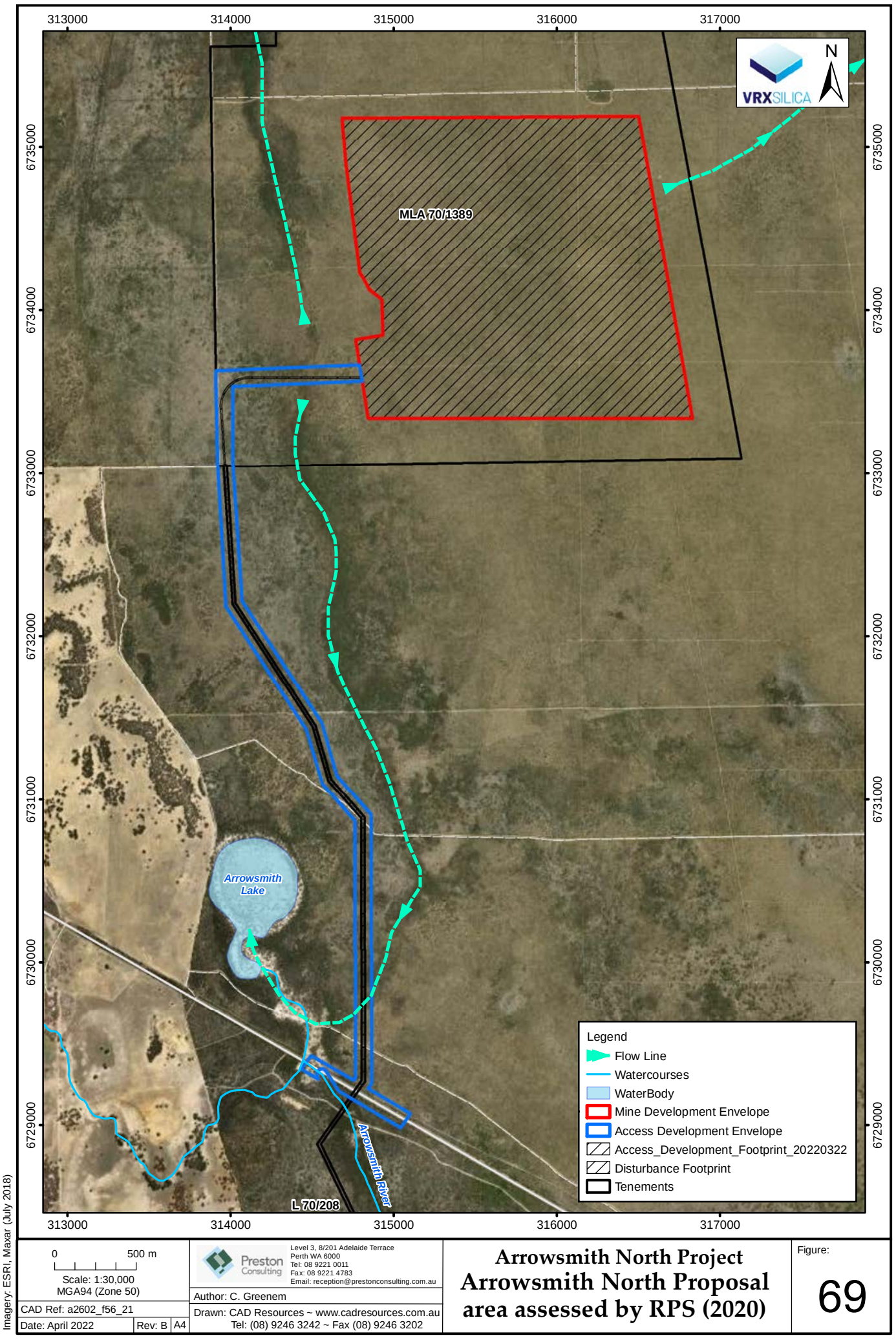
At a regional scale, surface water drains west and to the sea, notably in a dryland Arrowsmith River, and into Arrowsmith Lake (Figure 69). The Mine Development Envelope consists of a low, slightly undulating sandplain landscape with maximum terrain slopes in the order of 4 %. The Mine Development Envelope avoids existing infrastructure, trees, drainage lines and potential conservation areas. The land elevations over the Mine Development Envelope vary from about 30 – 50 m RL (Figure 70).

The Mine Development Envelope is not subject to external concentrated flows from water courses or creeks due to it having a higher elevation than the surrounding terrain, and the high infiltration rate of the sandy landscape around the area. Similarly, runoff from the area is limited by the sandy substrate. Due to the high infiltration characteristics of the sandy soils and lack of water courses in the area, runoff, within and from the site, has low potential and is only anticipated to occur in short intense rain bursts.

Key Surface Water Features

The closest significant surface water features are the Arrowsmith River, part of which is a registered Aboriginal Site (30068) (DPLH, 2020), and Arrowsmith Lake which lies to the south of the development envelopes.

The Arrowsmith River traverses the landscape westward from the small town of Arrino for approximately 85 km then heads north for 10 km before splitting into two arms, one of which terminates at Arrowsmith Lake, the other continues in a north westerly direction. This arm is ephemeral and is likely to only flow in extreme rain events such as when Arrowsmith Lake overflows. Arrowsmith Lake is a permanent pool approximately 2.9 km southwest of the Mine Development Envelope. It is 850 m long and approximately 30 ha in size. Arrowsmith Lake is one of the few permanent water bodies in the wider area, but has no recreational use. The location of Arrowsmith River and Arrowsmith Lake are shown in Figure 69.



Imagery: ESRI, Maxar (July 2018)

0 500 m

Scale: 1:30,000
MGA94 (Zone 50)

CAD Ref: a2602_f56_21

Date: April 2022 | Rev: B | A4

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Arrowsmith North Project
Arrowsmith North Proposal area assessed by RPS (2020)

Figure: 69

Figure 69: Surface water flows of the Proposal

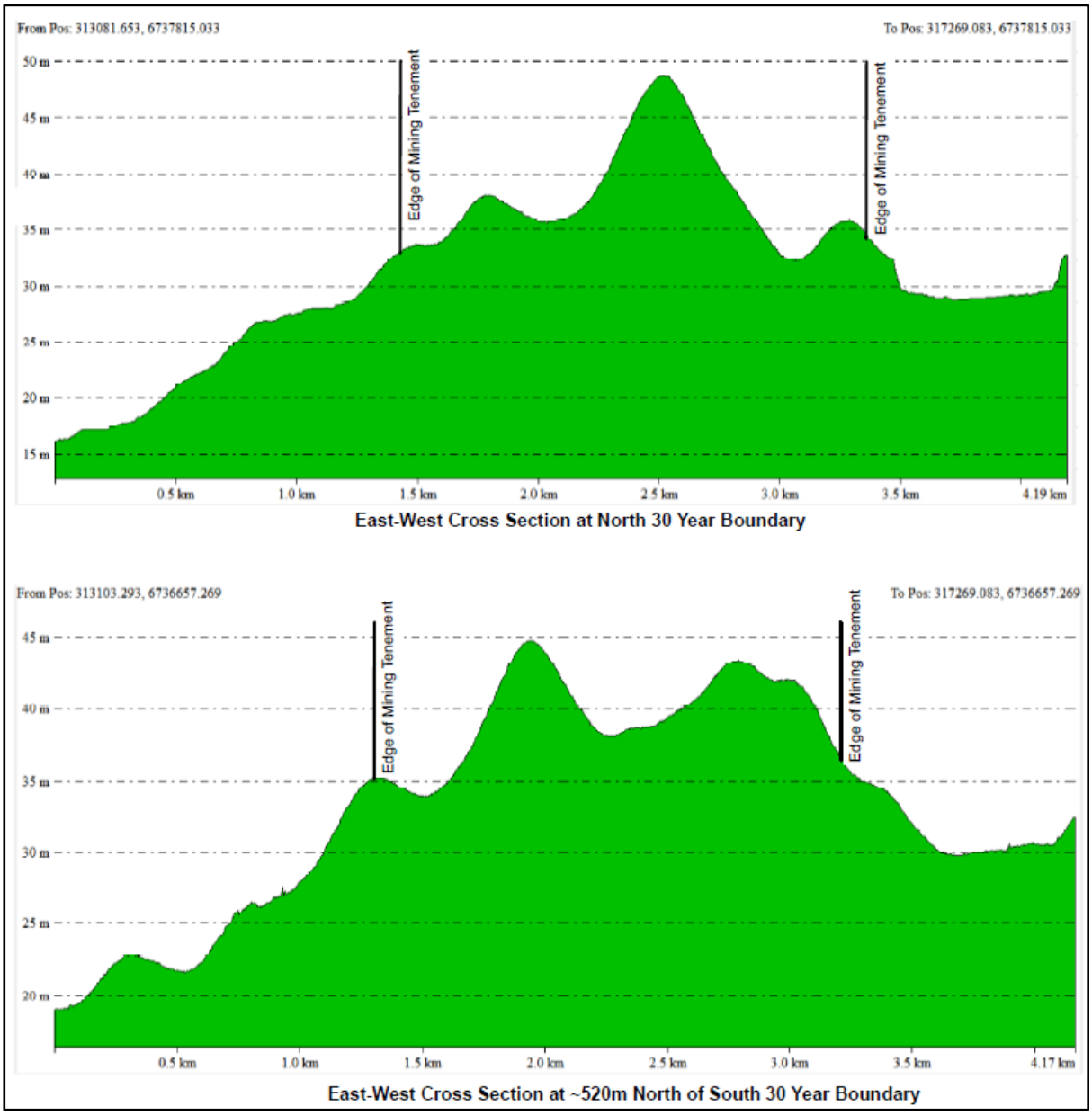


Figure 70: Topographical cross section of the southern end of the Mine Development Envelope (RPS, 2020)

7.3.4 GEOLOGY

The Proposal is situated upon the Swan Coastal Plain (Figure 71), which is up to approximately 30 km wide comprising several geomorphic units parallel to the coast. The Proposal is located upon the Eneabba Plain, which is made up of shoreline, lagoonal and dune deposits possibly reworked from late Tertiary alluvial fans. The Proposal lies within the northern Perth Basin, containing a succession of Quaternary to Permian age deposits up to a total of 12,000 m thick, but thinning to around 1,000 m over the Beagle Ridge southwest of the Proposal. A detailed description of the geology and hydrogeology in the northern Perth Basin is available in: 'Northern Perth Basin: Geology, hydrogeology and groundwater resources' (DoW, 2017).

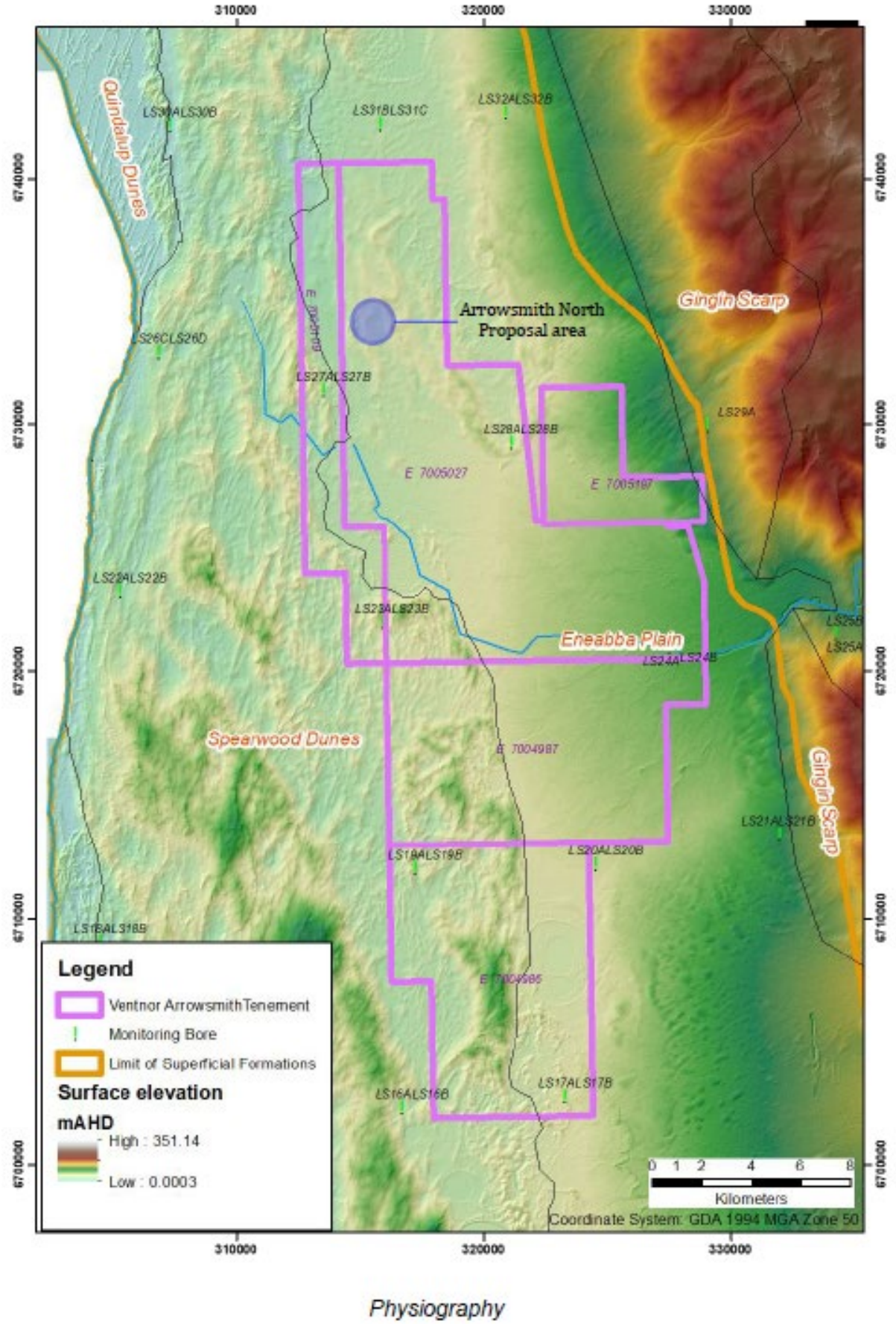


Figure 71: Hydrogeological assessment area (HydroConcept, 2019)

7.3.5 GROUNDWATER

The information contained within this section has been sourced from HydroConcept (2019; Appendix 21) unless otherwise stated. HydroConcept conducted the hydrological feasibility assessment on the Proposal tenement boundaries and surrounds as illustrated in Figure 71.

The Proposal lies entirely within the Eneabba Plains subarea of the Arrowsmith Groundwater Area defined by DWER in the Arrowsmith Groundwater Allocation Plan (DoW, 2010). There are two aquifers present beneath the Proposal; the relatively thin Superficial Formations, which are underlain by a major regional aquifer within the Yarragadee Formation.

Superficial Geology and Aquifer

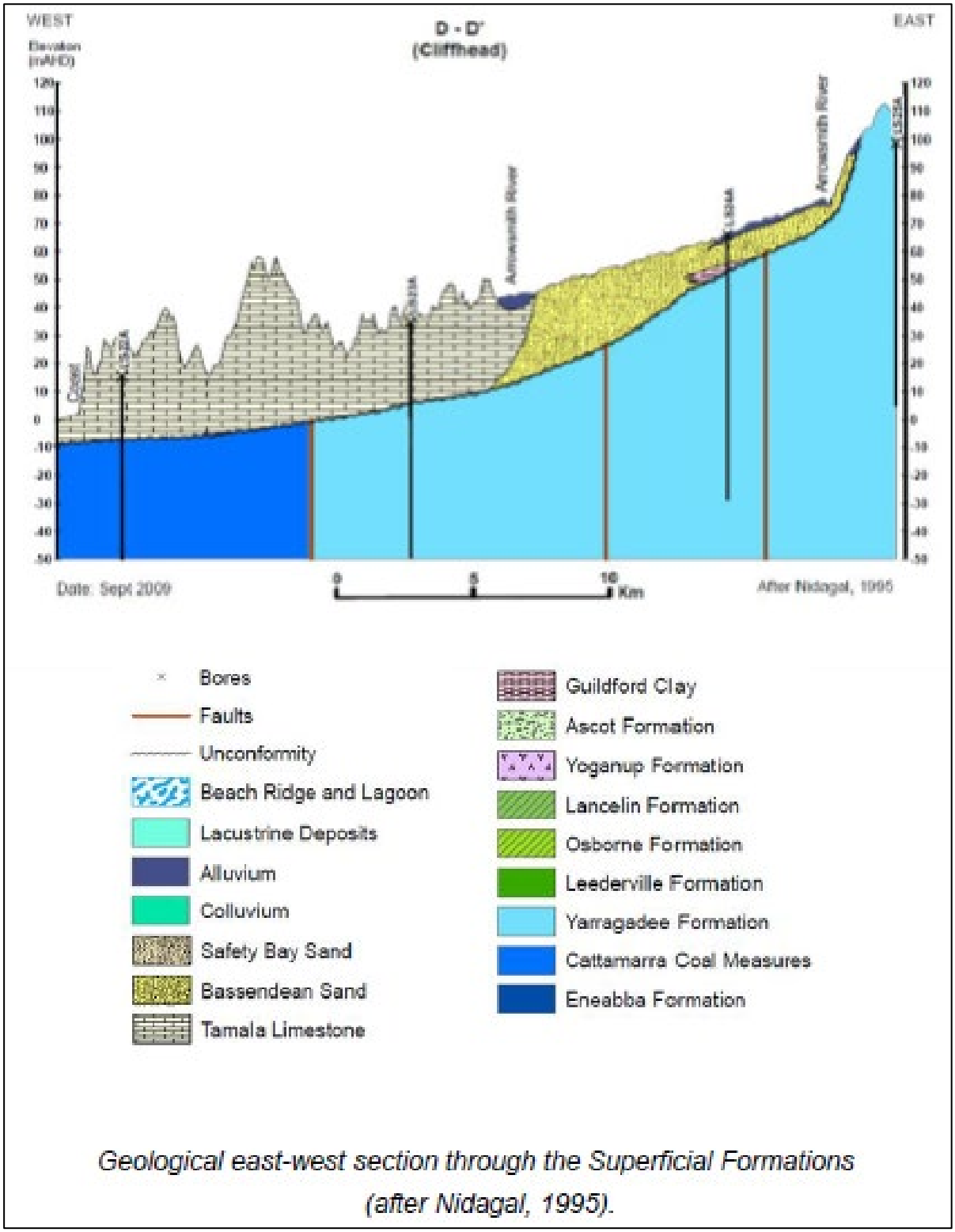
The Swan Coastal Plain is underlain by a sequence of Quaternary and Pliocene sedimentary deposit which unconformably overlie Mesozoic deposits upon a gentle, westward sloping erosional surface (Figure 72). The Superficial Formations form an unconfined aquifer referred to as the Superficial aquifer. The Mine Development Envelope is underlain by a relatively thin cover of sand belonging to the Bassendean Sand upon a thicker section of predominantly clayey sand forming the Guildford Clay, which is approximately coincident with the Eneabba Plain. Calcarenite limestone of the Tamala Limestone is located west of the Mine Development Envelope beneath the Spearwood Dunes, and frequently contain karstic cavities.

The water table within the Superficial aquifer falls from around 50 - 60 m AHD about the eastern margin of the coastal plain to sea-level at the coast (Figure 73). The water table under the Proposal ranges from 10 – 20 m AHD, or more than 15 m below current ground level. Near the inland margin of the coastal plain, the water table is typically within the Mesozoic formation (Yarragadee Formation) underlying the Superficial Formations, the Superficial aquifer is unsaturated.

Groundwater is recharged mainly by the infiltration of rainfall, but there is also a component of recharge by upward leakage from underlying aquifers, mostly about the central portion of the coastal plain. Groundwater recharge is also achieved through infiltration from streams and rivers flowing out onto the coastal plain, including the Arrowsmith River that discharges over the coastal plain. Groundwater flows down the hydraulic gradient toward the coast, where most of the groundwater is discharged to the ocean. A component of groundwater is lost via evaporation from lakes and evapotranspiration.

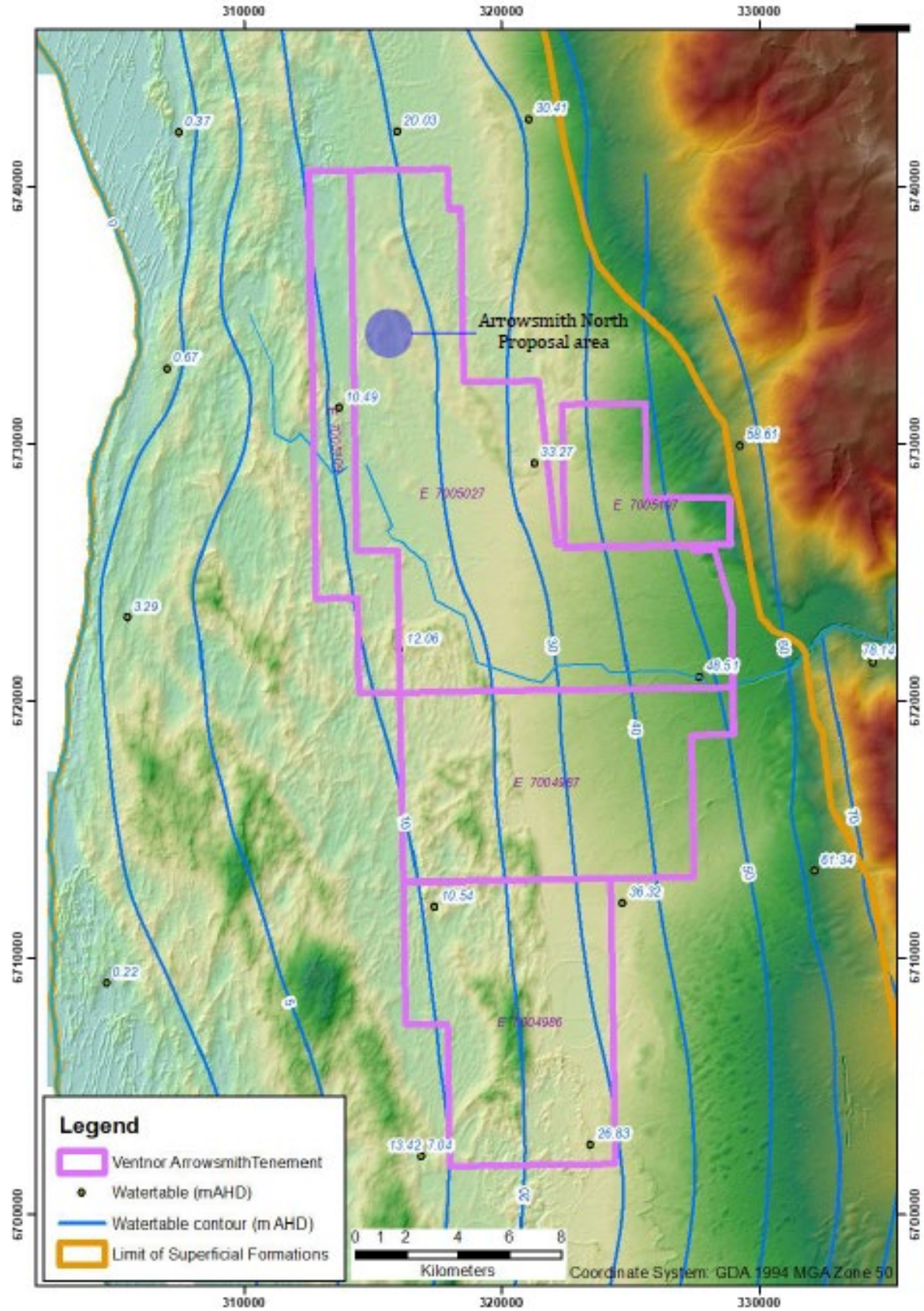
The saturated thickness of the Superficial aquifer is shown by the interpretive isopach in Figure 74. The inland margin of the Superficial aquifer is unsaturated. Below the Mine Development Envelope, the saturated thickness is mostly 10 – 15 m, with a saturated profile in the nearby monitoring bores of 11.2 m, 26.1 m and 19 m at LS27, LS28 and LS31 respectively (Figure 74).

Groundwater salinity within the Superficial aquifer is generally fresh at less than 1,000 mg/L Total Dissolved Solids (TDS) about its eastern margin, increasing toward the coast where it becomes saline. Beneath the Mine Development Envelope, the groundwater salinity is approximately 1,000 – 1,700 mg/L TDS.



Geological east-west section through the Superficial Formations (after Nidagal, 1995).

Figure 72: East-west geological cross section of the Mine Development Envelope (HydroConcept, 2019)



Watertable across the coastal plain

Figure 73: Water table across the Mine Development Envelope (HydroConcept, 2019).

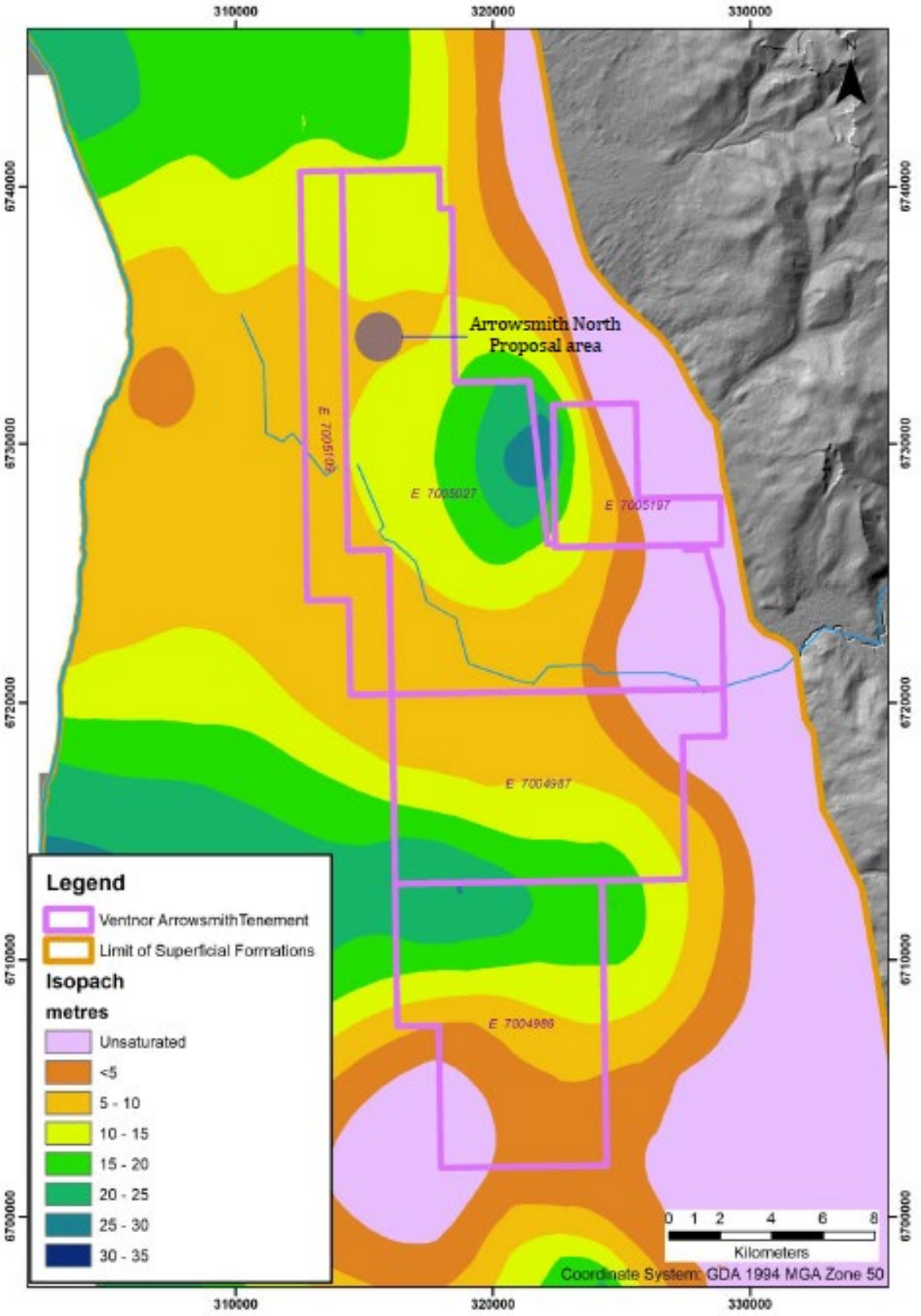


Figure 74: Isopach of the Superficial Aquifer beneath the Proposal (HydroConcept, 2019)

Transmissivity of the Superficial aquifer typically increases toward the coast, mostly because of more permeable strata present toward the coast. Tamala Limestone forms the most permeable portion of the aquifer due to the presence of karst features, from which relatively large bore yields can be obtained, such as around 1,000 – 2,000 kL/day from bores of the Jurien Bay town water supply borefield south of Arrowsmith. Hydraulic conductivity will be highly variable depending on the development of karst features below the water table but is mostly between 50 and 1,000 m/day (DoW, 2017).

Bassendean Sand within the eastern portion of the Superficial Formations is largely unsaturated, with the aquifer mostly comprising the Guildford Clay. As the Guildford Clay lithology is principally a clayey sand, it is anticipated to have a relatively low permeability, possibly in the range of 0.4 – 1 m/day, similar to that reported for comparable lithologies of the Guildford Clay in the Perth area (Davidson, 1995).

Yarragadee Geology and Aquifer

Beneath the Superficial Formations the Proposal is underlain by the Yarragadee Formation, which is Middle to Late Jurassic in age. Numerous deep wells have been drilled as part of petroleum exploration and development in the Arrowsmith area, which has provided geological mapping.

The Yarragadee Formation is a major, regionally extensive formation within the Perth Basin that can exceed 3,600 m thick. It consists of predominantly weakly to moderately cemented sandstone, with interbedded siltstone, shale and claystone (DoW, 2017). The Yarragadee Formation is conformably underlain by the Cadda Formation, comprising sandstone, siltstone and claystone. The Proposal is situated upon a down-faulted block just east of the Mountain Bridge Fault. The Superficial Formations are underlain by the Yarragadee Formation which extends to between about 1,000 m and 1,200 m depth.

The Yarragadee Formation contains the Yarragadee aquifer which is the largest regional aquifer within the northern and central Perth Basin, forming a thick, permeable aquifer. Hydraulic properties are dependent on the portions of sand versus silt and clay, and the degree of cementation. Evaluation of many pumping tests have found average and median values for hydraulic conductivity of 12 m/day and 5.6 m/day respectively (DoW, 2017). Bore yields are generally large, with pumping rates up to 6,000 kL/day obtained from production bores at Eneabba (Johnson and Commander, 2006).

Groundwater within the Yarragadee aquifer is recharged by downward rainfall infiltration over the dissected plateau region inland of the coastal plain referred to as the Arrowsmith Region. From the Arrowsmith Region groundwater flow is westward, discharging about the western margin of the Yarragadee Formation near the central portion of the coastal plain by upward leakage into the Superficial aquifer.

There is no direct measure of groundwater salinity from deeper portions of the Yarragadee aquifer at the Proposal, but the salinity has been recorded from the upper portion of the aquifer in nearby Leeman Shallow monitoring bores. The salinity in deeper sections has been estimated from regional mapping.

Monitoring bore LS31B (94 – 100 m; Figure 71) obtained groundwater from the upper portion of Yarragadee aquifer with a salinity of 860 mg/L (Nidagal, 1995). Regional groundwater salinity

mapping suggests that the salinity rises to 1,500 mg/L TDS by around 300 m depth, and 3,000 mg/L TDS toward the base of the Yarragadee aquifer.

Groundwater Licences

A query of DWER's Water Register shows there are five active groundwater licences issued under the RIWI Act for the Yarragadee Aquifer within the Dongara subarea (DWER, 2022; Table 36).

Table 36: Groundwater abstraction licences targeting the Yarragadee aquifer in proximity to the Proposal

Licensee	Licence Number	Expiry Date	Abstraction Rate (GL/yr)
Christian Joseph Serge Bechard	151147	9 July 2027	0.0221
Main Roads	181528	30 August 2030	0.015
Martin Lundy	184162	8 March 2027	0.0001
RCMA Australia Pty Ltd	202801	27 May 2029	0.45
VRX	N/A	Proposed	0.9
Total Abstraction Rate			1.3872

Water Balance

VRX, in conjunction with ProjX Pty Ltd and BHM Process Consultants (VRX, 2022), has assessed the water balance for the Proposal to determine the quantities of groundwater required for each activity. Given the simple nature of the Proposal, VRX is able to keep water requirements relatively low. The Proposal has a requirement for up to 0.9 GL of groundwater per annum. Water for the Proposal is primarily used in the process circuit and for dust suppression however losses are expected from the export of wet product, evaporation and seepage. Water for the Proposal is primarily used in the process circuit and for dust suppression however losses are expected from the export of wet product, evaporation and seepage. The following key assumptions have been made in respect to water requirements:

- Mining related water required includes the MFP and an allowance for dust suppression in the pit;
- Dust suppression has been estimated at six water trucks/day (25 m^3 per truck);
- Potable water requirements estimate 20 onsite personnel, at a consumption rate of 200 L/day;
    - Evaporation losses in the process water pond have been estimated based of meteorological data (WA's BoM) at an average of approximately 2,100 mm/annum. Based on the surface area of processing pond (6,000 m^2), this equates to approximately 1.45 m^3/hr as an average consumption rate over a year;
- Stockpile water for the various products (Coarse/Fine/Intermediate) have been estimated at a preliminary rate of 10 m^3/hr;
    - Note that this is currently undergoing a review;
    - Stockpiles are currently assumed to not be recovering any of the drained water;
- The rejects stockpile (Coarse and Fines) does not have spray water as these are depositing on their respective pads at a substantially higher moisture level than the other stockpiles and have been assumed to generate negligible dust as a result; and
- A centrifuge is included in the circuit (note if a centrifuge is not included, an additional 0.12 GL/annum of water is required).

The general water flow of the Proposal is shown in Figure 75.

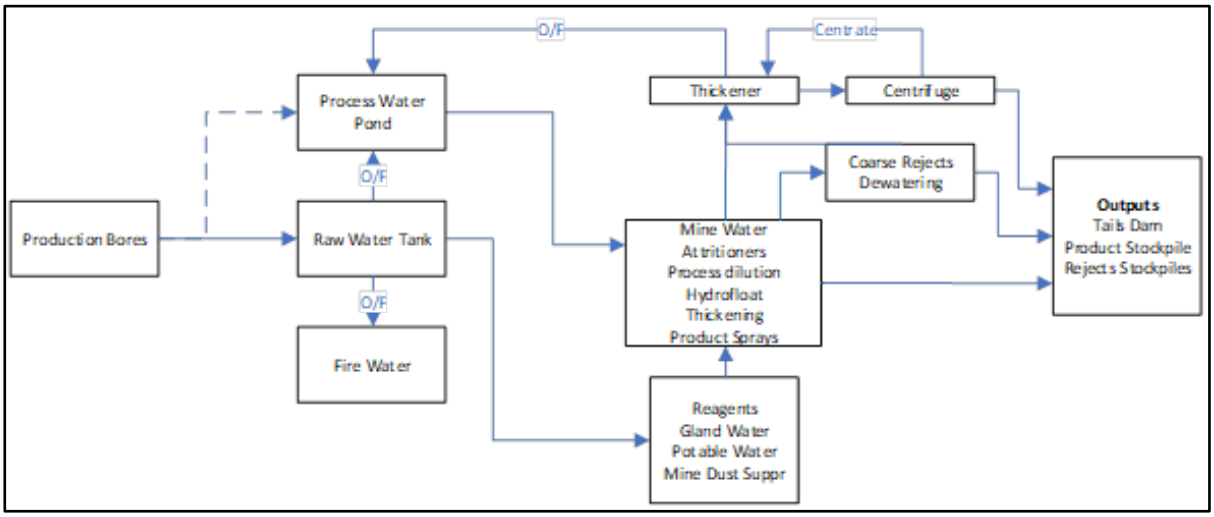


Figure 75: General water flow paths

The water balance detailed in Table 37 is indicative and based on the best current available information. Evaporation rates are dependent on climatic conditions and there is a possibility that water from stockpiles may evaporate quicker than anticipated. To ensure there is enough buffer in the water balance to wet down the stockpiles (for dust suppression) VRX has sought approval to abstract more water than what has been documented in the water balance. VRX will only use the water required for the Proposal but must maintain a buffer to allow safe operation.

Table 37: Water balance for the Proposal

Minimum Requirement	Volume (GL/annum)
Processing	0.54
Evaporation (Water Pond)	0.01
Dust Suppression	0.05
Annual Water Consumption (GL/a)	**0.6**

7.3.6 Potential Acid Mine Drainage

The information contained within this section has been sourced from the ABA analysis of the Proposal by MWM (2020; Appendix 22) unless otherwise stated. Composited samples used in the ABA and PSD analysis were taken from drill holes within the Proposal tenement identified in Figure 76. Three composite samples comprising nine primary samples were used for analysis. The primary samples were collected from drill holes of varying depths, ranging from 5 – 6 m below ground level (BGL) to 12 – 13 m BGL. The depths and ranges of the samples are provided in Table 38.

Figure 76: Location of drill holes and sampling locations

Table 38: Primary and composite drill hole sample details

Hole ID	Depth from surface (m)	Depth to base of drill hole (m)	Sample ID	Type	Composite ID
ANC011	8	9	CB09996A	Pulp	**ANARD Comp01**
ANC013	5	6	CB09977A		
ANC015	12	13	CB10044A		
ANC055	8	9	CB10458A	Pulp	**ANARD Comp02**
ANC057	12	13	CB10486A		
ANC059	11	12	CB10515A		
ANC079	12	13	CB10782A	Pulp	**ANARD Comp03**
ANC081	9	10	CB10811A		
ANC083	8	9	CB10831A		

ABA analysis was conducted to predict the acid generation characteristics of geological waste material through determination of the acid neutralising capacity and the maximum potential acidity. Although analysis of pH using distilled water is not a standard ABA test, it was completed to aid in the interpretation of the ABA data as ancillary information. All samples from the survey area were devoid of both acid generating and neutralising potential as demonstrated by total sulfur values less than the reporting limit for all samples and acid neutralising capacity equal to or less than 1 kg H_2SO_4/t in all samples.

When combining Nett Acid Production Potential and Nett Acid Generation pH results as per the Australian Mineral Industries Research Association (AMIRA) classification system (AMIRA, 2002), all samples are classified as non-acid forming. Rinse pH and electrical conductivity (EC) results demonstrate slightly acidic (5.5 – 6.5) fresh leachates with negligible salinity.

All of the composite samples from the Proposal that were analysed represent a low acidic drainage risk. The observed lack of acid generation and neutralisation capacity is in line with expectations for material collected from a silica sand deposit. Rinse EC results suggest a low risk of generating saline drainage.

7.3.7 Environmental Values

Based on the information provided in Section 7.3, the following environmental values were determined to require assessment for this factor:

- Surficial Aquifer beneath and surrounding the Proposal;
- Yarragadee Aquifer; and
- Surface waters.

7.4 Potential Impacts

Table 39 defines the potential impacts (direct, indirect and cumulative) on the environmental values for this factor in a local and regional context. Assessment of the potential impacts is provided in the following sections.

Table 39: Potential impacts on inland waters

Environmental value and current extent	Potential direct impacts	Potential indirect impacts	Impacts associated with other proposals	Total cumulative impacts
Superficial Aquifer Underlying groundwater within the Superficial Aquifer is fresh and >15 mbgl in the vicinity of the Mine Development Envelope.	No abstraction proposed Drawdown of aquifer due to leakage to Yarragadee aquifer	Contamination from hydrocarbon or chemical spills	1.001 GL/yr is approved to be abstracted under existing 5C Licences in the area Part of the development envelopes lie within a historical contaminated site classified as 'Contaminated – Restricted Land Use' under Section 13 of the CS Act. The nature of contamination is hydrocarbon contamination resulting from the development and operation of the Beharra Springs gas plant (approximately 7 km northeast of the Proposal). The extent of contamination is believed to be limited to an area immediately shrouding the plant. Extent of contamination beneath the Proposal is unknown.	No abstraction from the Superficial Aquifer is Proposed (none included in this Proposal) Some leakage due to abstraction of the Yarragadee aquifer Potential contamination from hydrocarbon or chemical spills, in addition to existing potential contamination from the Beharra Springs Gas Plant
Yarragadee Aquifer Underlying groundwater within the Yarragadee Aquifer is fresh to brackish. Bore yields are generally large, with pumping rates up to 5,000 kL/day. The Yarragadee Aquifer within the Eneabba Plains has an annual allocation limit of 22.5 GL.	Abstraction of 0.9 GL per year	No predicted indirect impacts	There are four active groundwater licences targeting the Yarragadee Aquifer in close in the Dongara sub area: • Christian Joeseph Serge Bechard: 0.0221 GL/yr • Main Roads: 0.015 GL/yr • Martin Lundy: 0.0001 GL/yr • RCMA Australia Pty Ltd: 0.45 GL/yr	Combined abstraction of 1.3872 GL per year from the Yarragadee Aquifer
Surface Waters Ephemeral portions of the Arrowsmith River and minor ephemeral drainage lines intersect the southern portion of the Access Development Envelope Arrowsmith Lake is approximately 1 km west of the Access Development Envelope	6 m wide crossing of a minor ephemeral drainage line	• Minor alterations to surface water flow regimes within mining areas • Contamination from hydrocarbon or chemical spills • Sedimentation during earthmoving or as a result of slurry pipeline spills	Brand Highway intersects with the Arrowsmith River west of the proposed intersection of the access corridor and the Brand Highway	• Crossing of a minor ephemeral drainage line • Alteration to surface water regimes within mining areas • Contamination from hydrocarbon or chemical spills • Sedimentation

7.5 ASSESSMENT OF IMPACTS

7.5.1 SUPERFICIAL AQUIFER

Yarragadee Aquifer Abstraction Impacts

VRX has commissioned Water Direct to conduct a H3 hydrological assessment (Water Direct, 2023; Appendix 23) which includes modelling of drawdown from groundwater abstraction required for both the Arrowsmith North and Central projects. Modelling is based on the combined extraction of both Proposals (currently proposed to be 1.3 GL/annum) and therefore provides a conservative assessment of the potential impacts of this Proposal. Existing abstraction allocations were considered up to 20 km from the proposals. Aquifer drawdown modelling was conducted for three operating scenarios for a 30 year mine life:

1. No Abstraction – steady state initial conditions, abstraction is set to zero;
2. Existing Allocations Abstracted (Base Case) – abstraction is set as the licensed allocation from 2015 - 2022, which is 6.283 GL/annum; and
3. VRX Proposed Abstraction (Arrowsmith North and Central Combined) – forward scenarios use the base case licenced allocation plus 1.30 GL/annum allocation to VRX, from their two productions bores, this is incremental to Scenario 2.

Scenario 2, where there is no VRX abstraction, show the drawdown for the Superficial aquifer at the Proposal as a maximum drawdown of up to 1m over 30 years. Scenario 3, where the 1.3 GL/annum combined VRX abstraction from the Yarragadee only is included, shows an additional drawdown of the Superficial Aquifer of less than 0.25 m over 30 years.

As there is no additional abstraction from the Superficial Aquifer in Scenario 3 the drawdown on this aquifer is due to leakage from the aquifer and the effects of climate change and subsequent reduction of rainfall. Modelling shows that abstraction of groundwater from the Yarragadee aquifer for the combined Arrowsmith North and Central Projects is likely to only contribute to a minor additional drawdown within the superficial aquifer (because of leakage) of 0 - 0.25 m over 30 years. This equates to an additional drawdown of 8 mm per year at the Proposal (assuming linear drawdown rates over 30 years). Review of the proposed superficial drawdown in the context of phreatophytic vegetation in the 0 – 3m depth to ground water category (the most groundwater dependant), drawdown would present a low risk as defined in Froend, *et al.*, (2004). The modelling takes a conservative approach and results indicate abstraction presents a low risk to groundwater dependant vegetation, it is possible actual drawdown is less and subsequently the risk is lower. Based on this the proposed abstraction is not expected to have a significant impact on any ecosystems that may be dependent on the Superficial Aquifer.

Indirect Impacts

The Proposal will require the storage of various hydrocarbons and chemicals including fuel, oil, hydraulic fluid, flocculant, coolant, surfactants and degreasers. Spills and improper management / disposal of these hydrocarbons and chemicals present a contamination risk for the Surficial Aquifer. Furthermore, the Proposal includes the operation of light vehicles, FELs and other machinery which may pose a risk of hydrocarbon spillages.

The flocculant used in the process is Floerger AN900 series Anionic Polyacrylamide. Anionic polyacrylamide has no systemic toxicity to aquatic organisms or micro-organisms. The polymer

is much too large to be absorbed into tissues and cells. The functional anionic groups do not interfere with the functioning of fish gills or daphnia respirators. Any adverse effects observed in laboratory tests are always seen at concentrations of over 100 mg/L and are probably due to the resulting viscosity of the test medium. The preparation of the test solutions at such concentrations requires high-energy stirring for long periods of time, sometimes several hours. Therefore, it can be concluded that these harmful concentrations will not exist in the natural environment (SNF Floerger, n.d.).

Anionic polyacrylamide has no potential to bioaccumulate, being completely soluble in water (solubility is only limited by viscosity) and insoluble in octanol. Additionally, being a flocculent, it adsorbs onto suspended matter and, in this way, is removed from the water phase. The sensitivity of polyacrylamide to ultra-violet light is well known and has been described in the scientific literature. Photolysis leads to the degradation of the polymer chain and the formation of much smaller molecules, or oligomers, which are accessible to microbial attack. A recent study financed by SNF Floerger, has demonstrated that photolysis followed by aerobic or anaerobic treatment resulted in efficient mineralization of the polymer. This study provides evidence that acrylamide polymers have the potential to be naturally broken down and biodegraded and do not persist or accumulate in the environment (SNF Floerger, n. d.).

With the implementation of controls (Section 7.6), hydrocarbon and chemical storage and spills are expected to be able to be managed to prevent significant impacts on the Superficial Aquifer.

7.5.2 YARRAGADEE AQUIFER

To enable the transport, processing and upgrading of mined sand, VRX will require up to 0.9 GL per annum of water. The area is constrained by areas of shallow water table that are likely to be impacted by groundwater abstraction from the Superficial aquifer (HydroConcept, 2019). Therefore, HydroConcept (2019) has identified the Yarragadee aquifer as the most prospective groundwater resource for the Proposal. There have been previous investigations that provide confidence that aquifer horizons are present in different units of the Yarragadee Formation. The aquifer can provide the required water supply from one production bore which would be capable of providing 5,000 kL per day (1.825 GL per annum). The production bore has been constructed and pump tested and is deemed suitable for the water requirements of the Proposal.

Currently, there are four active groundwater licences provided by DWER under the RIWI Act that target the Yarragadee aquifer in the Dongara subarea, the cumulative potential abstraction rate of these licences and the proposed abstraction from VRX is 1.3872 GL per annum.

The Yarragadee Aquifer within the Dongara subarea has a groundwater abstraction allocation limit of 4.5 GL, therefore a 0.9 GL increase in abstraction represents approximately 20% of the total groundwater allocation.

Climate projections (see Section 7.3.2) indicate less rainfall in winter and spring, increased intensity of heavy rainfall events, drought duration increases, increased average temperatures, increased evaporation rates and subsequently reduced soil moisture and surface runoff. Climate change is likely to change the way Western Australian's utilise water, in the future it is anticipated that groundwater abstraction allocations will be revised from time to time. VRX will implement industry best practice to minimise the amount of water required for the Proposal. VRX has applied for licences for the construction of a bore and abstraction of groundwater under section 26D and 5C of the RIWI Act. These applications fall within the groundwater resources allocations for the

Yarragadee aquifer. VRX will operate the Proposal in accordance with the licences, allocations and conditions issued by DWER under the RIWI Act and recognises that impacts of climate change may require change to future allocations. In consideration for WA's Climate Change Policy (DWER, 2020), alternative water sources (such as desalination) may be considered in the future if groundwater allocations at no longer available.

VRX has conducted a H3 hydrological assessment (Appendix 23) which includes modelling of drawdown from groundwater abstraction required for both the Arrowsmith North and Central projects. Modelling is based on the combined extraction of both proposals (currently proposed to be 1.3 GL/annum) and therefore provides a conservative assessment of the potential impacts of this Proposal. Existing abstraction allocations were considered up to 20 km from the proposals. Aquifer drawdown modelling was conducted for three operating scenarios for a 30 year mine life:

1. No Abstraction – steady state initial conditions, abstraction is set to zero;
2. Existing Allocations Abstracted (Base Case) – abstraction is set as the licensed allocation from 2015 to 2022, which is 6.283 GL/annum; and
3. VRX Proposed Abstraction (Arrowsmith North and Central Combined) – forward scenarios use the base case licenced allocation plus 1.30 GL/annum allocation to VRX, from their two productions bores, this is incremental to Scenario 2.

Scenario 2, where there is no VRX abstraction, show the drawdown for the Yarragadee Aquifer at the Proposal as a maximum drawdown of up to 1.25 m over 30 years.
Scenario 3, where the 1.3 GL/annum VRX abstraction from the Yarragadee only is included, the incremental drawdown for the Yarragadee Aquifer is predicted to be an additional maximum drawdown of up to 1.25m over 30 years.

Modelling shows that abstraction of groundwater from the Yarragadee Aquifer for the combined Arrowsmith North and Central Projects is likely to only contribute an additional 1.25 m of drawdown over 30 years at the Proposal. Drawdown within the Yarragadee aquifer is not predicted to directly impact any Groundwater Dependant Ecosystems due to physical isolation from these ecosystems.

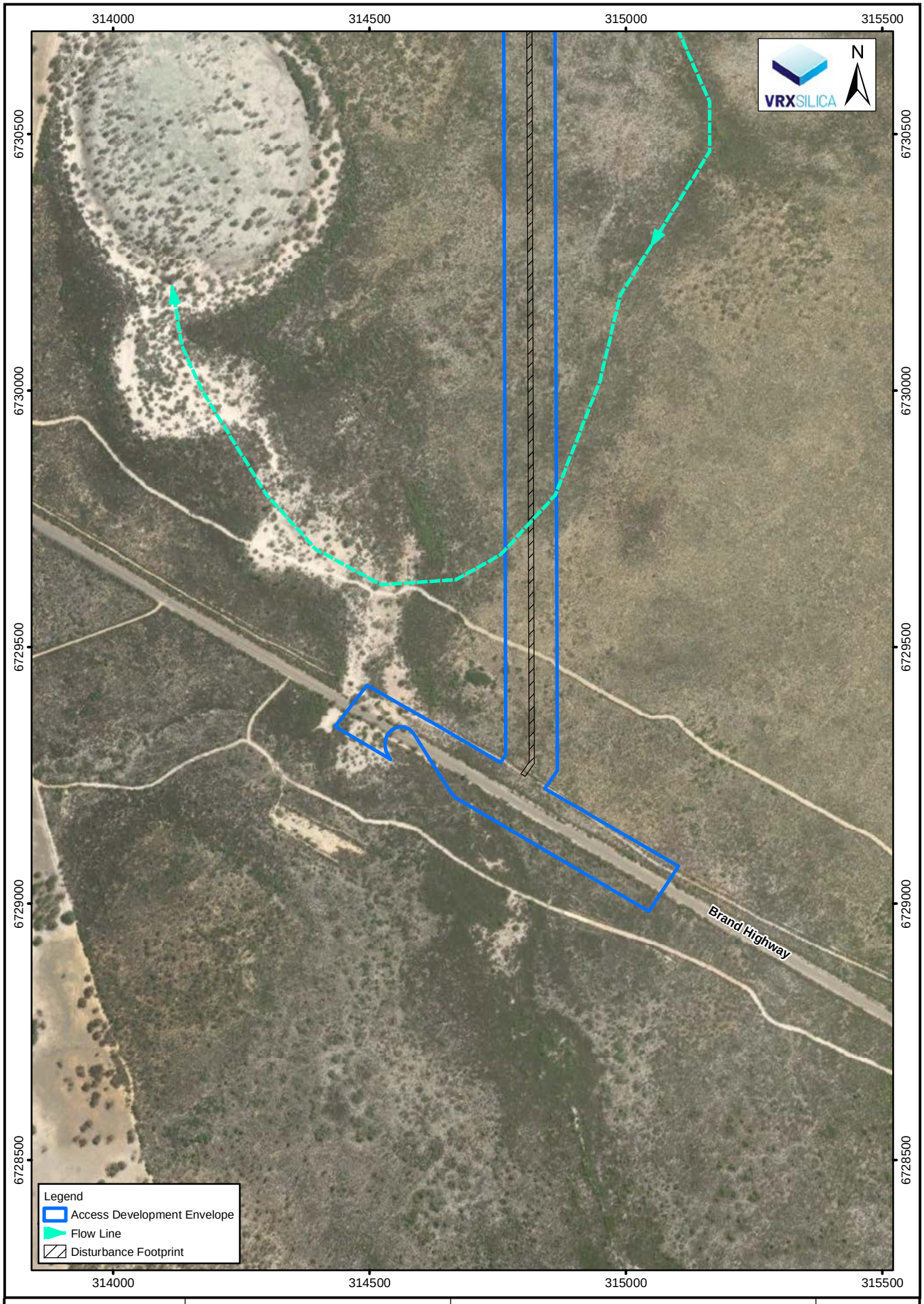
The proposed cumulative abstraction from the Yarragadee Aquifer is within the allocation limits set by DWER and will be managed under a 5C Licence issued under the RIWI Act. With the implementation of these controls VRX considers that the abstraction of 0.9 GL per annum can be undertaken without a significant impact on the Yarragadee Aquifer.

7.5.3 SURFACE WATERS

Alteration of Surface Water Regimes within the Access Corridor

The access corridor will require a 6 m wide crossing of a minor ephemeral drainage line, southeast of Arrowsmith Lake (Figure 77). This crossing is to occur in close proximity to the Brand Highway's crossing with the Arrowsmith River.

The crossing will be developed with a floodway given that it is a high-point of the drainage line and significant flows are likely to only occur during flood events. The water pipeline will be buried through this section to prevent damage from flood flows.



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Scale: 1:10,000
MGA94 (Zone 50)

CAD Ref: a2602_f56_23
Date: April 2022 | Rev: B | A4

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Arrowsmith North Project
Surface water flows of the Southern Alignment

Figure: 77

Figure 77: Minor ephemeral drainage line crossing

Given the narrow disturbance and the proposed location of the crossing it is considered unlikely that the Proposal will result in significant impacts to the surface water regimes of the drainage line.

Alteration of Surface Water Regimes within the Mine

The implementation of the Proposal has the potential to alter the direction and volume of surface water flows within and surrounding the Mine Development Envelope. These alterations are primarily a result of the changes to the soil characteristics and topography of the site. The changes to these characteristics and their potential impact to internal and external flooding are discussed below.

Internal Flooding

The soils of the Mine Development Envelope are characterised has having a high infiltration rate that is slightly reduced by a humus surface layer. Therefore, if surface runoff is generated it is anticipated that it will infiltrate the sandplain relatively quickly. Runoff from the site is only anticipated in short intense rain bursts (RPS, 2020).

The Proposal will remove 8 – 15 m of sand from the soil profile which will decrease the vertical separation between the surface and the water table. The underlying geology is comprised of uneven and sporadic sections of limestone with reduced permeability. The removal of sand from the soil profile will therefore result in the remaining sand horizon saturating more frequently, resulting in more run-off, however only in intense rainfall events. Given the unevenness of the underlying limestone, this effect would be somewhat erratic (RPS, 2020).

External flooding

The key surface water features in proximity to the development envelopes are the Arrowsmith River and Arrowsmith Lake. Arrowsmith River runs west before turning north and terminates in Arrowsmith Lake (a permanent pool), south of the Mine Development Envelope. The south-west corner of the Mine Development Envelope is located about 2.6 km north-east of the river and lake.

There is no survey data upon which to accurately estimate flood levels in the Arrowsmith River or produce a flood map. A rough cross-section of the river was developed based on Shuttle Radar Topography Mission (SRTM) data, this information was used to estimate flood levels (RPS, 2020).

The bed slope of the Arrowsmith River is about 0.2 %. The main channel appears to be a few metres wide with minimal capacity, this suggests that most flood flow is carried in the floodplain. A 100-year flood would be expected to flow about 1.4 m deep (on average) in the main channel, and up to 0.55 m deep in the floodplain footprint. A 10,000-year flood would be expected to flow about 2.3 m deep (on average in the main channel, and up to 1.1 m in the flood footprint).

The Mine Development Envelope represents a relatively insignificant extent (approximately 0.4 %) of the Arrowsmith River catchment area. Therefore, any alterations to the surface water flow volumes of the Mine Development Envelope are anticipated to have little to no impact to the key surface water features of the surrounding landscape. Furthermore, the Mine Development Envelope is not impacted by external concentrated flows due to its higher elevation within the surrounding terrain, and the sandy landscape around the site. Due to the sandy soils and lack of watercourses in the area, changes to external flooding from the site are anticipated to be minimal (RPS, 2020).

Surface Water Contamination

The implementation of the Proposal will require the development of supporting infrastructure and the maintenance and operation of machinery that has the potential to contaminate surface water with hydrocarbons and chemicals if spills were to occur.

The soils of the Mine Development Envelope have a high infiltration rate which limits the potential for runoff from the site, and therefore runoff is only anticipated to occur in rare, short, intense rain bursts. The Mine Development Envelope is disconnected from any key surface water features and concentrated surface water flows. Based on the above, any spills that occur within the Mine Development Envelope are unlikely to reach any surface water features, and mitigation measures are proposed (Section 7.6) to ensure spills are contained and cleaned up. Given this, and the low volumes of hydrocarbons and chemicals to be stored on site, the risk of a significant impact to surface water quality is considered unlikely.

Sedimentation and Erosion

The access corridor involves the clearing of a 6 m wide corridor (on average), which will include an access road and water pipeline. Sediment could be lost from this construction corridor during the construction period, while vegetation clearing or road construction is underway. Construction of this corridor would occur while the landscape is dry, and the construction period would be relatively short (weeks to months) given the minor scale of the infrastructure. The works are therefore unlikely to occur during periods of significant runoff which would limit the potential for sedimentation impacts to the minor drainage line. Mitigation measures are proposed (Section 7.6) to reduce this risk further to ensure sedimentation of the minor drainage line does not occur as a result of access corridor construction.

A water supply pipeline carrying groundwater abstracted from the Yarragadee aquifer will be constructed within the access corridor. A slurry pipeline will be constructed from the MFP to the Processing Plant (within the Mine Development Envelope). A rupture of either pipeline would result in water / sand slurry being deposited adjacent to the pipeline potentially resulting in sedimentation and / or erosion. Mitigation measures are proposed (Section 7.6) to reduce the likelihood of a rupture and to reduce the volumes that would be lost. In the event of a spill any spilt sand slurry would be cleaned up as soon as practicable. It is likely that the spilt sand slurry would settle quickly and the water would infiltrate the sand. Given the lack of fine material in the slurry and the infiltration characteristics of the sandy soil it is likely that any spills would not result in sedimentation or erosion over a large area, even during a flood event.

Based on the above, it is considered unlikely that the Proposal would result in significant sedimentation or erosion impacts to any surrounding surface water features.

7.6 MITIGATION

VRX 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.

7.6.1 AVOID

The key avoidance mechanism implemented by VRX was the design of the development envelopes to avoid key environmental features. VRX has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid the following:

- Mining within drainage lines;
- Arrowsmith River; and
- Arrowsmith Lake.

In addition to the above, the following avoidance mitigation measures have been incorporated:

- Impacts associated with abstraction of the Superficial Aquifer have been avoided by mining above the groundwater table and targeting the Yarragadee Aquifer for water supply; and
- Changes to soil infiltration regimes were avoided by finding a market for the tailings.

7.6.2 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 MFP, slurry and return water pipeline, power station and Processing Plant. These infrastructure 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. Routinely inspect the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately;
    b. The following controls will be implemented to minimise the risk of impact from unintentional slurry pipeline spills:
        i. Pipeline will be fitted with leak detection;
        ii. Flows will be shut off if leaks are detected;
        iii. Pipeline will be inspected regularly, especially during extreme heat or fire events;
        iv. Pipeline will be located off access road surfaces to reduce the risk of vehicle collisions;
        v. If the pipeline has to cross the access road then it 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;
2. **Obtain and comply with a MP issued under the Mining Act**. A MP will be required for the Proposal, for all works apart from works that may occur within the Brand Highway road corridor. The MP is a primary mechanism for ensuring the mining operations are conducted in a manner that does not pose a significant risk to inland waters;
3. **Obtain and comply with a 5C Licence for the abstraction of 0.9 GL/yr from the Yarragadee Aquifer.** The 5C Licence is the primary mechanism for ensuring the

groundwater abstraction is conducted in a manner that does not pose a significant risk to the Yarragadee Aquifer or other users;

4. **Obtain and comply with a DG Licence issued under the DG Act.** The DG Licence is required if large volumes (<100,000 L) of hydrocarbons are to be stored on site. DG Licences set standards for storage and management of hydrocarbons to ensure any risk of contamination to end environment is minimised;
5. **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;
6. **Design and install a suitable floodway crossing at the minor ephemeral drainage lines within the Access Development Envelope to maintain the natural hydrological regime**;
7. **Routinely inspect drainage infrastructure**, including the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately;
8. **Incorporate small gaps between VDT sod placements.** This will reduce surface runoff velocity and promote infiltration, minimising the potential for erosion during significant rainfall events;
9. **Inspect for erosion within the mine and along the access corridor**. If erosion is noted then install erosion controls to minimise further erosion; and
10. **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 maintenance areas and facilities, the siting and operation of wastewater storage systems, and the handling and storage of other waste materials, including contaminated soils**.**
11. **Develop and implement a GOS.** A GOS is required to be prepared and implemented to support application under the RIWI Act to abstract groundwater. The GOS will include provisions for the management of abstraction of groundwater in line with VRX's groundwater allocation limits.

7.6.3 REHABILITATE

Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT and infill planting. This includes physically landforming the site and replanting vegetation sods to ensure surface water regimes are not significantly altered and erosion is managed. At the completion of the Proposal the remainder of the site will be rehabilitated. One of the planned outcomes of all rehabilitated areas will be to reinstate inland water regimes.

A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; 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 access corridor will be rehabilitated with watercourse crossing structures removed;
2. The mine will be progressively landformed, with post-mining drainage to align with current conditions;
3. The mine will be revegetated with local native species; and
4. All infrastructure will be removed.

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 "maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected" (EPA, 2018).

The Proposal has been designed to ensure that hydrological regimes are maintained. The Mine Development Envelope has no surface water drainage features due to high infiltration rates and these high infiltration rates are predicted to remain after mining. There is one crossing of a minor ephemeral drainage line that only contains flow during flood events. VRX will ensure that a floodway crossing is installed in this location to ensure flows are maintained with minimal restrictions.

The Proposal is not expected to significantly impact the quality of groundwater or surface water. Processing requires the addition of a flocculant (discussed in Section 2.2.3) which is non-toxic and no waste products will be produced, with a market available for the fine tailings material. Leaks and spills of slurry sand 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 MFP, slurry pipeline, water pipeline and Processing Plant. The design and operation of all of these items will be regulated under Part V of the EP Act, the Mining Act and the DG Act.

Drawdown modelling indicates a minimal amount of drawdown may occur within the superficial and Yarragadee aquifers over the life of the Proposal. The small extent of drawdown is not expected to impact any groundwater dependant ecosystems. Construction of a bore and the abstraction of groundwater for the Proposal will be regulated under licences issued under Section 26D and 5C of the RIWI Act respectively.

The implementation of design and operation mitigation measures, and regulation under Part V of the EP Act, the Mining Act and RIWI Act, are expected to ensure that the Proposal does not significantly impact inland waters. The EPA objective for this factor is therefore able to be met.

8 SOCIAL SURROUNDINGS

8.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to protect social surroundings from significant harm.

8.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for social surroundings are summarised in Table 40 below.

Table 40: Policy and guidance relevant to the Social Surroundings key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered, although not deemed to be relevant to this section of the ERD (no environmental management plans have been prepared to support this section of the ERD).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Social Surroundings (EPA, 2016f)	This document was considered in the preparation of this section (Section 8) of the ERD.
Relevant EPA Technical Guidance	
Guidance Statement 41 – Assessment of Aboriginal Heritage (EPA, 2004)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
Commonwealth Government	
Key Documents	
Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act) (DotEE, 2016a)	Other Minister of the Environment (Cth) approval decision making considerations
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered, although not deemed to be relevant to this section of the ERD (no environmental management plans have been prepared to support this section of the ERD).

Policy and Guidance	How guidance has been considered
Environmental Management Plan Guidelines – template (DotE, 2018)	This document was considered, although not deemed to be relevant to this section of the ERD (no environmental management plans have been prepared to support this section of the ERD).
EPBC Act Condition Setting Policy (DAWE, 2020)	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared.
Relevant Technical Guidance	
Engage Early – Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DotE, 2016b)	This document was used as guidance for assessment and management of physical and social impacts on Aboriginal Heritage.

8.3 RECEIVING ENVIRONMENT

8.3.1 SURVEY EFFORT

VRX commissioned YMAC to conduct a Pre-clearance Aboriginal and Ethnographic survey of the development envelopes. Horizon Heritage Management (Horizon Heritage) was commissioned to conduct an assessment of Aboriginal Heritage Values and Traditional uses of the development envelopes and Sticks and Stones Cultural Resources Management (SandS CRM) conducted an Aboriginal Heritage Site Avoidance Survey for selected areas within the development envelopes. These surveys and their extent are outlined in the following sections.

Information in the following section is sourced from YMAC (2018 and 2020; Appendices 24 and 25), Horizon Heritage (2021; Appendix 26) and SandS CRM (2021; Appendix 27) unless otherwise referenced.

Work Area Clearance Aboriginal and Ethnographic Surveys

YMAC was commissioned by VRX to produce an archaeological and ethnographic Work Area Clearance (WAC) report on the Yamatji Nation Settlement (WC2019/008). WAC reports are designed to inform proponents where they can and cannot undertake works within a chosen area. Prior to undertaking fieldwork, the heritage team at YMAC completed a desktop assessment of the project areas via the DPLH Aboriginal Heritage Inquiry System (AHIS; 2020) to identify any registered Aboriginal sites, Other Heritage Places (OHPs), prior surveys and associated reports relevant to the project area.

An initial WAC archaeological and ethnographic heritage survey was conducted on extensions of existing exploration/drill lines within Mining Tenement (M 70/1389) in December 2018 (Figure 78). A second pre-clearance survey was conducted in October 2020 and covered part of the Mine Development Envelope (generally aligned with the indicative disturbance footprint) and the Access Development Envelope as shown in Figure 78. The surveys included walking the survey areas at a spacing of less than 20 m and recording locations of any Aboriginal heritage sites. Both WAC surveys included an ethnographic component which was conducted at the same time as the archaeological survey. The ethnographic component included consultation between an anthropologist and the Southern Yamatji (2018) or Amangu (2020) representatives and recording observations during the pedestrian transects of the survey areas.

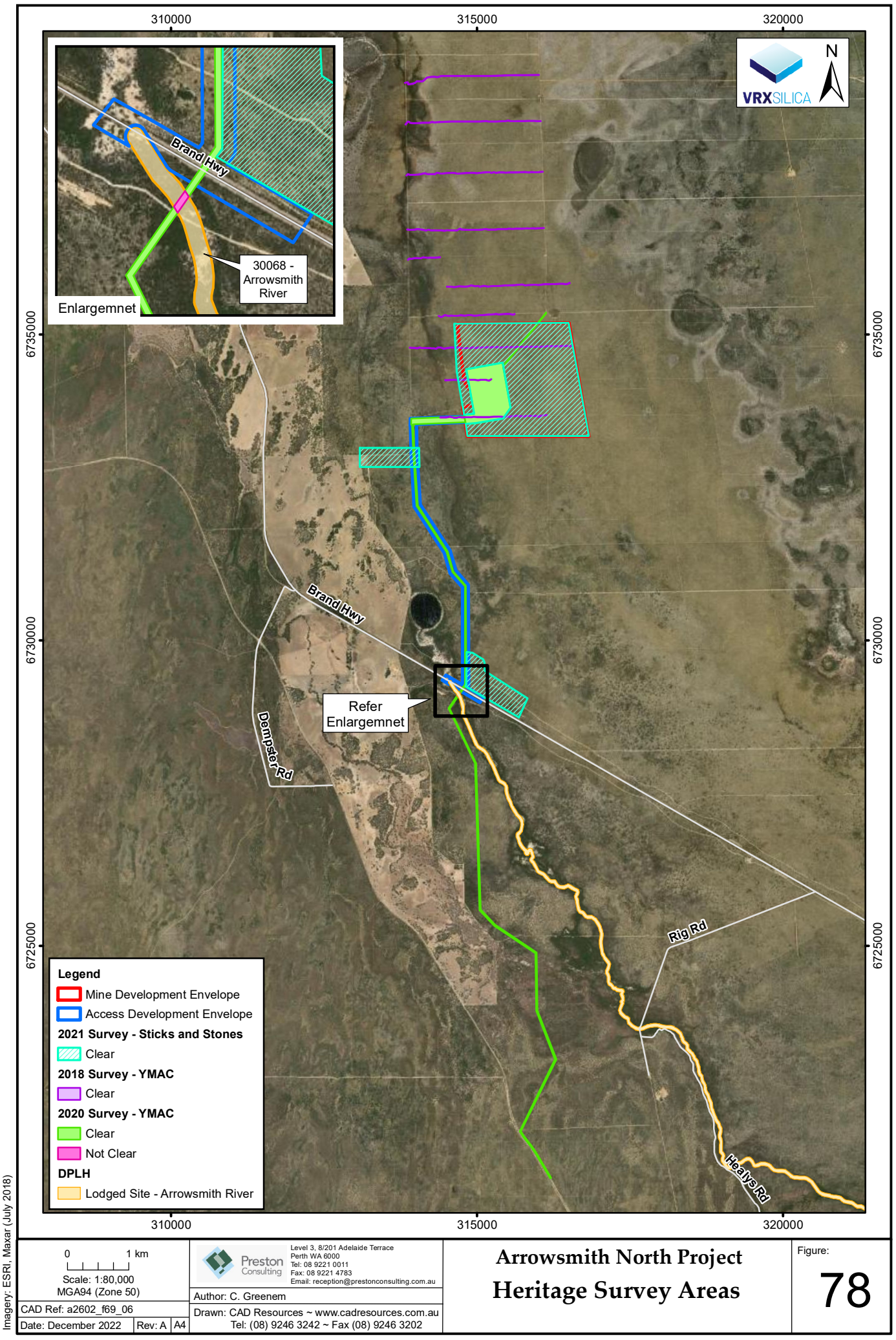


Figure 78: Aboriginal Heritage (YMAC, 2018, 2020 and SandS CRM, 2022) Survey Areas

Aboriginal Heritage Site Avoidance Survey

SandS CRM was engaged to undertake an Aboriginal heritage survey of selected areas within the development envelopes (Figure 78) and provide a report detailing the methods and outcomes of the survey. Fieldwork was conducted over a single session from 30 August to 4 September 2021 and involved personnel from the Yamatji Southern Regional Corporation, SandS CRM and one VRX representative (collectively referred to as the survey team).

Background research was conducted for the heritage survey which consisted of searches of the DPLH Site Register, records of the WAM and the corporate archives of SandS CRM. The survey team conducted field surveys which involved walking straight transects to cover the three survey areas. The transect lines were spaced between 25 m and 35 m apart between participants depending on archaeological visibility and potential. The extent of the survey areas is summarised in Table 41.

Table 41: SandS CRM Survey Area Details

Survey Area Name	Size	Priority
VRX 2021 Area 1	3.1 km²	1
VRX 2021 Area 2	0.3 km²	2
VRX 2021 Area 3	0.4 km²	3

Aboriginal Heritage Vales and Traditional Uses

Horizon Heritage was commissioned by VRX in July 2021 to undertake a desktop assessment of Aboriginal heritage and traditional values of the survey area (Figure 79) in order to understand the known and potential Aboriginal heritage values within and surrounding the development envelopes. The assessment included:

- Identification and assessment of any registered Aboriginal heritage sites that occur within the survey area or in close proximity;
- A contextual assessment of the general Aboriginal heritage values of the survey area;
- Identification of any features at the Proposal that may:
    - Be ethnographic sites;
    - Have a higher likelihood of the presence of archaeological sites;
    - Be of high values for bush tucker or bush medicine; and
    - Provide recommendations as appropriate to minimise impacts to Aboriginal heritage values.

8.3.2 YAMATJI NATION

The existence of native title determination (alternative settlement) is seen as sufficient to establish an Aboriginal person's 'right to speak' about heritage issues. The Yamatji Nation is made up of the Traditional Owner groups; Yamatji Nation, Hutt River, Southern Yamatji and Widi Mob native title claims and a portion of the Mullewa Wadjari native title claim. The Traditional Owners, who broadly identify as being Yamatji people, continue to hunt in the region, as well as practice their traditional culture, such as performing ceremonies and paying respects to ancestral spirits.

Figure 79: Horizon Heritage survey area

VRX has engaged with the Traditional Owners of the land and will continue to engage though the life of the Proposal. VRX has specifically consulted with the Yamatji People in relation to potential impacts of the Proposal on areas of cultural and heritage sensitivity. This included development of the following reports:

- An archaeological and ethnographic, WAC and heritage survey report in 2018 and 2020 of the Arrowsmith North and Central project areas prepared by YMAC (YMAC, 2018 and 2020);
- An assessment of Aboriginal Heritage Values and Traditional Uses of the Arrowsmith North Project area (Horizon Heritage, 2021); and
- An Aboriginal Heritage Site Avoidance Survey for selected areas within the Arrowsmith North Project Area conducted in September 2021 by SandS CRM (SandS CRM, 2021).

8.3.3 INDIGENOUS LAND USE AGREEMENT

The Yamatji Nation ILUA area covers approximately 48,000 km^2 of land in the Mid-West region of WA. The Agreement was signed on 24 February 2020, following a Federal Court hearing on 7 February 2020 recognising the native title rights and interests of the Yamatji Nation over significant parcels of land. The conclusive Registration Date under the Agreement was the 26 October 2020.

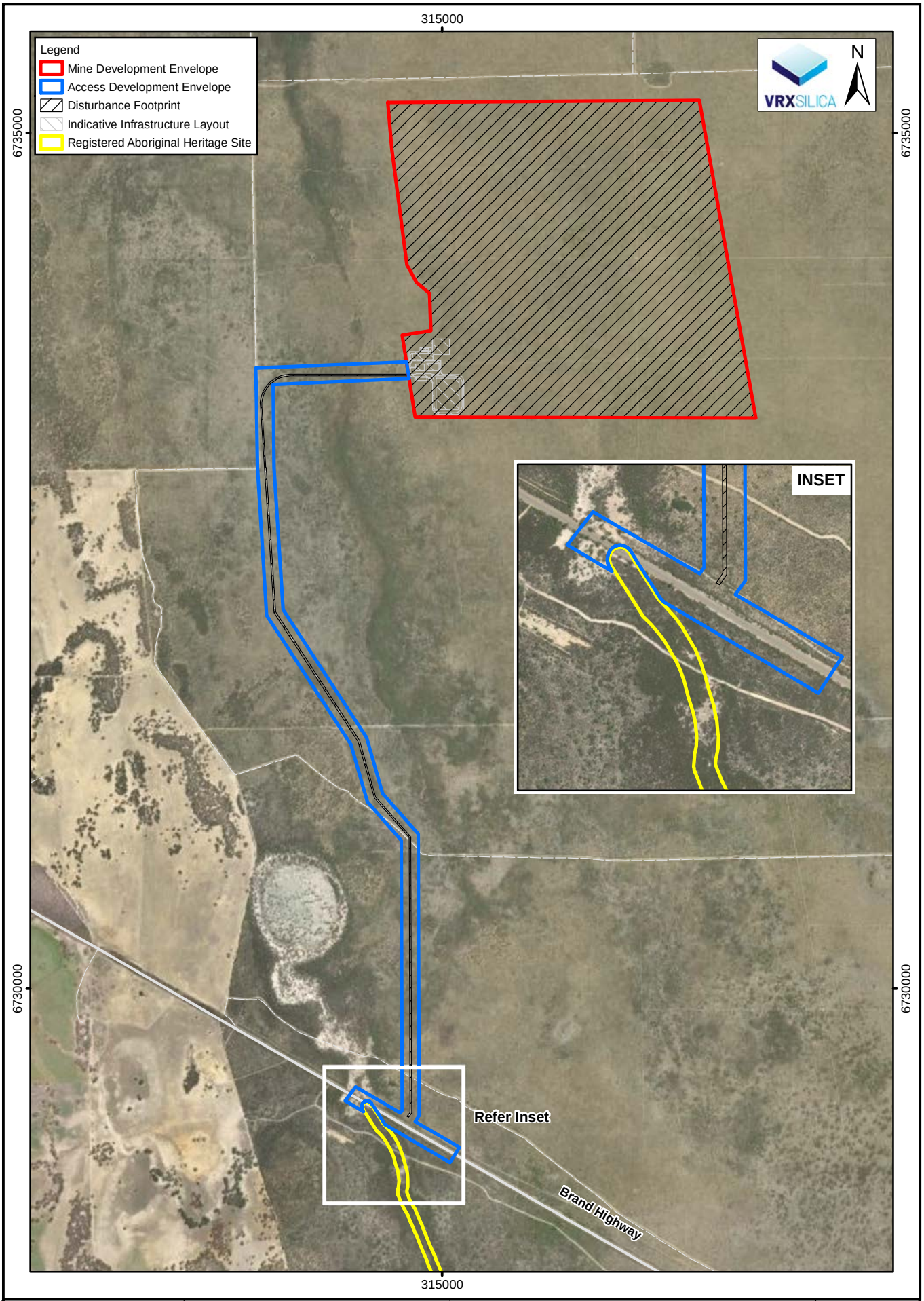
The Agreement provides an enduring benefits package that ensures self-determination and long-term economic independence for the people of the Yamatji Nation and comprises the following components: cash, economic development opportunities, cultural heritage protection measures, recognition of native title, housing, governance, land and conservation estate as well as access to water.

The ILUA binds the parties (including 'the State', which encompasses all State Government Departments and certain State Government agencies) to enter into a Yamatji Government Standard Heritage Agreements (YGSHA) when conducting Aboriginal Heritage Surveys in the ILUA area, unless they have an existing heritage agreement. It is also intended that other State agencies and instrumentalities enter into the YGSHA when conducting Aboriginal Heritage surveys in the ILUA area. It is recommended a YGSHA is entered into, and an 'Activity Notice' issued under the Noongar Standard Heritage Agreement (NSHA), if there is a risk that an activity will 'impact' (i.e., by excavating, damaging, destroying or altering in any way) an Aboriginal heritage site. The Aboriginal Heritage Due Diligence Guidelines, which are referenced by the YGSHA, provide guidance on how to assess the potential risk to Aboriginal heritage.

8.3.4 ABORIGINAL HERITAGE AND CULTURAL VALUES

No aboriginal heritage sites, OHPs, isolated artefacts or previously unrecorded suspected Aboriginal archaeological sites were recorded during any of the filed surveys conducted by YMAC (2018 and 2020) or SandS CRM (2021).

One registered Aboriginal Heritage site (Arrowsmith River, Figure 80) has been identified on the DPLH AHIS as being located within the Arrowsmith North Project assessment area. Three OHPs have been chosen for inclusion in this ERD to demonstrate that important Aboriginal cultural sites, features and materials have been recorded within Yamatji country surrounding the Arrowsmith North Project assessment area.



Source: Aerial Photography: ESRI, Digitalglobe, Maxar (March 2019), Tenements: DMIRS

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Date: April 2022 | Rev: B | A4

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Arrowsmith North Project
Arrowsmith River Registered Aboriginal Heritage Site

Figure: 80

Figure 80: Arrowsmith River

DPLH registered Aboriginal heritage sites and OHPs that are within close proximity to the Proposal are summarised in Table 42 below.

Table 42: DPLH registered sites and OHPs

Site ID & Name	Place Type	Status	Location (Coordinates)
Registered Aboriginal Heritage Sites			
30068, Arrowsmith River	Mythological, Water Source	Registered	340264vmE 6729578 mN (Reliable within Project Area)
Other Heritage Places			
5217, NAT GAS 137	Artefacts / Scatter	Stored Data / Not a Site	320739 mE, 6729651mN (Reliable)
5574, Cliff Head	Skeletal Material / Burial	Stored Data / Not a Site	304226 mE, 6728525 mN (Unreliable)
15297, Eneabba West	Ceremonial, Fish Trap, Camp, Water Source, Other: TRACK	Stored Data / Not a Site	305214 mE, 6704425 mN (Reliable)

DPLH 30068 Arrowsmith River

The Arrowsmith River is a registered Aboriginal site assessed by the Aboriginal Cultural Material Committee (ACMC) in May 2011 under the Section 5 of the Act and is afforded protection under the AHA. The DPLH register lists the site type as mythological and a water source.

The Arrowsmith River was recorded by Guy Wright in 2011 while undertaking heritage surveys with the Binyardi people, Widi Mob and Amangu people for the Three Springs Power Station and Gas Pipeline alignment project for ERM Power. The site has both a mythological *Bimarra* association (major spirit of the Yamatji culture) and a traditional water source significance. The water source was formed by the creative activities of the *Bimarra* whose spiritual essence still exists there. The *Bimarra* is said to live in the river. Yamatji people used to camp along the river and use the flora and fauna resources found here. The site boundary extends to the high water mark. The site is said to have a powerful spirit and the flow of the water being protected is of high importance (Horizon Heritage, 2021).

DPLH 5217 Natgas 137

Natgas 137 is listed as stored data on the AHIS register and has been assessed as 'Not a Site' under Section 5 of the AH Act. It was assessed by the ACMC in August 2000. The register lists the place type as an artefacts scatter. The site file and site boundary have no access restrictions. Natgas 137 was recorded in 1981 by Michael Pickering working for the WAM. The artefact assemblage totalled six quartz and quartzite flakes in exposed areas to the east and west of Beharra Spring (natural spring).

The Natgas 137 place is located outside of the Arrowsmith North Project assessment area to the southeast.

DPLH 5574 Cliff Head

Cliff Head is listed as stored data on the AHIS register and has been assessed as 'Not a Site' under Section 5 of the AH Act. It was assessed by the ACMC in August 2000. The register lists the place type as skeletal material. The site file and site boundary have no access restrictions. Cliff Head was skeletal remains found during road works in 1977. It was determined to be a complete

mature female skeleton in excellent condition and pre-contact. The bones were collected by the Geraldton Police and sent to the WAM. They were found approximately 46.3 km south of Dongara, 2 miles south of Cliff Head and 200-300 m from the water (ocean).

The Cliff Head place is located outside of the Arrowsmith North Project assessment area to the southwest.

DPLH 15297 Eneabba West:

Eneabba West is listed as stored data on the AHIS register and has been assessed as 'Not a Site' under Section 5 of the AH Act. It was assessed by the ACMC in April 1999. The register lists the place type as Ceremonial, Fish Trap, Camp and Water Source. The site file and site boundary have no access restrictions. The site file information is minimal with only a brief description of the place having a mythological association significance.

Eneabba West was recorded by Arnold Franks from the Moore River People in 1998. It is described as part of the Dreaming Kangaroo track that represents the true boundary between Wadjari and Nyungarda peoples. In the dreaming the Kangaroo passed through here on his journey south and formed the land as it is today.

The Eneabba West place is located outside the Arrowsmith North Project assessment area to the southwest.

8.3.5 TRADITIONAL USES

Feedback has been sought from Horizon Heritage in relation to traditional uses of the land for bush tucker or medicine within or adjacent to the development envelopes. Horizon Heritage (2021) noted that the following land and features should be considered in the assessment of traditional uses of the land.

Bush Tucker

Within the Midwest a myriad of faunal and botanical resources were readily available. The knowledge and use of various plants and animals by the peoples that occupy the region is indicative of the inherent ongoing connection they have to country. Reflecting the importance to the health and survival of the Yamatji people, plants and animals form part of the order of all forms of cultural life. Knowledge of wildlife, their location, a means of hunting and seasonal availability was essential to Yamatji people as they travelled throughout their country. The considerable range of fauna meant there was also great diversity in food types and preparation, many of which were gathered and consumed based around gender specifications.

Yamatji people have traditionally hunted and gathered food according to the seasons. The seasons are defined by patterns of weather. The seasons determine which fauna and flora resources are abundant at those times. Yamatji people know when it is the season for harvesting by signs in nature. Yamatji communities have always taken care to ensure the continued existence of animal and plant species. Vegetable foods collected and eaten by the Yamatji included roots, bulbs, tubers, seeds, nuts, fruit and fungus. Other main sources of food most readily available to Yamatji people would have been mammals, birds and their eggs, most reptiles, frogs, fish, turtle, freshwater crayfish and insects (e.g., larvae of beetles).

Within the Banksia woodland areas Yamatji people could have found fruits or berries (bush tomato), edible roots and leaves, flower nectar (Banksia, Dryandra, Hakea varieties), seeds and gum (Acacia varieties) and native honey (Eucalyptus) with many having ethnobotanical and cultural significance to Yamatji people. The wood from Acacia could be used to make spears, boomerangs, fighting sticks and digging tools. Bark was used to construct watertight huts covered with thatches of grass trees to protect against the cold and wind. The gum from grass trees was used to haft hammers. While the seeds of various trees and plants were harvested for flour to use in dampers. Sweet gum (*Bimba*) was collected from the cracks in the branches and trunks of Acacia for eating or to use as medicine for skin aliments and burns. Banksia plants are a food source and host for many species of native fauna. When flowering they attract birds, insects and small marsupials which could then be sourced by Yamatji people.

The commonly known WA Christmas tree (*Nuytsia floribunda*) holds special significance to Yamatji People and is commonly found in banksia woodlands. The tree is also used to determine seasonal outlooks with the onset of summer established by its either early or late flowering. Traditionally yams and other sweet potato varieties were commonly collected and consumed as part of the diet. Other potential fauna food species that could be found in the assessment area include wallabies, grey kangaroos, snakes (pythons), lizards (goanna and bobtail) and small marsupials (like the Quenda bandicoot). It is likely many species of birds occur in the woodlands area with emus, bush turkey (Australia Bustard), cockatoos and parrots.

It is likely some of the Arrowsmith North Project assessment area was utilised by past Yamatji people as a resource area for food and dietary sustenance. Wetlands and watercourse areas, even in drier times, were the focus of Yamatji economic activities which are present in the assessment area. Frogs, turtles, gilgie and waterfowl could be sourced from freshwater waterways, swamps and pools. The Arrowsmith River (outside the development envelopes) has been previously identified by Yamatji people as cultural heritage sites, partly for their resource (food and water) availability. OHPs like Cliff Head and Eneabba West demonstrate that Yamatji people used their traditional country.

Bush Medicine

To deal with ailments, Yamatji people regularly used a range of remedies, which included medicinal plants. As documented by Hansen (2016) Banksia flowers were drunk to relieve coughs and sore throats, or for a sweet refreshing drink. Pigface crushed leaves were used to treat diarrhoea, dysentery and stomach cramps, and as a gargle to relieve sore throats and mild bacterial or fungal infections of the mouth. The juice of the leaves were used externally, much like aloe vera, as a salve. The Yamatji people also ate the fruit as a food.

Jam Wattle gum was eaten to treat diarrhoea and ease congestion, while the flowers were crushed and the vapours inhaled to relax the mind for a good night's sleep, or made into weak infusions as a wash to aid healing. Eucalyptus leaves were used for to cure headaches by inhaling vapours from the crushed leaves, by rubbing the crushed leaves on the head and by sleeping in the smoke from a fire. Coughs and colds were relieved by inhaling the vapours from the crushed leaves of specific plants, especially eucalypts.

Additionally other varieties of plants such as wild tomato bush and Quandong berries were also commonplace bush foods found throughout the Midwest. Specialised uses of the Quandong included a form of tea which was drunk as a purgative. Quandong tree roots were also ground down and used as an infusion for the treatment of rheumatism. Typically, Quandong leaves were

crushed and mixed with saliva to produce a topical ointment for skin sores and boils. Encased within each Quandong seed is an oil rich kernel which was also processed in a similar fashion to treat skin disorders. Quandong kernels could also be eaten and some tribal groups were known to employ crushed kernels as a form of "hair conditioning oil". Ingeniously, Australia's Aboriginals appeared to be aware that Quandongs were a preferred food source of emus, and that a ready supply of Quandong seeds could be found in their droppings (Nullarbor Net, n.d.).

Goanna and Emu fat were highly prized for the healing of painful joints while ailing health was treated by eating cooked bobtail, goanna and echidna.

Feral Animals

Feral cats, pigs and the red fox (introduced species) are all a problem in the Shire of Irwin. Feral cats have a significant detrimental impact on the native animals and birds due to their natural hunting instincts. Feral pigs are known to use and damage waterways and native vegetation. They are a serious environmental and agricultural pest. Foxes are hunters and scavengers and have caused the decline of many small to medium-sized species of Australian native mammals. Foxes tend to eat whatever is most easily available to them. Feral animals have a negative impact on the bush tucker and medicine availability within the Projects region.

8.3.6 EUROPEAN HERITAGE AND CULTURAL VALUES

No European Heritage or cultural values have been identified within the development envelopes. A search of WA databases (AHIS) identified one European Heritage site in proximity to the Proposal; Green Grove Farmhouse Ruins. The site is located outside of the development envelopes approximately three kilometres south-southwest of the Mine Development Envelope, adjacent to Brand Highway. The following description of the Site's history is taken from the State Heritage Office website (accessed in October 2021):

> "The site of the Green Grove homestead has historic significance for its connection to the settlement of the Irwin district. The place is unusual in that it was the only known established house on the coastal lands between Dongara and Eneabba prior to the 1960s."

8.3.7 RECREATIONAL USES OF CROWN LAND

It is assumed there is little to no recreational use of the land within the development envelopes, and any uses would be sporadic. Since commencement of investigations within and surrounding the development envelopes, no recreational use of the area (including trail walking and 4WD / trail bike recreation) has been observed by VRX. The landscape has no significant features that would attract tourism however the area may be accessed for wildflowers.

Yardanogo Nature Reserve resides to the north of the development envelopes, and it is expected that recreational activities are pertained to the Reserve. Part of the land within the development envelopes will be restricted during mining to ensure safety to the public with exceptions to Traditional Owners' for traditional purposes. The general public can apply to access areas that are not actively being mined however, no access will be permitted to areas that are under rehabilitation (to optimise the chance of success).

Based on the above, recreational uses are not expected to be materially impacted by the Proposal.

8.3.8 Local Residents and Community

Land use of the area is dominated by dry-land agriculture, with lesser areas of conservation and UCL and crown reserves (Desmond & Chant, 2001). Other tenure surrounding the Proposal includes Exploration and Mining tenements, Licences, road reserves and stock routes.

Sensitive receptors within 5 km of the Proposal include three residential developments, sensitive receptors are discussed further in Section 8.4.1. The area west of the Proposal is sparsely populated, with the closest town of substantial population being Dongara, located approximately 30 km north-northwest of the Proposal.

PlanWA identified the following Local Planning Schemes within a 20 km buffer of the Proposal (DPLH, 2022):

- General farming; and
- Local Reserve.

Farms near the Proposal are often not in permanent use, and are considered to be managed for recreational purposes, rather than profit. No Regional Schemes, State Planning Policies, Structure Plans or other underlying land descriptions were identified.

8.3.9 Social Values

Based on the information provided above, the following social values were determined to require assessment for this factor:

- Local residents and community;
- Aboriginal heritage sites; and
- Land used for traditional purposes.

8.4 Potential Impacts

Table 43 defines the potential impacts (direct, indirect and cumulative) on the social values for this factor in a local and regional context. These impacts are informed by the results of studies described in Sections 5 – 10. Assessment of the potential impacts is provided in the following sections.

Table 43: Potential impacts on social surroundings

Social value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Local Residents and Community The Processing Plant is 3.3 km and the haul road is 1.7 km from the nearest sensitive receptor.	Noise emissions from construction or operation of the Proposal. The Access Corridor will be visible from the Brand Highway.	Restricted access to 408.5 ha of native vegetation within the development envelopes for the life of the Proposal. 14.5 ha of native vegetation to be cleared for the life of the Proposal with	VRX's Proposed Arrowsmith Central Silica Sand project is located approximately 20 km south of the Proposal and also connects to the Brand Highway. The spacing between the proposals and between the Proposal and Brand Highway is deemed sufficient to mitigate any cumulative impacts to Local Residents and Community There are no other Projects	The Proposal may be visible or heard from the nearest sensitive receptor

Social value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
		remainder of disturbance area being progressively cleared.	in close proximity of the Proposal that are likely to have a cumulative impact on local residents and community	
Aboriginal Heritage Sites One Registered Aboriginal Heritage Site (the Arrowsmith River) is located in close proximity the Proposal. Three OHPs have been identified within 9.5 km of the Proposal): • Arrowsmith Lake (1 km) • Mungenooka Springs (9.5 km) • Arramall Cave (5 km)	No direct impact to Aboriginal Heritage Sites	Indirect impacts to the Arrowsmith River and Arrowsmith Lake through alteration to hydrological regime including abstraction of up to 0.9 GL of water per annum from the Yarragadee Aquifer.	No other proposals are currently known to be impacting the Arrowsmith River; but the land surrounding parts of the Arrowsmith River upstream of the proposal are used extensively for agriculture	No cumulative impacts to Aboriginal Heritage Sites.
Land use for traditional purposes Areas of significance have been excluded from the disturbance envelopes.	Clearing of up to 353.8 ha of native vegetation. 14.5 ha of which is proposed for the life of the Proposal and 339.3 ha is to be progressively rehabilitated via VDT.	Alteration of land from mining operations. Altered access to land. Reduction in amenity	The Arrowsmith Central Project resides within the Yamatji Nation Settlement.	Clearing of 353.8 ha of native vegetation and restricted access to up to 408.5 ha of land

8.4.1 SENSITIVE RECEPTORS

EPA Guidance Statement No. 3 (EPA, 2005) provides advice on the use of generic separation distances (buffers) between industrial and sensitive land uses to avoid conflicts between incompatible land uses. The generic separation distances are a tool to assist in the determination of suitable distances between industry and sensitive land uses where industry may have the potential to affect the amenity of a sensitive land use. Where the separation between the industrial and sensitive land uses is greater than the generic distance, there will not usually be a need to carry out site-specific technical analyses to determine the likely area of amenity impacts due to emissions from the industry. These generic separation distances are also referenced in the Guideline for Dust Emission, released as a draft for external consultation by DWER in July 2021 (DWER, 2021a).

The EPA (2005) definition for sensitive land use – land use sensitive to emissions from industry and infrastructure, residential development, hospitals, hotels, motels, motels, hostels, caravan parks, schools, nursing homes, childcare facilities, shopping centres, playgrounds and some public buildings. Some commercial, institutional and industrial land uses which require high levels of amenity or are sensitive to particular emissions may also be considered "sensitive land uses".

Under the separation distances guidance (EPA, 2005), the Proposal is best described as an 'Extractive Industry – sand and limestone extraction', involving no grinding or milling works. The

corresponding generic buffer distance that is recommended is 300 to 500 m, depending on size. All sensitive receptors are located more than 1.7 km away from the Proposal.

The closest sensitive receptor to the mining operations and processing plant is the residence to the southwest (Receptor 4), located 3,300 m away and the residence to the northwest (Receptor 1), located 3,200 m away. The closest sensitive receptor to the proposed haulage road (to the Brand Highway) is the residence to the southwest (Receptor 4), located 1,700 m away.

The location of sensitive land uses (sensitive receptors) in the area is presented in Figure 81 and summarised in Table 44.

Table 44: Summary of Sensitive Receptors

Sensitive Receptor	Land Use Type	Separation Distances (m)	
		Processing Plant	Activity Boundary
1	Residence	4,000	3,200 (mining area)
2	Residence	4,300	1,900 (haulage road)
3	Gas Plant	7,400	5,100 (mining area)
4	Residence	3,300	1,700 (haulage road)

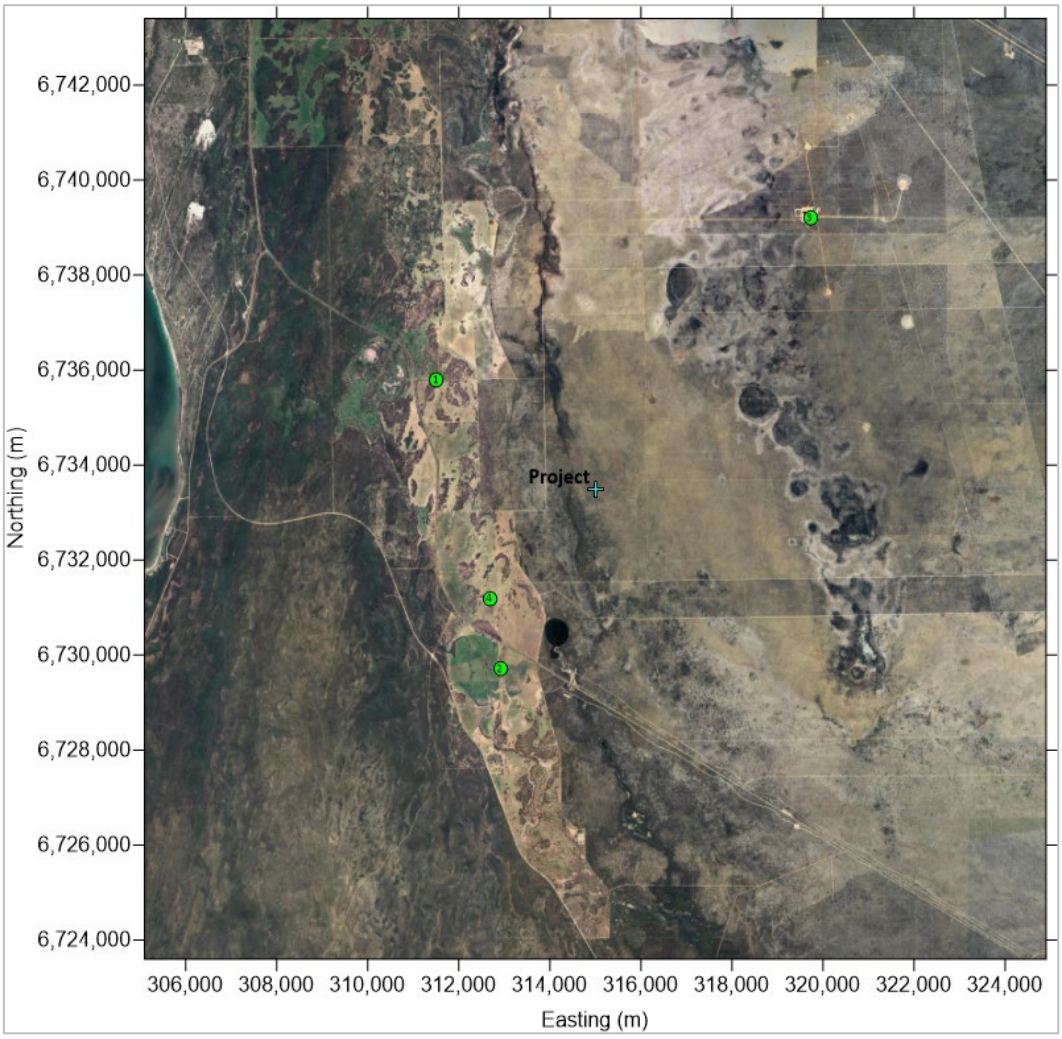


Figure 81: Location of sensitive receptors

8.4.2 NOISE

Implementation of the Proposal is expected to result in the emissions of noise. Key Proposal activities with the potential to emit noise include:

- Vehicle movements;
- Mining, VDT and infill planting;
- Process Plant (operation of pumps, screens, trommel etc.); and
- Power generation.

The Proposal has been designed to minimise vehicle movements at the mine by utilising a surface pipeline to pump ore as a slurry from the MFP to the Processing Plant. This limits earthmoving vehicle movements to only between the mine face and mobile MFP which will be positioned near the mine face. The trucks hauling the product will be speed-limited within the Access Corridor to minimise noise emissions.

Silica mining and VDT is a relatively simple process and only requires mulching of vegetation, extraction and placement of the vegetation sods and the extraction of silica ore. These activities are limited to mulching and the handling of materials. Only FELs with various attachments (mulcher, conventional bucket, VDT bucket) will be required for mining. No noise intensive (blasting, drilling, crushing, piling) activities are required.

The process circuit includes trommel screening, attritioning cells, classifier, spiral separation, magnetic separation, size screening, drying and stacking. A series of pumps, drive motors, sprayers and conveyors will operate to support the process circuit. No crushing, grinding or percussive processing is required therefore noise from the Processing Plant is expected to be primarily from the operation of pumps, drive motors, sprayers and conveyors. The Proposal will be powered by an on-site Power Station comprised of several natural gas fired electrical generators to produce up to 5 MW. VRX will use off the shelf gas generators with known noise emission values and options for noise attenuating mufflers.

Noise emission predictions for silica sands projects are difficult to determine given the small number of silica sand mines in Australia. In the absence of noise modelling and predicted noise levels for the Proposal, VRX has reviewed predicted noise levels for a proposed recent small-scale mineral sands project; the Image Resources Atlas Project. The Atlas Project is located near the Proposal (approximately 170 km north of Perth) and uses conventional mining methods similar to the Proposal. Noise emissions defined for the Atlas Project are summarised in Table 45.

Table 45: Noise source levels of the Atlas Project

Source	Noise Level (dB(A))
Cat D7 Dozer	112
Cat D9/D8 Dozer	110
Komatsu PC700 Excavator	108
Komatsu PC1250 Excavator	110
Haul trucks	117
Watercart	106
Cat 16M grader	102

Source	Noise Level (dB(A))
Cat 657G Scraper	113
Cat 980/966 loader	108
Feed Process Plant (FPP)	106
Wet Concentrator Plant (WCP)	113
Genset 1750 KVA Insulated Enclosure with Acoustic Louvres (equiv. to 85 dB(A) at 1 m)	92
HMC Truck Volvo FH16 Prime Mover Triple Wagon 60km/h	108

For context, noise modelling conducted for the Atlas Project demonstrated that compliance with the Noise Regulations can be achieved at the nearest sensitive receptor (1.2 km from the mine pit) provided noise mitigation is implemented. While mineral sands projects are likely the most similar, processing activities of mineral sands mines are generally more comprehensive than those of silica sand mining, therefore this comparison serves as a conservative assessment. The Proposal is also set back further from the nearest sensitive receptor than the Atlas Project (3.6 km as opposed to 1.2 km). Based on the above VRX expects noise emissions from the Proposal to be less than those from the Atlas Project and that further assessment of the noise emissions and the potential impact on sensitive receptors is not required.

8.5 Assessment of Impacts

8.5.1 Local Residents and Community

Potential impacts to amenity for local residents and the community include noise from construction and operation, alterations to land access and visual impacts. The Proposal is located 2.2 km away from the nearest sensitive receptor and approximately 3.3 km away from the closest public road.

The EPA Guidance Statement No. 3 (EPA, 2005) provides advice on the use of generic separation distances (buffers) between industrial and sensitive land uses to avoid conflicts between incompatible land uses. The generic separation distances are a tool to assist in the determination of suitable distances between industry and sensitive land uses where industry may have the potential to affect the amenity of a sensitive land use. Where the separation between the industrial and sensitive land uses is greater than the generic distance, there will not usually be a need to carry out site-specific technical analyses to determine the likely area of amenity impacts due to emissions from the industry.

Consistent with the EPA (2005) definition for sensitive land use – land use sensitive to emissions from industry and infrastructure (sensitive receptor), have been identified in the vicinity of the Proposal. This includes residential development – any permanent structure whose primary use is as a dwelling place, and various other locations where people are residing either on a temporary or permanent basis. Under the separation distances guidance (EPA, 2005), the Proposal is best described as an 'Extractive Industry – sand and limestone extraction', involving no grinding or milling works. The corresponding generic buffer distance that is recommended is 300 m to 500 m, depending on size. The Processing Plant is 3.3 km and the haul road is 1.7 km from the nearest sensitive receptor (sensitive receptors are discussed in more detail in Section 8.4.1).

The Proposal's setback distance to the nearest sensitive receptor far exceeds the EPA's recommended setback distances (EPA, 2005) for this industry. The Proposal also has a limited scope of noise emitting activities (construction, mining sand and processing), a relatively small operational footprint and vehicle movements have been restricted (speed and distance) where possible. The Proposal also has the potential to restrict access to 405.1 ha of Native Vegetation which comprises part of a much broader continuous landscape, this restriction represents 1.41 % of the remaining Native Vegetation within 10 km of the Proposal. Permission may be granted for access to areas that are not being actively mined or are under rehabilitation.

Based on the above, the Proposal is not expected to significantly impact the amenity of the natural landscape (through noise emissions, visual impact or restricted land access) for local residents and the community.

8.5.2 Aboriginal Heritage Sites

No Aboriginal Heritage sites, OHPs, isolated artefacts or previously unrecorded suspected Aboriginal archaeological sites were recorded during any of the field surveys conducted by YMAC (2018 and 2020) or SandS CRM (2021).

There is one Registered Aboriginal Heritage Site located in close proximity to the Proposal; the Arrowsmith River (Horizon Heritage, 2021). The Arrowsmith River adjacent to the Access Development Envelope and will not be impacted directly by the Proposal. Site access and product haulage is not expected to indirectly impact the Registered Aboriginal Heritage Site as the access corridor terminates at the intersection with the Brand Highway. It was the conclusion of the survey team and archaeologists that these sites will not be impacted by the Proposal (Horizon Heritage, 2021).

OHPs identified within proximity to the development envelopes include Arrowsmith Lake (1 km west of the Access Development Envelope), a common place of mythological and spiritual significance. Mungenooka Springs and Arramall Cave also reside close to the Proposal (9.5 km and 5 km northwest of the Mine Development Envelope, respectively), both sites will not be impacted directly by the Proposal.

Changes to the Hydrological Regime

Both Arrowsmith Lake and Arrowsmith River have the potential to be indirectly impacted by the Proposal through changes to the local hydrological regime. The Proposal includes the development of a crossing at a minor ephemeral drainage line within the access corridor and the abstraction of up to 0.9GL per annum of groundwater from the Yarragadee aquifer. The potential impacts of the Proposal on Arrowsmith Lake and Arrowsmith River have been assessed in Section 7.5. With the implementation of mitigation measures and controls described in Section 7.6, the Proposal is not expected to result in any significant hydrological impacts to Arrowsmith Lake and Arrowsmith River.

8.5.3 Land Used for Traditional Purposes

Clearing of Native Vegetation

It is likely some of the development envelopes were utilised by past Yamatji people as a resource area for food and dietary sustenance, however it is likely this would have been focussed on

wetlands and watercourse areas outside the development envelopes. OHPs like Cliff Head and Eneabba West demonstrate that Yamatji people used their traditional country.

The Proposal will result in clearing of up to 353.8 ha of native vegetation within the development envelopes, which would otherwise be available for traditional uses (such as bush tucker or medicine). 14.5 ha of clearing will be required for the life of the Proposal and 339.3 ha will be cleared and progressively rehabilitated using VDT and infill planting (described in detail in Section 2.2.3). The VDT method was chosen as it promotes a high level of live foliage cover, vegetation density and species richness, achieving results that are comparable to the natural vegetation in approximately eight years (Mattiske, 2019a).

At a regional scale disturbance for the Proposal occurs entirely within vegetation association 378.1, which has 65.0 % of its pre-European extent remaining. The Proposal will disturb 0.44 % of the remaining vegetation association, or 0.28 % of the pre-European extent. This minor reduction is unlikely to significantly reduce the availability of similar land available for traditional uses in the region.

At a local scale, mapped vegetation communities provide context about the types of vegetation that will be disturbed and what proportions will be retained. The Proposal will not disturb more than 46 % of the mapped extent of any vegetation communities within the survey area (Figure 50), with the greatest being 116.84 ha of the H3 vegetation community (45.3 % of extent mapped by Mattiske; 2022a). Given that more than 54 % of every vegetation community will remain, and the vegetation communities with the largest percentage loss are within the proposed VDT areas (i.e., the vegetation community is predicted to remain relatively intact), the Proposal disturbance is unlikely to have a significant impact on the availability of bush tucker and medicine species in the local area. Nevertheless, VRX will consult with the Yamatji People to ensure bush tucker and medicine species are included in rehabilitation monitoring (and infill planting if required) to ensure these species are represented in VDT areas.

Given the proposed progressive rehabilitation method (VDT and infill planting of bush tucker and medicine species if required), and the presence of similar habitat in the Survey Area the direct disturbance of the Proposal is therefore considered unlikely to have a significant impact on the availability of land used for traditional purposes.

Land Access

The development envelopes reside almost wholly on UCL within the Yamatji Nation ILUA. The Proposal will include some restrictions to parts of land within the development envelopes that would otherwise be available for traditional purposes. Areas within the development envelopes that are being actively mined or are under rehabilitation will not be accessible by the public however, additional exceptions will be made for Traditional Owners where safe to do so. Overall, access to the land for Traditional Owners may be improved by the development of the access road for the Proposal (note the use of this road will be limited to Traditional Owners and not the general public). VRX has committed to maintaining and improving Traditional Owners' access to land for traditional purposes wherever possible and safe to do so.

The Proposal is therefore unlikely to significantly restrict access to land for traditional purposes.

Amenity

The Proposal will affect the amenity of the area, through noise, dust and light emissions, however as discussed in Section 8.5.1 the scale of these emissions is likely to be minor and localised.

8.6 MITIGATION

VRX has mitigated the potential impacts to this factor according to the mitigation hierarchy; avoid, minimise, rehabilitate. Offsets are not expected to be required for this factor.

8.6.1 AVOID

The key avoidance mechanism implemented by VRX was the design of the development envelopes to avoid key features relevant to this factor, including:

- Aboriginal Heritage Sites;
- Arrowsmith River and
- Arrowsmith Lake.

There are no significant archaeological or ethnographic places identified within the development envelopes.

8.6.2 MINIMISE

The following mitigation measures are proposed to ensure that direct and indirect impacts to social surroundings are minimised:

1. **Obtain Access Agreement with Southern Yamatji People;**
2. **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 MFP, slurry and return water pipeline, power station and Processing Plant. The MFP, Processing Plant and power station present high noise emission 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 air quality. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum:
    a. Routinely inspect the condition and performance of gas generators, trommels, screens and dust suppressing systems, to ensure they are in acceptable condition and / or operating appropriately;
    b. The following controls will be implemented to minimise the risk of impact from noise:
        i. Routine noise monitoring will be conducted on site;
        ii. Equipment operation will be regulated to meet demand;
        iii. Low noise equipment will be favoured during procurement;
        iv. Investigations will be conducted into the cause of any excessive air emissions.
3. **Aboriginal heritage protocol.** Aboriginal Heritage will be managed in accordance with a heritage protocol agreed upon by VRX and the Southern Yamatji people
4. **Implement industry best-practice management measures for Aboriginal Heritage**:
    a. Undertake Aboriginal Heritage surveys across any areas proposed to be cleared;

   b. Vegetation clearing will be managed through internal ground disturbance procedures;
   c. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to dozer operators;
   d. Progressive clearing will be undertaken;
   e. The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation;
5. **If required, obtain and comply with approvals under the ACH Act for any Aboriginal Heritage sites (or OHPs that are likely to be sites) that are to be disturbed;**
6. **If required, ensure Aboriginal 'cultural salvage areas' are appropriately salvaged prior to disturbance;**
7. **Minimise clearing and access restrictions within areas used for traditional purposes;**
8. **Maintain and improve Traditional Owners' access to land for traditional uses;**
9. **Include bush tucker and medicine species in rehabilitation monitoring and infill planting if required;**
10. **Development of a Cultural Heritage Management Plan in consultation with Southern Yamatji People**.
    a. Cultural awareness training will be included in site inductions, to ensure all personnel are made aware of their obligations under the Cultural Heritage Management Plan and ACH Act
    b. Access to country is to be maintained wherever possible and safe to do so
    c. If human remains, skeletal materials that may be human or materials that may be a human grave are uncovered, then VRX and its contractors will stop work immediately and the materials and the area will be left undisturbed. The Southern Yamatji People will be informed immediately.
11. **Develop and implement a Ranger Program in consultation with the Southern Yamatji People.** The aim of the Ranger Program is to encourage participation by the local indigenous population in land management activities within and surrounding the Proposal. Land management activities will include environmental monitoring, Rehabilitation and feral animal control.

8.6.3 REHABILITATE

Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT. This includes physically land forming the site and replanting vegetation to ensure surface safe site access and water regimes are not significantly altered. At the completion of the Proposal the site will be rehabilitated. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to social surroundings are summarised as:

1. Bush tucker and medicine species will be included in rehabilitation monitoring and infill planting will be conducted if required;
2. The access corridor will be rehabilitated with watercourse crossing structures removed;
3. The mine will be progressively landformed, with post-mining drainage to align with current conditions;
4. The mining area will be revegetated with local native species; and
5. All infrastructure (including land access barriers) will be removed.

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 "protect social surroundings from significant harm" (EPA, 2016f).

The Proposal has incorporated extensive avoidance, minimisation and rehabilitation measures into the Proposal design and operational processes to ensure that the social surroundings are protected from significant harm. The Proposal is expected to result in negligible impacts to Local Residents and Community given the setback distances of the Proposal to the nearest sensitive receptors and the lack of observed recreational or other use of the land. As a result of the above, the Proposal is not expected to result in significant 'harm' to this social value.

VRX has conducted extensive Aboriginal Heritage, archaeological, ethnographic and WAC investigations on all proposed disturbance areas. Disturbance to all Aboriginal Heritage sites (including the Arrowsmith River registered heritage site) identified during those surveys have been avoided during Proposal design, eliminating direct impacts. Indirect impacts (i.e., those resulting from changes to the local hydrological regime) are possible; however, they are expected to be managed by licencing under the RIWI Act and the approval under the Mining Act. Based on the above, the Proposal is not expected to result in significant harm to Registered Aboriginal Heritage sites.

The Proposal will result in clearing of up to 353.8 ha of native vegetation within the development envelopes. A significant portion of this clearing is to be progressively rehabilitated with VDT and infill planting. VDT is expected to return vegetation assemblage and health to a condition comparable with the natural vegetation. The extent of clearing is not considered significant at a regional scale. The Proposal will result in restrictions to the land use of parts of the development envelopes. Restricted areas are to be limited to areas that are under rehabilitation, are actively being mined or contain infrastructure, therefore the proposed restricted areas will be relatively small. VRX has also committed to maintaining and improving access to land for the Traditional Owners, and minimising disturbance within any areas that may be used for traditional purposes. As a result, the Proposal is not expected to significantly impact Land Used for Traditional Purposes.

Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.

9 GREENHOUSE GAS EMISSIONS

9.1 EPA OBJECTIVE

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.

9.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for Greenhouse Gas Emissions are summarised in Table 46 below.

Table 46: Policy and guidance relevant to the Greenhouse Gas Emissions key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered, although not deemed to be relevant to this ERD (no environmental management plans have been prepared to support this ERD).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline for Greenhouse gas emissions (EPA, 2021g)	This document was considered in the preparation of this section (Section 9) of the ERD.
Relevant EPA Technical Guidance	
Technical Guidelines for the Estimation of Emissions by Facilities in Australia (DotEE, 2017a)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the GHG Emissions report for Arrowsmith North.
Commonwealth Government	
Key Documents	
Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DotE, 2013a)	This document was considered in determining whether the Proposal is likely to have a significant impact on a matter protected under the EPBC Act.
EPBC Act Environmental Offsets Policy (EPA, 2011) – including the Offset Assessment guide	This document was determined to not be required as offsets for the Greenhouse Gas environmental factor is not required.

Policy and Guidance	How guidance has been considered
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered, although not deemed to be relevant to this ERD (no environmental management plans have been prepared to support this ERD).
Environmental Management Plan Guidelines – template (DotE, 2018)	This document was considered, although not deemed to be relevant to this ERD (no environmental management plans have been prepared to support this ERD).
EPBC Act Condition Setting Policy (DAWE, 2020)	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared.

9.3 RECEIVING ENVIRONMENT

Information in the following sections is from Kewan Bond Pty Ltd (KBPL, 2021; Appendix 28) unless otherwise referenced.

9.3.1 NATIONAL AND STATE GHG EMISSIONS

The Quarterly Update of Australia's National Greenhouse Gas Inventory: March 2021 (DISER, 2021a) estimated Australia's emissions for the year to March 2021 to be 494.2 million tonnes (Mt) of carbon dioxide equivalent (CO_2-e). Australia's emissions have declined 23.4 % since their peak in the year to June 2007. Emissions in the year to March 2021 were 20.8 % below emissions in the year to June 2005.

State emission estimates are based on the latest (2019) national estimates calculated in *The National Inventory Report 2019* (DISER, 2021b). Estimates are calculated on a United Nations Framework Convention on Climate Change (UNFCCC) accounting basis. A total of 91.85 Mt CO_2-e GHG emissions was estimated for WA for the year.

A sectoral breakdown of Australia and WA GHG emissions for 2019 is provided in Table 47.

Table 47: Sectoral breakdown of National and State GHG emissions (DISER, 2021b)

Sector	Australian emissions (DISER, 2021a) (Mt CO_2-e)	WA	
		Emissions (DSIER, 2021b) (Mt CO_2-e)	Contribution to national emissions (%)
Energy	401.2	84.3	21
Industrial Processes	30.6	4.3	14.1
Agriculture	73.6	9.9	13.45
Waste	13.2	1.9	14.39
Land use, land use change and forestry	-24.5	-8.6	-35.1
Inventory Total	**494.2**	**91.9**	**18.59**

9.3.2 Environmental Values

Based on the information provided in Section 9.3, the following environmental values were determined to require assessment for this factor:

- VRX's GHG contribution to WA's (State) annual GHG emissions; and
- VRX's GHG contribution to Australia's (National) annual GHG emissions.

9.4 Potential Impacts

KBPL (2021) has undertaken an assessment to estimate the GHG emissions associated with the Proposal. KBPL (2021) reviewed available Proposal information including methods of ore transport, options of electricity generation, and other relevant emission sources to calculate GHG emissions.

Latest industry-accepted techniques were also used by KBPL (2021) to estimate Proposal GHG emissions.

The key assumptions of the assessment include:

- 30-year operational life;
- Production rate of 1 million tonnes per annum (Mtpa) for the first 3 years (single shift); and
- Production rate of 2 Mtpa thereafter (double shift).

9.4.1 Emission Sources

The 2021 KBPL assessment and calculation of GHG emissions for the Proposal includes Scope 1, Scope 2 and Scope 3 emissions as established by the National Greenhouse and Energy Reporting (NGER) Scheme (DotEE, 2017a).

Scope 1 emissions are the emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level. Scope 1 emissions associated with the Proposal include:

- Diesel (consumption by mining equipment and vehicles);
- Natural gas (consumption by on-site electricity generation units); and
- Diesel used by trucks to transport product to Geraldton Port (if controlled by VRX).

Scope 2 emissions are emissions released to the atmosphere from the indirect consumption of an energy commodity, such as grid electricity that is generated at another facility (DotEE, 2017a). The Proposal will not be associated with any Scope 2 emissions as it will not be consuming grid electricity. The Proposal will be generating its own electricity.

Scope 3 emissions are indirect GHG emissions other than Scope 2 emissions that are generated in the wider economy. These occur as a consequence of the activities of a facility, but from sources not owned or controlled by that facility's business (DotEE, 2017a). Examples of Scope 3 emissions associated with the Proposal include:

- Diesel used by trucks to transport product to Geraldton Port (by a transport company that is not owned or controlled by VRX);
- Fuel used by ships in exporting the product to overseas customers;
- Emissions associated with extracting, refining and transporting fuels that are eventually used at the Proposal site; and

- Fuel used by site personnel commuting to and from site.

In addition to emissions from the combustion of fossil fuels, GHG emissions will also result from the clearing and decomposition of vegetation from the development envelopes. The disturbed land is proposed to be progressively rehabilitated using VDT and infill planting. At closure remaining cleared areas will be revegetated with local native plant species. This revegetation will result in carbon sequestration and will contribute to offsetting the emissions from the original land clearing.

9.4.2 Emission Calculation Methods

Calculation methods used by KBPL (2021) for GHG emissions align mainly with the NGER Scheme (DotEE, 2017a), which is administered by the CER. Emissions were calculated by inputting Proposal elements (extent and type of vegetation clearing, fuel use, operating hours and life of mine) into relevant GHG emission calculators.

The GHG that are reported under the NGER Scheme include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6) and specified kinds of hydro fluorocarbons and perfluorocarbons. The main gases expected to be released from activities associated with the Proposal are CO_2, CH_4 and N_2O. These are expressed in units of tonnes carbon dioxide equivalent (CO_2-e), which takes into account the 'global warming potential' (GWP) of each gas. Carbon dioxide has a GWP of 1. Methane has a GWP of 28, such that 1 tonne of methane is expressed as 28 t CO_2-e. Nitrous oxide has a GWP of 265.

Scope 3 emissions and emissions from vegetation clearing are not required by the NGER Scheme (DotEE, 2017a) to be reported as emission sources. However, these emission sources have been estimated for inclusion within the Proposal's GHG emission assessment.

Land Use Change

The Proposal will result in the clearing of up to 353.8 ha of native vegetation, 14.5 ha of which will be cleared for the life of the Proposal and 339.3 ha will be progressively rehabilitated by VDT. KBPL (2021) calculated GHG emissions from clearing based on the original Proposal design which had a greater area of clearing than what is proposed in this ERD. GHG emissions estimations by KBPL are considered to be conservative as the reduced extent of clearing presented in this ERD will result in less GHG emissions.

KBPL (2021) calculated the estimated emissions from clearing and decomposition of carbon contained in vegetation, debris and soil using the 2020 Full Carbon Accounting Model (FullCAM; DISER, 2020a). The calculated emission estimates from FullCAM consider the Proposal location, vegetation types and the timing of events such as clearing and rehabilitation.

Construction of the Proposal is expected to involve an initial clearing of 14.5 ha for access roads and the process plant. Initial clearing figures had not been confirmed prior to KBPL (2021) undertaking this assessment therefore a more conservative assessment was conducted based on an initial clearing area of 21.5 ha. Mining is expected to involve the clearing of 11.5 ha per annum of new land within the mining envelope.

The disturbance of land for mining will be conducted using VDT which reduces the destruction of vegetation during mining. For the purposes of emission estimations, it is assumed that the

application of VDT will result in only 60 % of vegetation destruction/mortality, compared to 100 % under conventional land clearing practices.

Scope 1 Emissions

Scope 1 emission sources included in the assessment were natural gas consumed in the gas-fired gensets for electricity generation and diesel consumed by mine site equipment such as dozers, front-end loaders and trucks.

Forecast fuel consumption rates were estimated based on the following:

- Gas genset installation (5 MW) – high speed reciprocating engines;
- Constant electricity draw (4.5 MW);
- 1 x bulldozer;
- 4 x front-end loaders;
- 2 x 20-tonne articulated trucks (first 3 years only, until a feeder conveyor is installed);
- Water truck; and
- Light vehicles.

Gas genset efficiency rates (44.5 %) were sourced from KPS Power Generation. Fuel consumption rates for earthmoving equipment have been provided by professional estimators, Resource Utilization Consultants.

Transport of silica sand product from site to Geraldton Port (return trips)

The distance from the Proposal site to Geraldton is approximately 115 km. Fuel consumption rates by road trains to Geraldton were sourced from a road transport company.

Under the scenario that the transport of silica sand product to Geraldton is conducted under the 'operational control' (as defined in the NGERS) of VRX, then the associated emissions would be considered Scope 1 rather than Scope 3.

This scenario is considered unlikely under the current NGERS guidelines regarding the determination of operational control and reporting obligations. It is most likely that emissions associated with product transport to Geraldton will be considered outside of VRX's operational control and therefore a Scope 3 emission (similar to the shipping of the product from Geraldton port to international customers).

VRX acknowledges the EPA may take a different approach to defining emissions scopes and may consider GHG emissions from product transport as Scope 1 emissions because without implementation of the Proposal these emissions would not exist. For the purpose of this impact assessment, GHG emission from the transport of product have been included in the total Scope 1 GHG emissions.

Scope 3 Emissions

The GHG emission assessment for the Scope 3 emission sources included activities considered to be outside of the operational control of VRX. These are described as follows:

Transport of silica sand product from Geraldton to overseas customers

Silica sand will be exported to overseas customers from Geraldton Port. The most likely destination for the product is expected to be Korea, but it is possible that product could also be exported to other countries such as China, Indonesia or India. Shipping to Korea involves the greater distance and shipping-related GHG emissions compared to China, Indonesia or India.

Therefore, it has been assumed that all product will be exported to Korea for the purposes of the GHG emission assessment. Emissions associated with shipping from Geraldton to various international ports were sourced from the United Kingdom Department of Business, Energy and Industrial Strategy Conversion Factors (UK Government; 2020) and assume bulk carriers between 60,000-100,000 dead wight tonnes.

Commuting to and from site (drive-in, drive-out)

Site personnel are expected to drive their own vehicle to site each day. Fuel consumption associated with this commuting is included in the calculation of Scope 3 emissions. It is expected that full operations will involve a workforce of eighteen personnel. It is also assumed that half the workforce will commute from Dongara (45 km from site) and half will commute from Geraldton (115 km from site) for the purposes of estimating emissions.

Emissions associated with extracting, refining and delivery of fuels used at site

KBPL (2021) has estimated emissions for the extraction, refining and delivery of fuels consumed on site based on emission factors from Australian National Greenhouse Accounts Factors (DISER, 2020b).

9.4.3 GHG Emission Estimates

Estimated GHG emissions include consideration of Scope 1 and Scope 3 emissions. VRX has taken a conservative approach to estimating GHG emissions and has included emissions from land use changes (i.e., clearing of vegetation and the decomposition of organic material) and transport of product in the Scope 1 GHG emissions estimate. The Proposal will not be associated with any Scope 2 emissions as all electricity required for the Proposal is generated on site.

Scope 1 Emissions

Annual Scope 1 emissions are estimated to range from 17,121 t CO_2 -e per annum in the first three years, then increase to 30,743 t CO_2 -e per annum once the Proposal doubles production rates and moves to a 24-hour operation (average of 29,380 t CO_2-e per annum for the life of the Proposal). The majority (51.5 %) of Scope 1 emissions are predicted to be generated from the consumption of natural gas for electricity generation, 36.2% are predicted to be from road transport and the remaining (12.3 %) emissions are generated by diesel consumed by the various earthmoving equipment on site and clearing of native vegetation. The predicted Scope 1 GHG emissions for the life of the Proposal are provided in Figure 82 below (prior to the planned implementation of renewable energy).

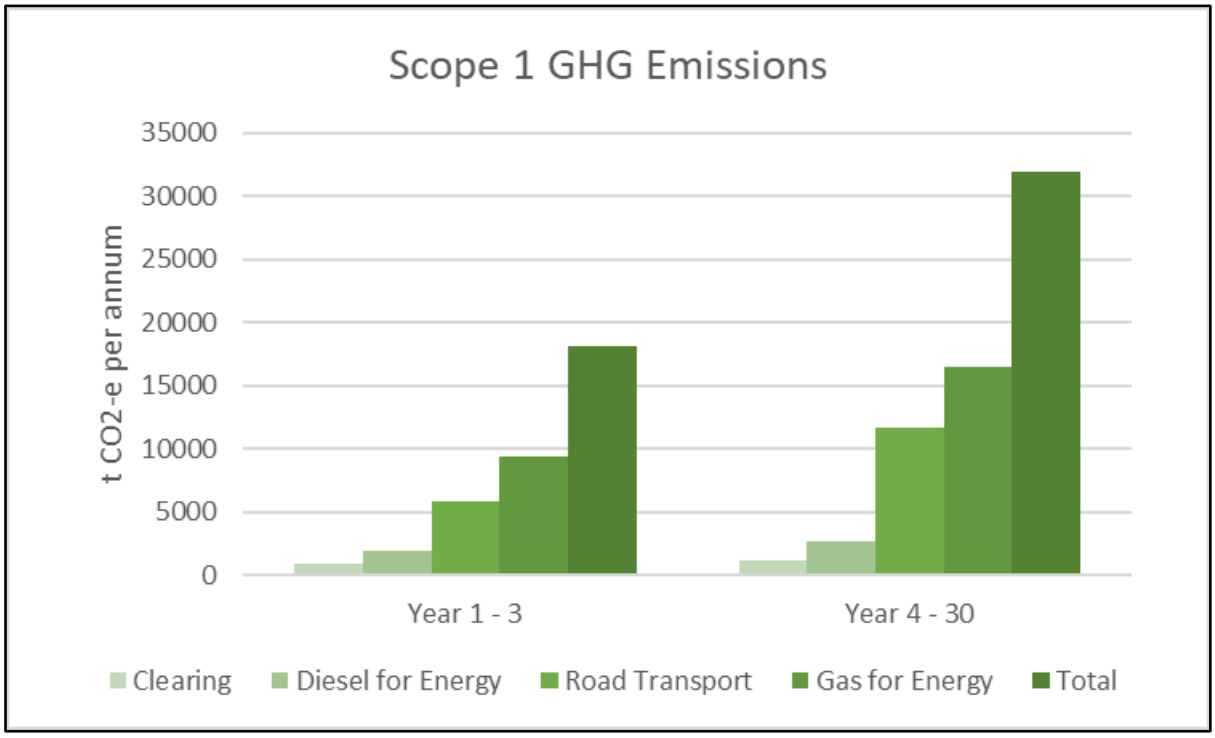


Figure 82: Estimated annual Scope 1 emissions from the Proposal

Land Use Change

KBPL (2021) estimated the total cumulative emissions from land clearing and revegetation to reach a peak of 33,160 t CO_2-e during the 30-year operational phase of the Proposal.

Figure 83 indicates a gradual increase in cumulative emissions as land clearing occurs throughout the Proposal's operational phase. Emissions then start reducing when the emission sequestration rates become higher than the emissions resulting from vegetation decomposition. The modelling data shows that net carbon sequestration commences from 'Year 36' as the vegetation growth continues and there is no further land clearing.

Total cumulative emissions from land use change after 100 years is estimated to be 12,126 t CO_2 -e (2 % of total Proposal GHG emissions).

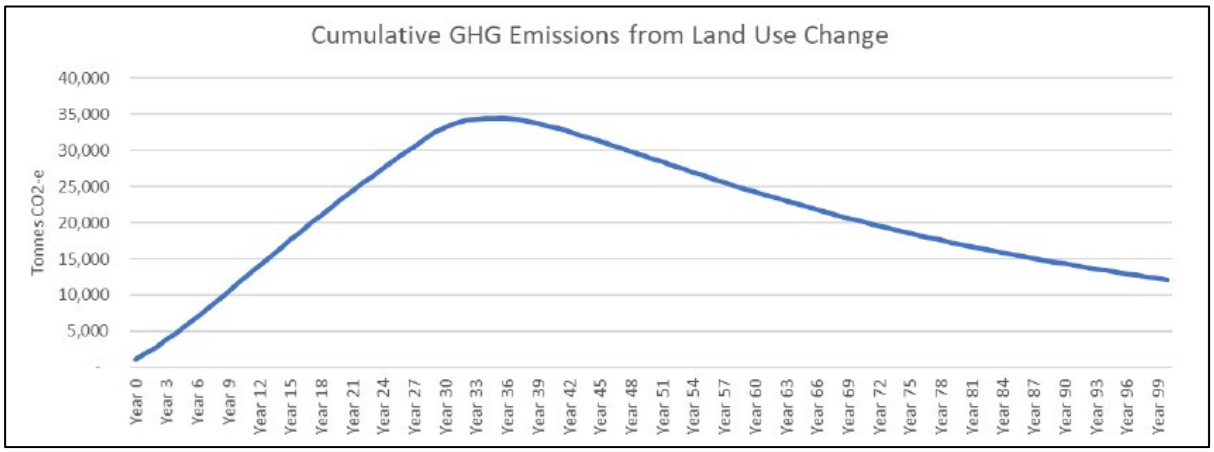


Figure 83: Estimated cumulative emissions from land use change

Transport of Product to Geraldton

Under the scenario that the transport of silica sand product to Geraldton is conducted under the 'operational control' (as defined in the NGERS) of VRX, then the associated emissions would be considered Scope 1 rather than Scope 3. This would have effect of up to 5,821 t CO_2 -e per annum (Year 1 – 3) then 11,643 t CO_2 -e per annum thereafter being added to the Scope 1 emissions profile, and being removed from the Scope 3 profile. Under this scenario, Scope 1 emissions for the Proposal would increase to 17,121 t CO_2-e per annum (year 1-3) and 30,759 t CO_2-e per annum thereafter.

Scope 3 Emissions

Figure 84 presents the estimated Scope 3 emissions under the scenario that the silica sand product is transported to Geraldton via truck (KBPL, 2021). During full production (after year 3), Scope 3 emissions are estimated to comprise:

- Natural gas extraction, refining and transport = 1,276 t CO_2-e per annum;
- Diesel extraction, refining and transport = 138 t CO_2-e per annum;
- Personnel commuting = 517 t CO_2-e per annum; and
- Shipping of silica sand product to overseas customers = 46,897 t CO_2-e per annum.

Based on the information provided above, the Proposal is predicted to produce up to 48,828 t CO_2-e per year of Scope 3 GHG emissions.

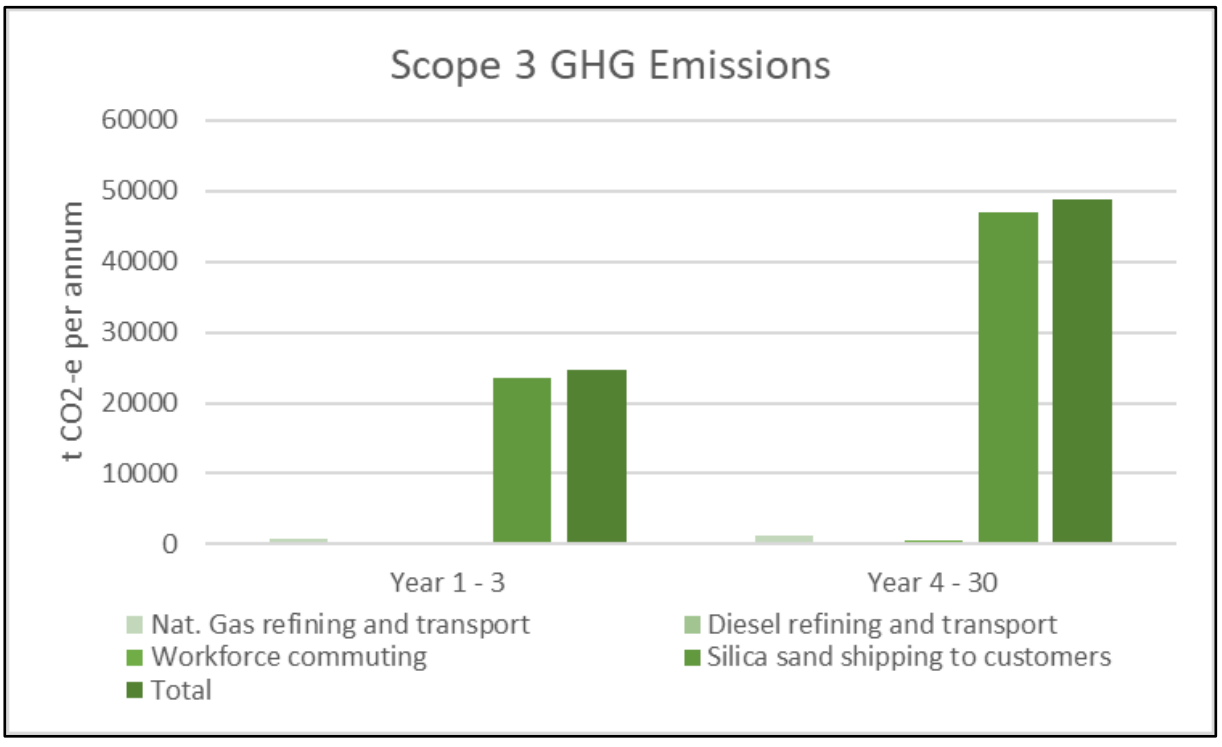


Figure 84: Annual Scope 3 GHG emissions

Total Emissions

The Proposal is expected to generate Scope 1 emissions of 915,149 t CO_2-e over its 30-year operational life. This includes 33,160 t CO_2-e (peak) from the clearing of vegetation and rehabilitation, which is not reportable under the current NGERS and will continue to be offset somewhat by ongoing carbon sequestration from the revegetation of the area after mining ceases.

It also includes emissions from the combustion of diesel for the transport of product to Geraldton port (5,821 t CO_2 -e per annum (Year 1 – 3) then 11,643 t CO_2 -e per annum thereafter) which would not be considered as Scope 1 emissions under the definition of operational control by NGERS. Scope 1 emissions also included natural gas as electricity generation and diesel consumption within site operations.

A total of 1,392,110 t CO_2-e of Scope 3 emissions are expected to be generated for the life of the Proposal. Scope 3 emissions comprise natural gas refining and transport, diesel refining and transport, workforce commuting and silica sand product shipping to overseas customers.

A summary of the estimated emissions inventory for the life of the Proposal is provided in Table 48. The consumption of natural gas for the generation of electricity contributes the majority (51.5 %) of the Scope 1 emissions. The export (shipping) of the silica sand product to overseas customers contributes the greatest proportion (96 %) of the Scope 3 emissions.

Table 48: GHG Emissions summary

Emissions	Average Emissions (t CO_2-e per year)	Total Emissions (t CO_2-e)	Percentage
Scope 1 emissions			
Land clearing and revegetation	1,105	33,160	3.6
Natura Gas – Electricity generation	15,734	472,041	51.5
Diesel – Site operations	2,604	78,129	8.5
Diesel – Road transport	11,060	331,819	36.25
Total Scope 1 Emissions	**30,504**	**915,149**	**100**
Scope 3 emissions			
Natural gas refining and transport	1,221	36,642	2.6
Diesel refining and transport	133	4,007	0.3
Workforce commuting	496	14,895	1.1
Silica sand shipping to customers	44,552	1,336,566	96.0
Total Scope 3 Emissions	**46,402**	**1,392,110**	**100**

Emissions Intensity

Emissions intensity for the Proposal has been calculated based on the total Scope 1 GHG emission produced per unit of product. During the first three years of operation, VRX will produce up to 1 Mt of product per annum while producing 17,121 t CO_2-e per annum. After the first three years VRX will produce up to 2 Mt of product per annum while producing 30,743 t CO_2-e per annum. This production rates and emissions rates equate to an emission intensity of:

- 0.0171 t CO_2-e / t product for the first three years; and
- 0.01537 t CO_2-e / t product for remaining life of the Proposal.

Emission intensity for the Proposal has been calculated based on the rate of product (i.e., t CO_2 e / t product). The mining process is expected to have a high product yield (~97 % product from ore) therefore a production based emissions intensity is expected to be similar to a processing based emissions intensity (i.e., t CO_2-e / t ore mined is almost the same as and t CO_2-e / t processed in this case).

Comparison with other Projects

There is limited publicly available GHG emissions estimates for other silica sand projects in WA and nationally. VRX has chosen to compare the predicted emission intensity from the Proposal to mineral sand projects of similar size and scope as they typically involve comparable mining and processing activities. Comparison of the Proposal's predicted GHG emissions intensity to similar projects is provided in Table 49.

Table 49: Comparison of the Proposal's GHG emission intensity with other similar projects

Project Name	Project Type	Mining and Processing Rate (t/annum)	GHG emissions (t CO_2-e)			Scope 1 Emissions intensity (t CO_2-e / t ore processed)	Reference
			Scope 1	Scope 2	Total		
Fingerboard Project – Kabal Operations Pty Ltd	Mineral Sands	11,300,000	33,672	27,883	61,555	0.002	DELWP, 2022
Yalyalup Mineral Sands Deposit – Doral Mineral Sands Pty Ltd	Mineral Sands	250,000	12,000	None	12,000	0.048	EPA, 2022a
Lucky Bay Garnet Mine – Australian Garnet Pty Ltd	Mineral Sands	6,900,000	22,581	None	22,581	0.003	EPA, 2022b

Table 50 defines the predicted GHG emissions (direct, indirect and cumulative) in a local and regional context.

Table 50: Predicted GHG emissions

Environmental value	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
GHG emissions	Up to 30,743 t CO_2-e of Scope 1 GHG emissions per year	No Scope 2 GHG emissions. Up to 48,827 t CO_2-e of Scope 3 emissions per year	Total annual State GHG emission of approximately 91.85 Mt CO_2-e (4.3 Mt CO_2-e of which are Scope 1 GHG emissions from industrial processes) Total annual National GHG emissions of approximately 494.2 Mt CO_2-e (30.6 Mt CO_2-e of which are Scope 1 GHG emissions from industrial processes)	Total annual State GHG emission of approximately 91.86 Mt CO_2-e (4.33 Mt CO_2-e of which are Scope 1 GHG emissions from industrial processes) Total annual National GHG emissions of approximately 494.28 Mt CO_2-e (30.63 Mt CO_2-e of which are Scope 1 GHG emissions from industrial processes)

9.5 ASSESSMENT OF IMPACTS

An estimate of the expected annual Scope 1 GHG emissions from the Proposal was calculated by KBPL (2021). A maximum of 30,743 t CO_2-e per annum is estimated to be produced over the life of the Proposal.

The Proposal is predicted to increase WA's annual GHG emissions from Industrial Processes on average by approximately 0.45% per annum, this represents an overall increase to WA's GHG emissions of 0.02% when compared to the State's total GHG emissions of 91.85 Mt of CO_2-e for 2019 (DISER, 2021a).

The Proposal is also predicted to increase Australia's annual GHG emissions from Industrial Processes on average by 0.06%, this represents an overall increase to Australia's GHG emissions of 0.004% when compared to the National total GHG emissions of 494.2 Mt CO_2-e for March 2021 (DISER, 2021b).

Based on the information provided above, the Proposal will result in a small contribution to WA (and subsequently, Australia's) annual GHG emissions. Given the relatively small contribution, the impact resulting from the implementation of the Proposal is not considered significant. Nevertheless, mitigation measures are proposed to minimise GHG emissions as far as practicable (Section 9.6).

9.6 MITIGATION

VRX 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

VRX has investigated several power supply options for the Proposal, including renewable sources including solar, wind and stored energy. Solar power could supplement a portion of the energy requirements of the Proposal, however landholder negotiations for a suitable solar farm site are unlikely to be completed prior to assessment. VRX will continue to investigate the development of a solar farm, with the intent to utilise existing cleared land.

9.6.2 MINIMISE

The following mitigation measures are proposed to avoid or minimise GHG emissions during the implementation of the Proposal:

1. **Progressive rehabilitation.** Mined areas will be progressively rehabilitated using VDT to minimise the extent of long term clearing and promote carbon sequestration.
2. **Optimise efficiencies during Proposal operations.** The operational scale of the Proposal is relatively small and has been optimised to reduce ore/product handling. Product will be pumped as a slurry from the MFP to the Processing Plant which is more efficient than conveyors or truck haulage.
3. **Explore and implement low/no emission power options.** VRX will continue to explore green energy options (solar and battery storage) to offset the power demand of the Proposal and minimise emissions. Given the long-term mine life these renewable energy sources are likely to be cost-effective;
4. **Utilise heavy haulage trucks along the haul road**. The private haul road allows VRX to run larger trucks between the mine and the Brand Highway. This improves the efficiency of the ore transport and reduces double handling, ultimately minimising GHG emissions;
5. **Maximise electrical efficiency**. The following activities will be managed to maximise electrical efficiency and 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 optimise efficiency;
c. Regular electrical calibration checks on the processing equipment;
d. Generators will be controlled to only satisfy power demand;
e. Use of high efficiency electrical motors throughout the mine site; and
f. Use of variable speed drive pumps, compressors and other processing equipment.

6. **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 to minimise diesel consumption;
    b. Site and mine access will be designed to limit the amount of effort required for machinery and trucks (i.e., roads constructed with low gradient);
    c. Haul roads will be compacted to reduce rolling resistance;
    d. The 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 inspections and monitoring; and
    f. Consideration of fuel efficiency of haul trucks will be undertaken during procurement.

9.6.3 REHABILITATE

Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT and infill planting. At the completion of the Proposal the site will be rehabilitated entirely. One of the planned outcomes will be to reinstate the native vegetation at all cleared areas. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a; 2020b). The MCP will describe 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; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to GHG emissions are summarised below:

- Mining areas will be progressively rehabilitated via VDT;
- Permanent disturbance areas at the mine and access corridor will be revegetated at closure; and
- All GHG emissions-producing infrastructure will be decommissioned and removed.

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 Proposal is estimated to produce an average of 30,743 t CO_2-e of Scope 1 GHG emissions per year over the 30 year mine life, which is not considered significant in comparison to EPA's assessable limit (100,000 t CO_2-e of Scope 1 GHG emissions) for the GHG Emissions Key Environmental Factor (EPA, 2020c).

The Proposal GHG emissions equates to only 0.45 % of the predicted annual emissions from Industrial Processes and 0.02 % of the overall predicted annual GHG emissions in WA (DISER, 2021b). Nevertheless, VRX is committed to minimising GHG emissions from the Proposal through the implementation of the mitigation measures described in Section 9.6.

The implementation of design and operational mitigation measures is 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 AIR QUALITY

10.1 EPA OBJECTIVE

The EPA Objective for this key environmental factor is to maintain air quality and minimise emissions so that environmental values are protected.

10.2 POLICY AND GUIDANCE

Relevant EPA and Commonwealth Government guidance documents for Air Quality are summarised in Table 51 below.

Table 51: Policy and guidance relevant to the Air Quality key environmental factor

Policy and Guidance	How guidance has been considered
WA Government	
Key EPA documents	
Statement of Environmental Principles, Factors and Objectives 2021 (EPA, 2021b)	This document was considered in the preparation of this ERD and to inform EIA. It was used identify the Key Environmental Factors likely to be impacted by the Proposal and the EPA's objective for each factor.
Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a)	This document has been considered in the design and planning of the Proposal, it has also been considered in the preparation of mitigation measures for the Proposal, including the preparation of VRX's rehabilitation strategy (Appendix 4).
EIA (Part IV Divisions 1 and 2) Administrative Procedures (EPA, 2021e)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
EIA (Part IV Divisions 1 and 2) Procedures Manual (EPA, 2021a)	This document has been considered in planning for the Part IV approval process and has been used to inform the preparation of this ERD.
Instructions on how to prepare EP Act Part IV Environmental Management Plans (EPA, 2021f)	This document was considered, although not deemed to be relevant to this ERD (no environmental management plans have been prepared to support this ERD).
Relevant EPA Factor Guidelines	
Environmental Factor Guideline – Air Quality (EPA, 2020c).	This document was considered in the preparation of this section (Section 10) of the ERD.
Relevant EPA Technical Guidance	
Guidance for the Assessment of Environmental Factors – Separation Distances between Industrial and Sensitive Land Uses No. 3 (EPA, 2005).	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Air Quality report for Arrowsmith North.
Other Policy and Guidance	
WA Environmental Offsets Policy (EPA, 2011)	This document was considered during EIA for Air Quality however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Guidelines (EPA, 2014a)	This document was considered during EIA for Air Quality however it was determined not be relevant as offsets were not required.
WA Environmental Offsets Template (EPA, 2014b)	This document was considered during EIA for Air Quality however it was determined not be relevant as offsets were not required.

Policy and Guidance	How guidance has been considered
National Environmental Protection Measure for Ambient Air Quality (NEPC, 2021)	This legislation was considered in the preparation of this section (Section 10) of the ERD.
Management of fibrous minerals in Western Australian mining operations – guideline (DMP, 2015)	This document was considered in the provision of this section (Section 10) of the ERD, although deemed not relevant to the Proposal.
Guidance Note on Public Health Risk Management of Asbestiform Minerals Associated with Mining (DoH, 2013).	This document was considered in the provision of this section (Section 10) of the ERD, although deemed not relevant to the Proposal.
Guideline – Dust Emissions, draft for external consultation (DWER, 2021a)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Air Quality report for Arrowsmith North.
Guideline – Air Emissions, draft for external consultation (DWER, 2019)	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Air Quality report for Arrowsmith North.
Commonwealth Government	
Key Documents	
Significant Impact Guidelines 1.1 – Matters of National Environmental Significance (DotE, 2013a)	This document was considered in determining whether the Proposal is likely to have a significant impact on a matter protected under the EPBC Act.
Environmental Management Plan Guidelines (DotE, 2014a)	This document was considered, although deemed not relevant to this ERD (no environmental management plans have been prepared to support this ERD).
Environmental Management Plan Guidelines – template (DotE, 2018)	This document was considered, although deemed not relevant to this ERD (no environmental management plans have been prepared to support this ERD).
EPBC Act Condition Setting Policy (DAWE, 2020)	This document was used as guidance for the referral process and EIA of the Proposal.
EPBC Act Outcomes-based conditions policy (DotE, 2016a)	This document is used to assist in designing outcome-based Management Plans, it was not required for the Proposal as no management plans have been prepared.
Relevant Technical Guidance	
Air Quality Modelling Guidance Notes (DoE, 2006)	This document was not deemed relevant to the provision of this section (Section 10) of the ERD.
United States Environmental Protection Agency (USEPA; 2011) *Air Emissions Factors and Quantification: AP-42 Compilation of Air Emission Factors*	This document was considered in the preparation of this section (Section 10) of the ERD.
National Pollutant Inventory (2008) *Emission Estimation Technique Manual for Combustion Engines. Version 3.0*	This document was used to inform the survey effort required to undertake EIA for the Proposal and is referenced throughout the Air Quality report for Arrowsmith North.
New South Wales Environmental Protection Authority (NSW EPA) (2017) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, Sydney, NSW*	This document was considered in the preparation of this section (Section 10) of the ERD.

10.3 RECEIVING ENVIRONMENT

Information in the following section is sourced from Environmental Technologies & Analytics' (ETA) (2021; Appendix 30) Air Emissions Desktop Assessment unless otherwise referenced.

10.3.1 METEOROLOGY

Prevailing winds

Wind speed and direction observations at some BoM weather stations are only performed twice a day, at 9 am and 3 pm (this is the case for Eneabba and Mingenew). The corresponding wind roses that are produced showing only 9 am and 3 pm average conditions are therefore not a reliable indicator of average wind conditions for daily periods or for periods when emissions occur, and are not used in regulatory assessment (DWER, 2021a).

In the absence of wind measurements for the Proposal and limitations in the wind measurement data available for the BoM's nearby weather station at Eneabba and Mingenew, the prevailing winds at the site have been characterised using wind speed and direction measurements obtained from the BoM's Geraldton Airport station (BoM station ID: 008315). Whilst the Geraldton Airport station is located 90 km north of the Proposal, it is a similar distance from the coastline and so has been used for indicative purposes only. The annual and seasonal wind roses derived from wind speed and direction measurements obtained from the BoM's Geraldton Airport station over a period of approximately ten years (July 2011 to March 2021) is presented in Figure 85.

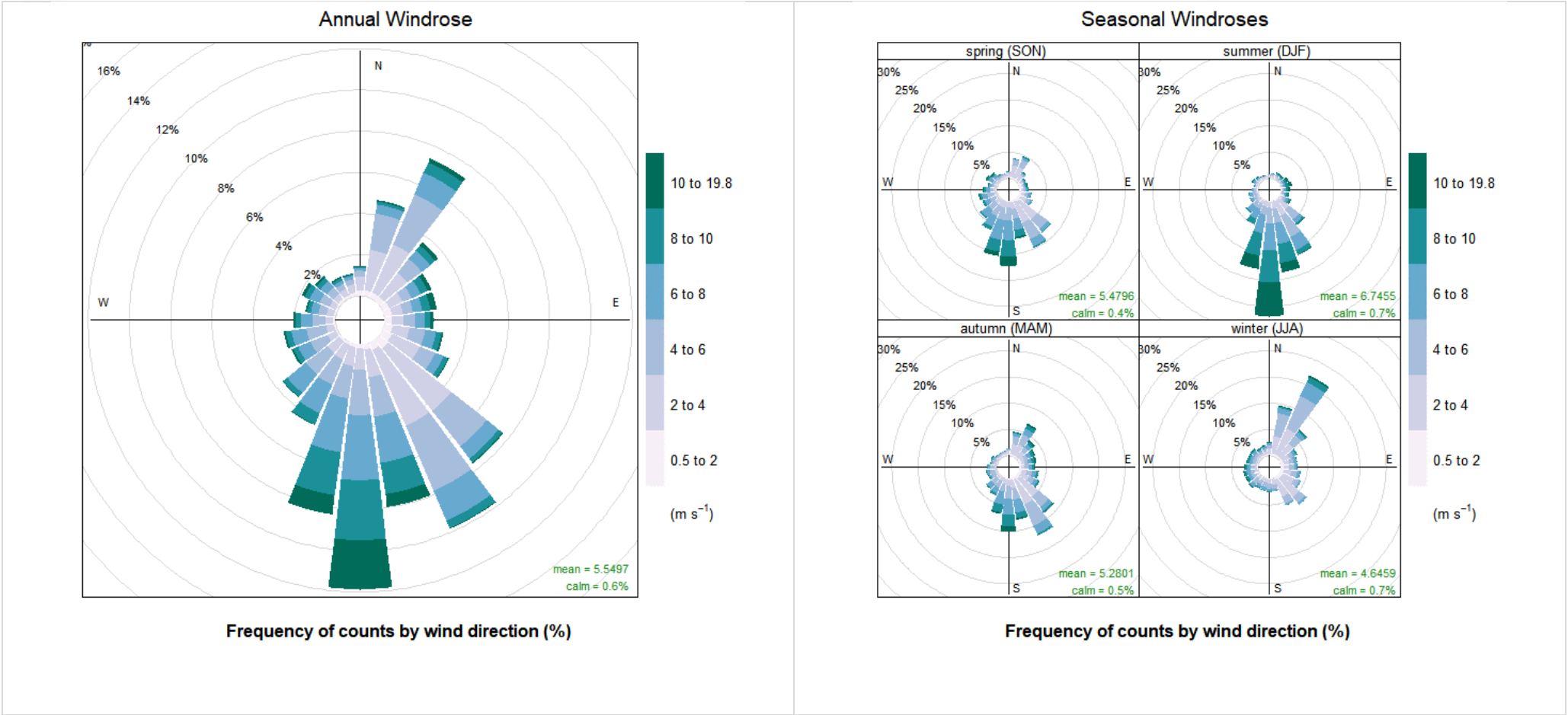
Wind speed and direction observations at some BoM weather stations are only performed twice a day, at 9 am and 3 pm. The corresponding wind roses that are produced showing only 9 am and 3 pm average conditions are not a reliable indicator of average wind conditions for daily periods, or for periods when emissions occur, and are not used in regulatory assessments (DWER, 2021a).

The major features of these wind roses (particularly those that are critical in terms of potential to generate wind-blown dust emissions) are as follows:

- The predominance of moderate to strong southerly winds is evident, particularly during summer and spring;
- During winter, moderate to strong north easterly winds occur more often than at other times of the year;
- Light to moderate south easterly winds are also predominant throughout the year, although tending to occur less often during winter;
- The average wind speed is 5.5 m/s. During summer the average wind speed is higher (6.7 m/s), and for the remainder of the time the average wind speed is similar: 5.5 m/s in spring, 5.3 m/s in autumn and 4.6 m/s in winter; and
- Calm conditions (<0.1 m/s) occur infrequently (0.6 %).

Summer is expected to be the more critical time of the year for dust management. The potential for the generation of wind-blown dust emissions is increased due to the higher wind strength and the lower rainfall and relative humidity. These conditions also tend to reduce the effectiveness of conventional dust abatement controls (i.e., wetting down of surfaces).

The location of sensitive receptors in the area relative to the prevailing winds is discussed in Section 8.4.1.



Note a different scale is used for annual and seasonal wind roses.

Figure 85: Geraldton wind roses, 2011 – 2021

10.3.2 TERRAIN

The Proposal is located in the Geraldton Sandplain bioregion of WA, characterised by the sandy earths of an extensive undulating sandplain. The Proposal site and surrounding landscape is relatively flat with terrain induced effects on local winds not expected to be significant. Figure 86 presents contours of terrain height for the area surrounding the Proposal, derived from 1 second (approximately 30 m) resolution SRTM obtained elevation data.

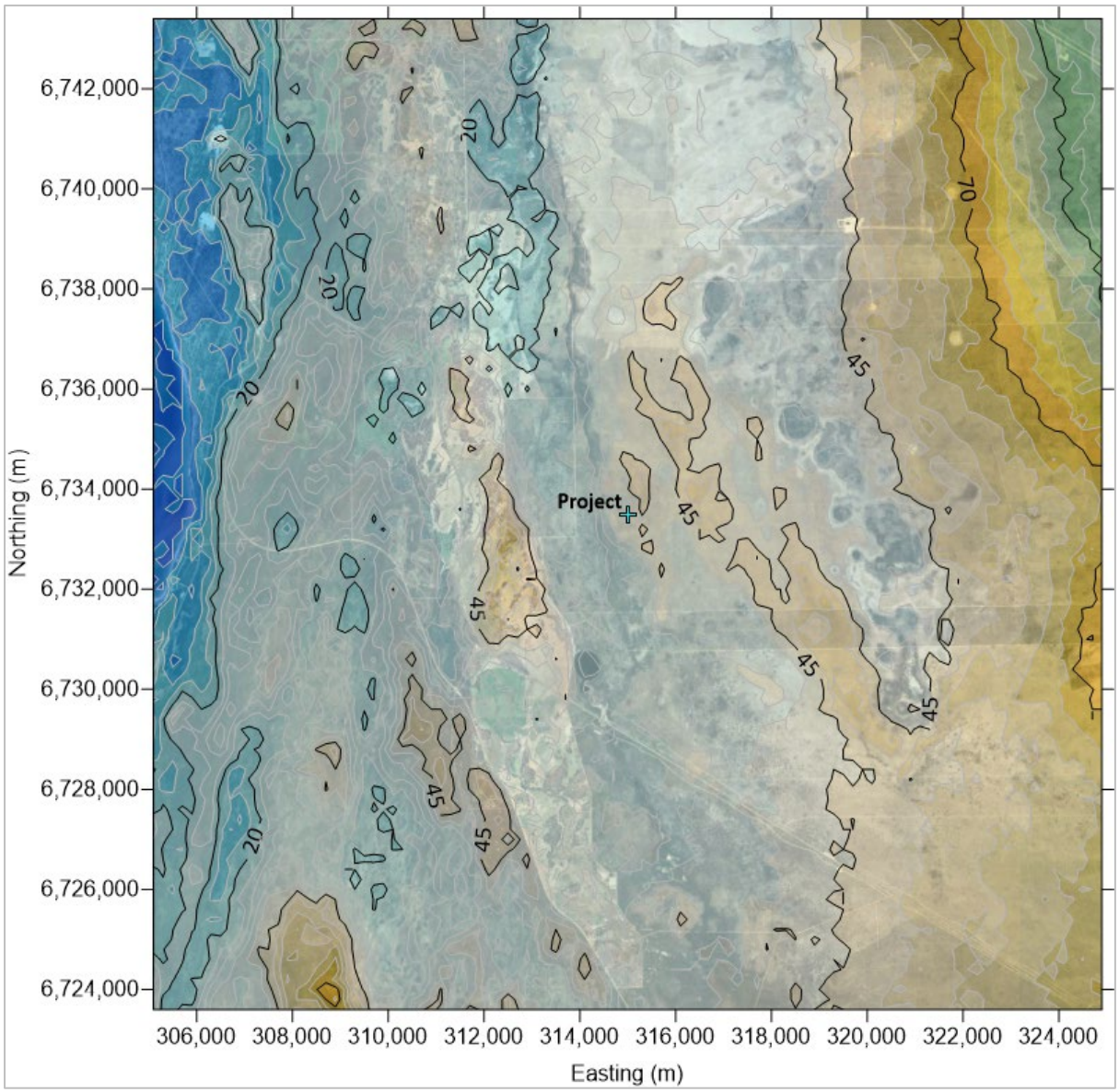


Figure 86: Terrain height contours (m)

10.3.3 KEY POLLUTANTS

Based on the Proposal description and referencing EPA advice on the preliminary key environmental factors for the Proposal, the key pollutants of interest are summarised in Table 52.

Table 52: Key air pollutants of interest

Pollutant	Description	
Particulate Matter (PM)	Airborne particles are a broad class of diverse substances that may be solid or liquid (liquid particles are often called aerosols) and are produced by a wide range of natural and human activities. Airborne particles are commonly classified by their size as total suspended particles (TSP), visibility reducing particles (PM_2), and inhalable particles (coarse fraction PM_{10} and fine fraction $PM_{2.5}$). Project mining and processing activities that involve the handling of dry materials are a potential source of PM. Periodically, windblown dust from exposed areas and stockpiles and wheel-generated dust truck haulage will also be sources of PM. Combustion emissions from the gas-fired power station and vehicle exhaust emissions from the mining and truck haulage fleet are expected to be minor contributing sources.	
	PM_{10}	Inhalable particles are grouped into two size categories: those with a diameter of up to 10 µm (PM_{10}) and those with a diameter of up to 2.5 µm ($PM_{2.5}$). Inhalable particles are associated with increases in respiratory illnesses such as asthma, bronchitis and emphysema, with an increase in risk related to their size, chemical composition and concentration. Particles in the PM_{10} size fraction have been strongly associated with increases in the daily prevalence of respiratory symptoms, hospital admissions and mortality.
	$PM_{2.5}$	Particles in the $PM_{2.5}$ size fraction can be inhaled more deeply into the lungs than PM_{10}, and have been associated with health effects similar to those of PM_{10}. There is some evidence to suggest that $PM_{2.5}$ might be more deleterious to health than other size fractions. No lower limit for the onset of adverse health effects has yet been observed.
	Deposited dust	Deposited PM is dust that, because of its aerodynamic diameter and density, falls from the air due to gravitational settling and deposits onto surfaces. The effects of deposited dust are primarily considered as an amenity issue. There is also the potential for deposited dust to have an effect upon the health of susceptible vegetation by adversely affecting photosynthesis and transpiration rates.
Products of Combustion	NO_2	Nitrogen dioxide (NO_2) is a brownish gas with a pungent odour. It exists in the atmosphere in equilibrium with nitric oxide. The mixture of these two gases is commonly referred to as nitrogen oxides (NOx). Nitrogen oxides are a product of combustion processes, and can arise when flame staging is non-ideal and nitrogen present in air is oxidised. Nitrogen dioxide can cause damage to the human respiratory tract, increasing a person's susceptibility to respiratory infections and asthma. Sensitive populations, such as the elderly, children, and people with existing health conditions are most susceptible to the adverse effects of nitrogen dioxide exposure. Nitrogen dioxide can also cause damage to plants, especially in the presence of other pollutants such as ozone and sulphur dioxide. Nitrogen oxides are also present in the reactions that lead to photochemical smog formation. Combustion emissions from the gas-fired power station and vehicle exhaust emissions from the mining and truck haulage fleet are sources.
	SO_2	Sulphur dioxide (SO_2) is a strong-smelling, colourless gas that can irritate the lungs, and can be particularly harmful for people with asthma. SO_2 and other sulphur oxides can react with compounds in the atmosphere to form fine particles that reduce visibility (haze formation). Combustion emissions from the gas-fired power station and vehicle exhaust emissions from the mining and truck haulage fleet are sources.
	CO	Carbon monoxide (CO) is a colourless, odourless gas. When inhaled, CO is rapidly absorbed into the bloodstream from the lungs. At extremely high exposures this can cause the formation of carboxyhaemoglobin which decreases the body's ability to carry oxygen. Long term (chronic) health effects from exposure to low levels of CO may produce heart disease and damage to the nervous system. Combustion emissions from the gas-fired power station and vehicle exhaust emissions from the mining and truck haulage fleet are sources.

10.3.4 Environmental Values

Based on the information provided in Section 10.3, the following environmental values were determined to require assessment for this factor:

- Local airshed and associated sensitive receptors.

10.4 Potential Impacts

Table 53 outlines the potential impacts (direct, indirect and cumulative) from the Proposal in relation to the Air Quality factor in a local content. These impacts are informed by the results of studies described in Sections 5 – 10. Assessment of the potential impacts is provided in the following sections.

Table 53: Potential impacts on Air Quality

Environmental value and current extent	Potential direct impact	Potential indirect impact	Impacts associated with other proposals	Total cumulative impact
Local airshed. Four sensitive receptors are located within 5 km of the Proposal.	Emissions of combustion products: • NO_x: 227,923 kg/year • SO_x: 392,193 kg/year • CO: 537 kg/year Emissions of dust consisting of 0.29 $\%_{wt}$ RCS	No indirect impacts identified.	Air emissions from the following projects: • Arrowsmith Central Silica Sands (Proposed) • Beach Energy / AWE limited – Beharra Springs Gas (Operational) • Perpetual Resources limited – Beharra Silica, Beharra West and Arrowsmith West (Proposed) • Strike and Warrego Energy – West Erregulla Gas Field (Proposed)	Emissions of combustion products in addition to those produced from other proposals: • NO_x: 227,923 kg/year • SO_x: 392,193 kg/year • CO: 537 kg/year Emissions of dust consisting of 0.29 $\%_{wt}$ RCS

10.5 Assessment of Impacts

The following section assess the potential impacts on each environmental value identified in Section 10.3.

VRX commissioned ETA to conduct a desktop air quality assessment to determine the potential air quality impacts from by the Proposal. The scope of the desktop assessment included an analysis of:

- Dust emissions from the various stages of Proposal development;
- Combustion emissions from the Proposal's power station; and
- Vehicle exhaust emissions.

The potential air quality impacts of the Proposal were determined based on considerations of:

- The nature and scale of the Proposal;
- Key pollutants of concern and potential emission sources;
- Separation distance to surrounding sensitive receptors (residences);

- Proposed dust controls incorporated into the design of the Proposal and management practices that will be available to minimise dust generation;
- Results of a screening model for emissions of products of combustion (NO_x, SO_2 and CO) from the gas fired power station and from diesel vehicle usage on site; and
- Other relevant factors that could potentially influence the extent of impacts, such as terrain, prevailing meteorology, and dust characteristics (physical properties, particle size, composition).

10.5.1 Particulate Matter

Dust Characteristics

The potential dust emission sources from the Proposal fall into three categories:

- Raw (in-situ) silica sand (mined material);
- Commercial grade silica sand (product); and
- Reject material (slimes) produced as the by-product of processing.

Comprehensive testing has been undertaken by VRX to characterise the properties of the above-mentioned materials, including (but not limited to):

- Dust Extinction Moisture (DEM);
- Particle Size Distribution (PSD); and
- Compositional analysis – elemental, trace metal leach testing, Respirable Crystalline Silica (RCS).

The results of this material testing have been used to determine the likely characteristics of dust emitted (including particle size, composition, and colour) that influence the potential health or amenity impacts.

Physical Properties

Silica sand is most commonly found as quartz – a crystalline silica polymorph composed of silicon and oxygen in the form of silicon dioxide (SiO_2). Quartz is a relatively hard mineral, and although it is very brittle, because it does not exhibit cleavage, it is relatively strong to mechanical stress. It has a specific gravity of between 2.6 and 2.7 depending on the type of quartz, with a low porosity. As a result of these properties, silica sand is not susceptible to the generation of dust from particle attrition and less susceptible to wind-blown dust owing to the higher wind speed threshold at which dust lift-off is expected to occur. The low porosity can however act to reduce the effectiveness of wetting down of surfaces for dust abatement.

In its purest form quartz is a translucent or white colour, but different impurities can cause the colour to change. The Proposal's reserves of silica sand are made up of translucent to transparent colourless quartz with some light yellow to orange-brown translucent quartz discolouration. Dust that may be generated would be a similar colour to the underlying soils in the area, and therefore is less likely to be of concern in terms of adverse amenity impacts from dust deposition.

Quartz is very stable and will not dissolve unless treated with very strong acids. The use of gravity and magnetic separation (wet processes) to upgrade to a commercial silica sand within the Processing Plant involves the use of water only. Notwithstanding the low impurity level of the

silica sand, any trace metals and other elements will not be leeched during processing, and rather will remain bound within the silica sand as occurs naturally.

Dust Extinction Moisture

DEM testing in accordance with AS 4156.6-2000 has been conducted of commercial grade silica sand product (Microanalysis Australia, 2021a). The DEM test result of 3.7 % will be used as a guide for the moisture level required to minimise dust when storing and handling of the product.

The graph of dust versus moisture level of the product is also useful as it illustrates the impact of adding moisture to the materials, for purposes of design and implementation of dust control measures Figure 87.

The proposed use of water cannons for wetting down of the product stockpile and during product load out is a suitable dust control measure provided moisture levels are maintained at or above the DEM level.

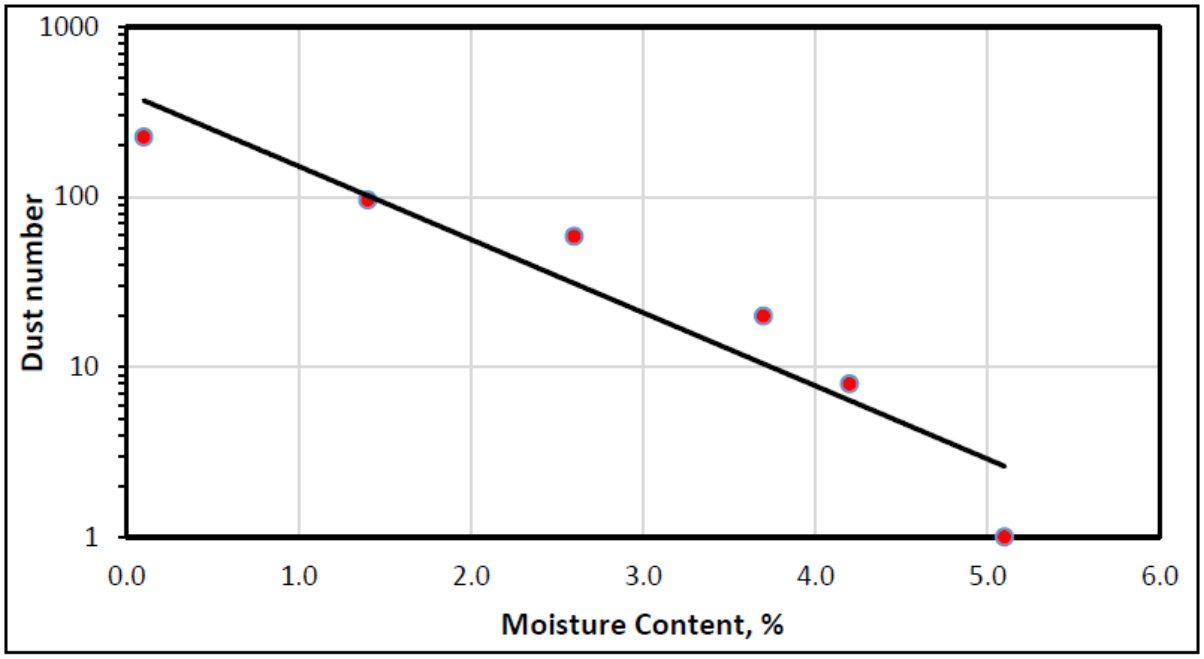


Figure 87: Dust Extinction Moisture – Commercial Grade Silica Sand Product (Microanalysis Australia, 2021a)

Particle Size

PSD testing using laser diffraction size distribution analysis following ISO 13320-1:2009 has been conducted of bulk samples of commercial grade silica sand, raw (in-situ) silica sand and reject material, summarised in Table 54. These results are of the bulk material samples and should not be misinterpreted as the anticipated PSD of dust emissions from the Proposal.

The very high percentages of the large particles that fall into the non-inhalable fraction (>100 µm), particularly in commercial grade silica sand product (99.8 %) and raw (in-situ) silica sand (97.1 %), indicates much of the material will not become readily airborne during material handling or due to wind erosion.

The relatively higher percentage of thoracic (PM_{10}) and respirable (PM_4) PM contained in the reject material indicates this material may become more readily airborne if allowed to dry out.

The respirable fraction of the bulk samples is used to evaluate the potential health risk associated with exposure to RCS.

Table 54: Particle Size Distribution

Sample	Size fraction (by aerodynamic diameter) volume percent				Analytical Report
	Non-inhalable	Inhalable, PM_{100}	Thoracic, PM_{10}	Respirable, PM_4	
Commercial grade silica sand product	99.8	0.2	0.1	0.03	Microanalysis Australia, 2021b
Raw (in-situ) silica sand	97.1	2.9	1.8	1.43	Microanalysis Australia, 2021c
Reject material	72.6	27.4	4.6	1.94	Microanalysis Australia, 2021d

Composition

Analytical testing of the commercial grade silica sand product, raw (in-situ) silica sand and reject material has been conducted to characterise the RCS content of these materials, to evaluate the potential public health risk to sensitive receptors from exposure to RCS in ambient air (i.e., excludes consideration of occupational health risk).

Bulk samples were collected by VRX and analysis for respirable (PM_4) silica content was undertaken by X-ray diffraction (XRD) and scanning electron microscope (SEM) using the modified size-weighted respirable fraction (SweRF) method (Pensis *et al,* 2014). The results are summarised in Table 55.

Table 55: Respirable Crystalline Silica Material Content

Description	Respirable (PM_4) of the bulk material (%wt)			Analytical Report
	α-Quartz	Crystobalite	Tridymite	
Commercial grade silica sand product	0.001	<0.001	<0.001	Microanalysis Australia, 2021b
Raw (in-situ) silica sand	0.103	<0.001	<0.001	Microanalysis Australia, 2021c
Reject material	0.290	<0.001	<0.001	Microanalysis Australia, 2021d

Assuming that PM_4 concentrations associated with dust emissions from the Proposal approached the relevant national air quality standards for PM_{10} (NEPC, 2021) at the surrounding sensitive receptor locations, which is highly unlikely (overly conservative), a screening-level assessment can be conducted that compares the estimated concentrations of RCS derived from the results of the bulk material content, to relevant ambient air assessment criteria for RCS sourced from the DWER (2019) and the Californian Office of Environmental health Hazard Assessment (OEHHA) (2005). This is summarised in Table 56.

Table 56: Respirable crystalline silica screening assessment

RCS Content (%wt)	Description	24-hour Average (µg/m³)		Annual Average (µg/m³)	
		PM_{10}	RCS	PM_{10}	RCS
< 0.290	Screening Concentrations	50	<0.15 [1]	25	<0.07 [2]
	Assessment Criteria		10 [3]		3 [4]
	% of Criteria	-	<1.4 %	-	<2.3 %

Notes:

1. *0.29 % of 50 µg/m³ = 0.15 µg/m³*
2. *0.29 % of 25 µg/m³ = 0.07 µg/m³*
3. *Acute exposure (24-hour average) assessment criteria for silica sourced from DWER (2019).*
4. *Chronic exposure (annual average) assessment criteria for RCS sources from OEHHA (2005).*

Despite the very conservative nature of such a screening assessment approach, the analysis shows that the estimated concentrations of RCS in ambient air at sensitive receptor locations is not expected to be equivalent to more than 2.3 % of the relevant assessment criteria. This confirms the in-situ content of RCS in the materials being handled is extremely low and does not present a potential public health risk to sensitive receptors from exposure to dust emissions from the Proposal.

10.5.2 Combustion Products

Emissions

The primary emission sources of combustion products (NOx, CO and SO_2) emitted from the Proposal include:

- Natural gas fired power station – CAT G3520E or similar gas engine; and
- Exhaust emissions from diesel industrial vehicles, comprised of:
  - FEL (x3) – CAT 988K or similar;
  - Water truck; and
  - Road trains.

Credible emission estimates have been derived for these emission sources, presented in Table 57. The manufacturer specification sheet for a representative gas engine (G3520E; Caterpillar, 2021) was used as the basis for the emission estimates for the power station. Projected diesel fuel consumption information was used as the basis for the emission estimates from vehicle exhausts. The methodology used to estimate emissions is outlined in further detail in Appendix 28.

Table 57: Emission estimates – combustion sources

Source	NOx	CO	SO_2
	kg/yr		
Power generation	160,660	370,483	492
FEL	45,043	12,826	29
Water truck	8,181	3,528	6
Road transport	14,038	5,357	11
Total	**227,923**	**392,193**	**537**

Emissions from the power station are the primary source of combustion products estimated for the Proposal, representing 70 % (NOx), 94 % (CO) and 92 % (SO_2) of total emissions on an annual basis. The significance of the emissions of combustion products from the Proposal has been evaluated using a screening model.

Screening Analysis

The screening air dispersion model, SCREEN3, has been applied as a conservative approach to the assessment of the significance of emissions of combustion products estimated for the Proposal. SCREEN3 is a USEPA screening model, which provides maximum predicted concentrations for a range of 'worst case' meteorological conditions. Screening models are often applied to determine if the potential air quality impacts from a source warrants more detailed (refined) air dispersion modelling.

The use of a screening model is preferred over the draft DWER (2019) screening analysis approach in this case to account for the distance to sensitive receptors, an important aspect of the Proposal.

The maximum predicted 1-hour average concentrations of NO_2, CO and SO_2 expected to occur at sensitive receptors located more than 3 km downwind of the Proposal, are summarised in Table 58. The maximum predicted concentrations were compared to relevant assessment criteria to provide an objective evaluation of the potential air quality impact of the Proposal.

Table 58: Screening model results

Pollutant	Avg. Time	Max. Concentration (µg/m³)			Downwind Distance (m)	Assessment Criteria		% of Criteria
		Power Station	Vehicle Exhaust	Combined Emissions		µg/m³ [1]	Reference	
NO_2 [2]	1-hour	29.1	0.3	29.4	3,000	151	NEPC (2021)	19 %
CO	1-hour	227	140	366	3,000	35,000	WHO (2021)	1 %
SO_2	1-hour	0.3	0.3	0.6	3,000	262	NEPC (2021)	0.2 %

Notes:
1. Referenced at ambient conditions (25°C, 101.3 kPa).
2. Empirically derived generic conversion factor (NOx to NO2) of 30 % has been applied (Katestone, 2017).

The screening model results show the maximum predicted concentrations are well below the relevant assessment criteria at a downwind distance of at least 3 km. As such, the emissions of combustion products from the Proposal are not considered to be significant in terms of their potential to cause adverse air quality impacts at the identified sensitive receptor locations. Detailed (refined) air dispersion modelling of combustion emissions from the Proposal was therefore not considered to be warranted.

10.5.3 Reduced Air Quality – Human Health

Respirable Crystalline Silica

The physical properties of silica sand (hardness, specific gravity) generally make it less susceptible to dust generation from particle attrition and wind erosion, however low porosity can act to reduce the effectiveness of wetting down of surfaces for dust abatement (ETA, 2021). Bulk materials testing of reject materials and raw and commercial grade silica sand, found that the PM_4 (respirable fraction) to be less than 0.29 % for any analyte (α-Quartz, Crystobalite or Tridymite).

ETA (2021) predicted that RCS concentrations would be less than 2.3 % of the acute or chronic exposure limit criteria when compared to the relevant ambient air assessment criteria for RCS at sensitive receptors (using a conservative assumption that the concentrations approached the national air quality standards for PM_{10} (NEPC, 2021)).

Based on ETA's (2021) conservative assessment, RCS emissions from the Proposal are not expected to have a significant impact on Air Quality.

Combustion Products

ETA (2021) applied the screening air dispersion model, SCREEN3, as a conservative approach to the assessment of the significance of emissions of estimated combustion products at the Proposal. ETA determined the maximum concentration of NO_x, CO or SO_x would be less than 20 % of the assessment criteria at any sensitive receptor. Combustion products from the Proposal are therefore considered unlikely to be significant in terms of their potential to cause adverse air quality impacts at the identified sensitive receptor locations. Detailed (refined) air dispersion modelling of combustion emissions from the Proposal was therefore not considered to be warranted.

Based on ETA's (2021) assessment, combustion products from the Proposal are not expected to have a significant impact on Air Quality.

10.6 Mitigation

VRX 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.

10.6.1 Avoid

No specific avoidance measures have been included as part of the Proposal, however VRX is committed to implementing renewable energy during the initial phase of the Proposal (from external sources). When implemented this will avoid or minimise the subsequent air emissions from the power station.

VRX has designed the Proposal to avoid impacts to Air quality. The primary avoidance measure of the Proposal is the location of the Processing Plant and power station. The Processing Plant and Power Station are both significant contributors to the overall air emissions of the Proposal. VRX has designed the Proposal to ensure that buffers between the Processing Plant and Power

Station, and the nearest sensitive receptors are maximised. As a result, the buffer distances are well beyond the EPA's recommended buffer distances for this industry type. Additionally, the relatively small size of the Proposal and limited operational footprint limits the limits the emissions.

10.6.2 MINIMISE

1. **Ensure buffers are incorporated into Proposal design**. VRX has designed the Proposal to minimise impacts to air quality. The primary avoidance measure is the location of the processing plant and power station, which are the two main contributors to the air emissions of the Proposal. VRX has designed the Proposal to ensure that buffers between these sites and the nearest sensitive receptors are maximised. As a result, the buffer distances are well beyond the EPA's recommended buffer distances for this industry type;
2. **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 MFP, slurry and return water pipeline, power station and Processing Plant. The MFP, Processing Plant and power station present high air quality 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 air quality. The Works Approval and Licence will ensure that the following mitigation measures are implemented at a minimum:
    a. Routinely inspect the condition and performance of gas generators, trommels, screens and dust suppressing systems, to ensure they are in acceptable condition and / or operating appropriately;
    b. The following controls will be implemented to minimise the risk of impact from air emissions:
        i. Routine air emissions (NO_x, SO_x and CO) monitoring will be conducted on site;
        ii. Energy generation will be regulated to meet demand;
        iii. Natural gas used for energy generation will be from a reputable supplier and be appropriate for the type of generator;
        iv. Routine dust monitoring (dust deposition and opportunistic dust observations) will be conducted;
        v. Dust suppressant systems (water cannons and sprayers) will be installed where required to minimise dust generation;
        vi. Silica will be processed wet;
        vii. Ore and product stockpiles will be kept wet;
        viii. Investigations will be conducted into the cause of any excessive air emissions;
3. **Obtain and comply with the other environmental approvals:**
    a. Ministerial Statement to be issued under Part IV of the EP Act; and
    b. MP to be approved under the Mining Act.
4. **Implement progressive mining and VDT methods.** Sequential block mining and VDT rehabilitation techniques – limits the annual mining footprint for the Proposal, such that the open areas susceptible to wind erosion are kept relatively small;
5. **Implement industry best practice management measures for air quality:**

a. Water or dust suppressants will be applied to disturbed areas, mining areas and product transfer/storage areas as required to minimise dust generation;
b. Vegetation clearing will be managed through internal ground disturbance procedures;
c. The disturbance footprint will be developed to the minimum required to ensure minimal disturbance;
d. Progressive clearing and rehabilitation will be undertaken using VDT;
e. Boundaries of areas to be cleared or disturbed will be identified by GPS coordinates and maps of boundaries will be provided to the dozer operator to minimise clearing;
f. Limit the number and height of stockpiles;
g. A conveyor will be used to transfer dry silica sand from the mine to the MFP. The transfer of material via conveyor is preferred to truck haulage, eliminating wheel generated dust generated with truck haulage on unsealed roads;
h. The moisture content of the reject material will be relatively high (~10 %) and will be stacked in a dewatering tailings stack. Tails will be taken offsite for sale in the local market;
i. A dedicated watering truck will operate at the site for wetting down the haulage road (unsealed section) and open areas susceptible to wind erosion;
j. The surface of the haul road will be regularly maintained to retain surface integrity;
k. Vehicle speeds will be limited on unsealed roads to minimise wheel generated dust;
l. Wet processes are used to upgrade raw sand to a commercial grade silica sand. There is no crushing or dry screening;

6. **Implement the Rehabilitation Strategy.** The Rehabilitation Strategy is provided in Appendix 4 and will be implemented during VDT;
7. **Explore and implement low/no emission power options.** VRX will continue to explore green energy options (solar and battery storage) to offset the power demand of the Proposal and minimise emissions;
8. **Utilise heavy haulage trucks along the haul road**. The private haul road allows VRX to run larger trucks between the mine and the Brand Highway. This improves the efficiency of the ore transport and reduces double handling, ultimately minimising emissions;
9. **Maximise electrical efficiency**. The following activities will be managed to maximise electrical efficiency, minimise power demand and therefore minimise 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 optimise efficiency;
    c. Regular electrical calibration checks on the processing equipment;
    d. Generators will be controlled to only satisfy power demand;
    e. Use of high efficiency electrical motors throughout the mine site; and
    f. Use of variable speed drive pumps, compressors and other processing equipment.
10. **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 to minimise diesel consumption;

b. Site and mine access will be designed to limit the amount of effort required for machinery and trucks (i.e., roads constructed with low gradient);
c. Haul roads will be compacted to reduce rolling resistance;
d. The 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 inspections and monitoring; and
f. Consideration of fuel efficiency of haul trucks will be undertaken during procurement.

10.6.3 Rehabilitate

Throughout the implementation of the Proposal the site will be progressively rehabilitated via VDT. This includes land-forming the site and replanting vegetation which will ensure wind-driven erosion is minimised. Once production has completed, emissions from product handling and processing will cease. A MCP will be prepared prior to construction in accordance with DMIRS Guidelines (2020a & b). The MCP will describe 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; and
- Completion criteria, monitoring and reporting during closure.

The key rehabilitation measures from the MCP that relate to air quality are summarised below:

1. The haul road will be rehabilitated with vegetation to reduce the potential for dust lift off;
2. The mining area will be progressively landformed and rehabilitated using VDT;
3. The mining area will be revegetated with local native species; and
4. All infrastructure will be decommissioned and removed.

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.

10.7 Predicted Outcome

The EPA's environmental objective for this factor is "to maintain air quality and minimise emissions so that environmental values are protected" (EPA, 2020c).

The Proposal has been designed to ensure that impacts arising from air emissions are avoided and minimised where possible. The location of the Proposal has been chosen so that a buffer, sufficient for the activities of the Proposal, is in place to ensure air quality at sensitive receptors is not significantly impacted. The Proposal activities have been optimised to keep product handling and energy requirements low, subsequently minimising emissions from combustion products.

To minimise dust emissions, the Proposal design includes a small operational footprint and a relatively low annual area of disturbance. Furthermore, mined areas are rehabilitated

progressively, limiting the total mined area at any given time. The silica sand upgrading process is predominately a wet process and the product is stored and hauls wet to minimise dust generation.

VRX commissioned ETA (2021) to conduct an air emissions desktop assessment to support the Proposal. The assessment considered the factors that influence air quality, specifically in relation to:

- Dust emissions from the various stages of Proposal development;
- Combustion emissions from the power station; and
- Vehicle exhaust emissions.

Based on ETA's assessment it is considered unlikely that the Proposal will have a significant impact on air quality. The nature and scale of the Proposal, and the separation distance to surrounding sensitive receptors far exceeds the EPA's minimum recommended buffer and adverse impacts to Air Quality are not expected to occur. By implementing the controls detailed in the section above, airborne dust generation can be maintained within acceptable levels.

Based on the above, VRX considers that the Proposal can be implemented such that there are no significant residual impacts to this factor, and the EPA objective can be met.

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.

VRX has engaged in rigorous planning, including the commissioning of numerous environmental surveys and studies for the Proposal. Assessment of these surveys and research has enabled VRX to make informed changes to the Proposal design to avoid and minimise significant impacts to the key environmental factors relevant to the Proposal. Changes were also made to avoid and minimise operational impacts, such as implementing VDT rehabilitation and targeting the deeper Yarragadee Aquifer for process water

The application of these avoidance mechanisms in Proposal design and operations has meant that impacts to key environmental values have been significantly reduced. VRX understands that this conclusion is in part based on studies, and as such monitoring has been committed to in order to verify the study outputs.

The WA Environmental Offsets Guidelines (EPA, 2014a) 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".

11.1 SUMMARY OF SIGNIFICANT RESIDUAL IMPACTS

The Proposal will disturb and progressively rehabilitate up to 339.3 ha of native vegetation which represents moderate to high value Carnaby's Cockatoo foraging habitat. An initial 14.5 ha of similar foraging habitat will be cleared for permanent infrastructure. Foraging habitat under rehabilitation will initially have no foraging value and for the purposes of offsets can be considered 'unavailable' to Carnaby's Cockatoo for foraging. After 10 years, foraging habitat subject to rehabilitation will become viable Carnaby's Cockatoo foraging habitat and can be considered 'available', but will be of a lower quality. VRX predicts that VDT can return the foraging value of native habitat to moderate (5 out of 10) value after ten years, a net reduction in foraging value from the pre-mining rating of 7 (BCE, 2022).

Mining is proposed to occur at a steady rate with 120 ha proposed to be disturbed in the first decade, 120 ha in the second and 99.5 ha in the third. This means that the area of foraging habitat that is not available will gradually increase over the first ten years, peaking at a maximum of 134.5 ha before reaching a general equilibrium (after ten years the area of rehabilitation that begins to return foraging values will grow at the same rate as new clearing). As an example, at year 30, a total of 219.5 ha of moderate to high value (7 out of 10) Carnaby's Cockatoo habitat would have

been mined and rehabilitated via VDT and infill planting (the remaining 134.5 ha will be unavailable). The WA Environmental Offsets Calculator (DWER, 2021b) calculates the significant residual impact of a Proposal by considering the significance of the impact to the target species and the benefit of any proposed rehabilitation. VRX will incorporate progressive rehabilitation and VDT (described above) which minimises the significant residual impact of the Proposal.

The significant residual impacts to Carnaby's Cockatoo have been calculated with the WA Environmental Offsets Calculator (DWER, 2021b; Appendix 32) and can be summarised as:

1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo). This loss represents a total quantum of impact of 10.15 ha. The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year rehabilitation period. A rehabilitation credit of 2.88 ha is applied and the significant residual impact is calculated as 7.27 ha; and

Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo). This loss represents a total quantum of impact of 237.51 ha. The rehabilitation is assumed to reach a foraging value of 5 out of 10 after this ten year period. Foraging value may increase in subsequent years. A rehabilitation credit of 96.37 ha is applied and the significant residual impact is calculated as 141.14 ha.

The residual significant impact used in the EPBC Act calculator should be determined after application of the mitigation hierarchy but prior to the consideration of benefits from progressive rehabilitation. Therefore, for the EPBC Act calculator, the residual significant impact to Carnaby's Cockatoo is the quantum of impact to foraging habitat as a result of the Proposal. The residual significant impact includes a loss of up to 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat for the life of the Proposal.

Application of the WA Environmental Offsets Calculator to determine significant residual impacts of the Proposal and the suitability of the proposed offset are discussed further in Section 11.3. Application of the EPBC Act Offsets Calculator to determine the suitability of the proposed offsets are discussed further in Section 11.6.2.

VRX has assessed the residual impacts of the Proposal against the residual impact significance model provided in the WA Environmental Offsets Guidelines (EPA, 2014a). The findings of this assessment is provided in Table 59.

As described in Table 59, the Proposal will affect habitat utilised by Threatened Fauna and therefore the significance of the residual impacts on these habitats was assessed to determine whether these impacts would be considered 'significant residual impacts'. Direct impacts on fauna are necessarily generally based on assessment of impacts to habitat. Based on the findings of the EIA in this ERD, VRX considers that the proposed disturbance of moderate to high value Carnaby's Cockatoo foraging habitat is considered significant and will require offsets.

Table 59: Assessment against residual impact significance 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*	No residual impacts are considered to meet this criteria: • No Threatened Flora records are located within the survey areas • Impacts to Priority Flora are not considered significant	No residual impacts are considered to meet this criteria – no TECs were recorded within the development envelopes	No residual impacts are considered to meet this criteria	No residual impacts are considered to meet this criteria as no wetlands or waterways that are protected by statute lie within the development envelopes 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 development envelopes or would be indirectly impacted by the Proposal	No residual impacts are considered to meet this criteria, the Kwongan Heath vegetation is known to have high diversity however the residual impacts on these areas are not considered significant given the area of intact habitat that will remain outside the development envelopes	Residual impacts to Carnaby's Cockatoo foraging habitat are considered likely to meet this criteria. The significant residual impact to Carnaby's Cockatoo include a loss of up to 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat for the life of the Proposal. Indirect impacts include: • Increased predation or competition from introduced fauna. • Alterations to behaviour (including feeding or breeding characteristics) as a result of elevated dust, light or noise emissions. • Reduction in habitat health as a result of: ○ Alterations to fire regimes ○ Burying as a result of unintentional discharge of sand slurry from surface pipelines ○ Establishment or spread of weed species / populations. ○ Hydrocarbon spills ○ Introduction or spread of dieback
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*	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	No residual impacts are considered to meet this criteria – refer above	No other residual impacts are considered to meet this criteria – refer above
Residual impacts that are not significant	No Threatened Flora listed under the EPBC Act or BC Act were recorded in the development envelopes. The Proposal will result in clearing of up to 14.5 ha of vegetation for the life of the Proposal and up to 339.3 ha of remnant vegetation clearing and progressive rehabilitation via VDT.	No other residual impacts are considered to meet this criteria – refer above	Clearing of up to 14.5 ha of remnant vegetation for the life of the Proposal and up to 339.3 ha of remnant vegetation clearing and progressive rehabilitation via VDT. All remaining vegetation have 65 % or more of their pre-European extent remaining and impacts will be less than 0.45 % of any vegetation association therefore residual	No other residual impacts are considered to meet this criteria – refer above	No other residual impacts are considered to meet this criteria – refer above	Clearing of up to 14.5 ha of vegetation for the life of the Proposal and up to 339.3 ha of vegetation clearing and progressive rehabilitation via VDT. The Kwongan Heath vegetation is known to have high diversity however the residual impacts on these areas are not considered significant given the area of intact	The Proposal will result in clearing of up to 14.5 ha of vegetation for the life of the Proposal and up to 339.3 ha of remnant vegetation clearing and progressive rehabilitation via VDT. This vegetation is representative of habitat for threatened fauna (other than Carnaby's Cockatoo) including:

	Seven Priority species were recorded within the development envelopes. The distribution of these species is shown in Figure 26 - Figure 28. Of these, four are predicted to have more than 5 % of the recorded individuals within the disturbance footprint. Impacts to these species includes: 1. 1,277 *Banksia elegans* (P4) individuals (37.6% of survey records); 2. 30 *Comesperma rhadinocarpum* (P3) individuals (50.85% of survey records); 3. 98 *Hemiandra sp. Eneabba* (H. Demarz 3687) (P3) individuals (42.4% of survey records); and 4. 167 *Schoenus sp. Eneabba* (F. Obbens & C. Godden I154) (P2) individuals (35.67% of survey records). Based on the individual assessments of these species in Section 5.5.2 the Proposal is unlikely to significantly impact the local or regional extent of this species. In summary, no significant residual impacts to significant flora are anticipated as a result of the Proposal and, as such, offsets are not proposed. Potential impacts to significant flora (Priority flora species) will be avoided and minimised through implementation of the Final Infrastructure Design Plan.		impacts from clearing are not significant.			habitat that will remain outside the development envelopes.	• *Lieopa ocellata* (Vulnerable); and • *Apus pacificus* (Marine; Migratory). Based on the individual assessments of these species in Section 12.4 the Proposal is unlikely to significantly impact these species. Fauna habitats in the Proposal area are well represented locally and regionally and do not support species that are considered restricted to the area.

11.2 DETAILS OF PROPOSED OFFSET

To counterbalance the significant residual impacts of the Proposal, VRX proposes to designate a 1,367.1 ha portion of their Arrowsmith North Mining Lease (M 70/1389) for use as an Offset Area. This area generally lies to the north of the Mine Development Envelope and aligns with the boundary of M 70/1389 (excludes the development envelopes; Figure 88). The Offset Area contains large areas of native vegetation in Excellent to Pristine condition that is representative moderate to high value Carnaby's Cockatoo foraging habitat.

A draft Offset Strategy has been developed and provided in Appendix 29 that provides details of the proposed offset. This section summarises the content provided in the draft Offset Strategy.

11.2.1 VALUES AND QUALITY OF OFFSET SITE

Vegetation condition

The condition of the vegetation within the Offset Area ranges from Pristine to Excellent, with the majority of the area considered Pristine (96.5 %) according to the Keighery (1994) scale. Some areas (3.5 %) on the western part of the Offset Area, near tracks, were downgraded to Excellent. Vegetation condition of the Offset Area is shown in Figure 33.

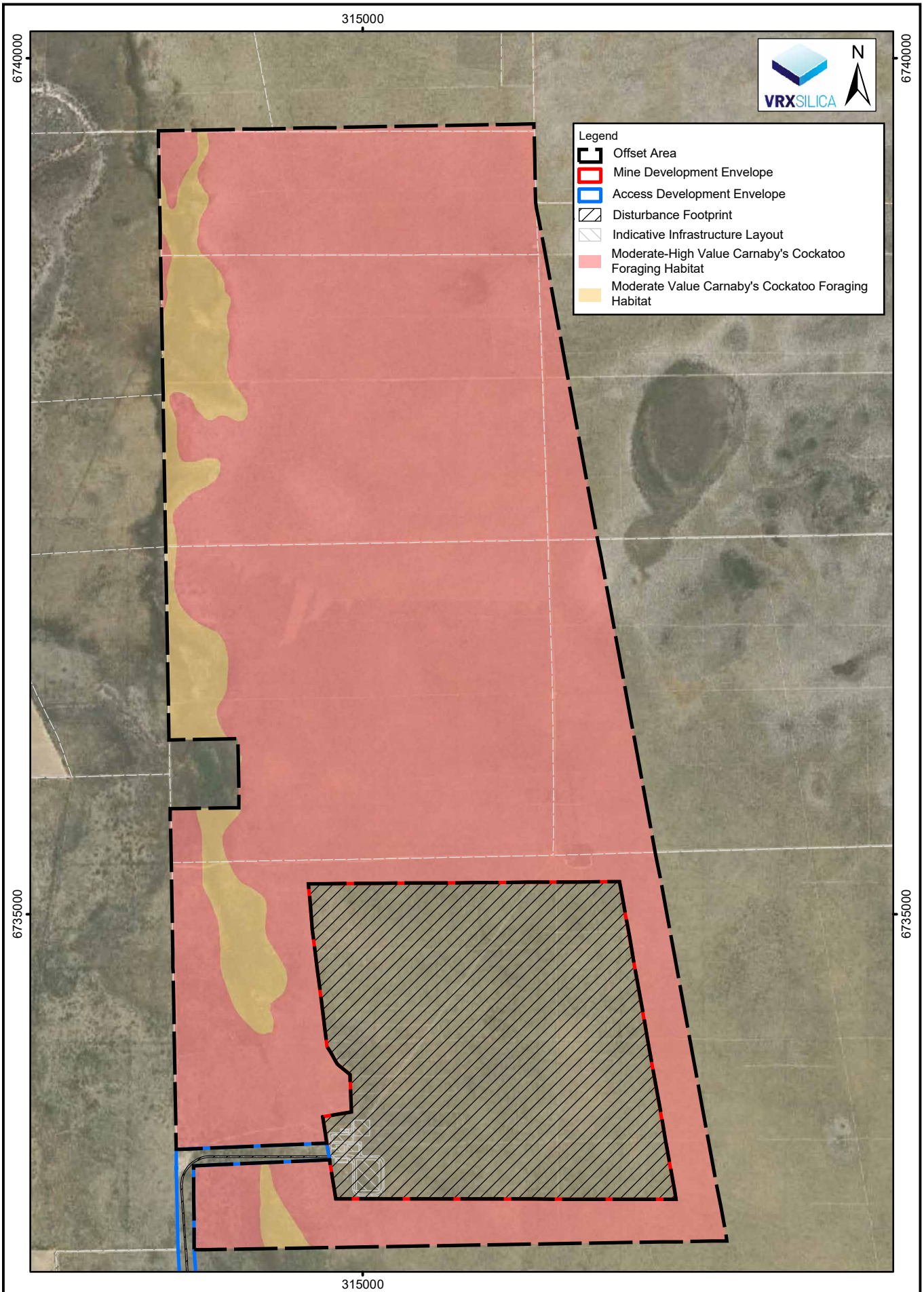
Foraging Value

The Offset Area is comprised entirely of native vegetation that represents foraging habitat for Carnaby's Cockatoo. BCE (2022) combined broad vegetation types, the soils or other substrates with which they are associated and the landform to define VSAs. The Offset Area is comprised of 1,152.2 ha of VSA1, 119.5 ha of VSA2 and 95.4 ha in VSA3. Both VSA1 and VSA3 (1,247.6 ha) are identified as Moderate to High value foraging habitat for Carnaby's Cockatoo, VSA2 is considered moderate value (foraging habitat is discussed further in Section 6.3.6). The extent of Carnaby's Cockatoo foraging habitat within the Offset Area is shown in Figure 88.

11.2.2 MANAGEMENT OF OFFSET SITE

VRX proposed to protect and maintain Carnaby's Cockatoo foraging habitat as an offset for the residual impacts of the Proposal. Offsets include protection and maintenance activities to maintain (and potentially improve) the condition of the native vegetation and reduce the threats to Carnaby's Cockatoos within the Offset Area. Protection and maintenance activities include but are not limited to:

1. Demarcation of the Offset Area;
2. Access restrictions into the area to minimise damage from off-road vehicles;
3. Erection of signs to identify the boundaries of the Offset Area;
4. Regular monitoring for signs of weed propagation, spread of dieback and changes in vegetation condition and foraging value;
5. Removal / treatment of weeds and treatment of dieback affected areas (if present);
6. Implementing the DMP (Appendix 13);
7. Regular monitoring for signs of feral animals (including Fox, Cat, Dog, Pig, Rabbit);
8. Feral animal trapping and management with a particular focus on Foxes and Cats; and
9. Consistent with Section 8.6.2, develop and implement a Ranger Program.



Source: Aerial Photography: LESRI, DigitalGlobe, Maxar (March 2019), Tenements: DMIRS

0 500 m
Scale: 1:30,000
MGA94 (Zone 50)

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Date: July 2022 | Rev: D | A4

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Arrowsmith North Project
Offset Area

Figure: 88

Figure 88: Offset Area and Carnaby's Cockatoo foraging habitat

Implementation of the management mechanisms listed above is expected to protect the Offset Area from any impacts that may lower the foraging value to Carnaby's Cockatoo and ensure that extensive areas of moderate and moderate to high foraging value is available for a minimum of 30 years. The protection mechanisms listed above may have the added benefit of reducing predator numbers and improving the quality of foraging habitat.

11.2.3 Protection of Offset Site

The proposed offset site lies entirely within M 70/1389 (excluding the area within the development envelopes), a lease held by VRX under the Mining Act. The area has been drilled and confirmed to contain large deposits of silica sand, with predictions of nearly 100 years of available silica sand at Arrowsmith North. VRX intends to gradually mine the area after the completion of this Proposal (i.e., from approximately Year 30 onwards). Prior to this occurring however, the area is available for use as a long-term preservation area (i.e., for at least 30 years) and it is likely that some areas could remain relatively untouched for nearly 100 years. For the purposes of this assessment a 30-year timeframe has been assumed.

The presence of silica sand in this portion of M 70/1389 means that VRX will have justification to hold and renew the tenement for the life of the Proposal. Exploration for other minerals within the tenement has not returned any results, therefore silica sand is likely to remain as the only marketable product within the tenement.

VRX acknowledges that there may be minor disturbances associated with linear infrastructure (powerlines, roads, pipelines etc.) that could occur in the 30-year timeframe however this has been accounted for in the offset calculations.

11.2.4 Justification of Offset Site

VRX are aware that the proposed offset is unique and differs from typical land acquisition offsets usually proposed for Carnaby's Cockatoo offsets. It was chosen given the unique scenario that the Proposal presents:

1. The Proposal clearing occurs at a very slow rate, meaning that clearing is not conducted all at once like many other mining operations;
2. Given the slow rate of mining the offset area is predicted to remain uncleared for a **minimum** of 30 years, with most of the area likely to remain uncleared for up to 100 years based on future mine plans. It is not planned to clear the area as soon as the 30-year period is complete;
3. The foraging habitat within the offset area is habitat that likely will never be able to be added to conservation estate given the silica sand resource it contains;
4. Given the resource, the land would otherwise be at significant risk of disturbance during the life of the Proposal;
5. The land does not contain any other resources other than silica sand, therefore it is not at risk of being mined for another resource;
6. VRX's commitment to preserve and manage the offset area for at least 30 years provides a conservation outcome over an area that would not normally be protected or actively managed;
7. The Proposal is for 30 years of resource, therefore at the end of the life of the Proposal there will be almost 30 years of VDT rehabilitation that has occurred at the Proposal, and

VRX (and Government) will have actual site-specific data on the success of the re-establishment of Carnaby's foraging species. This data will be critical in determining if mining can continue on the Mining Lease, i.e., if VDT is not shown to be highly successful then approval will be difficult to obtain. The success of the rehabilitation is therefore critical for VRX. If mining is to continue after the 30-year period (subject to separate approvals) there will be approximately 300 ha of established rehabilitated foraging habitat at the Proposal at that stage.

VRX considers that the proposed offset presents an opportunity to provide long-term protection and management of a large continuous area of moderate to high value Carnaby's Cockatoo foraging habitat that would otherwise be unlikely to be able to be protected. This opportunity is likely to provide better outcomes for Carnaby's Cockatoo than the purchase of lower quality smaller sites.

The proposed offset is a significant commitment by VRX as it will have the following implications:

- VRX will not be able to mine the offset area during the 30 year period;
- VRX will not be able to on-sell the offset area to another silica sand miner during the 30 year period; and
- VRX will be responsible for funding the ongoing management of the offset site for the entire 30-year period.

11.2.5 Summary Table

Table 60 describes the measures proposed to offset the residual impacts to moderate to high value Carnaby's Cockatoo foraging habitat.

Table 60: Proposed terrestrial fauna offsets

Objective & intended outcome	Offset actions	Details	Success criteria	Governance / Responsibilities	Timing	Risks and contingency measures	Monitoring	Reporting
To counterbalance the significant residual impacts to 14.5 ha of Carnaby's Cockatoo foraging habitat for the life of the Proposal	Protect and maintain an estimated 1,247.6 ha of moderate to high and 119.5 ha of moderate value Carnaby's Cockatoo foraging habitat within the Offset Area	14.5 ha of foraging habitat will be cleared for the life of the Proposal and rehabilitated at closure. It is expected that lessons learned from the mining and progressive rehabilitation will allow VRX to achieve effective rehabilitation (up to a value of 5/10) within 10 years using conventional methods (respreading topsoil and infill planting of select species). VRX is proposing to use a long-term land conservation offset to offset the significant residual impact to 14.5 ha of foraging habitat directly by protecting and maintaining moderate to high quality Carnaby's Cockatoo foraging habitat for the life of the Proposal. VRX will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 11.2.2. The offset would adequately offset the foraging habitat impacts associated with the loss of availability of 14.5 ha of foraging habitat (Section 11.4). VRX intends to commission experienced contractors to complete the work with direction and advice from VRX ecological consultants. The Offset Area has been assessed against the total residual impact of the Proposal using the WA Environmental Offsets Calculator and the EPBC Act Offsets Calculator and exceeds the minimum offset criteria within DSEWPaC (2012a; Appendix 31) and DWER (2021b; Appendix 32).	1,247.6 ha of moderate to high value (average value of at least 7/10) and 119.5 ha of moderate value (average value of 4/10) Carnaby's Cockatoo foraging habitat protected and maintained that would exceed the minimum offset criteria (DSEWPaC, 2012a; DWER, 2021b). Initial and ongoing management works are completed in accordance with Section 11.2.2. Carnaby's Cockatoo foraging habitat values are maintained or improved.	VRX: • Preservation of offset site • Funding of upfront and ongoing management costs for 30 years • Ultimate responsibility for the conservation of the environmental values of the offset site Environment Manager: • Overseeing the monitoring, management and reporting on the status of environmental values of the offset site Site Manager: • Onsite implementation of the Protection Mechanisms Technical Officers: • Carrying out routine monitoring and management of the Offset Site	Offset established and initial management costs provided within 12 months of implementation of the Proposal. Ongoing management provided for a minimum 30 years.	Dieback: • Implement DMP; • Restriction of access • Education of contractors carrying out firebreak and fencing maintenance • Application of Phosphite to affected vegetation (or other methods in consultation with DBCA) Weeds: • Targeted control of high impact weed species that may be present or may become established • Weed hygiene controls during works Grazing and feral animals: • Monitor current use • Targeted control of high impact feral animal species if required Unauthorised access (rubbish dumping, timber cutting, 4WD): • Installation of fences where appropriate around the vegetation to restrict all off-road vehicle access (including bikes)	Annual monitoring to confirm foraging values are being protected. Annual monitoring of foraging use of the site Carnaby's Cockatoo. Weed, dieback, boundary and firebreak monitoring / inspections every three months (i.e., weed infestations, feral animal use, fence lines, firebreaks, dieback)	Initial report of management actions completed prior to implementation. Annual report of management actions and monitoring results.
To counterbalance the significant residual impacts of clearing and progressive VDT rehabilitation of 339.3 ha of moderate to high value Carnaby's Cockatoo. It is expected that this will result in a reduction in foraging value from 7 /10 to 5/10.		VRX expects to obtain significant knowledge of rehabilitation during the first years of the Proposal. This knowledge will be used to determine the most effective revegetation methods for Carnaby's Cockatoo foraging habitat. VRX has nominated a conservative revegetation value of 5/10 based on advice within Bamford (2020), which stated values between 2 and 6 could be achieved. Over the life of the Proposal 219.5 ha of foraging habitat will be rehabilitated via VDT. VDT will reinstate some foraging values but overall will reduce the foraging value	As above	As above	As above	As above	As above

Objective & intended outcome	Offset actions	Details	Success criteria	Governance / Responsibilities	Timing	Risks and contingency measures	Monitoring	Reporting
		to Carnaby's Cockatoo by 2 (7/10 to 5/10). VRX is proposing to use a long-term land conservation offset to offset the significant residual impact to 339.3 ha of foraging habitat directly by protecting and maintaining an estimated 1,247.6 ha of moderate to high and 119.5 ha of moderate quality Carnaby's Cockatoo foraging habitat for the life of the Proposal. VRX will manage and pay costs for the maintenance and protection of the proposed offset commensurate with the protection mechanisms in Section 11.2.2. The Offset Area has been assessed against the total residual impact of the Proposal using the WA Environmental Offsets Calculator and the EPBC Act Offsets Calculator and exceeds the minimum offset criteria within DSEWPaC (2012a; Appendix 31) and DWER (2021b; Appendix 32).						

11.3 WA Offsets Template

VRX has completed a WA Offsets Template as per the requirements of the WA Environmental Offsets Guideline (EPA, 2014a), provided in Table 61.

Table 61: WA offsets policy template

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
General flora and vegetation – Up to 14.5 ha of native vegetation clearing and up to 339.3 ha of native vegetation rehabilitation via VDT Reduction in vegetation health due to indirect impacts	**Avoid** Development envelopes were revised to avoid: • Four of the 11 Priority Flora species recorded within the Survey Area (refer to Section 5.5.2); and • The north-south drainage line and associated riparian vegetation along the western boundary of the Study Area **Minimise** • Implement industry best practice management measures for flora and vegetation • Implement the Rehabilitation Strategy • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the values are either predicted to be retained during the VDT process or can be included in direct seeding / planting with VDT rehabilitation areas. **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia spp.*, *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region **Time lag?** Up to two years for some species depending on rainfall events, up to ten years for some deeper rooted species to become fully established	No				

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
			Credibility of the rehabilitation proposed (evidence of demonstrated success) Credible, VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2).						
Priority Flora – Disturbance of: • 1277 *Banksia elegans* (P4) individuals • 30 *Comesperma rhadinocarpum* (P3) individuals • 98 *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) individuals • 11 known *Hypocalymma gardneri* (P3) individuals • 1 known *Schoenus griffinianus* (P4) individuals • 167 *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) individuals • 6 *Stawellia dimorphantha* (P4) individuals • Other potential species that may be present	**Avoid** Development envelopes were revised to avoid: • 62.4 % of *Banksia elegans* (P4) individuals • 49.15 % of *Comesperma rhadinocarpum* (P3) individuals • 57.6 % of *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) individuals • 64.3 % of *Schoenus* sp. Eneabba (F. Obbens & C. Godden I154) (P2) individuals • >95 % of *Hypocalymma gardneri* (P3), *Schoenus griffinianus* (P4) and *Stawellia dimorphantha* (P4) individuals **Minimise** • Implement industry best practice management measures for flora and vegetation • Conduct additional significant flora searches of final disturbance footprints • Ensure impacts to Priority Flora within the Access and Mine Development Envelope do not exceed those predicted in Section 5.5.2 • Prepare a SFMP • Implement the Rehabilitation Strategy • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the values are either predicted to be retained during the VDT process or can be included in direct seeding / planting with VDT rehabilitation areas. **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia spp.*, *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region. **Time lag?** Up to two years depending on rainfall events **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2).	No				
General fauna species and habitat – Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal Up to 399.5 ha of habitat rehabilitation via VDT Potential death or injury of fauna from vehicle strike or entrapment Some indirect impacts to fauna habitat health and fauna behavioural impacts	**Avoid** VRX has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid almost all of the constrained VSA2 (Dense riparian thickets). The Proposal utilises previously cleared areas where possible such as utilising existing tracks for access. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Prepare and implement FMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the habitat values are either predicted to be retained during the VDT process or can be improved by direct seeding / planting within VDT rehabilitation areas **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia* spp., *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region. **Time lag?** Up to two years depending on rainfall events	No				

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
	• Comply with Water Quality Protection Guidelines and guidance notes		**Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2).						
SRE Fauna – 9 potential SRE fauna (including one Priority 1 SRE *Idiosoma kwongan*) have been recorded within the development envelopes. Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal Up to 339.5 ha of habitat rehabilitation via VDT Potential death or injury of fauna from vehicle strike or entrapment Some indirect impacts to fauna habitat health and fauna behavioural impacts	**Avoid** VRX has conducted numerous ecological surveys and this information has been utilised to design the Proposal and its development envelope boundaries to avoid almost all of the constrained VSA2 (Dense riparian thickets). The Proposal utilises previously cleared areas where possible such as utilising existing tracks for access. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Ensure no confirmed SREs are restricted to the disturbance footprint. • Prepare and implement FMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills Comply with Water Quality Protection Guidelines and guidance notes	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the habitat values are either predicted to be retained during the VDT process or can be improved by direct seeding / planting within VDT rehabilitation areas **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia* spp., *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region. **Time lag?** Up to two years depending on rainfall events **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2).	No				
Malleefowl and potential habitat – Up to 14.5 ha of fauna habitat clearing to remain cleared for the life of the Proposal Up to 339.3 ha of habitat rehabilitation via VDT Potential death or injury from vehicle strike or entrapment Some indirect impacts to habitat health and behavioural impacts	**Avoid** The Proposal also utilises previously cleared areas where possible, such as locating the solar farm completely on cleared land, and utilising existing tracks for the western access corridor option. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Prepare and implement FMP • Conduct pre-clearance Malleefowl mound searches • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the habitat values are either predicted to be retained during the VDT process or can be improved by direct seeding / planting within VDT rehabilitation areas **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia spp.*, *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region **Time lag?** Up to two years depending on rainfall events for most species, up to ten years for deeper-rooted species **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Credible, VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2) however infill planting is expected to be required.	No				

Existing Environment / Impact	Mitigation			Significant Residual Impact	Offset Calculation Methodology				
	Avoid and Minimise	Rehabilitation Type	Likely Rehabilitation Success		Type	Risk	Likely Offset Success	Time Lag	Offset Quantification
Carnaby's Cockatoo foraging habitat – Up to 14.5 ha of medium to high value foraging habitat clearing to remain cleared for the life of the Proposal Disturbance and progressive VDT rehabilitation of up to 339.3 ha of moderate to high value foraging habitat Some indirect impacts to habitat health and behavioural impacts	**Avoid** The Proposal also utilises previously cleared areas where possible, such as locating the solar farm completely on cleared land, and utilising existing tracks for the western access corridor option. **Minimise** • Implement industry best practice management measures for terrestrial fauna • Implement the Rehabilitation Strategy • Prepare and implement FMP • Implement preventive measures to minimise the risk and impact of hydrocarbon spills • Comply with Water Quality Protection Guidelines and guidance notes	339.3 ha of progressive VDT rehabilitation 14.5 ha of traditional mine rehabilitation – vegetation to be rehabilitated with stripped topsoil and seeded with impacted species if required and suitable	**Can the environmental values be rehabilitated / Evidence?** Yes, the foraging habitat values are predicted to be rehabilitated by direct seeding / planting within VDT rehabilitation areas **Operator experience in undertaking rehabilitation?** VRX is conducting VDT trials and will use information gathered to refine rehabilitation methods. VRX will utilise experienced operators trained in VDT rehabilitation to conduct the rehabilitation works, and given progressive rehabilitation is proposed this experience will improve further over the life of the Proposal **What is the type of vegetation being rehabilitated?** Predominantly Kwongan heath defined by Beard (1976) as: Shrublands; scrub-heath with scattered *Banksia* spp., *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats in the Geraldton Sandplain Region **Time lag?** Up to ten years for deeper-rooted foraging species **Credibility of the rehabilitation proposed (evidence of demonstrated success)** Some limitations have been noted with Banksia revegetation conducted in mine rehabilitation to-date. VDT has been trialled and evidence of demonstrated success is provided in Mattiske (2019a; Appendix 2).	Yes	Protection and maintenance of an estimated 1,247.6 ha of moderate to high value (minimum average value of 7 out of 10) Carnaby's Cockatoo habitat	Low – VRX has identified sufficient foraging habitat within M 70/1398 suitable as an offset.	<u>Can the values be defined and measured?</u> Yes – value to species can be measured <u>Operator experience/Evidence?</u> VRX will manage the land or will utilise an experienced land management contractor <u>What is the type of vegetation being revegetated?</u> None – VRX is protecting and maintaining existing Kwongan heath.	Protects and maintains critical habitat upon agreement – no time delay	Offset would ensure protection and maintenance of moderate and moderate to high value foraging habitat, which based on the WA Offset Calculator (DWER, 2021b; Appendix 32) is considered to be suitable to offset the foraging habitat impacts associated with the long term impact to 14.5 ha and availability of 120 ha of foraging habitat. This is considered adequate by DCCEEW and satisfies the minimum 90% offset criteria within DSEWPaC (2012a; Appendix 31)
					Protection and maintenance of an estimated 119.5 ha of moderate value (minimum average value of 7 out of 10) Carnaby's Cockatoo habitat	Low – VRX has identified sufficient foraging habitat within M 70/1398 suitable as an offset.	<u>Can the values be defined and measured?</u> Yes – value to species can be measured <u>Operator experience/Evidence?</u> VRX will manage the land or will utilise an experienced land management contractor <u>What is the type of vegetation being revegetated?</u> None – VRX is protecting and maintaining existing Kwongan heath.	Protects and maintains critical habitat upon agreement – no time delay	Offset would ensure protection and maintenance of moderate to high value foraging habitat, which based on the WA Offset Calculator (DWER, 2021b; Appendix 32) is considered to be suitable to offset the reduction in value of foraging habitat associated with 219.5 ha of rehabilitation via VDT. This is considered adequate by DCCEEW and satisfies the minimum 90 % offset criteria within DSEWPaC (2012a; Appendix 31)

11.4 ASSESSMENT AGAINST WA OFFSETS CALCULATOR

VRX proposes to offset the significant residual impact of the Proposal on Carnaby's Cockatoo foraging habitat by protecting and maintaining suitable areas of moderate to high and moderate value Carnaby's Cockatoo foraging habitat within the Offset Area (Figure 88).

The Offset Area is comprised of 119.5 ha of moderate and 1,247.6 ha of moderate to high value Carnaby's Cockatoo foraging habitat, VRX proposes to protect and maintain the entire Offset Area to satisfy the offset requirements detailed above, with the exception of any minor disturbances that may be required in the future for infrastructure such as powerlines, roads and pipelines (noting none are currently planned). These minor disturbances have been accounted for in the calculations.

The WA Offsets Calculator (DWER, 2021b; Appendix 32) has been used to quantify the area of foraging habitat required to be protected to offset the significant residual impact of the Proposal. The proposed offset has been evaluated to ensure it meets the minimum requirements of the Calculator. The assessment was run in two separate calculations:

1. **Offset 14.5 ha of clearing of foraging habitat for the life of the Proposal.** The value of the cleared foraging habitat is 7/10 therefore the total quantum of impact is 10.15 ha. The calculation includes rehabilitation of the cleared land by respreading topsoil and direct seeding at mine closure. Rehabilitation was calculated to provide a credit of 2.88 ha, therefore the significant residual impact of this clearing is 7.27 ha. A minimum of 24.42 ha of moderate to high value habitat is required to offset this significant residual impact;
2. **Offset 339.3 ha of clearing and progressive VDT rehabilitation.** The value of this cleared habitat is 7/10 therefore the total quantum of impact is 237.51 ha. Rehabilitation via VDT and infill planting was calculated to provide a credit of 96.37 ha, therefore the significant residual impact of this clearing is 141.14 ha. A minimum of 473.98 ha of moderate to high value habitat is required to offset the significant residual impact.

The values used in the calculator, and the justification for the value is provided in Table 62. Appendix 32 contains copies of these calculators for reference.

Table 62: Criteria used in WA Offsets Calculator

Criteria	Value used	Justification / Rationale
Quality of impacted area	Moderate to High Value (7/10) for Carnaby's Cockatoo foraging habitat	The Proposal will require clearing of native vegetation that represents Moderate to high value Carnaby's Cockatoo habitat as described by BCE (2022).
Quality of rehabilitation site	0/10	Site would have recently been cleared to implement the Proposal
Future quality of rehabilitation site without rehabilitation	1/10	It is possible for the site to regrow naturally to some extent – however it is not expected to provide any significant foraging value in the near-medium term.
Future quality of rehabilitation site with rehabilitation	5/10	As described by Bamford (2020). VRX acknowledges that rehabilitation of Carnaby's Cockatoo foraging habitat is difficult however VRX proposes to undertake rehabilitation by VDT and infill planting. VDT has been identified as being the best rehabilitation method for the Proposal (discussed further in Section 5.7). The Proposal has a 30 year mine life, progressive implementation of rehabilitation will provide VRX with opportunities to refine the VDT and infill

Criteria	Value used	Justification / Rationale
		planting methodology. For these reasons it is expected that rehabilitation of the Proposal will be successful, nevertheless VRX has chosen to take a conservative approach and predicts a value lower than the maximum provided in Bamford (2020).
Time until ecological benefit	10 years	Vegetation is expected to represent foraging habitat 10 years after rehabilitation works are completed (Bamford, 2020).
Confidence in rehabilitation result	80%	VRX has given this a high confidence as the target quality is relatively low (i.e., 80% confidence of achieving only 5/10). VDT trials have been conducted and an assessment of the VDT methodology in the context of the Proposal has been provided (Mattiske, 2019a, 2020a). A rehabilitation Strategy has been prepared by VRX and will be updated as new site specific information on rehabilitation and VDT is learned.
Quality of offset area	Moderate to High Value (7/10) Carnaby's Cockatoo foraging habitat	As described by BCE (2022).
Future quality of offset site without offset	6/10	VRX has assumed that no development will occur within the area and the reduction in value presented here is the result of incidental anthropogenic activities. If development was to occur, the future quality would be significantly less.
Future quality of offset site with offset	7/10	Active, on ground protection of the proposed offset site will maintain the value of native vegetation.
Time until ecological benefit	1 year	VRX is the sole lease holder of the proposed offset site and is able to protect the area from development immediately. 1 year is the lowest value available, but VRX intends to protect and maintain the offset from the commencement date of the Proposal.
Confidence in offset result	90%	Predicted changes in quality are conservative therefore confidence is relatively high
Duration of offset	20 years	20 years is the highest value available. VRX proposes to preserve and maintain the offset site for a minimum of 30 years
Time until offset site secured	0 year	VRX is the sole lease holder and intends to protect and maintain the offset from the commencement date of the Proposal
Risk of future loss of the offset site if offset was not in place	80%	20 year timeframe was used as per the duration of the offset listed above. The offset site overlies a significant mineral resource therefore there is a high likelihood that it would be developed if protection for an offset is not implemented.
Risk of future loss of the offset site if offset is in place	40%	20 year timeframe was used as per the duration of the offset listed above. The offset site will be protected from development therefore future loss is avoided. VRX acknowledges that this offset type is not the equivalent of a conservation covenant and therefore a conservative estimate of 40% risk of future loss has been applied.

Based on the calculations, VRX is required to offset the significant residual impact with a minimum of 498.4 ha of moderate to high value Carnaby's Cockatoo foraging habitat. The proposed Offset Area contains a total of 1,367.1 ha of foraging habitat (comprised of 119.5 ha of moderate and 1,247.6 ha of moderate to high value habitat). The proposed offset is deemed suitable to offset the significant residual impact of the Proposal on Carnaby's Cockatoo foraging habitat as, at a minimum, the moderate to high component exceeds the minimum required offset by 749.2 ha (approximately 2.5 times the required offset area).

VRX acknowledges that there may be minor disturbances within the Offset Area associated with linear infrastructure (powerlines, roads, pipelines etc.) that could occur in the 30-year timeframe however this has been accounted for in the offset calculations, with the available area significantly exceeding the minimum requirement.

11.5 Assessment against Environmental Offsets 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 (EPA, 2011). The Proposal and proposed offset have been assessed against each of these principles, provided in Table 63.

Table 63: 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.	VRX has applied the mitigation hierarchy by identifying measures to avoid, minimise and rehabilitate. VRX's main action to meet this policy's requirements was site selection and design, which avoided development in areas of native vegetation with potential Carnaby's Cockatoo breeding sites, and reduce the development envelope to the smallest size possible.
2	Environmental offsets are not appropriate for all projects.	It is acknowledged that offsets are not appropriate for all projects. As the Proposal will result in significant residual impacts due to impact on a threatened / protected fauna species, an offset is considered to be appropriate.
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 initial retention and conservation of existing remnant vegetation, in close proximity to the Proposal, meaning that much of the same equipment and personnel could be used for management. Potential Carnaby's Cockatoo foraging habitat is proposed to be cleared during the implementation of the Proposal. The proposed Offset Area contains correlating Carnaby's Cockatoo foraging habitat values that represent those that will be lost during the implementation of the Proposal. 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 are aligned with the Carnaby's Cockatoo Recovery Plan (DPaW, 2013a). The protection and maintenance of the Offset Area will ensure its protection from development, and that it is managed to maintain its natural values for at least 30 years.
5	Environmental offsets will be applied within a framework of adaptive management.	The proposed Offset Area will provide significant opportunities within the framework of adaptive management. It can potentially be used as a trial or pilot site for new approaches to threat reduction. In consultation with DBCA or other land management specialists, VRX will review the management mechanisms (Section 11.2.2) to ensure best practice management techniques are applied. Offsets have been designed to be adaptive, VRX will undertake regular monitoring and reporting to assess the performance of protection mechanisms and identify areas for improvement. This allows information and knowledge captured during operation to be used in an adaptive manner for ongoing maintenance and protection.
6	Environmental offsets will be focused on longer term strategic outcomes.	VRX acknowledges that the proposed offset does not offset native vegetation in perpetuity however, the offset does align with the long-term strategy within the Carnaby's Cockatoo Recovery Plan (DPaW, 2013a). The proposed offsets have been designed to offset the impacts of the Proposal from the outset. It focuses on protection and enhancement of important habitat through management.

No.	Principle	Assessment outcome
		Management actions have been developed to align with the recovery actions of the recovery plan, generally these include: • Prevent clearing and permanent habitat loss; • Feral animal monitoring and control; • Management of fire regimes, salinity, weeds and dieback; and • Promote regeneration. The protection and maintenance of the Offset Area will ensure its protection from development, and that it is managed to maintain its natural values for at least 30 years. It is expected that the foraging value of vegetation disturbed during mining will recover (to a lesser quality pending further evidence of rehabilitation outcomes) during the 30 year period. At the cessation of the 30 year protection period the land may be subject to development (subject to approvals at that time). Without protection, the proposed offset could be subject to development at any time.

11.6 Assessment of Proposed Offsets – EPBC Act

The Commonwealth Minister for the Environment determined that the Proposal (EPBC 2020/8788) is a controlled action under the EPBC Act as it is likely to have a significant impact on one or more MNES. It was determined that the proposed action is likely to have a significant impact on the following matters protected by the EPBC Act:

- Carnaby's Cockatoo (*Zanda latirostris*) – Endangered;
- Malleefowl (*Leipoa ocellata*) – Vulnerable; and
- Sandplain Duck Orchid *(Paracaleana dixonii)* – Endangered.

The Proposal will be assessed as an 'accredited assessment' under Part IV of the EP Act. Section 87 of the EPBC Act makes provisions for the EPA to undertake this accredited assessment of the potential impacts to MNES on behalf of DCCEEW.

11.6.1 Commonwealth Environmental Offsets Guidelines

Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment. Where appropriate, offsets are considered during the assessment phase of an EIA under the EPBC Act.

The EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) states:

> "The term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant.
>
> Offsets can help to achieve long-term environmental outcomes for matters protected under the EPBC Act, while providing flexibility for proponents seeking to undertake an action that will have residual impacts on those protected matters."

11.6.2 Assessment Against EPBC Offsets Calculator

VRX proposes to offset the residual significant impact of the Proposal on Carnaby's Cockatoo foraging habitat by protecting and maintaining moderate to high and moderate value Carnaby's Cockatoo foraging habitat within the Offset Area (Figure 88).

The Commonwealth and WA Governments have similar offset calculators that allow a general assessment of the suitability of offsets in counterbalancing the residual impacts of a proposal. The calculators consider factors such as:

- The quality of the impacted area and offset sites (with and without the offset being applied);
- The likelihood that the offset sites will be disturbed (with and without the offset being applied);
- The size of the offset areas; and
- The likely change in quality with and without an offset.

The residual significant impact used in the EPBC Act Offsets Calculator includes 358.3 ha of Carnaby's Cockatoo habitat (i.e., the quantum of impact before consideration of benefits from progressive rehabilitation). Other values used in the calculator, and the justification for the value, is provided in Table 62. Appendix 31 contains copies of these calculators for reference.

The proposed offset site has been assessed against the EPBC Offsets Calculator (DSEWPaC (2012a; Appendix 31). The assessment was run in two separate calculations to determine the contribution of the proposed offset towards counterbalancing the residual impact of the Proposal. The calculations considered the:

1. **Offset value of the 119.5 ha moderate Carnaby's Cockatoo foraging habitat.** An offset of 119.5 ha of moderate value Carnaby's Cockatoo foraging habitat was suitable to offset 6.33% of the residual impact; and
2. **Offset value of 1,247.6 ha of moderate to high value Carnaby's Cockatoo foraging habitat.** An offset of 1,247.6 ha of moderate to high value foraging habitat is suitable to offset 108.96% of the residual impact.

Using the EPBC Act calculator, the offset sites contain sufficient areas of Carnaby's Cockatoo foraging habitat to adequately offset the total residual significant impact of the Proposal i.e., exceeds the minimum 90% offset criteria in DSEWPaC (2012a). VRX notes that, unlike the WA Offsets Calculator, the EPBC Act calculator does not account for rehabilitation of the Proposal when determining residual impacts (i.e., it assumes foraging habitat would be cleared forever). Furthermore, the calculator assumes that all clearing will be conducted immediately and remain cleared permanently. Given the entire Proposal will be progressively rehabilitated with portions expecting to reach a moderate foraging value within ten years this rehabilitation is considered to significantly reduce the residual impacts such that the proposed offset far exceeds the minimum offset requirements.

VRX acknowledges that there may be minor disturbances within the Offset Area associated with linear infrastructure (powerlines, roads, pipelines etc.) that could occur in the 30-year timeframe, however this has been accounted for in the offset calculations, with the available area significantly exceeding the minimum requirement.

In this instance, the EPBC Act offsets calculator is considered to be very conservative and the proposed offset sites are suitable to offset the residual significant impact of the Proposal on Carnaby's Cockatoo foraging habitat.

11.6.3 Offset Principles

Table 64 provides the overarching principles that are applied in determining the suitability of offsets. In assessing the suitability of an offset, government decision-making will be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty and conducted in a consistent and transparent manner.

Table 64: EPBC Act overarching principles applied in determining the suitability of offsets

No.	Principle	Offset suitability
1	Offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter	The protection of Carnaby's Cockatoo foraging habitat is a direct offset for the impacts of the Proposal. Implementation of Management (11.2.2) and Protection (11.2.3) mechanisms will ensure that the Offset Area will remain viable for the use as foraging habitat for Carnaby's Cockatoo for a minimum of 30 years. The proposed offset includes monitoring of the Offset Site to determine the change in foraging value over time. Monitoring information will provide VRX with a better understanding of the impacts that weeds, dieback and feral animals will have on forging habitat. This information will be used to inform the protection and maintenance measures for the Offset Area which are likely to result in an improvement to the viability of the foraging habitat.
2	Offsets must be built around direct offsets but may include other compensatory measures	The proposed offsets are direct offsets.
3	Offsets must be in proportion to the level of statutory protection that applies to the protected matter	VRX acknowledges the level of statutory protection that apply to the protected matter. This was considered when assessing the significance of the residual impacts. The scale of the proposed offsets takes into account these considerations.
4	Offsets must be of a size and scale proportionate to the residual impacts on the protected matter	The proposed offsets are significant in size and scale, proportionate to the predicted residual impacts.
5	Offsets must effectively account for and manage the risks of the offset not succeeding	The risk of the proposed offsets not succeeding is low. Proposed offsets include the protection and maintenance of existing native vegetation. VRX has commissioned extensive surveys of the Offset Area. Maintenance measures specific to the proposed offset have been determined based on the assessment of potential impacts to foraging habitat.
6	Offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs	The proposed offsets are in addition to that which is already required, determined by law or planning regulations, or agreed to under other schemes or programs. The offset site is not protected as conservation estate by any current legislation.
7	Offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable	The proposed offset targets a portion of existing native vegetation representative of Carnaby's Cockatoo foraging habitat. VRX has already secured tenure over this area and has a vested interest in maintaining tenure for a timeframe that exceeds the life of the Proposal (i.e., more than 30 years). Implementation of the offset can commence at any time following the approval date. The proposed offset is considered to be effective, scientifically robust and reasonable.
8	Offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	VRX will be responsible for the protection and maintenance of the proposed offset. VRX has a corporate governance statement that sets out the main corporate governance policies and practices. Under this statement, VRX has an environmental policy to ensure the integrity of the environment for all employees, contractors and external stakeholders associated with operations. An Offset Strategy has been provided in Appendix 29 that provides further details on the proposed offsets. The Offset Strategy includes requirements to monitor and report (annually) the outcomes of the offset.

12 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

12.1 CONTROLLED ACTION PROVISIONS

A pre-referral meeting was held with DAWE in August 2019. DAWE determined that the Proposal may be a controlled action and VRX was advised by the DAWE to undertake further studies to inform the assessment of potential impacts of the Proposal on MNES. Based on the studies completed for the Proposal the controlling provisions for the Proposal are likely to be:

- 'Listed threatened species and communities' (Sections 18 and 18A of the EPBC Act).

Based on the studies conducted and the information provided in Sections 5 – 10 of this ERD, the species in Table 65 were considered to be potentially impacted by the Proposal and require assessment under the EPBC Act. Species that were determined to have a low likelihood of occurrence have not been included.

Table 65: MNES that may be impacted by the Proposal

Common Name	Species Name	Conservation Status	Recorded
Carnaby's Cockatoo	*Zanda latirostris*	Endangered	Confirmed
Malleefowl	*Leipoa ocellata*	Vulnerable	Not Recorded
Fork-Tailed Swift	*Apus pacificus*	Marine; Migratory	Not Recorded

12.2 POLICY AND GUIDANCE

The relevant policy and guidance for MNES includes:

- Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DPaW, 2013a);
- Conservation Advice for *Conostylis dielsii* subsp. *teres* (TSSC, 2016a);
- Conservation Advice for *Conostylis micrantha* (TSSC, 2016b);
- Conservation Advice for *Hemiandra gardneri* (TSSC, 2016c);
- Conservation Advice for *Paracaleana dixonii* (DEWHA, 2008a);
- Draft survey guidelines for Australia's threatened orchids (DotE, 2013b);
- EPBC Act– section 269A – Adoption of State Plans as Recovery Plans (21/10/2005);
- Environmental Management Plan Guidelines (DotE, 2014a);
- EPBC Act Condition Setting Policy (DAWE, 2020);
- EPBC Act Environmental Offsets Policy (DSEWPaC, 2012a) – including the Offset Assessment guide;
- EPBC Act Outcomes-based conditions policy (DotE, 2016a);
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (DAWE, 2012);
- Fauna Profile: Carnaby's Cockatoo (DBCA, 2017);
- Generic guidelines for the content of a draft EPBC Act PER/EIS (including the objects and principles of the EPBC Act, 1999) (DotEE, 2016a);
- Irwin's Conostylis (*Conostylis dielsii* subsp. *Teres*) Interim Recovery Plan 2005-2009 (Chant, Stack and English, 2005);

- National recovery plan for Malleefowl (Benshemesh, 2007);
- Other Minister of the Environment (Cth) approval decision making considerations;
- Referral guideline for 14 birds listed as migratory species under the EPBC Act *DRAFT* (DotE, 2015a);
- Significant Impact Guidelines: 1.1 – Matters of National Environmental Significance (DotE, 2013a);
- Small Flowered Conostylis *(Conostylis micrantha*) Interim Recovery Plan 2004-2009 (Chant and Stack, 2004);
- Red Snakebush (*Hemiandra gardneri*) Interim Recovery Plan -2004 – 2009 (Stack and Broun, 2004);
- South Coast threatened birds recovery plan (DPaW, 2014);
- Survey guidelines for Australia's threatened birds (DEWHA, 2010);
- Threat abatement plan for competition and land degradation by rabbits (DotEE, 2016b);
- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* (DotE, 2014b);
- Threat abatement plan for predation by feral cats (DotE, 2015b);
- Threat abatement plan for predation by the European red fox (DEWHA 2008b);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by unmanaged goats (DEWHA, 2008c);
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (DotEE, 2017b);
- Threatened (Declared Rare) and Priority List (DBCA, 2018b);
- Threatened Flora – Rare Flora Notice (DBCA, 2018c); and
- Threatened Species Strategy – Year 3 Priority Species Scorecard (2018): Malleefowl *Leipoa ocellata* (National Environmental Science Program Threatened Species Research Hub, 2019).

12.3 DESCRIPTION OF THE ENVIRONMENT

A summary of surveys conducted to date and a detailed description of survey findings relevant to each of the MNES species and their respective habitats is provided in Section 5 (Flora MNES), and Section 6 (Terrestrial Fauna MNES). A summary of the findings is provided below.

12.3.1 SURVEY EFFORT

Flora and Vegetation

A number of flora and vegetation desktop and field surveys have been undertaken within and in close proximity to the development envelopes by Mattiske. These surveys include:

- Flora and Vegetation Assessment of Arrowsmith North Survey Area (Mattiske, 2022a; Appendix 6);
- Investigation of Root Systems of the Priority Flora species recorded in the Arrowsmith North mine survey area (Mattiske, 2022b; Appendix 9);
- Review of Roots and VDT (Mattiske, 2020a; Appendix 8);
- Phytophthora Dieback Occurrence Assessment of Arrowsmith North (Glevan, 2020; Appendix 10); and

- Phytophthora Dieback Occurrence Assessment of Arrowsmith North Access (Glevan, 2021; Appendix 11).

The information contained within the following sections has been sourced from the surveys listed above unless mentioned otherwise. Section 5.3.1 describes these surveys in detail. The Mattiske (2022a) Survey Areas are defined in Figure 14.

Results

During the desktop assessments of the survey areas, Mattiske identified 13 flora species listed as threatened under the EPBC Act as having the potential to occur within the survey areas. Mattiske assessed the likelihood of recording any of the listed threatened taxa within the survey areas, based on factors including soil type, topography and distribution. This assessment is provided in Table 66.

Table 66: Likelihood of threatened species occurring within the Proposal survey areas

Species	Conservation Status	Likelihood of Occurrence
Threatened Species		
Conostylis dielsii subsp. *teres*	Endangered.	Low
Conostylis micrantha	Endangered.	Low
Daviesia speciosa	Endangered.	Low
Eucalyptus crispata	Endangered.	Low
Eucalyptus x impensa	Endangered.	Low
Eucalyptus leprophloia	Endangered.	Low
Eucalyptus x balanites	Endangered.	Low
Hemiandra gardneri	Endangered.	Low
Paracaleana dixonii[1]	Endangered.	Low
Styphelia obtecta	Endangered	Low
Tetratheca nephelioides	Critically Endangered.	Low
Thelymitra stellata	Endangered.	Low
Wurmbea tubulosa	Endangered.	Low

[1]Named *Caleana dixonii* on the DCCEEW Species Profile and Threats Database (DCCEEW; 2023) but known in WA, and refered to in this document, as *Paracalena dixonii*.

No threatened flora listed under the EPBC Act were recorded within the Survey Areas, despite intensive targeted searches (20 m spacing).

Terrestrial Fauna

A Level 1 fauna assessment, Level 2 fauna assessment and targeted surveys for significant fauna were conducted by BCE in November 2018, September 2019 and October 2019. The targeted surveys were to record or determine the likelihood of the Carnaby's Cockatoo and the Western Ground Parrot being recorded within the survey areas. These surveys were undertaken between 23 – 25 October 2019.

BCE conducted an additional desktop assessment on the Access Corridors in 2020.

Desktop Assessment

A desktop assessment of relevant databases, literature and spatial data preceded the field assessment to:

- Produce a species list that represents the likely vertebrate fauna assembly of the survey area; and
- Assess the potential presence of MNES fauna.

Database survey areas produced a generous general species list. Some species that were returned by one or more of the data searches were excluded because their ecology, or the environment within the survey area, meant that it is highly unlikely that these species will be present.

The databases and literature used to develop the species list are detailed below:

- Atlas of Living Australia;
- DBCA NatureMap (Incorporating the WAM's FaunaBase and the DBCA Threatened and Priority Fauna Database);
- BirdLife Australia's Birdata Database;
- EPBC Protected Matters Search Tool; and
- BCE database.

Field Assessment

The Survey Area (Figure 58) has been visited by BCE on three occasions as part of investigations for VRX (November 2018, October 2019 and December 2021). It was first visited on 18 November 2018 to conduct a site inspection, but adjacent areas had previously been visited multiple times over the period 2002 to 2012 by BCE personnel for studies undertaken for Tronox (formerly Tiwest Joint Venture; see references). The nearby Beharra Springs Silica project area was also visited in August 2020 and December 2021, the latter in conjunction with studies at Arrowsmith North. The purpose of the site inspection was to gain a better understanding of the fauna values of the Survey Area, and to place the expected species list generated from the desktop assessment into the context of the environment of the Survey Area. This involved traversing the Survey Area to examine vegetation and substrate present (these observations are used to define fauna habitats, Section 6.3.3), and to record opportunistic observations of fauna.

A further visit was undertaken between 23 and 25 October 2019 specifically for Carnaby's Cockatoo and the Western Ground Parrot. A walkover survey was undertaken to search for evidence of Black Cockatoo foraging and to assess the foraging value of the vegetation, and a search of the surrounding landscape was carried out for features that could support roosting and breeding Carnaby's Cockatoos. A vantage point survey on one evening took place to watch for any evening movements of Carnaby's Cockatoos, which can reveal roosting and nesting sites.

Given there was a possibility that the Western Ground Parrot could occur within the survey area, targeted surveys were conducted. Four ARUs were deployed in and around the survey areas on 23 and 24 September 2019 and collected on 18 October 2019. They were set up to sample for calling Western Ground Parrots and make further assessment of their potential presence. One ARU was an AudioMoth (Hill *et al*., 2018 & 2019) running firmware version 1.2.2, while the other three were SOLO biological recorders (Whytock and Christie, 2017) running SOSI-2019-09-20.img.zip. These ARUs were chosen for their cost effectiveness and compatible audio response

with that of commercial ARUs. Both recorders were placed in low-lying, dense heath (maximum of 1 m high), set to record during peak calling periods of the Western Ground Parrot; a minimum of one hour after sunset and a minimum of one hour before sunrise. Recorders recorded over 70 nights in total. The software for the SOLO recorder was customised by James Christie and Barry Shepherd for the particular timing. The location of the ARUs are shown in Figure 56. None of the ARU recordings identified any evidence of this species.

12.3.2 Recorded or Likely Species

The MNES species identified in Table 65 have either been recorded during studies for the Proposal or they were considered likely to occur (moderate likelihood or greater) given the presence of suitable habitat within or surrounding the survey areas. A likelihood assessment of Threatened Flora and Terrestrial Fauna occurring within the Study Area has been conducted by Mattiske (2022a) and BCE (2022), a summary is provided in Table 67.

Table 67: Likelihood of MNES occurring within the survey areas

Species and conservation rating	Range/habitat preference	Likelihood of Occurrence
Terrestrial Fauna		
Carnaby's Cockatoo (*Zanda latirostris*), Endangered	The Carnaby's Cockatoo is endemic to the south-west of WA, with a widespread distribution. The species is highly mobile and displays a seasonal migratory pattern that is linked to breeding (Saunders, 1980 & 1990; Berry, 2008). Breeding takes place between late July and December and most breeding occurs in the inland parts of its distribution, in areas receiving between 300 – 750 mm of annual average rainfall (Saunders, 1974). During the non-breeding season (January – July) the majority of the birds move to the higher rainfall coastal regions of their range including the mid-west coast, Swan Coastal Plain and south coast (Saunders, 1980 & 1990; Berry, 2008; Saunders *et al.,* 2011; Johnstone *et al.,* 2011; DPaW, 2013a).	Recorded, regular migrant (species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle)
Fork-Tailed Swift (*Apus pacificus)* Marine, Migratory	In WA, there are sparsely scattered records of the Fork-tailed Swift along the south coast, ranging from near the Eyre Bird Observatory and west to Denmark. They are widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley. They are also recorded in the Timor Sea, both at sea and around islands such as the Ashmore Reef. Isolated records occur at Neale Junction in the Great Victoria Desert and on the Nullarbor Plain (Higgins, 1999).	Not recorded, but likely to be a regular migrant (species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle)
Malleefowl (*Leipoa ocellate*) Vulnerable	In WA, Malleefowl are found in shrublands dominated by *Acacia*, and occasionally in woodlands dominated by *Eucalypts* such as *Wandoo E. wandoo, Marri Corymbia calophylla* and *Mallet E. astringens* (Storr, 1985, 1986 & 1987; Storr & Johnstone, 1988; Benshemesh & Malleefowl Preservation Group, 2001; Sanders *et al.,* 2003; Benshemesh, 2007).	Not recorded, but likely to be an irregular visitor (species that occur within the survey area irregularly such as nomadic and

Species and conservation rating	Range/habitat preference	Likelihood of Occurrence
	Parsons (2008) has recently examined the distribution of Malleefowl within the WA Wheatbelt. Malleefowl distribution was associated with landscapes that had lower rainfall, greater amounts of mallee and shrubland that occur as large remnants, and lighter soil surface textures. At a finer scale, malleefowl occurrence was associated with mallee / shrubland and thicket vegetation with woodland representing poor habitat for the species. Parsons (2008) also examined the occupancy of small remnants in the wheatbelt and found that remnants occupied by Malleefowl typically possessed a greater amount of litter, greater cover of tall shrubs, greater abundance of food shrubs and a greater soil gravel content than those that were not occupied (Benshemesh, 2007).	irruptive species. The length of time between visitations could be decades but when the species is present, it uses the survey area in at least moderate numbers and for some time)

12.3.3 HABITAT SUITABILITY FOR MNES

The information contained within this section is from BCE (2022) unless otherwise referenced.

Vegetation Soil Associations

Vegetation types within the survey areas can be broadly classed into a series of VSAs which combine vegetation with some similarity in floristics and structure, and some similarity in landscape position and substrate type.

Three VSAs were recorded in the BCE survey areas:

1. Kwongan Heath;
2. Riparian Thickets; and
3. Open Woodland.

These VSAs are described in detail in Section 6.3.3 and shown in Figure 60 and Figure 66.

Carnaby's Cockatoo

One species of Black-Cockatoo of conservation significance has been confirmed in the general area, Carnaby's Cockatoo. The other two significant black-cockatoos in the South-West, Baudin's and the Forest Red-tailed, do not occur on the northern Swan Coastal Plain. Red-tailed Black-Cockatoos in the general region of the Proposal are a different and widespread (inland) sub-species (*Calyptorhynchus banksia escondidus*). Carnaby's Cockatoo may forage on proteaceous and myrtaceous vegetation in the Survey Area and roost in large trees near water courses. Foraging and roosting by Carnaby's Cockatoos have been confirmed adjacent to the Survey Area and is discussed below. Locations of foraging signs and sightings of Carnaby's Cockatoo collected in September 2019 and December 2021 are shown in Figure 64. Breeding nearby is also a possibility but is unconfirmed.

<u>*Breeding habitat*</u>

The Survey Area are unlikely to support breeding by Carnaby's Cockatoos. There are no large trees (trees of sufficient size to provide nesting hollows) in the Survey Area, while just one large tree with two potential (but unused) hollows was found in the access corridor. There were also large trees (River Gums *Eucalyptus camaldulensis*) along the drainage system to the east and possibly along the Arrowsmith River to the south and west (outside the development envelopes), and it is possible these contain hollows of suitable size for nesting by Black-Cockatoos. The

nearest known breeding by Carnaby's Cockatoo is at Coomallo Creek, about 100 km south of the Arrowsmith area (DBCA, 2019b; Saunders and Dawson, 2017).

Roosting habitat

Three Carnaby's Cockatoo roost sites have been confirmed and one is suspected within proximity of the Survey Area. Bamford and Chuk (2015 – 2017) recorded a flock of 300+ individuals roosting 10 km south of the Mine Survey Area, 2 km east of the southern alignment along the Arrowsmith River (Figure 64). In April 2015, Bamford (pers. Obs.) recorded a roost of 500+ individuals approximately 13 km north, near the north-eastern boundary of Yardanogo Nature Reserve. Two groups of Carnaby's Cockatoos of ten or so individuals were seen flying very directionally and at speed across the Brand Highway (one group flying west, the other east) approximately 5 km south of the Mine Survey Area on 23 September 2019 just after dusk. This timing and flight pattern suggest they were travelling to roost sites. Additionally, approximately 45 minutes before sunrise on 24 and 25 September 2019, Carnaby's Cockatoos could be heard calling from the Western Flora Caravan Park where the surveyors were staying; this lies just over 18 km south-east of the Survey Area. Static calls at this time of the day strongly suggest the presence of a roost. On 6 December 2021, a roost of at least 60 birds was found just west of Brand Highway and about 4 km east of the Survey Area.

Data retrieved from the Great Cocky Count coordinator, Adam Peck (pers. comm) confirmed the absence of any other known Carnaby's Cockatoo roosts within 12 km of the Mine Survey Area. While there are no large trees within the Survey Area that are likely to be used for roosting, there are large trees nearby, particularly along drainage lines that may be suitable. The presence of the roosts 4 km west, 10 km south and 13 km north to the south means that the Survey Area may regularly be visited by foraging Carnaby's Cockatoos.

While watching and listening at dusk on the evening of 24 September 2019 from a vantage-point located 1.7 km south of the site no Carnaby's Cockatoo were seen or heard. This suggests low activity of the species in the area during the breeding season, but observations made in August 2020 in the Beharra Project area to the north (a small flock of mostly male Carnaby's Cockatoos) suggests that some breeding may be occurring in the region. A search of the wider landscape for suitable roosting and breeding trees was conducted in September 2019. This identified several locations with trees of possibly suitable stature along the Arrowsmith River and around wetlands to the south and east of the Survey Area.

Foraging habitat

Banksias, hakeas, eucalypt trees, acacias and Woody Pears (*Xylomelum*) provide foraging habitat for Carnaby's Cockatoos, Acacias and Banksias in particular are widespread throughout the Survey Area. Furthermore, a large number of scattered and chewed Banksia inflorescences consistent with Carnaby's were found across the Mine Survey Area in September 2019. Two flocks (one of 50 individuals) were also spotted flying over the Mine Survey Area in the mid-afternoon during the September 2019 survey. Flocks have occasionally been recorded in the general area, foraging in Kwongan heath and Banksia low woodland, including approximately 500 individuals north of Yardanogo Nature Reserve (April 2015; Bamford *et al.,* 2015) and flocks of over 300 individuals near the Arrowsmith River west of Brand Highway (Bamford and Chuk, 2015-2017).

BCE (2022) assigned a foraging value score to the VSAs in the Survey Area for Carnaby's Cockatoo. The vegetation characteristics score (out of 6) were assigned as follows:

- VSA 1 (Kwongan Heath). Vegetation characteristics score of 4 out of 6. Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40 % projected foliage cover;
- VSA 2 (Riparian Thicket). Vegetation characteristics score of 2 out of 6. Shrubland in which species of foraging value, such as shrubby banksias, have <10 % projected foliage cover. However, some patches of Riparian Thicket supported a wide range of other foraging species such as *Hakea*, *Acacia* and Myrtaceae such as *Calothamnus*, and therefore the score was adjusted slightly by assigning a context score of 1 out of 3; and
- VSA 3 (Open Woodland): Vegetation characteristics score of 4 out of 6. This score is based on the vegetation being a blend of 'Woodland with tree banksias 5-20 % projected foliage cover' (score of 3 out of 6) and 'Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40 % projected foliage cover'.

The context score was the same (2) for VSAs 1 and 3, but this is based upon the total survey area and could be lowered to a context score of 1 if impact areas and rehabilitation effectiveness are taken into account. VSA 2 had a context score of 1 as while it received a vegetation characteristics score of only 2, it is limited in area and has some secondary foraging species. Site Context is a function of site size, availability of nearby habitat and the availability of nearby breeding areas. The Survey Area lies in a landscape with extensive similar vegetation in two nature reserves, which lowers the context value, but the total impact area is uncertain so the assessment is based on the total survey area. If breeding were confirmed nearby then a higher context score could be applied. The species density score of 1 is used for VSAs 1, 2 and 3, as Carnaby's Cockatoos were seen regularly in the area.

Overall, the Kwongan heath (VSA 1) and the low, open woodland (VSA 3) have a high foraging value for the species (7 out of 10). This is on the basis of having high proportions of key food plants, notably banksias. The Kwongan Heath (VSA 1), however, is much more extensive. The Riparian Thicket (VSA 2) is also extensive and has a moderate foraging value with few banksias but high densities of acacias and some hakeas.

The foraging value of the VSAs present in the survey areas are detailed in Table 28 and foraging evidence sites are shown in Figure 65.

12.4 RELEVANT IMPACTS

Sections 5 and 6 of this ERD have assessed the potential impacts on MNES in detail. To avoid repetition, Table 68 summarises the findings of those assessments as applicable to MNES.

Table 68: Relevant impacts to MNES

Potential Impact	Assessment of Impacts	Relevant MNES
Direct disturbance / loss of habitat		
Up to 353.8 ha native vegetation disturbance within the development envelopes	**Nature and extent of impact:** Clearing of up to 339.3 ha of native vegetation (within the Mine Development Envelope) which will be progressively rehabilitated via VDT Clearing of up to 14.5 ha of native vegetation within the development envelopes for the life of the Proposal. **Unknown, unpredictable or irreversible impacts**: There is some uncertainty about the resultant quality of the vegetation that will be translocated via VDT, and the likely success of infill planting for Carnaby's Cockatoo foraging species. Impacts to Malleefowl are uncertain as this species has not been recorded in the survey areas however, it is likely to be an irregular visitor (BCE, 2022). No unknown impacts are predicted from this direct disturbance of habitat. **Significance of impacts**: Impacts to species other than Carnaby's Cockatoo are not considered significant. Malleefowl and Fork-tailed Swift utilise widespread habitats and the rehabilitated habitats will be suitable for use by these species. The residual impacts to Carnaby's Cockatoo foraging habitat are considered to be significant and can be summarised as: 1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo); 2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo); and 3. Longer-term reduction in foraging habitat value of 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat. **Additional technical data:** • Section 6.3.3 provides detail on the VSAs recorded within the survey area • Section 5.3.4 provides detail on the vegetation communities recorded in the survey area • Mattiske (2022a; Appendix 6) provides further technical information on the vegetation communities within the survey areas • BCE (2022; Appendix 14) provides further technical information on the VSAs within the survey areas	Carnaby's Cockatoo Malleefowl Fork-tailed Swift
Vehicle / earthmoving equipment strike	**Nature and extent of impact:** There is a risk of fauna death or injury if fauna are struck by earthmoving equipment during clearing, VDT or mining. 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 careful use of the VDT method. It is likely however that there will be some fauna injuries or deaths during these activities. VRX will implement management measures to minimise this likelihood (refer to Section 6.6). Although no Malleefowl mounds were identified during the surveys, there is a small risk of the disturbance of new Malleefowl mounds during earthmoving. VRX will check for the presence of Malleefowl mounds prior to clearing if mounds are found and ensure no active mounds are disturbed until Malleefowl have left the mound. **Unknown, unpredictable or irreversible impacts**: Vehicle / earthmoving equipment strikes were able to be predicted.	Carnaby's Cockatoo Malleefowl

Potential Impact	Assessment of Impacts	Relevant MNES
	No irreversible impacts are predicted from indirect impacts if mitigation measures are implemented. **Significance of impacts:** With appropriate vehicle strike mitigation measures in place, any vehicle / earthmoving impacts to MNES are likely to be extremely rare. **Additional technical data:** Section 2.2.3 provides detailed information on the Proposal, including the vehicles and equipment required.	
Indirect Impacts		
Introduced fauna	**Nature and extent of impact:** Introduced species were recorded in fauna surveys within the study areas including cats and foxes (BCE, 2022). The Proposal has the potential to introduce additional species or increase the population of existing introduced species, through the following vectors: • Food wastes at work areas; or • Presence of cleared corridors that may be utilised by introduced fauna for access or predation. The workforce will be relatively small, and 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 access 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). **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The presence of introduced species is known as a result of fauna surveys. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: 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. **Additional technical data:** BCE (2022; Appendix 14) provide further technical information regarding introduced species and use of the study area.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift
Alteration of behaviour as a result of noise, or light emissions.	**Nature and extent of impact:** The Proposal has a small operational footprint and will produce low levels of artificial light and noise emissions. The main source of noise and light emissions will be the Processing Plant (24-hour operations), which covers only several hectares. Equipment moving within the mining area will produce noise emissions however this will be limited to a small area given the progressive mining footprint. Nevertheless, it is expected that MNES will keep some distance from the mining area while operating. **Unknown, unpredictable or irreversible impacts**: Noise and light impacts from the proposal are known and can be predicted. No irreversible impacts are predicted from this indirect impact. **Significance of impacts**: With the implementation of controls (refer to Section 6.6) potential increased risks to MNES from light or noise emissions are expected to be able to be appropriately mitigated such that impacts are not significant. **Additional technical data:** BCE (2022; Appendix 14) provide further technical information on the potential impacts fauna within the survey areas.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift

Potential Impact	Assessment of Impacts	Relevant MNES
Alterations to fire regimes	**Nature and extent of impact:** The Eridoon land system is characterised as experiencing frequent wildfires, this is reflected in the high proportions of reseeder and resprouter species present within the vegetation assemblage. Generally, the vegetation is fire-dependant, with much of the Study Area already impacted by wildfire. Mining activities have the potential to ignite bushfires through hot work and other activities. **Unknown, unpredictable or irreversible impacts**: No impacts would be considered unknown. The frequency of fire is well known in the area and therefore predictable. An intense and uncontrolled fire could have irreversible impacts to local MNES populations. **Significance of impacts**: With appropriate firefighting and prevention management measures in place (Section 5.6 and 6.6), the development of the Proposal will provide improved access subsequent ability to fight fire outbreaks and prevent them from spreading. The potential for increased fire risk impacts is therefore not expected to be significant. **Additional technical data:** Section 5.5.1 provides detail regarding the impacts of fire on flora and vegetation. Section 6.5.4 provides more information of the impacts that a loss of foraging habitat has on the Carnaby's Cockatoo.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift
Establishment or spread of weed species / populations	**Nature and extent of impact:** 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. Eight introduced species were identified during flora / vegetation surveys (Mattiske, 2021a & b). None of these taxa are listed as WoNS, however two were listed as having a high ecological impact (*Aira caryophyllea* and *Ursinia anthemoides*). Given the presence of these weed species, weed management measures will be implemented to prevent or minimise the spread of weeds and any increased competition with native species **Unknown, unpredictable or irreversible impacts**: This impact would not be considered unknown, unpredictable or irreversible. **Significance of impacts**: With appropriate weed management measures in place VRX will be able to prevent and minimise the spread of weed, mitigating competition with other species. Therefore, impacts to MNES arising from the establishment or the spread of weeds is considered to be minimal. **Additional technical data:** Mattiske (2022a; Appendix 6) provides further technical information on the weed species present within the survey areas. Section 5.6 provides further detail on weed management measures that will be implemented.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift
Reduction of groundwater depth	**Nature and extent of impact:** The removal of silica sand within the mining footprint will reduce the depth to groundwater in those areas. There is the potential that more deep-rooted species become established over time as they will be able to access this shallower groundwater table. Over an extended period, this may lead to a change in vegetation community characteristics. **Unknown, unpredictable or irreversible impacts**: It is unknown what changes this impact will have on vegetation community characteristics. The impact from this change will be irreversible. **Significance of impacts**: This impact may result in higher densities of deeper-rooted species utilised by Carnaby's Cockatoo for foraging.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift

Potential Impact	Assessment of Impacts	Relevant MNES
	Additional technical data: Mattiske (2022a; Appendix 6) provides further technical information on the flora species present within the survey areas. RPS (2020; Appendix 20) provides further technical information on the surface and groundwater hydrology of the survey areas. HydroConcept (2019; Appendix 21) provides further technical information on the hydrogeology of the survey areas.	
Hydrocarbon spills	**Nature and extent of impact:** Considering 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. **Unknown, unpredictable or irreversible impacts**: This impact would not be considered unknown, unpredictable or irreversible. **Significance of impacts**: With the implementation of controls this impact is unlikely to be significant. **Additional technical data:** Proposed control measures are identified in Section 5.6 and are designed to further reduce the risk of vegetation impacts from hydrocarbon spillage.	Carnaby's Cockatoo Malleefowl
Introduction or spread of dieback	**Nature and extent of impact:** The introduction of *P. cinnamomi* to the development envelopes could likely result in a significant vegetation decline, based on the observed impacts to vegetation at Eneabba that share similar environmental conditions. Given the risk of dieback, hygiene management measures will be implemented to prevent the introduction of dieback (Section 5.6). **Unknown, unpredictable or irreversible impacts**: This impact would not be considered unknown, unpredictable or irreversible. **Significance of impacts**: With the implementation of controls this impact is unlikely to be significant. **Additional technical data:** Glevan (2020 and 2021; Appendix 10 and 11) provide further technical information on the extent of dieback within the survey areas.	Carnaby's Cockatoo Malleefowl

12.5 ASSESSMENT AGAINST SIGNIFICANT IMPACT CRITERIA FOR LISTED THREATENED SPECIES AND ECOLOGICAL COMMUNITIES

Assessment against the significant impact criteria for each listed threatened species listed in Table 65 has been provided in Table 69 and Table 70 below. Where appropriate, some species have been assessed as a group if they share similar habitats and potential impacts.

Table 69: Carnaby's Cockatoo

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
Lead to a long-term decrease in the size of a population	Carnaby's Cockatoo occurs widely throughout south-western WA, from the lower Murchison in the north and south to Esperance, and as far east as Forrestania (Storr and Johnstone, 1998). Clearing in the southern Wheatbelt has resulted in two genetically distinct subpopulations: a western and an eastern (White *et al.,* 2014). The western subpopulation is relevant to the Proposal, which breeds in the Avon-Wheatbelt, Geraldton Sandplains and Jarrah Forest IBRA bioregions, as far as Morawa in the north, and migrates to the Swan Coastal Plain during the non-breeding season, between January and June. It has been estimated that Carnaby's Cockatoo has disappeared from more than one-third of its historical breeding range because of extensive habitat loss in the Avon-Wheatbelt region (Saunders, 1990). Subsequently, the breeding distribution of Carnaby's Cockatoo has shifted westward through the Jarrah Forest region, where it now also breeds (Johnstone and Kirkby, 2008; Storr and Johnstone, 1998). Collisions with motor vehicles has been identified as a key risk to this species. DPaW (2013a) identifies paving of gravel roads and associated increases in speed as a contributing factor to the frequency of vehicle collisions. The Proposal will include the development of an access track however the road will be speed limited and adequately signed such that the risk of vehicle collision is minimised. Loss of habitat critical to the survival of this species, including more 'diffuse' critical habitat such as feeding habitat (DPaW, 2013a) like Kwongan heath is a key threat to this species. It is difficult to accurately designate and quantify the value of feeding habitat, mainly because the species is highly mobile and adaptive, and uses resources spread over a relatively large area. Black cockatoos are known to be mobile and widely-distributed, and the variation in flock compositions (for example, between breeding and non-breeding seasons). For black cockatoos, it is more appropriate to consider significance in terms of impacts on habitat rather than a resident population (DSEWPaC, 2012b). This assessment is provided below.
Reduce the area of occupancy of the species	VSA1 – 3 would be considered an area of occupancy for this species as it provides feeding habitat, with BCE (2022) classifying it as moderate to high value foraging habitat. The Proposal will result in the disturbance of up to 353.8 ha of moderate to high value Carnaby's Cockatoo, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of moderate to high value foraging habitat will be progressively rehabilitated via VDT. While being particularly useful for translocation of recalcitrant species, VDT has limited advantages when translocating deeper-rooted flora species (such as *Banksia attenuata, Banksia menziesii* and *Banksia prionotes*) favoured by Carnaby's Cockatoo as foraging habitat. As Banksias have been found to be underrepresented in trial VDT (Mattiske, 2019a), it is proposed that direct seeding and/or infill planting of Banksias and other foraging species will be conducted, however the effectiveness of this is uncertain. The actual foraging value of revegetation created through VDT and infill planting will depend largely on the density / projected foliage cover of key food plants (shrubby Banksias). Banksias can be difficult to establish in conventional rehabilitation but it is not known how they will respond in VDT. After ten years, it can be assumed that some establishment of Banksias can be achieved, with a value score predicted between 2 and 6 (out of 10; BCE, 2022) VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success, however infill planting of deeper rooted species used for foraging by Carnaby's Cockatoo will be required to attempt to reinstate the original foraging habitat values. There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers. Management and monitoring is proposed to improve the performance of VDT with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats (refer to Section 12.7).

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
	After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: 8. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo); 9. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo); and 10. Longer-term reduction in foraging habitat value of 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat. These residual impacts are considered likely to temporarily reduce the area of occupancy of the species and are proposed to be counterbalanced by offsets (refer to Section 11 and Section 12.7).
Fragment an existing important population into two or more populations	The term 'important population' has not been defined for black cockatoos, due to the mobile and widely-distributed nature of these species, and the variation in flock compositions (for example, between breeding and non-breeding seasons). For black cockatoos, it is more appropriate to consider significance in terms of impacts on habitat rather than a resident population (DSEWPaC, 2012b). This assessment is provided below.
Adversely affect habitat critical to the survival of a species	The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DpaW, 2013a) identifies habitat critical to the survival of this species as being: • The eucalypt woodlands that provide nest hollows used for breeding, together with nearby vegetation that provides feeding, roosting and watering habitat that supports successful breeding • Woodland sites known to have supported breeding in the past and which could be used in the future, provided adequate nearby food and/or water resources are available or are re-established • In the non-breeding season the vegetation that provides food resources as well as the sites for nearby watering and night roosting that enable the cockatoos to effectively utilise the available food resources Based on the above classification, VSA1 – 4 would be considered habitat critical to the survival of a species as it provides feeding habitat, with BCE (2022) classifying it as moderate to high value foraging habitat. The Proposal will result in the disturbance of up to 353.8 ha moderate to high value Carnaby's Cockatoo foraging habitat, 14.5 ha of which will remain cleared for the life of the Proposal, and up to 339.3 ha of which will be progressively rehabilitated via VDT. While being particularly useful for translocation of recalcitrant species, VDT has limited advantages when translocating deeper-rooted flora species (such as *Banksia attenuata, Banksia menziesii* and *Banksia prionotes*) favoured by Carnaby's Cockatoo as foraging habitat. As Banksias have been found to be underrepresented in trial VDT (Mattiske, 2019a), it is proposed that direct seeding and/or infill planting of Banksias and other foraging species will be conducted, however the effectiveness of this is uncertain. The actual foraging value of revegetation created through VDT and infill planting will depend largely on the density / projected foliage cover of key food plants (shrubby Banksias). Banksias can be difficult to establish in conventional rehabilitation but it is not known how they will respond in VDT. After ten years, it can be assumed that some establishment of Banksias can be achieved, with a value score predicted between 2 and 6 (out of 10; BCE, 2022) VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success, however infill planting of deeper rooted species used for foraging by Carnaby's Cockatoo will be required to attempt to reinstate the original foraging habitat values. There will therefore be unavoidable impacts to Carnaby's Cockatoo foraging habitat values within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers.

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
	Management and monitoring is proposed to improve the performance of VDT with regards to Carnaby's Cockatoo foraging values, and minimise indirect impacts to foraging habitats (refer to Section 12.7). After the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: 1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo); 2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo); and 3. Longer-term reduction in foraging habitat value of 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat. These residual impacts are considered likely to adversely affect habitat critical to the survival of a species and are proposed to be counterbalanced by offsets (refer to Section 11 and Section 12.7).
Disrupt the breeding cycle of an important population	The Survey Area are unlikely to support breeding by Carnaby's Cockatoos. There are no large trees (trees of sufficient size to provide nesting hollows) in the Survey Area, while just one large tree with two potential (but unused) hollows was found in the access corridor. The disturbance footprint has been designed to avoid this tree. The Proposal is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	As described above, after the implementation of avoidance, minimisation and rehabilitation mitigation measures the residual impacts to Carnaby's Cockatoo foraging habitat are summarised as: 1. Loss of up to 14.5 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of 40 years (30 years operation plus ten years before rehabilitation is suitable for foraging by Carnaby's Cockatoo); 2. Loss of 339.3 ha of moderate to high value Carnaby's Cockatoo foraging habitat for a period of ten years (based on a period of ten years before VDT rehabilitation is suitable for foraging by Carnaby's Cockatoo); and 3. Longer-term reduction in foraging habitat value of 353.8 ha of moderate to high value Carnaby's Cockatoo foraging habitat. Mining and extraction activities (particularly extraction of sand) are identified as a key threat to this species as these activities result in the clearing of native vegetation. This is particularly problematic for activities that result in an overall change to the final land use. Where mining occurs within foraging habitat and is followed by revegetation this could be considered only a short to medium term loss of habitat depending on the quality of revegetation (DPaW, 2013a). These residual impacts of the Proposal are considered likely to temporarily modify and decrease the availability or quality of habitat for this species, however not to the extent that the species is likely to decline, given the rehabilitation methods proposed and the availability of suitable habitat in the area.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	**Weeds** Weeds have the potential to outcompete and displace flora species 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. VRX will implement weed management measures to ensure that the spread and introduction of weed species is minimised. **Feral Animals** The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively using VDT and infill planting. It is unlikely that the Proposal will modify fauna behaviours to the extent that would further impact this species.
Introduce disease that may cause the species to decline	The Proposal is not expected to be a vector for any disease for Carnaby's Cockatoo. The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DpaW, 2013a) however identifies Tree Health, particularly impacts from the introduction and spread of *Phytophthora cinnamomi* (dieback) as a threat to the habitat for this

Significant impact criteria (Endangered)	Assessment of impacts to Carnaby's Cockatoo
	species. Dieback hygiene and management measures / procedures will be implemented to prevent the introduction or spread of dieback as a result of construction and operation of the Proposal. Disease (particularly beak and feather disease virus, avian polyomavirus and chlamydophilosis) is identified as a key threat for this species. Activities associated with the Proposal are not expected to introduce or spread any diseases listed above.
Interfere with the recovery of the species	The Carnaby's Cockatoo (*Zanda latirostris*) Recovery Plan (DpaW, 2013a) identifies the protection and management of important habitat as a key recovery action for this species. The Proposal will require the temporary disturbance of important habitat for this species (refer above) and as such may interfere with its recovery. This impact is proposed to be counterbalanced by offsets, which includes further protection and management of important habitat (refer to Section 11 and Section 12.7).

Table 70: Malleefowl

Significant impact criteria (Vulnerable)	Assessment of impacts to Malleefowl
Lead to a long-term decrease in the size of an important population of a species	An 'important population' is defined by the Significant Impact Guidelines 1.1 (DotE, 2013a) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • Key source populations either for breeding or dispersal; • Populations that are necessary for maintaining genetic diversity, and/or • Populations that are near the limit of the species range. The National Recovery Plan for Malleefowl *Leipoa ocellata* (Benshemesh, 2007) states that no particular populations or general areas can be described as being of greater importance for the long-term survival of Malleefowl than any other at this stage. No evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be impacted by the Proposal. Regardless of this, the Proposal will only have minor disturbance to the broad habitat of this species and indirect impacts are able to be easily mitigated with well-established controls (Section 12.7). The Proposal is therefore unlikely to lead to a long-term decrease in the size of an important population of this species.
Reduce the area of occupancy of an important population	As discussed above, no evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be impacted by the Proposal. Clearing has been identified as a key threat to this species (Benshemesh, 2007). Malleefowl occur in a wide range of habitat types and habitat critical to the survival of the species is known only in broad terms. No particular populations or general areas can be described as being of greater importance for the long-term survival of Malleefowl than any other at this stage. In the absence of a definition of habitat critical to the survival of this species and any formal records, VSA1 has been considered to be habitat (possibly foraging; as much of the vegetation may be too low as the Malleefowl usually occurs in woodlands and tall shrublands, BCE 2022). Regardless of this, the Proposal will only have minor disturbance to the potential area of occupancy of any populations that may be in the area, and indirect impacts are able to be easily mitigated with well-established controls (Section 12.7). The Proposal is therefore unlikely to lead to reduce the area of occupancy of an important population of this species.
Fragment an existing important population into two or more populations	Fragmentation is identified as a key threat to this species (Benshemesh, 2007), no evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no known important population that may be fragmented into two or more populations impacted by the Proposal.

Significant impact criteria (Vulnerable)	Assessment of impacts to Malleefowl
	Regardless, the Proposal is situated in an extensive, continuous landscape comprised primarily of Kwongan heath. For the purpose of this impact assessment VRX has assumed this is representative of Malleefowl habitat despite there being no evidence to suggest there is a resident breeding population. Malleefowl may use this area for foraging and to move between areas of suitable (foraging or breeding). The extent of disturbance required for the Proposal is relatively small in comparison to the surrounding environment and the disturbance footprint does not intercept, isolate or fragment any unique habitat. The Proposal will also be implemented in a progressive manner with disturbed areas being rehabilitated via VDT and infill planting. This methodology is anticipated to result in areas of mining being rehabilitated fully prior to the completion of mining (vegetation is expected to reach maturity within 10ten years), re-establishing fauna habitats. It is expected, that with the implementation of the Proposal, sufficient habitat of the same type and quality will remain to maintain connectivity with the surrounding habitats. Considering the factors described above, the Proposal is not expected to fragment or isolate any fauna habitats for Malleefowl. If any local fragmentation were to occur, it is not expected to persist, with mining areas only anticipated to be open for months at a time.
Adversely affect habitat critical to the survival of a species	Malleefowl occur in a wide range of habitat types and habitat critical to the survival of the species is known only in broad terms (Benshemesh, 2007). While suitable habitat exists within the development envelopes, this habitat is widespread throughout the area, including large areas within conservation reserves. The habitat within the development envelopes would be unlikely to be considered 'habitat critical to the survival' of this species.
Disrupt the breeding cycle of an important population	No Malleefowl mounds were recorded within the development envelopes and VRX has committed to not disturb any new mounds that may be created or discovered while being used for breeding purposes. As discussed above, no evidence of Malleefowl populations or individuals were identified within the development envelopes, therefore there is no important population that is known to utilise the habitat within the development envelopes. The Proposal is therefore unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Proposal will result in the disturbance of up to 14.5 ha of potential Malleefowl habitat, which will remain cleared for the life of the Proposal, and up to 339.3 ha of habitat translocation via VDT. VDT is noted to be the best available rehabilitation method for the Proposal, given the shallow root structure of the majority of the fauna habitat vegetation, and the progressive mining method proposed. Previous VDT trials have provided promising results and VDT is expected to result in the best chance of rehabilitation success. Infill planting of deeper rooted species will be undertaken as required to target the original habitat structure. There will be unavoidable impacts to Malleefowl habitat health within rehabilitated VDT areas, however the health of these areas are predicted to improve close to background over time. There may also be some changes to habitat structure as a result of improved access to groundwater, with deeper rooted species predicted to be able to become established in greater numbers. Management and monitoring is proposed to prevent direct impacts to Malleefowl habitat, to improve the performance of VDT and minimise indirect impacts to Malleefowl habitats (refer to Section 12.7) Based on the above the Proposal is considered unlikely to modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	**Weeds** Weeds have the potential to outcompete and displace flora species 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. VRX will implement weed management measures to ensure that the spread and introduction of weed species is minimised. **Feral Animals** Impacts from grazing and predation have been identified as key threats to this species (Benshemesh, 2007). Rabbits, feral pigs and goats present a grazing threat that may indirectly impact malleefowl through degradation and loss of habitat. Red Fox and cats are identified as a predation threat. The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively using VDT and infill planting. It is unlikely that the Proposal will introduce feral animals or modify fauna behaviours to the extent that would increase the threat of predation or grazing,

Significant impact criteria (Vulnerable)	Assessment of impacts to Malleefowl
	resulting in further impact this species.
Introduce disease that may cause the species to decline	There is no information on disease in wild Malleefowl populations although the species is susceptible to a range of common diseases in captive situations and may also be susceptible to exotic diseases, especially those found in other Galliformes (R. Woods pers. comm.). The Proposal is not expected to be a vector for any disease for this species.
Interfere substantially with the recovery of the species	The National Recovery Plan for Malleefowl *Leipoa ocellata* (Benshemesh, 2007) identifies the management of populations as a key recovery action for this species. The Proposal will not impact any known populations and the temporary reduction in habitat extent is limited in the context of the wide-ranging nature of this species. The Proposal is therefore considered unlikely to iinterfere substantially with the recovery of this species

12.6 ASSESSMENT AGAINST SIGNIFICANT IMPACT CRITERIA FOR LISTED MIGRATORY SPECIES

One species listed as migratory under the EPBC Act was considered likely to occur in the vicinity of the Proposal (Fork-tailed Swift) based on an assessment of habitat requirements (Section 12.3.2). An assessment of the significance of impacts to the Fork-tailed Swift is provided in Table 71.

Table 71: Fork-tailed Swift

Significant impact criteria	Assessment of impacts to Fork-tailed Swift
Potential to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	An area of 'important habitat' for a migratory species is defined in the Significant Impact Guidelines 1.1 (DotE, 2013a) as habitat that is: a. Utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or b. Of critical importance to the species at particular life-cycle stages, and/or c. Utilised by a migratory species which is at the limit of the species range, and/or d. Within an area where the species is declining. The Fork-tailed Swift was only identified as a regular migrant to the area and the habitat within the development envelopes was not identified as meeting any of the above criteria. The Proposal is therefore considered unlikely to substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for this species.
Potential to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species.	As described above, the Fork-tailed Swift was only identified as a regular migrant to the area and the habitat within the development envelopes was not identified as meeting any of the criteria for 'important habitat'. The Proposal is therefore considered unlikely to result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species. Feral cats are identified as being a potential threat to this species (DCCEEW, 2022). The mining and rehabilitation methodology will not result in extensive areas of permanently cleared land. Mining will be rehabilitated progressively using VDT and infill planting. It is unlikely that the Proposal will introduce feral animals or modify fauna behaviours to the extent that would increase the threat of predation, resulting in further impact this species.
Potential to seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	The Fork-tailed Swift is widespread in coastal and subcoastal areas between Augusta and Carnarvon, including some on nearshore and offshore islands. They are scattered along the coast from south-west Pilbara to the north and east Kimberley region, near Wyndham. There are sparsely scattered inland records, especially in the Wheatbelt, from Lake Annean and Wittenoom. They are found in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley. The habitat within the development envelopes is relatively uniform and well represented in the surrounding area and is therefore unlikely to be significant habitat for Fork-tailed Swift breeding, feeding, migration or resting behaviour. The Fork-tailed Swift was also only identified as a regular migrant to the area and therefore the development envelopes are unlikely to contain an ecologically significant proportion of the population of this species.

12.7 PROPOSED SAFEGUARDS AND MITIGATION MEASURES

The proposed mitigation measures relevant to MNES are outlined in Table 72.

Table 72: Proposed mitigation measures relevant to MNES

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
Hydrological / Water Quality					
1.	Development envelopes designed to avoid key surface water features	The development envelopes have been designed to avoid the following: • Mining within drainage lines • Arrowsmith River • Arrowsmith Lake	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Construction	All
2.	Mining activities to avoid groundwater	The depth of mining has been limited so that all activities will occur above the water table.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Construction and Operation	All
3.	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 MFP, slurry and return water pipeline, processing plant and power station. These infrastructure 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: • Routinely inspect the condition and performance of pipelines, containment systems and internal drainage structures, to ensure they are in acceptable condition and / or operating appropriately; • The following controls will be implemented to minimise the risk of impact from unintentional slurry pipeline spills: o Pipeline will be fitted with leak detection; o Flows will be shut off if leaks are detected; o Pipeline will be inspected regularly, especially during extreme heat or fire events; o Pipeline will be located off access road surfaces to reduce the risk of vehicle collisions; o If the pipeline has to cross the access road then it will be buried; and o Investigations will be conducted into the cause of any spills, and remedial actions will be taken to minimise the chance of reoccurrence.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Construction and Operation	All
4.	Obtain and comply with a DG Licence issued under the DG Act.	The DG Licence is required if large volumes (<100,000 L) of hydrocarbons are to be stored on site. DG Licences set standards for storage and management of hydrocarbons to ensure any risk of contamination to end environment is minimised;	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Construction and Operation	All
5.	Implement measures to minimise the risk and impact of hydrocarbon spills	• Hydrocarbons will be stored either within a bunded area or within self-bunded tanks; • All spills will be controlled, contained and cleaned up as soon as practicable; • Service vehicles will be fitted with spill kits; • Spill kits will be located at all workshop and fuel storage areas; • Environmental incident recording, investigation and reporting system.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
6.	Incorporate gaps between VDT sod placements	This will reduce surface runoff velocity and promote infiltration, minimising the potential for erosion during significant rainfall events	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Construction and Operation	Mining areas
7.	Comply with WA 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	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
8.	Develop and implement a GOS.	A GOS is required to be prepared and implemented to support application under the RIWI Act to abstract groundwater. The GOS will include provisions for the management of abstraction of groundwater in line with VRX's groundwater allocation limits.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
Fauna					
1.	Implement industry best practice management measures for terrestrial fauna	• Vegetation clearing will be managed through internal ground disturbance procedures; • 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; • Progressive clearing will be undertaken; • The disturbance footprint will be developed to the minimum required to ensure safe and adequate construction and operation; • Water or dust suppressants will be applied to disturbed areas and product transfer/storage areas as required to minimise dust generation; • Emergency response capabilities will be maintained to prevent fire outbreaks where possible;	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All

Mitigation Number	Key Mitigation	Detail	Species Affected	Timing	Location
		• Weed and dieback hygiene and management measures / procedures will be implemented through the DMP to prevent spread of weeds / dieback and the introduction of new weed species as a result of construction and operation; • Any trenches will be dug with shallow interior slope angles or exit points to allow fauna escape; • Any trenches will be progressively opened and closed; • Fauna egress mechanisms will be installed at all trenches and turkeys nests / water ponds; • Any open trenches (if required) will be inspected less than two hours after sunrise for the presence of trapped fauna; • Training will be provided to ensure that fauna are not fed by site personnel; • Food wastes will be stored in bins that are not easily accessible to fauna; • Low noise equipment will be used where practicable; • All incidents resulting in fauna injury or death will be reported internally; • Vehicle speed limits will be set and enforced;			
2.	Obtain and comply with the following approvals	• Ministerial Statement to be issued under Part IV of the EP Act; • Works Approval(s) and Licence to be issued under Part V of the EP Act; • MP to be approved under the Mining Act; and • DG Licence issued under the DG Act if required.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
3.	Implement the Rehabilitation Strategy	The Rehabilitation Strategy is provided in Appendix 4 and will be implemented during VDT.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	Mining areas
4.	Prepare and implement a FMP	The FMP will include commitments to minimise the impacts to fauna habitat, and in particular Carnaby's Cockatoo foraging habitat, including: • Commitments to minimise habitat disturbance during construction and operations; • Minimum infill planting or seeding requirements for species utilised for Carnaby's Cockatoo foraging in VDT rehabilitation areas; • Annual monitoring of the rehabilitation success of VDT areas, in particular the species utilised for Carnaby's Cockatoo foraging; • Reporting and recording of Carnaby's Cockatoo and other significant fauna sightings; • Reporting of introduced fauna sightings within VDT areas; • Annual targeted fauna survey of VDT rehabilitation areas to assess the usage characteristics of these areas against baseline sites;	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
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.	Malleefowl	Construction and Operation	All
6.	Implement measures to minimise the risk and impact of hydrocarbon spills	• Hydrocarbons will be stored either within a bunded area or within self-bunded tanks; • All spills will be controlled, contained and cleaned up as soon as practicable; • Service vehicles will be fitted with spill kits; • Spill kits will be located at all workshop and fuel storage areas; • Environmental incident recording, investigation and reporting system.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
7.	Comply with WA 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	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	All
Rehabilitation					
1.	Implement the Rehabilitation Strategy	The Rehabilitation Strategy is provided in Appendix 4 and will be implemented during VDT.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	All phases	Mining areas
2.	Prepare and implement a MCP	At the completion of the Proposal the site will be further rehabilitated to reinstate the flora and vegetation of areas that were disturbed for the life of the Proposal. A MCP will be required under the Mining Act and the key rehabilitation measures that relate to flora and vegetation are summarised below: • All infrastructure will be removed from site; • All long-term disturbance areas 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 or dieback introduction; • Threatened Flora may be included in the rehabilitation seed mix if recorded and suitable; and • All depressions will be shaped to prevent the formation of new semi-permanent water sources. The MCP will be submitted to DMIRS for assessment and approval prior to the construction of the Proposal and will be reviewed and revised at least every three years.	Carnaby's Cockatoo Malleefowl Fork-tailed Swift	Closure	All

12.8 SUMMARY OF MNES IMPACTS

Table 73 summarises the key impacts to MNES.

Table 73: Summary of MNES impacts

Listed threatened species and communities (sections 18 & 18A)	Recovery Plan	Threat Abatement Plan	ACA	Listing advice	Bioregional Plan	Survey Guidelines	Other references	References	Adequate survey/abundance	Impact	Avoidance	Mitigation	Residual	Offset
Carnaby's Cockatoo (*Zanda latirostris*) - Endangered	DPAW (2013a)	None	None	None	N/A	DEWAH (2010)	DSEWPaC (2012b) DotEE (2017c)	BCE (2022)	Surveys conducted in accordance with guidelines. Two flocks observed flying over the BCE (2022) Survey Area. Three Carnaby's Cockatoo roost sites have been confirmed and one is suspected within proximity of the BCE (2022) Survey Area. The Survey Area is unlikely to support breeding by Carnaby's Cockatoos. There are no large trees (trees of sufficient size to provide nesting hollows) in the mine portion of the Survey Area,	Up to 14.5 ha of medium to high value foraging habitat clearing to remain cleared for the life of the Proposal Clearing and progressive rehabilitation of up to 339.3 ha of moderate to high value foraging habitat. No roosting or breeding habitat will be impacted as a result of the Proposal.	Ecological studies around the Proposal, including a Detailed fauna assessment by BCE (2022) were used to inform the design of the Proposal, specifically the design of the development envelopes, to avoid almost all of the constrained VSA2 (Dense riparian thickets) fauna habitat.	Prepare and implement the Rehabilitation Strategy. Prepare and implement a FMP. Implement measures listed in Section 5.6.2 to minimise potential slurry and hydrocarbon spills.	Clearing for the life of the Proposal (plus 10 years before quality is reinstated) of 14.5 ha of moderate to high value foraging habitat. Loss of 339.3 ha of moderate to high value foraging habitat for a period of 10 years.	Proposed offset area of 1,367.1 ha portion of M 70/1389. The offset area contains large areas of native vegetation in Excellent to Pristine condition that is representative of moderate to high value foraging habitat.
Fork-Tailed Swift (*Apus pacificus*) – Marine; Migratory	None	Cats (DotE, 2015b)	None	None	N/A	N/A	DotE (2015a) DotE (2015c)	BCE (2022)	Surveys conducted in accordance with guidelines. Not recorded within the BCE (2022) survey area although expected to be an irregular visitor of the Proposal area.				Clearing of 353.8 ha of vegetation association 378.1, which has 65.0 % of its pre-European extent remaining. The Proposal will disturb 0.44 % of the remaining vegetation association, or 0.28 % of the pre-European extent. 28,656,5 ha of native fauna habitat remains within 10 km of the Proposal, 58,621.2 within 15 km and 90,125.7 ha within 20 km.	None proposed.
Malleefowl (*Leipoa ocellata*) – Vulnerable	Benshemesh, J (2007)	Cats (DotE, 2015b) Rabbits (DotEE, 2016b) Feral pigs (DotEE, 2017b) Red Fox (DEWHA, 2008b) Goats (DEWHA, 2008c)	None	None	N/A	DEWAH (2010)		BCE (2022)	Surveys conducted in accordance with guidelines. Not recorded within the BCE (2022) survey area, although the Storr-Johnstone Bird Databank (R. Johnstone, pers comm.) has records of disused mounds of the Malleefowl 10km south of Eneabba (c.50km south of the Survey Area) and at a location along the Arrowsmith River about 10km south of the Survey Area. The latter was of two mounds found in 2008, with one described as 'fairly new'. The two disused mounds were in acacia shrubland and such vegetation associated with the Arrowsmith River is the most likely environment in the broader region to provide habitat for the Malleefowl.	Up to 14.5 ha of habitat clearing to remain cleared for the life of the Proposal Up to 339.3 ha of habitat clearing to be rehabilitated progressively via VDT Disturbance of mounds (if developed in the future) or death or injury due to vehicle strike or earthmoving equipment		Prepare and implement the Rehabilitation Strategy. Prepare and implement a FMP. Conduct pre-clearance surveys for active Malleefowl mounds. Implement measures listed in Section 5.6.2 to minimise potential slurry and hydrocarbon spills.	Clearing of up to 353.8 ha of potential Malleefowl habitat, representing 1.2 % of native fauna habitat within 10 km of the Proposal.	None proposed.

12.9 Principles of Ecologically Sustainable Development

Table 74 assesses the Proposal against the principles of ecologically sustainable development listed in Section 3A of the EPBC Act.

Table 74: Assessment against the principles of ecologically sustainable development

Principle	Assessment
(a) decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations	The Proposal is a long-term project that provides silica sand to support the ongoing increase in demand for glass. The environmental and social impacts associated with the Proposal are incremental (progressive clearing and rehabilitation), meaning that short-term impacts are minor and only increase slowly.
(b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	While VRX has commissioned numerous ecological studies in order to inform the design of the Proposal, and there are several examples where measures have been taken to prevent environmental degradation, such as: • Removal of areas of significant flora and vegetation from the development envelopes; • Transporting ore as a slurry through a pipeline to avoid potential impacts to the environment caused by manual transport; • Restricting mining to above the water table only; • Finding a market for the tailings to remove the requirement for onsite disposal; and • Limited requirement for chemicals in the processing of the ore (only an environmentally sensitive, biodegradable flocculant will be required).
I the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	As stated above, the Proposal is a long-term project that provides silica sand to support the ongoing increase in demand for glass for future generations. The Proposal includes rehabilitation commitments and techniques specifically designed to ensure the health, diversity and productivity of the environment is progressively reinstated close to background levels over time.
(d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	The conservation of biological diversity and ecological integrity was a fundamental consideration in decision-making when determining the mining and rehabilitation method for the Proposal, as well as the location of the initial mining areas and access road.
I improved valuation, pricing and incentive mechanisms should be promoted	The Proposal is a long-term project that provides silica sand to support the ongoing increase in demand for glass. The silica sand deposit is high-grade, and allows VRX to target high-quality glass markets (such as the solar panel market) as demand increases, improving the valuation of the product.

12.10 Economic Impacts of the Proposal

The Bankable Feasibility Study for the Proposal identified that the Proposal earnings (before interest, taxes, depreciation, and amortization) are predicted to be $15 – 20 million per year, resulting in $1 – 2 million in royalties paid each year. The Proposal is predicted to employ up to 60 personnel during construction and up to 25 personnel during operations.

13 HOLISTIC IMPACT ASSESSMENT

For each relevant Key Environmental Factor, the ERD provides a detailed assessment of the potential impacts associated with the Proposal, application of the mitigation hierarchy and the management strategies proposed. The Key Environmental Factors relevant to the Proposal include:

- Flora and Vegetation;
- Terrestrial Fauna;
- Inland Waters;
- Social Surroundings;
- Greenhouse Gas Emissions; and
- Air Quality.

Each relevant Key Environmental Factor has been assessed separately in Sections 5 – 10. Linkages of varying strengths exist between the relevant Key Environmental Factors. The potential impacts of the Proposal have been considered in a holistic context and a conceptual model demonstrating links between key environmental factors is provided in Figure 89. A linkage is considered to be present if any two Key Environmental Factors share the same impact. The strength of the links are based on the significance of the impact and the interconnectivity of each Key Environmental Factor with another. Linkages are represented by lines, strong linkages are shown as solid black lines and weaker linkages are represented by grey dotted lines.

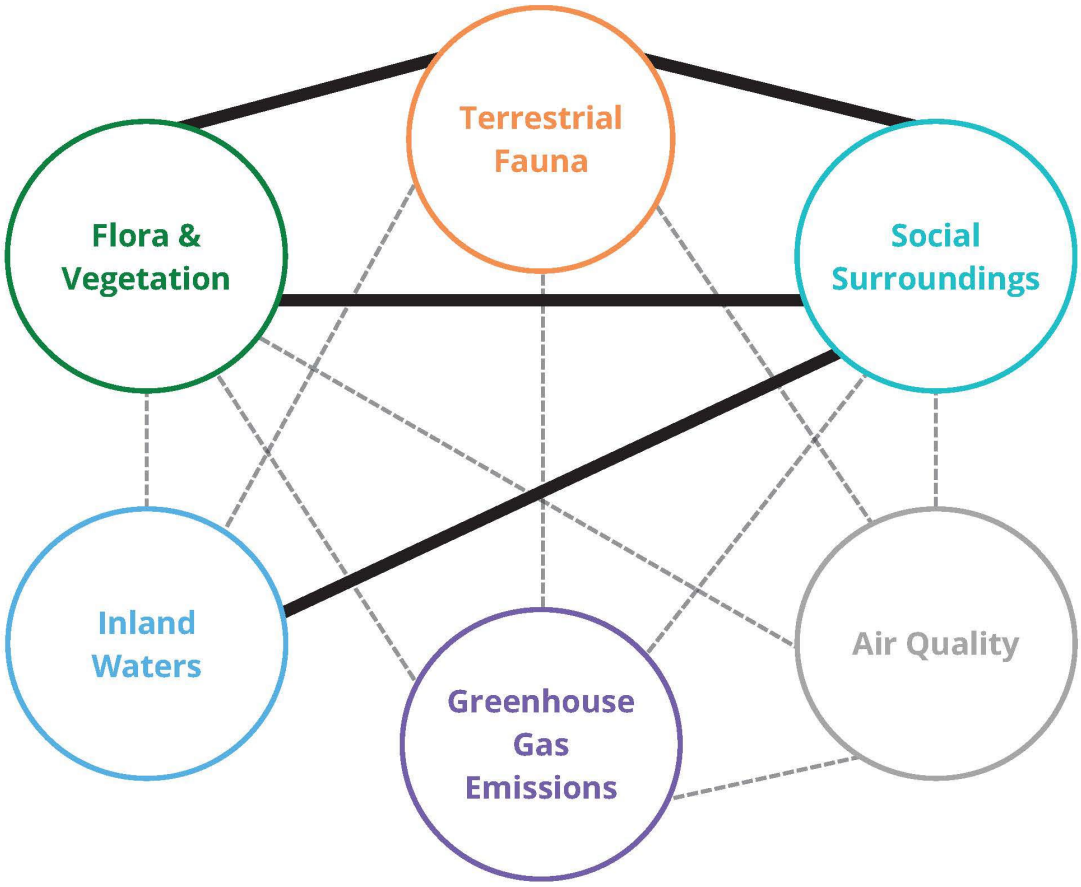


Figure 89: Conceptual model of linkages between Key Environmental Factors

Potential overarching impacts relevant to each Key Environmental Factor have been summarised in Table 75. While many potential impacts are shared between multiple factors, key impacts (those which have been identified as creating a strong linkage) have been identified with red ticks.

Table 75: Potential impacts shared by key environmental factors

Key Environmental Factor	Relevant Potential Impacts						
	Clearing	Dieback/ Weeds	Groundwater Abstraction	Contamination	Dust Emissions	Air Emissions	Noise
Flora & Vegetation	✓	✓	✓	✓	✓		
Terrestrial Fauna	✓	✓	✓	✓	✓		✓
Inland Waters	✓		✓	✓			
Social Surroundings	✓	✓	✓	✓	✓		✓
Greenhouse Gas Emissions	✓					✓	
Air Quality	✓				✓	✓	

Clearing of native vegetation is identified as a key impact as it will directly impact three Key environmental factors. Clearing will impact the Flora and Vegetation and Terrestrial Fauna key environmental factors by removing or disturbing significant flora species and reducing the quality and availability of significant flora and fauna habitat. Clearing will also impact the Social Surroundings factor by reducing the quality and availability of vegetation that may otherwise be used by Yamatji People for bush tucker or bush medicine. VRX also acknowledges that native vegetation values are related to the availability of faunal and botanical resources and represents a connection to Country.

While not a direct impact, the introduction and spread of dieback and weeds has the potential to impact three key environmental factors and therefore has also been considered as a key impact. Introduction and spread of dieback and weeds has the potential to impact the Flora and Vegetation and Terrestrial Fauna key environmental factors through mortality (flora) and a reduction in habitat extent and quality (flora and fauna). The introduction of dieback and weeds also impacts the Social Surroundings key environmental factor as it has the potential to result in plant deaths and a reduction in the quality and extent of native vegetation on Yamatji Country, including those that may be used for bush medicine or bush tucker.

The Proposal is not predicted to result in a significant impact to groundwater as abstraction only targets the deeper Yarragadee aquifer. Regardless, groundwater abstraction has been identified as a key impact due to the significance of the linkage between the Inland Waters and Social Surroundings key environmental factors. Generally, water is recognised as being of high importance to Traditional Owners typically through mythological associations (such as the *Bimarra* in the case of the Arrowsmith River; Section 8.3.4), significance in song lines and represents a connection to Country.

VRX acknowledges that other impacts of the Proposal (contamination, dust and air emissions, and noise) provide linkages between the other key environmental factors however these impacts are unlikely to be significant and therefore linkages are not considered to be as strong as the others

mentioned above. All linkages have been considered in the design of the Proposal, application of the mitigation hierarchy and proposed management measures.

The Proposal is a long-term project that allows gradual small-scale annual impacts and progressive rehabilitation, in contrast to mining projects that require large areas to be cleared up-front and remain cleared for the entire mine-life.

The Proposal lies within the Geraldton Sandplains Bioregion, an area noted for its biological diversity, and in some areas, it is under pressure from land clearing. The Proposal also occurs within the range of the Carnaby's Cockatoo (Endangered; BC Act and EPBC Act), and several significant flora species were identified within the survey areas. The Proposal has unavoidable impacts associated with vegetation clearing and habitat loss, therefore it was imperative that these impacts were avoided and minimised as far as practicable, and rehabilitation methods were best-practice.

Given the above, VRX 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 up to 366.5 ha of native vegetation that was moderate to high value Carnaby's Cockatoo foraging habitat. VRX has since reduced the extent of the Mine Development Envelope to exclude Priority Flora populations as much as practicable, and as a result the extent of clearing of Carnaby's Cockatoo has been reduced by 12.7 ha to 353.8 ha.

In addition to the above, VRX has incorporated extensive avoidance and minimisation measures into the Proposal design and operational processes, the key measures being:

- The adoption of a progressive mining and immediate rehabilitation approach;
- The use of VDT as a rehabilitation method;
- The mining of a raised dune system, to avoid leaving an excavation at closure;
- The avoidance of riparian and drainage areas to the west of the Mine Development Envelope;
- Revising the Mine Development Envelope to avoid Priority Flora populations;
- Revising the Access Development Envelope to avoid the Arrowsmith River Registered Heritage site; and
- The use of existing cleared areas where available (access corridor).

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:

- Slurry spills and leaks and process plant emissions will be regulated under Part V of the EP Act;
- Mine pit 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 permanent and temporary disturbance within each development envelope;
- A limit on groundwater abstraction volumes;

- The implementation of the Rehabilitation Strategy to ensure that VDT and other rehabilitation impacts on flora and vegetation and fauna habitat are minimised as far as practicable;
- The implementation of a FMP to ensure that impacts on terrestrial fauna habitats (in particular Carnaby's Cockatoo foraging habitat) are strictly monitored and managed to provide the best possible habitat quality during rehabilitation; and
- The implementation of an Offset Strategy.

Based on the above, and the assessment provided in Sections 5 - 10, the Proposal is expected to be able to meet the EPA's objectives for all potential key environmental factors, with the exception of Terrestrial Fauna.

Residual impacts to Carnaby's Cockatoo foraging habitat are considered to remain significant once mitigation measures are implemented. Offset measures are required to counterbalance these residual impacts to ensure that the EPA objective for Terrestrial Fauna can be met. VRX has proposed offsets and assessed the suitability of the offset against the WA and EPBC offset guidance, provided in Section 11. Specifics of these offset measures will be reviewed and refined during the development of an Offsets Strategy (expected to be a Ministerial Condition) through discussions with DMIRS, DBCA, DAWE and EPA Services to ensure they meet the required outcomes and adequately counterbalance the residual impacts.

VRX considers that the residual impacts to Carnaby's Cockatoo foraging habitat is able to be counterbalanced by the implementation of the offsets detailed in Section 11, such that the EPA's objectives are able to be met for all Key Environmental Factors.

14 CUMULATIVE ENVIRONMENTAL IMPACT ASSESSMENT

VRX conducted an assessment of the potential and residual environmental impacts for each Key Environmental Factor relevant to the Proposal. A cumulative EIA was included to assess the successive, incremental and interactive impacts of the Proposal on the environment in addition to impacts from past, present and reasonably foreseeable future activities. The results of this assessment are summarised in the following sections. Impacts to Inland Waters, Social Surroundings, Greenhouse Gas Emissions and Air quality were not considered significant in a cumulative context therefore they have not been included in the summary.

Eight other operational or planned proposals in close proximity to the Proposal were considered relevant for assessing the cumulative impacts of the Proposal. These proposals are summarised in Table 76 and shown in Figure 90.

Table 76: Other projects in proximity to the Proposal that are relevant for cumulative impact assessment

Proponent	Project	Status	Distance and origination from the Proposal
Beach Energy / AWE Limited	Beharra Springs Gas Plant	Operational	7 km northeast
Hudson Diatomaceous Earth	Dongara Project	Proposed	16 km north
Infinite Green Energy	Arrowsmith Hydrogen Project	Proposed	4.2 km southwest
Perpetual Resources	Arrowsmith West	Proposed	2.6 km southwest
	Beharra Silica	Proposed	4.7 km northeast
	Beharra West	Proposed	3.6 km northwest
	Eneabba North	Proposed	19 km southeast
Strike and Warrego Energy	West Erregulla Gas Plant	Proposed	23 km northeast
VRX	Arrowsmith Central Project	Proposed	20 km southeast

14.1 CLEARING OF NATIVE VEGETATION / HABITAT

Clearing of native vegetation and habitat is the primary impact from the Proposal on Flora and Vegetation and Terrestrial Fauna. Impacts from the Proposal are considered to be relatively small and include:

- 0.4% of the remaining native vegetation within 20 km;
- 0.44% of the current pre-European extent of Vegetation Association 378.1;
- Less than 46% of any local vegetation community;
- Avoiding >95% of records for three Priority Flora species and greater than 49% of all other Priority Flora recorded within the Survey Areas; and
- Less than 22% of mapped local moderate – high value Carnaby's Cockatoo foraging habitat.

VRX has assessed the impacts of the Proposal against potential and existing cumulative impacts of other proposals in close proximity to the Proposal. VRX has identified six projects within 20 km of the Proposal that may have a cumulative impact on the extent of native vegetation (Figure 90). The majority of the projects are proposed and therefore the extent of clearing required for each has not yet been quantified. As most (four) projects are for silica sand mining, VRX assumes these projects will be similar in size and scope to the Proposal (with the exception of the Perpetual Resources Beharra Silica project that is proposed to clear approximately 600 ha; Perpetual Resources Limited, 2022) and will require approximately 450 ha of native vegetation clearing each. A green energy project has also been referred to the EPA (Infinite Green Energy Arrowsmith Hydrogen Project; Assessment Number: 2345) that will require clearing of approximately 140 ha of native vegetation. Based on this assumption, the cumulative native vegetation clearing of all projects is estimated to be:

- Up to 2,990 ha or only 3.3% of the remaining native vegetation extent within 20 km of the Proposal;
- Up to 2,540 ha or only 4.3% of the remaining native vegetation extent within 15 km of the Proposal; and
- Up to 2,540 ha or only 8.9% of the remaining native vegetation extent within 10 km of the Proposal.

This estimate is expected to be conservative due to the following reasons:

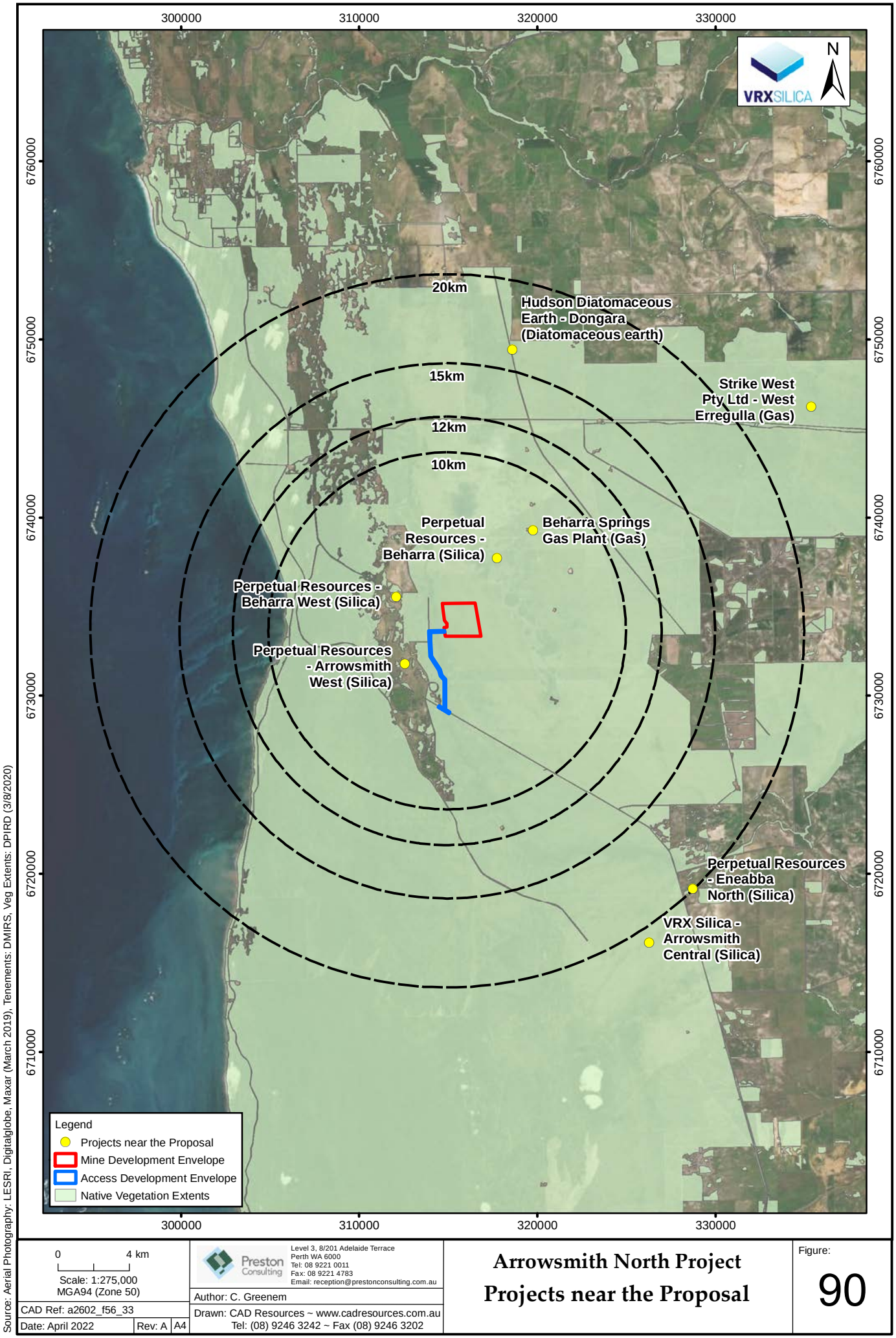
- Not all projects will be viable and proceed through to development; and
- The Beharra Springs Gas plant has only resulted in approximately 50 ha of clearing.

These projects are also expected to occur within the Eridoon (378.1) Vegetation Association which has 65% of its pre-European extent remaining (80,734.1 ha). No significant planned proposals have been identified within this vegetation association that would reduce the current extent by more than a few percent (the Proposal will result in only a 0.44% reduction in comparison).

Five projects have been identified within 12 km (the expected foraging range of local Carnaby's Cockatoo) of the Proposal. Using the same methodology above (450 ha of clearing required for three projects, 600 ha for the Beharra silica project and 140 ha for the Arrowsmith Hydrogen Project) it is assumed there could be a cumulative impact of up to 2,090 ha of native vegetation clearing (assuming all proposals proceed). It is impossible to determine what percentage of the remaining vegetation would be considered foraging habitat, however it is reasonable to assume that the percentage within the potential impact areas is similar to that elsewhere. Based on this assumption, the cumulative impact is expected to result in a reduction of available Carnaby's Cockatoo foraging habitat by approximately 4.7%.

VRX will implement offsets to counteract the residual impact of the Proposal on significant fauna habitat (Section 11) which will include protecting a significant portion of native vegetation from development for 30 years. The Proposal includes progressive rehabilitation of mined land. At the end of the Proposal it is anticipated that 219.5 ha of land will be fully rehabilitated, with an additional 134.5 ha to be completed ten years later.

Based on the above, VRX considers that the implementation of the Proposal is not expected to significantly contribute to the cumulative impacts on Flora and Vegetation or Terrestrial Fauna.



Source: Aerial Photography: LESRI, Digitalglobe, Maxar (March 2019), Tenements: DMIRS, Veg Extents: DPIRD (3/8/2020)

0 4 km
Scale: 1:275,000
MGA94 (Zone 50)

CAD Ref: a2602_f56_33
Date: April 2022 | Rev: A | A4

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Arrowsmith North Project
Projects near the Proposal

Figure: 90

Figure 90: Current and planned proposals potentially impacting native vegetation within 20 km of the Proposal

14.2 ABSTRACTION OF GROUNDWATER FROM THE YARRAGADEE AQUIFER

The Proposal will require the abstraction of 0.9 GL of water per annum from the Yarragadee aquifer. The Yarragadee Aquifer within the Dongara subarea has a groundwater abstraction allocation limit of 4.5 GL, therefore a 0.9 GL increase in abstraction represents approximately 20 % of the total groundwater allocation.

VRX has reviewed the licences allocated to current local groundwater users. There are four active groundwater licences provided by DWER under the RIWI Act that are within close proximity to the Proposal that target the Dongara subarea, the cumulative potential abstraction rate of these licences and the proposed abstraction from VRX is currently 1.4 GL per annum.

VRX has also identified likely local groundwater users in close proximity to the Proposal. Within 20 km of the Proposal, there are three other projects that are likely to target groundwater from the Yarragadee within the Dongara subarea (Perpetual Resources' projects Beharra and Beharra West, and the Infinite Blue Energy Arrowsmith Hydrogen Project). The Perpetual resources Projects may be smaller in size and scope to the Proposal (noting that the Beharra project is proposed to produce 1.5 Mtpa; 0.5 Mtpa less than the Proposal) however for simplicity and to ensure a conservative assessment, VRX has assumed that these projects will also require 0.9 GL / annum each. The Infinite Blue Energy Arrowsmith Hydrogen Project is proposed to abstract approximately 0.85GL / annum. Assuming all proposals proceed at the same time (conservative assumption) the total cumulative impact would be up to 4.05 GL/ annum or 90 % of the allocation limit for the Dongara subarea. Cumulative impacts are within the allocated limit for this subarea and therefore unlikely to be significant.

GLOSSARY

Term	Meaning
µm	Micro siemens
221 Cy	Correy System
221 Ta	Tamala South System
4WD	Four wheel drive
ABA	Acid Base Accounting
ACA	Approved Conservation Advice
ACH Act	*Aboriginal Cultural Heritage Act 2021* (WA)
ACMC	Aboriginal Cultural Material Committee
AEP	Average Exceedance Probabilities
AH Act	*Aboriginal Heritage Act 1972 (WA)*
AHIS	Aboriginal Heritage Inquiry System
AMIRA	Australian Mineral Industries Research Association
ARI	Average Recurrence Intervals
ARU	Audio Recording Unit
ASS	Acid Sulphate Soils
AUD	Australian Dollar
BC Act	*Biodiversity Conservation Act 2016* (WA)
BCE	Bamford Consulting Ecologists
BMCB	Brian Morgan Consultant Botanist
BoM	Bureau of Meteorology
CALM	Conservation and Land Management
CH_4	Methane
CITES	Convention on International Trade of Endangered Species
cm	Centimetre
CO	Carbon Monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CS Act	*Contaminated Sites Act 2003* (WA)
Cth	Commonwealth
DAWE	Department of Agriculture, Water and the Environment
dB(A)	Decibels A
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEM	Dust Extinction Moisture
DEWHA	Department of Environment, Water, Heritage and the Arts (now DotEE)

Term	Meaning
DG	Dangerous Goods
DG Act	*Dangerous Goods Safety Act 2004* (WA)
DISER	Department of Industry, Science, Energy and Resources
DJTSI	Department of Jobs, Tourism, Science and Innovation (WA)
DMIRS	Department of Mines, Industry Regulation and Safety (WA)
DMP	Dieback Management Plan
DoT	Department of Transport (WA)
DotE	Department of the Environment (now DCCEEW)
DotEE	Department of the Environment and Energy (now DCCEEW)
DoW	Department of Water (WA), now DWER
DpaW	Department of Parks and Wildlife (WA)
DPC	Department of the Premier and Cabinet (WA)
DPIRD	Department of Primary Industries and Regional Development (WA)
DPLH	Department of Planning, Lands and Heritage (WA)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Commonwealth), (now DCCEEW)
DWER	Department of Water and Environmental Regulation
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERD	Environmental Review Document
ESD	Environmental Scoping Document
ETA	Environmental Technologies & Analytics
F	Foraging
FEL	Front End Loader
FEM047	Phytophthora Dieback Interpreter's Manual for Lands Managed by the Department
FMP	Fauna Management Plan
FNA	File Notation Area
FullCAM	Full Carbon Accounting Model
GHG	Greenhouse Gas
GL	Gigalitre
GL/yr	Gigalitre per year
Glevan	Glevan Consulting Pty Ltd
GOS	Groundwater Operating Strategy

Term	Meaning
GPS	Global Positioning System
GWP	Global warming potential
H'	Shannon-Weiner diversity indices
ha	hectares
Horizon Heritage	Horizon Heritage Management Pty Ltd
HydroConcept	HydroConcept Pty Ltd
IBRA	Interim Biogeographic Regionalisation for Australia
IBSA	Index of Biodiversity Surveys for Assessments
ILUA	Indigenous Land Use Agreement
KBPL	Kewan Bond Pty Ltd
km	kilometres
Km^2	Square kilometres
L	Litter collection
LAA	*Land Administration Act 1997* (WA)
m	Metres
m AHD	Australian Height Datum
m BGL	Meters Below Ground Level
m RL	Meters Reduced Level
M^2	Square metres
M^3	Cubic metres
Marsh	Daniel Marsh Botanical Consulting
Mattiske	Mattiske Consulting Pty Ltd
MCP	Mine Closure Plan
MFP	Mine Feed Plant
mg/L	Milligrams per Litre
Mining Act	*Mining Act 1978* (WA)
MLA	Member of the Legislative Assembly
mm	millimetres
MNES	Matters of National Environmental Significance
MP	Mining Proposal
Mt	Million tonnes
Mtpa	Million tonnes per annum
MW	Megawatts
MWDC	Mid-West Development Commission
MWM	Mine Waste Management
N_2O	Nitrous oxide

Term	Meaning
NEPC	National Environment Protection Council
NGER	National Greenhouse and Energy Reporting
NHT	National Heritage Trust
NO_2	Nitrogen dioxide
NOx	Nitrous oxides
NSHA	Noongar Standard Heritage Agreement
NSW	New South Wales
OEHHA	(Californian) Office of Environmental health Hazard Assessment
OHP	Other heritage places
P1	Priority 1; as listed under the *Biodiversity Conservation Act 2016* (WA)
P2	Priority 2; as listed under the *Biodiversity Conservation Act 2016* (WA)
P3	Priority 3; as listed under the *Biodiversity Conservation Act 2016* (WA)
P4	Priority 4; as listed under the *Biodiversity Conservation Act 2016* (WA)
PEC	Priority Ecological Communities – plant communities listed as being potentially threatened under the *Biodiversity Conservation Act 2016*
PER	Public Environment Report
PM	Particulate Matter
Proposal	Arrowsmith North Silica Sand Project
PSD	Particle Size Distribution
R	Reserve
RCS	Respirable Crystalline Silica
RIWI Act	*Rights in Water Irrigation Act 1914*
RL	Relative Level
RNE	Register of the National Estate
RPS	RPS Group
S43A	Section 43A of the *Environmental Protection Act 1986* (WA)
SandS CRM	Sticks and Stones Cultural Resources Management
SCC	State Conservation Code
SEM	Scanning electron microscope
SF_6	Sulphur hexafluoride
SFMP	Significant Flora Management Plan
SiO_2	Silicon dioxide
SO_2	Sulphur dioxide
SRE	Short-range Endemic
SRTM	Shuttle Radar Topography Mission
SweRF	Size-weighted respirable fraction
SWWASY	South-west Western Australia Sustainable Yields

Term	Meaning
t	tonnes
T	Threatened
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*
Tr	Wet trapping
TSP	Total suspended particles
TSSC	Threatened Species Scientific Committee
UCL	Unallocated Crown Land
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
VDT	Vegetation Direct Transfer
VRX	VRX Silica Limited
VSA	Vegetation and Substrate Association
VSA1	Kwongan Heath
VSA2	Riparian Thickets
VSA3	Open Woodland
VSA4	*E. erythrocorys* low woodland
VSA5	*E. drummondii* malee
VSA6	Cleared Land
WA	Western Australia
WAC	Work Area Clearance
WAH	Western Australian Herbarium
WAM	Western Australia Museum
Water Direct	Water Direct Pty Ltd
WoNS	Weeds of National Significance
XRD	X-ray diffraction
YGSHA	Yamatji Government Standard heritage Agreements
YMAC	Yamatji Marlpa Aboriginal Corporation

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