Perpetual
RESOURCES LIMITED

BEHARRA SILICA SAND PROJECT

Native Vegetation Clearing Permit (Purpose Permit)

Supporting Document

JUNE 2022

Prepared by

TETRIS ENVIRONMENTAL

Document Details

Proposal Title:	Beharra Silica Sand Project
Proponent Name:	Perpetual Resources Ltd (ASX: PEC)
Document Type:	Native Vegetation Clearing Permit Supporting Document

Authority

I hereby certify that; this document has been prepared by Tetris Environmental Pty Ltd on behalf of Perpetual Resources Ltd and accurately reflects the intention of the Beharra Silica Sand Project.

Signed: 

Name: Robert Benussi, Managing Director, Perpetual Resources Limited

Date: 22 June 2022

Document Control

Document No.	Version	Reason for Issue	Date	Author	Review/Approved
Beharra NVCP 20220601	1	Draft for internal review	7/6/2022	Tetris Environmental Pty Ltd	Tetris Environmental Pty Ltd
Beharra NVCP 20220608	2	Draft for PEC review	9/6/2022	Tetris Environmental Pty Ltd	Perpetual Resources Ltd
Beharra NVCP 20220622	0	Final	22/6/2022	Tetris Environmental Pty Ltd	Perpetual Resources Ltd

Glossary

Acronym / Unit	Description
AH Act	*Aboriginal Heritage Act 1972*
BAM Act	*Biosecurity and Agriculture Management Act 2007*
BC Act	*Biodiversity Conservation Act 2016*
CALM Act	*Conservation and Land Management Act 1984*
DGS Act	*Dangerous Goods Safety Act 2004*
DMIRS	Department of Mines, Industry Regulation and Safety
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GLpa	Gigalitres per annum
ha	Hectares
km	Kilometre(s)
km^2	Square kilometres
LOM	Life of mine
m^3	Cubic metres
mbgl	Meters below ground level
Mining Act	*Mining Act 1978*
mm	Millimetres
Mt	Million tonnes
Mtpa	Million tonnes per annum
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
PEC	Perpetual Resources Limited
PFS	Prefeasibility study
ROM	Run of mine
SiO_2	Silicon dioxide
TiO_2	Titanium dioxide
WA	Western Australia

TABLE OF CONTENTS

Index of Tables

Index of Figures

1. INTRODUCTION

Perpetual Resources Limited (PEC) is proposing to develop the Beharra Silica Sand Project (the Proposal), a silica sand operation approximately 300 km north of Perth, 96 km south of the port town of Geraldton and 25 km southeast of Dongara in the Shire of Irwin in Western Australia (Figure 1-1). The Proposal is expected to generate a >99.5%+ SiO_2 purity silica sand product at a production rate of nominally 1.5 Million tonnes per annum (Mtpa).

1.1 Document Purpose

Approval to clear native vegetation for the Proposal is being sought under Part V Division 2 of the *Environmental Protection Act 1986* (EP Act) and *Environmental Protection* (Clearing of Native Vegetation) *Regulations 2004*.

This document serves to provide supplementary information in support of the native vegetation clearing assessment process (Purpose Permit) and has been prepared in accordance with the "Guideline – Native Vegetation Clearing Referrals: Native Vegetation Clearing Activities Regulated under the *Environmental Protection Act 1986* and *Environmental Protection* (Clearing of Native Vegetation) *Regulations 2004* (DWER 2021).

The Proposal will also be referred separately to the Minister for the Environment under the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC Act).

1.2 Proponent

The proponent of the Proposal is:

Perpetual Resources Limited (ASX: PEC)

223 Liverpool St, Darlinghurst, NSW, 2010

The application contact on behalf of the proponent is:

James Hesford (Principal Advisor), Tetris Environmental Pty Ltd

Email: James.H@pecsilica.com.au

1.3 Proposal Tenure

The land tenure of the Proposal is classified as Unallocated Crown Land (Type 3 V), over which the Proposal is covered by tenements issued under the *Mining Act 1978* and held by PEC Tenement descriptions are outlined in Table 1-1 and presented in Figure 1-2. Tenement summary reports for these tenements is provided in Appendix 1.

Table 1-1 Proposal Tenements

Tenement	Holder(s)	Grant date	End date	Area (ha)
M 70/1406	Perpetual Resources Limited	18/06/2021	17/06/2042	1,035.2 ha
L 70/219	Perpetual Resources Limited	18/11/2020	17/11/2041	1,036.1 ha

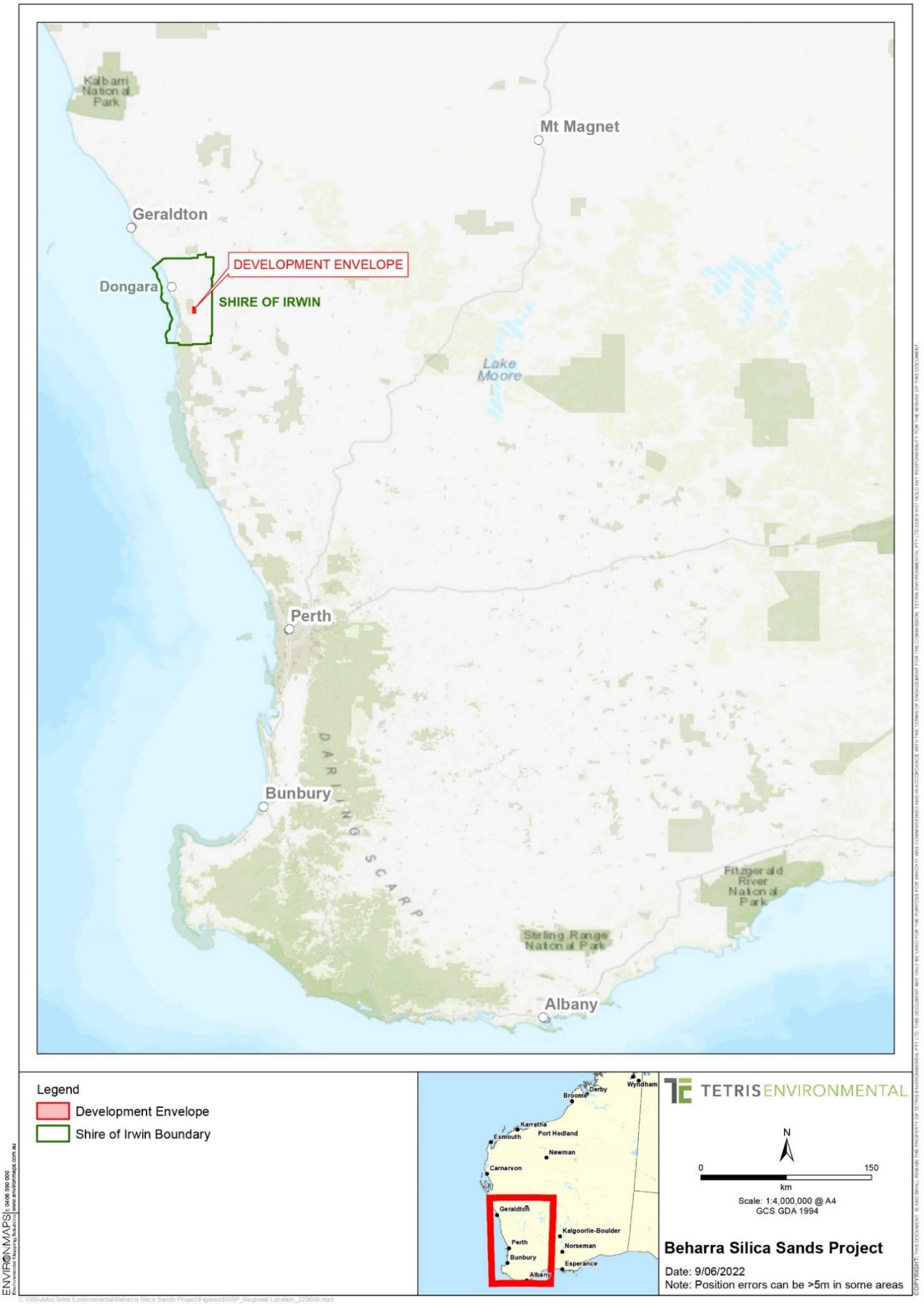

Figure 1-1 Proposal Location

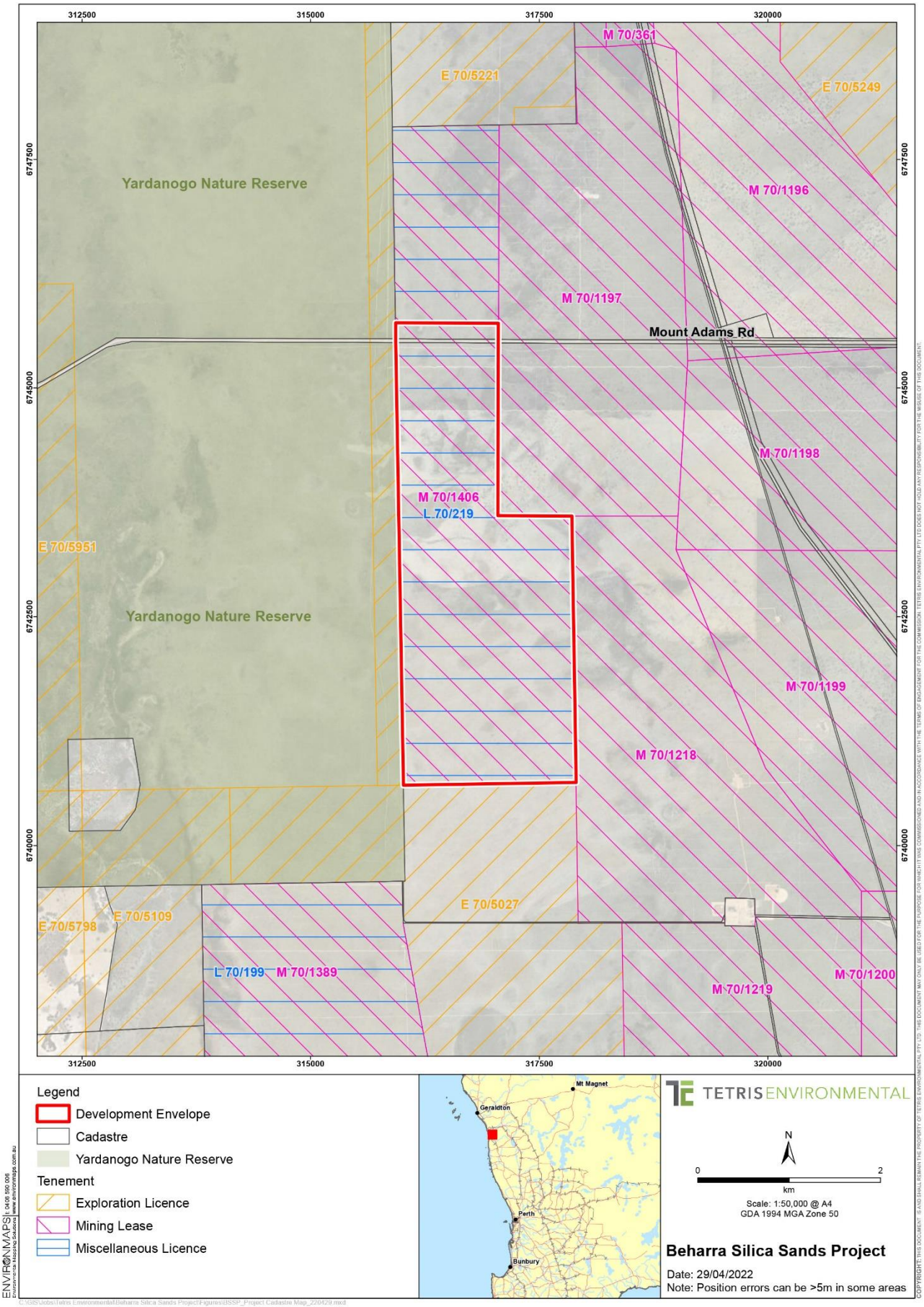

Figure 1-2 Land Tenure

2. PROPOSAL DESCRIPTION

The Proposal will require a clearing up to 586 ha (Footprint) within a 788 ha Application Area (hereafter referred to as the Development Envelope) over a 32 year life of mine (LOM). The Footprint will comprise ~550 ha mine pit area, ~30 ha processing and mine infrastructure (including administration, workshops, laydown areas, processing plant and product stockpiles) and ~6 ha mine haul/access road. Up to 100 ha will be cleared in the first two years and then incrementally at an annual rate of up to 15 to 20 ha over approximately 30 years.

A map of the Proposal and the proposed Development Envelope is presented in Figure 2-1.

The Proposal is based on the production of 50 Mt of high-grade silica sand (>99.6% SiO_2) over the LOM. Proposal start-up is envisaged for late 2023 with a run of mine (ROM) production rate of 2.0 Mtpa producing nominally 1.5 Mtpa of high grade silica sand product for export.

The water table is relatively shallow, between 7 to 10 m below ground level (mbgl). Mining has been designed to remain above the water table.

The Proposal will require up to 0.56 GLpa of groundwater, abstracted from Eneabba Plains Groundwater Reserve for mining and processing operations via a lease arrangement with the Southern Yamatji Regional Corporation.

The mine area has been split into four mining panels based on a grouping sequence aimed at accessing higher grade material first, whilst minimising haul distance and road development (Figure 2-2). Each mining panel is further subdivided into 24 mine cells, each of which is approximately 4-5 ha in size. Up to four cells will be mined on an annual basis.

Systematic mining within small mine cells will ensure that only discrete pockets of vegetation are cleared at one time and rehabilitation is progressive on an annual basis commencing in year 3, following the completion of each small mine cell. Each year PEC plan to mine and progressively rehabilitate four mine cells, representing up to 20 ha of open mine pit, with all previous mined cells under varying stages of rehabilitation.

Extraction will be based on a bulk mining approach using a conventional truck and shovel mining system, which will deliver ROM feed to a primary screening and magnetic separation plant. Following processing, the final product will be dewatered and stockpiled. A rejects stream will be generated from the processing and will comprise of a sand/clay material with approximately 10% moisture content. This will be returned to the pre-mined pit floor and pit batters for use in rehabilitation.

The final product will be transported from site via articulated road train's utilising the Mt Adam's Road and Brand Highway to the Port of Geraldton for export to overseas markets in China and Japan.

The key elements of the Proposal are further described below.

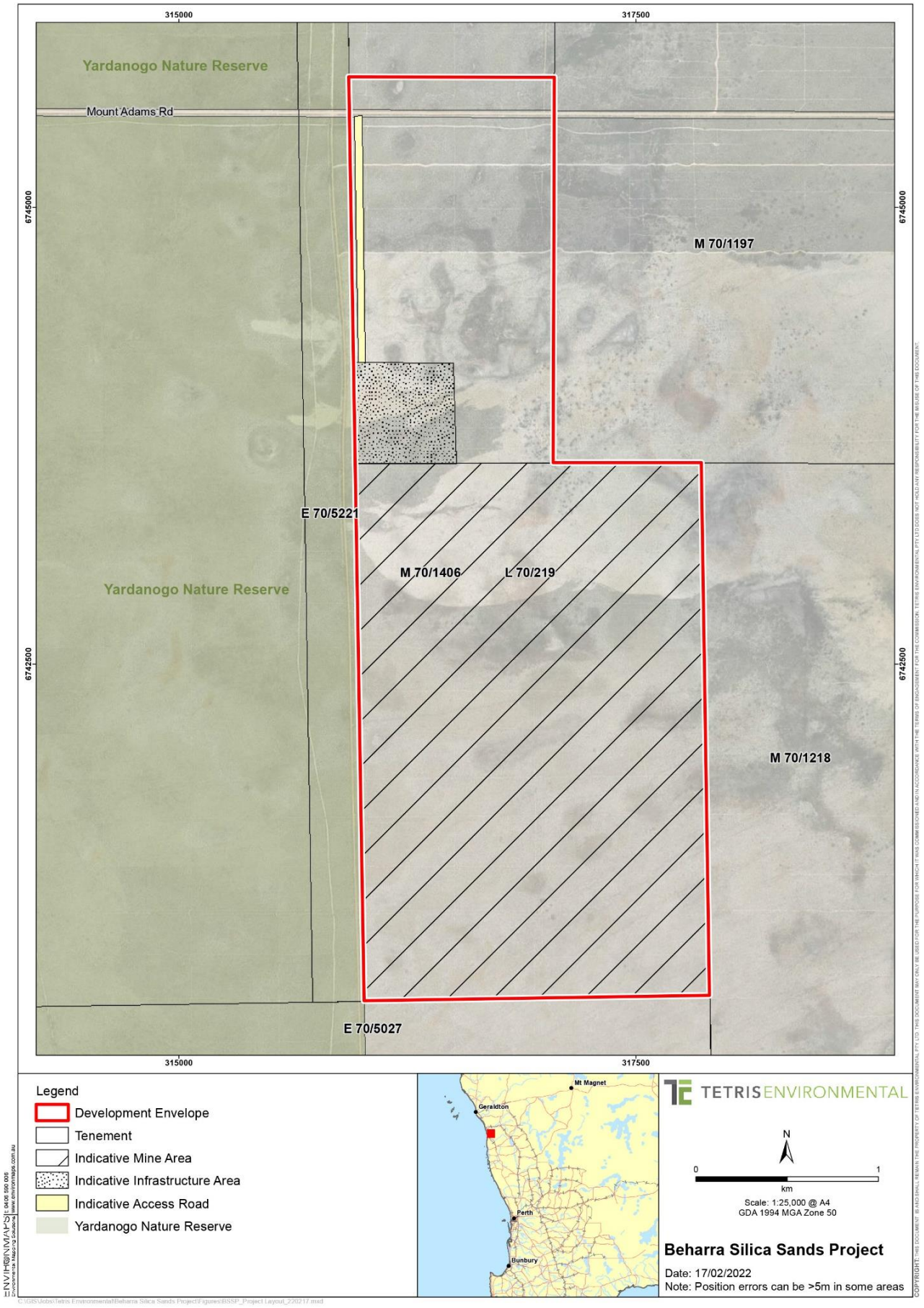

Figure 2-1 Proposal Layout

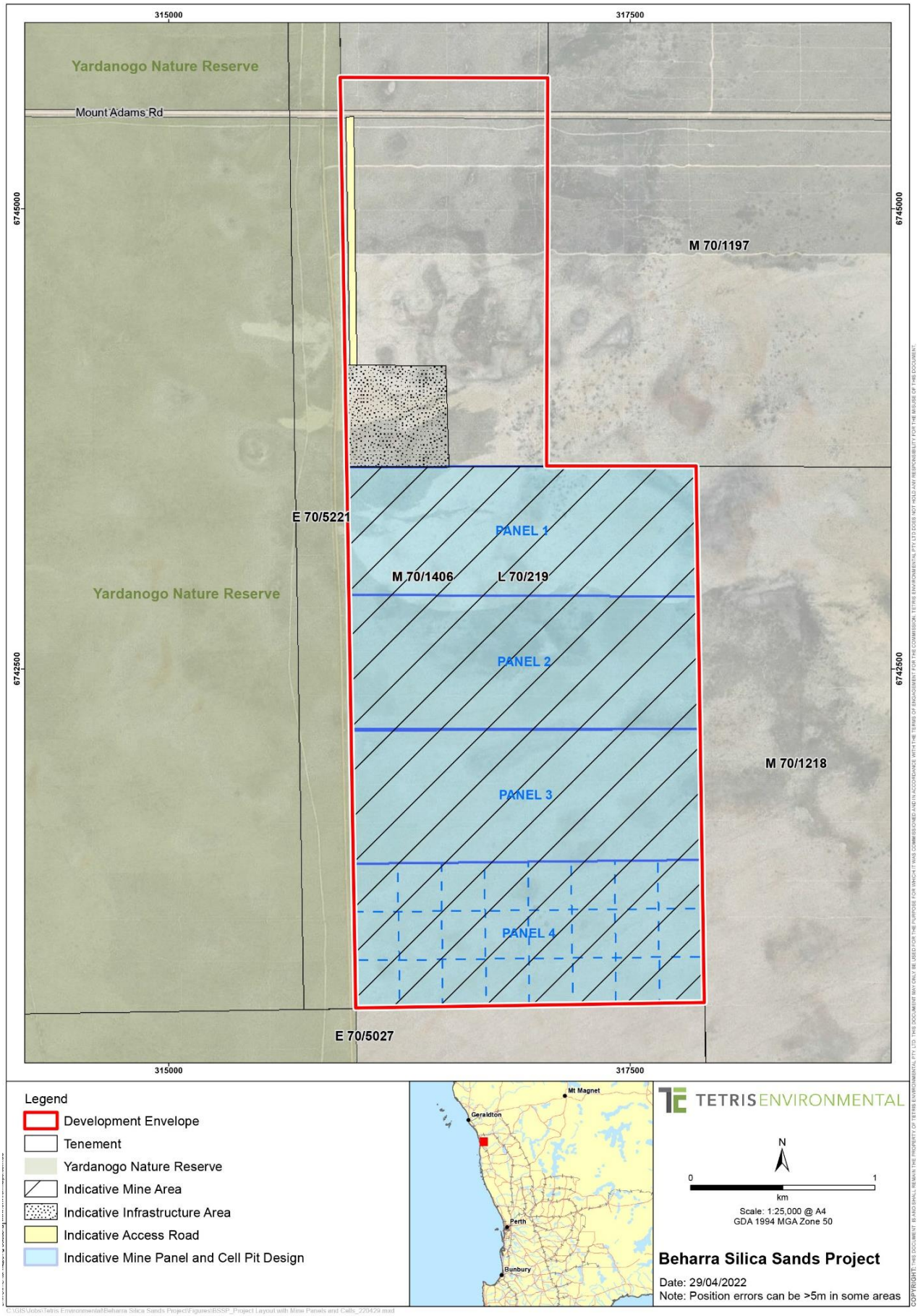

Figure 2-2 Mine Panel Layout

2.1 Clearing and Stripping

Proposal areas will be cleared of vegetation and topsoil using graders and track dozers. Vegetation will be cleared, mulched and stockpiled near the pit for immediate use on the rehabilitated surfaces of the previous mine cell. Vegetation buffers of 50 m will be applied for mine pit areas adjacent to the Yardanogo Nature Reserve, while an 80 m clearing buffer will be applied for infrastructure and haulage areas adjacent the Yardanogo Nature Reserve. A 20 m vegetation buffer will also be maintained along all other tenement boundaries.

The topsoil resource, typically yellow sand with humus in the upper 300 mm, will be stripped to a depth of approximately 500 mm and also stockpiled into windrows near the pit for immediate rehabilitation.

2.2 Excavation

The targeted white and yellow sand resource will be excavated within their distinct profiles, up to a maximum height of 6 m. Above this height, the profile will be split into benches.

Excavation will be achieved using frontend loaders and/or excavators.

2.3 Loading and Hauling

Once material has been excavated, it will be loaded using 50-tonne front end loaders. An example of this equipment is shown in Plate 2-1.

Due to the nature of the material being mined, the soft and uneven ground conditions will reduce trafficability in and around the site. Articulated dump trucks will be used to haul material from the pit as they operate well in sandy environments compared to rigid body haul trucks. All material will be hauled using 55-tonne capacity articulated dump trucks, as shown in Plate 2-2. Occasionally, roads will be sheeted if they are semi-permanent, or if any clay areas are encountered.

Plate 2-1 50-tonne Operating Weight Front End-Loader for Excavation

Plate 2-2 Articulated Dump Truck used for Haulage

2.4 Processing

All material will be loaded using front end loaders and hauled using articulated dump trucks. Ore will be direct tipped into a feed hopper to remove oversized material. The feed will then be transferred via conveyor to a rotating trommel screen, which will wash and slurry the sand feed, removing +2 mm oversize sand, rocks and organic material as a benign rejects stream for return to the pit void via dump truck.

Material from the trommel screen will gravitate to a bin and be pumped to the processing plant. The processing plant will further refine the sand product using gravity and magnetic separation with no chemical additives. Plate 2-3 presents a typical sand plant with various product streams.

PEC will minimise the use of water during processing, incorporating tank recirculated process water, belt filtration and no open process water ponds to reduce evaporation losses. Water disposal is not required as the operations will be a nett user of water.

The final dry product stockpile will then be loaded onto road trains using front-end loaders and transported to the Geraldton port for export via existing roads and port infrastructure.

Plate 2-3 Example Image of a Typical Sand Processing Plant

2.5 Backfilling and Rehabilitation

Once completed, all mine cells will be progressively rehabilitated commencing in year 3 of operations. To increase the stability of the rehabilitated pit, the angles of the post mine pit wall will be reduced using backfilled benign reject material. The remainder of the reject material will be backfilled to the pit floor. Figure 2-3 presents a conceptual backfill section following mining. The process of excavation, backfill and rehabilitation per mine cell is depicted in Figure 2-4.

A comprehensive study was undertaken to determine the most suitable progressive rehabilitation method for the Proposal, based on the existing environment, consultation and benchmarking with other extractive sand miners in the local area, as well as expert rehabilitation practitioners to assist in developing the method outlined in Table 2-1.

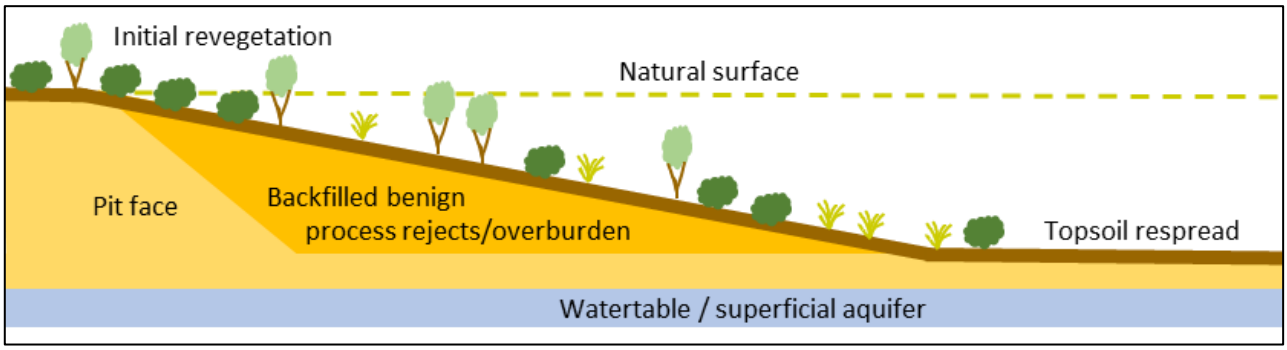

Figure 2-3 Conceptual Planned Backfill and Rehabilitated Pit Walls

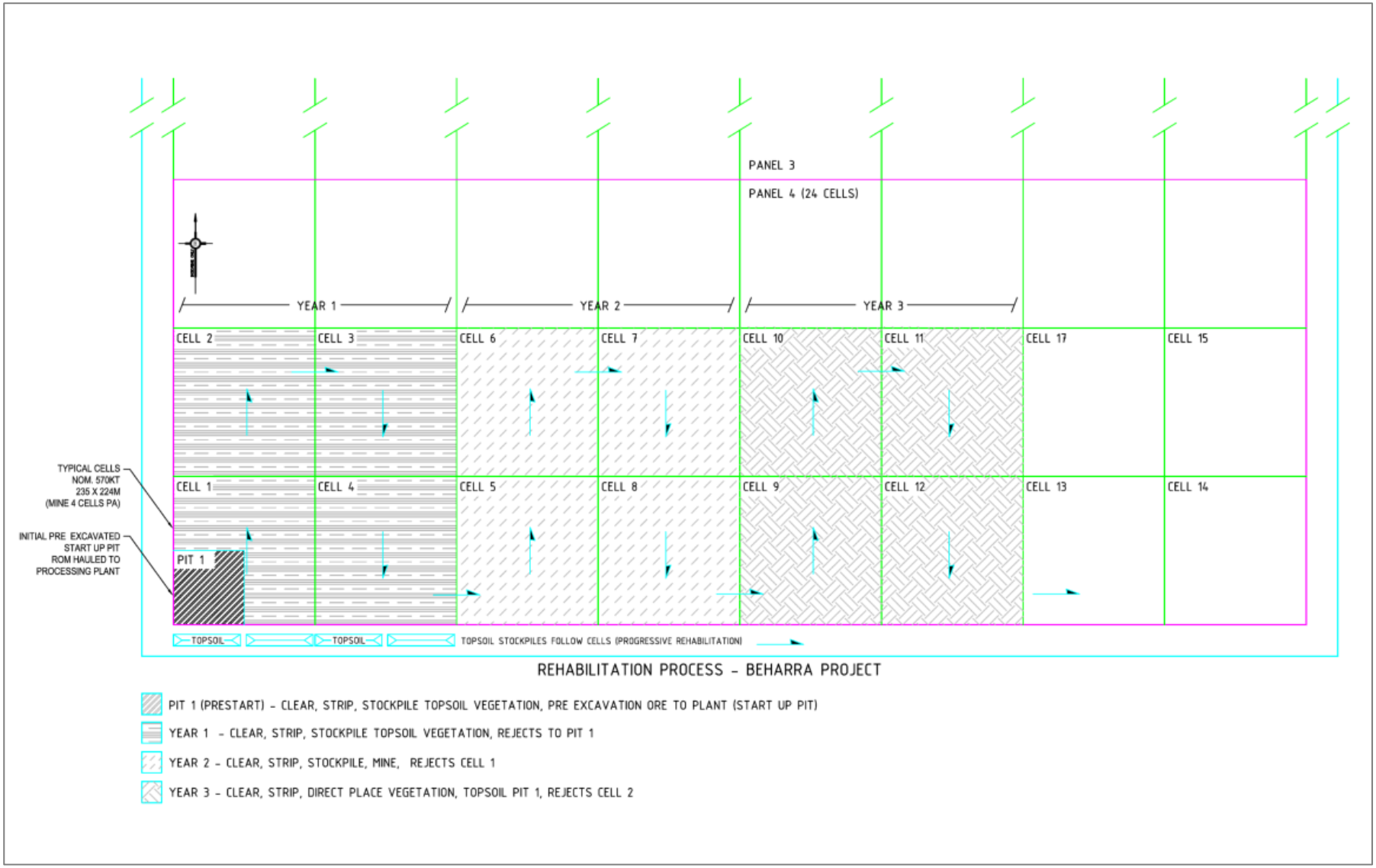

Figure 2-4 Rehabilitation Process

Table 2-1 Proposal Rehabilitation Method

Activity	Method
Acquire and store seed	A seed mix will be defined based on veg units with a focus on Carnaby Cockatoo foraging species and collected on an annual basis up to 250 kg per annum (benchmarked on Iluka Eneabba program), dependent on reproductive success and climatic conditions. The first location for seed acquisition will be that which can be acquired prior to clearing. This may involve picking seed over the entire LOM and in adjacent local areas outside of the disturbance footprint within a provenance zone where species relevant to the vegetation types can be harvested. It will be important not to have the provenance zone too constrained as this can sometimes be the case without practical knowledge from seed pickers and benchmarks from other sites. Seed would be stored at a controlled temperature, in an approved supplier's facility. Different seed types would be treated with various dormancy breaking treatments (scarification/smoky water etc.); however, a percentage of seeds would go untreated. Further work is required on defining recalcitrant flora species (typically Restionaceae, Cyperaceae, Dilleniaceae) and methods for enhancing germination success. Some species may require supply from nursery tube stock and direct planted.
Clear and grub area, mulch vegetation place in separate stockpile	Vegetation will be cut from the surface, usually with a light dozer, and windrowed. If the vegetation has root balls below the surface, ideally these will be removed during clearing and grubbing as they will interfere with the spread of topsoil. The windrowed material will be fed into a tub grinder/mulcher to generate a wood mulch with pieces generally no larger than 50 cm long x 10 cm in diameter, with the majority much smaller. This will be stockpiled separately as with the soil. However, direct placement after soil placement will occur where it is feasible to do so.
Load, haul and dump top 500 mm to soil to stockpile	Load, haul and dump of growth media will occur from areas which has been cleared of vegetation. Although the nominal depth for soil harvest/excavation is 500 mm of soil and subsoil, pit testing demonstrates a very large variety of both soil type near the surface and subsoils at depth. In many cases there will be little value in harvesting the barren sands below the top 100–300 mm of soil. The Project will be best served to manage depth of harvest very carefully and not mix good quality growth media with the underlying barren material which has little if any growth media properties. As such, a smaller volume may be harvested to achieve the best results when re spread. However, this needs to occur based on educating the supervising and operators with to respond to the inherent variability of depth and soil type. Single recovery depth of topsoil only will be the most appropriate approach as there is too little depth and too little distinction between soil types to harvest two soil types. The material will be stored in paddock dumped piles no greater than 2 m high. This soil material is highly susceptible to mechanical degradation. Hence, the material should be placed in dumped piles at the correct density to spread the material to up to 500 mm depth with minimal pushing distance. The material will be rotated onto the next available rehabilitation surface. Where direct transfer is feasible, this should occur.
Load, haul, dump and spread rejects on floor area	During production activities trucks will return waste material back to the mined pit floor to increase the distance to the water table and limit seasonal inundation of the root zone and act as growth media. It is important rejects clay content is maintained from 4% to 12% to enable suitable moisture retention within the soil profile for plant availability. This material should be spread evenly on the pit floor

Activity	Method
	(and not dumped on the pit batters) and well mixed so as to not form clay layers that will limit water and plant root penetration. Dumped material will be pushed flat so another layer can be placed. If the material moisture content is too high (rejects anticipated to be around 5% moisture content) it may need to lie fallow for some time before rehabilitation commences to avoid issues associated with compaction. Monitoring of clay content will occur progressively at this time.
Dozer trim all dumped/spread surfaces in preparation for soil growth media placement	Prior to the placement of soil on rehabilitation surfaces, including side batters and pit floor, all rehabilitation will be cut to a very high quality of trim. This is generally completed with a dozer and the objective is to achieve very even compaction and no significant windrows or gaps. Such features will increase the susceptibility of soil erosion post closure. Ideally, after trimming the only thing visible on a surface is track shoe marks. Given the low grades of batters, it may be worth experimenting with a grader. Generally, a light dozer is used otherwise. See below.
Load, haul, dump and spread stockpile topsoil to rehabilitation face	Growth media is rehandled from stockpile to the rehabilitation face. This soil material is highly susceptible to mechanical degradation. Hence, the material should be placed in dumped piles at the correct density to spread between 200 mm and 300 mm depth with minimal pushing distance. A light dozer (Komatsu 155 or Cat D7) would be much more suited to this task to minimise track degradation due to machine weight. Given the low hectares for rehabilitation each year, the surface trimming and topsoil spreading may be best carried out by a contractor with rehabilitation experience and fit for purpose machinery.
Load, haul, dump and spread stockpiled timber mulch to rehabilitation face	As is the case, timber mulch piles placed at the ideal density for spreading evenly, with fit for purpose machinery and an experienced operator. Note the timber mulch should be spread as soon as practicable to protect the soil surface from wind erosion. It will also be a very valuable source of seeds.
Spread native seed	Some sites, where there is a dense placement of timber mulch, choose not to cross rip. Cross ripping is generally undertaken to enhance infiltration and minimise erosion. In this instance the materials into which the seed is sown is high infiltration with adequate clay content and dispersal through the growth media. The timber mulch is similar to a rock mulch or other erosion resistant covers. From a seed broadcast perspective, further to benchmarking and trials, it may be that the seed is hand broadcast at the optimal time of year after the timber mulch is placed at a rate similar to nearby peers. Alternatively, because of the differences in the mining processes at Beharra, if the soils and timber mulch are direct placed which is likely to have suitable seed retention, it may be the case that the rehab success is assessed at least 24 months after final timber spreading in each cell, and if adequate species diversity and density is not achieved per defined completion criteria (pending rehabilitation/closure plan), seed/tube stock can be dispersed. Seed to be dispersed at 5 kg per hectare.
Monitoring/reporting and maintenance	Subject to the development of detailed Rehabilitation Plan, a formal rehabilitation monitoring will commence within 24 months after final rehabilitation activities within the first 15 ha cell and once per annum after that (note this frequency can be adjusted based on findings). Having a regular monitoring regime in the early years will assist identifying opportunities for improvement in the rehabilitation process and adjusting/trialling different operational and rehabilitation methods to improve future revegetation outcomes. It's not uncommon that the first few years of revegetation, consistent with ecosystem regeneration (such as after fire) will

Activity	Method
	feature short lived early colonisers and monitoring results will report this accordingly. Monitoring results will be analysed with previous data and outcomes reported internally to PEC and externally via the regulatory annual reporting processes. The strategies of selecting the highest quality soils, converting tree trash into a mulch product, developing gentle slope angle and the favourable clay contents in the substrate, the Project will develop very favourable conditions to re-establish an ecosystem generally similar to that which occurs as the baseline. Based on the low batter angles on the outer pit walls, sandy soil profile and lack of local surface water drainage features that may contribute to water erosion, it is not expected that significant repair or maintenance earthworks will be required after rehabilitation of each cell. Typical maintenance that could be expected would include: • Repair of minor erosion gullies • Respond to unplanned ponding of water locally • Re-seeding where revegetation performance is not aligned with broader performance • Weed surveillance and treatment where required • Reinstatement of drainage control drains and bunds (drains to remove water from topsoil stockpile storage areas, for instance.

2.6 Site Photos

This section presents a series of photographs from the Proposal site taken in 2021, providing an indication of the typical vegetation types, soils, general terrain and disturbance conditions of the area.

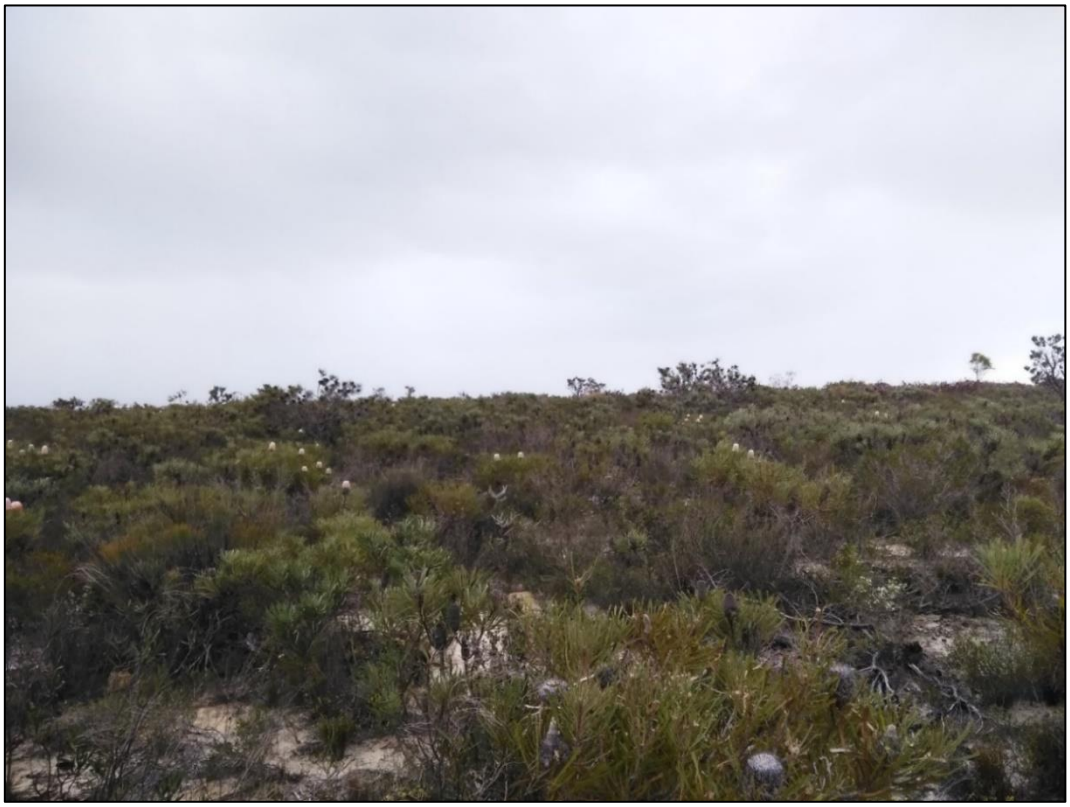

Plate 2-4 Typical Kwongan Heath Vegetation Dominating the Proposal

Plate 2-5 Typical Dampland Thicket Vegetation Scattered within the Proposal

Plate 2-6 Typical Kwongan Heath Vegetation with Scattered *Banksia* sp.

Plate 2-7 Typical Kwongan Heath Vegetation with Drill Line Clearing Tracks

Plate 2-8 Prescribed Fire Disturbance South Mt Adams Rd Following Burns in 2021

3. ENVIRONMENTAL LEGISLATIVE FRAMEWORK

The principal legislation in Western Australia governing the environmental assessment of the Proposal is the EP Act.

PEC has submitted the Proposal to be assessed via the Native Vegetation Clearing Permit (NVCP) process, under Section 51(E) of the EP Act.

The principal Commonwealth legislation governing the environmental assessment of the Proposal is the EPBC Act.

Under the EPBC Act, actions that have, or are likely to have, a significant impact on Matters of National Environmental Significance (MNES) require approval from the Australian Government Minister for the Environment.

Other approvals relevant to the Proposal are summarised in Table 3-1.

Table 3-1 Other Approvals

Relevant Legislation	Approval	Environmental Factor/Issue Regulated	Can statutory decision-making process regulate and mitigate impacts? (Yes/No) Summary of reasons
Commonwealth, Department of Agriculture Water and the Environment			
Environment Protection and Biodiversity Conservation Act 1999	Section 133 Approval	Matters of National Environmental Significance	Yes. Foraging habitat of moderate value for the Endangered Carnaby Black Cockatoo (*Calyptorhynchus latirostris*) occurs in the Development Envelope and will be progressively cleared and rehabilitated over the 32 year mine life. Whilst this is not deemed a significant impact that will affect the survival of the species, the Proposal will be referred to DAWE for consideration. If defined a Controlled Action due to significant impacts, DAWE will formally assess the Proposal and assign a set of conditions to monitor and manage the potential impacts from the Proposal and offset any residual impacts. Annual compliance reporting with conditions of the permit submitted to DAWE for assessment.
WA State, Department of Water and Environmental Regulation			
Environmental Protection Act 1986 - Part V Division 3	Works Approval Environmental Licence	Emissions and discharges to Air, Land and Water from a Prescribed Premises Environmental Pollution	Yes. Prescribed Category 5 Processing or beneficiation of metallic or non-metallic ore >50,000t/annum is the main category relevant to the Proposal and is associated with the construction, commissioning and operation of the processing plant. DWER can adequately assess and regulate emissions from prescribed activities and the general operations such as noise, dust and waste water to the environment through prevention, mitigation

Relevant Legislation	Approval	Environmental Factor/Issue Regulated	Can statutory decision-making process regulate and mitigate impacts? (Yes/No) Summary of reasons
			and monitoring conditions imposed on Works Approval and Operating Licence permits. Annual Audit Compliance Report confirming compliance to conditions of the Licence submitted to DWER for assessment.
Rights in Water and Irrigation Act 1914	Licence to construct a bore (26D) Licence to take water (5C)	Abstraction of groundwater from the Yarragadee aquifer Groundwater quality and quantity Groundwater Dependent Ecosystems	Yes. 26D Licence approved - CAW206520(1). The 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 has been submitted and water exploration drilling work plan agreed with DWER. Application assessment pending drilling and submission of detailed hydrogeological reporting to consider the potential impacts of the abstraction on the environment and other users. Groundwater Dependent Ecosystems are included by DWER in assessment of 5C application. Once the 5C is approved, 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 and to verify this through monitoring in accordance with an Approved Groundwater Operating Strategy. Annual/Triennial reporting on compliance with the Operating Strategy submitted to DWER for assessment.

Relevant Legislation	Approval	Environmental Factor/Issue Regulated	Can statutory decision-making process regulate and mitigate impacts? (Yes/No) Summary of reasons
Environmental Protection (Noise) Regulations 1997	N/A	Noise Emissions	Yes. No sensitive receptors nearby. While not expected to be significant, the primary source of noise 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 noise emissions are minimised and do not result in significant impacts to any sensitive receptors.
WA State, Department of Mines, Industry Regulation and Safety (DMIRS)			
Mining Act 1978	Mining Proposal Mine Closure Plan	Biodiversity Water Resources Land and Soils Rehabilitation Social Surroundings	Yes. Key legislation and Decision Making Authority regulating mining operations in Western Australia. A Mining Proposal 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 Mine Closure Plan will be submitted to DMIRS with the Mining Proposal prior to any disturbance at the Proposal and will be revised every 3 years or with subsequent Mining Proposal applications. 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.

Relevant Legislation	Approval	Environmental Factor/Issue Regulated	Can statutory decision-making process regulate and mitigate impacts? (Yes/No) Summary of reasons
			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. Environmental monitoring programmes during operations and for some time post closure will be conducted in accordance with the approved schedules to confirm the achievement of the set environmental outcomes. Requires the proponent to undertake an appropriate level of Stakeholder identification and consultation throughout the Proposal stages. Annual Environmental Report on compliance with tenement conditions, commitments made in the MP and MCP submitted to DMIRS for assessment.
Dangerous Good Safety Act 2004 (DGS Act)	Dangerous Goods Licence	Contamination of soils, groundwater and surface water (hydrocarbon spills) Fire risk (combustion of stored flammable goods)	Yes. The storage and management of hydrocarbons will already be regulated under Part V of the EP Act and the Mining Proposal / MCP however the DG Licence provides additional mitigation for the design and storage of larger volumes of dangerous goods (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.

Relevant Legislation	Approval	Environmental Factor/Issue Regulated	Can statutory decision-making process regulate and mitigate impacts? (Yes/No) Summary of reasons
			Having a DG Licence ensures potential spills and combustion risks from the Proposal are mitigated.
WA State, Department of Planning, Lands and Heritage (DPLH)			
Aboriginal Heritage Act 1972; or *Aboriginal Cultural Heritage Act 2021*	Section 18 Permit	Disturbance to matters of Aboriginal heritage significance	PEC and Yamatji Southern Regional Corporation (YSRC) have signed a Yamatji Proponent Standard Heritage Agreement that defines requirements for heritage surveys on PEC tenements. A letter of project endorsement has also been provided by the YSRC Chairperson. Heritage surveys conducted across the Development Envelope in 2020 and 2021 did not identify any matters of archaeological or ethnographic significance.
WA State, Department of Health (DoH)			
Health Act 1911 *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974*	Permit to construct apparatus for the treatment and disposal of sewage Regulations 1974 provides for approval to construct or install an apparatus for the treatment of sewage, and the disposal of wastewater (sewage).	Treat and dispose sewage, and wastewater	Yes If discharge of waste water does not trigger a prescribed activity under Part V of the EP Act, the Health Act Permit is the primary approval to regulate health and environmental matters associated with the treatment and potential discharge of waste water effluent on site.

4. STAKEHOLDER ENGAGEMENT

Since acquiring tenements in 2018, PEC has consulted broadly during the course of technical investigations, design and evaluation of the Proposal. Key stakeholders identified and engaged are listed in Table 4-1.

PEC will continue to actively consult with neighbours, representatives of interested parties and regulatory agencies as the Proposal progresses. Key relevant topics raised with stakeholders to date are summarised in Appendix 2.

Table 4-1 Key Stakeholders for the Proposal

Stakeholder Group	Key Stakeholder
Government Agencies	• Department of Agriculture, Water and the Environment (Cwlth) • Department of Biodiversity Conservation and Attractions • Department of Mines, Industry Regulation and Safety • Department of Water and Environmental Regulation (EPA Services) • Department of Water and Environmental Regulation (Industry Regulation) • Department of Water and Environmental Regulation (Science & Planning) • Department of Water & Environmental Regulation (Water) • Main Roads Western Australia • Mid-West Ports Authority • Shire of Irwin • Mid West Development Commission
Community	• Yamatji Southern Regional Corporation
Industry	• VRX Silica Ltd • Tronox Management Pty Ltd

5. EXISTING ENVIRONMENT

5.1 Surveys and Investigations

The environmental values of the Development Envelope have been primarily derived from the survey work to support the environmental permitting process and undertaken in accordance with current technical guidance.

Table 5-1 summarises the Proposal-specific surveys and investigations undertaken to identify and delineate the values of a wide range of environmental factors associated with the Proposal.

Table 5-1 Summary of Surveys and Investigations Undertaken for the Proposal

Report Title and Reference (Section Reference)	Survey / Investigation Effort	Guidance	Key Outcomes
Flora and Vegetation			
Beharra Silica Sand Project, Detailed and Targeted Flora and Vegetation Survey Report Reference: Umwelt 2022 (see Section 5.6 and 5.7)	Investigation Type: Detailed and Targeted Flora and Vegetation survey Survey Area: Proposal Study Area~1,960 ha Survey Timing: 6-10th and 20-24th of September 2021; 1-5th and 15-19th November 2021.	Survey approach and method undertaken with consideration of the Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016b).	Native vegetation of the Development Envelope represents five vegetation types, all of which are widespread throughout the region. No decline in any vegetation association to a point below which that association could be considered endangered (i.e. below 10% pre-European extent). No TEC or PEC. No Threatened flora. No loss of important populations of conservation significant flora. Populations of 8 DBCA listed Priority flora and one potentially undescribed taxon, from the proposed Footprint. All species are known within widespread vegetation types across the region.
Beharra Silica Sand Project, Desktop review and gap analysis of previous Flora and Vegetation assessments Reference: Woodman Environmental / Umwelt 2021 (see Section 5.6 and 5.7)	Investigation Type: Desktop Assessment. Survey Area: Desktop Study Area ~125,000 ha (regional assessment): Development Envelope ~837 ha	This analysis reviewed reporting and data collected against all requirements of the EPA Technical Guidance (EPA 2016b).	Flora and Vegetation gap analysis of all previous survey work to identify gaps in the knowledge and method of survey previously undertaken within the Desktop Study Area.
Dieback Assessment and Management Plan Reference: Bark 2019 (see Section 5.6.6)	Investigation Type: Dieback Field Assessment and Sampling Survey Area: E70/5221 Tenement Survey Timing: 22 October 2019.	• CALM (2003) *Phytophthora cinnamomi* and disease caused by it. Volume I: Management Guidelines. • DPaW (2015) Forest and Ecosystem Management Division 2015. Phytophthora Dieback Interpreter's manual for lands managed by DPaW. • DWG Management of Phytophthora Dieback in Extractive Industries.	Soil/plant-tissue samples were collected and sent to the DBCA laboratory for testing. Two samples collected in the vicinity of the western boundary/gravel road were found to contain *Phytophthora arenaria* which is common on the northern sandplain. No *Phytophthora cinnamomi* was found in the Development Envelope and its surrounds. Minimal risk of introduction of Phytophthora dieback.
Vertebrate Terrestrial Fauna			
Beharra Silica Sand Project Fauna Values Assessment Reference: Bamford 2020 (see Section 5.8 and 5.9)	Investigation Type: Basic and Targeted survey and site inspection Survey Area: Beharra Silica Sand Tenement Area, ~1000 ha Survey Timing: 19-20 August 2020	• Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c) • Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2020a)	Proposal represents: • 538 ha of Kwongan Heath habitat, representing 1.9% of its regional extent • 48 ha of Dampland Thicket haboitat, representing 4% of its regional extent No individual habitat type will be reduced by more than 5% of its current regional extent. Habitat types of the Proposal are not unique to, or restricted to, the Development Envelope and are known to occur broadly throughout the regional area. Large areas are known to occur within the reserves.

Report Title and Reference (Section Reference)	Survey / Investigation Effort	Guidance	Key Outcomes
Beharra Silica Sand Project, Detailed Assessment of Terrestrial Fauna Values Reference: Bamford 2022 (see Section 5.8)	Investigation Type: Detailed fauna survey. Survey Area: Beharra Silica Sand Proposal Area, Field assessment area comprised 788 ha within the Development Envelope. Survey Method: Systematic fauna sampling based on four transects of trap and census points. The transects consisted of either 10 or 20 sampling points spaced approximately 20 metres apart, with a total of 60 sampling points. Survey Timing: 1-10 December 2021.	• Technical Guidance: Sampling methods for terrestrial vertebrate fauna (EPA 2020a) • Matters of National Environmental Significance: Significant impact guidelines 1.1 • EPBC Act Referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo, Baudin's cockatoo and Forest red-tailed black cockatoo (DSEWP) • Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan (DPaW/CoA, 2013) • National Recovery Plan for Malleefowl (*Leipoa ocellata*) (Benshemesh, 2007)	Field assessments recorded 71 species occurring within the Development Envelope, comprising of two frogs, 17 reptiles, 44 birds and eight mammals (four of which are introduced species). Fauna habitat and assemblage has been considerably altered due to frequent fire regime over the last 20 years. One species is listed under both State and Commonwealth legislation was recorded in the Development Envelope, Carnaby's Cockatoo (*Calyptorhynchus latirostris*). Only moderate value foraging habitat recorded. No roosting or breeding trees were recorded within the Development Envelope that were of suitable DBH, nor suitable for providing current or future breeding opportunities.
Short Range Endemic (SRE) Fauna			
Beharra Silica Sand, Short Range Endemic (SRE) Invertebrate Desktop and Survey Report Reference: Bennelongia 2022a (see Section 5.9)	Investigation Type: Detailed Short-Range Endemic (SRE) assessment. Survey Area: Beharra Silica Sand Proposal Area. ; Field assessment area comprised 788 ha within the Development Envelope. Survey Timing: 26-29 July 2021	• EPA Environmental Factor Guideline: Terrestrial Fauna • EPA Technical Guidance: Sampling Short Range Endemics Invertebrate Fauna (2016d)	Five SRE species recorded within the Development Envelope, including two priority listed species, *Bothriembryon perobesus* (P1) and *Idiosoma kwongan* (P1), both of which are widespread.
Subterranean Fauna			
Beharra Silica Sand Project Subterranean Fauna Desktop Assessment. March 2022 Reference: Bennelongia 2022b (see Section 5.9)	Investigation Type: Desktop assessment of Subterranean Fauna. Survey Method: Review habitat information and relevant biological records to appraise the conservation values of subterranean fauna in the Development Envelope and surrounds. Assess the level of possible threat to subterranean fauna	• Technical Guidance – Subterranean Fauna survey (EPA 2021e) • Water Quality Guidelines (ANZECC/ARMCANZ 2018, revision of 2000 guidelines).	The troglofauna specimens recorded in the region are associated with coastal cave systems, which are not associated with the Proposal. Stygofauna found nearby are considered widespread across the region and associated with widely distributed aquifer formations. A bore located near the Development Envelope yielded no stygofauna.
Hydrogeology (Groundwater)			
Beharra Silica Sand Project Hydrogeological Assessment Reference: Advisian 2022a (see Section 5.11)	Investigation Type: Assessment of the aquifers and numerical modelling to assess the potential impacts associated with groundwater abstraction.	Assessment approach undertaken with consideration of the Factor Guideline Inland Waters (EPA 2018).	Superficial groundwater ~8 mbgl. The base of the mine pit will remain above water table, with no mine pit dewatering. The Yarragadee formation acts as a confining layer between the Superficial and Yarragadee aquifers, which will limit indirect drawdown in the Superficial aquifer from groundwater abstraction of the Yarragadee aquifer. Modelling of abstraction predicts a maximum drawdown in the Superficial aquifer of approximately 1.35 m at the bore, dissipating to 0.2 m 1.2 km from the bore.

Report Title and Reference (Section Reference)	Survey / Investigation Effort	Guidance	Key Outcomes
Hydrology (surface water)			
Beharra Silica Sand Project Surface Water Assessment Reference: Advisian 2022b (see Section 5.10)	Investigation Type: Surface Water assessment of the Development Envelope included 1% AEP and 0.1% AEP surface water modelling under Existing and Post-development conditions. Assessment also identified surface water management requirements for operations and closure and assessed potential surface water impacts.	Assessment approach undertaken with consideration of the Factor Guideline Inland Waters (EPA 2018).	The Proposal is within the Arrowsmith River Catchment. There is no permanent watercourse in the area and drainage systems are poorly defined. The highly permeable sandy soils of the area recharge groundwater locally and further limit surface flow events.
Land and Soils			
Beharra Silica Sand Project, Acid Base Accounting Analysis Reference: Tetris Environmental 2021 (see Section 5.11)	Investigation Type: Acid base accounting to predict the acid generation characteristics of geological waste material through determination of the acid neutralising capacity and the maximum potential acidity. Investigation Methods: The assessment was conducted using 18 samples across the Development Envelope and analysed at Intertek Genalysis for the following analytical schemes.	• Environmental Factor Guideline – Terrestrial Environmental Quality (EPA 2016f) • Planning for integrated mine closure: toolkit. International council on mining and metals (I'M 2019). • Statutory Guidelines for Mine Closure Plans (DMIRS 2020a). • Water Quality Guidelines (ANZECC/ARMCANZ 2018, revision of 2000 guidelines). • ARD Test Handbook: Prediction & Kinetic Control of Acid Mine Drainage (AMIRA International 2002)	Results of the acid base accounting analysis and acid mine drainage classification show that samples are devoid of both acid generating and neutralising potential. Overall, the geology at the Development Envelope is NAF and has a low risk of generating saline drainage.
Air Quality			
Beharra Silica Sand Project, Air Quality Assessment. November 2021 Reference: GHD 2021a	Investigation Type: Air dispersion modelling, to assess the following parameters: • three dust size fractions (total suspended particulates (TSP), particulate matter with an aerodynamic diameter of 10 microns or less (PM10) and 2.5 microns or less (PM2.5)) • deposited dust and gaseous emissions (nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAH) and volatile organic compounds (VOC)) • predicted ground level concentrations of the above pollutants against relevant air quality criteria.	• Environmental Factor Guideline – Air Quality (EPA 2020b) • National Environment Protection (Ambient Air Quality) Measure (NEPC 2021) (Air NEPM) • National Environment Protection (Air Toxics) Measure (NEPC 2011) (Air Toxics NEPM) • Draft State Environmental (Ambient Air) Policy 2009 (Government of Western Australia 2009) (Draft SEP) • Environmental Protection (Kwinana) (Atmospheric Waste) Policy (EPA WA 1999) (Kwinana EPP) • Department of Water and Environment Regulation's (DWER) Draft Guideline: Dust Emissions (DWER 2021b) (DWER Dust Guideline) • DWER's Draft Guideline: Air Emissions (DWER 2019) • Draft Environmental Assessment Guideline Separation Distances Between Industrial and Sensitive Land Uses (EPA WA 2015) (Draft Guidelines)	The Proposal is not located near a city or town with the closest being Dongara ~25 km north-west. The closest sensitive receptor a rural residence is ~6 km southwest. Dispersion modelling demonstrated that none of the 1,468 identified residential and educational sensitive receptors experienced exceedances of the adopted assessment criteria for the protection of human health (Air NEPM, Air Toxics NEPM and Draft SEP criteria). Dispersion modelling also found that the Proposal demonstrated compliance with all relevant air quality criteria at known the Black Cockatoo roosting and breeding sites in the broader region.

Report Title and Reference (Section Reference)	Survey / Investigation Effort	Guidance	Key Outcomes
Greenhouse Gas Emissions			
Beharra Silica Sand Project Greenhouse Gas Assessment Reference: Greenbase 2021	Investigation Type: Greenhouse Gas accounting estimate Investigation Methods: Use of emissions factors from the National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination). The key inputs for estimating the greenhouse gas emissions from the Proposal are diesel combustion from the power station, mining fleet and haulage, and land clearing activities. Two scenarios were considered: • Scenario 1 - combined solar-diesel for on-site electricity generation • Scenario 2 - diesel only fuelled power station.	• Environmental Factor Guideline – Greenhouse Gas Emissions (EPA 2021f) • GHG Emissions Policy for Major Projects (WA Gov 2019) • National Greenhouse and Energy Reporting Scheme Measurement Technical Guidelines for the estimation of emissions (DoEE 2017) • National Greenhouse and Energy Reporting Act 2007 (NGER Act) • National Greenhouse and Energy Reporting (Measurement) Determination 2008 (NGER Determination) • Full Carbon Accounting Model (FullCAM) (Department of Industry, Science, Energy and Resources 2020) • Carbon Credits (Carbon Farming Initiative – Avoided clearing of native regrowth) Methodology Determination 2015	All emissions from diesel combustion and land clearing are categorised as Scope 1 emissions as defined by NGER. The results show that over the life of mine (~30 years), the estimated total greenhouse gas emissions: • Scenario 1 (solar-diesel) is 524,812 tCO_2-e, with an average of 16,400 tCO_2-e/year • Scenario 2 (diesel only) is 568,373 tCO_2-e over life of mine, with an average of 17,762 tCO_2-e/year.
Noise			
Beharra Silica Sand Project, Acoustic Assessment. December 2021 Reference: GHD 2021b	Investigation Type: Noise emissions modelling Investigation Methods: Computer Aided Noise Abatement (CadnaA) (Version 2021 MR1) noise modelling software. Noise levels generated were predicted at each sensitive receiver and noise contour maps were developed.	• Environmental Factor Guideline: Social Surroundings (EPA, 2016g) • Environmental Protection (Noise) Regulations 1997. • State Planning Policy 5.4 Road and Rail Noise (SPP 5.4) prepared under Part Three of the Planning and Development Act 2005. • Engineering Noise Control: Theory and Practice (Bies and Hansen 2009)	Nosie emission modelling found that the highest predicted noise level at any industrial receiver was 35 dB(A), which is 30 dB(A) below the noise criteria for the receiver type. The highest predicted noise level for a residential receiver is 15 dB(A), which is 20 dB(A) below the residential noise criteria. No predicted noise levels exceeded the relevant operational noise criteria.
Social Surrounds – Aboriginal Heritage and Culture			
Beharra Silica Sand Project Area (M70/1406) YSRC Heritage Survey. December 2021 Reference: SandS CRM 2021 (see Section 5.3)	Investigation Type: Archaeological and Ethnographic heritage surveys of the Development Envelope Survey Area: The Development Envelope, including all M70/1406. Survey Timing: March 2020 and November 2021 Survey Methods: An Aboriginal heritage survey (Archaeological and Ethnographic) with the full involvement of Southern Yamatji representatives.	• Environmental Factor Guideline: Social Surroundings (EPA, 2016g) • Engage Early - Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (CoA 2016b)	The Proposal is located within the Southern Yamatji portion of the Yamatji Nation Indigenous Land Use Agreement area, which is administered by the Yamatji Southern Regional Corporation Ltd. A search of the Department of Planning, Lands, and Heritage's (DPLH) Aboriginal Heritage Enquiry System (AHIS) identified no Registered Aboriginal Sites or Other Heritage Places within the Development Envelope. Archaeological and Ethnographic heritage surveys of the Development Envelope found no isolated artefacts, archaeological sites or ethnographic sites during the march 2020 and November 2021 survey. Yamatji Proponent Standard Heritage Agreement (YPSHA) has been in place between the Yamatji Southern Regional Corporation (YSRC) and PEC since 2021 and a letter of support for the Proposal has also been provided by YSRC.

5.2 Bioregion

The Proposal is located in the Geraldton Sandplains IBRA Bioregion, specifically within the GES02 Lesueur Sandplain IBRA subregion (CoA 2012b) (Figure 5-1). The Lesueur Sandplain subregion comprises mainly of proteaceous scrub-heaths, rich in endemics (Desmond and Chant 2001).

The Geraldton Sandplains bioregion is composed mainly of proteaceous scrub-heaths, rich in endemics, on the sandy earths of an extensive, undulating, lateritic sandplain mantling Permian to Cretaceous strata.

The Lesueur Sandplain (GES02) comprises coastal Aeolian and limestones, Jurassic siltstones and sandstones (often heavily lateritised) of central Perth Basin. Alluvials are associated with drainage systems. There are extensive yellow sandplains in south-eastern parts, especially where the subregions overlap the western edge of the Pilbara Craton. Shrub-heaths rich in endemics occur on a mosaic of lateritic mesas, sandplains, coastal sands and limestones. Heath on lateritised sandplains along the subregions north-eastern margins (Desmond and Chant 2001).

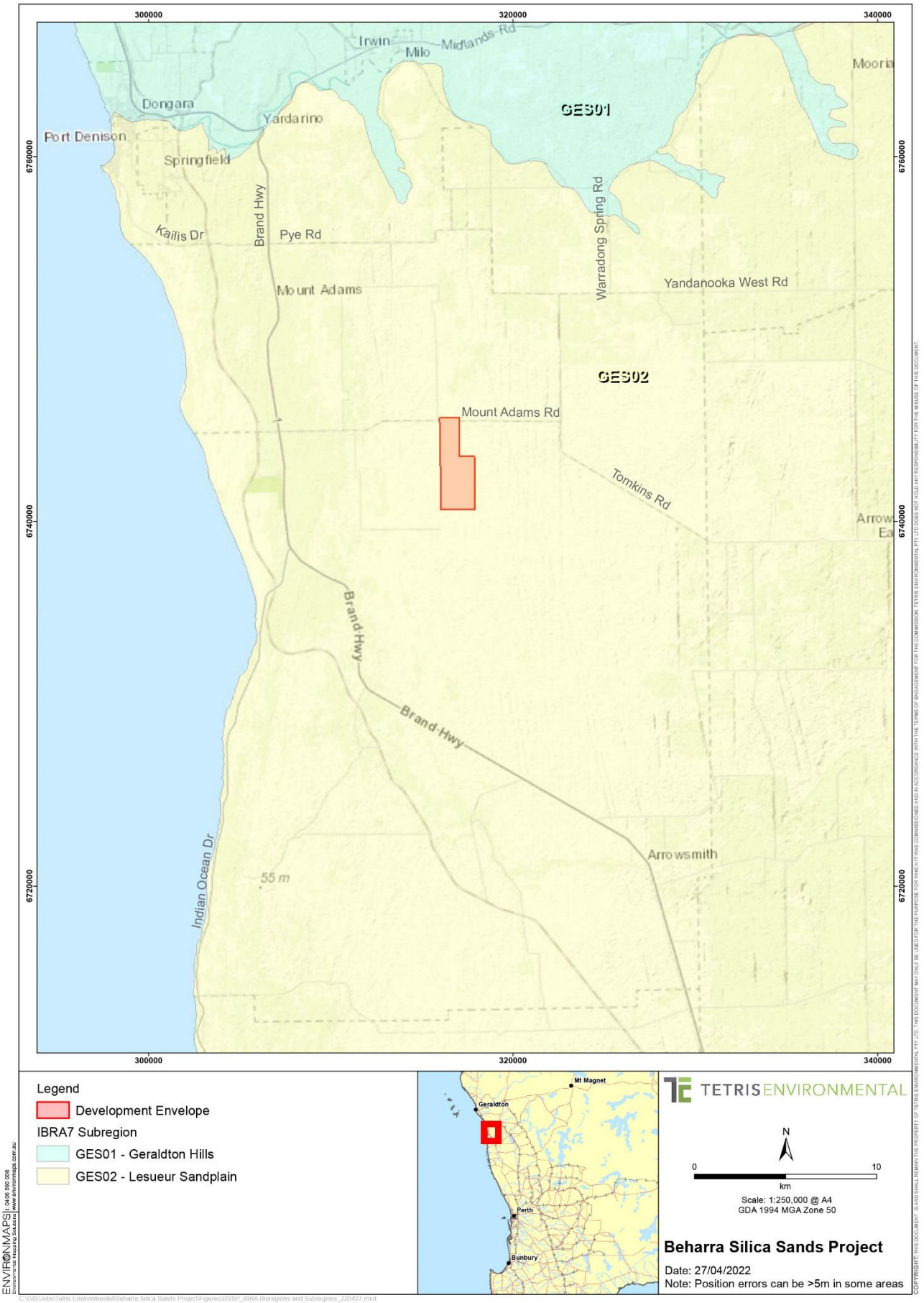

Figure 5-1 IBRA Subregion of the Development Envelope

5.3 Land Use

Although the Proposal is zoned 'General Farming' (Zone No. 649, Local Planning Scheme – Zones and Reserves, DPLH-071), the site has not been developed for farming.

The western boundary of the Proposal is immediately adjacent the Yardanogo Nature Reserve (R36203), which is vested under the Conservation Commission of WA for the purpose of conservation of flora and fauna (*Conservation and Land Management Act 1984*, (CALM Act) section 5(1)(d)).

5.3.1 Regional Community

The Proposal is located 25 km southeast of the coastal village of Dongara, 41 km south west of the agricultural centre of Mingenew and 96 km south of the port city of Geraldton, all situated in the Mid-West region of WA.

The Mid West is a sparsely populated region of WA with a diversified economy dominated by mining, (i.e., iron ore, mineral sands, gold, nickel), agriculture, fishing and tourism. The Shire of Irwin population is 3,569.

The location of the Proposal is relatively remote. Besides the Yardanogo Nature Reserve on the western boundary, all neighbouring properties are *Mining Act 1978* (Mining Act) tenements or Unallocated Crown Land. The nearest residential dwelling to the Proposal is a rural property approximately 6 km to the southwest.

5.3.2 Yamatji Nation

The Proposal is located within the Southern Yamatji portion of the Yamatji Nation Indigenous Land Use Agreement area, which is administered by the Yamatji Southern Regional Corporation Ltd (Figure 5-2).

Yamatji Proponent Standard Heritage Agreement (YPSHA) has been in place between the Yamatji Southern Regional Corporation (YSRC) and PEC since 2021. A letter of support for the Proposal has also been provided by YSRC (Appendix 3).

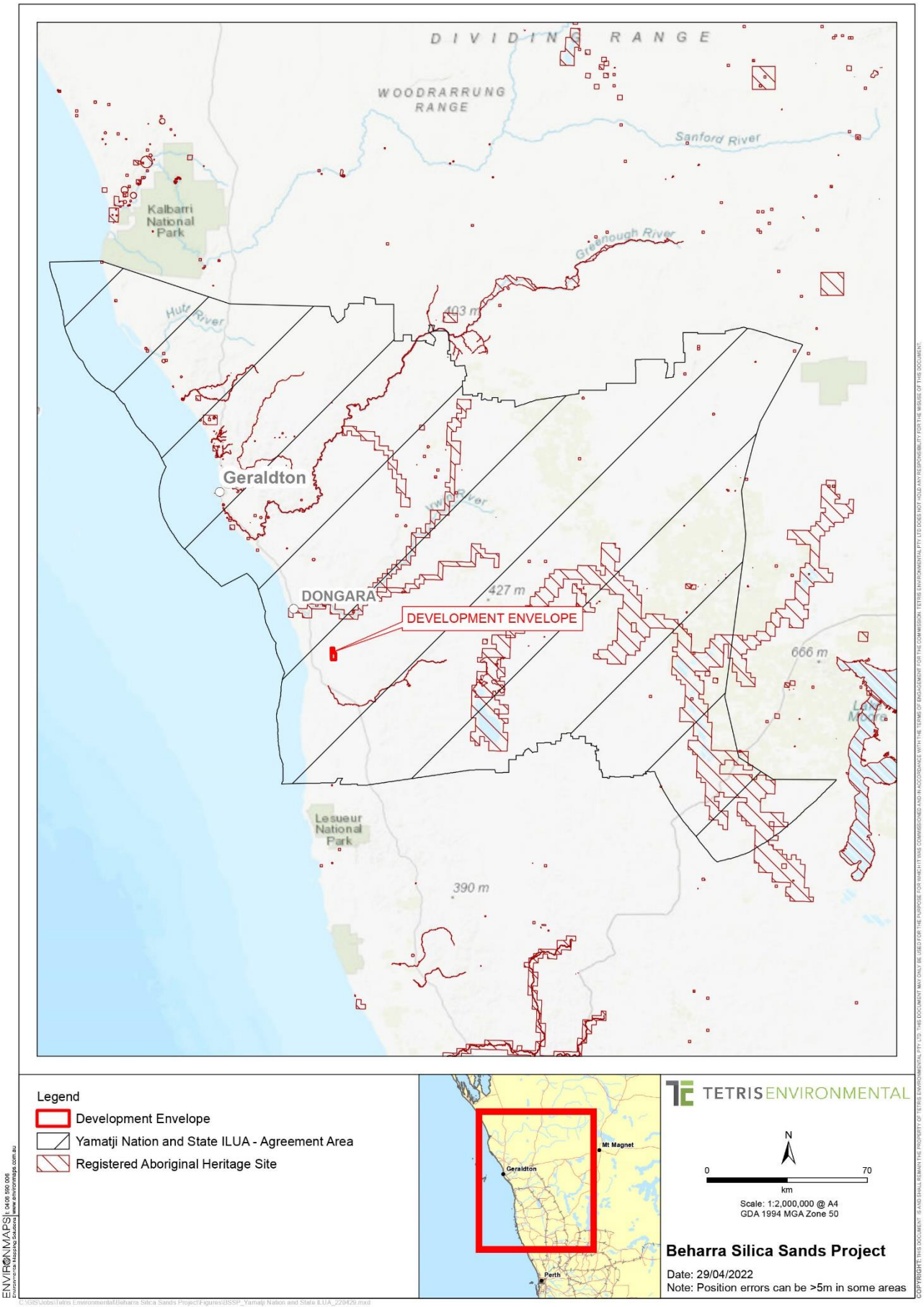

Figure 5-2 Yamatji Nation Indigenous Land Use Agreement area

5.3.3 Reserves

The Yardanogo Nature Reserve (R 36203) is immediately west of the Development Envelope, vested under the Conservation Commission of WA for the purpose of conservation of flora and fauna (Figure 5-3).

Other conservation estates in the region include the Breaksea Inland Wildlife Reserve (9.6 km west), Tathra National Park (53 km south west); and Mingenew Nature Reserve (34 km north east).

A query of the Directory of Important Wetlands in Australia (DAWE, 2021) did not identify these wetlands as Ramsar Wetlands or wetlands of national importance. The closest wetland listed in the Directory of Important Wetlands (DBCA-045) is the Lake Logue – Indoon System (40 km south).

5.3.4 Other Projects

Three other developments are located within 5 km of the Proposal (Figure 5-3):

- Beharra Springs Energy Project is an operating processing plant for natural gas, located approximately 2 km southeast.
- Tronox Dongara Mineral Sands project is currently approved and undeveloped, located approximately 1 km east (Ministerial Statement 1120)
- VRX Arrowsmith North Silica Sand project is currently under Part IV assessment, located approximately 3 km southwest (EPA Assessment Number 229)

Within 20 km of the Proposal, there are an additional two natural gas processing plants and one power station. Further afield (over 70 km from the Proposal), other mineral mines and processing plants are scattered throughout the region. A summary other major projects within 150 km of the Proposal is provided in Table 5-2.

Table 5-2 Other Developments

Distance / Direction	Project	Site Code (Project)	Site Type	Stage	Commodity
Less than 5 km from Proposal					
1 km E	Dongara Minerals Sands / Tronox	S0018998 (J02458)	Mine (Open pit)	Proposed	Heavy Mineral Sands
2 km SE	Beharra Springs Energy	S0005925 (J02369)	Infrastructure (Processing Plant)	Operating	Natural Gas
3 km SW	Arrowsmith North Silica Sand	S0236948 (J05434)	Mine (Open pit)	Proposed	Silica Sand
Between 10-20 km from Proposal					
12.8 km N	Xyris Processing Plant	S0021642 (J03002)	Infrastructure (Processing Plant)	Operating	Natural Gas
13.2 km N	Mondarra Underground Gas Storage Facility	S0236299 (J05330)	Infrastructure (Processing Plant)	Operating	Natural Gas
19.3 km NW	Centauri 1 Power Station	S0022977 (J03358)	Infrastructure (Power Plant)	Proposed	Power
Next nearest (70-150 km) from Proposal					
73.2 km E	Three Springs Talc	S0019195 (J00913)	Mine (Open pit)	Operating	Talc
74.6 km NE	Oxley Potash	S0230608 (J04414)	Deposit	Undeveloped	Potash

Distance / Direction	Project	Site Code (Project)	Site Type	Stage	Commodity
78.7 km NW	Eneabba / Iluka Narngulu Dry Plant	S0001244 (J00514)	Infrastructure (Processing Plant)	Operating	Heavy Mineral Sands
78.7 km NW	Haber	S0239822 (J05955)	Infrastructure (Processing Plant)	Proposed	Urea
124 km S	Atlas /Image - North Perth Basin	S0022716 (J00748)	Mine (Open pit)	Proposed	Heavy Mineral Sands
150.4 km SE	Kemerton Silicon / Simcoa (Moora Silica - Coomberdale)	S0023090 (J00918)	Mine (Open pit)	Operating	Silica Sand

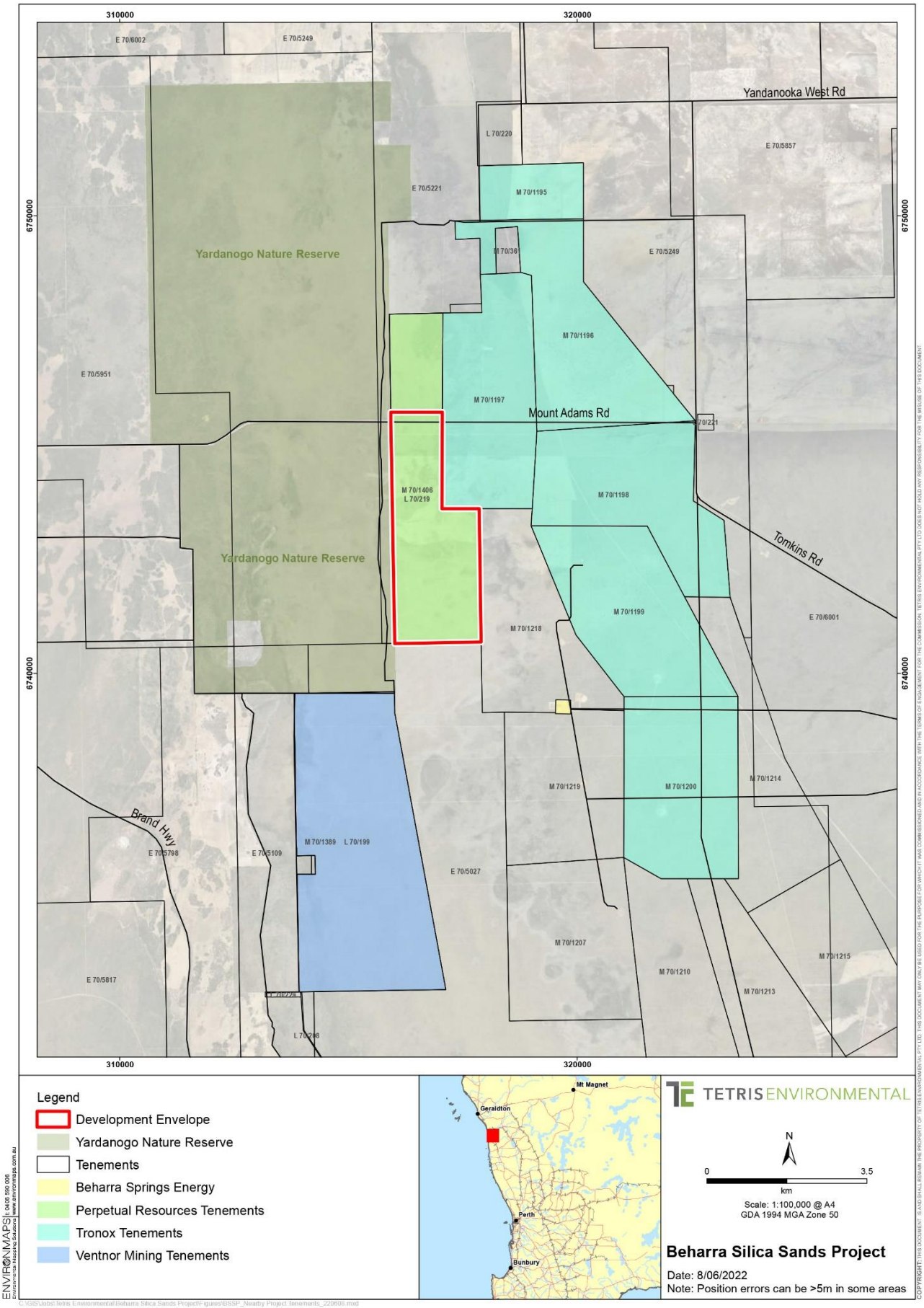

Figure 5-3 Reserves and Other Key Projects

5.4 Climate and Fire History

The Proposal experiences a Mediterranean type climate with hot dry summers and cool wet winters. Weather patterns are dominated by rain-bearing cold fronts from the Indian Ocean in winter, and dry easterly air flows from the WA interior in summer.

The nearest weather station is Mingenew (BoM Station No. 8088), ~50 km north east of the Proposal. Rainfall data from Mingenew has recorded an annual mean rainfall of 399.5 mm. Monthly mean rainfall ranges from 6.3 mm in December to 80.4 mm in June. The majority of rainfall generally occurs between May and September, with the lowest rainfall recorded between November and February (BoW 2021a). Mean rainfall and temperature data are presented in Figure 5-4.

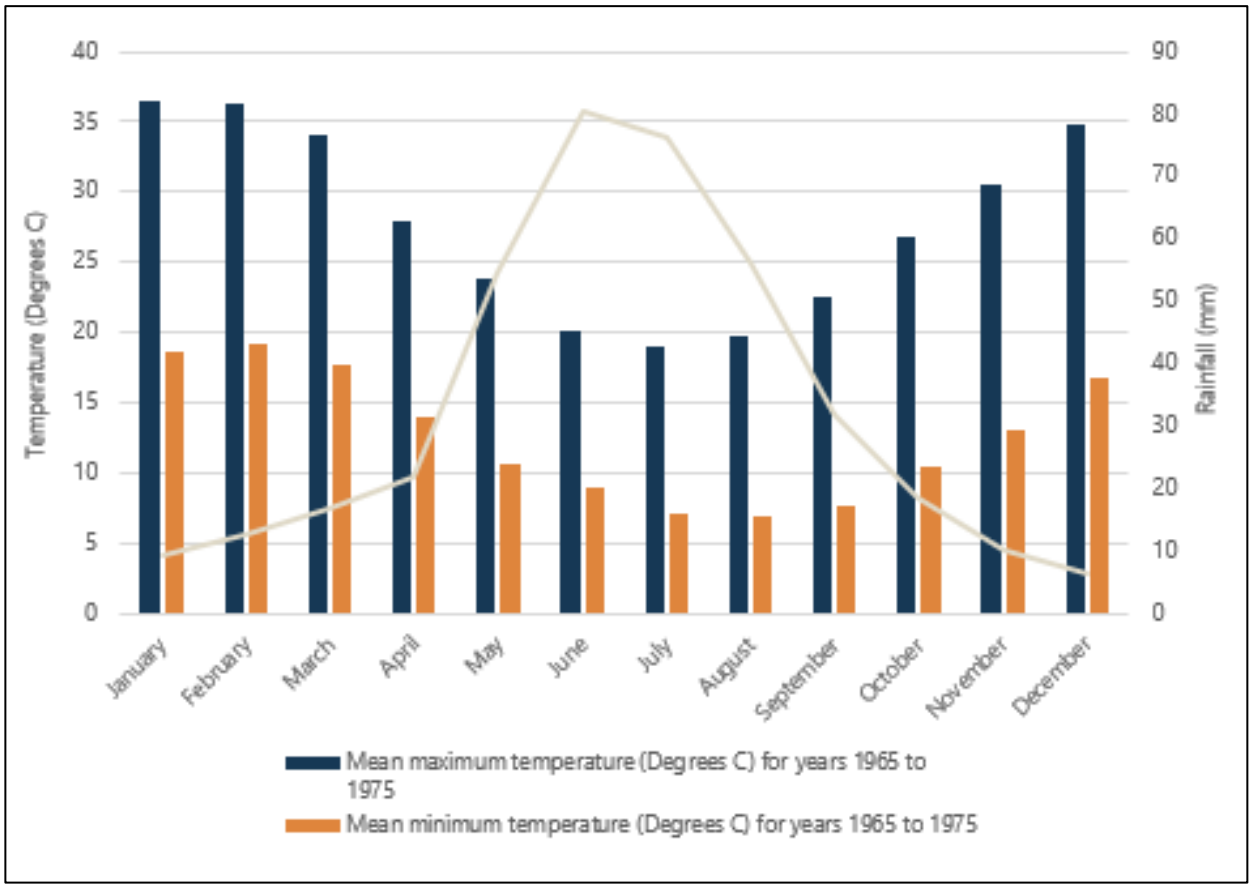

Figure 5-4 Average Rainfall and Temperature Data (BoM, 2021a)

The area within the Development Envelope, and region more generally, has been subject to multiple prescribed fires. These multiple recent fires are likely to have affected the vegetation and fauna assemblage, with an estimated seven fires within the Development Envelope in the last 20 years (Figure 5-5).

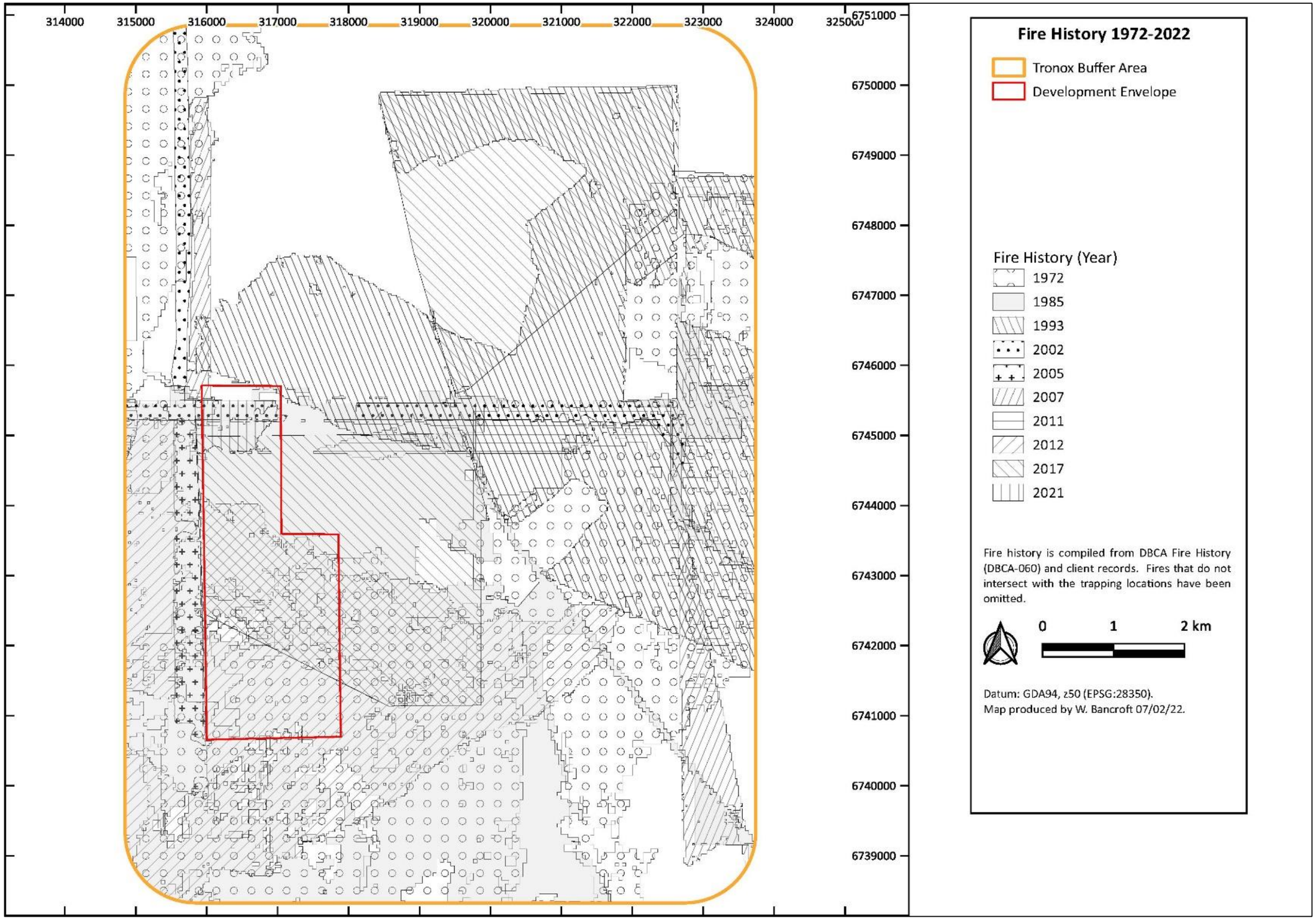

Figure 5-5 Fire History at the Development Envelope

5.5 Geology, Topography and Soils

The Proposal is underlain by a sequence of unconsolidated superficial formations, which overlie the Yarragadee Formation comprising shale, sand and sandstone. At the Proposal site, the superficial formations comprise Quaternary Bassendean Sands that typically extend 30 m to 55 metres below ground level (mbgl), thinning out and becoming unsaturated eastwards towards the Gingin Scarp (DWER 2017; Advisian 2021).

The topography is relatively flat and grades upwards to the east beyond the Proposal, where the Gingin scarp manifests as a series of rolling hills, and after levelling out at the base of the scarp, grades slowly to the west and north where a series of surface wetlands occur. To the west is a limestone ridge that runs approximately north-south (FB&A, 2011). Topographic survey data shows ground elevations of the Proposal varying between 25 m AHD and 34 m AHD (Figure 5-6).

According to the Western Australian Soil Group (WASG) classification, the soil of the Development Envelope is classified as '446 - Yellow Deep Sands' (Figure 5-7) (Schoknecht and Pathan 2013). Common in the region, this soil group comprises deep uniform sand profiles, which may vary from fine- to coarse-grained sand. The soil of the Development Envelope is also highly permeable, characterised by high infiltration rates and saturated conductivity rates, producing negligible rainfall runoff in storm events.

An acid base accounting (ABA) analysis of 18 composited samples was conducted over the Development Envelope (Tetris 2021). The analysis found the site to devoid of both acid generating and neutralising potential as demonstrated by total sulfur values less than reporting limit for all samples and ANC equal to or less than 1 kg H_2SO_4/t in all samples. The geology of the Proposal is considered NAF with a very low risk of generating saline drainage (Tetris Environmental 2021), which is also consistent with similar studies at nearby Proposal sites.

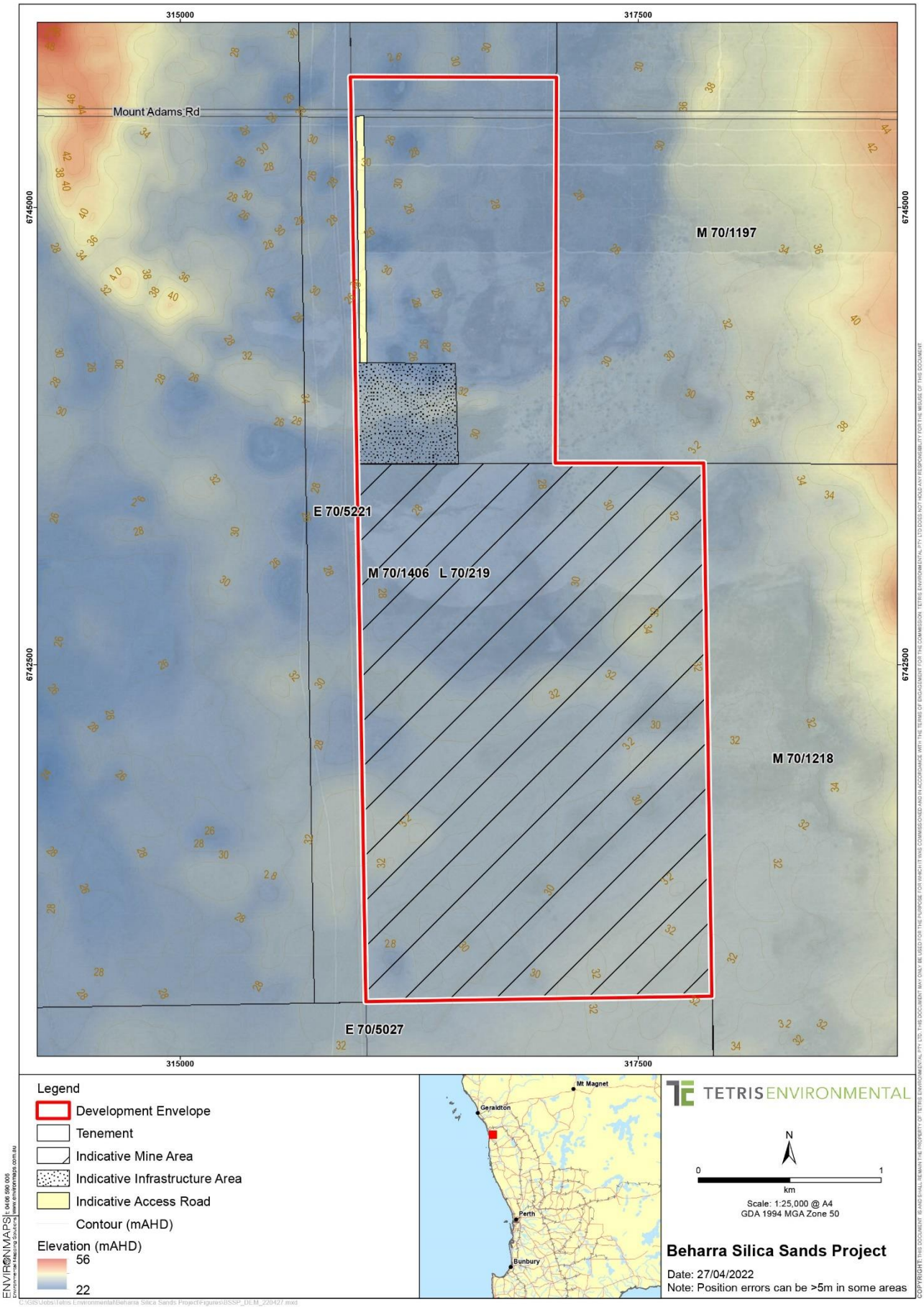

Figure 5-6 Digital Elevation Model of the Development Envelope

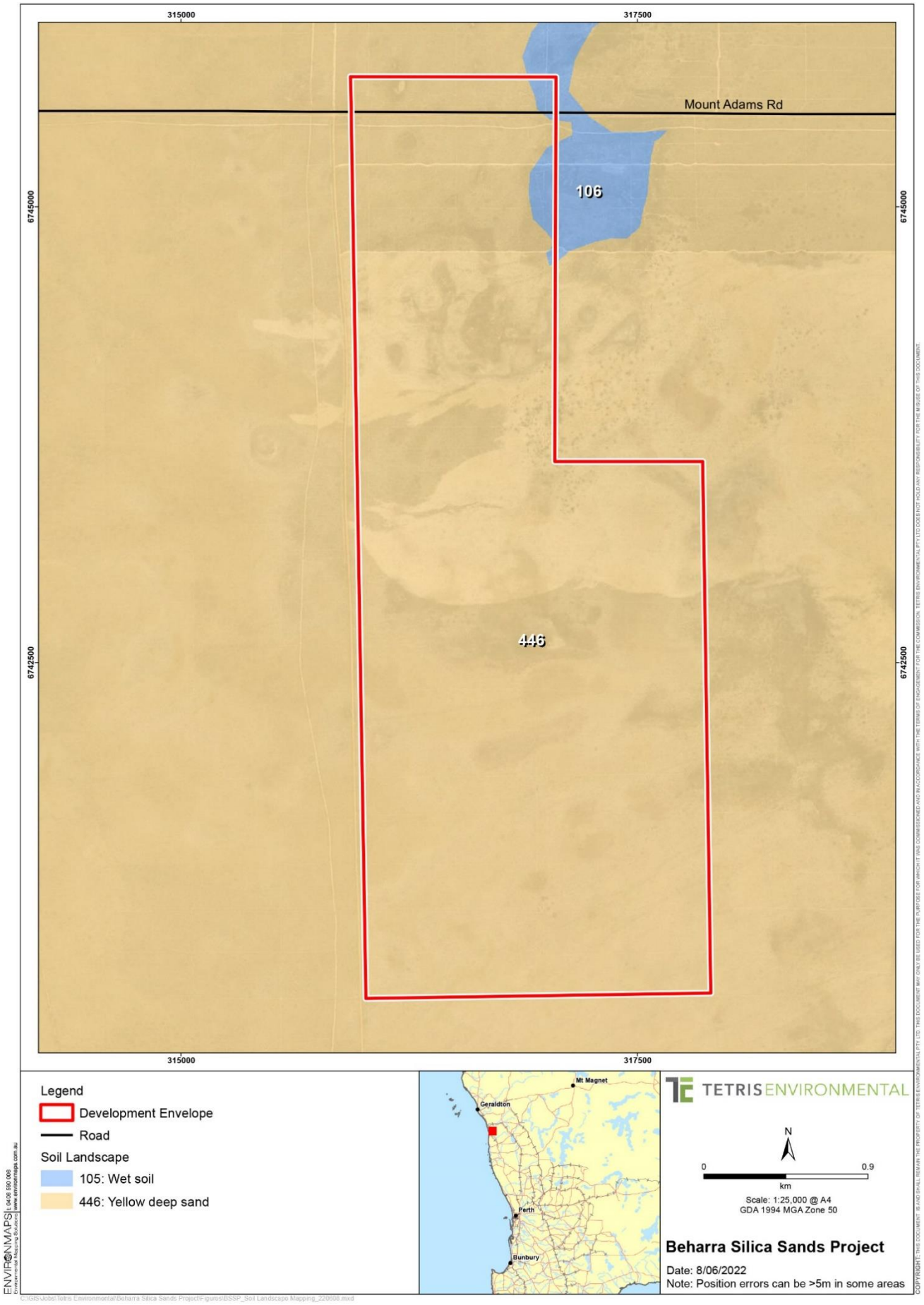

Figure 5-7 Soil Classification of the Development Envelope

5.6 Vegetation

A dataset containing vegetation extent polygons from the mapping of remnant vegetation is presented in Figure 5-8 (Native Vegetation Extent, DPIRD-005). This figure shows the Development Envelope within a broad expanse of remnant vegetation.

5.6.1 Pre-European Vegetation Associations

Vegetation presumed to have existed prior to European settlement has been mapped at a scale of 1:250,000 as vegetation system associations (Beard et al. 2013; DPIRD 2021, Government of Western Australia 2019b).

Two vegetation system associations occur in the Development Envelope, as presented on Figure 5-9 and Table 5-3. Both vegetation system associations that occur within the Development Envelope have undergone either minimal or moderate clearing, with over 65 % of their pre-European extent remaining.

Table 5-3 Pre-European Vegetation Association Extent

Vegetation System Association No.	**Eridoon 378**	**Eridoon 392**
Description	Shrublands; scrub-heath with scattered *Banksia* spp., *Eucalyptus todtiana* and *Xylomelum angustifolium* on deep sandy flats	Shrublands; *Melaleuca thyoides* thicket
Area Relevant to the Regional Area		
Pre-European Extent (ha)	93,524 ha	439 ha
Current Extent (ha)	60,827 ha	430 ha
Pre-European Extent Remaining (%)	65.0 %	97.9 %
Current Extent held in IUCN Class I-IV Reserves (%)	21.9 %	3.3 %
Area Relevant to the Proposal		
Umwelt (2022) Survey Area (ha)	1,882 ha	78 ha
Development Envelope (ha) (% of Development Envelope)	757 ha (96 %)	31 ha (4 %)
Footprint (ha)	586 ha	0 ha

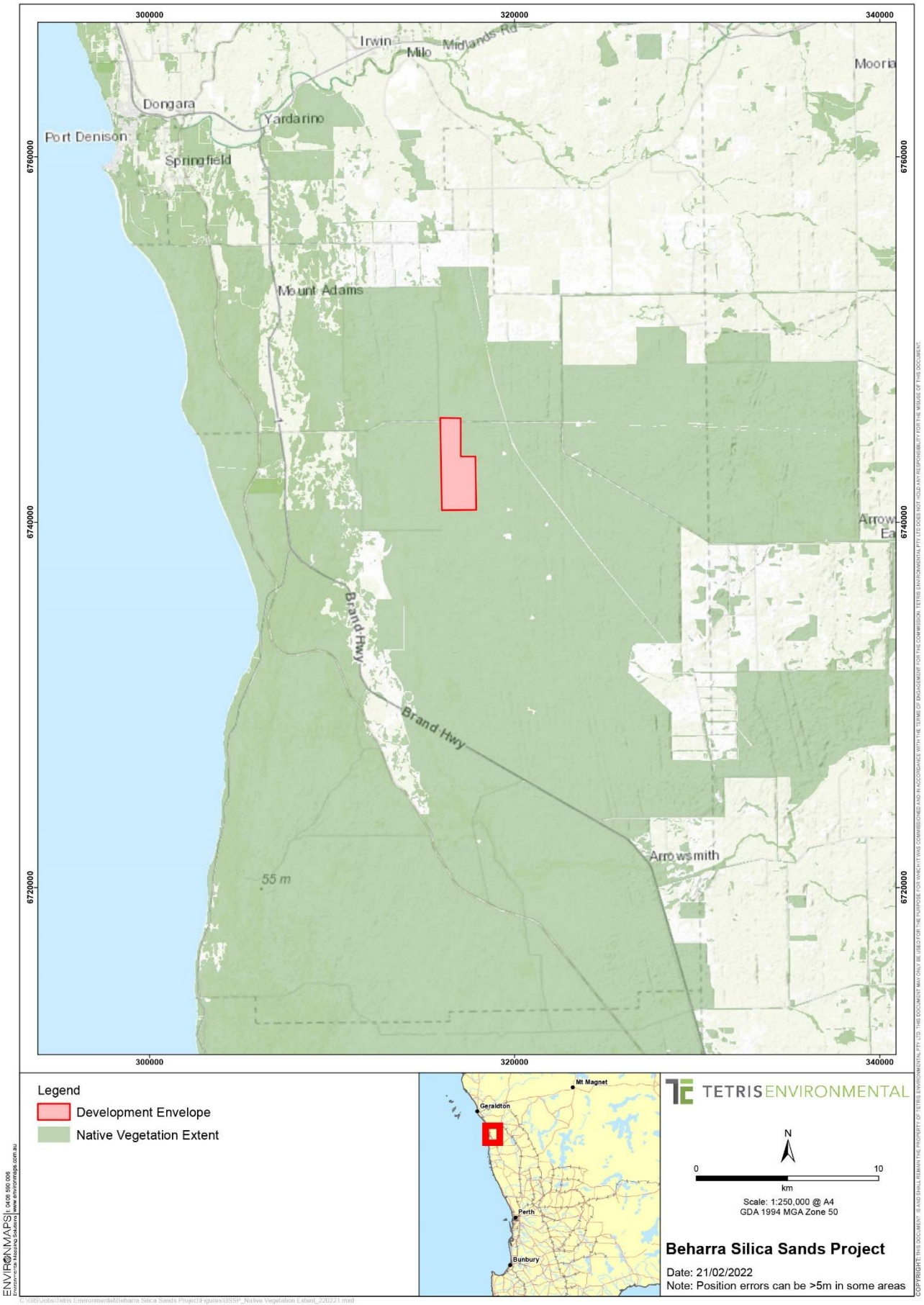

Figure 5-8 Vegetation Extent

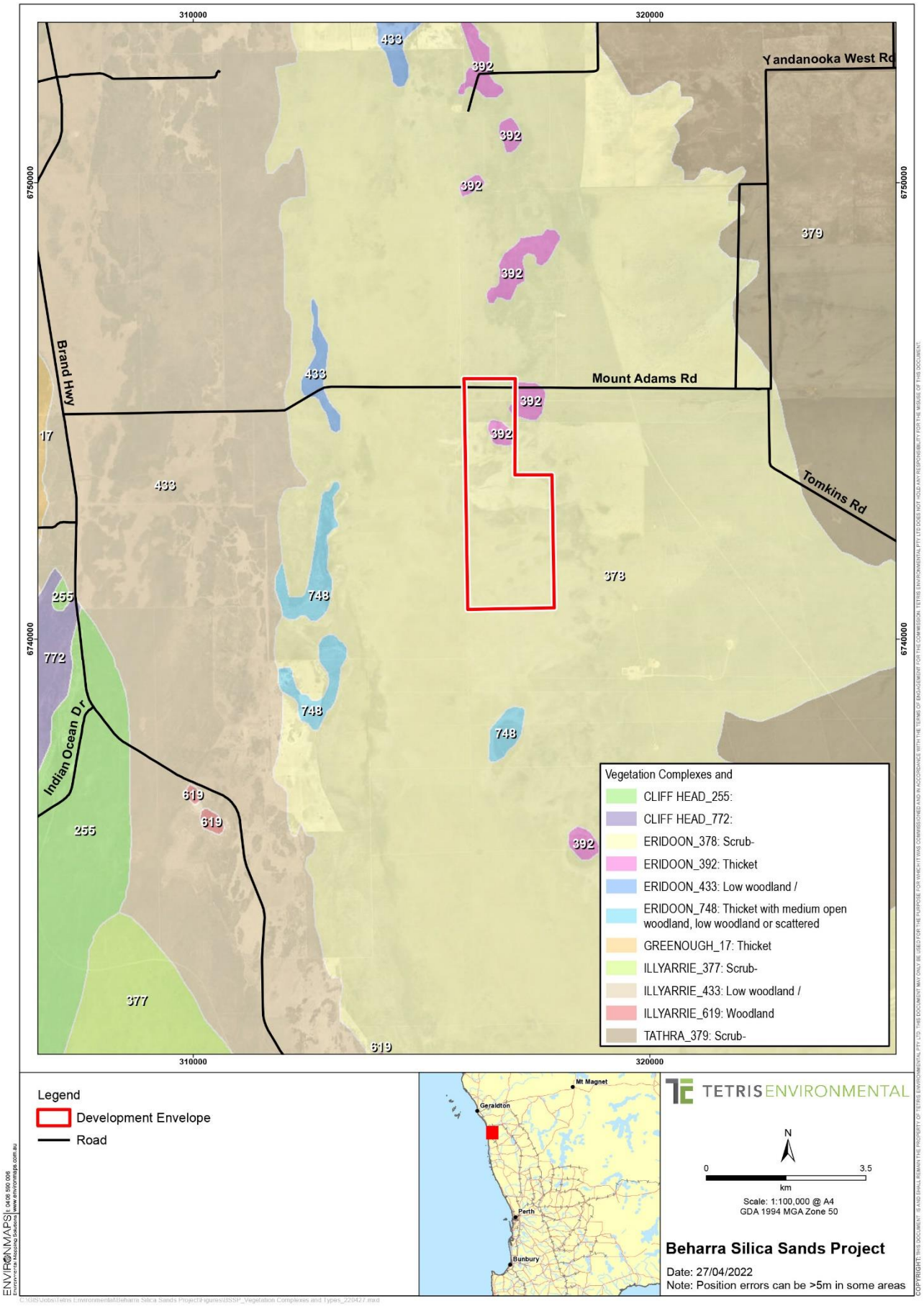

Figure 5-9 Pre-European Vegetation

5.6.2 Vegetation Types

Five vegetation types were defined in the Development Envelope based on floristic classification analysis, as well as detailed investigation of species composition, topography, soils, and geographic location (Umwelt 2022) (Appendix 4).

Table 5-4 describes the vegetation types and Figure 5-10 presents the extent of these vegetation types within the Umwelt Study Area, the Proposal Development Envelope and Footprint.

All mapped vegetation types were considered widespread in the region and representative of the extensive Eridoon vegetation association (Figure 5-9).

Areas where natural vegetation has been disturbed for roads and access tracks have been mapped as 'Cleared', and represents 23 ha of the Umwelt Study Area and ~11.8 ha within the Development Envelope.

Table 5-4 Mapped Vegetation types within the Development Envelope

Vegetation Type (VT)	Description	Photo of vegetation type	Proportion of each Vegetation Type		
			Study Area*	Development Envelope#	Footprint
VT 1	Mid sparse to open shrubland of *Acacia scirpifolia* over low mixed shrubland dominated by *Calothamnus hirsutus* and *Calothamnus quadrifidus* subsp. *angustifolius* over low sparse forbland of mixed species including *Drosera erythrorhiza, Schoenus nanus* and *Stylidium burbidgeanum* on lower slopes and flats on grey sandy clay.		151.6 ha	89.1 ha	41.2 ha
VT 2	Tall open shrubland to shrubland of *Acacia scirpifolia* over mid sparse to open shrubland dominated by *Allocasuarina campestris*, *Allocasuarina humilis* and *Banksia attenuata* over low sparse shrubland dominated by Jacksonia hakeoides, *Melaleuca leuropoma* and *Verticordia densiflora* var. *cespitos*a over low sparse forbland / segeland of mixed species including *Centrolepis aristata, Levenhookia stipitata, Schoenus nanus and Trachymene pilosa* on flats and open depressions on grey sandy clay		94.4 ha	22.6 ha	22.2 ha
VT 3	Low shrubland dominated by *Banksia leptophylla* var. *melletica*, *Calothamnus hirsutus, Kunzea micrantha* subsp. *petiolata* and *Verticordia densiflora* var. *cespitosa* over mixed sparse forbland on closed depressions and flats on grey sandy clay or light clay sometimes with limestone stones		54.7 ha	13.9 ha	9.7 ha

Vegetation Type (VT)	Description	Photo of vegetation type	Proportion of each Vegetation Type		
			Study Area*	Development Envelope#	Footprint
VT 4	Low open woodland of *Banksia attenuata* and *Banksia menziesii* over low open shrubland dominated by *Beaufortia elegans*, *Eremaea beaufortioides* var. *beaufortioides, Melaleuca leuropoma* and *Scholtzia laxiflora* over low sparse sedgeland of *Alexgeorgea nitens* and *Lyginia imberbis* on undulating plains on white or grey sand		1109.5 ha	524.3 ha	391.6
VT 5	Low open woodland of *Banksia attenuata* and *Banksia menziesii* over mid sparse to open shrubland dominated by *Banksia hookeriana* and *Conospermum boreale* subsp. *boreale* over low open shrubland dominated by *Daviesia divaricata* subsp. divaricata, *Eremaea beaufortioides* var. *beaufortioide*s, *Melaleuca leuropoma* and *Scholtzia laxiflora* over low sparse sedgeland dominated by *Lepidobolus preissianus* and *Mesomelaena pseudostygia* on undulating plains and crests on white, brown or yellow sand		527.3 ha	126 ha	112.8
Cleared			23	11.8	8.7
TOTAL			**1960.5**	**787.7**	**586.2**

*Umwelt (2022) Study Area

Reflects revised Development Envelope calculations subsequent to Umwelt (2022) which used a larger DE polygon which was subsequently revised by PEC

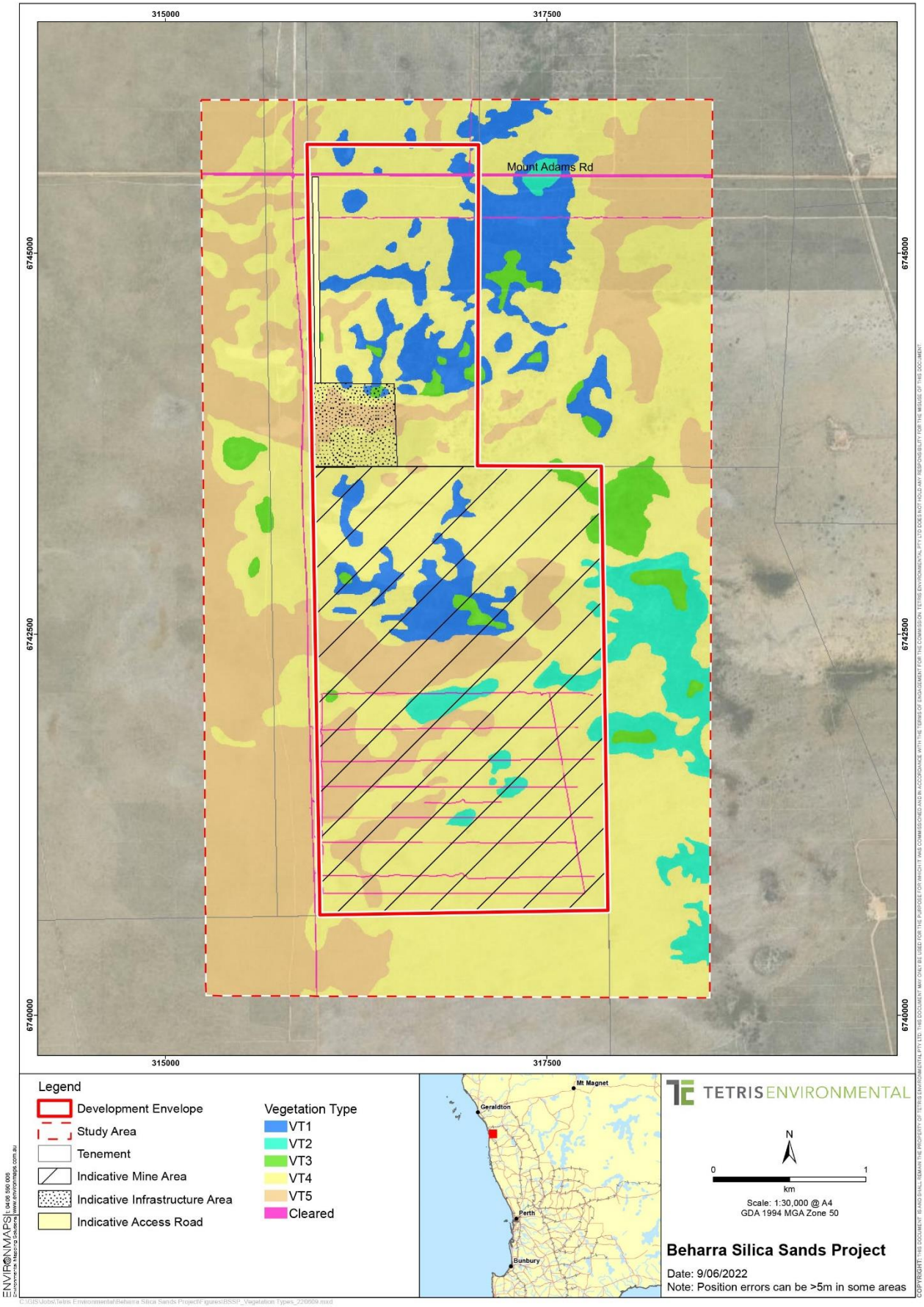

Figure 5-10 Vegetation Types of the Development Envelope

5.6.3 Vegetation of Conservation Significance

A desktop assessment did not identify any State or Commonwealth listed Threatened Ecological Communities (TECs) or State listed Priority Ecological Communities (PECs) within Development Envelope. The nearest listed ecological community, the 'Subtropical and Temperate Coastal Saltmarsh' TEC, was located ~23 km north west of the Proposal (DBCA 2021b) (Figure 5-11).

Field surveys found no vegetation types mapped in the Development Envelope to represent any formally-listed TECs or PECs, nor are they considered significant for any other reasons as per EPA (2016a, 2016b). Based on field observations and aerial photography interpretation, all vegetation types mapped within the Development Envelope are known to extend broadly outside the Study Area.

5.6.4 Vegetation Condition

In accordance with the Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016b), vegetation condition across the Development Envelope has been mapped and quantified following multiple survey efforts.

Vegetation condition ratings were assigned in accordance with the EPA (2016b) recommended scale for the Eremaean botanical province, the results of which are presented in Table 5-5 and on Figure 5-12.

The condition of the vegetation in the Development Envelope was rated Excellent, with little to no historical mechanical disturbance and an absence or low levels of introduced flora. Some parts have been impacted by small areas of clearing associated with seismic lines and vehicle tracks, and occasional weeds at low levels. There was also varying levels of fire history recorded throughout the Development Envelope.

Table 5-5 Vegetation Condition within the Development Envelope

Condition Rating	Study Area	Development Envelope
Excellent	1937.5 ha	775.9 ha
Very Good	-	-
Good	-	-
Degraded	-	-
Completely Degraded (cleared)	23 ha	11.8 ha
Total	**1,960.5 ha**	**787.7 ha**

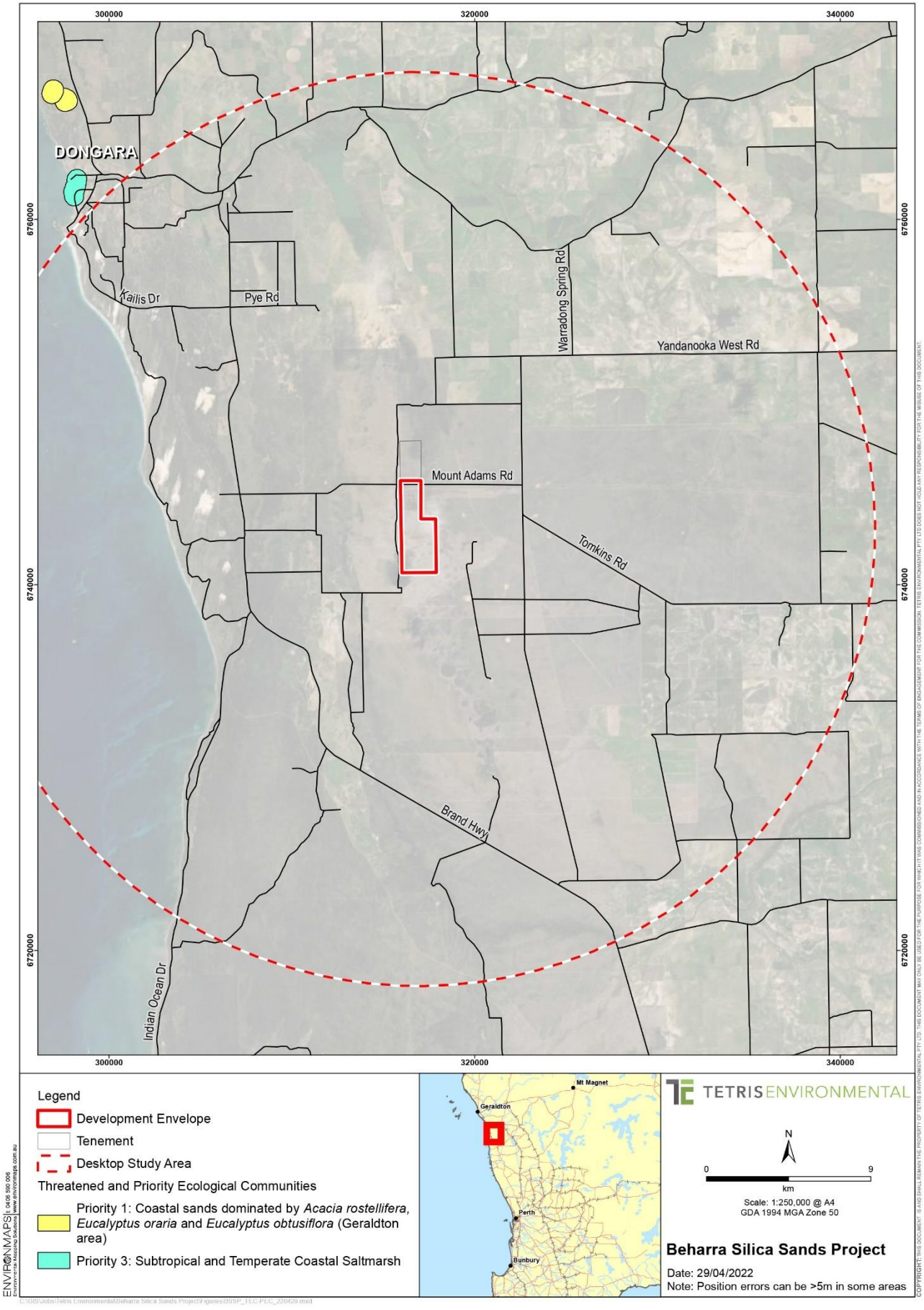

Figure 5-11 Vegetation of Conservation Significance

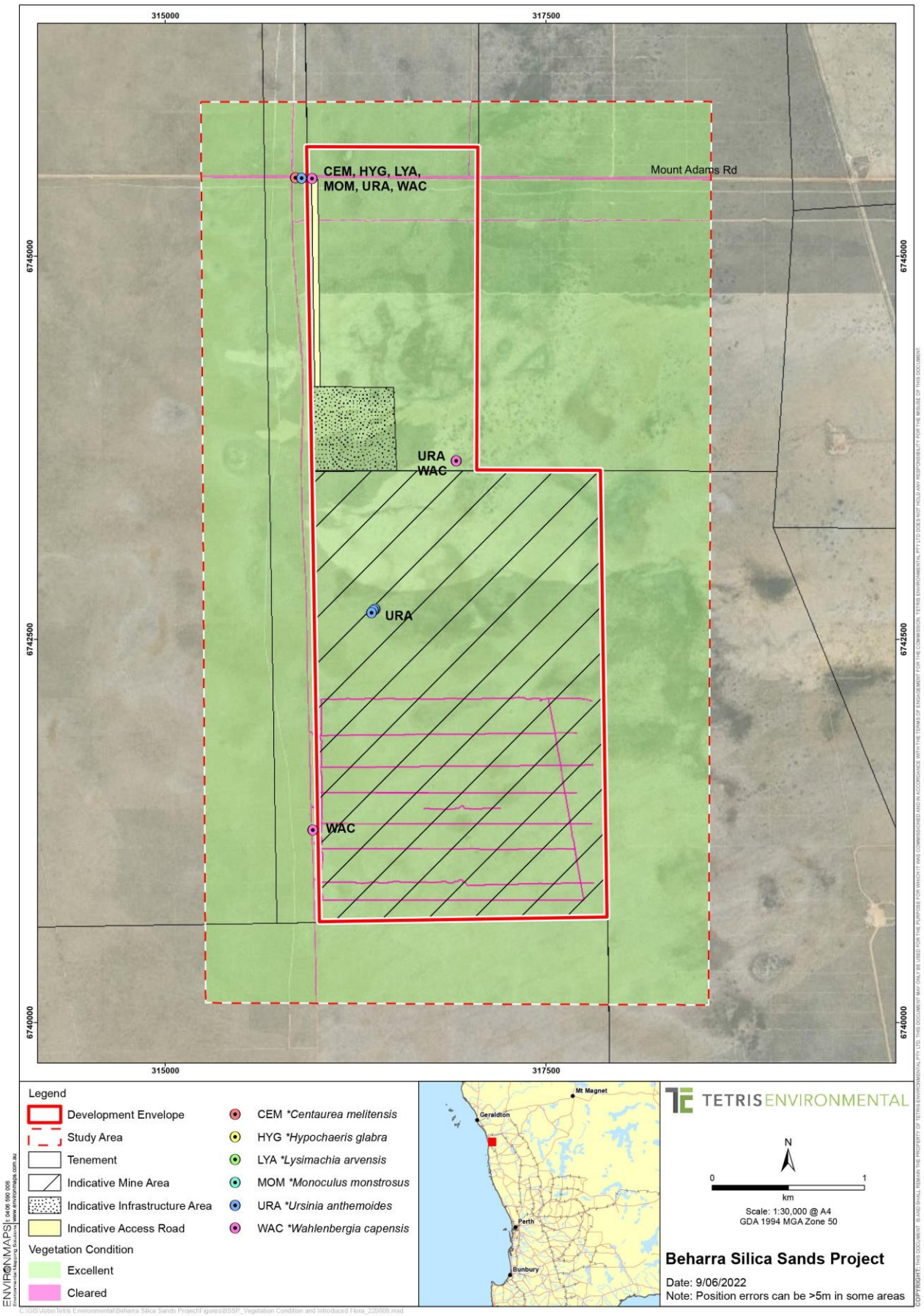

Figure 5-12 Vegetation Condition

5.6.5 Groundwater Dependent Vegetation

Desktop assessment of the Groundwater Dependent Ecosystem (GDE) Atlas (BoM, 2021b) showed there is a high potential for terrestrial GDE presence within the Development Envelope. The environments which may potentially constitute GDEs in this area are likely damplands and associated fauna. It should be noted that the National Assessment is based on coarse resolution satellite and remote sensing data and has not been ground-truthed or confirmed with field assessment.

Two flora species recorded in the Development Envelope during field surveys, *Banksia attenuata* and *Banksia menziesii,* are known to be facultative phreatophytes and will use accessible groundwater sources where they are available. Umwelt (2022) note that groundwater within 10 m of the surface may be a water source for *Banksia attenuata* and *B. menziesii* (associated with VT4 and VT5) for at least part of the year, and particularly in times of drought. Based on investigations by Advisian (2022a) and local water bore records, the Superficial Aquifer is known to occur within ~7.6-8 m of the topographical surface.

5.6.6 Dieback

The Development Envelope and surrounds was inspected by a Dieback Interpreter in October 2019 (Bark Environmental 2019). Evidence of *Phytophthora* Dieback infestation were observed in vegetation alongside the main access road off Mt Adams Road within the adjacent Yardanogo Nature Reserve.

Soil/plant-tissue samples collected and tested at the DBCA laboratory found two samples, collected from the access track off Mt Adams Road adjacent the Yardanogo Nature Reserve, to contain *Phytophthora arenaria*, which is common on the northern sandplain. No *Phytophthora cinnamomi* was detected.

5.7 Flora

5.7.1 Flora Taxa

A desktop assessment by Umwelt (2021 and 2022) identified 88 listed significant flora taxa as potentially occurring within the Development Envelope prior to field assessment. Of these, eight were recorded during detailed field surveys.

It is considered that all of the remaining 80 significant flora taxa were identifiable during the Umwelt (2022) field surveys, either because the survey period coincided with the taxon's flowering period, or the taxon can be identified reliably when in fruit or sterile. However, of these 80 taxa, none are considered likely to occur in the Development Envelope; in most cases, no suitable habitat is considered to be present. Refer to Appendix 4 (Umwelt 2022) for the complete list of species identified during the likelihood of occurrence assessment.

Umwelt (2022) recorded a total of 268 flora taxa within the Development Envelope, comprising 54 families and 142 genera. This includes 260 native taxa and eight introduced taxa. The most well-represented families were Myrtaceae (31 taxa), Proteaceae (27 taxa), Asteraceae (18 taxa) and Fabaceae (17 taxa). Average taxon richness per quadrat was 35.2 (± 10.8), with the greatest number of flora taxa recorded in a single quadrat being 59 (in VT4), and the lowest number being 18 (in VT3).

Eight introduced flora were recorded within the Development Envelope. Table 5-6 lists location information and comments regarding the significance of these taxa, including ecological impact and invasiveness ratings for each introduced taxon under Ecological Impact and Invasiveness Ratings from the Department of Parks and Wildlife for the Midwest Region (DBCA 2014). None of the recorded

introduced flora taxa are Declared Pests under the *Biosecurity and Agriculture Management Act 2007* (BAM Act) (DPIRD 2022) or Weeds of National Significance (Weeds Australia 2022).

Table 5-6 Introduced Flora of the Development Envelope

Taxon	Common Name	Number of Locations	Ecological Impact*	Invasiveness
Aira cupaniana	Silvery Hairgrass	1	High	Rapid
Arctotheca calendula	Cape Weed	1	High	Rapid
Centaurea melitensis	Maltese Cockspur	1	High	Rapid
Hypochaeris glabra	Flatweed	10	Low	Rapid
Lysimachia arvensis	Scarlet Pimpernel	1	Low	Rapid
Monoculus monstrosus	Stinking Roger	1	Unknown	Rapid
Ursinia anthemoides	Ursinia	7	High	Rapid
Wahlenbergia capensis	Cape Bluebell	3	Unknown	Rapid

* Data from DBCA (2014).

5.7.2 Flora of Conservation Significance

Systematic targeted survey for significant flora taxa was undertaken during detailed and targeted surveys in 2021, with a list of significant flora taxa likely to be encountered compiled as part of the Desktop Study prior to field work (see Umwelt 2022, Appendix 4). Information relating to identifying characteristics, flowering period and habitat of these significant taxa was provided to all field team members prior to undertaking targeted survey. Multiple targeted surveys were undertaken over the entire Footprint via transects spaced approximately 20 m apart. Where plants of significant flora taxa were encountered, or where transects intersected habitat of less conspicuous flora, additional survey were undertaken between transects.

Targeted survey for *Paracaleana dixonii* (T) were also undertaken during the optimum flowering period of this species (mid-late November). Suitable habitat for this taxon within the Footprint was traversed on foot, with transects spaced approximately 10 m apart (Umwelt 2022, Appendix 4).

No State or Commonwealth listed Threatened flora were recorded by Umwelt within or adjacent to the Development Envelope. Of note, *Paracalaena dixonii* (T) was not recorded within the Development Envelope, despite comprehensive searches (Umwelt 2022).

Eight DBCA-listed Priority flora taxa were recorded in the Development Envelope, with seven of these taxa found within the Footprint. Significant flora are detailed in Table 5-7 and displayed in a Figure series between Figure 5-13 and Figure 5-16.

One additional taxon, Scaevola sp. (potentially undescribed), was recorded from five locations (Umwelt 2022). Several local collections, believed to be this entity, are currently lodged in the WA Herbarium, and 10 records of *Scaevola anchusifolia* within the vicinity by previous Woodman Environmental surveys, are likely to represent the same entity (Umwelt 2022). Although *Scaevola* sp. (potentially undescribed) appears restricted, it is considered likely that the entity is relatively widespread within and in the vicinity of the area.

Table 5-7 Flora of Conservation Significance

Species	Number of Individuals Recorded			Vegetation Types
	Study Area	Development Envelope	Footprint	
Banksia elegans **(P4)**	10,755	7662	6,796	1,2 3, 4^, 5^, C
Centrolepis milleri **(P3)**	1	0	1	2
Comesperma griffinii **(P2)**	2	0	0	2^
Comesperma rhadinocarpum **(P3)**	1	0	1	4
*Hemiandr*a sp. Eneabba **(P3)**	6190	4089	3,491	1,2, 4^, 5^, C
Persoonia rudis **(P3)**	3	3	2	4^, 5^
Schoenus griffinianus **(P4)**	69,790	52,756	42,934	1,2 3, 4, 5, C
Stawellia dimorphantha **(P4)**	92	55	55	1, 4^, 5^, C

^represents preferred habitat

Banksia elegans

Banksia elegans (P4) is a shrub growing up to 4 m high (Plate 5-1) that occurs on sandplains and low consolidated dunes on yellow, white or red sand (WA Herbarium 1998-). It has a range of approximately 175 km in WA, from north-west of Dongara in the north-west, to near Hill River in the south-east. This taxon is known from 46 regional records on DBCA databases, nine of which occur within DBCA conservation tenure including Beekeepers Nature Reserve, Lake Logue Nature Reserve, Lesueur National Park and Yardanogo Nature Reserve.

A total of 10,755 individuals of *Banksia elegans* (P4) were recorded at 2,244 points by Umwelt (2022), of which 6,796 individuals (63.2%) from 1,502 locations (66.9%) occur within the Footprint (Figure 5-13 and Table 5-7). This taxon was widespread, recorded in all five vegetation types mapped in the Development Envelope.

Plate 5-1 *Banksia elegans* (P4) (Source: Umwelt 2022)

Hemiandra sp. Eneabba (P3)

Hemiandra sp. Eneabba (H. Demarz 3687) (P3) is a shrub growing to 0.9 m high (Plate 5-2) that occurs on sandplains, slopes and flats with sand (WA Herbarium 1998). It has a range of approximately 66 km from south east of Port Denison to south of Eneabba. This taxon is known from 35 regional records on DBCA databases, two of which occur within DBCA conservation tenure including Yardanogo Nature Reserve and South Eneabba Nature Reserve. A total of 6,190 individuals of Hemiandra sp. Eneabba (H. Demarz 3687) (P3) were recorded at 2,512 locations, of which 3,491 individuals (56.4%) from 1,661 locations (66.1%) occur within the Footprint (Figure 5-14 and Table 5-7). This taxon was widespread recorded from within four of the five vegetation types of the area (VT1, VT2, VT4 and VT5).

Plate 5-2 *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3) (Photos: Umwelt)

Schoenus griffinianus (P4)

Schoenus griffinianus (P4) is a small herbaceous sedge growing to 0.1 m high (Plate 5-3) that occurs on plains, flats and slopes with sand (WA Herbarium 1998-). Its range is approximately 370 km in WA, from south-east of Geraldton to east of Perth. This taxon is known from 40 regional records, six of which occur within DBCA conservation tenure including Lake Logue Nature Reserve, Moore River National Park and South Eneabba Nature Reserve.

A total of 69,790 individuals of *Schoenus griffinianus* (P4) were recorded at 2,276 locations by Umwelt (2022), of which 42,934 individuals (61.5%) from 1,424 locations (62.6%) occur within the Footprint (Figure 5-15 and Table 5-7). This taxon was widespread and recorded from all five vegetation types of the Development Envelope.

Plate 5-3 *Schoenus griffinianus* (P4) Umwelt specimen (Photos: Umwelt)

Centrolepis milleri (P3)

Centrolepis milleri (P3) is a herb growing to 0.1 m high (Plate 5-4) that occurs on sandplains, undulating plains and disturbed sites with sand or sandy clay (WA Herbarium 1998-). It has a range of approximately 623 km in WA, from north of Eneabba to east of Mount Barker. This taxon is known from eight regional records on DBCA databases, one of which occurs within DBCA conservation tenure at Mount Benia Reserve (WA Herbarium 1998-).

Centrolepis milleri (P3) was recorded at one location within the Footprint (Figure 5-16 and Table 5-7) in VT2. Identified during plant identifications post-survey, it is likely that there are more occurrences of this taxon within the Development Envelope. The recorded location represents a range extension of the taxon's known range (~25 km north).

Plate 5-4 *Centrolepis milleri* (P3) Herbarium specimen (Photos: Umwelt)

Comesperma griffinii (P2)

Comesperma griffinii (P2) is a herb growing to 0.15 m high (Plate 5-5) that occurs on yellow or grey sand on plains (WA Herbarium 1998-). Its range is approximately 830 km in WA, from Geraldton to Esperance. This taxon is known from 15 regional DBCA database records, five of which occur within DBCA conservation tenure including Kenwick Wetlands Nature Reserve, South Eneabba Nature Reserve, Yardanogo Nature Reserve, Indarra Spring Nature Reserve and Helms Arboretum Miscellaneous Reserve (WA Herbarium 1998-).

Four individuals of *Comesperma griffinii* (P2) were recorded at two locations outside the Development Envelope (Figure 5-16 and Table 5-7), within vegetation type VT2.

Plate 5-5 Comesperma griffinii (P2) Herbarium specimen (Photos: Umwelt)

Comesperma rhadinocarpum (P3)

Comesperma rhadinocarpum (P3) is a perennial herb growing to 0.2 m high (Plate 5-6) that occurs on lower slopes, undulating plains and flats on sand or clay (WA Herbarium 1998-). It has a range of approximately 972 km in WA, from north of Gregory to Cannington, Perth in the south, to east of Kalgoorlie. This taxon is known from 17 regional records on DBCA databases, five of which occur within DBCA conservation tenure including Mount Manning Nature Reserve, Fynes Road Nature Reserve, Lake Logue Nature Reserve, Drummond Nature Reserve, Kenwick Wetlands Nature Reserve, and Howatharra Hill Reserve.

One individual of *Comesperma rhadinocarpum* (P3) was recorded at one location within the Footprint (Figure 5-16 and Table 5-7), in the extensive vegetation type of VT4.

Plate 5-6 *Comesperma rhadinocarpum* (P3) Left Herbarium specimen (Photos: Umwelt)

Persoonia rudis (P3)

Persoonia rudis (P3) is a shrub growing to 1 m high (Palte 5-7) that occurs on white, grey or yellow sand, often over laterite (WA Herbarium 1998-). Its range is approximately 266 km in WA, from Port Denison to Bullsbrook. This taxon is known from 41 regional records, 11 of which occur within DBCA conservation tenure including Boonanarring Nature Reserve, Bullsbrook Nature Reserve, Lesueur National Park and South Eneabba Nature Reserve.

Three individuals of Persoonia rudis (P3) were recorded at two locations, one of which is located within the Footprint (Figure 5-16 and Table 5-7). The taxon was recorded in two of widespread vegetation types, VT4 and VT5.

Plate 5-7 *Persoonia rudis* (P3) (Photos: Umwelt)

Stawellia dimorphantha (P4)

Stawellia dimorphantha (P4) is a stilt-rooted perennial herb growing to 0.2 m high (Plate 5-8) that occurs on lower slopes and undulating plains with white, grey or yellow sand (WA Herbarium 1998-). Its range is approximately 89 km in WA, from Dongara to near Eneabba. This taxon is known from 23 regional records, two of which occur within DBCA conservation tenure including Beekeepers Nature Reserve and Yardanogo Nature Reserve.

A total of 92 individuals were recorded at 38 locations by Umwelt (2022), 37 individuals (59.8%) from 17 locations (44.7%) were recorded within the Footprint, across the widespread vegetation types of VT1, VT4 and VT5.

Plate 5-8 *Stawellia dimorphantha* (P4) (Photos: Umwelt)

Scaevola sp. (potentially undescribed)

Umwelt (2022) made three collections of an entity not well accommodated by the currently available taxonomy (M. Hislop pers. comm.). *Scaevol*a sp. (potentially undescribed; Plate 5-9) was recorded at five locations by Umwelt (2022), one location was within the Footprint (Table 5-7, Figure 5-16).

There are currently three collections of what appears to be the same entity collected from Mt Adams Road (near the Proposal) that are lodged at the WA Herbarium. Ten historical records of *Scaevola anchusifolia* have also been made within the vicinity of the Proposal, which is believed to represent the same entity. It is therefore considered that Scaevola sp. (potentially undescribed) is relatively widespread within the area.

Plate 5-9 *Scaevola* sp. (potentially undescribed) Umwelt specimen (Photos: Umwelt)

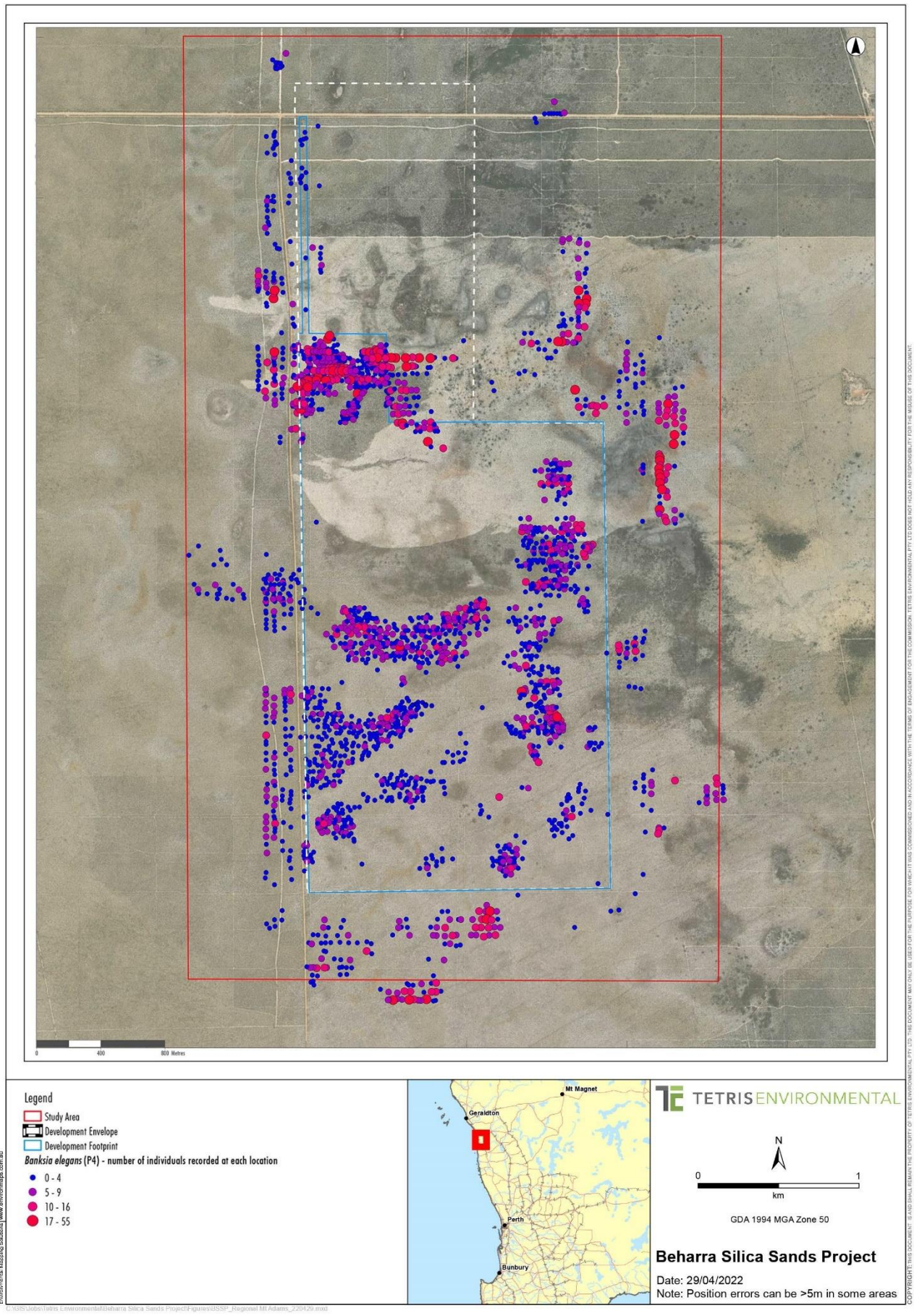

Figure 5-13 Significant Flora – *Banksia elegans*

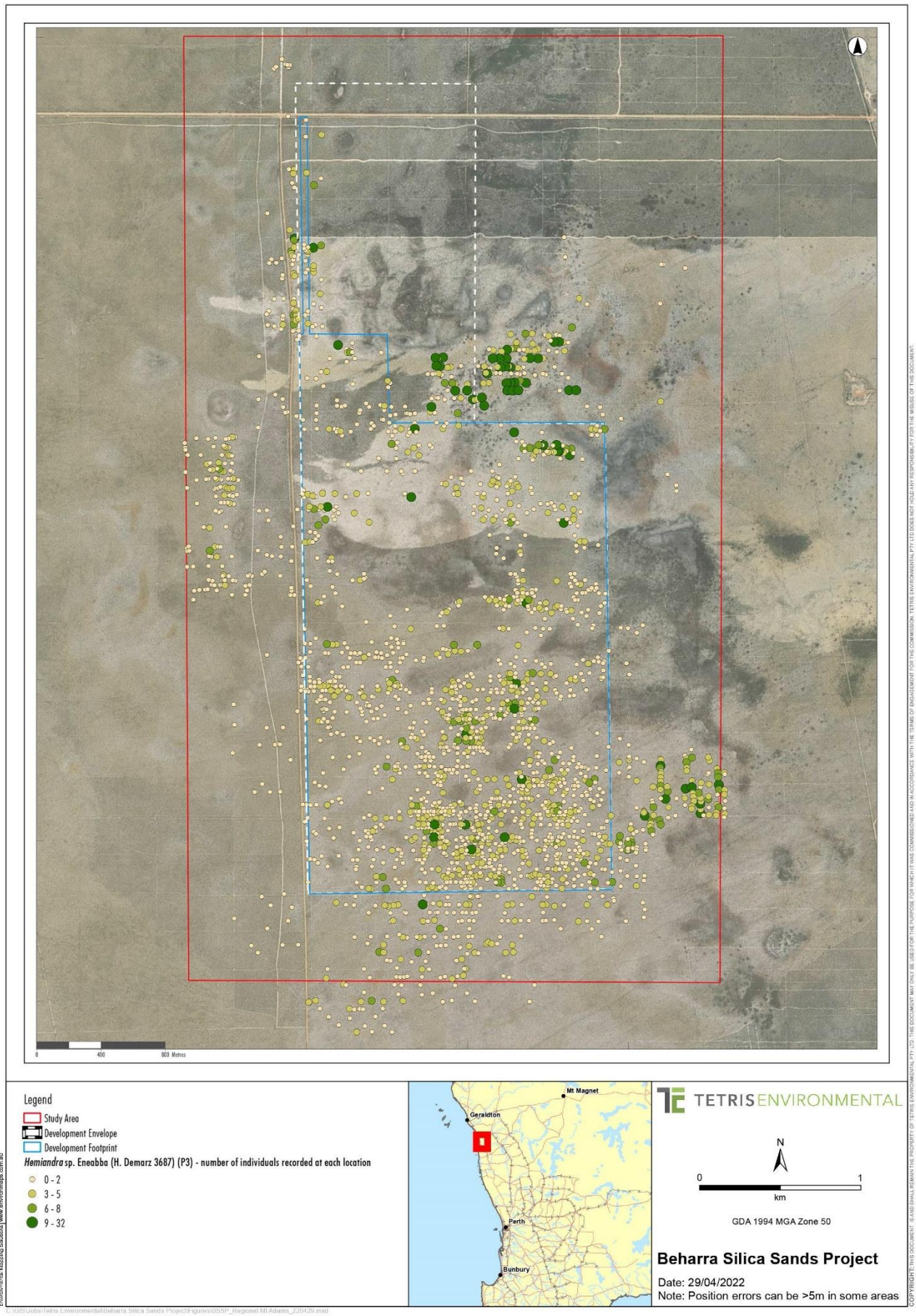

Figure 5-14 Significant Flora – *Hemiandra* sp. Eneabba

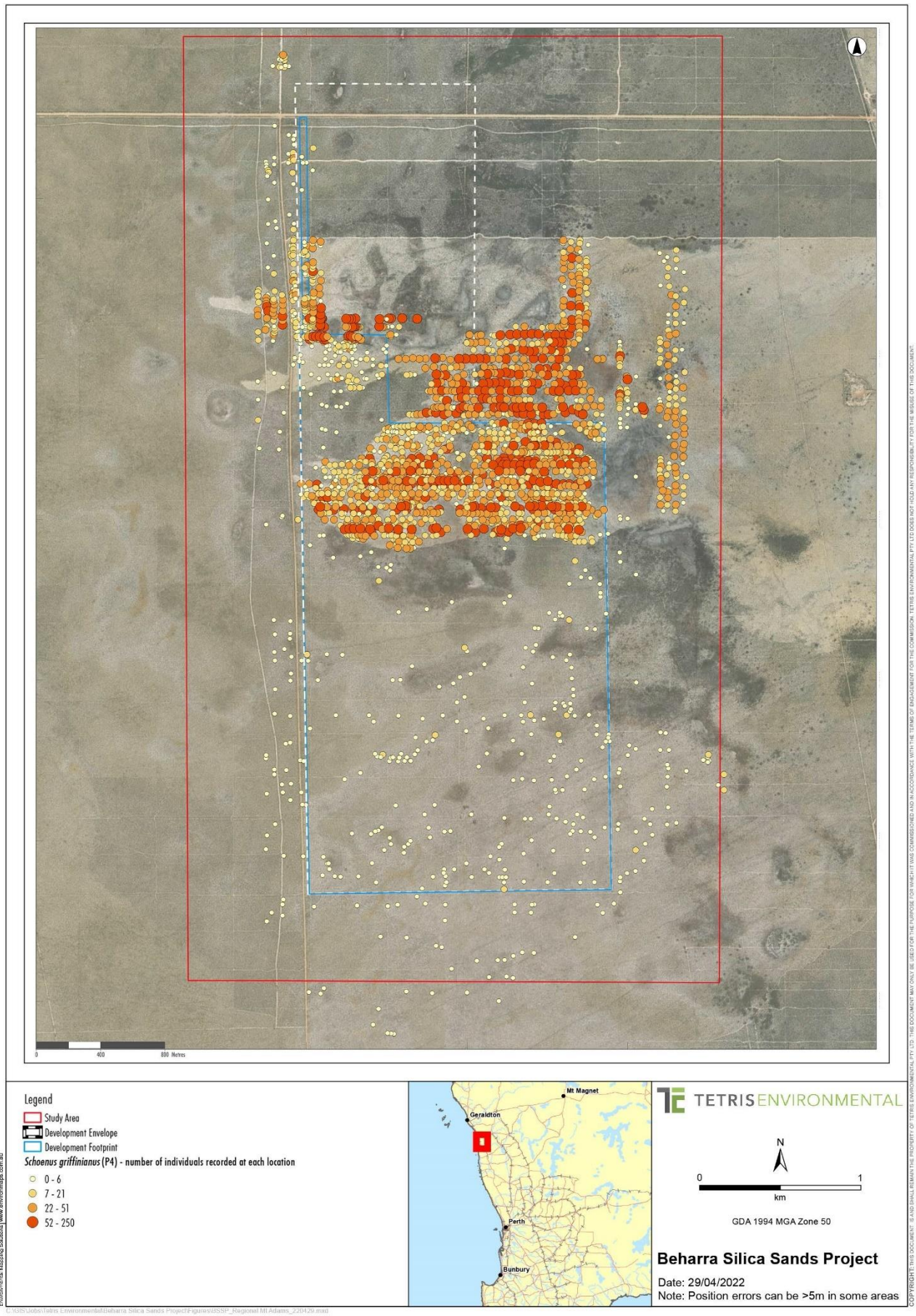

Figure 5-15 Significant Flora – *Schoenus griffinianus*

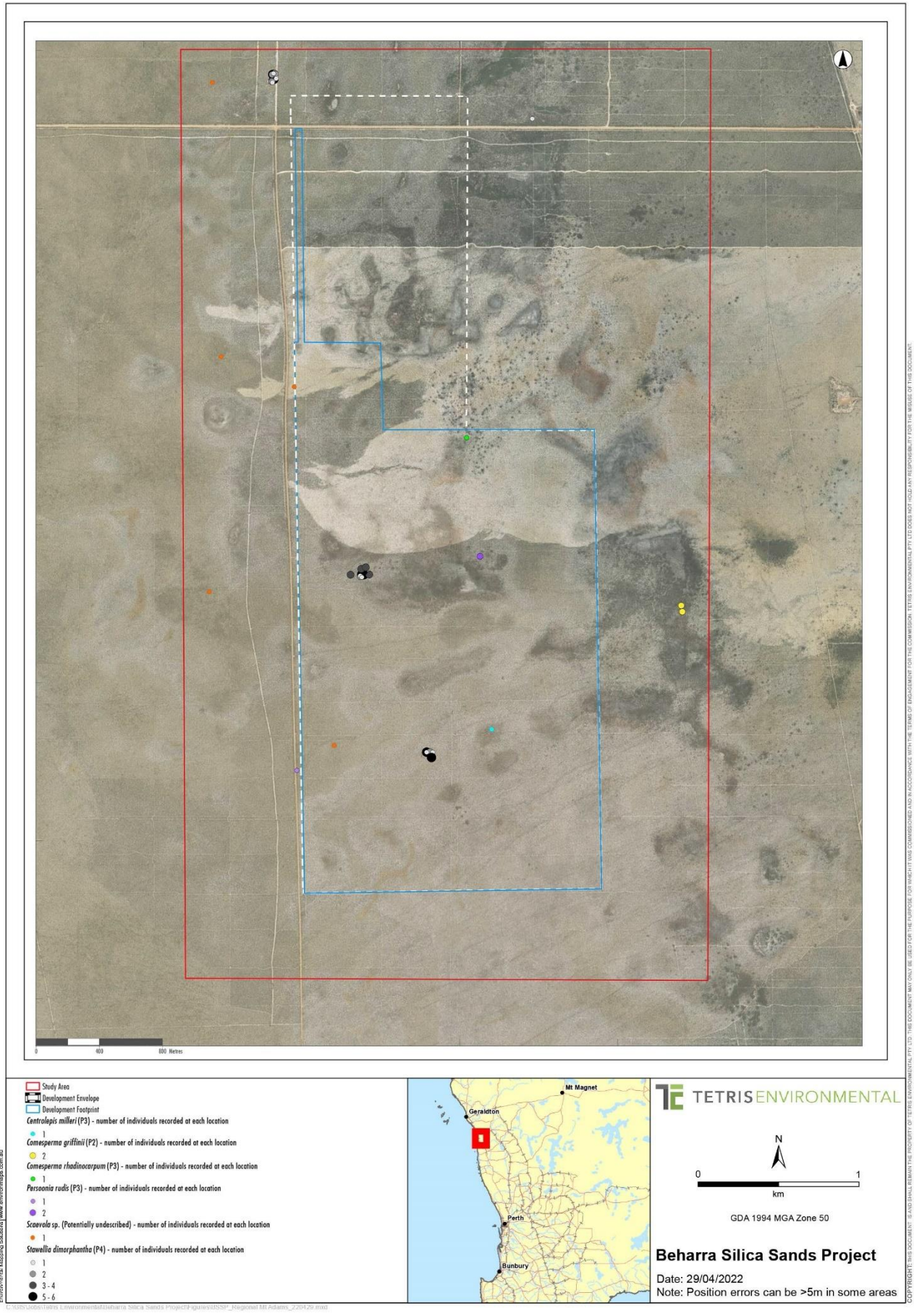

Figure 5-16 Significant Flora – Other

5.8 Vertebrate Fauna

5.8.1 Fauna Habitat

The Development Envelope is situated within two broad fauna habitat types (BCE 2022):

- VSA1: Kwongan Heath
- VSA2: Dampland Thicket

These habitat types were derived through consideration of FCT analysis undertaken by Woodman (2011) and confirmed through on-ground fauna surveys in 2020 and 2021 (BCE 2022, Appendix 5). Following a review of third-party regional surveys and interrogation of aerial photography, none of the recorded habitat types are unique to the Development Envelope and occur commonly throughout the region (Figure 5-17). The recorded habitat types and their local extents are summarised in Table 5-8 and presented in Figure 5-18. The VSA1 is the most extensive habitat type present, accounting for 96% of its mapped regional extent and 89% of the Development Envelope.

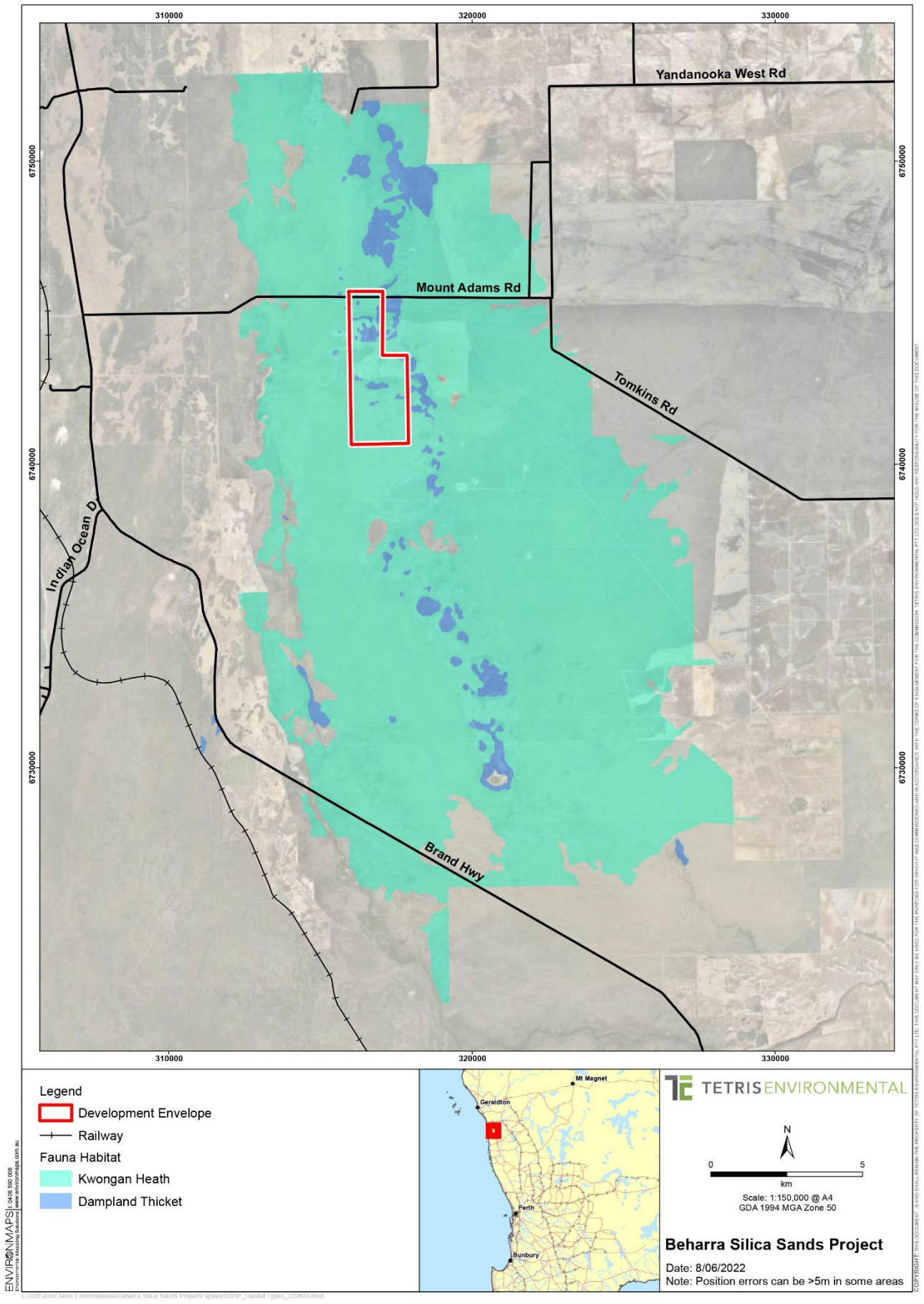

Figure 5-17 Regional Fauna Habitat

Table 5-8 Vertebrate Fauna Habitat Extent

Habitat type	Description	Known Regional extent	Development Envelope	Footprint	Representative Photo
VSA1 Kwongan Heath	Kwongan shrubland on sandy soils more or less high in the landscape and with several banksia species prominent (*Banksia attenuata, Banksia hookeriana, Banksia menziesii* and in some areas *Banksia elegans*	27,286 ha	698 ha	538 ha	 (Photo Source: Bamford, 2020)
VSA2 Dampland Thicket	Thickets on heavier soils subject to winter waterlogging low in the landscape, usually with *Banksia leptophylla* and *Acacia* sp.. Often with patches of a low *Verticordia* sp.	1,187 ha	90 ha	48 ha	 (Photo Source: Bamford, 2020)

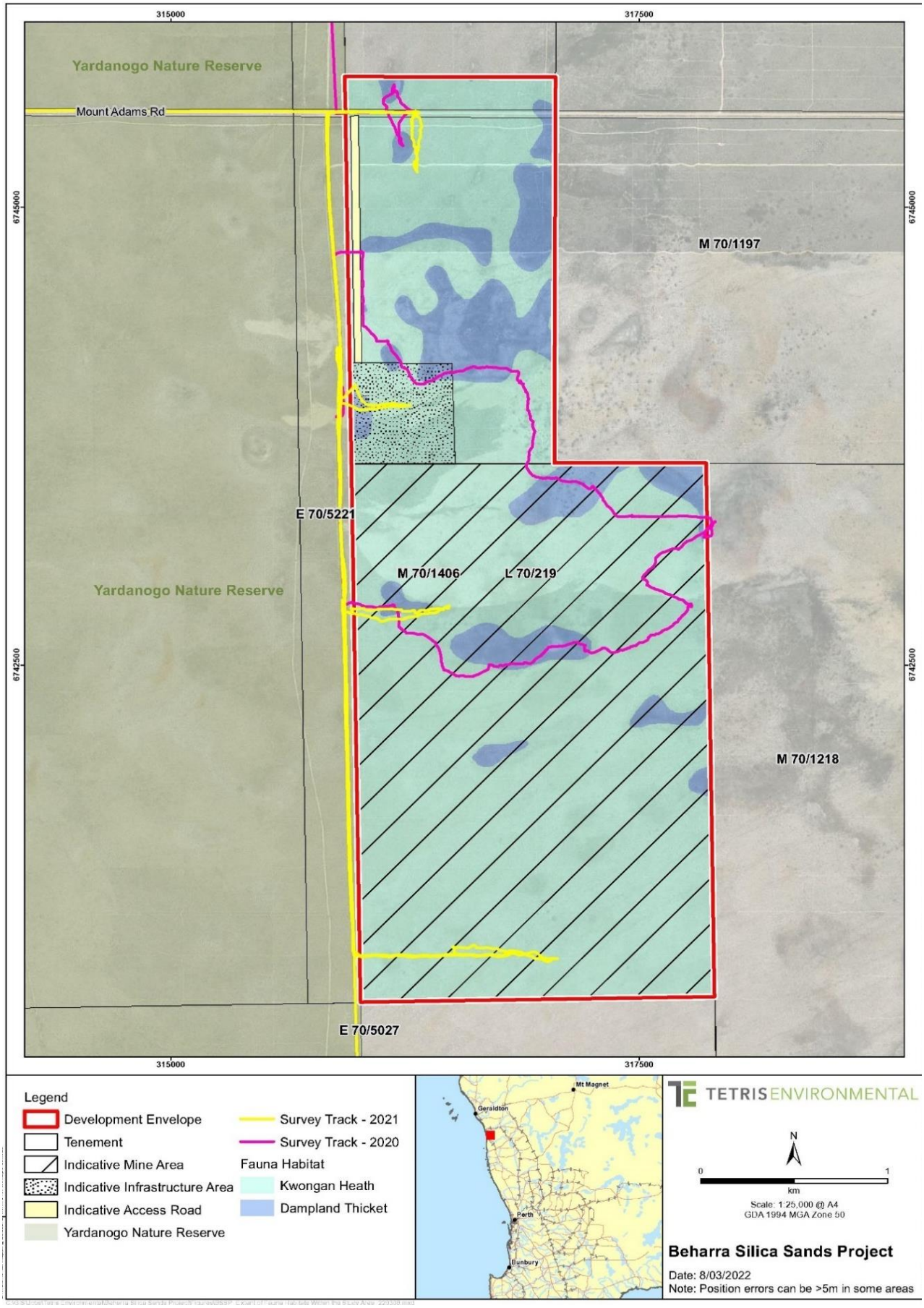

Figure 5-18 Terrestrial Fauna 2021 Survey Area and Habitat Mapping

5.8.2 Fauna Assemblage

Desktop assessments identified 205 vertebrate fauna species as potentially occurring in the Development Envelope, comprising of 10 frogs, 51 reptiles, 119 birds and 25 mammals. Eight of the species recorded are of conservation significance. Multiple recent fires are likely to have affected the fauna assemblages, with about eight fires occurring within the Development Envelope in the last 50 years (BCE 2022).

A likelihood of occurrence assessment for significant fauna was conducted based on the habitats present within the Development Envelope and the findings from third-party surveys in the region. The assessment determined that three taxa are residents/regular visitors to the Development Envelope (including the one listed above), three taxa are irregular visitors to the Development Envelope, one taxa are vagrants in the Development Envelope and two taxa are likely to be locally extinct. A summary of the listed conservation significant fauna occurrence assessment for the Development Envelope is provided in Table 5-9. Fauna records, including conservation significant fauna, within the Development Envelope are presented in Figure 5-19. In addition to the taxa summarised in Table 5-9, a further seven were considered locally significant by BCE (2022). Although considered as being other significant fauna, these taxa are not listed under the EPBC Act, BC Act or by DBCA.

Field assessments recorded 71 species occurring within the Development Envelope, comprising of two frogs, 17 reptiles, 44 birds and eight mammals (four of which are introduced species – Cat, Red Fox, House Mouse, Rabbit). One species which is listed under both State and Commonwealth legislation was recorded in the Development Envelope, the Carnaby's Cockatoo (*Calyptorhynchus latirostris*).

Native vegetation of the Development Envelope has been subject to a frequent prescribed fire regime fire and while appropriate fire management can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. BCE suggests there is some evidence that the reptile (and possibly small mammal) assemblage has been altered by frequent fires, and the probable local extinction of the Western Ground Parrot is likely to be a result of infrequent but extensive fires that have destroyed a former mosaic of fire ages.

Table 5-9 Summary of Conservation Significant Fauna and Expected Occurrence (BCE, 2022)

Species	Common name	Conservation Status	Expected Occurrence
Aspidites ramsayi	Woma	Priority One (P1)	Locally Extinct
Neelaps calonotos	Black-striped Snake	Priority Three (P3)	Resident
Leipoa ocellata	Malleefowl	Vulnerable	Irregular Visitor
Apus pacificus	Fork-tailed Swift	Migratory	Irregular Visitor
Falco peregrinus	Peregrine Falcon	Other specially protected	Irregular Visitor
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	Endangered	Resident (Recorded)
Pezoporous flaviventris	Western Ground Parrot	Critically Endangered	Locally Extinct
Notamacropus irma	Brush Wallaby	Priority Four (P4)	Resident
Hydromys chrysogaster	Rakali (water-rat)	Priority Four (P4)	Vagrant

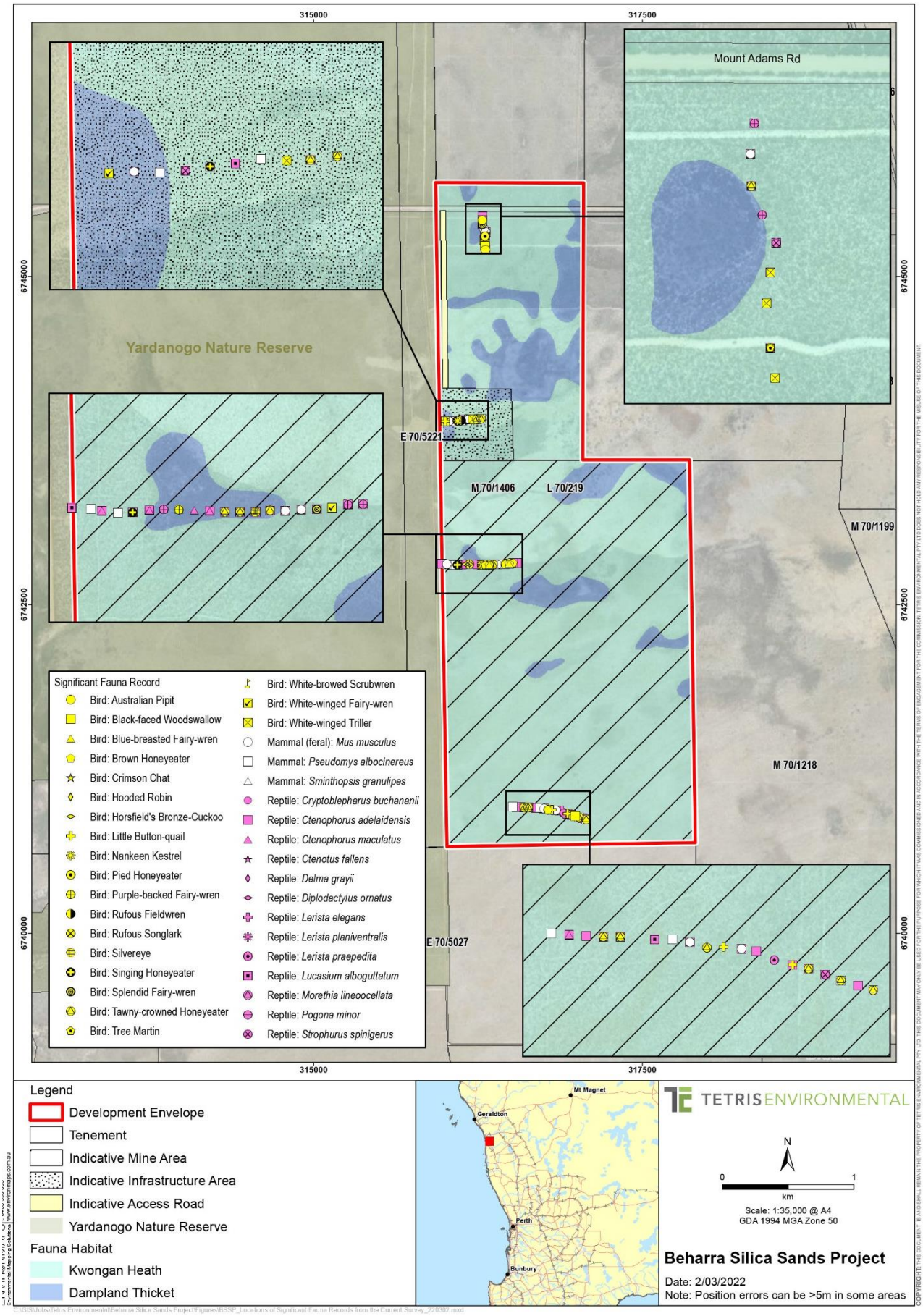

Figure 5-19 Fauna Records (including species of conservation significance)

5.8.3 Carnaby's Black Cockatoo

The Proposal is located outside of the mapped distribution of both the Baudin's Cockatoo and the Forest Red-tailed Black Cockatoo. Furthermore, desktop assessment results did not identify any records of these species within 40 km of the Development Envelope. As such, these two species will not be considered further.

The Proposal is located within the mapped distribution range of the Carnaby's Cockatoo, but outside of the modelled breeding range. The following sections describe the environmental values present within the Development Envelope in the context of the species.

Foraging habitat

Evidence of foraging within the Development Envelope was recorded during field surveys, and on 20th August 2020 a group of eight birds feeding on flowers of B. hookeriana were observed. Key foraging species present include *Banksia attenuata*, *Banksia hookeriana* and *Banksia menziesii*.

The two broad fauna habitat types within the Development Envelope, VSA1 and VSA2, are considered to provide potential foraging habitat for the species. These habitat types have been assigned foraging values for the species, based upon vegetation characteristics, context and species density as described in BCE (2022; Appendix 5). The foraging values for the habitat present within the Development Envelope, and their regional and local extents are summarised in Table 5-10 and presented in Figure 5-17 (regional) and Figure 5-18 (Local).

Table 5-10 Foraging Value of the Development Envelope

Habitat type	Description	Foraging value	Area within Development Envelope	Regional Extent	% of Regional Extent
VSA1 - Kwongan health	Kwongan shrubland on sandy soils more or less high in the landscape and with several banksia species prominent (*Banksia attenuata*, *Banksia hookeriana, Banksia menziesii* and in some areas *Banksia elegans*	6 out of 10 (moderate to high value)	698.2 ha	27,286 ha	2.6 %
VSA2 - Dampland thickets	Thickets on heavier soils subject to winter waterlogging low in the landscape, usually with *Banksia leptophylla* and *Acacia* sp. Often with patches of a low *Verticordia* sp.	4 out of 10 (low to moderate value)	89.5 ha	1,188 ha	7.5 %

Breeding habitat

DSEWPaC (2012) defines breeding habitat as trees of species known to support breeding, such as jarrah, marri and wandoo, within the range of the species which have a suitable nest hollow or are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most tree species, suitable DBH is 500 mm, while for salmon gum and wandoo, suitable DBH is 300 mm.

No trees were recorded within the Development Envelope that were of suitable DBH, nor suitable for providing current or future breeding opportunities. Within the regional area, suitable habitat that could support breeding occurs along the Arrowsmith River to the south and Irwin River to the north,

and large trees around seasonal wetlands to the east. None of these areas are within 10 km of the Development Envelope. Recorded breeding sites are presented on Figure 5-20.

Roosting habitat

There is no roosting habitat present within the Development Envelope. Carnaby's Cockatoo usually roost in the tallest trees in a region and noting the results of the local and regional surveys, there are no tall trees within the area of the Proposal. The nearest potential roosting habitat is located 5 km from the Proposal.

BCE (2022) discuss that there are two roosts known in the region. These roost sites consist of:

- One roost located along the Arrowsmith River, 15 km south of the Proposal, where 300+ birds were observed in June 2016 (Bamford and Chuk 2017)
- Second roost in large trees near the north-eastern boundary of Yardanogo Nature Reserve, where 500+ birds were seen in April 2015 (M. Bamford pers. obs.). The second roost is about 5 km north of the Proposal.

There are also more distant (>30 km) roosts sites identified as part of the Great Cocky Count.

All known roost sites are presented in Figure 5-20.

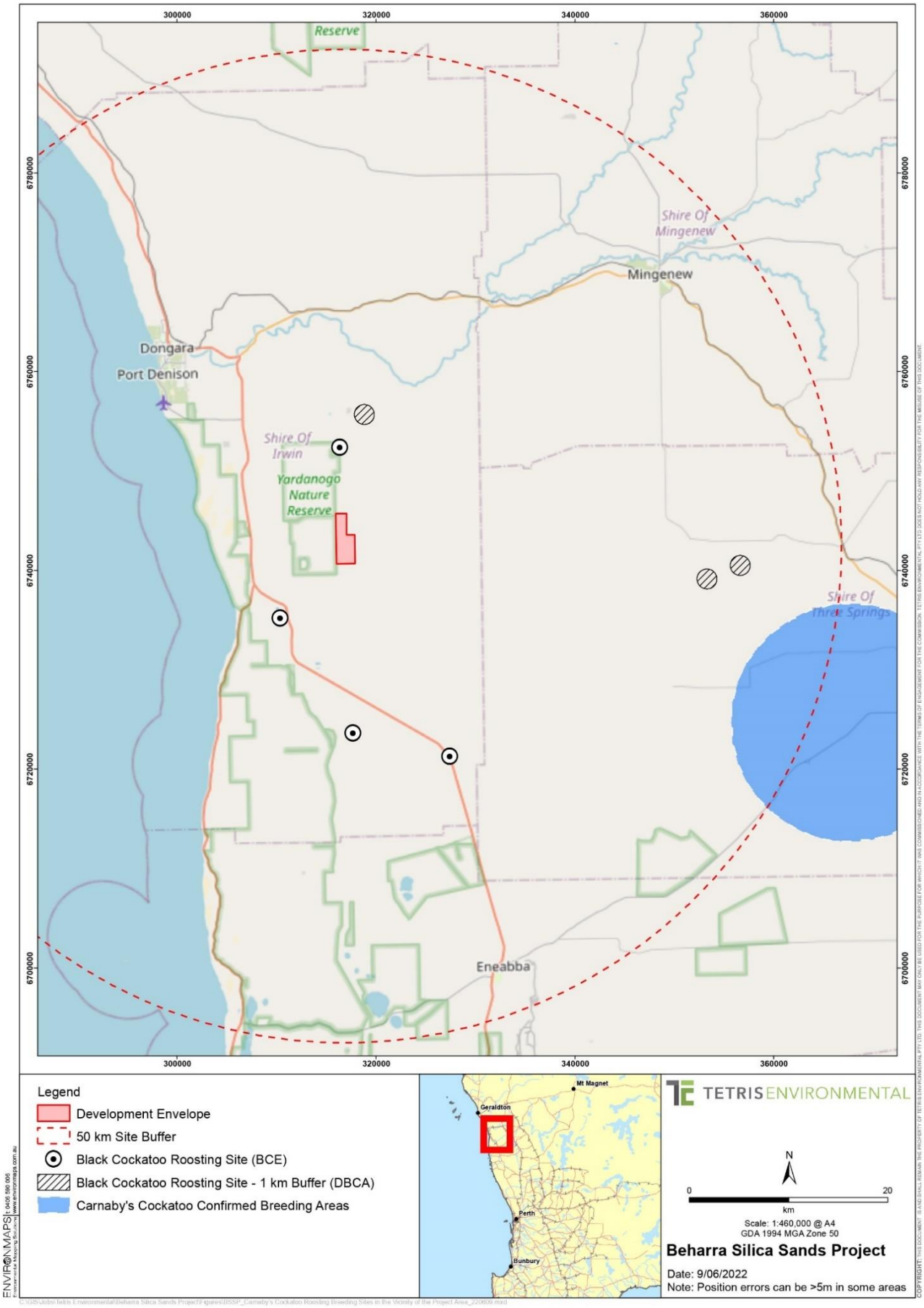

Figure 5-20 Carnaby's Black Cockatoo roost and breeding sites within 50 km of Development Envelope

5.9 Invertebrate Fauna

5.9.1 Short Range Endemic Invertebrates

Short Range Endemic (SRE) fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002).

Bennelongia (2022) (Appendix 6), undertook a detailed desktop assessment for SRE occurrence, utilising records collated from the Western Australian (WAM) and Bennelongia databases, including records from recent surveys in tenements held by VRX Silica that are adjacent to the Proposal (Bennelongia 2021a, b), along with records in published taxonomic literature.

Desktop results returned records of three Priority species; the land snail *Bothriembryon perobesu*s, the trapdoor spider *Idiosoma kwongan* and the bee *Hylaeus globuliferus*. The most commonly recorded of these species within the search area was *B. perobesus*, which has been collected from several locations surrounding the Development Envelope. The other species were collected from locations between 20 and 50 km south-east of the Development Envelope, with *I. kwongan* collected from one location and *H. globuliferus* collected from three locations in the search area. Following the desktop assessment, Bennelongia (2022) undertook a detailed field survey of the Development Envelope.

Within the Development Envelope, Bennelongia (2022) recorded two main landforms that contained habitat traits favourable to SRE species listed above, these are:

- Sandy plain consisting of Banksia species and heath shrubland
- Low lying damplands consisting of Allocasuarina and Acacia on clay soils.

Both landforms are consistent with the two Vertebrate Fauna habitat types recorded within the Development Envelope, VSA1 and VSA2. The SRE survey and sampling sites are presented in Figure 5-21.

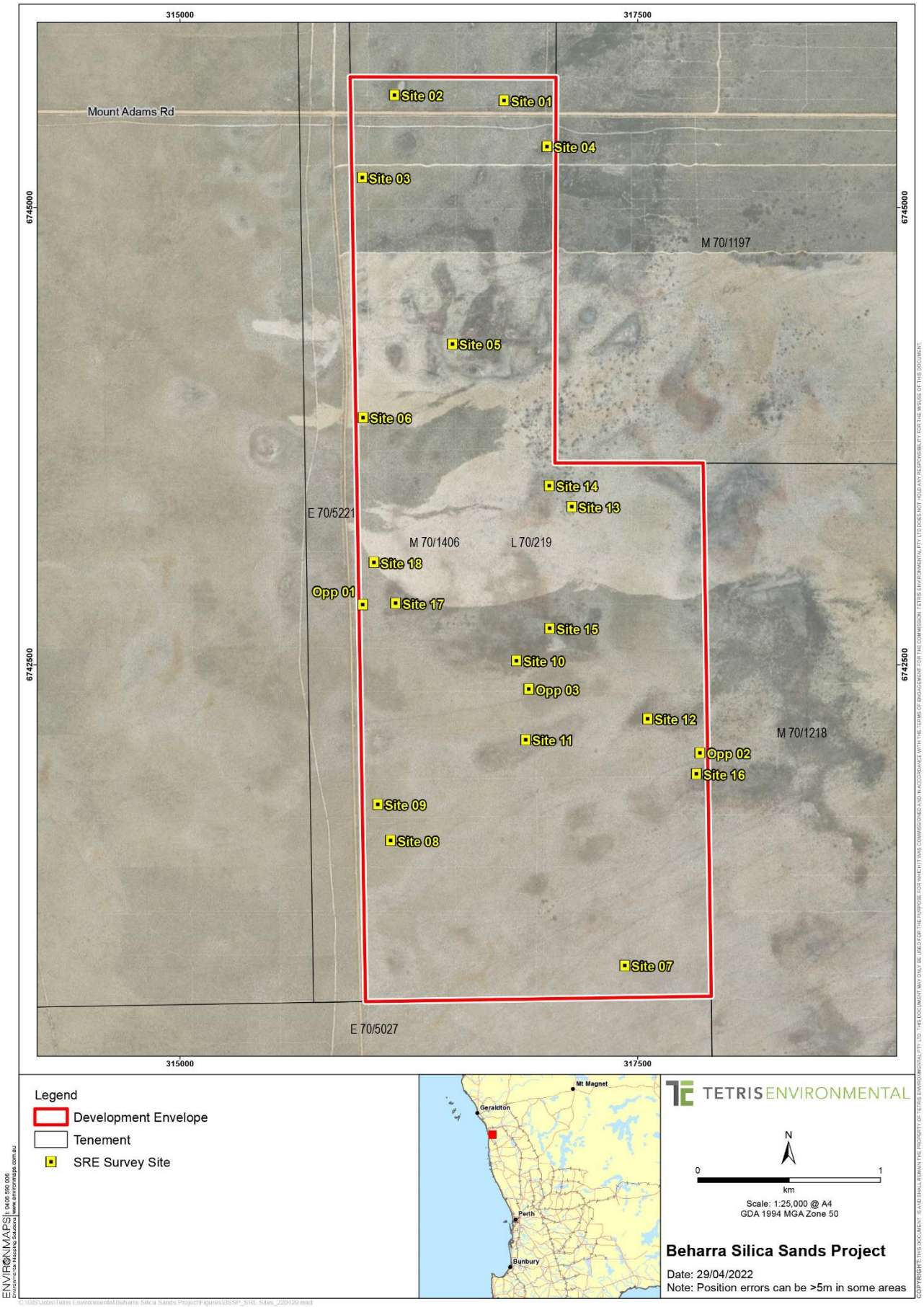

Figure 5-21 SRE Sampling Extent

Bennelongia (2022) recorded a total of 169 specimens belonging to at least 21 SRE Group species, The SRE Groups recorded included trapdoor spiders (six species), isopods (four species), pseudoscorpions (three species), scorpions (three species), centipedes (three species), and snails (two species).

Two of these are listed SRE species:

- Idiosoma kwongan (P1)
- Bothriembryon perobesus (P1)

With regards to *I. kwongan*, two specimens were collected within the Development Envelope but outside of the Footprint (site 1 and site 2, Figure 5-21), representing one female and one juvenile. These individuals were recorded from within both identified habitat types, with one collection from an isolated dampland patch dominated by *Allocasuarina* while the other was from the widespread *Banksia attenuata* and *B. menziesii* woodland habitat. This indicates that the species is not restricted to anyone habitat type and that potential habitat is not unique to the Development Envelope. This is further supported by Bennelongia (2022) who discuss that *I. kwongan* has previously been collected in Kwongan habitats between 20 and 50 km south of the Development Envelope.

Bennelongia (2022) further outline that this survey along with others in third-party tenements (VRX) has extended the known range of the species. The results support the conclusion by Rix et al. (2018a) that the known distribution of this species is underestimated. Based on known range information, Bennelognia (2022) concluded that it can confidently be stated that the extent of Development Envelope, and associated disturbance will cover less than 2% of *I. kwongan's* range.

Twenty-eight specimens of *B. perobesus* were collected from nine sites and a variety of habitats (site 3, site 5, site 6, site 7, site 8, site 9, site 13, site 14 and site 18, Figure 5-21). This species is considered to be widespread with a north-south range of approximately 300 km. The extent of disturbance as a result of the Proposal will cover less than 0.1% of the species' range.

At least six recorded individuals coincide with the proposed Footprint.

5.9.2 Subterranean Fauna

A database and literature search found records of 717 subterranean fauna specimens from within a 100 km x 100 km search area around the Proposal.

Local troglofauna specimens were associated with cave systems, the geology and soils of which are not associated with the Proposal.

Stygofauna records were mostly reported from small outcrops of limestone, also not associated with the Proposal.

The subterranean desktop assessment concluded that the Proposal is unlikely to significantly impact subterranean fauna values because:

- there is lack of suitable troglofauna habitat present,
- stygofauna species present are likely to be widespread at the sub-regional level and
- the groundwater drawdown (≤1.8 m, most likely 1.35m) will result in minimal reduction in the volume of stygofauna habitat.

5.10 Surface Water

5.10.1 Hydrological Setting

The Proposal is outside of any RIWI Act Proclaimed Surface Water or Public Drinking Water Source Areas and is within the Arrowsmith River Catchment, which is 1,604.2 km^2 (Figure 5-22). The river commences north-west of Three Springs and flows in a westerly direction for 85 km to the coast and terminates in Arrowsmith Lake.

As mentioned in Section 5.3.3, a query of the Directory of Important Wetlands in Australia (DAWE, 2021) did not identify these wetlands as Ramsar Wetlands or wetlands of national importance. The closest wetland listed in the Directory of Important Wetlands (DBCA-045) is the Lake Logue – Indoon System (40 km south).

The highly permeable sandy soils of the area recharge groundwater locally and further limit surface flow events. Flows in local watercourses are infrequent and episodic, with gauging at Mt Adams Creek indicating only one stream flow event (for less than two hours) between 2007 and 2012 (Endemic, 2012, in Advisian 2022b).

There is no permanent watercourse in the area and drainage systems are poorly defined. Following prolonged rainfall, watercourses can originate in the Gingin Scarp to the east of the Proposal and drain west, terminating in the interconnected damplands and interdunal depressions of the Eneabba Sand Plains where the Proposal is located (Advisian 2022b).

Figure 5-23 shows damplands of the area, based on mapping and assessments by Endemic (2012) and Semeniuk (1994). These areas are defined by Semeniuk (1994) as “intermittent damplands: interdunal depressions experiencing seasonal waterlogging in response to rainfall events”.

Given the highly permeable sandy soil of the Development Envelope, rainfall infiltrates without producing runoff. Surface drainage does not flow within the Proposal and as such, the damplands within the Proposal are sustained by direct and localised rainfall-runoff and not from inflows from surrounding drainage lines or groundwater (Advisian 2022b).

Plate 5-10 shows the highly sandy and permeable nature of the surficial soils across the Development Envelope. The sandy soils are characterised by high infiltration losses and saturated conductivity rates, producing negligible rainfall runoff in storm events.

5.10.2 Hydrological Modelling

A surface water modelling study using 1% Annual Exceedance Probability (1 in 100 year AEP) under existing and post-development conditions was undertaken to assess surface water impacts and identify surface water management requirements for operations and closure.

The 1% AEP flood maps in Figure 5-24 and Figure 5-25 show the site is sparsely inundated with floodwaters generally at low velocity. A large portion of the streamflow enters the Development Envelope from the east via drainage lines and reports to topographic depressions, which appear to have capacity greater than the 1% AEP flood volume. Given the sandy soil conditions, floodwater accumulating in these depressions is expected to rapidly infiltrate to groundwater. Peak velocities are less than 2 m/s in the mine development area.

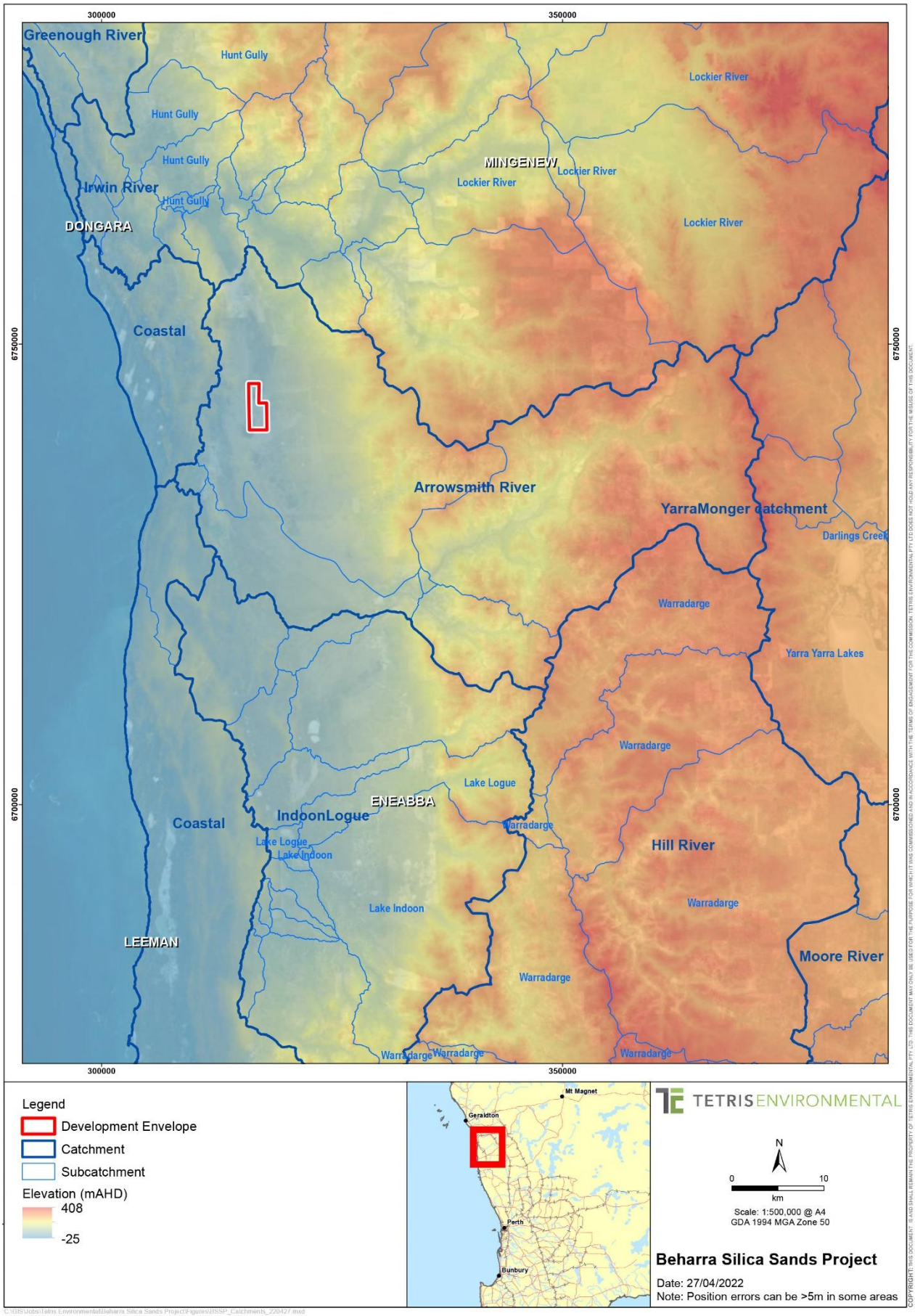

Figure 5-22 Catchments of the Development Envelope

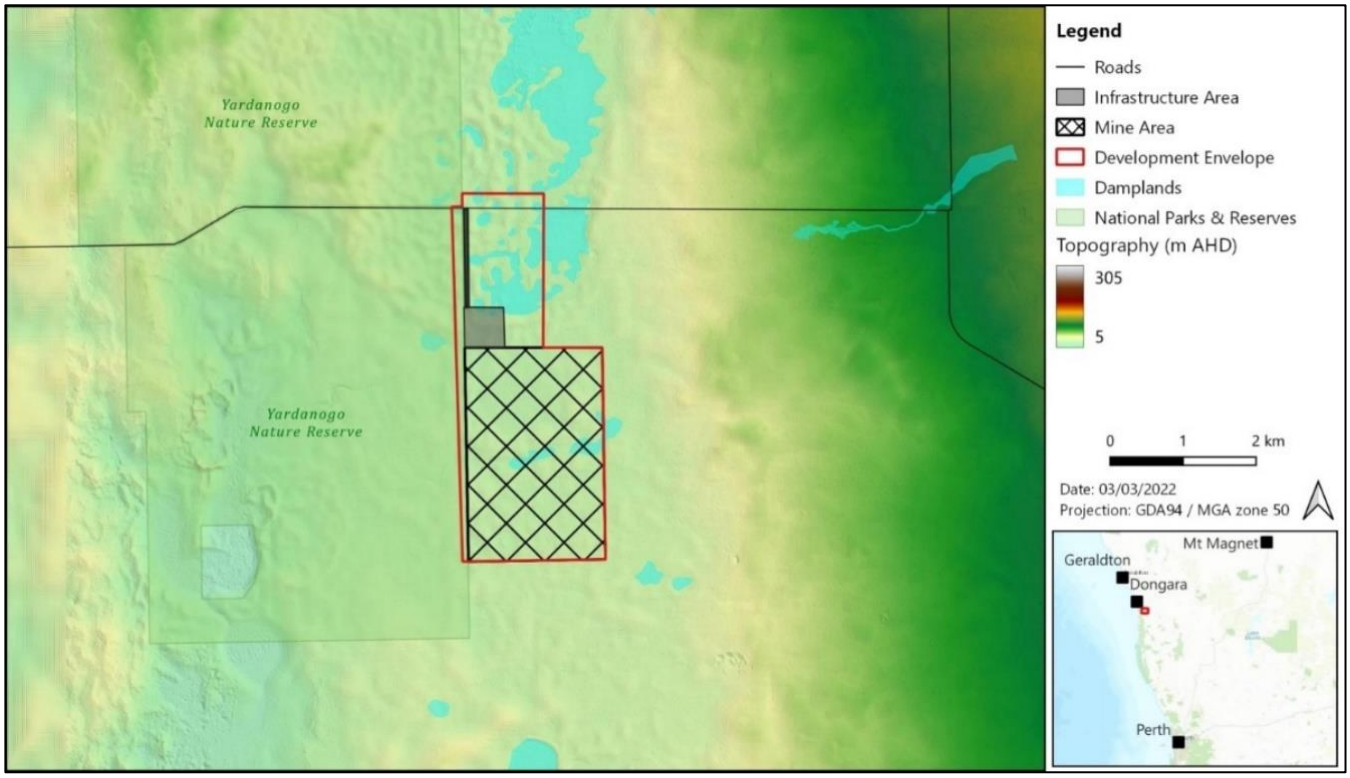

Figure 5-23 Intermittent Damplands in the Development Envelope (Source: Advisian 2022b).

Plate 5-10 Highly permeable surficial sands across the Development Envelope

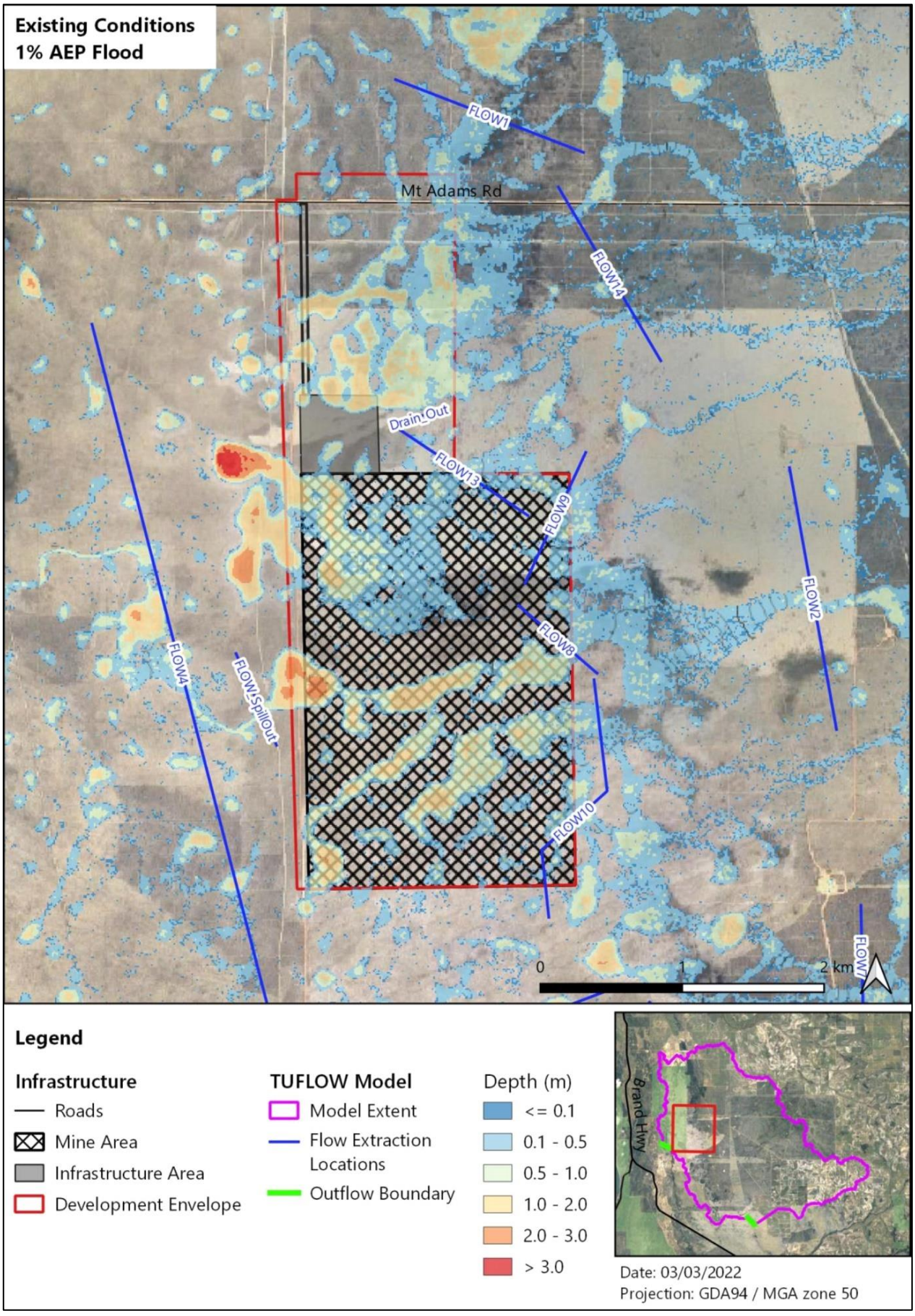

Figure 5-24 1% AEP flood depth under existing conditions (Source: Advisian 2022b).

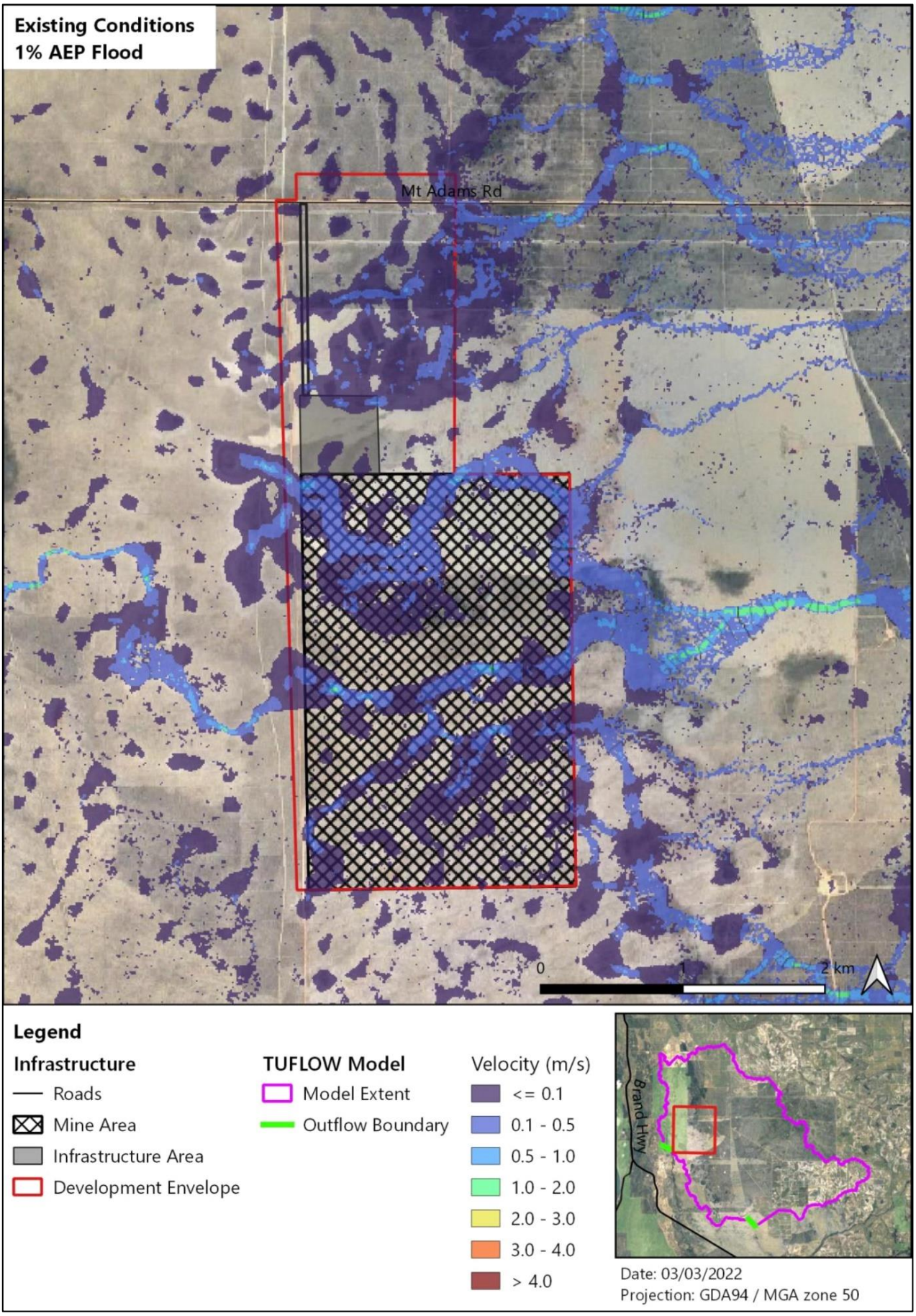

Figure 5-25 1% AEP flood velocity under existing conditions (Source: Advisian 2022b).

5.11 Groundwater

5.11.1 Hydrogeological Setting

The Proposal is located in the northern Perth Basin, which stretches approximately 450 km north to south and up to 90 km from west to east, covering 35,000 km^2 (DoW 2017).

The sediments of the Perth Basin have been deposited within relatively low-lying topography 300 million years ago. It is these sediments, up to 12 km thick that provide most water resources to the region. Two of the largest fresh groundwater resources within the northern Perth Basin underly the Proposal, the Superficial and the Yarragadee aquifers. (DoW 2017).

Locally, the Proposal is located within the RIWI Act Proclaimed Arrowsmith Groundwater Area (Eneabba Plains Groundwater subarea) (DWER-034), which is managed under the 'Managing the Water Resources of the Arrowsmith Groundwater Area - Interim Sub-regional Allocation Strategy, 2002'.

Bores within the Development Envelope indicate that the closest water table to the surface, the Superficial aquifer, is approximately 7.8 mbgl (Advisian 2022a). Figure 5-26 presents the groundwater level measured at bore 70130021 (Yarragadee aquifer bore) and Bore 70130022 (Superficial aquifer bore), bores that are located approximately 1.5 m apart. Note, although the Yarragadee monitoring bore indicates a shallower groundwater level (1.4 mbgl – 2.7 mbgl), this indicates upward groundwater gradient pressure and demonstrates that the Yarragadee aquifer is semi- to fully-confined from the Superficial aquifer in this area (Advisian 2022a).

Groundwater recharge into the Superficial aquifer is via direct infiltration following rainfall, with very little overland flow. Based on the relatively low salinity levels in the uppermost Yarragadee Formation (<1000 mg/L) recharge to the Yarragadee aquifer is by direct rainfall infiltration over outcrop areas as well as downward leakage from overlying saturated superficial formations on the eastern side of the plain (DoW, 2017). Groundwater flow is in a westerly direction towards the coast.

5.11.2 Hydrogeological Modelling

A groundwater model was developed for the Development Envelope to predict the extent of drawdown for abstraction at 15 L/s from the Yarragadee aquifer. The model involved the development of a three-dimensional groundwater numerical model, using FEFLOW modelling software (Diersch 2014, in Advisian 2022a).

A series of sensitivity scenarios were modelled to address the potential hydraulic parameters of the upper Yarragadee confining layer. Figure 5-27 represents the drawdown contours of the most likely conductivity scenario based on the material description and bore monitoring results, with Table 5-11 summarising the sensitivity analysis undertaken for the most likely scenario.

Simulated drawdown indicates an extent of approximately 1000 – 1250 metres around the production bore with drawdown approximately 1.3 m below current levels at the proposed production bore location extending to 0.2 m approximately 1.2 km from the bore (Figure 5-27). The difference in predicted drawdown at the monitoring locations are due to the confining layer (aquitard) between the Superficial and Yarragadee.

Based on the modelling results, the expected drawdown in the Superficial aquifer is less than in the Yarragadee aquifer. Leakage from the Superficial aquifer reduces the modelled drawdown in the Yarragadee aquifer while causing some of the drawdown to be transmitted to the Superficial aquifer.

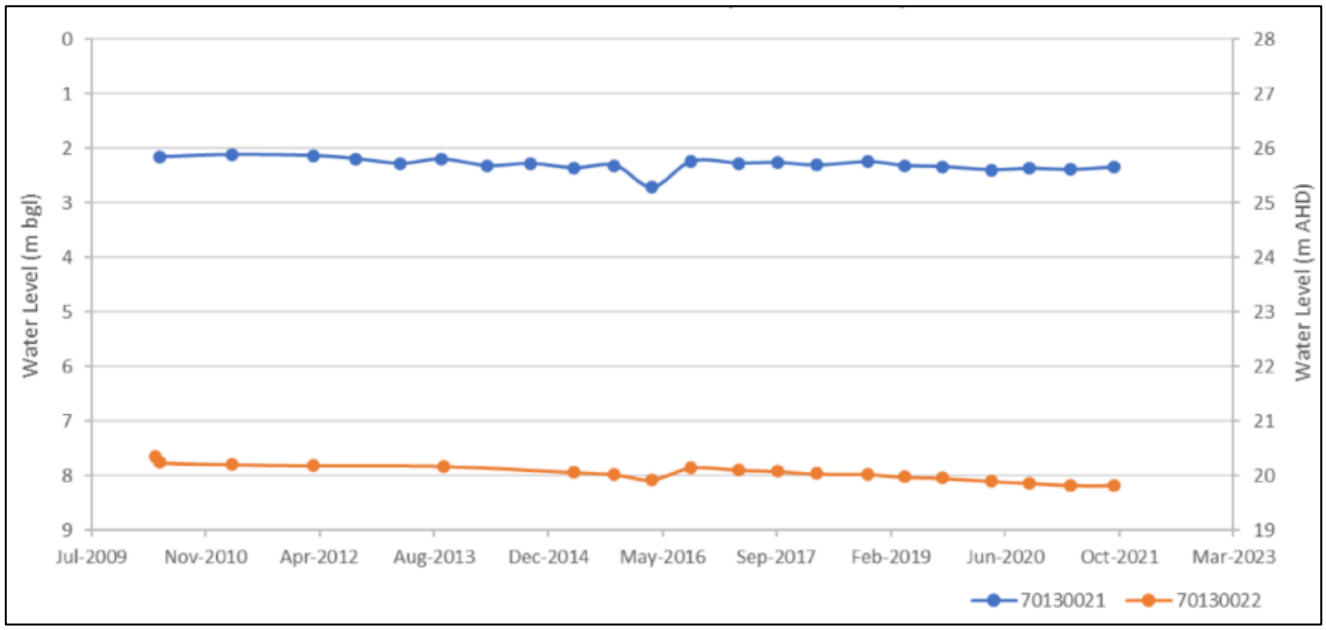

Figure 5-26 Groundwater levels at Bore 70130021 (Yarragadee aquifer bore) and Bore 70130022 (Superficial aquifer bore) (Source DWER, 2022).

Table 5-11 Base case sensitivity scenario modelled for the groundwater affected flow

Parameter and Formation	K Superficial (m/day)	K Confined Yarragadee (m/day)	K Yarragadee (m/day)	Faults (m/day)	Superficial Drawdown Extent (m)	Yarragadee Drawdown Extent (m)
Base Case	3.2	0.01	0.8	0.01	1.35	7.6

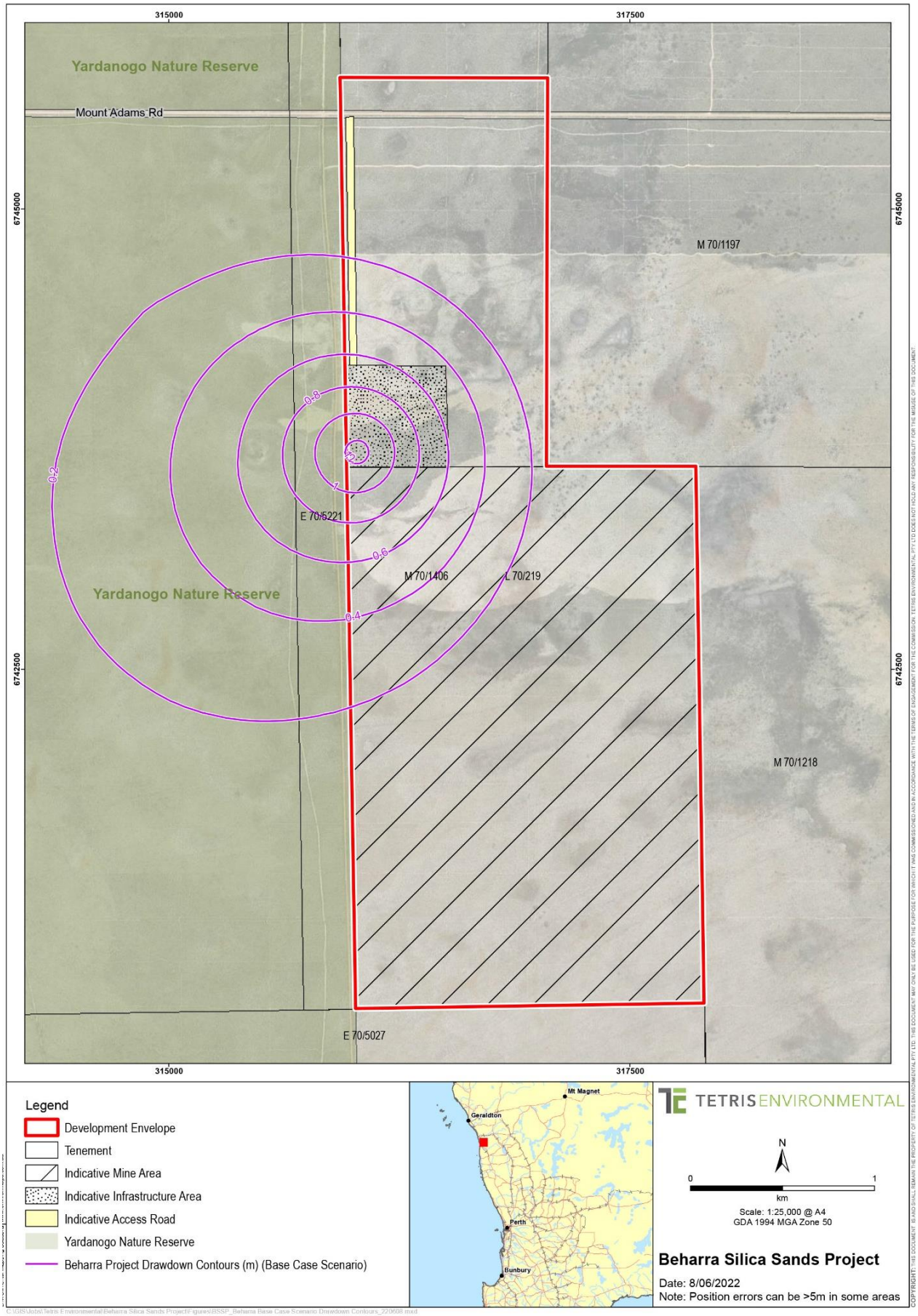

Figure 5-27 Base case drawdown for groundwater abstraction (15L/s).

6. ENVIRONMENTAL MANAGEMENT MEASURES

PEC will control the environmental risks associated with the Proposal through the implementation of management actions contained within the PEC Environmental Management Plan (EMP) (PEC-EMP-PLN-01), provided in Appendix 7. The EMP is also the means by which PEC gives effect to its Environmental Policy.

The EMP also contains a series of Work Instructions and Forms to assist in the management of specific activities, including:

- Site Disturbance Permit Work Instruction (PEC-EMP-WI-01)
- Site Disturbance Form (PEC-EMP-ENVF-01_SDP)
- Clearing Work Instruction (PEC-EMP-WI-02)
- Aboriginal Heritage Work Instruction (PEC-EMP-WI-03)
- Topsoil Handling and Management Work Instruction (PEC-EMP-WI-04)
- Fauna Work Instruction (PEC-EMP-WI-05)
- Dust Management Work Instruction (PEC-EMP-WI-06)
- Hygiene Management Work Instruction (PEC-EMP-WI-07)
- Hygiene Certificate Form (PEC-EMP-ENVF-02_HC)
- Bushfire Management Work Instruction (PEC-EMP-WI-08)
- Hydrocarbon and Chemical Management (PEC-EMP-WI-09)
- Waste Management Work Instruction (PEC-EMP-WI-10)

Table 6-1 provides a summary of key commitments and management actions as presented in the EMP and as they apply to the Mitigation Hierarchy.

Table 6-1 Application of the Mitigation Hierarchy

Mitigation hierarchy	Commitments and Management Actions
Avoid	• Apply a no clearing buffer from the Tenement boundary with the Yardanogo Nature Reserve • Avoid clearing VT3 for processing and linear infrastructure • Avoid unauthorised and/or over clearing by demarcating authorised clearing boundaries and communicating all stages of disturbance to all on-site staff • Prevent the introduction of weeds and dieback to site by requiring all vehicles, plant and equipment are clean, inspected and certified prior to entry (Hygiene Management Work Instruction, PEC-EMP-WI-07) • No mining below the water table
Minimise	• Adhere to the control measures prescribed in the PEC EMP (PEC-EMP-PLN-01) and associated Work Instructions (listed above) • Clearing for mine pits will be offset 50 m from the Yardanogo Nature Reserve and 20 m from tenement boundaries

Mitigation hierarchy	Commitments and Management Actions
	• Clearing for mine infrastructure and haul roads will be offset 80 m from the Yardanogo Nature Reserve • Vegetation will not be cleared unless the purpose for which the clearing is authorised is enacted within six months • In excessively windy conditions when dust emissions cannot be adequately controlled, operations will be postponed until dust suppression can abate dust emissions (refer to PEC Dust Management Work Instructions, PEC-EMP-WI-06) • Prior to disturbance, conduct follow-up targeted searches for conservation significant flora previously recorded in low numbers (e.g. *Centrolepis milleri*) • Staff and contractors are trained on the existing conservation significant flora and fauna and required management actions to avoid unnecessary disturbance to individuals or their habitat • Open trenches are constructed to permit safe egress for entrapped fauna and will be inspected daily, with entrapped fauna safely removed • Maintain appropriate fire suppression appliances and equipment on site and employees trained in their use • Implement speed limit restrictions, right of way for fauna and the prohibition of off-road driving • Hydrocarbons and chemicals are transported, stored, handled and disposed of according to regulations and site procedures (PEC Hydrocarbon and Chemical Management Work Instructions, PEC-EMP-WI-09) • Diversion bunds and drains will redirect 1% AEP floodwater to topographic depressions north of the mine infrastructure area, where it will infiltrate in accordance with the Advisian (2022b) basis of design • All surface water management structures will be regularly inspected and maintained • In the event of care and maintenance, water management structures will be inspected and remediated prior to and during the cessation of work • Groundwater to be abstracted in accordance with RIWI Act licence conditions • Monitor vegetation in the vicinity of groundwater abstraction sites and along the boundary of the Yardanogo Nature Reserve • Monitor groundwater levels against predicted drawdown and mitigate in accordance with licence requirements issued under the RIWI Act • Investigate methods of water reuse and water use efficiency throughout site • Minimise dust impacts through Dust Management Work Instructions (PEC-EMP-WI-06) with key mitigation actions including minimise exposed cleared areas, the use of water carts, monitor of product stockpiles and implement speed limits
Rehabilitate	• Prepare a detailed Rehabilitation and Mine Closure Plan for assessment and approval by DMIRS • Continue consultation and bench marking rehabilitation methods with other sand mining operations • Investigate rehabilitation methods that enable the return of recalcitrant or Priority flora species and *Banksia* species • Adhere to the measures prescribed in the PEC Rehabilitation methods which include: ◦ Progressively backfill mine pits / void with overburden upon completion of each mine cell

Mitigation hierarchy	Commitments and Management Actions
	◦ Contoured backfilled landscape commensurate with surrounding landforms and drainage patterns ◦ Reinstate surface with topsoil and mulch to create a self-sustaining ecosystem representative of pre-mining vegetation ◦ All other disturbed areas (e.g., roads etc) will be ripped, re-contoured rehabilitated with topsoil and mulch ◦ Conduct annual rehabilitation monitoring against completion criteria

7. ASSESSMENT AGAINST CLEARING PRINCIPLES

To determine whether the Proposal is likely to have significant impacts on the environment, the proposed clearing of vegetation was assessed against the Ten Clearing Principles (*Environmental Protection Act 1986*; Schedule 5) and is presented in Table 7-1.

Table 7-1 Assessment against Clearing Principles

Principle	Assessment
(a) Native vegetation should not be cleared if it comprises a high level of biological diversity	The Proposal does not occur within a recognised Biodiversity Hotspot. Implementation of the Proposal will result in the clearing of up to 586 ha of native vegetation from within the Development Envelope (788 ha). Potential direct impacts to Pre-European Vegetation Associations are outlined in Section 5.6. Based on the proposed Footprint, there will be a 0.96% reduction in the regional area extent of the Eridoon-378 vegetation association and no reduction in the regional area extent of the Eridoon-392 vegetation association. Detailed and targeted surveys (2021) over 1960 ha (including the Development Envelope and surrounds), confirmed 263 native taxa and eight introduced taxa. No threatened flora and nine significant flora were recorded, including eight DBCA listed Priority (P) flora and one potentially undescribed taxon. Of the Priority flora recorded, there was one P2, four P3 and three P4 flora species identified that are well dispersed in the bioregion: • *Banksia elegans* (P4) – removal of 6,796 individuals mapped locally in Umwelt (2022) Study Area. This taxon was widespread and recorded in all five vegetation types of the Development Envelope. It has a range of approximately 175 km, from north-west of Dongara to near Hill River in the south-east. This taxon is known from 46 regional records, nine of which occur within DBCA conservation tenure • *Centrolepis milleri* (P3) – removal of one known individual. This taxon has a range of approximately 623 km in WA, from north of Eneabba to east of Mount Barker in the south-east. The recorded location of this taxon in the Study Area represents a range extension of the taxon's known range, approximately 25 km to the north. • *Comesperma griffinii* (P2) – no impact (mapped outside footprint) • *Comesperma rhadinocarpum* (P3) – removal of one known individual. This taxon was recorded in vegetation type VT4, the most widespread VT in the local area. It has a range of approximately 972 km, from north of Gregory to Cannington, Perth in the south, to east of Kalgoorlie in the east. This taxon is known from 17 regional records, five of which occur within DBCA conservation tenure • *Hemiandr*a sp. Eneabba (P3) – removal of 3,491 mapped locally in the Umwelt (2022) Study Area. This taxon is widespread and was recorded from four vegetation types of the Development Envelope. It has a range of approximately 66 km, from south east of Port Denison to south of

Principle	Assessment
	Eneabba. This taxon is known from 35 regional records, two of which occur within DBCA conservation tenure • *Persoonia rudis* (P3) – removal of two known individuals. The taxon was recorded in two widespread vegetation types, VT4 and VT5. It has a range of approximately 266 km, from south-east of Port Denison to north-west of Bullsbrook. This taxon is known from 41 regional records, 11 of which are within DBCA conservation tenure • *Schoenus griffinianus* (P4) – removal of 42,934 individuals mapped locally in the Umwelt (2022) Study Area. This taxon was widespread and recorded from all five vegetation types of the Development Envelope. It has a range of approximately 370 km, from south-east of Geraldton to east of Perth. This taxon is known from 40 regional records, six of which occur within DBCA conservation tenure • *Stawellia dimorphantha* (P4) – removal of 55 individuals mapped locally in the Umwelt (2022) Study Area. The taxon was recorded in three widespread vegetation types, VT1, VT4 and VT5. It has a range of approximately 89 km, from north of Dongara to near Eneabba. This taxon is known from 23 regional records, two of which occur within DBCA conservation tenure • *Scaevola* sp. (potentially undescribed) – impact to one mapped individual. There are currently three collections of what appears to be the same entity collected from Mt Adams Road (near the Proposal) lodged at the WA Herbarium. Ten historical records of *Scaevola anchusifolia* have also been made within the vicinity of the Proposal, which is believed to represent the same entity. It is therefore considered that Scaevola sp. (potentially undescribed) is relatively widespread within the area Compared to similar surveys in adjacent vegetation, VRX recorded 221 taxa and Tronox recorded 543 taxa, suggesting that the diversity of flora found in the Proposal site is within the range of similar environments in the region and does not have a significantly higher diversity than other areas in the Bioregion. Tronox surveyed its adjacent 35,000 ha tenement areas and confirmed 504 native taxa and 39 introduced taxa. One Threatened species and 24 Priority (P) flora were also recorded, five of which were also found within the Development Envelope of this Proposal. Directly south of the Proposal, VRX surveyed 1,025 ha and recorded 213 native taxa and eight introduced plants. No Threatened taxa were found and eight Priority taxa were recorded, six of which are also found within the Development Envelope of this Proposal. A desktop survey did not identify any Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) that were considered to occur or likely to occur within the Development Envelope (Umwelt 2022). The nearest recorded PEC or TEC is the 'Subtropical and Temperate Coastal Saltmarsh' TEC (EPBC) (classified as PEC by DBCA), as identified by the interrogation of DBCA's Threatened and Priority Ecological Communities

Principle	Assessment
	Database (DBCA 2021b, in Umwelt 2022). Potential habitat for this TEC is not considered to occur in the Development Envelope, given it is located 15 km east of the nearest tidal area. Three locally significant vegetation types, as assessed using the methods presented by DBCA (2022b), also occur more than 25 km from the Development Envelope. Based on field observations and aerial photography interpretation, all vegetation types mapped within the Development Envelope are known to extend broadly outside the Development Envelope. Vegetation from within the Development Envelope has been affected by frequent prescribed fire regime compared to surrounding vegetation particularly in the Yardanogo Nature Reserve.
(b) Native vegetation should not be cleared if it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	Bamford (2022) recorded 71 fauna taxa within the Development Envelope over multiple survey events. Fauna records within the Development Envelope are relatively low compared to other studies in the region, where up to 145 fauna taxa have been confirmed. Bamford (2022) concludes that the frequent fire regimes that have impacted the Development Envelope and its immediate surrounds are the major cause for this, due to altered vegetation structure. Bamford (2022) recorded one species listed under both State and Commonwealth legislation in the Development Envelope, Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*). **Carnaby's Black Cockatoo** The Proposal will require the removal of up to 586 ha of suitable habitat for the species, comprised of: • 538 ha of Kwongan Heath (VSA1) that is described as 'Kwongan shrubland on sandy soils more or less high in the landscape and with several banksia species prominent (*Banksia attenuata, Banksia hookeriana, Banksia menziesii* and in some areas *Banksia elegans*.' • 48 ha of Dampland Thicket (VSA2) describes as 'Thickets on heavier soils subject to winter waterlogging low in the landscape, usually with *Banksia leptophylla* and *Acacia* sp.. Often with patches of a low Verticordia sp.' The following section provides an assessment of the potential impacts to foraging, breeding and roosting habitat in the context of the Proposal, informed by the findings of surveys undertaken in support of the Proposal and other third-party operations in the region. **Breeding and Roosting Habitat** The Proposal is located within the mapped distribution range of the Carnaby's Black Cockatoo, but outside of the species modelled breeding range. No breeding habitat was recorded either within the Development Envelope, and no known breeding occurs within 10 km of the Proposal (Bamford, 2022). Considering this, the Proposal will not result on any impacts to a known breeding area for the species. Bamford (2022) noted that the Development Envelope is absent large trees that would provide suitable roosting habitat for the species. The nearest know roost site for Carnaby's Cockatoo is located approximately 11 km north of the

Principle	Assessment
	Development Envelope. As such, the Proposal will not result in any direct impacts on a known roosting area. **Foraging Habitat** Bamford (2022) assessed the quality of habitat suitable for Carnaby's Cockatoo within the Development Envelope to vary between 'Moderate' to 'Low', with >70% of the Development Envelope comprised of 'Moderate' quality habitat. Evidence of foraging was recorded in three locations across the extent of the Development Envelope. Foraging habitat utilised by Carnaby's Cockatoo is extensive throughout the region and not unique to the Development Envelope. The Kwongan heath habitat type is regionally extensive, with large areas of similar vegetation occurring within the adjacent Yardanogo Nature Reserve and the nearby Beekeepers Nature Reserve (Bamford, 2022). Based on publicly available datasets and regional survey findings derived from Bamford Consulting Ecologists, the known regional extent for the 'Moderate' quality foraging habitat of the Kwongan Heath (VSA1) is 27,286 ha and 1,188 ha for the 'Low to Moderate' quality foraging habitat of the Dampland Thicket (VSA2). Whilst not specifically mapped, the distribution of the VSA's are known to extend well beyond these mapped areas in the region. The Development Envelope represents 2.6% of the Bamford (2022) mapped extent of VSA1 and 7.5% of the Bamford (2022) mapped extent of VSA2. Clearing for the Proposal will be undertaken in defined stages and subject to progressive rehabilitation will be commence from year 3. At no time will the full extent of the Development Envelope be cleared or absent of native vegetation. Furthermore, it is anticipated that by year 8, progressive rehabilitation efforts will ensure foraging value has been reinstated in areas previously cleared. While noting that the Proposal will not impact on any known or former breeding habitat, nor will it directly impact on known roosting habitat, the progressive removal of up to 586 ha of potential foraging habitat of ~30 years is not considered to be significant when assessed at the regional extent and that progressive rehabilitation will restore habitat value to the local area.
(c) Native vegetation should not be cleared if it includes, or is necessary for the continued existence of, rare flora.	Umwelt (2022) conducted a comprehensive spring survey in 2021 following an exceptional winter period. Four field visits were conducted from September to November 2021. Targeted searches for significant flora taxa was undertaken at the appropriate time for individual taxa as required (e.g. *Paracaleana dixonii* (T) was surveyed in November 2022). Targeted surveys were undertaken over the entirety of the Footprint via transects spaced approximately 10-20 m apart. Despite the intense survey effort and experienced team, no Threatened flora taxa were recorded within or adjacent to the Development Envelope.

Principle	Assessment
(d) Native vegetation should not be cleared if it comprises the whole or a part of or is necessary for the maintenance of a Threatened Ecological Community.	Field surveys found no vegetation types mapped in the Development Envelope to represent any formally-listed TECs nor are they considered significant for any other reasons as per EPA (2016a, 2016b). The nearest listed TEC, the 'Subtropical and Temperate Coastal Saltmarsh', was located ~23 km north west of the Proposal (DBCA 2021b).
(e) Native vegetation should not be cleared if it is significant as a remnant of native vegetation in an area that has been extensively cleared.	Vegetation presumed to have existed prior to European settlement has been mapped at a scale of 1:250,000 as vegetation system associations (Beard et al. 2013; DPIRD 2021, Government of Western Australia 2019b). Two vegetation system associations occur in the Development Envelope, Eridoon 378 and Eridoon 392. Both vegetation system associations that occur within the Study Area have undergone either minimal or moderate clearing, with 65% of Eridoon 378 and 98% of Eridoon 392 remaining of their pre-European extent, as summarised in Section 5.6.1. Clearing for the Proposal will reduce the regional area extent of Eridoon 378 by 0.9%, and no reduction in the area extent of Eridoon 392. Furthermore, vegetation within the Development Envelope has been subjected to significant alteration due to a frequent prescribed fire regime. The vegetation present in the Development Envelope is not representative of vegetation adjacent to, and nearby within reserves and unburnt area.
(f) Native vegetation should not be cleared if it is growing in, or in association with, an environment associated with a watercourse or wetland.	There are no surface water drainage features or drainage lines in the vicinity of the Development Envelope and none of the mapped vegetation types are considered to be riparian. A query of the Directory of Important Wetlands in Australia (DAWE, 2021) did not identify any Ramsar Wetlands or wetlands of national importance in the vicinity of the Proposal. The closest wetland listed in the Directory of Important Wetlands (DBCA-045) is the Lake Logue – Indoon System (40 km south). The catchment of the Proposal is the Arrowsmith River Catchment, which is 1,604.2 km^2. The river commences north-west of Three Springs (55 km east of the Proposal) and flows in a westerly direction for 85 km towards the coast, terminating in Arrowsmith Lake. At its closest point, the Proposal is approximately 13.5 km north of the Arrowsmith River and its terminating Lake. Given the highly permeable sandy soil present across the Proposal and within the surrounding catchments, rainfall infiltrates without producing runoff and surface drainage does not occur within the Proposal. It is Advisians (2022b) assessment that the damplands within the Development Envelope are sustained by direct and localised rainfall-runoff and not from inflows from surrounding regional drainage lines or groundwater.
(g) Native vegetation should not be cleared	Rainfall infiltrates the highly permeable sandy soils of the local area, without producing runoff for the more frequent events.

Principle	Assessment
if the clearing of the vegetation is likely to cause appreciable land degradation.	The soils of the Development Envelope occur within Purdie et al. (2004)'s Geraldton Coastal Zone of the Greenough Province, which they describe as being 'dunes with alluvial plains and sand sheets; low hills of Pleistocene Tamala Limestone; Recent calcareous and siliceous dunes' (Umwelt 2022). According to the Western Australian Soil Group (WASG) classification, the soil of the Development Envelope is classified as '446 - Yellow Deep Sands'. Soil landscape mapping by DPIRD (2018) defines the most common soil landscape unit of the Development Envelope is the "Beharra 4" Unit, which is described as "Level to gently undulating sandplain with numerous small playas and swampy depressions. Yellow and pale deep sands with some swamp soils". This soil unit represents 529.2 ha (90.3%) of the Footprint (Umwelt 2022). Soil landscape surveys of the local area by Blandford (2007) described the soil profiles of the Development Envelope as not subject to prolonged inundation or extended periods of waterlogging. Surface water modelling (Advisian 2022b) found larger rainfall events to be managed through flood diversion or protection measures to prevent water erosion beyond the Development Envelope. Damplands located outside the mine Footprint (pit shells, mine infrastructure area and roads) are not expected to be impacted by diversion of external drainage lines as they rarely contribute flow. Under Closure conditions, the pit void is partially backfilled and pre-development flow paths reinstated to allow the majority of floodwater to flow from the east into the partially backfilled pit area where it infiltrates, consistent with existing (pre-mine) conditions (Advisian 2022b). Results of the acid base accounting analysis and acid mine drainage classification show that the targeted soil profile is devoid of both acid generating and neutralising potential, with total sulfur values less than reporting limits for all samples and ANC equal to or less than 1 kg H_2SO_4/t in all samples (Tetris Environmental 2021). To further minimise the risk from ASS, mining is above the water table, with no potential ASS material exposed from lowered groundwater levels.
(h) Native vegetation should not be cleared if the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	The Yardanogo Nature Reserve (R 36203) is immediately west of the Development Envelope, vested under the Conservation Commission of WA for the purpose of conservation of flora and fauna (Figure 5-3). Vegetation and habitat types of the Development Envelope extend into the Yardanogo Nature Reserve and no clearing will take place within the Reserve itself. Vegetated buffers will be retained within the Development Envelope, to minimise potential edge effect impacts within the Nature Reserve such as from dust emissions. Clearing for mine pits will be offset 50 m from the Yardanogo Nature Reserve boundary, while clearing for haulage and mine infrastructure will be offset 80 m from the Yardanogo Nature Reserve. Note, an existing Road within the

Principle	Assessment
	Yardanogo Nature Reserve is frequently used and has not reduced the condition of the surrounding vegetation, as assessed and mapped by Umwelt (2022). Drawdown of the Superficial Aquifer is expected to be ~1.35 m at the proposed production bore site, increasing in depth to 0.2 m at 1.2 km from the bore, including into the Yardanogo Nature Reserve. For vegetation dominated by *Banksia attenuata* and *Banksia menziesii*, which are faculative phreatophyties where the groundwater is within 10 m of the surface, the predicted drawdown contours are still within this preferred groundwater source range. Vegetation monitoring will be conducted within the YNR to assess potential indirect impacts such as from dust emissions or groundwater draw down. Further afield, other conservation estates in the region include the Breaksea Inland Wildlife Reserve (9.6 km west), Tathra National Park (53 km south west); and Mingenew Nature Reserve (34 km north east).
(i) Native vegetation should not be cleared if the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	<u>Vegetation clearing:</u> Clearing will be undertaken progressively at a very low annual rate of up to 20 ha from year 3 of operations when progressive rehabilitation will commence. This will ensure no disruptions in the hydrological local and regional regime that may typically be associated with rapid large scale clearing in environments where there are significant surface water flows. Similarly, clearing and progressive rehabilitation of small pockets of relatively shallow rooted vegetation will not result in rising groundwater levels and subsequent salinisation, such as that associated with historical large scale clearing for agriculture. The highly permeable environment also suggests that because rainfall infiltrates rapidly the opportunity for exacerbated flows to generate from the Proposal that may affect the quality and quantity of waters downstream is highly unlikely. Acid base accounting my Tetris Environmental (2021) has also found that the geology of the Proposal is considered NAF with a very low risk of generating saline drainage during clearing and topsoil stripping activities. <u>Groundwater:</u> The Proposal will not require mine pit dewatering as the mine will not extend below the water table. Modelling predicts an indirect drawdown of the Superficial Aquifer of ~1.35 m at the bore site, increasing in depth to 0.2 m at 1.2 km from the bore. For vegetation dominated by *Banksia attenuata* and *Banksia menziesii*, which are phreatophytic where the groundwater is within 10 m of the surface, the predicted drawdown contours are still within this preferred groundwater source range and are not expected to be affected by the very minor reduction in groundwater levels. The targeted Yarragadee Aquifer will be utilised within approved allocations in the Eneabba Plains Groundwater Reserve with minimal impact to surrounding groundwater users. Abstraction will comply with DWER, and the RIWI Act Licence and Operating Strategy.

Principle	Assessment
	To ensure that groundwater resources are not contaminated, hydrocarbons and chemicals will be transported, stored, handled and disposed of according to regulations and site procedures. Surface Water: There are no Proclaimed Surface Water or Public Drinking Water Source Areas in the vicinity of the Proposal. Local sub-catchments of the Development Envelope and surrounds are internally draining, with streamflow from seasonal rainfall-runoff events reporting to intermittent damplands located in topographic depressions within the Development Envelope. This runoff infiltrates within these dampland areas without producing runoff for the more frequent events. The Proposal does not contain ephemeral or permanent surface water pools or drainage lines, and will therefore have not impact on these features. Under Closure conditions, the pit void is partially backfilled and pre-development flow paths reinstated to allow the majority of floodwater to flow from the east into the partially backfilled pit area where it infiltrates, consistent with existing (pre-mine) conditions (Advisian 2022b).
(j) Native vegetation should not be cleared if clearing the vegetation is likely to cause, or exacerbate, the incidence or intensity of flooding.	Available topographic survey data (Landgate DEM) was used to develop a regional DEM and delineate the catchment area and drainage lines reporting to the Proposal. The topography is relatively flat, with ground elevations within the Development Envelope varying between 25 m AHD and 34 m AHD. There is no permanent watercourse in the area and drainage systems are poorly defined. Rainfall infiltrates the highly permeable sandy soils of the local area, without producing runoff for the more frequent events. Surface drainage does not flow within the Development Envelope and as such, the damplands present within the Development Envelope are sustained by direct and localised rainfall-runoff and not from inflows from surrounding drainage lines or groundwater (Advisian 2022b). The sandy soils of the Development Envelope are characterised by high infiltration losses and saturated conductivity rates, producing negligible rainfall runoff or ponding in storm events. An operational surface water model using 1% AEP was undertaken to assess surface water impacts and identify surface water management requirements (Advisian 2022b). The 1% AEP flood maps (Figure 5-24 and Figure 5-25) show the site is sparsely inundated with floodwaters at low velocity, reporting to topographic depressions, which appear to have capacity greater than the 1% AEP flood volume. Accumulating floodwater is expected to rapidly infiltrate to groundwater given the sandy soils of the Development Envelope. Diversion bunds and drains will redirect 1% AEP floodwater to topographic depressions north of the mine infrastructure area, where it will infiltrate. The location of diversion bunds/drains and concept designs for these surface water management structures are presented in Advisian (2022b) basis of design.

Principle	Assessment
	As mentioned previously, clearing will be undertaken progressively, to ensure that only discrete pockets of vegetation (approximately 20 ha per year) are cleared and then immediately rehabilitated. Small scale clearing each year will reduce the potential risk of increased flooding incidences or intensity at the Proposal aera.

8. BIBLIOGRAPHY

Advisian (2021). Beharra Silica Sand Project, Pumping Test Work Plan. Unpublished report for Tetris Environmental, October 2021

Advisian (2022a). Beharra Silica Sand Project Hydrogeological Assessment. Unpublished report for Tetris Environmental, March 2022.

Advisian (2022b). Beharra Silica Sand Project Surface Water Assessment. Unpublished report for Tetris Environmental March, 2022.

Agriculture and Resource Management Council of Australia and New Zealand and Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ) (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Australian Government. 2018 Revision of 2000 Guidelines.

AMIRA International (2002) ARD Test Handbook: Prediction & Kinetic Control of Acid Mine Drainage, AMIRA P387A. Ian Wark Research Institute and Environmental Geochemistry International Ltd., Melbourne.

Bamford Consulting Ecologists (Bamford) (2008a). Mt Adams Rd Project Threatened Fauna Investigations. Unpublished report prepared for Tiwest, October 2008.

Bamford Consulting Ecologists (Bamford) (2008b). Survey for the Western Ground Parrot *Pezoporus wallicus flaviventris* within the Mt Adams Road Project Area. Unpublished report prepared for Tiwest, November 2008.

Bamford Consulting Ecologists (Bamford) (2012). Fauna Assessment of Tiwest's Dongara Project. Unpublished report prepared for Tiwest, March 2012.

Bamford Consulting Ecologists (Bamford) (2020). Beharra Silica Project Level 1 Fauna Values Assessment. Unpublished report for Tetris Environmental, September 2020 and revised March 2022.

Bamford Consulting Ecologists (Bamford) (2022). Beharra Silica Sand Project, Detailed Assessment of Terrestrial Fauna Values. Unpublished report for Tetris Environmental, March 2022.

Bark Environmental (Bark) (2019). Exploration Dieback Management Plan. Beharra Silica Sands – Stage 1 South (E70/5221).

Beard JS (1976) The Vegetation of the Dongara Area Western Australia – Map and explanatory memoir, 1:250 000 series, Vegmap Publications, Perth.

Beard, J.S., Beeston, G.R., Harvey, J.M., Hopkins, A.J.M. and Shepherd, D.P. (2013) The vegetation of Western Australia at the 1:3,000,000 scale. Explanatory memoir. Second edition. Conservation Science Western Australia 9: 1-152.

Bennelongia Environmental Consultants (Bennelongia) (2022a). Beharra Silica Sand Project Short Range Endemic Fauna Assessment. Unpublished report for Tetris Environmental, March 2022

Bennelongia Environmental Consultants (Bennelongia) (2022b). Beharra Silica Sand Project Subterranean Fauna Desktop Assessment. Unpublished report for Tetris Environmental, March 2022

Benshemesh, J. (2007). National Recovery Plan for Malleefowl. Department for Environment and Heritage, South Australia.

Blandford & Associates (Blandford) (2007). An Investigation into the Soils and Soil Landscapes of the Dongara Project Area, unpublished report prepared for Tiwest, July 2007.

Blandford & Associates (Blandford) (2008). Soils Investigations of the Dongara Project Area Stage 2, unpublished report prepared for Tiwest, May 2008.

Bureau of Meteorology (BoM) (2021a). Climate data for Station No. 8088, Mingenew,

Bureau of Meteorology (BoM) (2021b). Groundwater Dependent Ecosystem Atlas. http://www.bom.gov.au/water/groundwater/gde/map.shtml

Commonwealth of Australia (CoA) (2008a). Approved Conservation Advice (s266B of the *Environment Protection and Biodiversity Conservation Act 1999*) Approved Conservation Advice for *Paracaleana dixonii* Hopper & A.P.Br. nom. inval. (Sandplain Duck Orchid). This Conservation Advice was approved by the Minister / Delegate of the Minister on 16/12/2008.

Commonwealth of Australia (CoA) (2008b). Background Document for the Threat Abatement Plan for predation by the European red fox 2008. Department of the Environment, Water, Heritage and the Arts.

Commonwealth of Australia (CoA) (2010). Survey guidelines for Australia's threatened bats. Guidelines for detecting bats listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government - Department of the Environment, Water, Heritage and the Arts.

Commonwealth of Australia (CoA) (2011a). Survey guidelines for Australia's threatened mammals. Guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government - Department of Sustainability, Environment, Water, Population and Communities.

Commonwealth of Australia (CoA) (2011b). Survey guidelines for Australia's threatened reptiles. Guidelines for detecting reptiles listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government - Department of Sustainability, Environment, Water, Population and Communities.

Commonwealth of Australia (CoA) (2012a). *Environment Protection and Biodiversity Conservation Act 1999*, Environmental Offsets Policy October 2012. Australian Government - Department of Sustainability, Environment, Water, Population and Communities.

Commonwealth of Australia (2012b) Interim Biogeographic Regionalisation for Australia, Version 7. Department of the Agriculture, Water and the Environment (DAWE). Available: http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html#ibra

Commonwealth of Australia (CoA) (2013). Matters of National Environmental Significance Significant impact guidelines 1.1 *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government - Department of the Environment.

Commonwealth of Australia (CoA) (2014a). Environmental Management Plan Guidelines. Australian Government - Department of the Environment

Commonwealth of Australia (CoA) (2014b). Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomic. January 2014. Australian Government - Department of the Environment.

Commonwealth of Australia (CoA) (2015). Threat abatement plan for predation by feral cats. Australian Government - Department of the Environment.

Commonwealth of Australia (CoA) (2016a). Outcomes-based conditions policy, Environment Protection and Biodiversity Conservation Act 1999. March 2016. Australian Government - Department of the Environment.

Commonwealth of Australia (CoA) (2016b). Engage Early Guidance for proponents on best practice Indigenous engagement for environmental assessments under the *Environment Protection and Biodiversity Conservation Act 1999* . Department of the Environment. February 2016.

Commonwealth of Australia (CoA) (2017). Survey guidelines for Australia's threatened birds. Guidelines for detecting birds listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government - Department of the Environment, Water, Heritage and the Arts.

Commonwealth of Australia (CoA) (2020). Environment Protection and Biodiversity Conservation Act 1999, Condition-setting Policy. March 2020. Australian Government - Department of Agriculture, Water and the Environment.

Department of Biodiversity, Conservation and Attractions (DBCA) (as Department of Parks and Wildlife) (2014). Invasive Plant Prioritization Process – Impact and Invasiveness Ratings – Midwest Region. Available: https://www.dbca.wa.gov.au/parks-and-wildlife-service/threat-management/plant-diseases/weeds

Department of Biodiversity, Conservation and Attractions (DBCA) (2021a) Interrogation of the DBCA Western Australian Herbarium specimen database, Threatened and Priority Flora database and Threatened and Priority Flora List, performed 24/02/2021. Reference: 36-0221FL.

Department of Biodiversity, Conservation and Attractions (DBCA) (2021b) Interrogation of the DBCA Threatened Ecological Communities and Priority Ecological Communities database, performed 16/03/2020. Reference: 19-0321EC.

Department of Biodiversity, Conservation and Attractions (DBCA) (2021c) Priority Ecological Communities for Western Australia Version 32. Species & Communities Branch, Department of Parks and Wildlife. Published 15thJuly 2021. Available: https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/priority_ecological_communities_list.pdf

Department of Environment (DoE) (2004). Identification and investigation of acid sulfate soils, Department of Environment, Perth, Western Australia.

Department of Environment and Conservation (DEC) (2007). Draft Framework for Mapping, Classification and Evaluation of Wetlands in Western Australia, unpublished report.

Department of Mines, Industry Regulation and Safety (DMIRS) (2020). Statutory Guidelines for Mine Closure Plans. March 2020.

Department of Mines, Industry Regulation and Safety (DMIRS) (2015). Geological map of Western Australia 14th edition: Explanatory Notes.

Department of Parks and Wildlife (DPaW) (2017). Interim guideline for preliminary surveys of Night Parrot, *Pezoporus occidentalis*. Version 1, May 2017.

Department of Parks and Wildlife and Commonwealth of Australia (DPaW and CoA) (2013). Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Western Australian Wildlife Management Program No. 52 Department of Parks and Wildlife October 2013.

Department of Primary Industries and Regional Development (DPIRD) (2021) Pre-European Vegetation (DPIRD-006). Last updated 31st October 2021. Available: https://catalogue.data.wa.gov.au/dataset/pre-european-dpird-006

Department of Primary Industries and Regional Development (DPIRD) (2022). Declared Organism Search. Available: http://www.agric.wa.gov.au/organisms. Accessed February 2022.

Department of Water (DoW) (2007). Hydrogeology of the Dongara Borehole Line, Hydrogeological Record Series Report HG 4, DoW, Perth.

Department of Water (DoW) (2009a). Environmental Considerations for Groundwater Management in the Northern Perth Basin, Environmental Water Report Series, Report No. 8. May 2009.

Department of Water (DoW) (2013). Western Australian Water in Mining Guideline. Water Licensing Delivery Report Series, Report No. 12. May 2013.

Department of Water (DoW) (2017). Northern Perth Basin: Geology, Hydrogeology and Groundwater Resources. Hydrogeological Bulletin Series Report No. HB1, Department of Water, Government of Western Australia, Perth.

Department of Water and Environmental Regulation (DWER) (2021a). Water Quality Protection Note No 15. Basic Raw Materials Extraction. February 2021.

Department of Water and Environmental Regulation (DWER) (2021b), Draft Guideline: Dust Emissions, Government of Western Australia, Joondalup, July 2021.

Department of Water and Environmental Regulations (DWER) (2022). Water Information Reporting, Government of Western Australia, Perth. Source [http://wir.water.wa.gov.au/Pages/Water-Information-Reporting.aspx], date accessed 10 February 2022.

Desmond, A. and Chant, A. (2001) A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002 - Geraldton Sandplain 3 (GS3 - Lesueur Sandplain subregion). Published by the Department of Conservation and Land Management, November 2001.

Endemic (2012). Revised Wetland Mapping and Impact Assessment – Mt Adams Road, Dongara. Unpublished report prepared for Tiwest, April 2012.

Environmental Protection Authority (EPA) (2004). Guidance Statement 51: Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact in Western Australia.

Environmental Protection Authority (EPA) (2016a). Environmental Factor Guideline: Flora and Vegetation EPA, Western Australia. December 2016.

Environmental Protection Authority (EPA) (2016b). Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment. EPA, Western Australia. December 2016.

Environmental Protection Authority (EPA) (2016c). Environmental Factor Guideline: Terrestrial Fauna. EPA, Western Australia. December 2016.

Environmental Protection Authority (EPA) (2016d). Technical Guidance - Sampling of short-range endemic invertebrate fauna. December 2016.

Environmental Protection Authority (EPA) (2016e). Environmental Factor Guideline – Subterranean Fauna. December 2016.

Environmental Protection Authority (EPA) (2016f). Environmental Factor Guideline – Terrestrial Environmental Quality. December 2016.

Environmental Protection Authority (EPA) (2016g). Environmental Factor Guideline – Social Surroundings. December 2016.

Environmental Protection Authority (EPA) (2018). Environmental Factor Guideline: Inland Waters. EPA, Western Australia. June 2018.

Environmental Protection Authority (EPA) (2020a). Technical Guidance – Terrestrial vertebrate fauna surveys for Environmental Impact Assessment. EPA, Western Australia. June 2020

Environmental Protection Authority (EPA) (2020b). Environmental Factor Guideline: Air Quality. EPA, Western Australia. April 2020.

Environmental Protection Authority (EPA) (2021a). Statement of Environmental Principles, Factors and Objectives. EPA, Western Australia. October 2021.

Environmental Protection Authority (EPA) (2021b). Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures. EPA Western Australia. October 2021.

Environmental Protection Authority (EPA) (2021c). Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual. EPA, Western Australia. October 2021.

Environmental Protection Authority (EPA) (2021d). Instructions on how to prepare EP Act Part IV Environmental Management Plans. Western Australia. October 2021.

Environmental Protection Authority (EPA) (2021e). Technical Guidance – Subterranean fauna surveys for Environmental Impact Assessment. EPA, Western Australia. December 2021.

Environmental Protection Authority (EPA) (2021f). Environmental Factor Guideline – Greenhouse Gas Emissions. EPA, Western Australia. June 2021.

FB & A, (2011). Tiwest Dongara Mineral Sands Project Groundwater Dependent Ecosystem Impact Assessment. Forend, Bowen & Associates. November 2011.

Froend, Bowen & Associates (2011). Tiwest Dongara Mineral Sands Project Groundwater Dependent Ecosystem Risk Assessment Final. Unpublished report prepared for Tiwest, September 2011.

GHD (2021a). Beharra Silica Sand Project – Air Quality Assessment. Unpublished report for Tetris Environmental, November 2021.

GHD (2021b). Beharra Silica Sand Project – Acoustic Assessment. Unpublished report for Tetris Environmental, December 2021.

Glevan Consulting (Glevan) (2006). Dieback Assessment of Tiwest Joint Venture Dongara infill and exploration drilling Unpublished report prepared for Tiwest, December 2006.

Glevan Consulting (Glevan) (2007). Tiwest Dongara Dieback Assessment. Unpublished report prepared for Woodman Environmental Consulting, 2007.

Government of Western Australia 2009, State Environmental (Ambient Air) Policy 2009: Draft Policy for Public and Stakeholder comment, June 2009.

Government of Western Australia (WA Gov) (2011) WA Environmental Offsets Policy.

Government of Western Australia (WA Gov) (2014a) WA Environmental Offsets Guidelines. August 2014.

Government of Western Australia (WA Gov) (2014b) WA Environmental Offsets Template. 23 September 2014. Excel spreadsheet

Government of Western Australia (WA Gov) (2019a) Greenhouse Gas Emissions Policy for Major Projects.

Government of Western Australia (2019b) 2018 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of March 2019. WA Department of Biodiversity, Conservation and Attractions, Perth. Available: https://www2.landgate.wa.gov.au/web/guest/downloader

Greenbase (2021). Greenhouse Gas Assessment for Beharra Silica Sand Project. Greenbase Environmental Accountants. Unpublished report for Tetris Environmental, August 2021.

Hydrosearch (2011). Hydrogeological Appraisal of the Proposed Titanium Minerals Project near Dongara, Western Australia. Unpublished report for Tiwest Pty Ltd. November 2011.

Mattiske (2018). Flora Survey for the Beharra Springs Clearing Permit (CPS 4607). Unpublished report prepared for Beach Energy Ltd., December 2018.

Mattiske (2020a) Flora and Vegetation Assessment – Arrowsmith North Transport Corridor Survey Area. Unpublished report for VRX Silica Limited, June 2009

Mattiske (2020b). Flora and Vegetation Assessment – Arrowsmith North Survey Area. Unpublished report for VRX Silica Limited, April 2009.

National Environment Protection Council (NEPC) (2011). National Environment Protection (Air Toxics) Measure, Australian Government, September 2011, Accessed 6 September 2021 from: https://www.legislation.gov.au/Details/F2011C00855.

National Environment Protection Council (NEPC) (2021). National Environment Protection (Ambient Air Quality) Measure, Australian Government, May 2021, Accessed 19 August 2021 from: https://www.legislation.gov.au/Details/F2021C00475.

New South Wales Environmental Protection Authority (NSW EPA) (2017). Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, State of New South Wales, January 2017, Accessed 19 August 2021 from: https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/air/approvedmethods-for-modelling-and-assessment-of-air-pollutants-in-nsw-160666.pdf.

Nidagal, V. (1994). Hydrogeology of the Coastal Plain between Leemand and Dongara Perth Basin. Record 1994/10. V. Western Australia Geological Survey. Perth 1995.

Patrick SJ & Brown AP (2001). Western Australian Wildlife Management Program No. 28 – Declared Rare and Poorly Known Flora in the Moora District, Department of Conservation and Land Management, Western Australia.

Pennington Scott (2010). Northern Perth Basin groundwater bulletin, report for the Department of Water, September 2010 (unpublished).

Perpetual Resources Limited (PEC) (2020). Beharra Silica Sands Project, E70/5221 - Groundwater Investigations Briefing Note. 5221-CI-LET. December 2020.

Perpetual Resources Limited (PEC) (2021). Beharra Silica Project: Pre-Feasibility Study. March 2021.

Rockwater (2011). Dongara Mineral Sands Project Subterranean Fauna Sampling Programme. Unpublished report for Tiwest, June 2011.

Sticks and Stones Cultural Resources Management (SandS CRM) (2021). Beharra Silica Project Area (M70/1406) YSRC Heritage Survey. Unpublished report for Perpetual Resources and YSRC, December 2021.

Schoknecht, N. and Pathan, S. (2013). Soil Groups Of Western Australia: A simple guide to the main Soils of Western Australia. Fourth Edition. Resource Management Technical Report 380. Department of Agriculture and Food. Government of Western Australia.

Semeniuk Research Group (1994). Ecological assessment and evaluation of wetlands in the System 5 region. Unpublished report prepared for the Australian Heritage Commission.

Shepherd D, Beeston G & Hopkins A (2001). Native Vegetation in Western Australia Extent, Type and Status, Resource Management Technical Report 249, Department of Agriculture, South Perth, Western Australia.

Sinclair Knight Merz (2001). Environmental Water Requirements of Groundwater Dependent Ecosystems, Environmental Flows Initiative Technical Report Number 2, report prepared for Department of Environment and Heritage, Canberra, Australian Capital Territory.

Strategen (2012). Dongara Titanium Minerals Project – Public Environmental Review.

Tetris Environmental (2021). Beharra Silica Sand Project – Acid Base Accounting Analysis. October 2021.

Tiwest (2010). Dongara Project Area – Survey for Carnaby's Cockatoo nesting habitat, unpublished report prepared for Tiwest, August 2010.

Umwelt (2022). Beharra Silica Sand Project. Detailed and Targeted Flora and Vegetation Survey. Unpublished report for Tetris Environmental, March 2022.

Weeds Australia (2022) Weeds Australia - Weeds of National Significance. Available: https://weeds.org.au/weeds-profiles/. Accessed February 2022.

Western Australian Herbarium (WAHerb) (2020) How to Collect Herbarium Vascular Plant Specimens. Department of Biodiversity, Conservation and Attractions. Available: https://www.dpaw.wa.gov.au/plants-and-animals/wa-herbarium

Western Australian Herbarium (WAHerb) (1998-) Florabase—the Western Australian Flora. Department of Parks and Wildlife. Available: https://Florabase.dpaw.wa.gov.au/. Accessed October 2021.

Woodman Environmental (2007), Flora, Vegetation and Phytophthora cinnamomic Assessment, unpublished report prepared for Tiwest, June 2007.

Woodman Environmental (2008a). Search for *Paracaleana dixonii* along drill and access lines for the 2008 and 2009 exploration programs, letter to Tiwest, 18 November 2008.

Woodman Environmental Consulting (Woodman) (2008b). Conservation Significance Assessment of Declared Rare and Priority Flora known from the Eneabba area, Volume 1, unpublished report prepared for Iluka Resources Limited, September 2008.

Woodman Environmental (2009) Dongara Tenements Flora and Vegetation Studies Regional FCT analysis. Unpublished report prepared for Tiwest (Tronox) Pty Ltd (TIW07-36-01) October 2009.

Woodman Environmental (2010) Spring 2009 Re-Assessment of FCT Quadrats established at Eneabba between 2001 and 2007. Unpublished report prepared for Iluka Resources Ltd (Iluka09-43) October 2010.

Woodman Environmental (2011) Dongara Titanium Minerals Project Flora and Vegetation Impact Assessment. Unpublished report prepared for Tiwest (Tronox) Pty Ltd (TIW11-61-01) November 2011.

Woodman Environmental (2015) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox14-32-02) January 2015.

Woodman Environmental (2016) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox15-19-03) January 2016.

Woodman Environmental (2017) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox16-16-03) January 2017.

Woodman Environmental (2018) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox17-37-04) February 2018.

Woodman Environmental (2019) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox18-64-02) February 2019.

Woodman Environmental (2021) Dongara Exploration Area Desktop Review and Risk Assessment, Field Survey and Impact Assessment. Unpublished report prepared for Tronox Management Pty Ltd (Tronox20-56-04) March 2021.

Woodman Environmental / Umwelt (2021) Desktop review and gap analysis of previous Flora and Vegetation assessments – Beharra Silica Sands Project. Tetris21-16-01 Rev 1. April 2021.

World Health Organisation (WHO) (2000). The Air Quality Guidelines for Europe Second Edition, WHO Regional Publications, European Series, No. 91. ISBN 92 890 1358 3, Copenhagen, Accessed 19 August 2021 from: https://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf.

9. APPENDICES

- APPENDIX 1: Tenement Summary Reports
- APPENDIX 2: Stakeholder Consultation Register
- APPENDIX 3: YSRC Letter of Support
- APPENDIX 4: Umwelt 2022 Flora and Vegetation Report
- APPENDIX 5: Bamford 2022 Terrestrial Fauna Report
- APPENDIX 6: Bennelongia 2022 Short Range Endemics Report
- APPENDIX 7: Environmental Management Plan