Sulphur Springs Zinc-Copper Project

Environmental Review Document

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SULPHUR SPRINGS ZINC-COPPER PROJECT
ENVIRONMENTAL REVIEW DOCUMENT

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CORPORATE ENDORSEMENT

I hereby certify that, to the best of my knowledge, the information within this Environmental Review Document is true and correct.

Name:	Piers Goodman	Signed:	Piers Goodman
Position:	Environment Manager	Date:	28 January 2020

SCOPING CHECKLIST

Task No	Required Work	Section and Page No
EPA Factor 1 – Flora and Vegetation		
1.	Identify and characterise flora and vegetation in accordance with the standards of Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, December 2016). The detailed survey should take into account areas that are likely to be directly or indirectly impacted as a result of the proposal.	Section 6.1.3 Page 59
2.	Undertake baseline mapping of weed affected areas in any area likely to be directly or indirectly impacted as a result of the proposal.	Section 6.1.3.8 Page 69 6.1.5.6 Page 80
3.	Provide an analysis of flora and vegetation present within the Development Envelope and also present in the indirect disturbance areas outside of the Development Envelope. Where relevant, include in this analysis the conservation significance of flora and vegetation in a local and regional context. Analysis of impacts on vegetation to include: • The area (in ha) of each vegetation unit to be impacted (directly and indirectly) as a result of the proposal if no mitigation measures were taken. • The total area (in ha) of each significant vegetation unit to be impacted (directly or indirectly) as a result of the proposal. • Identification of vegetation units which may represent a component of Threatened or Priority Ecological Communities. Analysis of impacts on conservation significant flora to include: Identification of any conservation significant flora present or likely to be present. • The number of plants and the number of populations of plants and habitat, to be impacted (directly and indirectly) as a result of the proposal. • The total known number of plants and populations within the local area or study area. • A summary of the known populations of the species including distribution, number of populations and the number of plants or an estimate of the number of plants in the regional area.	Section 6.1.3 Page 59 Table 29 Page 73 Section 6.1.5 Page 71 Section 6.1.3.5 Page 66 Section 6.1.3.5 Page 66 Table 25 Page 63 Table 26 Page 66 Section 6.1.4 Page 71 Section 6.1.5 Page 71 Section 6.1.3.3 Page 63
4.	Provide tables and figures of the proposed direct impact (or predicted extent of loss) and the predicted indirect impact to flora and vegetation, including but not limited to Threatened and/or Priority Ecological Communities, potential groundwater dependent ecosystems, Threatened flora, Priority flora and unnamed new flora species.	Section 6.1.5 Page 71 Table 29 Page 73 Table 35 Page 87
5.	Discuss and quantify (where possible to quantify) the potential exposure of flora and vegetation to deposition of dust during mining, acid mine drainage and seepage from the Tailings Storage Facility (TSF).	Section 6.1.5 Page 71
6.	Provide a detailed description of the cumulative impacts associated with the proposal on flora and vegetation, including direct impacts from clearing, and indirect impacts such as groundwater drawdown, altered drainage, changes in water quality, spread of weeds, fragmentation of vegetation, altered fire regimes, and dust.	Section 6.1.6 Page 86 Section 6.1.5 Page 71

Task No	Required Work	Section and Page No
7.	Discuss and determine significance of potential direct, indirect (such as dust, downstream impacts, and weed invasion, etc.) and cumulative impacts to flora and vegetation as a result of the proposal at a local and regional level.	Section 6.1.5 Page 71 Section 6.1.6 Page 86
8.	Discuss management measures, outcomes/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 6.1.7 Page88 Section 6.1.8 Page 91
9.	Demonstrate that all practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the Development Envelope based on progress in the proposal design and understanding of the environmental impacts.	Section 2.3.2 Page 46 Section 6.1.8 Page 91 Appendix 12
10.	If required, provide a Flora and Vegetation Management Plan to address significant residual impacts to flora and vegetation. Where relevant, the following should be addressed in the plan: • Invasive species control - control of weeds, in particular through construction of infrastructure, transport and/or entry and exit points, riparian and GDE areas, vegetation units considered to have high local significance (e.g. rare units, habitat for conservation significant species) and in areas identified as in 'Excellent condition'. • Monitoring program - to monitor the significant flora and vegetation communities identified. • Management program - develop adaptive management actions to be triggered should monitoring show a decline as a result of implementing the proposal. • Management of any offset.	Appendix 18
11.	Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015), which includes methodologies and criteria to ensure progressive rehabilitation of disturbed areas with vegetation composed of native species of local provenance.	Appendix 8
12.	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation.	Section 6.1.7 Page88
13.	Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	Section 6.1.8 Page 91 Appendix 12
14.	If the proposal is likely to have any significant residual environmental impacts, identify environmental offsets, consistent with the requirements in the: • WA Environmental Offsets Guidelines, which includes the use of the WA Environmental Offsets Guidelines template.	Section 8 Page 161
15.	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	Section 6.1.8 Page 91
EPA Factor 2 – Subterranean Fauna		
16.	Undertake a desktop study to document the regional context of the subterranean fauna of the Proposal area including, but not limited to, existing regional subterranean fauna surveys, and assessment of the likely presence and characteristics of subterranean fauna habitat.	Section 6.2.3, Page 92 Appendix 19
17.	Conduct Level 2 surveys inside and outside areas subject to direct and indirect impacts, following EPA policy and guidance. Where historical survey reports are relied upon as the primary reference, the information should be updated to include the most recent species, habitat, and proposal information.	Section 6.2.3, Page 92 Appendix 19
18.	Present the results of all relevant subterranean fauna surveys. Include comprehensive mapping of the distributions of species in relation to the proposed disturbance (including groundwater drawdown), and of the geology or	Section 6.2.3, Page 92 Appendix 19 Appendix 20

Task No	Required Work	Section and Page No
	hydrology predicted to support subterranean fauna habitats (including its extent outside the Development Envelope).	Figure 19 Figure 20
19.	Discuss habitat prospectivity and demonstrate habitat connectivity within and outside the proposed disturbance area.	Section 6.2.3.1 Page 92
20.	Identify and assess the potential direct, indirect, and cumulative impacts of the proposal on subterranean fauna, within the Proposal area and regionally. Consider temporary (e.g. construction) vs ongoing (e.g. operations) impacts, including altered water regimes and water quality.	Section 6.2.4 Page 97 Section 6.2.5 Page 97
21.	For taxa that may be impacted, provide information, including maps, on habitat connectivity and an explanation of the likely distribution of species within those habitats. Provide detailed descriptions of potential impacts to conservation significant species.	Section 6.2.5 Page 97
22.	Identify any limitations associated with the historical survey data or existing knowledge and discuss their implications for the impact assessment.	Section 6.2.3.2 Page 97
23.	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to subterranean fauna.	Section 6.2.6 Page 102
24.	Discuss proposed management objectives, measures, and outcomes sought to ensure residual direct and indirect impacts are not greater than predicted.	Section 6.2.6 Page 102 Section 6.2.8 Page 104
25.	Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	Section 6.2.8 Page 104 Appendix 12
26.	Demonstrate and document in the ERD how the EPA objective for this factor can be met.	Section 6.2.8 Page 104

Task No	Required Work	Section and Page No
EPA Factor 3 – Terrestrial Environmental Quality and Inland Waters Environmental Quality		
27.	Include rationale for site selection of WRD (i.e. favourable meteorological, geological and geographical characteristics). Include rationale for site selection of the TSF (i.e. favourable meteorological, geological and geographical characteristics). Include rationale for the selection of the 'valley fill' TSF design and analysis of other TSF options. Also include rational for including the heap leach facility within the footprint of the TSF and analysis of other design options for the heap leach facility.	Section 2.3.2 Page 46. Table 18 Section 2.2.6.1, Page 29. N/A
28.	Present a baseline soil quality assessment of the Development Envelope.	Section 6.3.3.1 Page 107 Appendix 22
29.	Include in the ERD, figures of the mapped soil units.	Figure 23 Table 42 Section 6.3.3.1 Page 107 Appendix 22
30.	Conduct chemical and physical characterisation of the waste materials, including characterisation of tailings pore water.	Section 2.2.4.1 Page 21 Section 2.2.6.2 Page 29 Appendix 2 Appendix 3
31.	Assess the mineralogy for likelihood of asbestiform minerals occurring.	Section 7.4.3.1 Page 158
32.	Conduct long term (1000 years) Landform Evolution Modelling of behaviour and performance of landforms associated with containment systems including the TSF, modelled under a range of climatic events. Include the modelling of the appropriate Probable Maximum Precipitation (PMP) and associated Probable Maximum Flood (PMF) scenarios.	Appendix 4
33.	For each tailings stream, identify: • geochemical properties, including acid forming potential; and • any issues with drainage and tailings consolidation.	Section 2.2.6.2 Page 29 Section 2.2.6.3 Page 32
34.	Assess impacts on the surrounding environment if there was failure of TSF integrity.	Section 6.3.5.3 Page 120
35.	Assess impacts on the surrounding environment from the Heap Leach solution channels and solution ponds or evaporation ponds during an extreme rainfall event.	No longer applicable for heap leach solution channels and ponds. Section 6.3.5.6 Page 123
36.	Demonstrate conformance with internationally recognised design criteria for TSF design. Include a conceptual design of the TSF that should ensure long-term encapsulation of tailings/wastes that reduces any risks to the environment and environmental values to an acceptable level, noting that more detailed reports will be provided to the DMIRS as part of the Mining Proposal.	Section 2.2.6.4 Page 33 Appendix 4
37.	Provide a graphical conceptual representation of the final TSF	Figure 12 Appendix 4
38.	Provide details of stability of the site from a geotechnical and geochemical perspective, noting that more detailed reports will be provided to the DMIRS as part of the Mining Proposal.	Section 2.2.6.7 Page 34 Section 2.2.6.2 Page 29 Appendix 7 Appendix 4
39.	Determine and document if the TSF is likely to be listed as a contaminated site under the Contaminated Sites Act 2003 (WA).	Section 6.3.5.7 Page 123

Task No	Required Work	Section and Page No
40.	Describe the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the proposal has addressed the mitigation hierarchy in relation to impacts (direct and indirect) on soils. This description should contain recommendations for soil handling to minimise erosion of stockpiled soils.	Section 6.3.6 Page 126
41.	Describe how concentrate will be stored and transported.	Section 2.2.5.6 Page 27
42.	Describe how chemical reagents will be stored.	Section 2.2.5.7 Page 28
43.	Characterise the baseline surface water and groundwater quality and quantity, both in a local and regional context, including but not limited to, water levels, water chemistry, spring and stream flows, flood patterns, catchment boundaries. This is to include a detailed description of the hydrogeological framework within the zone to be impacted by groundwater abstraction and potentially impacted by seepage from the TSF. Include any interdependence between surface and groundwater features/bodies. Also include, where relevant, influences on water availability.	Section 6.3.3.3 Page 112 Section 6.3.3.4 Page 113 Section 6.3.3.5 Page 116 Section 6.3.3.6 Page 116 Appendix 16 Appendix 17 Appendix 21
44.	Provide a detailed description of the design and location of the proposal with the potential to impact surface water or groundwater.	Section 6.3.3.3 Page 112 Section 6.3.3.4 Page 113 Section 6.3.5 Page 118 Appendix 9 Appendix 16 Appendix 17 Appendix 21
45.	Provide a conceptual model of the surface and groundwater systems incorporating the results of monitoring conducted, including the extent of connectivity between surface and groundwater systems.	Section 6.3.3.5 Page 116 Figure 18 Appendix 16
46.	Analyse, discuss and assess surface water and groundwater impacts. The analysis should include but not be limited to: • Nature, extent, and duration of impacts on water quality. • Impact of changing water quality on environmental values. • Cumulative impacts with other projects and referred proposals, for which relevant information is publicly available. Where relevant, describe the proposed management, monitoring and mitigation methods to be implemented demonstrating that the design of the proposal has addressed the mitigation hierarchy in relation to impacts (direct and indirect) on surface and groundwater quality. Management options may include triggers, thresholds and contingencies.	Section 6.3.4.2 Page 118 Section 6.3.5 Page 118 Section 6.3.6 Page 126 Section 6.3.7 Page 131 Appendix 9 Appendix 17
47.	Identify a suitable water source and discuss the potential direct and indirect impacts. Identify contingency options discuss the impact of each option.	Section 2.2.7 Page 37 Section 6.3.7 Page 131 Appendix 17 Section 6.1.5 Page 71 Section 7.3.4 Page 156
48.	Provide a conceptual mine water balance over the life of the proposal and discuss the capacity to reuse surplus mine dewater.	Appendix 9

Task No	Required Work	Section and Page No
49.	Discuss current and future potential water users in the Proposal area and how they may be impacted by the water abstraction during construction and operation. Also impacts to beneficial use from contamination of groundwater should be discussed.	Section 2.2.7 Page 37 Section 6.3.5 Page 118 Section 7.3.4 Page 156 Appendix 9
50.	Characterise wastes, including intermediate processing wastes, effluents and tailings according to contaminant and leachable concentrations including base metals present in the deposits to allow for waste processing and tailings seepage issues to be addressed. Leach test studies should include the use of on-site water and the characterisation of the leaching potential of all waste materials under a range of probable pH conditions and varying solid-liquid ratios.	Section 2.2.6.2 Page 29 Appendix 3
51.	Document and include any potential pathways for contamination including but not limited to: • dust from the Run of Mine pad, processing plant (processing reagents, chemicals) and the TSF; • seepage of heap leach facility and/or tailings water; • operational leaks and spills; • failure of TSF integrity; • seepage from sewage treatment plants; • seepage or overflow from decant and evaporation ponds; • drainage from and erosion of WRD surfaces; and • saline final void pit lake contaminating surrounding ground water.	Section 6.3.5 Page 118
52.	Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Terrestrial Environmental Quality and Inland Waters Environmental Quality.	Section 6.3.6 Page 126
53.	Prepare a Mine Closure Plan consistent with Department of Mines and Petroleum and EPA Guidelines for Preparing Mine Closure Plans (2015) which addresses the development of completion criteria to maintain the quality of land and soils and groundwater and surface water so that environmental values are maintained post closure.	Appendix 8
54.	Undertake consultation with Department of Mines, Industry Regulation and Safety and provide evidence from this consultation that indicates whether mine closure can be readily managed by the Department of Mines, Industry Regulation and Safety through the Mine Closure requirements of the Mining Act 1978.	Section 2.2.9 Page 43 Appendix 10
55.	Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Section 6.3.7 Page 131
56.	Demonstrate and document in the ERD how the EPA objectives for these factors can be met.	Section 6.3.8 Page 134 Section 9 Page 163

EXECUTIVE SUMMARY

INTRODUCTION

The Sulphur Springs Zinc-Copper Proposal (Sulphur Springs, the Proposal) is a proposed greenfield mine development, owned by Venturex Resources Limited (Venturex). The site is located approximately 144 km south east of Port Hedland and 57 km west of Marble Bar in the Pilbara region of Western Australia. Venturex proposes to mine and process ore, generating zinc and copper concentrates, which will be transported to Port Hedland for export.

This Environmental Review Document (ERD) addresses potential impacts from the Proposal and was prepared in accordance with guidance within the *Environmental Impact Assessment (EIA) (Part IV Divisions 1 and 2) Administrative Procedures 2016* (EPA 2016a), the *EIA Procedures Manual* (EPA 2018a) and Part IV of the *Environmental Protection Act 1986* (WA) (*EP Act*). The form of this ERD is consistent with the Environmental Review Document Template (EPA 2018b) and addresses the issues identified in the Proposal's Environmental Scoping Document (ESD) (EPA 2017, Appendix 1).

BACKGROUND AND CONTEXT

Sulphur Springs has undergone several changes in name, ownership and development concepts since an initial feasibility study in 2002. A Public Environmental Review (PER) for the project (then referred to as the Panorama Project) was submitted by CBH Sulphur Springs Pty Ltd in November 2007 (EPA Assessment No. 1664) (URS 2007d). This Proposal was withdrawn following Venturex's acquisition of the Sulphur Springs tenements in 2011. Venturex completed a feasibility study of a revised design in early 2013 and submitted a Mining Proposal for an underground operation and dry stacked tailings to the then Department of Mines and Petroleum (DMP) in 2014. This Mining Proposal was approved under the *Mining Act 1978* in April 2014.

Since 2014, further mine optimisation, environmental baseline and impact assessment studies have led to a different approach to project development.

Venturex now proposes to progress Sulphur Springs as an open cut and underground operation with a valley-fill tailings storage facility (TSF). The Proposal was referred to the Western Australian Environmental Protection Authority (EPA) in December 2016 and in July 2017 the EPA determined the Proposal required formal assessment and set the level of assessment at Environmental Review - no public review. Preliminary key environmental factors identified for the Proposal include Flora and Vegetation, Subterranean Fauna, Terrestrial Environmental Quality and Inland Waters Environmental Quality.

Extensive baseline environmental data exists for the Proposal area which has been supplemented with a number of additional studies to specifically address the EPA requirements outlined in the Environmental Scoping Document (ESD). Venturex has continued to engage with stakeholders and has progressively refined the design to reduce key operational and post-closure risks. These activities have provided more detailed information regarding environmental values (at both a local and regional scale) and afforded greater confidence in the assessment of potential impacts.

In November 2019, the EPA consented to a request from Venturex to amend the Proposal to accommodate a change in the location of the TSF (and associated sundry changes) made to reduce post-closure environmental risks. The assessment of the amended Proposal presented in the ERD (this document) determined that impacts to all preliminary key environmental factors can be avoided or adequately mitigated and the project implemented such that EPA objectives are met through careful and considered project design and implementation of management measures.

OVERVIEW OF THE PROPOSAL

The Proposal comprises:

- An open pit (up to 1.5 Mtpa) to mine the top portion of the orebody during years 1 to 5.
- An underground mine (up to 1.5 Mtpa), accessed via a portal external to the mine pit, to mine the remainder of the orebody from year 5.
- A conventional flotation processing plant which will produce separate copper and zinc concentrates.
- A 'valley fill' Tailings Storage Facility (TSF).
- A permanent waste rock dump (WRD).
- Associated mine elements (stormwater management infrastructure (bunds and drains), internal mine roads, Site Access Road, topsoil and vegetation stockpiles, construction material stockpiles, power station, accommodation village, wastewater treatment plants (WWTPs), mine water treatment plant, water storage ponds and mine support facilities).

The copper and zinc concentrates will be transported by road to the deep-water port at Port Hedland.

Following completion of detailed design and subject to approvals, construction of the project will take around 12 months. The estimated project life is 10 years, although this may be extended if geological exploration identifies additional resources.

A summary of the key physical and operational characteristics of the Proposal is presented below:

Summary of the Proposal	
Proposal Title	Sulphur Springs Zinc-Copper Project.
Proponent Name	Venturex Resources Limited.
Short Description	Venturex Resources Limited proposes to develop and operate a zinc – copper mine and processing plant in the Sulphur Springs area located 57 km west of Marble Bar and 144 km south-east of Port Hedland in the Pilbara region of Western Australia.

Location and Proposed Extent of Physical and Operational Elements		
Element	**Location**	**Proposed Extent**
Physical Elements		
Mine and associated infrastructure	Figure 4	Clearing no more than 313.6 ha within the 889.2 ha Development Envelope.
Operational Elements		
Tailings storage facility	Figure 4, Figure 5	A 42 ha conventional 'valley fill' TSF for disposal of no more than 8.8 million tonnes (Mt) of tailings.
Waste rock dump	Figure 4, Figure 5	One 79.6 ha permanent WRD with no more than 17.5 million loose cubic metres (LCM).
Processing plant	Figure 4, Figure 5	A processing plant (up to 1.5 Mtpa) and associated facilities covering an area of 71 ha. Includes the footprint of a HDPE lined storage/evaporation pond (south pond).
Dewatering	Figure 21	Mine dewatering of up to 0.64 gigalitres/year (GL/yr), all to be used on site.
Water supply	Figure 13	Water abstraction of up to 0.32 GL/yr.

Open pit and supporting infrastructure	Figure 4, Figure 5	Includes open pit, accommodation camp, borrow pits, topsoil stockpiles, abandonment bund, sediment ponds, water management infrastructure, access roads, haul roads, communications, pipelines and powerlines covering an area of 122 ha. Includes a HDPE lined storage/evaporation pond (north pond).

SUMMARY OF POTENTIAL IMPACTS, PROPOSED MITIGATION AND OUTCOMES

Key Preliminary Environmental Factors

Key preliminary environmental factors for the Proposal are:

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

Other Environmental Factors or Matters

Other relevant environmental factors for the Proposal are:

- Terrestrial Fauna.
- Social Surroundings.
- Hydrological Processes.
- Air Quality.

Impact Assessment

A risk-based approach was used to assess potential impacts from the Proposal during construction, operations and closure. The likelihood and consequence of a potential impact were used to determine the level of inherent and residual risk of an environmental impact.

Likelihood describes the probability of a stressor impacting on an environmental factor. Where practicable, likelihood was quantified based on quantitative information or data.

A number of aspects were considered in determining the consequence of each potential impact, including:

- Type of impact (direct or indirect).
- Geographic extent, size and scale.
- Duration, frequency, reversibility of the potential impact.
- Whether the potential impacts are from planned or unplanned events.
- Sensitivity of the receptor/resource and the value of the receptor/resource.

The inherent risks (i.e. raw risks, prior to application of management measures) were determined by assessing the likelihood and consequence of each potential impact. Potential impacts considered to have the highest inherent risks included:

- Direct loss of native vegetation including conservation significant species.
- Contamination of soils or surface water due to overtopping the pit lake at closure.

- Contamination of soils, surface water or groundwater due to a TSF embankment failure.
- The TSF becomes listed as a contaminated site under the *Contaminated Sites Act 2003*.
- Disruption to traditional use of the land and loss of access to sites of cultural significance.
- Disturbance of heritage sites due to uncontrolled vehicle movements.

Mitigation and management measures were developed following a hierarchy of controls:

- **Avoid**: Measures that prevent an impact.
- **Minimise**: Measures that minimise or reduce an impact (examples include storing hydrocarbons in impermeable storage areas or implementing measures to reduce dust emissions from vehicle travel on unsealed roads).
- **Rehabilitate**: Measures that rectify, repair, rehabilitate or restore an impact.
- **Offset**: Required in the event that significant residual environmental impacts remain following the application of the above measures.

The residual risks were then determined by assessing the likelihood and consequence after mitigation and management measures are applied. Application of proposed mitigation and management measures has resulted in 'medium' or 'low' residual risks for all potential impacts.

ENVIRONMENTAL ACCEPTABILITY

This ERD provides an assessment of the potential impacts to the environment as a result of the implementation of the Proposal. Mitigation and management measures have been applied to minimise the residual environmental impact of the Proposal. Venturex is confident that the Proposal can be undertaken in such a way as to meet the EPA objectives for preliminary key environmental factors and other environmental factors or matters. Potential impacts, mitigation measures and predicted outcomes for preliminary key environmental factors are summarised in the tables below.

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Preliminary Key Environmental Factor 1 – Flora and Vegetation **EPA Objective:** ***To protect flora and vegetation so that biological diversity and ecological integrity are maintained.***				
• Statement of Environmental Principles, Factors and Objectives (EPA 2016b). • Environmental Factor Guideline – Flora and Vegetation (EPA 2016c). • Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016d).	• Thirteen vegetation communities occur within the Development Envelope. • The majority of flora taxa recorded within the Development Envelope are widespread both locally and more broadly within the associated biogeographical subregion. • One Threatened flora species; *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4), listed as Endangered under both the *Environment Protection and Biodiversity Conservation Act 1999* and the *Biodiversity Conservation Act 2016* was recorded at seven locations (59 individuals in total) within the Development Envelope. One additional plant was recorded outside the Development Envelope but within 50 m of the Proposal footprint. Over 9,848 individuals have been recorded within the Pilbara region. • Two Priority taxa; *Euphorbia clementii* (P3) and *Ptilotus mollis* (P4), were recorded within the Development Envelope. A third Priority taxa; *Gymnanthera cunninghamii* (P3) was recorded in the survey area, but outside the Development Envelope. • A number of potential groundwater dependent ecosystems (GDEs) have been inferred within the Development Envelope and wider region. • No Threatened Ecological Communities (TECs) or Priority Ecological Communities (PECs) occur within the Development Envelope or adjacent areas. • Three introduced (weed) species have been recorded within the Development Envelope (**Calotropis procera* (Rubber Bush), **Cenchrus ciliaris* (Buffel Grass) and **Setaria verticillata* (Whorled Pigeon Grass)). None of these species are listed as Weeds of National Significance (WONS).	• Direct loss of native vegetation, including conservation significant species. • Indirect impacts to native vegetation from modification of surface water or groundwater quality due to spills. • Indirect impacts to vegetation communities 1a and 2a due to overtopping of pit lake at closure. • Indirect impacts to native vegetation in the Sulphur Springs Creek catchment from contamination of groundwater due to seepage from the TSF, WRD or pit. • Indirect impacts to native vegetation due to dust emissions. • Introduction and/or increased spread of weeds. • Indirect impacts to vegetation communities in the Minnieritchie Creek and Six Mile Creek catchment areas from contamination of groundwater due to seepage from the TSF. • Indirect impacts to vegetation communities in the Minnieritchie or Sulphur Springs Creek catchment areas from contamination of groundwater due to seepage from storage ponds. • Indirect impacts to GDEs due to mine dewatering. • Indirect impacts to native vegetation from contamination of groundwater due to seepage from low grade stockpile or ROM pad. • Altered fire regime impacting vegetation health and condition. • Indirect impacts to native vegetation from modification of groundwater flows and/or groundwater levels. • Erosion of mine waste landforms resulting in sediment discharge and smothering of plants. • Vehicle movements off designated roads and tracks resulting in loss or reduced health	**Measures to Avoid:** • Project infrastructure has been located away, as far as practicable, from identified Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals and the associated 50 m buffer area surrounding them. • Known locations of conservation significant species will be included in the site's GIS to ensure locations are avoided during any future activities. • Pre-clearance surveys undertaken prior to land clearing to erect clearly demarcated exclusion zones around Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) populations. • Land clearing to be conducted in accordance with internal Ground Disturbance Procedure. • Chemicals, hydrocarbons and other environmentally hazardous materials will be stored and handled in accordance with the Dangerous Goods Safety Act 2004 and associated regulations, including use of a bunded and sealed assembly area for hazardous chemicals (containerised) prior to offsite treatment/disposal by a licenced and authorised waste contractor. • Facilities containing hydrocarbons and/or chemicals have been designed within bunds to contain 110% of the contents of the material stored. • Pipelines containing chemical, hydrocarbons or tailings will either be double skinned or located within lined corridors to avoid any spills contacting soil, surface water or groundwater sources. • Storage of PAF waste rock and tailings within the catchment of the mine pit. • Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink. • Known locations of weeds will be avoided, where practicable, for the development of project infrastructure. • Weed control will be implemented on areas to be disturbed for infrastructure. **Measures to Minimise:** • Land disturbance will be kept to the minimum necessary for development of the Proposal. • A Flora and Vegetation Environmental Management Plan will be implemented. • Ground disturbance procedures and an internal permitting system will be implemented. • Existing disturbed areas will be used wherever possible to minimise total ground disturbance. • The site induction program will provide written and verbal information on protection of vegetation, conservation significant flora and ground disturbance authorisation procedures. • Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material. • Overland pipes will be installed within bunds with catchment sumps constructed at low elevation points as required to provide containment capacity in the case of a pipeline leak. • Flow/pressure sensors will be fitted along pipelines to enable detection of flow anomalies (i.e. pipeline leaks). • Isolation valves will be installed at appropriate intervals along pipelines. • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. • Location of TSF upgradient of the mine pit in steep sided, confined valley • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Internal drainage collection and seepage monitoring and interception downstream of main embankment.	The majority of proposed vegetation clearing encompasses communities that are common and widespread with all 13 vegetation communities to be directly impacted well represented outside of the clearing footprint and Development Envelope. The Proposal footprint overlies one individual of a Priority 4 taxa as listed by DBCA (*Ptilotus mollis)* but has been carefully designed to avoid all known *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) locations and minimise development within the 50 m ESA surrounding them. The Proposal footprint does sit within 50 m of eight *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals. The loss of these individuals would have an insignificant impact on the viability of the species. Potential impacts associated with dust, increased presence of weeds, modification of surface water flows and fire regimes will be localised and incidental. Impacts from dewatering to GDEs are also expected to be localised to small areas immediately below the pit. No known GDEs occur within the Development Envelope. Therefore, the residual impacts are expected to be localised and minor in consideration of the potential GDEs mapped in the wider region. Venturex considers that the potential impacts to flora and vegetation can be adequately managed such that there are no significant residual impacts and the EPA objective for flora and vegetation (EPA 2016c) will be met.

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
		and condition of native vegetation. • Habitat fragmentation or modification for conservation significant species. • Seepage from the TSF causing groundwater mounding and indirect impacts to vegetation health and condition. • Indirect impacts to native vegetation due to overtopping of storage ponds. • Indirect impacts to native vegetation from modification of surface water flows. • Direct or indirect impacts to other significant flora.	• Saddle dams constructed with appropriate seepage prevention measures (low permeability cut off trench and embankment core, drainage collection on the upstream face). • Ongoing mine closure planning during the operational phase of the project, including TSF cover trials, to refine proposed designs. • pH amendment via lime addition conducted prior to final layers of tailings discharge to prevent the top surface of the tailings generating acid following sub-aerial deposition. • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • Design of PAF cells in the WRD to minimise ingress of oxygen and water. • Diverting 'clean' surface water flows away from operational areas as far as practicable. • A standardised elemental suite will be included for all future waste rock, leachate and water analysis. • Further studies of potential additional measures for the diversion of runoff away from the mine pit. • Dust suppression measures will be implemented. • Vehicle speed restrictions will apply. • Locations of weeds identified during baseline surveys within the Proposal footprint will be targeted for application of appropriate management actions during construction and operations. • A weed hygiene system will be implemented to avoid the spread of existing populations and the establishment of new populations. • Inspections targeting weeds will be conducted following significant rainfall, and depending on results, appropriate management actions will be implemented. **Measures to Rehabilitate:** • Further studies to confirm recoverable topsoil volumes and characteristics. • Progressive and early rehabilitation will be undertaken on disturbed areas where possible. • Monitoring of rehabilitated areas will be undertaken to track progress against short, medium and long-term objectives. • Local provenance seed collection will be undertaken throughout the project life for use in rehabilitation activities. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Spills will be cleaned up and contaminated soils will either be remediated or removed from site by a licenced third party. Incident investigation will be undertaken as required to determine the cause of environmentally harmful spills/leaks and control measures identified to prevent future incidents. As required, spills will be reported to the relevant authorities. • Decommissioning and removal of all storages and pipelines. • TSF cover design to minimise infiltration. • Monitoring TSF seepage during operations for consideration in closure design. • Lysimeters and ion-specific probes will be utilised during the operational and short-term post-closure phases to validate TSF modelling assumptions. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure. • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions. • WRD rehabilitation to a design to maximise surface stability and minimise infiltration around PAF areas. • Early rehabilitation of final outer slopes of WRD. • Rehabilitation procedures to achieve surfaces that minimise susceptibility to wind erosion. • Rehabilitation monitoring to include presence of weeds to enable appropriate management actions to be implemented.	

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Preliminary Key Environmental Factor 2 – Subterranean Fauna **EPA Objective:** ***To protect subterranean fauna so that biological diversity and ecological integrity are maintained***				
• *Environment Protection and Biodiversity Conservation Act 1999* (Cth). • *Biodiversity Conservation Act 2016* (WA). • *Environmental Protection Act 1986* (WA). • EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b). • EPA Environmental Factor Guideline – Subterranean Fauna (EPA 2016e). • EPA Technical Guidance – Sampling methods for Subterranean fauna (EPA 2016f). • EPA Technical Guidance – Subterranean fauna survey (EPA 2016g).	• Subterranean fauna surveys recorded 24 stygofauna species and one troglofauna species within the Development Envelope. • Of the 24 stygofauna species, 20 are known to also occur outside the Development Envelope. The remaining four consisted of two nematodes and two oligochaetes (Phreodrilidae Gen. et sp. indet. and Tubificidae SS sp. 1). • A single specimen of Phreodrilidae Gen. et sp. indet. was recorded in Sulphur Springs Creek, within unconsolidated alluvial sediments (the hyporheic zone). One specimen of Tubificidae SS sp. 1 was recorded at bore along the Site Access Road and a further 20 individuals were recorded approximately 2.9 km upstream, within Sulphur Springs Creek. • Stygofauna species identified are indicated to have wide distributions through hydraulic connection within the secondary aquifer system • The one troglofauna species recorded was a cockroach (Blattodea sp. 1). Surveys across the broader region have demonstrated that this species is locally widespread, occurring in zones well outside of the Development Envelope (Kangaroo Caves, Bernts and the Outokumpu Camp areas).	• Degradation of subterranean fauna habitat due to seepage from the TSF, WRD or pit. • Permanent loss of subterranean fauna habitat and individuals due to open pit development. • Loss of subterranean fauna habitat and individuals from groundwater drawdown due to mine dewatering or borefield groundwater abstraction. • Degradation of subterranean fauna habitat due to spills (hydrocarbons, reagents, chemicals or wastewater). • Loss of subterranean fauna habitat and individuals due to increased sediment loads in hyporheic zone along Sulphur Springs Creek. • Degradation of subterranean fauna habitat and individuals downgradient of pit due to pit lake overtopping at closure. • Loss of subterranean fauna habitat due to altered groundwater flow regime. • Degradation of subterranean fauna habitat due to poor quality seepage from water storage ponds. • Loss of subterranean fauna habitat and individuals within the Minnieritchie Creek or Six Mile Creek catchments due to seepage from the TSF	**Measures to Avoid:** • Siting key proposal elements (WRD and TSF) adjacent to the mine pit to confine any seepage extent. **Measures to Minimise:** • TSF location adjacent to the mine pit with minimised footprint. • Siting of encapsulated PAF cells in the WRD within the pit catchment. • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • Design of PAF cells in the WRD to minimise ingress of oxygen and water. • Siting of other mine infrastructure and associated surface water management infrastructure to minimise impacts to catchment areas. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. **Measures to Rehabilitate:** • Shaping the final WRD and TSF landforms to shed surface runoff away from the mine pit to ensure the pit remains a hydraulic sink. • Monitoring TSF seepage during operations for consideration in closure design. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure. • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions.	Limited groundwater drawdown is predicted to result from mine dewatering and groundwater abstraction (water supply). The majority of stygofauna species recorded are confirmed to be well distributed beyond the potential impact area. The remaining stygofauna species are also believed, based on habitat usage, to be well represented beyond the impact area. The single troglofauna species recorded within the impact area is well represented beyond the Development Envelope. Groundwater and surface water modelling indicate that proposed recontouring of the pit catchment will ensure the pit becomes a hydraulic sink at closure. Thus, significant impacts to the groundwater quality in surrounding areas are not expected. Any seepage from the TSF or encapsulated PAF cells in the WRD will be captured in the pit lake, making significant impacts to the groundwater quality in surrounding areas unlikely. Taking into account the broad distribution of subterranean fauna beyond the impact area, the proposed mitigation measures including robust TSF and WRD design, development and implementation of a groundwater management plan and implementation of appropriate chemical storage and handling procedures, a significant impact on subterranean fauna as a result of the degradation of habitat is not expected. Given this, it is believed that the EPA objective 'to protect subterranean fauna so that biological diversity and ecological integrity are maintained' will be met.

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Preliminary Key Environmental Factor 3 – Terrestrial Environmental Quality and Inland Waters Environmental Quality **EPA Objectives: To maintain the quality of land and soils so that environmental values are protected.** **To maintain the quality of groundwater and surface water so that environmental values are protected.**				
• *Environmental Protection Act 1986* (WA). • *Rights in Water and Irrigation Act 1914* (WA). • *Country Areas Water Supply Act 1947* (WA). • Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015). • EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b). • EPA Environmental Factor Guideline – Terrestrial Environmental Quality (EPA 2016h). • EPA Environmental Factor Guideline – Inland Waters Environmental Quality (EPA 2016i). • Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Commonwealth) (ANZECC and ARMCANZ 2000). • Water Quality Protection Guidelines No. 11, Mining and Mineral Processing, Mine Dewatering (WRC 2000a). • *Statewide Policy No. 5, Environmental Water Provisions Policy for Western Australia* (WRC 2000b). • National Water Quality Management Strategy (ANZECC and ARMCANZ 1994). • Pilbara Regional Water Plan (DoW 2010). • Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (DMP 2015).	• Topography in the region is characterised by numerous rocky hills and small gorges that control the flow of surface water. • Soils underlying and within the immediate vicinity of granite hills across the Proposal area are dominated by red shallow sands. Hills give way to broad gently sloping plains with red sandy earths, red deep sands and red loamy earths. Minor soil types include red shallow loams with some red shallow sands. Soils become deeper downslope. In these areas, the dominant soils are stony surfaced red loamy earths. • Groundwater and surface water flow systems in the area are complex, variable and linked. There are strong correlations with topography, geology and structure. Recharge takes place in upland areas and groundwater discharges to valley floor domains and associated watercourses. • Groundwater quality in the Development Envelope varies widely. Within the mineralised zone, oxidation of in situ sulphide materials has resulted in groundwater that is low in pH and contains elevated concentrations of salinity, sulphate and metals/metalloids including aluminium, cadmium, copper, nickel, iron, manganese and zinc. This mechanism has led to the development of acidic conditions and elevated metal concentrations in a zone of the Sulphur Springs Creek system. Outside of this zone, surface water and groundwater are typically of near-neutral pH, low in salinity and contain lower concentrations of metals and metalloids. • Surface water quality in the Development Envelope also varies widely. In the Sulphur Springs Creek catchment, water quality is influenced by perennial discharges from mineralised bedrock with low pH and elevated concentrations of salinity, sulphate and metals/metalloids including cadmium, copper, nickel and zinc. Across other catchments, surface water generally has a close to neutral pH, low salinity and lower concentrations of metals and metalloids.	• Contamination of soils or surface water due to overtopping of the pit lake at closure. • Contamination of soils, surface water or groundwater due to spills. • Contamination of soils, surface water or groundwater due to a TSF embankment failure. • Contamination of soils, surface water or groundwater due to overtopping the TSF. • Contamination of surface and/or groundwater due to seepage from the TSF, WRD or pit. • Contamination of soils or surface water due to overtopping of surface water storages. • The TSF becomes listed as a contaminated site under the Contaminated Sites Act 2003. • The WRD or pit becomes listed as a contaminated site under the Contaminated Sites Act 2003. • Contamination of soils due to particulate emissions from the TSF surface. • Contamination of groundwater due to seepage from storage ponds. • Loss of topsoil and/or viability due to erosion, compaction or inappropriate handling and storage regime. • Contamination of groundwater due to seepage from low grade stockpile or ROM pad.	**Measures to Avoid:** • Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink. • Chemicals, hydrocarbons and other environmentally hazardous materials will be stored and handled in accordance with the Dangerous Goods Safety Act 2004 and associated regulations. • Facilities containing hydrocarbons and/or chemicals have been designed within bunds to contain 110% of the contents of the material stored. • Pipelines containing chemical, hydrocarbons or tailings will either be double skinned or located within lined corridors. • Location of the TSF immediately upgradient of the mine pit. • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • TSF design to include extreme storm storage volume equivalent to a 1 in 1,000 year AEP 72 hour duration storm with no release, evaporation or decant. • TSF design to accommodate wave run-up associated with a 1:50 AEP wind velocity with an additional freeboard of 0.5 m. • OBE and MDE design earthquake loadings of 1 in 1,000 AEP and 1 in 5,000 AEP, respectively. • Construction supervised by Dams Engineer and Specialist (where relevant) to ensure the TSF is constructed as per design with as-built drawings. • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Routine inspections of the TSF by operations personnel. • Implementation of a TSF operating manual. • Consideration of PMP and PMF scenarios in project infrastructure and closure designs to contain any potential seepage from PAF cells in the WRD in the pit lake catchment. • Encapsulation of PAF waste rock within the WRD and within the catchment of the mine pit. • Designs and operational practice for water storages to ensure sufficient freeboard for a 1 in 100 year 72 hour rainfall event. • All available topsoil will be stored for use in future rehabilitation. • Topsoil will be stored in low stockpiles no higher than 2 m to optimise retain the viability of seeds. • During operations, underground PAF waste rock that cannot be immediately disposed in underground workings will be stored in the pit and within the mine dewatering cone of depression and either returned to the underground void or retained in the base of the pit where it will be covered by the pit lake post closure. **Measures to Minimise:** • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Review of options for further reduction in pit surface water catchment. • Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material.	The majority of the higher inherent risk impacts associated with the Proposal arise from construction of landforms containing PAF materials (TSF and permanent WRD) and surface water/groundwater management. Extensive study of baseline geotechnical, soils, hydrological and hydrogeological conditions, together with geochemical characterisation of materials, has provided a higher level of certainty in the assessment of potential impacts. It has also allowed a very comprehensive and robust approach to engineering design which has significantly reduced the likelihood of impacts. Proposed designs meet or exceed relevant guidelines and industry best practice and modelling of key parameters (surface and groundwater flows and quality, erosion) across the operational and closure phases indicates that proposed management measures will be sufficient to ensure the risk of impacts to the receiving environment remain low. Although mining activities are regarded as a 'potentially contaminating activity' under Western Australia's *Assessment and Management of Contaminated Sites - Contaminated Sites Guidelines* (DER 2014), appropriate design, management and closure measures for the TSF and WRD are capable of limiting potential pathways. Provided mitigation measures are met, the TSF and WRD are not expected to be classified under the *Contaminated Sites Act 2003* (WA). No impacts beyond minor, local scale changes to soil, surface water or groundwater quality are predicted and no significant impacts to the dependent environmental values are expected. The EPA objective 'to maintain the quality of land, soils, groundwater and surface water so that environmental values are protected' will be met.

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Preliminary Key Environmental Factor 3 – Terrestrial Environmental Quality and Inland Waters Environmental Quality **EPA Objectives: To maintain the quality of land and soils so that environmental values are protected.** **To maintain the quality of groundwater and surface water so that environmental values are protected.**				
			• Overland pipes will be installed within bunds with catchment sumps constructed at low elevation points as required to provide containment capacity in the case of a pipeline leak. • Flow/pressure sensors will be fitted along pipelines to enable detection of flow anomalies (i.e. pipeline leaks). • Isolation valves will be installed at appropriate intervals along pipelines. • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Spills will be cleaned up and contaminated soils will either be remediated or removed from site by a licenced third party. • Any material issues identified during routine inspections of the TSF will be rectified. • Location of the TSF immediately upgradient of the mine pit. • Implementation of a TSF operating manual. • Routine inspections of the TSF by operations personnel. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions • Internal drainage collection and seepage monitoring and interception downstream of TSF main embankment. • TSF embankments constructed with appropriate seepage prevention measures (low permeability cut off trench and embankment core, drainage collection on the upstream face). • Monitoring at potential TSF seepage points and seepage recovery implemented where warranted. • Ongoing mine closure planning during the operational phase of the project, including TSF cover trials, to refine proposed designs • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Multi-element analysis of representative samples of each waste rock lithology will be conducted during future resource definition drilling programs to consolidate the value of the existing waste rock database. • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • A standardised elemental suite will be included for all future waste rock, leachate and water analysis. • Design of PAF cells in the WRD to minimise ingress of oxygen and water. • Subject to geological assessment, installation of one monitoring bore to assist in characterising the hydrological characteristics of the fault beneath the design floor of the pit and another upstream of the pit, close to surface water monitoring site MCI. • Sediment ponds downstream of the processing area will include an engineered spill point to minimise damage from overflow during an extreme rainfall event. • The duration that topsoil is stockpiled will be minimised as far as practicable, and where possible, topsoil will be returned directly to areas that are ready to be rehabilitated. • All topsoil stockpiles will be located away or protected from stormwater flows, minimising potential losses via erosion.	

Policy and Guidance	Existing Environment	Potential Impact	Management Measures	Predicted Outcomes
Preliminary Key Environmental Factor 3 – Terrestrial Environmental Quality and Inland Waters Environmental Quality **EPA Objectives: To maintain the quality of land and soils so that environmental values are protected.** **To maintain the quality of groundwater and surface water so that environmental values are protected.**				
			• Where practicable, topsoil will not be handled when wet to avoid damaging soil structure and composition. • A series of sediment traps will be installed in zones where surface water modelling has indicated concentrated flows may result around infrastructure. This will reduce flow energy and remove sediment from stormwater. • Vehicle movements will be restricted to authorised roads and tracks. • Project induction to contain information about not driving out of designated areas. • Diverting 'clean' surface water flows away from operational areas as far as practicable. • Siting of other mine infrastructure and associated surface water management infrastructure to minimise impacts to catchment areas. • Maintaining a wetted tailings surface during operations. • Adoption of additional dust suppression measures for the TSF surface (such as binding agents or water spray) during embankment raises and the period between cessation of operations and installation of a TSF cover. **Measures to Rehabilitate:** • Preparation and regular update of a MCP consistent with Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015). • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Early and progressive rehabilitation of final landform surfaces (TSF and WRD) where practicable. • Decommissioning and removal of all storages and pipelines. • TSF closure design which includes a water shedding, erosion resistant cover designed to minimise infiltration. • Shaping edges of the TSF cover around the valley sides such that they integrate into the hillside face. • Routine inspections of TSF by a Dams Engineer during the first five years of the closure phase. • TSF spillway included in closure design with capacity for a 1 in 100,000 year AEP and freeboard allowance. • Monitoring TSF seepage during operations for consideration in closure design. • Lysimeters and ion-specific probes will be utilised during the operational and short-term post-closure phases to validate TSF modelling assumptions. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure. • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions. • WRD rehabilitation to a design to maximise surface stability and minimise infiltration around PAF areas. • Removal of all surface water storages during the decommissioning and rehabilitation stages of the project. • TSF closure design which includes a water shedding, erosion resistant cover designed to minimise infiltration.	

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APPENDICES

1. INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS ERD

This Environmental Review Document (ERD) has been prepared for the Sulphur Springs Zinc-Copper Project (Sulphur Springs, the Proposal). Sulphur Springs is a proposed greenfields mine development about 144 km south east of Port Hedland and 57 km west of Marble Bar in the Pilbara region of Western Australia (Figure 1). The term 'Proposal area', used later in this document, refers to the Development Envelope and broader region in which the Proposal is located.

The Proposal was referred to the Western Australian Environmental Protection Authority (EPA) by Venturex Resources Limited (Venturex) on 14 December 2016. On 13 July 2017 the EPA determined the Proposal required formal assessment with the level of assessment set as Environmental Review - no public review.

An Environmental Scoping Document (ESD) prepared by the EPA (Appendix 1) to define the form, content, timing and procedure of the ERD was released by the EPA on 2 October 2017.

The ERD has been prepared to fulfil the requirements for assessment of the Proposal pursuant to Part IV of the Western Australian *Environmental Protection Act 1986* (*EP Act*). It has been prepared in accordance with the *EP Act Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016* (EPA 2016a), the guidelines for preparing an ERD (EPA 2018b) and to the requirements of the ESD (Appendix 1).

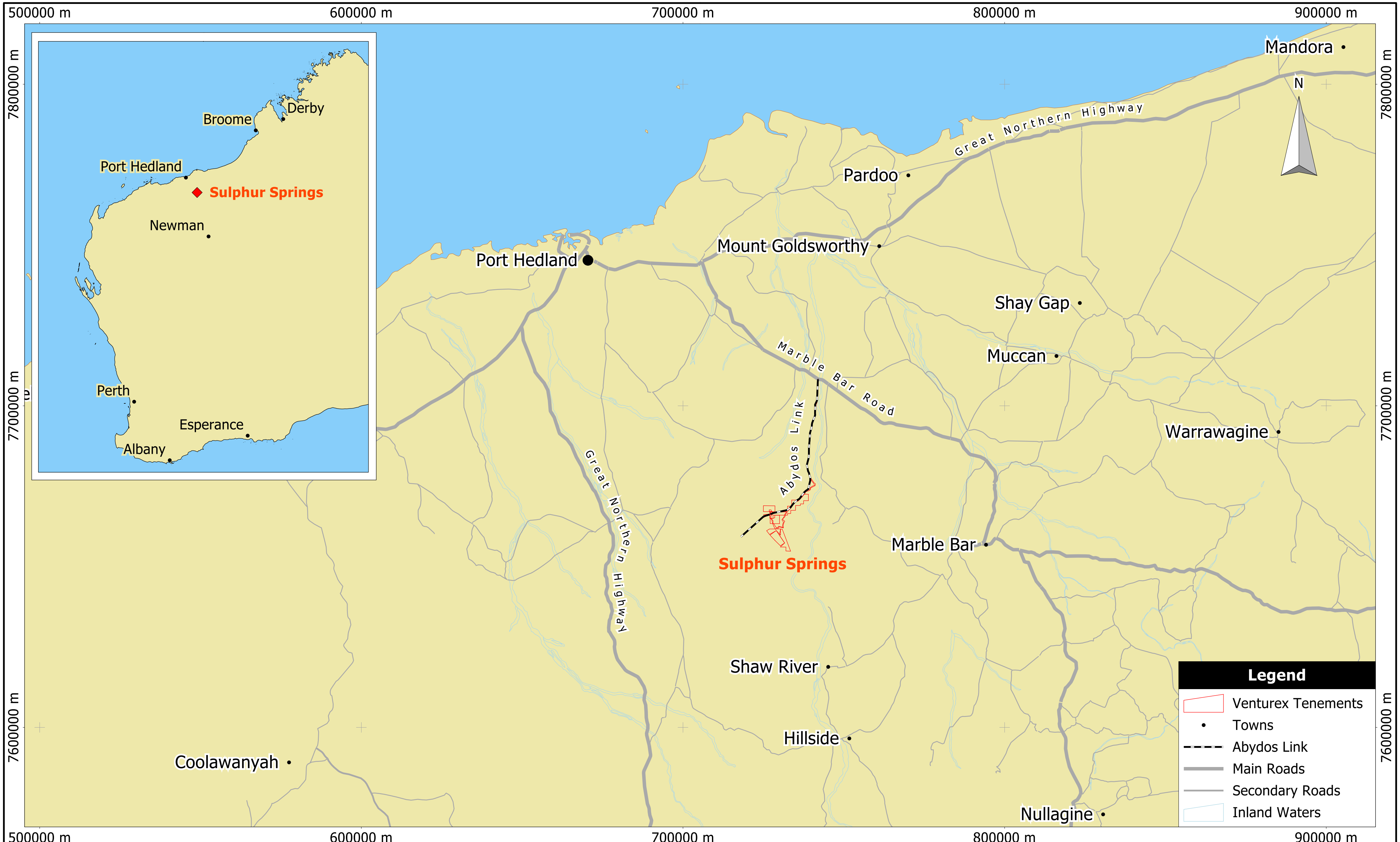
The ERD was first submitted to the EPA on 6 June 2018. Since then, the document has undergone a number of revisions in response to feedback from regulatory agencies, outcomes of further analyses and recommendations of independent peer reviews completed in 2019. On 28 November 2019, the EPA approved a request from Venturex to amend the proposal to accommodate a change in the location of the Tailings Storage Facility (TSF) (and associated sundry changes) made to reduce post-closure environmental risks.

This current revision of the ERD (Revision 6) details the environmental impact assessment of the amended proposal. The supporting studies included as appendices contain some information that pertains to the prior proposal design. This information is reflective of the depth of investigations conducted to define and assess the Proposal, helps illustrate the progression of Proposal design to mitigate environmental impacts and in some instances is applicable to the current Proposal.

1.2 PROPONENT

The owner and proponent of Sulphur Springs is Venturex Resources Limited, a company incorporated in Australia and listed on the Australian Stock Exchange (ASX: VXR).

The proponent can be contacted at:	Venturex Resources Ltd Level 2, 91 Havelock Street West Perth WA 6005 ABN 28 122 180 205 ACN 122 180 205
The key contact for the Proposal is:	Piers Goodman Environment Manager Telephone: (08) 6389 7400 Email: Admin@venturexresources.com



Scale: 1:1500000
Original Size: A4
Grid: MGA94(50)

0 40 km

Venturex Resources Limited
Sulphur Springs Project

Figure 1

Project Location

4 Cook St
West Perth WA 6005
Ph: (08) 9226 3166
Fax: (08) 9226 3177
info@mbsenvironmental.com.au
www.mbsenvironmental.com.au

W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Location Plan.map 5/06/2018 F1 Project Location A4L

1.3 LEGISLATIVE FRAMEWORK

1.3.1 Environmental Protection Act 1986

The Western Australian *EP Act* is the primary legislation governing environmental protection and impact assessment in the State. Approvals can be required under two parts: Part IV and Part V. Projects with the potential to significantly impact on the environment, or of sufficient public interest, are assessed under Part IV.

The construction and operation of facilities that constitute a 'Prescribed Premise' (as listed under Schedule 1 of the *Environmental Protection Regulations 1987*) requires approval under Part V. Part V also imposes a requirement for permits to clear native vegetation under certain circumstances, including when ground disturbance is proposed and has not been evaluated under Part IV.

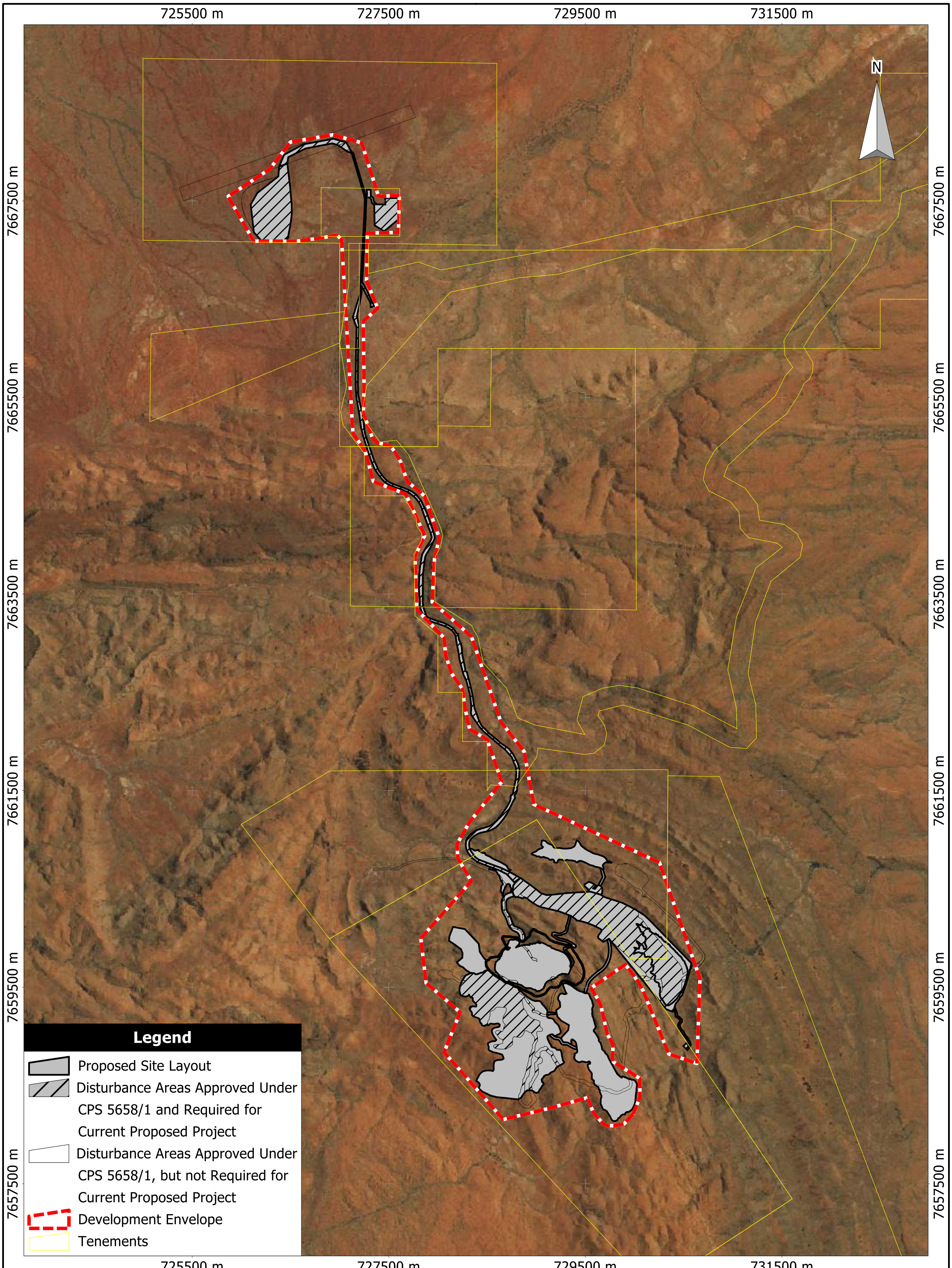
1.3.1.1 Part IV Environmental Impact Assessment

This Proposal was referred to the EPA on 14 December 2016. On 13 July 2017, the EPA determined that the Proposal would be assessed under Part IV of the *EP Act* and the level of assessment was set as Environmental Review - no public review. An ESD was prepared by the EPA to address impact assessment requirements and released as final on 2 October 2017 (Appendix 1). Preliminary key environmental factors included Flora and Vegetation, Subterranean Fauna, Terrestrial Environmental Quality and Inland Waters Environmental Quality

1.3.1.2 Part V Environmental Regulation

Under Part V of the *EP Act,* Works Approvals and Environmental Licences are required for a range of activities prescribed within Schedule 1 of that Act. Works Approvals and Environmental Licences are administered by the Department of Water and Environment Regulation (DWER) to allow construction and operation of key infrastructure (respectively) used for pollution control management including ore processing plants, water transfer infrastructure, water holding dams, power generation facilities, and waste treatment and disposal facilities (i.e. TSFs, landfill and sewage treatment plants). A Works Approval and Environmental Licence will be required for the construction and operation of Sulphur Springs. Activities expected to trigger the requirement for a Works Approval and Environmental Licence include ore processing and tailings disposal, mine dewatering, power generation, wastewater treatment plant and landfill.

Additionally, the *EP Act* and *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* (clearing regulations) regulate the clearing of native vegetation in Western Australia. A Clearing Permit, for clearing up to 193 ha of native vegetation, was approved in August 2013 (CPS 5658/1) for a previous iteration of the Sulphur Springs Project. No clearing under CPS 5658/1 has been carried out. As the Proposal is being formally assessed under Part IV of the *EP Act,* any resulting Ministerial Statement would regulate clearing for the Proposal. Figure 2 compares the area of clearing assessed for CPS 5658/1 with that for the current Proposal.



Scale: 1:50000 Original Size: A4 Image source: Landgate Locate Mosaic Air Photo Date: 2012 Grid: MGA94(50) 0 1000 m	Venturex Resources Limited Sulphur Springs Project	**Figure 2** **Comparison of Clearing Assessed for CPS 5658/1 and that Required for this Proposal**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD (from EPA Referral V4).map 28/01/2020 F2 Comparison (Whole Project) Layout

1.3.2 Environmental Protection and Biodiversity Conservation Act 1999

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* is administered by the Commonwealth Department of the Environment and Energy (DoEE). Commonwealth approval is required if Matters of National Environmental Significance (MNES), as defined in the *EPBC Act*, are potentially impacted, including migratory birds, listed Threatened flora, fauna, or Threatened Ecological Communities (TECs), listed heritage sites or Commonwealth marine areas, Commonwealth land, Commonwealth activities, and nuclear actions.

Several Threatened flora and fauna species listed under the *EPBC Act* occur in and around the Proposal area. The *EPBC Act* provides guidelines for self-assessment of whether an action is likely to have a significant impact on MNES. Venturex, in consultation with MBS Environmental, has conducted a self-assessment against the relevant factors and determined there will be no significant impacts on MNES. Discussions with DoEE on 20 September 2018 confirmed this was an appropriate approach and therefore the Proposal has not been referred under the *EPBC Act*. The Proposal amendment consented to by the EPA in November 2019 has not altered the conclusion of the self-assessment.

1.3.3 State Agreement

A State Agreement is a legal contract between the Western Australian Government and a proponent of a major project in Western Australia. There are no active State Agreements that relate to this Proposal.

1.4 OTHER APPROVALS AND REGULATIONS

In addition to assessment of the Proposal under Parts IV and V of the *EP Act*, a range of other environmental assessments and authorisations will, or may, be required for the Proposal. Key approvals are summarised in Figure 3 and a more comprehensive list of additional consents/approvals is provided in Table 1.

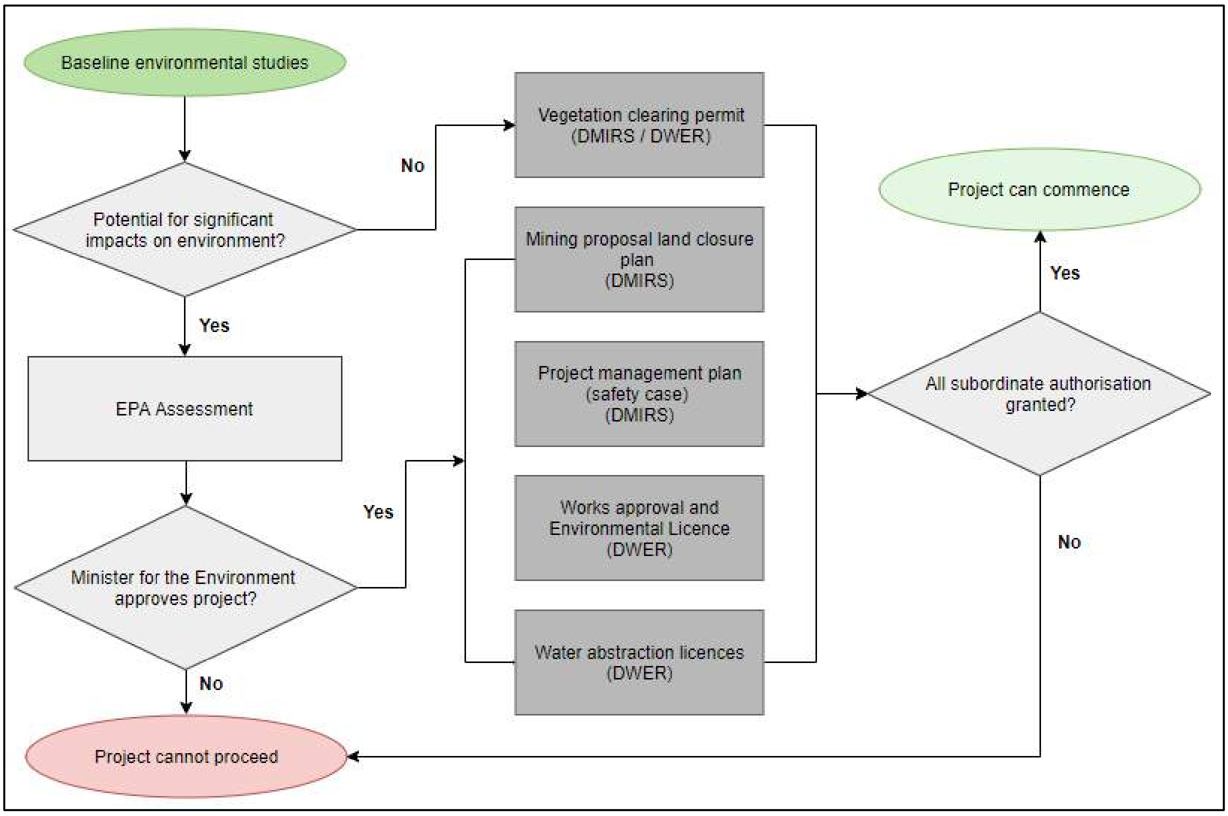


Figure 3: Western Australian Environmental Approvals

Table 1: Other Approvals and Regulations

Activity	Land Tenure/Access	Approval	Legislation (Regulatory Body)
Land access	• Mining tenure • Majority of Proposal: Crown Land • Northern section: pastoral lease	Grant of tenure	*Mining Act 1978* (DMIRS)
Mining Activities: ore processing and ancillary activities (excluding accommodation village and borrow pit)	• Mining tenure • Unallocated Crown Land	Approval to operate via Project Management Plan	*Mines Safety and Inspection Act 1994* (DMIRS)
		Environmental approval via Mining Proposal and Mine Closure Plan	
		Dangerous Goods Licence	*Dangerous Goods Safety Act 2004* (DMIRS)
Mine rehabilitation	• Mining tenure • Unallocated Crown Land • Pastoral lease	Annual payment of Mining Rehabilitation Fund levy	*Mining Rehabilitation Fund Act 2012* (DMIRS)
Taking or disturbing flora or fauna	• Mining tenure • Unallocated Crown Land • Pastoral lease	Permit to Take	*Biodiversity Conservation Act 2016* (Department of Biodiversity Conservation and Attractions) (DBCA)
Construction of water abstraction bores	• Mining tenure • Unallocated Crown Land • Pastoral lease	26D licence	*Rights in Water & Irrigation Act 1914* (DWER)
Groundwater abstraction		5C licence	
Development of Proposal footprint		Section 17 Bed and Banks Permit	
Zinc-copper production/processing	• Mining tenure • Unallocated Crown Land	Works Approval and Environmental Licence	*Environmental Protection Act 1986 – Part V* (DWER)
Transport, storage and loading of concentrate for export at Port Hedland	• Pilbara Ports Authority – Port of Port Hedland • Main Roads WA • Shire of East Pilbara • Town of Port Hedland	Port Environmental Licence. Restricted Access Vehicle (RAV) network access permit	*Port Authorities Act 1999* *Environmental Protection Act 1986 – Part V* *Road Traffic (Vehicles) Act 2012*
Support activities (wastewater treatment plant (WWTP), power generation, operation of landfill)	• Mining tenure • Unallocated Crown Land • WWTP located on Pastoral lease	Works Approval and Environmental Licence or registration	*Environmental Protection Act 1986 – Part V* (DWER)

Activity	Land Tenure/Access	Approval	Legislation (Regulatory Body)
Construction and use of accommodation village and associated waste treatment and management facilities	• Mining tenure • Pastoral lease	Planning consent, building approvals,	*Building Act 2011* *Planning and Development Act 2005* *Health Act 1911* (Shire of East Pilbara) *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974.* (DWER)
Land access and ground disturbance in areas of cultural significance	• Mining tenure • Unallocated Crown Land • Pastoral lease	Section 18 approval(s) (if required)	*Aboriginal Heritage Act 1972* (Department of Planning, Lands and Heritage) (DPLH)

The Department of Mines, Industry Regulation and Safety (DMIRS) is the lead government agency with regards to approvals for mining operations in Western Australia. The *Mining Act 1978* requires that, to conduct mining activities (as defined under the Act); a Mining Proposal is to be submitted to DMIRS, who assess and assign environmental conditions to the relevant tenements if approved.

Mining Proposals are required to include a Mine Closure Plan (MCP) compliant with the joint Department of Mines and Petroleum (DMP)/EPA *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). This is assessed as part of the Mining Proposal assessment process and reviewed every three years. Mining Proposals can only be approved where Mining Lease, General Purpose Lease and/or Miscellaneous Licence tenements have been granted.

A Mining Proposal will be developed and submitted to DMIRS for approval for the Proposal following the EPA assessment process.

Existing approvals for the Proposal area granted under the *Mining Act 1978* are summarised in Table 2.

Table 2: Existing Approvals Under the Mining Act 1978

Year	Proponent	Approval Title
2007	CBH	REG ID 19227 Panorama Project Temporary Exploration Camp Low-Impact Mining Proposal
2013	Atlas Iron Limited	REG ID 37527 Abydos DSO Project: Proposed Abydos Link Project – including the Abydos Haul Road
2014	Venturex	REG ID 40542 Venturex Sulphur Springs Pty Ltd. Sulphur Springs Copper-Zinc Project

Clearing and construction activities associated with Mining Proposals REG ID 19227 and REG ID 37527 are complete. No activities approved under Mining Proposal REG ID 40542 have been carried out to date.

2. THE PROPOSAL

2.1 BACKGROUND

Sulphur Springs is a volcanogenic massive sulphide copper-zinc deposit located predominantly within the George Range of the Pilbara Craton. Base metal sulphide mineralisation was first discovered at the site in 1991. Since this time, a number of exploration programs, studies and reviews have been conducted to further define the resource and develop a viable project development concept. These studies include:

- A feasibility study by Outokumpu Zinc Australia and Sipa Resources Limited in 2002, which proposed an underground operation at Sulphur Springs. This project did not proceed to development as it was not considered economically viable at the time.
- A detailed feasibility study of the project by CBH in 2007, which identified that the total resource could be economically mined via a 43 million bank cubic metre (BCM) open pit mine and associated waste rock dumps (WRDs) with an indicative project footprint of 590 ha (55 % greater than current proposed project). CBH submitted a Public Environmental Review (PER) for the development to the EPA in 2007 (URS 2007d). Following the purchase of CBH by Toho, the project was sold to Venturex in 2011. The assessment process was terminated by the EPA at the request of Venturex on 2 July 2012.
- A detailed feasibility study of the Proposal was completed by Venturex in 2012/2013, based on mining the total resource via an underground mine. A Mining Proposal for this option was assessed and approved by DMP in 2014 (REG ID 40542) and included an underground mine, sulphide concentrator and dry stacked tailings storage. DMP consulted with the Office of the Environmental Protection Authority (OEPA) during the assessment and approval of this Mining Proposal. Due to unfavourable market conditions, no activities approved under MP Reg ID 40542 (and associated clearing permit CPS 5658/1) have been carried out to date.
- An optimisation study by Venturex in 2015, based on mining the resource using a combination of a 17 M BCM open pit and an underground mine, together with adoption of a conventional 'valley fill' TSF with a combined High Density Polyethylene (HDPE) and compacted low permeability sub-base liner. The study determined that this option would result in a significant reduction in the financial and operational risks.
- Development of a new geological model and resource estimate in 2016, which identified a supergene resource in the upper section of the orebody containing approximately 800,000 t at a grade of 4.2 % Cu. An initial desktop review confirmed the viability of a separate heap leach process stream to recover copper from the supergene and oxide deposits.

Venturex now proposes to progress the project via a revised project design that incorporates an open pit, underground mine, sulphide concentrator, valley-fill TSF and associated infrastructure.

The Proposal was referred to the Western Australian Environmental Protection Authority (EPA) by Venturex Resources Limited (Venturex) on 14 December 2016. On 13 July 2017 the EPA determined the Proposal required formal assessment with the level of assessment set as Environmental Review - no public review. An Environmental Scoping Document (ESD) for the Proposal was released by the EPA on 2 October 2017. Since this time, the following two changes to the Proposal have been approved under Section 43A of the *EP Act*:

- Incorporation of water management infrastructure and sediment control ponds and an increase in the disturbance footprint from 321.9 ha to 326.7 ha. A notice of decision to consent to this change was issued by the EPA on 5 July 2018.
- Removal of the heap leach facility, changes to the design and location of the TSF, a reduction in the disturbance footprint from 326.7 ha to 313.6 ha and an increase in the development envelope from 848.3 ha to 889.2 ha. A notice of decision to consent to this change was issued by the EPA on 28 November 2019.

2.2 PROPOSAL DESCRIPTION

Venturex proposes to:

- Develop an open pit to mine the top portion of the orebody during the first five years of the project life.
- Develop an underground mine, accessed via a portal external to the mine pit, to mine the remainder of the orebody.
- Construct and operate a conventional flotation processing plant (up to 1.5 Mtpa) to produce separate copper and zinc concentrates.
- Construct and operate a 'valley fill' TSF for the storage of process tailings.
- Construct a waste rock dump (WRD) for storage of waste rock from the pit.
- Construct supporting elements such as stormwater management infrastructure (bunds and drains), internal mine roads, Site Access Road, topsoil stockpiles, construction material stockpiles, power station, accommodation village, wastewater treatment plants (WWTPs), mine water treatment plant, water storage ponds and mine support facilities.
- Transport copper and zinc concentrates to the port of Port Hedland for export.

The Proposal and extent of project elements are summarised in Table 3 and Table 4. The Development Envelope and conceptual infrastructure layout (or disturbance footprint) are shown in Figure 4.

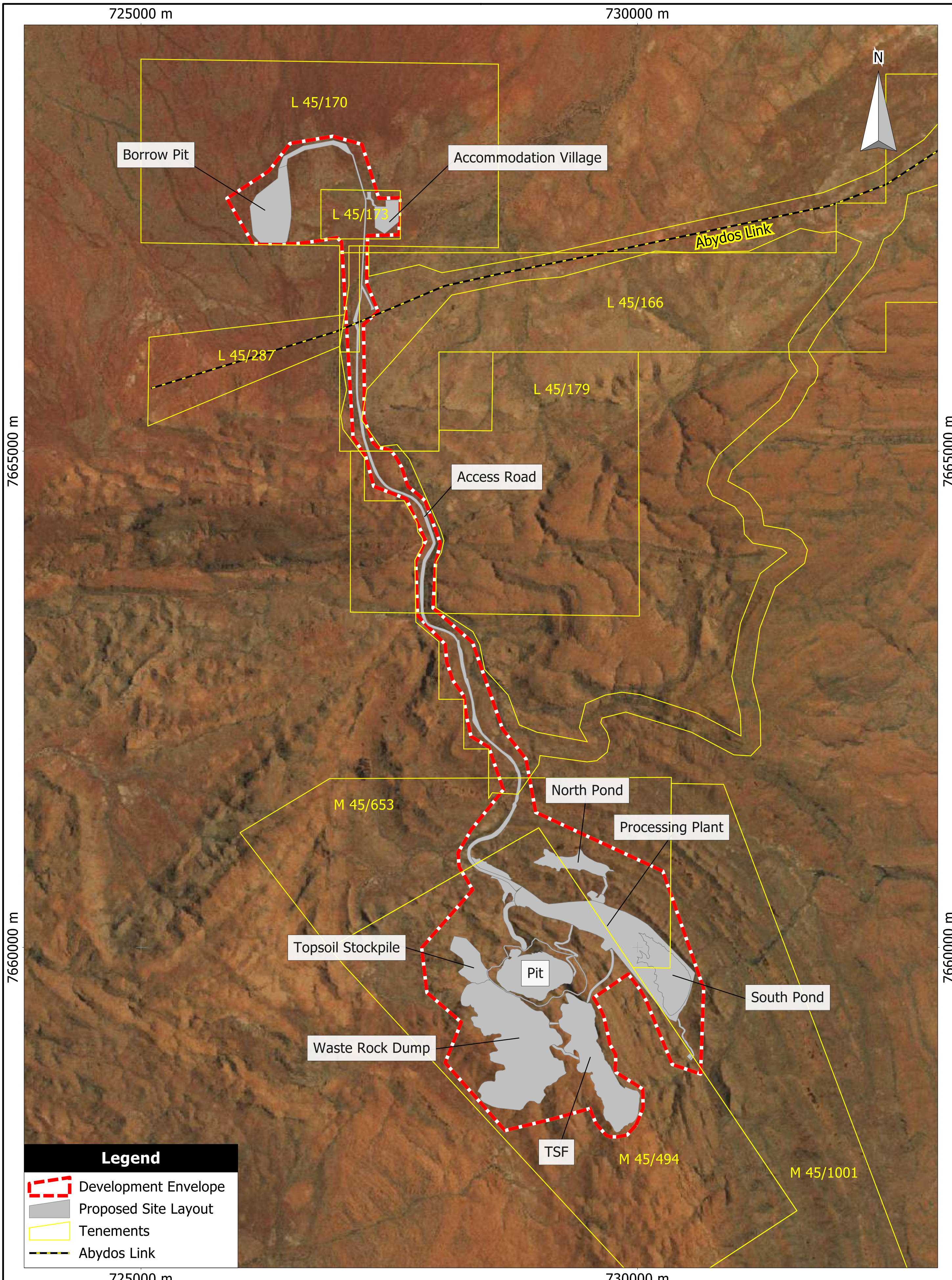
The current estimated project life is 10 years.

Table 3: Key Characteristics of the Proposal

Proposal Title	Sulphur Springs Zinc-Copper Project
Proponent Name	Venturex Resources Limited
Short Description	Venturex Resources Limited proposes to develop and operate a zinc – copper mine and processing plant in the Sulphur Springs area located 57 km west of Marble Bar and 144 km southeast of Port Hedland in the Pilbara region of Western Australia.

Table 4: Location and Proposed Extent of Physical and Operational Elements

Element	Location	Proposed Extent
Physical Elements		
Mine and associated infrastructure	Figure 4	Clearing no more than 313.6 ha within the 889.2 ha Development Envelope.
Operational Elements		
Tailings Storage Facility	Figure 4, Figure 5	A 42 ha conventional 'valley fill' TSF for placement of no more than 8.8 million tonnes (Mt) of tailings.
Waste Rock Dump	Figure 4, Figure 5	One 79.6 ha permanent WRD with no more than 17.5 million loose cubic metres (LCM).
Processing plant	Figure 4, Figure 5	A processing plant (up to 1.5 Mtpa) and associated facilities covering an area of 71 ha. Includes the footprint of a HDPE lined storage/evaporation pond (south pond).
Dewatering	Figure 4	Mine dewatering of up to 0.64 gigalitres/year (GL/yr), all to be used on site.
Water supply	Figure 13	Water abstraction of up to 0.32 GL/yr.
Open pit and supporting infrastructure	Figure 4, Figure 5	Includes open pit, accommodation camp, borrow pits, topsoil stockpiles, abandonment bund, sediment ponds, water management infrastructure, access roads, haul roads, communications, pipelines and powerlines covering an area of 122 ha. Includes a HDPE lined storage/evaporation pond (north pond).



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Venturex Resources Limited
Sulphur Springs Project

Figure 4

Development Envelope, Tenement Plan and Conceptual Mine Layout

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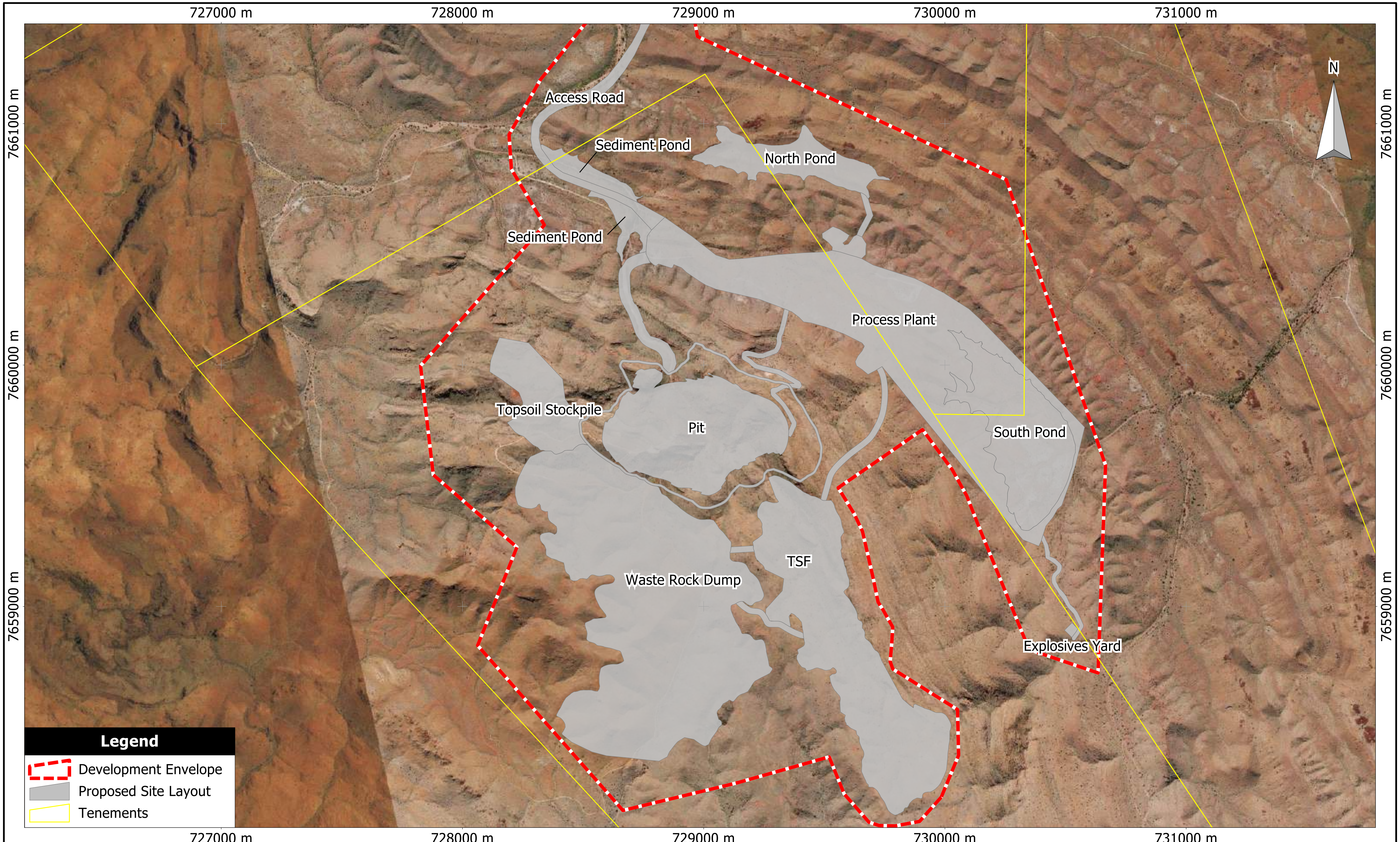

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Venturex Resources Limited
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Figure 5

Mine Site Layout

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2.2.1 Tenure

The Proposal is predominantly on Unallocated Crown Land, with the site access road and accommodation village on the Panorama and Strelley Pastoral Leases (Figure 6). Mineral exploration and development activities are enabled through tenure granted to Venturex under the *Mining Act 1978* and listed in Table 5.

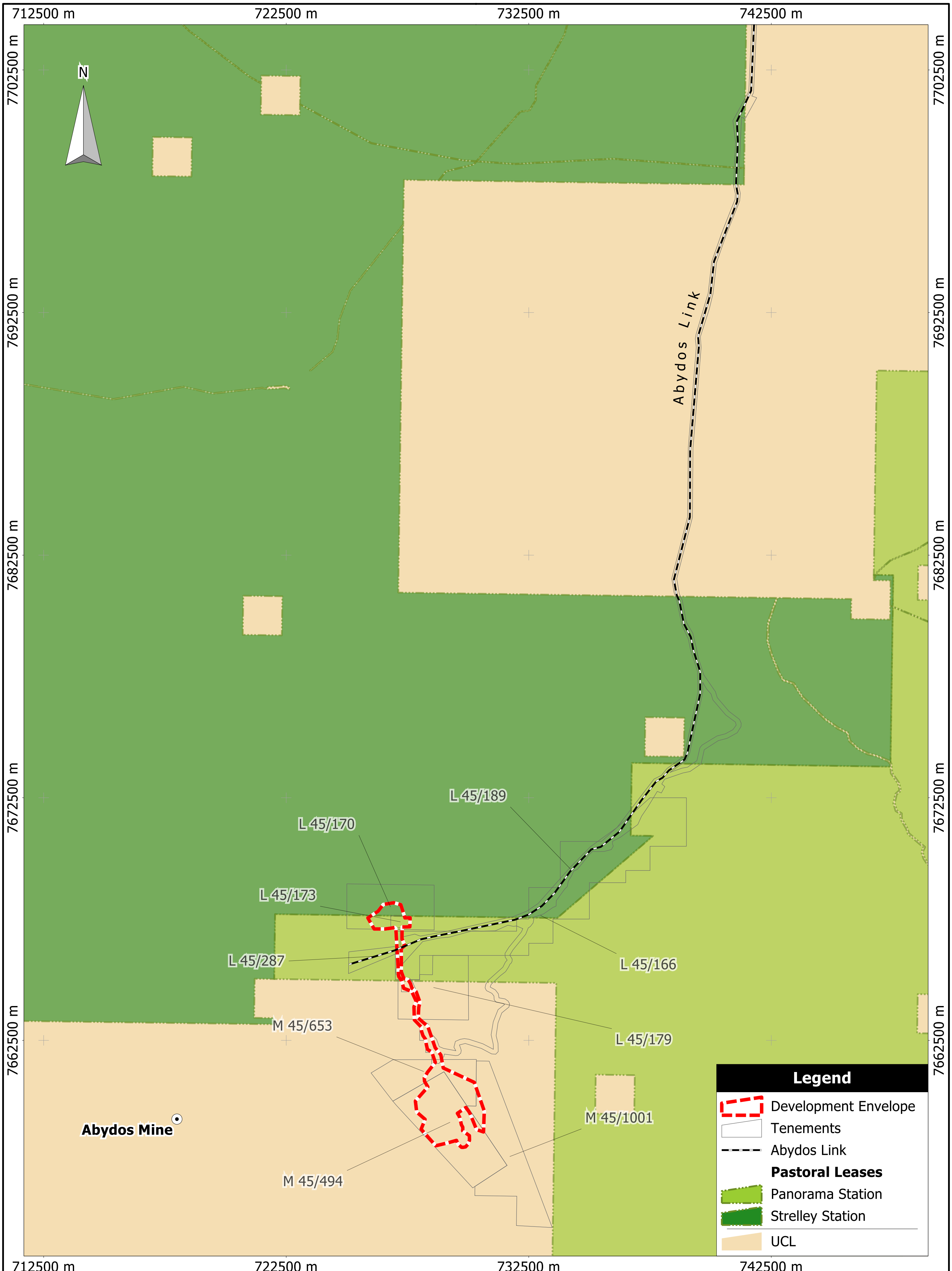
Table 5: Sulphur Springs Tenement Summary

Tenement	Area (ha)	Grant Date	Expiry Date
M45/494	972	22/10/1990	21/10/2032
M45/653	497	29/09/1995	28/09/2037
M45/1001	873	22/01/2008	21/01/2029
L45/189	1,808	20/11/2009	19/11/2030
L45/170	688	18/09/2009	17/09/2030
L45/173	40	24/08/2012	23/08/2033
L45/166	2,183	01/05/2009	30/04/2030
L45/179	636.9	01/04/2011	31/03/2032
L45/287	117	28/09/2012	27/09/2033

2.2.2 Site Access

The site will be accessed from Port Hedland (Figure 1, Figure 4) using the:

- Great Northern Highway (sealed dual carriageway) for approximately 39.7 km from Port Hedland to the Marble Bar Road.
- Marble Bar Road (sealed dual carriageway) for approximately 54.6 km to the Abydos Link Road.
- The Abydos Link comprises an unsealed private dual carriageway extending for 62 km to Atlas Iron Limited (Atlas)'s Abydos project.
- A new 8.2 km long Site Access Road (part of the Proposal), which will be used to access the Sulphur Springs mine. The Site Access Road will accommodate two-way traffic and heavy vehicles.



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Venturex Resources Limited
Sulphur Springs Project

Figure 6

Proposal Tenure

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2.2.3 Mining Operations

2.2.3.1 Open Pit Mine

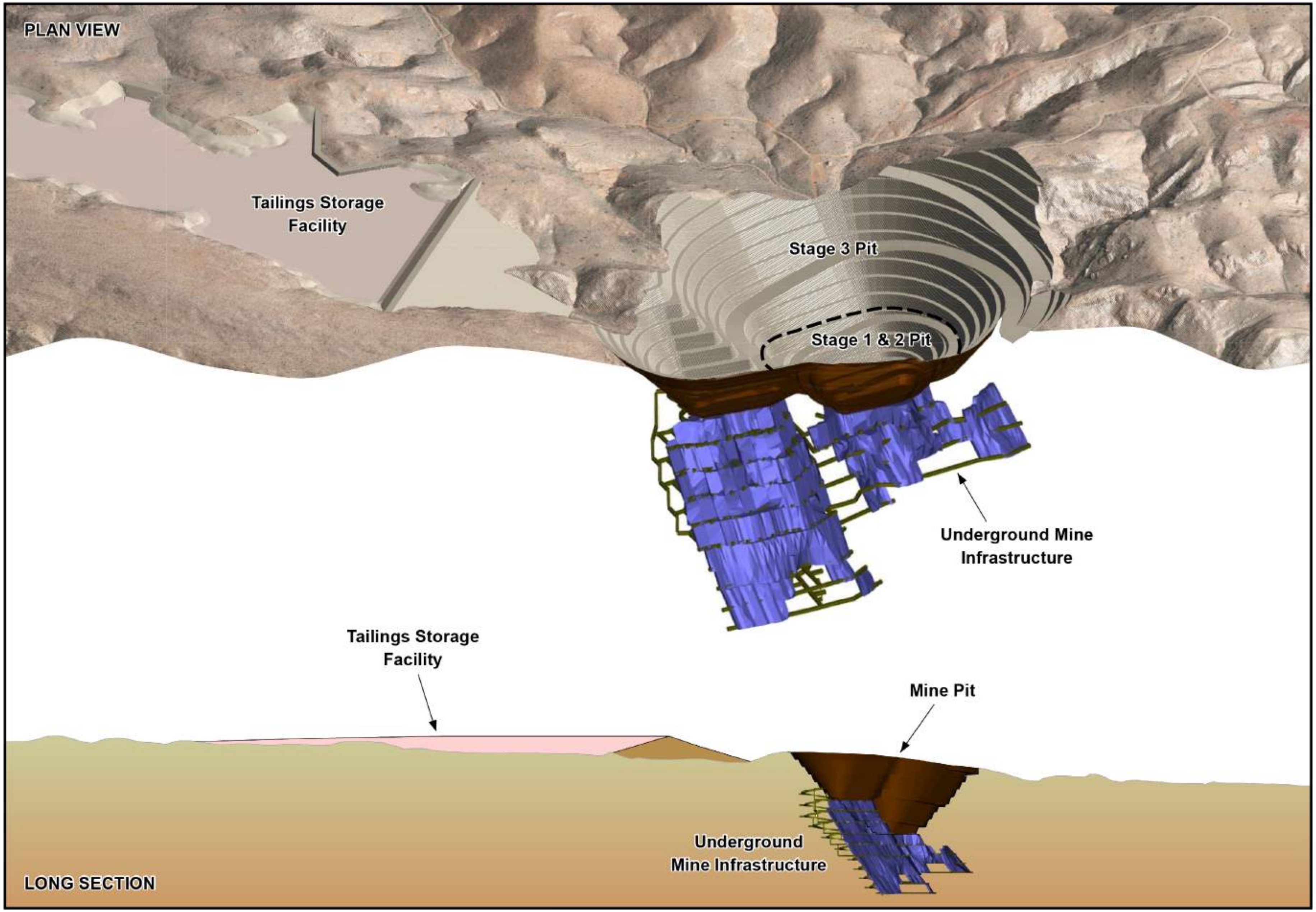
The upper portion of the Sulphur Springs deposit will be mined via an open pit. The pit will be developed in three stages, with the first stage accessing ore in the western lode of the deposit and the second and third stages taking the pit to its final limit. Figure 7 details the developed open pit, subsequent underground mine and the TSF.

All material will be mined using conventional drilling and blasting. Final pit dimensions will be approximately 450 m wide (north-south), 645 m long (east-west) and 150 m deep. Final pit floor elevations will be 1,160 mRL and 1,100 mRL in the western and eastern zones respectively. Surface topography at the orebody is rugged (Plate 1) and the existing elevation difference across the extent of the proposed pit is approximately 100 m. The deposit is centred on Sulphur Springs Creek, with the upper limit of the ore zone at approximately 10 m below the creek level (Entech 2016).

Plate 1: Site of Proposed Pit Centres on Sulphur Springs Creek

Waste rock produced during pre-stripping, to establish the open pit, will provide approximately 1.2 Mt of benign material for construction of the processing plant platform, Run of Mine (ROM) pads, TSF embankments, and access road. Surplus material will be transported to a WRD located to the south (Figure 4).

ROM ore will be hauled to a ROM pad adjacent to the processing plant. Low grade ore will be carted to a separate stockpile adjacent to the processing plant. This is discussed further in Section 2.2.8.



Source: Entech 2020

Venturex Resources Limited
Sulphur Springs Project

Figure 7

Open Pit, Underground Mine and Tailings Storage Facility Layout

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2.2.3.2 Underground Mine

The deeper portion of the deposit will be mined using a primary stoping method referred to as core and shell. This method requires a pattern of generally evenly spaced and sized rib pillars separating the primary (core) stopes, which are connected via an overlying sill pillar. The sill pillar separates the active mining area from the overlying mined out area which contains waste rock fill introduced from a pass breaking through to a designated area in the floor of the pit.

The underground mine will be developed through a decline with the portal east of the mine pit. The underground mine design is shown in Figure 8.

2.2.3.3 Mine Dewatering

The pit void will be excavated to an elevation that is below the baseline water table and a mine dewatering system will therefore be required to allow dry mining conditions. The predicted dewatering volume is up to 0.64 GL/yr. Dewatering will be undertaken via a combination of in-pit and underground sumps and groundwater abstraction bores.

Water produced in dewatering the orebody will be used for ore processing, washdown and dust suppression. Subject to the quality of the water, which is expected to vary (improve) during the operational phase, the water will be directed to a water treatment plant prior to use with any excess volume transferred to one of the two water storage ponds (North Pond and South Pond).

2.2.3.4 Pit Catchment Water Management

The pit will intersect Sulphur Springs Creek near the headwaters of the catchment. Mine pit sub-catchments are shown in Figure 9. During operations, runoff from the sub- catchments upstream of the pit will be intercepted through waste rock and tailings embankments. Water from the sub-catchment used for tailings placement will be utilised in processing and intercepted runoff from the WRD catchments will be re-directed to Sulphur Springs Creek downstream of the pit or adjacent Six Mile Creek.

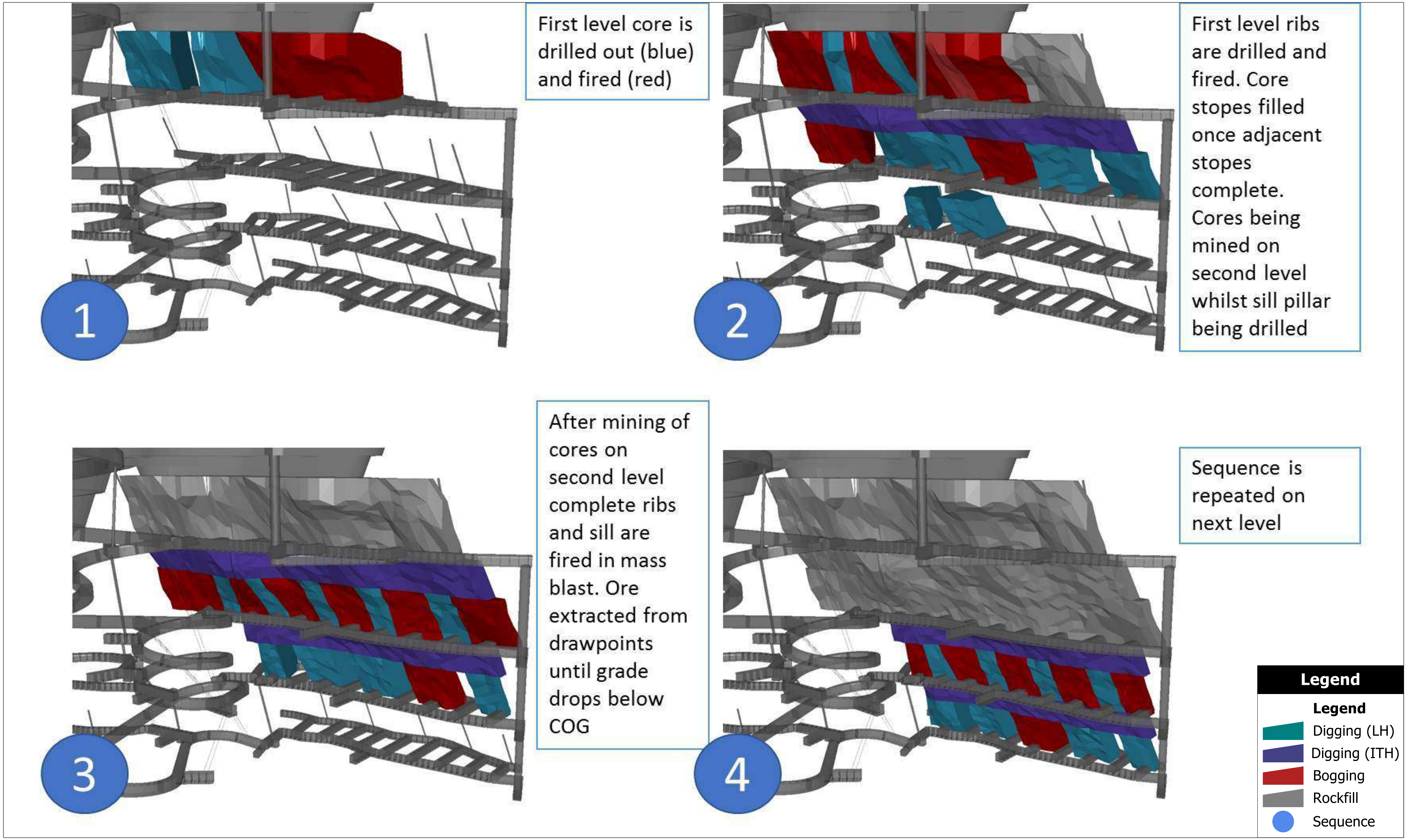
At closure, the mine void will slowly fill with groundwater and surface water runoff to form a pit lake. The volume of surface runoff, governed by the amount of rainfall and extent of the pit catchment, is a dominant influence on the pit water balance and predicted equilibrium water level. Without any diversion of runoff from the pit catchment, the pit lake will slowly fill over 90 – 100 years and is likely to become a groundwater source in the long term (AECOM 2020d, Appendix 9). To mitigate this risk, the following sub-catchment modifications are proposed:

- PSC 2 and PSC 3: Final surface of WRD in these sub-catchments shaped to divert a portion of surface runoff into Six Mile Creek.
- PSC 5: Final surface of TSF in sub-catchment shaped to divert approximately 80% of surface runoff into Minnieritchie Creek and/or Six Mile Creek catchments.

Table 6 shows the indicative revised catchment areas and areas following these modifications.

Table 6: Mine Pit Sub-Catchments

<table>
<tr><th rowspan="2">Sub-Catchment ID</th><th rowspan="2">Infrastructure</th><th colspan="2">Pit Sub-Catchment Area (ha)</th><th rowspan="2">Proposed Modifications</th></tr>
<tr><th>Unmodified</th><th>Modified</th></tr>
<tr><td>PSC 1</td><td>Haul road, pit</td><td>29</td><td>29</td><td>None</td></tr>
<tr><td>PSC 2</td><td>Haul road, WRD</td><td>33</td><td rowspan="2">27.5</td><td rowspan="2">Part of catchments recontoured with WRD to drain into Six Mile Creek</td></tr>
<tr><td>PSC 3</td><td>Topsoil stockpile, WRD</td><td>25</td></tr>
<tr><td>PSC 4</td><td>Topsoil stockpile</td><td>11</td><td>11</td><td>None</td></tr>
<tr><td>PSC 5</td><td>TSF, service corridors</td><td>55</td><td>13</td><td>Final TSF surface capped and contoured to drain into Six Mile Creek and Minnieritchie Creek</td></tr>
<tr><td>PSC 6</td><td>Haul road</td><td>3</td><td>3</td><td>None</td></tr>
<tr><td colspan="2">TOTAL</td><td>156</td><td>83.5</td><td></td></tr>
</table>



Original Size: A4
Source: Venturex Resources Limited 2018

Venturex Resources Limited
Sulphur Springs Project

Figure 8

Underground Mine Layout

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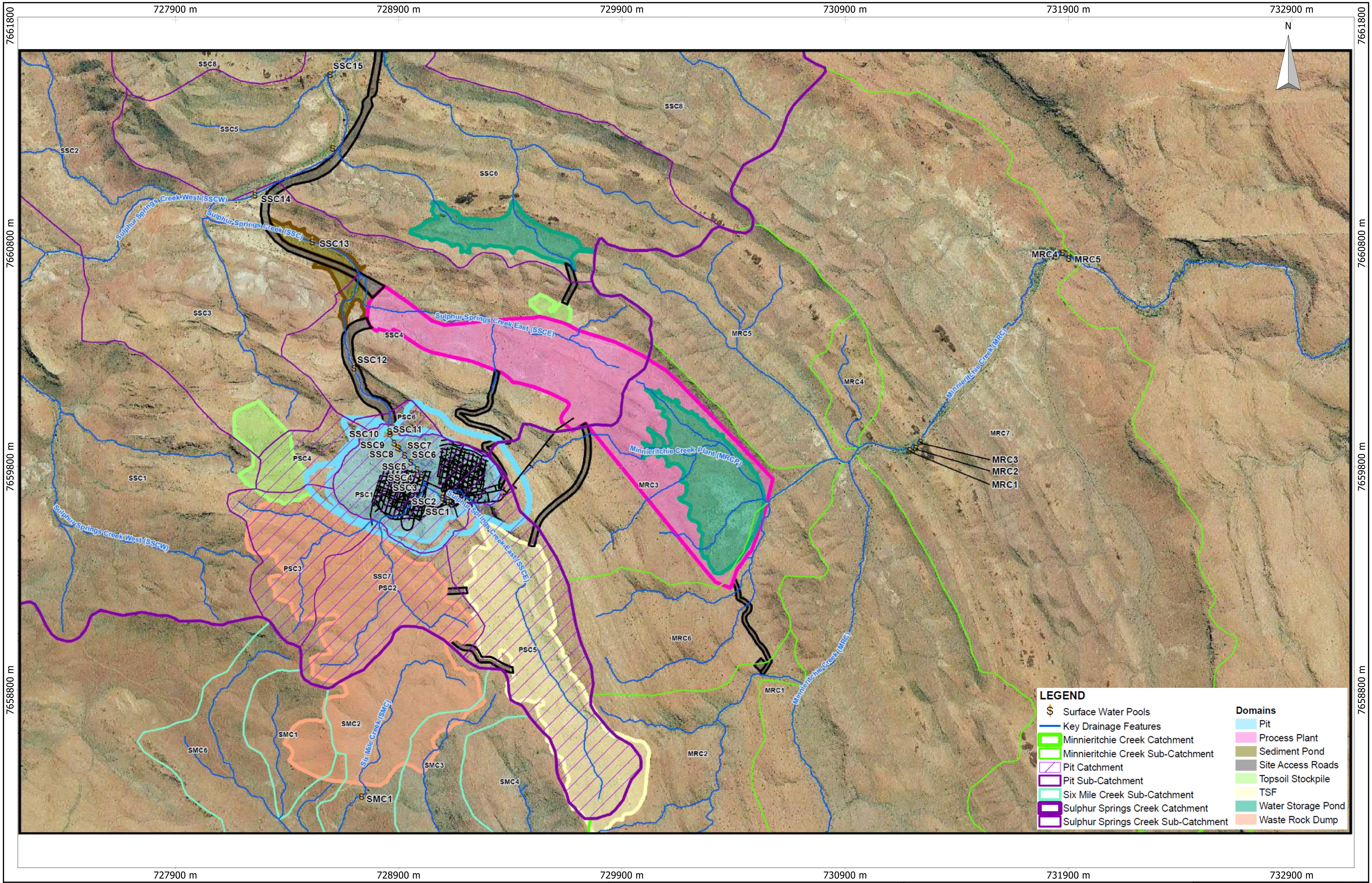

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Source: AECOM Sulphur Springs Project Surface Water Assessment 2020

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Venturex Resources Limited
Sulphur Springs Project

Figure 9

Mine Area Sub-Catchments

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2.2.4 Waste Rock

2.2.4.1 Geochemical Characterisations

Geochemical studies have been conducted on over 2,300 samples representing waste rock lithologies likely to be encountered during development and operation of the project (Table 7). The high number of samples, relevant lithologies assessed and application of both static and kinetic test methodologies means the characteristics of waste materials are well understood.

Table 7: Waste Rock Geochemical Characterisation Studies

Year	Author	Study Details
2007	URS	Static and kinetic testing on 3 samples collected across the profile of the proposed 2007 pit.
2008	Lutherborrow	Sulphur analysis on 2,248 drill core samples from 118 drill holes, collected across the profile of the proposed 2007 pit.
2008	RGS	Static testing on 60 samples collected across the profile of the proposed 2007 pit and kinetic testing of six composite samples prepared from this sample set. Kinetic leach column tests were monitored over a period of five months.
2012	GCA	Static testing on 17 waste rock samples collected from deeper within the deposit profile. These samples are considered to be representative of underground waste material.
2018	MBS	Review of previous waste rock characterisation studies, identification of information gaps and static testing on 35 additional waste rock samples to fill all information gaps relevant to the Proposal.

Results of geochemical analysis indicated the following (MBS 2018, Appendix 2):

- Hanging wall waste rock: This material occurs as a sequence of sedimentary lithologies comprising mainly sandstone, siltstone, polymictic breccia and chert and is expected to contribute more than 80% of open pit waste rock. The upper 30 metres of the hanging wall is highly weathered and expected to provide significant volumes of non-acid forming (NAF), non-saline waste rock. However, acid formation from weathered and fresh hanging wall waste cannot be accurately predicted by lithology alone. A more comprehensive approach utilising existing data for lithology, degree of weathering and total sulphur concentration has been proposed. This involves applying a total sulphur cut-off grade of 0.5% for breccia, sandstone and siltstone lithologies and managing non-weathered chert as PAF-LC or applying a lower total sulphur cut-off grade (0.2%) to this lithology.
- Footwall waste rock: This material is comprised predominantly of dacite/rhyodacite volcanics of the Kangaroo Caves Formation (Sulphur Springs Group). These lithologies contain moderate to very high concentrations of sulphide minerals. In combination with elevated sulphur concentrations and typically low acid neutralising capacity (ANC), most of the footwall waste rock is classified as potentially acid forming – high capacity (PAF-HC). Leachate from these freshly mined materials is predicted to be moderately acidic and contain slightly elevated concentrations of copper, lead, ferrous iron and zinc, with fresh to slightly brackish salinity. Kinetic leach column studies (RGS 2008) indicate that the sulphide minerals are very reactive when exposed to air and water and are predicted to produce highly acidic, metalliferous and saline seepage within several months of exposure.

Data from these studies was used to extrapolate across the open pit profile to provide an estimate for the relative volumes of PAF and NAF waste rock to be mined (Table 8, Entech 2018).

Table 8: PAF/NAF Waste Rock Material Tonnage from Pit

Material Type	Waste (Mt)	Proportion of Waste (%)
PAF	8.1	19.6
NAF	33.2	80.4
Total	**41.3**	**100**

2.2.4.2 Waste Rock Management

Geochemically benign waste rock from the pit will be used for construction and rehabilitation/closure works and the remainder placed in a permanent WRD. The NAF material to be used for rehabilitation and closure will be temporarily stored within the footprint of the WRD. PAF waste rock from the pit will be preferentially disposed in underground workings where the mine schedule allows. Provision has been made for up to 8.1 Mt of this material to be encapsulated within the WRD. The PAF material will be placed within the catchment of the mine pit, ensuring any seepage from the material over time will report to the mine pit.

The WRD will be constructed within the valley south of the pit (Figure 4). The waste rock placement strategy will approach that of a valley fill with the northern and southern outer walls of the WRD constrained by the valley ridgelines. Plate 2 shows the northern ridgeline for the WRD site. This site was selected for the following reasons:

- It is large enough to contain predicted pit waste volumes.
- The final WRD height will blend with existing ridgelines.
- Use of the valley ridgelines as outer batters where possible will improve stability of the final landform and facilitate achievement of closure outcomes.
- The northern half of the WRD footprint lies within the pit catchment, making this area ideal for encapsulation of any PAF material. WRD seepage in this area will be captured within the mine dewatering system during operations and the pit lake at closure.

Design features for the WRD are summarised in Table 9.

Table 9: Waste Rock Dump Design Details

Dimension	WRD
Height	No higher than surrounding topography (up to 1,370 mRL)
Length	Approximately 1,400 m
Width	Approximately 1,000 m
Capacity	Approximately 40 Mt
Final Slope Angles	16º

Plate 2: Valley Fill Site for Permanent WRD (Looking North)

PAF material to be located in the WRD (about 20% of total volume) will be encapsulated in cells to limit the potential for oxidation. WRD dimensions and the tonnages of PAF and NAF materials to be stored annually are shown in Table 10. This footprint includes the stockpiling of NAF waste to be utilised for the rehabilitation of the TSF surface.

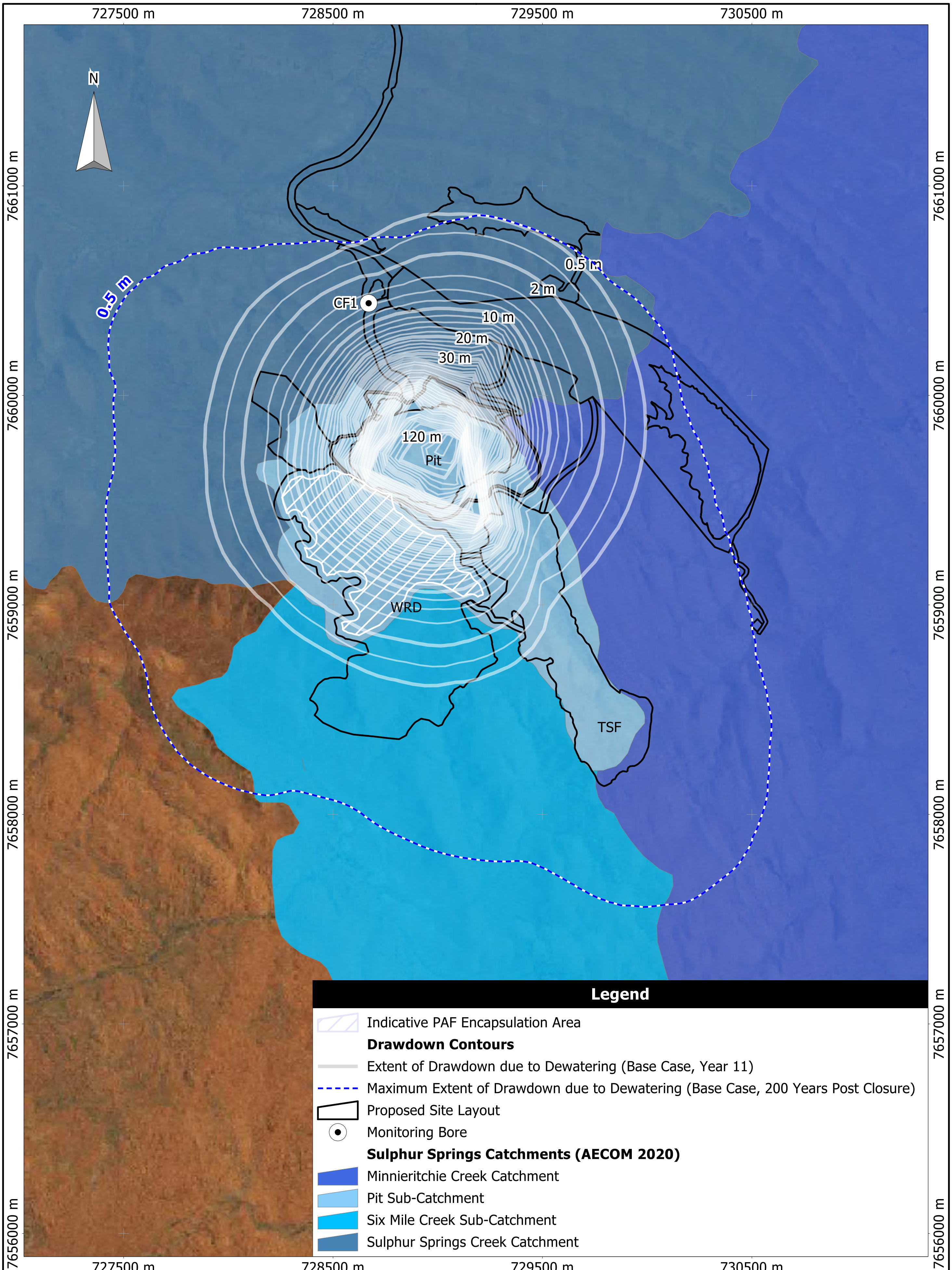
Table 10: WRD Development (Cumulative)

Year	Footprint Area (ha)	Top Surface Area (ha)	NAF (Mt)	PAF (Mt)
1	40.5	33.7	12.4	1
2	67.4	57.6	23.2	5.4
3	70.9	59.8	30.7	7.2
4	79.6	62.4	31.2	8.1
Closure	79.6	62.4	31.2	8.1

All PAF cells will be located in the northwest corner of the WRD (Figure 10). Cells will have a minimum 5 m thick base, a minimum 10 m wide selvage on the outer edges and a minimum cover of 5 m. The base, selvage and cover will be constructed of NAF material placed in layers less than 3 m thick and compacted by heavy vehicle traffic. A typical cross section of a PAF encapsulation cell within the WRD is shown in Figure 11.

After each cell is filled with PAF material, the stockpile will be compacted to achieve uniform consolidation, maximise evaporation of rainwater and minimise preferred pathway infiltration. Once a PAF encapsulation area reaches capacity, a 5 m NAF layer will be placed over the waste. In accordance with the progressive rehabilitation schedule, the entire area will be covered with NAF waste and shaped in accordance with final mine closure design requirements as part of the WRD. The WRD will reach its maximum size by the end of Year 4 as the mining operations transition from open pit to underground. All underground waste will either be stockpiled in the base of the pit or used to backfill underground workings.

PAF encapsulation cells will be designed to capture incidental rainfall only during operations (Years 1 to 4). Drainage will be engineered to prevent surrounding runoff from entering the area. External drains will divert rain from other areas of the WRD away from the PAF depositional areas. Surface water runoff from outside the WRD will, where required, be diverted away by permanent stormwater structures designed and operated to convey and withstand a 1 in 100-year storm event.



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Original Size: A4
Air Photo Date: 2012
Grid: Australia MGA94 (50)
0 400 m

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Figure 10

PAF Encapsulation Area Within Groundwater Drawdown Area (Operations and Closure)

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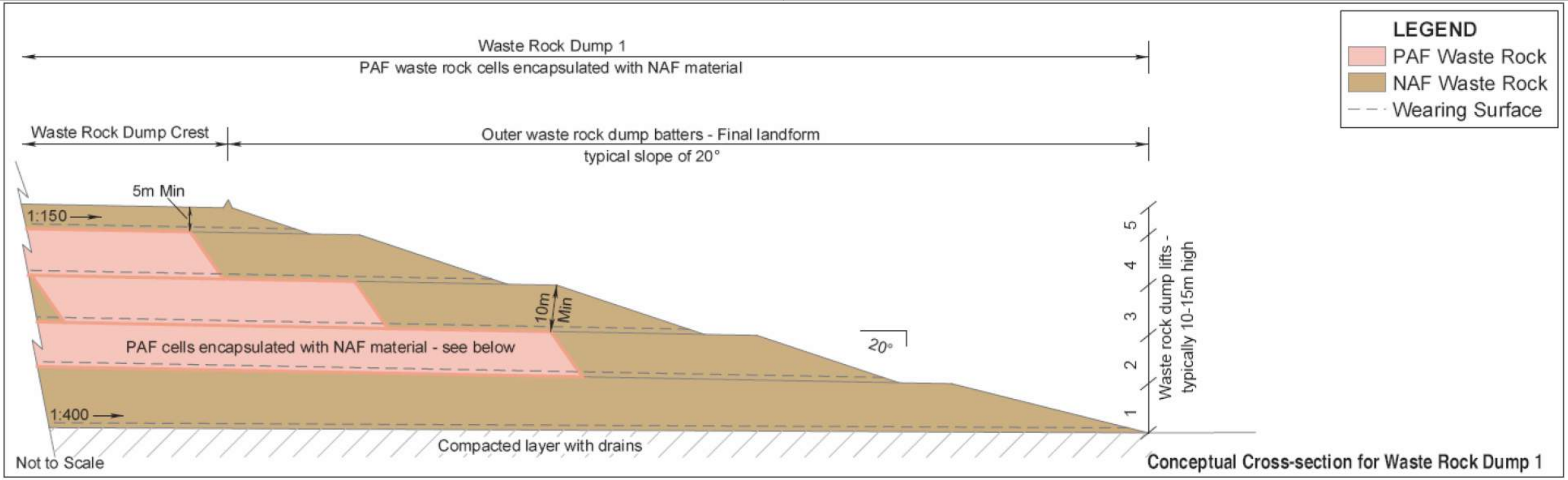

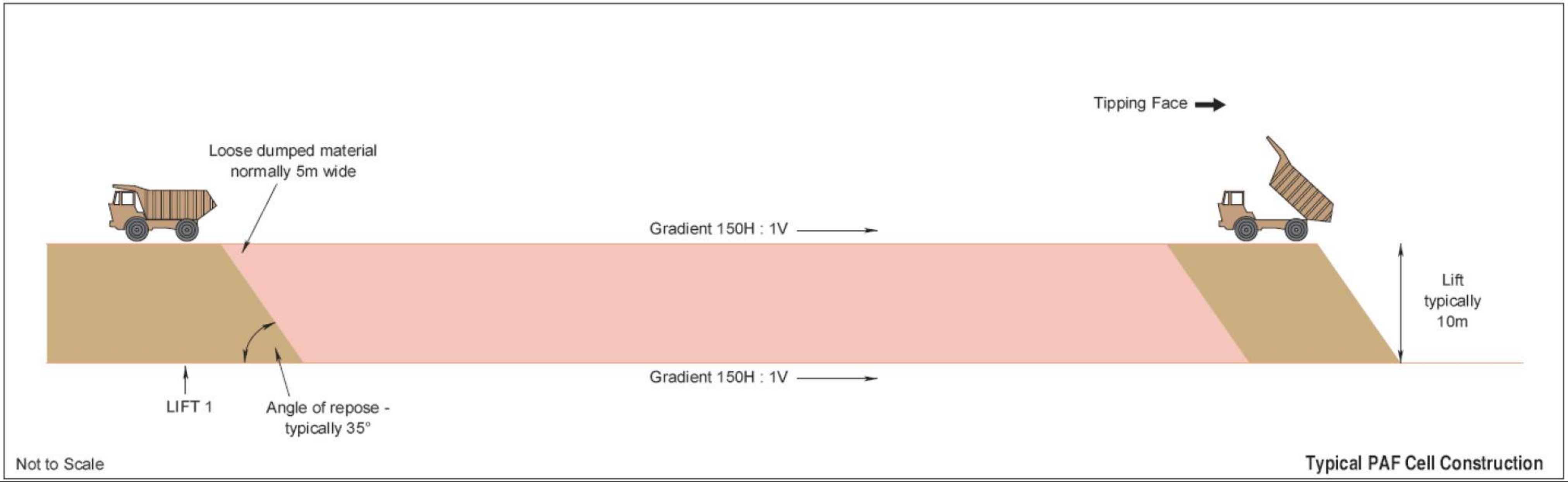

Not to Scale
Original Size: A4
Source: URS 2007

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Figure 11

PAF Encapsulation Cell Schematic

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W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\PAF Cross-section.map 7/01/2020 F11 PAF Encapsulation Cell Schematic Layout

2.2.5 Ore Processing

2.2.5.1 Processing Plant Location

The ore processing plant will take ROM ore and concentrate the copper and zinc bearing minerals to produce separate copper and zinc concentrates and a barren tailings stream. The footprint and operation will be similar to the design approved under Mining Proposal REG ID 40542 in 2014.

The plant will be sited in the valley to the north of the pit where the terrain is relatively flat (Plate 3 and Plate 4).

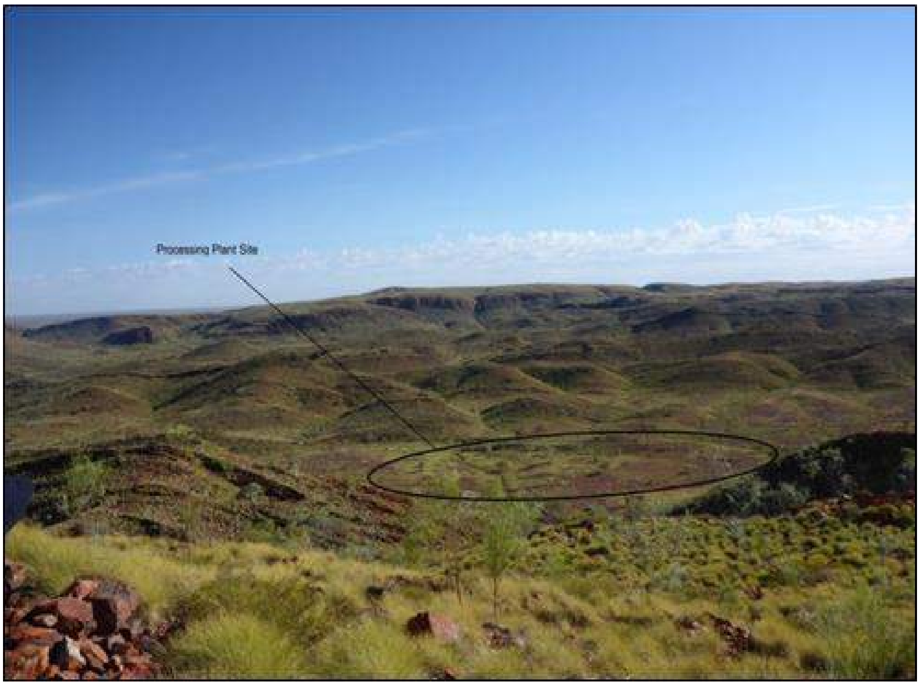


Plate 3: Processing Plant Valley Site (Looking North)

Plate 4: Processing Plant Site

Process facilities have been designed in accordance with accepted industry practice and will include:

- ROM pad.
- Crushing and Coarse Ore Storage.
- Semi-autogenous grinding (SAG) and ball milling combination (SAB).
- Flotation.
- Concentrate handling.
- Tailings disposal.
- Reagents.
- Services and ancillaries.

These facilities are discussed further in the following sections.

2.2.5.2 ROM Pad

Ore will be delivered to the ROM pad from the pit and subsequent underground mine. The ROM pad will be composed of NAF material obtained from the open pit pre-stripping activities, cut-fill material derived from cutbacks required to build the access road to the mine, and from material removed from the process plant footprint. It will be approximately 200 metres long and 170 metres wide, giving an operating stockpile surface of approximately 3.4 ha.

2.2.5.3 Crushing and Grinding

Ore will be reclaimed from the ROM pad, crushed and ground to produce a 35% solids slurry with an 80% passing size (P_{80}) of 63 µm, which will then gravitate to the copper flotation circuit.

2.2.5.4 Copper Flotation

Cyclone overflow from the grinding circuit will gravitate to an agitated copper conditioning tank where reagents (including sodium metabisulphite, collector (A3894) and lime) are added to the slurry. Slurry is then directed to the head of the copper flotation circuit where methyl isobutyl carbinol (MIBC) is added to act as a froth stabilising agent. The copper flotation circuit consists of six copper rougher/scavenging cells and two stages of four cleaner cells. Final copper concentrate will be pumped to the copper concentrate thickener and tailings from the copper circuit will pass to the zinc flotation circuit.

2.2.5.5 Zinc Flotation

Copper flotation tailings will be directed to the zinc conditioning tank where reagents (including potassium amyl xanthate (PAX), copper sulphate and lime) are added to the slurry. The zinc flotation circuit is similar to the copper circuit. Its configuration includes six rougher/scavenging cells and two stages of four cleaner cells which produce a zinc-rich product and a barren tailing. Final zinc concentrate will report to the zinc concentrate thickener and tailings will be pumped to the tailings thickener.

2.2.5.6 Concentrate Handling

Concentrate Thickening and Filtration

Copper concentrate from the flotation circuit will be pumped to a high-rate thickener to increase the solids content to 65% solids by weight and discharged to the copper concentrate storage tank. The thickener overflow will gravitate to the copper flotation water tank for recycling to the flotation circuit. The same process will apply for zinc concentrate from the zinc flotation circuit.

Thickened copper concentrate slurry will be pumped from the copper concentrate storage tank to a horizontal plate and frame pressure filter for dewatering. The filter will separate water and solids to produce a filter cake, containing nominally 10% moisture by weight, and a filtrate solution. The filtrate solution will gravitate to the copper concentrate thickener. The copper filter cake will discharge into a concentrate bunker under the filter. The same process will apply for zinc concentrate from the zinc concentrate storage tank.

Concentrate Storage and Transport

The entire concentrate facility, including the loading area, will be contained within a shed constructed on a concrete bunded area. The facility will incorporate a weighbridge and has been sized to accommodate four to seven days inventory for all concentrates. This will cater for times when the access roadway to site may be closed due to inclement weather. The handling of concentrate will take place within the shed. Entry and exit points will have wheel wash facilities and shed doors will remain closed when not in use.

Concentrate will be transported to Port Hedland Port in nominal 120 tonne quad configured road trains using half height containers fitted with lids (Qube Holdings' 'Rotabox' containers, as used by others, or similar). The concentrate will be loaded into the containers and directly onto the road train by wheel loader within the enclosed concentrate facility.

Assessment of Venturex copper and zinc concentrates (Glossop 2012) determined these final products are low in pyrrhotite and high in pyrite. Such concentrates are considered to have low reactivity with oxygen and consequently are highly unlikely to combust or cause agglomeration.

2.2.5.7 Reagents and Services

Reagent Mixing, Storage and Distribution

A number of reagents will be consumed in the process plant. These include the following:

- Lime. Supplied in bulk tankers and transported pneumatically into a 50 t silo on site. This will be mixed to 15% slurry and pumped via a ring main for distribution to the plant.
- Sodium Metabisulphite. Supplied in 1 t bulker bags. This will be mixed to a 15% solution and pumped by individual dosing pumps to the plant.
- A3894 copper collector. Supplied in 150 L drums. This will be mixed to a 15% solution and pumped by individual dosing pumps to the plant.
- Methyl Isobutyl Carbinol. Supplied in 200 L drums as a liquid. This will be distributed at full strength by individual dosing pumps to the plant.
- Potassium Amyl Xanthate Zinc Collector. Supplied in 1 t bulker bags. This will be mixed to a 15% solution and pumped by individual dosing pumps to the plant.
- Copper Sulphate Activator. Supplied in 1 t bulker bags as crystals. This will be mixed to a 15% solution and pumped by individual dosing pumps to the plant.
- Flocculant. Supplied in dry powder form in 25 kg bags. This will be mixed using a proprietary mixing plant to 0.25% solution strength and metered direct to the thickeners.

All chemical reagents will be stored within tanks in appropriately bunded facilities whereby 110% of the largest vessel is contained and 25% of the total volume is contained according to *Australian Standards AS1940* and *AS1692*. Stocks of reagents will be stored in a designated reagent shed, appropriately designed to comply with all relevant legislation.

Water Services

A number of water systems will operate in the process plant. These include the following:

- Process Water. Supplied from the tailings thickener overflow and treated decant return and topped up with raw water as required. This will be used for major processing plant dilution, plant washdown and tails line flushing.

- Copper Circuit Water. Supplied from the copper concentrate thickener overflow and topped up with raw water as required. This will be used for dilution, sprays and launder water in the copper flotation circuit.
- Zinc Circuit Water. Supplied from the zinc concentrate thickener overflow and topped up with raw water as required. This will be used for dilution, sprays and launder water in the zinc flotation circuit.
- Raw Water. Sources from groundwater and reticulated from a raw water tank for power station, crushing and agglomeration area, reagent mixing, thickening and filtration.
- Accommodation Village Potable Water. Supplied from one of the existing bores SSWB036, SSWB038, or SSWB040, which are licenced under GWL 176408(3). A 5 m^3/hr potable water treatment plant will be installed to treat this water, prior to use in the accommodation village.
- Process Plant Potable Water. Supplied from mine dewatering and/or an abstraction bore proposed for the project (SSWB006). A 2 m^3/hr potable water treatment plant will be installed for the process plant.
- Fire Water. A reserve will be held in the raw water tank and reticulated to the process plant hydrant and hose reel system via a pump skid incorporating electric and diesel pumps.
- Storm Water. Two HDPE lined ponds will be constructed to capture and store rainfall runoff within site infrastructure areas. The ponds will be sized to contain runoff from plant areas associated with a 1 in 100 year, 72 hour event.

2.2.6 Tailings Storage Facility

Process tailings will be thickened before being pumped to a 'valley fill' TSF located southeast of the plant as shown in Figure 4. A concept design has been developed that demonstrates the capacity for storage of up to 10.5 Mt of tailings, comfortably providing for the proposed tailings volume of 8.8 Mt (Table 3) and freeboard, as depicted in Figure 12.

2.2.6.1 Location

The overriding rationale for the proposed TSF site is the location within the long term hydraulic capture zone of the mine pit, which ensures any seepage from the TSF will report to the pit. Proposed catchment modifications outlined in Section 2.2.3.4 will ensure the pit is maintained as a permanent hydraulic sink.

2.2.6.2 Tailing Geochemical Characterisation

Geochemical characterisation studies on simulated tailings samples produced during bench-scale metallurgical investigations for Sulphur Springs ore are summarised in Table 11.

Table 11: Summary of Geochemical Studies on Sulphur Springs Tailings

Author	Year	Tailings Sample Details	Study	Testwork
Roger Townend and Associates	2002	Tailings produced during metallurgical testwork on Sulphur Springs ore using conventional sulphide flotation, producing copper concentrate, zinc concentrate and final tailings slurry. Tailings sample considered analogous to material to be generated by current proposed project.	Mineralogical examination	Static (acid-base testwork) and multi-element analysis on solids and supernatant.
Graeme Campbell and Associates (GCA)	2002		Geochemical assessment, including static (acid-base testwork) and multi-element analysis on solids and supernatant.	
URS	2007	A bulk tailings sample generated during metallurgical testwork on Sulphur Springs ore. Testwork utilised conventional sulphide flotation producing copper concentrate, zinc concentrate, and final tailings slurry and tailings sample is considered analogous to material to be generated by current proposed project.	Geochemical assessment of tailings	Static (acid-base testwork) and multi-element analysis on solids and supernatant. Kinetic testwork (saturated and unsaturated conditions) for 159 days of leaching.
GCA	2011	N/A	Literature Review and Generic Discussion to Facilitate Conceptual Planning for Process Tailings Management.	
KP	2018	Two bulk tailings slurry samples generated from 2018 metallurgical testwork	Geochemical assessment.	Static (acid-base testwork) and multi-element analysis on solids and supernatant.
MBS Environmental (Appendix 3)	2020	N/A	Desktop Review of Previous Geochemical Studies for Sulphur Springs Tailings Samples	

Assessment results, summarised in Appendix 3 (MBS 2020), indicate:

- Both the static and kinetic geochemical studies (GCA 2002, URS 2007c) determined that tailings samples are classified as PAF-HC, with low acid neutralising capacity. Samples contained high total sulphur concentrations (26 to 28%), mostly in the sulphide form and therefore capable of generating acidity.
- Initial supernatant generated from tailings was pH neutral, with selenium the only element to exceed the ANZECC 2000 Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000) (0.32 mg/L versus a guideline of 0.02 mg/L).
- Tailings leachate is likely to become acidic and highly saline following a relatively short period of exposure to oxidising conditions (order of weeks). Concentrations of soluble aluminium, antimony, arsenic, cadmium, cobalt, copper, nickel, lead, selenium, zinc and sulphate are expected to exceed ANZECC 2000 Guidelines for Livestock Drinking Water Quality under these conditions (ANZECC and ARMCANZ 2000).
- Kinetic leaching test data demonstrated that mercury, chromium and lead, although enriched in the tailings samples, were not significantly leached following oxidation.
- There is currently no data available to adequately characterise tailings pore-water geochemistry. This is normally assessed at a solid:solution ratio of 1:2 in order to evaluate contaminant solubility. Whilst such analyses have not been performed, kinetic leach data generated during the URS 2007 study, at a solid:solution ratio of approximately 1:10, is considered to be more representative and informative for field

conditions. Static leach tests on fresh tailings at different solid:solution ratios do not reflect the potential for slight-to-moderate oxidation and resultant concentrations are often solubility-limited (Appendix 3).

- Tailings seepage source terms were characterised, based on tailings supernatant fluid composition. Although some oxidation of exposed tailings beaches may result in surface tailings porewater compositions similar to that predicted by unsaturated kinetic column tests, most of the soluble oxidation productions will return to the decant pond following high rainfall events, from where acidic constituents will be neutralised by alkali addition when the decant return water is recycled through the processing plant. Predicted base case concentrations are shown in Table 12.
- In line with the AMIRA ARD Test Handbook (AMIRA 2002), the kinetic leaching studies conducted to date have used deionised water as the standard leaching solution, as opposed to on-site water. Use of site-water for static leaches is not common practice due to the following:
  - Background concentrations of metals will vary with sampling location and season. For example, it is noted from baseline monitoring data (URS 2007a) that copper, which is naturally enriched in site groundwater, can vary in concentration from 0.002 to 3.0 mg/L.
  - Interferences or higher limits of laboratory reporting if site water has high salinity.

Table 12: Predicted TSF Seepage Quality

Constituent	Units	Expected Case Tailings Seepage Quality
pH	pH units	7.34
TDS	mg/L	1,800
Bicarbonate	mg HCO_3/L	50
Aluminium	mg/L	<0.01
Arsenic	mg/L	0.005
Calcium	mg/L	227
Cadmium	mg/L	0.005
Chloride	mg/L	140
Cobalt	mg/L	0.012
Chromium	mg/L	<0.01
Copper	mg/L	0.02
Iron	mg/L	0.34
Mercury	mg/L	0.0003
Potassium	mg/L	16
Magnesium	mg/L	37
Manganese	mg/L	6.5
Sodium	mg/L	182
Nickel	mg/L	0.22
Lead	mg/L	0.02
Antimony	mg/L	0.006
Selenium	mg/L	0.2
Sulphate	mg/L	782
Zinc	mg/L	1.1

2.2.6.3 Tailings Physical Properties

Detailed physical testing has been carried out on a number of tailings samples dating from 2002 to 2018 to assess particle size distribution, supernatant liquor density, solids particle density, Atterberg limits, undrained and drained sedimentation, air drying, permeability and high strain consolidation. Results of these tests have been incorporated into the TSF design and associated water balance. The most recent physical testing was carried out on two tailings samples; a copper transition composite and a zinc transition composite, to determine density and water release design parameters (KP 2020, Appendix 4). Results are summarised in Table 13.

Table 13: Tailings Physical Properties

Parameter	Zinc Tailings	Copper Tailings
Solids Specific Gravity (t/m^3)	3.72	3.53
80% Passing Particle Size (µm)	58	68
Rate of Supernatant Release	Fast - Majority released in less than one day	Relatively Fast - Majority released within 1 – 2 days
Expected Water Release from Slurry (%)	55 – 65%	45 – 55%
Initial Settled Density (drained) (t/m^3)	1.74	1.70
Predicted Final Settled Density (t/m^3)	1.95 – 2.05	1.9 – 2.0
Vertical Permeability (m/s)	5×10^{-7}	2×10^{-7}

Following deposition and release of water, the initial settled densities (1.7 - 1.74 t/m^3) represent tailings material that is 100% saturated. Over time the tailings is expected to consolidate, through moisture loss, to a terminal density of 1.9 - 2.0 t/m^3 (Appendix 4) and remain at or close to 100% saturation. The relationship between dry density, moisture content and degree of saturation is presented in Plate 5 (drawn from Appendix 5).

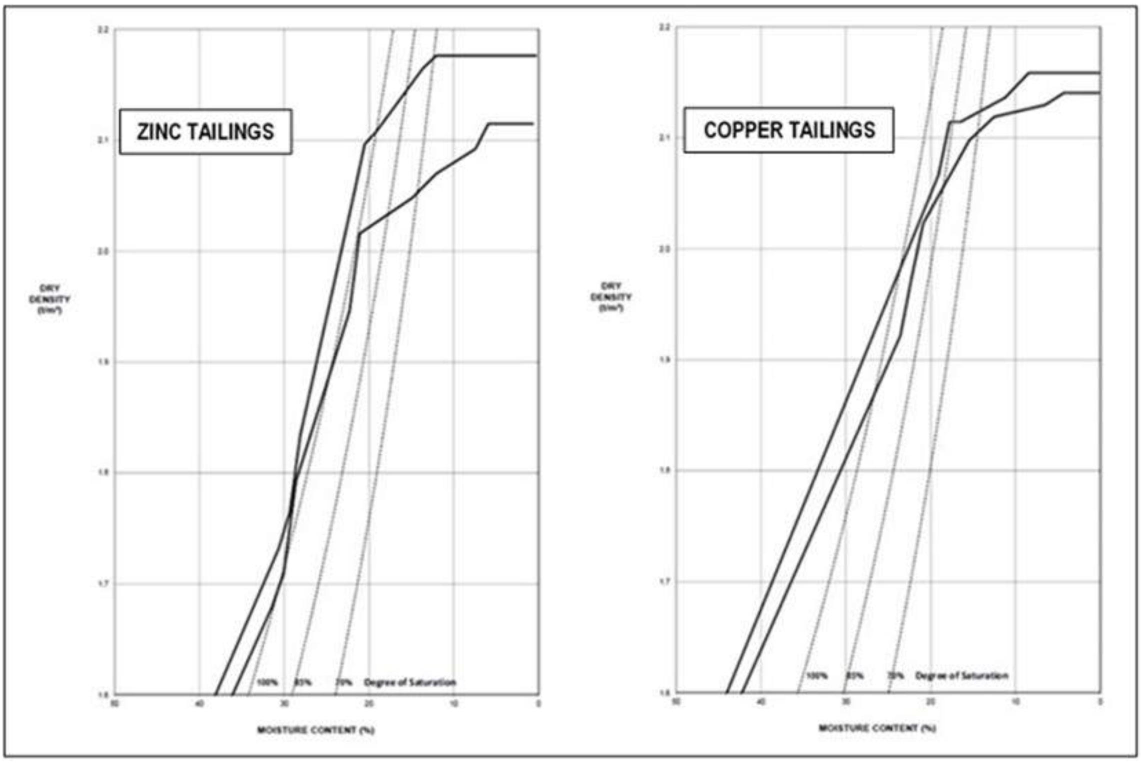


Plate 5: Zinc and Copper Tailings Moisture Content Versus Dry Density

2.2.6.4 Design

The conceptual TSF design comprises a cross-valley storage, operated as a single cell facility. It is assessed as a 'High B' consequence category using the Australian National Committee on Large Dams (ANCOLD) *Guidelines on Tailings Dams, Planning, Design, Construction, Operation and Closure – Revision 1* (ANCOLD 2019, Appendix 4). As the final embankment height will exceed 15 metres, the TSF is classified 'Category 1' in accord with the *Code of Practice Tailings storage facilities in Western Australia* (DMP 2013) and the detailed design will comply with the *Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities* (DMP 2015). The TSF design comprises:

- An element over overdesign to be satisfied that the facility/valley can retain the proposed volume of tailings (8.8Mt), maintain adequate freeboard for high rainfall and can accommodate a potential mid-valley embankment to establish 2 cells within the facility (refer to Section 2.2.6.5 below).
- A Main and South Saddle Embankment, constructed in a downstream configuration in stages to suit the valley profile and rate of tailings generation. The embankments will be constructed as multi-zoned earth and rockfill and include a low permeability zone won from local borrow or benign mine waste, conditioned and compacted. The downstream structural zone will be constructed of selected weathered mine waste from the open pit placed, moisture conditioned and compacted by heavy vehicle traffic (Figure 12).
- Three secondary saddle dams, potentially required along the western perimeter late in the project life (years 7 - northern-most dam; year 9 - central and southern dams). Construction of the northern-most saddle dam will be undertaken in Year 7 of the LOM in the event projections of the tailings surface at the time indicate the dam is warranted to ensure protection of three *Pityrodia sp.* Marble Bar individuals on the western flank of the TSF (Figure 12). The timing and location are adjusted slightly from the conceptual design proposed by Knight Piésold (Appendix 4).
- A partial basin underdrainage system comprising main collector drains along part of the basin spine designed to drain by gravity to a collection sump located at the toe of the main embankment.
- Deposition of tailings from both the Main and South Saddle Embankment. Deposition modelling undertaken using the RIFT TD tailings modelling package indicates the supernatant pond will form towards the centre of the facility. Decants will be used to return supernatant to the water treatment plant prior to reuse in the processing plant.
- Cycling of tailings deposition to ensure exposed beaches are re-wet at least every two weeks to assist in maintaining high tailings saturation levels.
- Monitoring bores installed to monitor the phreatic surface within the embankments and groundwater levels/quality downgradient of the embankments. Select bores will be sized such that they can be converted into recovery bores to abstract water if required.
- Covering the final tailings surface with a 'store and release cover' incorporating a low permeability capping that minimises infiltration to the tailings surface and a NAF waste rock layer placed to ensure contours shed surface runoff to the south into the adjacent Six Mile Creek and Minnieritchie Creek catchments.

The conceptual layout of the TSF is shown in Figure 12.

2.2.6.5 Ongoing Design Investigations

The final design, to be incorporated into a Mining Proposal for assessment under the *Mining Act 1978* will be subject to the outcomes of specific site geotechnical investigations and ongoing detailed design studies. In particular, the division of the proposed TSF, within the constraint of the currently proposed footprint and key operational parameters, into several cells by an embankment midway along the valley is in the process of being proved up.

Division into several tailings cells offers the following advantages:

- It would allow disposal into only the southern portion of the TSF (Cell 1) in the first years of operation, thus maximising the separation distance between the mine pit and tailings during the period that the pit is active (Years 1 to 4). Construction of the first stages of the main northern embankment prior to the commencement of operations provides a robust measure of secondary containment in the unlikely event of any breach or failure of the mid-valley embankment.

- Confinement of tailings deposition to one cell limits the extent of tailings beach exposed to evaporation and consequently drying at the surface. The beaches are more frequently covered by freshly deposited tailings as the location of discharge points is rotated.
- The tailings cell is filled to design capacity more rapidly, bringing forward the opportunity for surface capping and rehabilitation.
- Experience and data gained with the in-situ behaviour of the tailings and seepage in Cell 1 can be applied to the completion of construction of Cell 2 (the northern cell, years 5 on).

In the absence of any significant and insurmountable flaws being identified, Venturex expects the detail of the TSF design, that conforms with the location and outline described in this ERD and is to be set out in the Mining Proposal, will prescribe a staged approach (i.e. utilising cells) to tailings deposition and management.

2.2.6.6 Seepage Management

The TSF is located within the catchment of the open pit. The 'V' shaped geometry of the valley will focus seepage from tailings to the invert of the valley. Leachate not collected by the underdrainage system will move vertically to the water table and then migrate with groundwater towards the pit. The rate and quality of TSF seepage/groundwater will be monitored between the main TSF embankment and the pit. Recovery bores will be utilised as necessary to limit flow to the pit. Abstracted groundwater will be pumped to storage ponds or the water treatment plant, depending on processing water demands.

Monitoring bores will be installed to monitor for any seepage at the saddle embankments and at other targeted locations around the TSF, and contingency measures that include seepage recovery will be implemented in the unlikely event of any significant seepage.

2.2.6.7 Stability

A seismic hazard assessment undertaken for the project site is detailed in Appendix 6. The hazard assessment informs the determination of stability parameters to be applied in the detailed design of the TSF embankments and other structures. The resulting TSF embankment/earthquake criteria detailed in Appendix 6 (Table 3.2) were determined with reference to Australian National Committee on Large Dams (ANCOLD) guidelines. Design to meet these criteria will ensure the embankment will be stable under the seismic and static loadings considered. The design criteria are confirmed, and stability modelling undertaken in the course of detailed design of the facility which will be included in a Mining Proposal to be assessed by DMIRS.

A desktop assessment of the geotechnical conditions of the proposed TSF site has been undertaken drawing on the detailed geotechnical studies of the proposed mine pit and underground mine, and understanding of the local geology (Entech 2020, Appendix 7). Key outcomes of the assessment include:

- The weathering profile is likely to be very shallow, as evidenced in the mine pit area and surrounds.
- The sub-surface rock mass conditions of the prevalent lithologies, dacite, marker chert and quartzite are classified as Strong to Extremely Strong.
- These characteristics are generally associated with stable, competent rock formations.

These conditions, and other characteristics, are expected to be confirmed by site studies during the detailed design phase. On current information the construction and operation of a TSF in accordance with regulatory criteria and ANCOLD guidelines to ensure required safety and structural stability is considered feasible (Appendix 4).

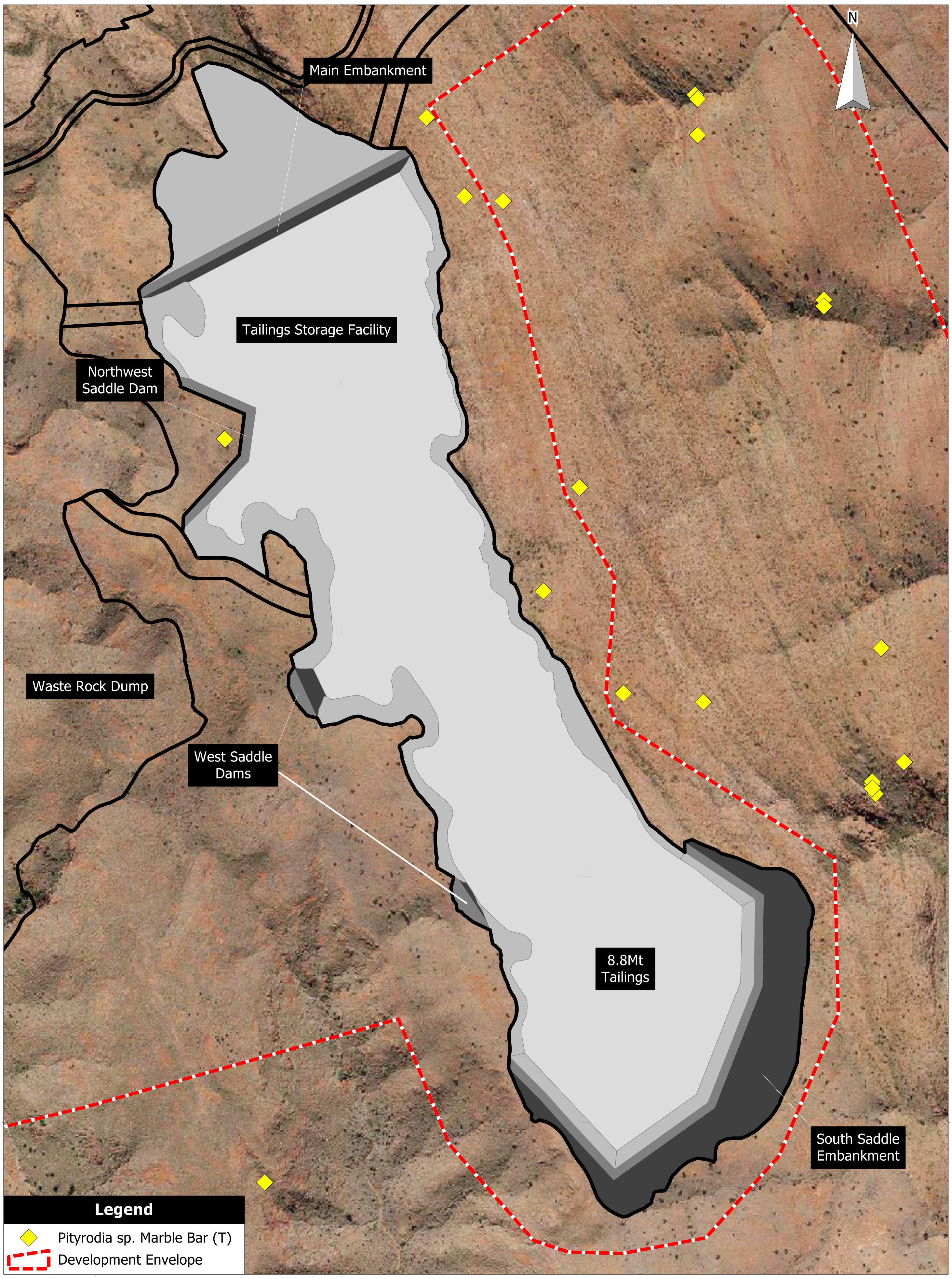
2.2.6.8 TSF Water Balance

A TSF water balance has been developed to model changes in the level and surface area of water ponding on the TSF across the mine life. This water balance has been modelled using specially developed computer software. The program is a computer model written in Visual Basic/Excel, specifically for tailings storage facilities and incorporates a database of information derived from both laboratory and field data accumulated over the past 20 years by Knight Piésold (Appendix 4). The program calculates tailings densities achieved in the storage and determines the volume of water available for return to the process plant taking into account rainfall, evaporation, and supernatant and underdrainage release from the tailings due to consolidation. The model incorporates the results of the tailings physical testing at 50% and 55% solids and includes calculation of change in tailings % solids, consolidation, settled density and water release resulting from changes in surplus dewatering water added to the tailings stream. The modelling (Appendix 4) has demonstrated that:

- The maximum decant return rate will be approximately 110 m^3/hr.
- The facility experiences a total water shortfall of 4 GL under dry climatic conditions and ranges from 5,000 to 83,000 m^3/month. Recycle to the process plant varies from 27% to 100% of water in slurry during the operation and ranges from 15,000 to 72,000 m^3/month.
- Under average climatic conditions, the pond volume remains at the minimum (20,000 m^3) except for one or two months during each wet season. The maximum pond volume is 43,000 m^3.
- The pond level will always be below the tailings level at the Main and South Saddle Embankments.

2.2.6.9 Surface Water Management

The final TSF will occupy about 76% of the mine pit sub-catchment PSC5. During operations, the TSF valley will direct surface water runoff from outside undisturbed areas to the TSF for capture and re-use in the processing plant. Runoff and incident rainfall that collects in the pit will be pumped to the process water circuit. After closure, runoff from the rehabilitated TSF surface area will be directed to tributaries of Minnieritchie Creek and Six Mile Creek.



Scale: 1:6000
Original Size: A4
Air Photo Date: 2019
Grid: MGA94(50)
0 150 m

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Sulphur Springs Project

Figure 12

TSF Conceptual Design

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2.2.7 Water

2.2.7.1 Site Water Balance

A site water balance is provided in Appendix 9 and project make-up water requirements are shown in Table 14. Water supplies for project construction will be sourced from several existing bores within and outside the Sulphur Springs mine catchment. During operations the processing plant will recycle water from the TSF decant to maximise the settlement and compaction of tailings. Makeup water supplies for ore processing will be primarily sourced from mine dewatering. Predicted shortfalls in the water inventory will be made up from existing bores located around the project site. Total groundwater abstraction for the Proposal (from both mine dewatering and bores) will be approximately 0.94 GL/yr. Bore locations are shown in Figure 13.

Table 14: Project Water Requirements (AECOM 2020b, Appendix 21)

Water Use	Approximate Water Volume Required (kL/day)	Source/s
Construction Phase		
Site Office	50	Bore SSWB06
Construction and Dust Suppression	800	Bores SSTP01, SSTP03, SSWB12 and SSWB20
Operations Phase		
Processing	1,600	Mine dewatering and water returned from TSF decant
Site Dust Suppression	600	Bores SSTP01, SSTP03, SSWB12 and SSWB20
Underground Mine Development	400	Mine dewatering
Accommodation Village	50	Potable bore
Access Road Maintenance	Up to 1,000	SSWB36, SSWB38, SSWB40 and PAN60

2.2.7.2 Make-Up Water Sources

Mine Dewatering

A mine dewatering system will be required to allow safe mining operations. The predicted dewatering volume is up to approximately 0.64 GL/yr. Dewatering will be affected via a combination of in-pit sumps and groundwater abstraction bores.

Site Access Road Bores

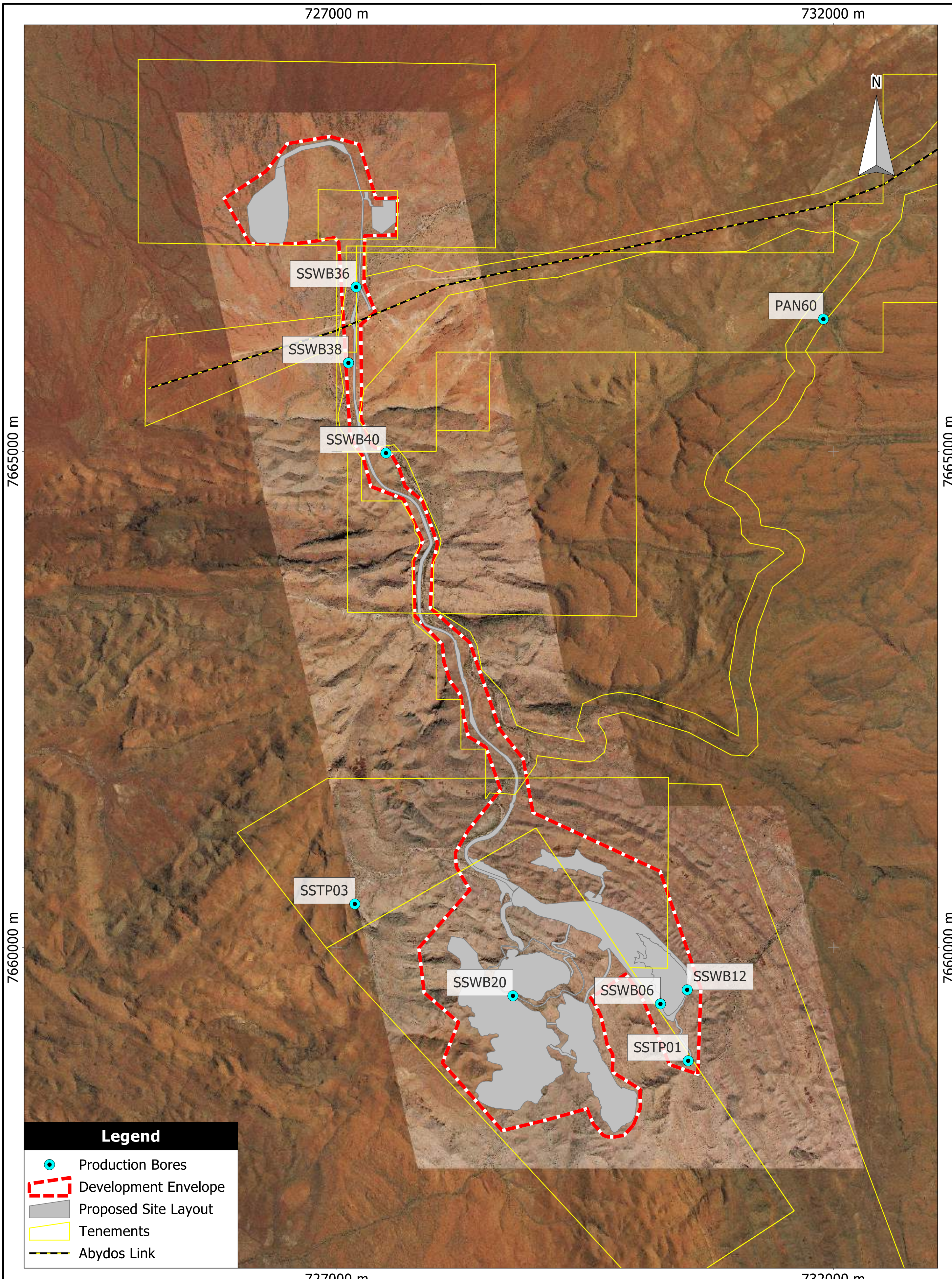
Water drawn from bores adjacent to the Venturex Site Access Road (from existing bores SSWB036, SSWB038, SSWB040 and PAN60) will also be used to supply Venturex's accommodation village and the Site Access Road (during construction and for ongoing dust management as required). GWL 176408(3), issued to Atlas, permits abstraction of up to 0.315 GL/yr from these bores, which are all located on Venturex tenements. Venturex has collaborated with Atlas to develop a Water Management Plan and a Site Water Operating Plan for the licenced abstraction. No change to the permitted abstraction volume of 0.315 GL/yr is proposed and no additional clearing or infrastructure is required.

Groundwater quality in the vicinity of these bores was measured in reconnaissance surveys conducted in 2006 and 2007 (RMDSTEM 2013). Salinity concentrations in samples were low and within, or close to, ANZECC 2000 Drinking Water Guidelines for Humans (ANZECC and ARMCANZ 2000) (436 to 764 mg/L total dissolved solids (TDS)), with a slightly alkaline pH range (7.1 to 8.2). Groundwater was Mg-HCO_3 in type, with the major ions being bicarbonate, magnesium, sodium and chloride. Dissolved silica concentrations were relatively high (40.7 to 54.8 mg/L).

Other Site Bores

Water drawn from existing bores in proximity to the mine and processing plant (including SSWB006, SSTP01, SSTP03, SSWB12 and SSWB20) will be utilised, if required, for construction, dust suppression and potable water supply. Previous groundwater studies (URS 2013) indicate yields of up to 0.57 GL/yr are available from these bores.

These bores will only be utilised to supplement possible intermittent shortfalls in volumes from mine dewatering or Site Access Road bores. With their use, total groundwater abstraction for the Proposal (from both mine dewatering and bores) will not exceed 0.94 GL/yr.



Scale: 1:50000 Original Size: A4 Air Photo Date: 2019 Grid: MGA94(50) 0 1000 m	Venturex Resources Limited Sulphur Springs Project	**Figure 13** **Groundwater Abstraction Bores Layout**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au

W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD.map 24/01/2020 F13 Groundwater Abstraction Bores Layout

2.2.7.3 Water Licences

Venturex holds Groundwater Licence GWL 165207(4), which permits abstraction of up to 150,000 kL/yr from the fractured rock aquifer within M45/494, M45/1001 and M45/653 for general campsite purposes, dust suppression for mining purposes and mineral exploration activities. Venturex will seek to amend the licence to permit increased abstraction for the purposes of mine dewatering and ore processing.

GWL 176408 (3) is held by Atlas and permits abstraction of up to 1,198,368 kL/yr from nine production bores within the fractured rock aquifer for the purposes of dust suppression, earthworks and construction and potable water supply. Four of these bores (SSWB036, SSWB038, SSWB040 and PAN60) are located on Venturex tenements (L45/188, L45/189 and L45/287) and the associated Site Water Operating Plan (Atlas 2013) stipulates abstraction of up to 0.315 GL/yr from these four bores. Arrangements for cooperation on access to groundwater is provided for in an agreement between Atlas and Venturex.

2.2.7.4 Water Storages

A series of water storages will be constructed within the Proposal Development Envelope to ensure suitable storages and buffers are maintained for water supply and management. Anticipated storages are described in Table 15.

Table 15: Mine Water Storage Infrastructure

Water Storage ID	Input Source(s)	Purpose
Mine Service Area Site Runoff Pond	Runoff from Mine Services Area.	Capture of runoff prior to discharge into the Mine Water Settling Pond.
Process Plant Area Site Runoff Pond	Runoff from the Process Plant Area.	Capture of runoff prior to use in the processing plant.
Admin Area Site Runoff Pond	Runoff from the Admin Area	Capture of runoff prior to use in the processing plant.
Mine Water Settling Pond	Mine dewatering and Mine Service Area Site Runoff Pond.	Storage of water before delivery to the mine water treatment system.
Water Treatment Plant Pond	Excess water from mine water treatment system and process plant.	Storage/evaporation of excess water.
Raw Water Pond	Bore water.	Storage of water used for dust suppression and/or ore processing.
Sediment Pond 1	Runoff from the haul road and associated infrastructure.	Capture of runoff from the haul road to allow sediments to settle out prior to discharge to Sediment Pond 2.
Sediment Pond 2	Sediment Pond 1 overflow.	Additional settlement pond utilised to ensure the quality of contained water is comparable to background conditions prior to discharge to Sulphur Springs Creek.
North Pond and South Pond	Mine water, local runoff, TSF decant.	Water storage ponds providing additional storage for smoothing water supply and retaining mine water.

2.2.8 Support Facilities

Support facilities proposed for the project are summarised in the sections below. These facilities have been sited with consideration of factors such as:

- Avoiding potential mineralised areas.
- Landform and topography.
- Avoiding conservation significant flora, fauna (habitat) and communities.
- Locations of watercourses and associated flood zones.
- Heritage sites.
- Distances to other associated Sulphur Springs infrastructure.
- Separation distances to protect human health.

2.2.8.1 Power Supply

Power will be generated on site using diesel and natural gas. The facility will consist of 5 x 2 MW gensets. Generators will be housed in containers and located on a flat earthen pad and fuel supply will be piped from a day tank and pump.

The power station and associated fuel storage facilities will be located south of the processing facilities to allow easy access for fuel unloading and a clear path for high voltage distribution to the process plant via a pipe rack. Power will be generated at 11 kV and reticulated to two substations; one at the primary crushing area and one next to the grinding mills. Power will be stepped down to 415 V for reticulation to the remainder of the process plant.

The accommodation village and remote facilities will be powered by standalone diesel generators.

Open pit mine dewatering will utilise trailer mounted pumps equipped with a standalone generator

2.2.8.2 Fuel Storage

Diesel will be stored on site in 110 kL self-bunded tanks. Natural gas, delivered to site via road tankers, will be stored in vacuum insulated vessels. The fuel storage facility will include a fuel unloading system, access, lighting and all necessary safety systems.

A single (110 kL) self-bunded diesel tank will be installed at the accommodation village to supply the standalone generator.

2.2.8.3 Low Grade Stockpile

Provision has been made for storage of low grade ore within a HDPE lined pad to the east of the processing plant. Up to 120 kt of low grade ore will be stored on this pad at any one time during the life of the project.

2.2.8.4 Water Treatment Plant

TSF decant return and mine dewatering water to be used in the processing plant will report to a water treatment plant to adjust the pH and precipitate dissolved metal salts, prior to use in the circuit. The treatment plant will be a standard vendor supply item (e.g. Aquasol, Tristar), to be determined at the detailed design phase. Feed water will be pumped into an aeration tank where sodium hydroxide or lime will be dosed to raise the alkalinity and enable precipitation of the dissolved metals as hydroxides. Precipitated solids will be removed via clarifier tank(s) aided by reagent dosing if required and disposed to the TSF or storage ponds.

If required clear water from the clarifier overflow will be polished through a filtration system to remove micro particles and metals remaining. Discharge from the filters will be monitored for pH & conductivity.

An indicative and proprietary flowsheet is detailed in Plate 6. The treatment plant, or variations of, is installed at many locations around the world and is proven capable of treating water of the quality expected from tailings decant, seepage and natural acidic groundwater to potable standard (not that this standard is required for process water).

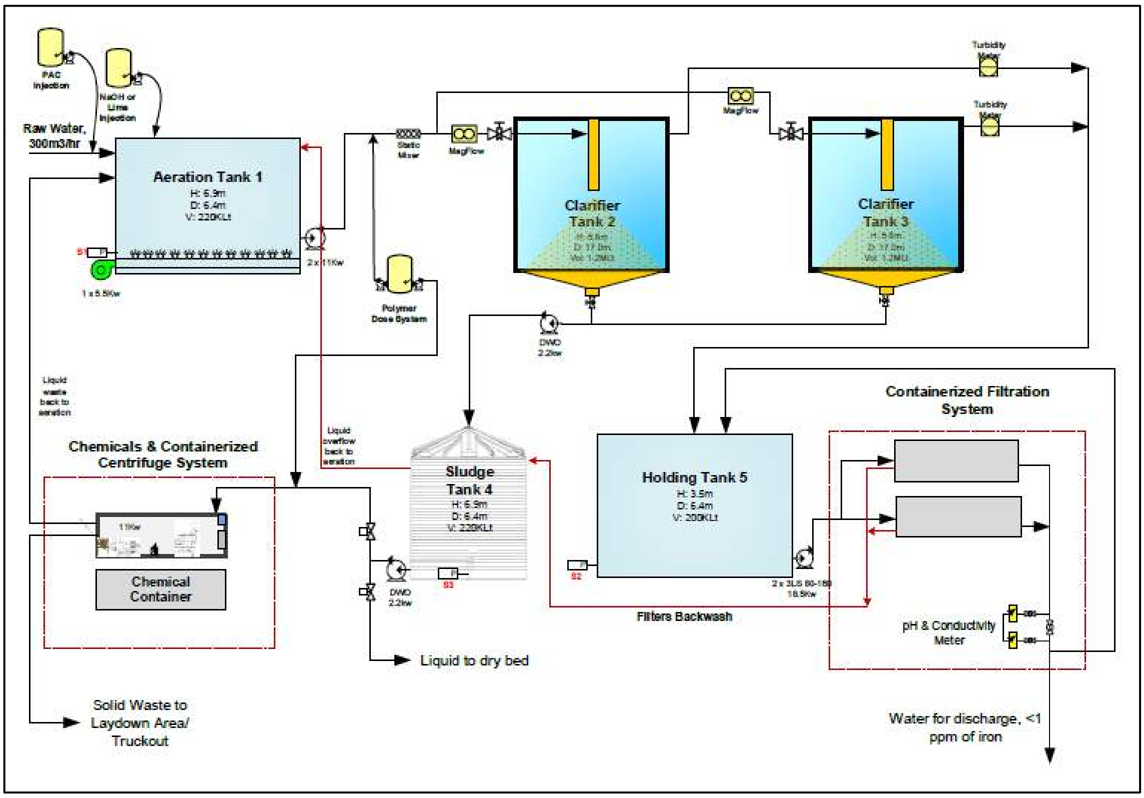


Plate 6: Indicative Water Treatment Flowsheet

2.2.8.5 Communication Systems

Communication to the site will be via a microwave system linked to the Atlas Abydos mine infrastructure located 9.5 km from the village. From there, it will be linked via the Atlas microwave network to the Telstra optic fibre network at Wodgina. Systems will include:

- Phone and data.
- Local-area network (LAN) and Information Technology (IT) network.
- Two-way radio and private automatic branch exchange (PABX).
- Fibre optic cabling.
- Microwave communications.

2.2.8.6 Plant Buildings

A number of support buildings including a laboratory, administration office, first aid centre, crib room, mine office, plant office, workshop/warehouse, control room, ablutions and reagent storage will be constructed for the Proposal.

2.2.8.7 Laydown Areas

Two laydown areas (plant and core yard) will be established for the Proposal.

2.2.8.8 Accommodation Village

A 200-room permanent village will be established on site and an additional, temporary village will be installed for construction. The nearby Abydos accommodation village will also be utilised, if required, for any additional accommodation required during construction.

An alternative site for the accommodation village (closer to the operational area) was considered. However, due to potential impacts on habitat for significant fauna and Threatened flora species, this option was discounted.
The Proposal will be operated on a drive-in drive-out basis from Port Hedland. It is expected that a significant portion of the workforce will live in Port Hedland with the remainder commuting from Perth and other regional centres.

2.2.8.9 Wastewater Treatment

Two 20 m^3/day package wastewater treatment plants will be installed for the Proposal; one for the accommodation village and one for the processing plant and site office area.

2.2.8.10 Landfill

Two landfills will be established on site; one for inert waste and one for putrescible waste. The putrescible waste landfill will be established in proximity to the accommodation village and the inert waste landfill will be established close to the processing plant.

2.2.8.11 Washdown Facility

A washdown facility will be constructed, consisting of light/heavy vehicle drive through areas with high pressure spray water for cleaning. Solids and dirty washdown water will drain to a primary settlement sump where the solids settle out. Oily water will overflow to an adjacent cell where oil will be separated using an oil skimmer and pumped to a small waste oil tank.

Waste oil will be removed from site by a licenced contractor for disposal at a licenced facility in Port Hedland.

Excess water will be pumped to a runoff water pond for either evaporation or reuse.

2.2.8.12 Roads

An 8.2 km access road (referred to as the Site Access Road) connecting the mine site to the Abydos Link will be constructed along the route shown in Figure 4. Two major creek crossings are required along this route where cross-cutting valleys direct water flows into the main creek system. The crossings have been designed with sufficient drainage pipes to handle predicted creek flows resulting from a rainfall intensity of 5.3 mm/h for a 72 hour 1 in 100 year event, without overtopping. In the event of shorter, higher intensity storms the road may overtop for short periods.

Several additional (internal) site roads will also be required to connect site elements. Roads shall generally be 12 m wide for two-way traffic and constructed with drains on either side to allow for runoff water. The roads will be designed to accommodate heavy vehicles that will be required to supply the Proposal with construction equipment, deliveries of fuel, consumables, reagents and other general goods.

2.2.9 Rehabilitation and Closure

A conceptual MCP for Sulphur Springs, consistent with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015) is provided in Appendix 8. This document addresses the development of completion criteria to maintain the quality of land and soils and groundwater and surface water so that environmental values are maintained post closure. The MCP will be revised at the detailed design phase prior to submission to DMIRS for approval under the *Mining Act 1978*. The MCP will also be periodically updated to reflect developments in rehabilitation planning during the operational phase of the project.

In accordance with Appendix G of the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015), progressive rehabilitation will be undertaken where possible. External slopes of the WRD will have been completed by the end of Year 4 with rehabilitation occurring during the remainder of the Proposal's operational period. Most other land areas disturbed during development and operations will remain in use for the life of the project and will generally not be available for progressive rehabilitation prior to closure. At the completion of project construction, there may be opportunity to rehabilitate certain laydown yards and access roads established purely for construction purposes. The feasibility of staging the rehabilitation of the surface of the TSF will be examined in greater detail and there may also be other limited opportunities to rehabilitate laydown areas and other disturbances over the life of operations. Exploration or resource definition disturbances will generally be reinstated progressively over the life of operations (subject to the prospectivity of exploration results).

Venturex has consulted extensively with DMIRS throughout the conceptual design phase of the project as outlined in Table 16. The proceedings of these workshops and discussions have been considered in the preparation of the MCP.

Table 16: Venturex Consultation with DMIRS Regarding Mine Closure

Date	DMIRS Personnel	Key Points Discussed
30/07/2015	Danielle Risbey	Possible change from dry stack tailings to a conventional valley filled tailings for the Proposal. DMP indicated no objection to the concept of a valley filled tailings facility – closure issues would however need to be adequately addressed.
18/08/2015	Phil Boglio	Informal meeting regarding the concept of developing an open pit as part of the Sulphur Springs Project optimisation study. DMP indicated no objection to the concept of an open pit as long as design and closure were adequately addressed.
28/10/2015	Phil Boglio	DMP provided an e-mail with background information on the environmental issues regarding the proposed TSF that were discussed in 2007 and 2008 as part of the CBH proposal. The e-mail contained correspondence between DMP and EPA as part of the CBH PER assessment.
25/01/2017	Rob Irwin Phil Boglio Adam Ashby	Meeting to discuss mine closure matters for the Proposal. DMP indicated that they did not have sufficient information to determine whether the Proposal (as originally referred to the EPA on 14 December 2016) could be closed without significant environmental harm (TSF seepage and cover primary concerns). Concerns were raised regarding possible risks associated with the original proposed valley-fill TSF when compared to the current approved TSF (dry stacked tails).
23/02/2017	Phil Boglio Danielle Risbey	Meeting with DMP to discuss mine closure aspects for the Proposal, specifically relating to the original proposed TSF.
10/03/2017	Phil Boglio Jay Ranasooriya	Meeting with DMP to discuss alternative TSF location on WRD at Sulphur Springs. KP had developed a conceptual plan for this option. The concept will be further developed by KP in the coming weeks and a meeting between KP and DMP will be arranged to discuss design criteria.
6/04/2017	Phil Boglio	A copy of the draft closure criteria developed by O'Kane for inclusion into the original TSF closure concept cover design report was emailed to DMP for review and comment to ensure all DMP requirements were addressed in the closure cover design.
4/05/2017	Phil Boglio Ryan Mincham	Met with DMP to confirm outcomes of the TSF options assessment from meeting held on 26th April and briefly discuss Venturex's planned response to the EPA.
10/05/2017	Phil Boglio	DMP was emailed a copy of the additional information package provided to the EPA for their information.
7/12/2017	Phil Boglio	Meeting with DMIRS to discuss environmental approvals progress. Provided details of additional surveys that have been undertaken and the results obtained to date from those surveys. Also discussed the MCP and requirement for DMIRS to agree in principal to the preliminary MCP as outlined in the EPA scoping document.

Date	DMIRS Personnel	Key Points Discussed
10/05/2018	Phil Boglio	Venturex provided an update on Proposal progress and key findings of studies completed. Also discussed mine closure aspects particularly associated with the TSF, WRD and pit water diversion.
05/09/2018	Phil Boglio Ryan Mincham Emma Ryan-Reid	Discussed aspects of the Proposal where more detail in the ERD or MCP would assist assessment. Specifically, DMIRS requested that: • The impact of TSF seepage on potential Groundwater Dependent Ecosystem (GDE) located along Minnieritchie Creek (site MRC2) (for original TSF location and design) be addressed in the ERD and included in the project risk assessment. • Further investigation on pit lake water management (pit diversion options) post closure be undertaken to support concepts presented in the ERD.
24/10/2018	Phil Boglio Melissa Harrison	Venturex met with DMIRS to discuss findings of the following studies: • Additional modelling to quantify potential indirect impacts of poor quality TSF seepage (based on original TSF design) on vegetation along Minnieritchie Creek under various seepage rate and water quality scenarios. Findings were used to inform risk assessment of potential impacts to significant vegetation, surface water, groundwater, subterranean fauna and terrestrial fauna in Revision 5 of the ERD. • A comparison of options for diversion of the catchment upstream of the pit. This study identified nine possible options which were assessed from an environmental, engineering and economic viewpoint.
30/10/2018	Phil Boglio Melissa Harrison Jay Ranasooriya	Venturex met with the Resources Safety Division of DMIRS to discuss closure concept design options for diversion of water in the catchment upstream from the pit - specifically regarding the preferred option of a pit diversion dam and tunnel. Resources Safety representative indicated they were comfortable with a tunnel design concept.
29/08/2019	EPA EPA Services DMIRS DWER	Multi agency meeting to discuss outstanding regulatory issues/concerns including TSF seepage (for original design), pit lake water quality, surface water diversion and mine closure risks.
30/10/2019	Phil Boglio Melissa Harrison	Meeting to discuss key unresolved matters including: • TSF seepage (for original TSF design) during operations and post closure; long term stability and management post closure. • Longevity of pit diversion dam and tunnel/s. • Opening discussion on potential to relocate TSF (as now proposed) to address closure risks.
11/11/19	DMIRS (Compliance and Resource Safety)	Proposal and assessment background/history. Geotechnical/safety considerations of locating tailings upgradient of mine pit. Preliminary risk reduction measures
10/12/19	DMIRS	Project update TSF relocation studies/safety mgt. ERD V6 timing (late January 2020). Reconciliation of existing approved and future Mining Proposals

2.3 JUSTIFICATION

In accordance with Clauses 5 and 10.2.4 of the *Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016* (EPA 2016a) this section outlines the justification for Sulphur Springs and summarises alternative options considered. The intent of this section is to provide an overview of the options that have been considered by Venturex to minimise potential environmental impacts resulting from the Proposal.

2.3.1 Need for Proposal

Sulphur Springs will produce approximately 335 kt of zinc and 146 kt of copper over the mine life and is considered a major copper zinc asset in the Pilbara region of Western Australia. Global demand for zinc and copper is increasing, as signalled by higher commodity prices. Zinc is in structural shortage following major mine closures and is expected to perform very strongly on any demand strength (IIR 2018). In addition to meeting an identified market demand, development of Sulphur Springs will increase diversification across resource commodities in the Pilbara, creating a more robust regime for continued economic growth.

The Proposal will contribute to the regional economy of Australia through export earnings, taxes, salaries and purchase of goods and services during construction and operation of the mine. It will contribute to the regional economy, both directly and indirectly, as a result of contractual opportunities to local communities, including indigenous groups and full-time employment for approximately 180 people on an ongoing basis. Further contribution will be created by the flow-on effects for service industries and other sectors of the economy. Economic benefits to Western Australia and the region are summarised in Table 17.

Table 17: Summary of Benefits Generated by Sulphur Springs

Benefit	Detail
Direct Employment	180 people
Indirect Employment	720 people
State Royalties (across mine life)	$100 million

2.3.2 Alternative Technologies or Options

Alternative technologies and options considered to minimise environmental impacts and improve the environmental performance of the Proposal are listed in Table 18.

Table 18: Consideration of Alternative Technologies or Options

Activity	Alternative Technologies or Options Considered	Environmental Outcome(s)
Infrastructure Location	• Waste rock dump • Tailings Storage Facility • Communications Tower • Accommodation Village • Site Access Road • Heap Leach Facility	Tailings Storage Facility The following TSF sites were considered: • Option 1: Adjacent to the pit, in pit sub-catchments PSC2 & PSC3 within the footprint of the current WRD. • Option 2: Within broad valley to the northeast of the processing plant (predominantly in the Minnieritchie Creek catchment). • Option 3: Adjacent to the pit in pit sub-catchment PSC5. In comparisons between Options 1 and 2, a comprehensive risk assessment conducted in consultation with DMIRS and DWER determined the valley to the northeast of the processing plant (Option 2) was the preferred site due to the lower ANCOLD risk rating for this design (High C versus High A for Option 1) and significantly lower total Proposal footprint (326.7 ha versus 367.5 ha). In subsequent analyses and feedback during the course of the impact assessment, Option 3 was adopted due to the significant reduction achieved in post-closure environmental risk. The ANCOLD risk rating for Option 3 (High B), is greater than Option 2, but after careful consideration and advice it was concluded the safety/geotechnical risks can be managed through appropriate design and operational measures. The EPA consented to amending the Proposal to include Option 3 in November 2019. Heap Leach Facility Partly as a consequence of relocating the TSF, an initially proposed heap leach facility described in earlier versions of the ERD has been removed from the Proposal. Communications Tower The communications tower and associated access track were moved from near the pit wall to the proposed location in order to avoid disturbance of several *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals. Accommodation Village The site for the proposed accommodation village was relocated from approximately 2.3 km west northwest of the processing plant to approximately 7.8 km north northwest of the processing plant due to the presence of potential Northern Quoll habitat adjacent to the former location. Venturex has also been liaising with Atlas to determine whether utilizing the existing Abydos mine village would be a suitable alternative to constructing a separate village for the Sulphur Springs Project, further reducing the overall Proposal footprint. These discussions are ongoing. Site Access Road A valley access road, similar to that proposed under REG ID 40542, was chosen over the alternative overland route extending northeast from the mine site, connecting to the Abydos Haul Rd, close to Lalla Rookh. The valley route was selected as the alternative overland route would require major earthworks and result in a larger disturbance footprint. The overland route also intersected potential habitat for conservation significant fauna. Minor realignments to the valley access road alignment were subsequently made to avoid indigenous rock art and scatter sites identified during Aboriginal heritage surveys and minimise potential impacts to ephemeral pools and associated vegetation. Waste Rock Dump Several footprints within the proposed valley site were considered, but acceptable options were limited due to site topography, environmental values (including conservation significant flora, potential habitat for conservation significant fauna and surface water catchments) and ore haulage costs. The adopted location is proximal to the mine pit and enables the placement of PAF material within the catchment of the pit, limiting the risk of off-site mobilisation of acid drainage (if any).
Ore Processing	Processing of Sulphur Springs ore only, as opposed to the co-processing of ore from Whim Creek and Sulphur Springs (as approved under REG ID 40542).	Co-processing these ores at Sulphur Springs would require construction and operation of a lead flotation circuit, and transport of lead concentrate to Port Hedland.
Tailings Disposal	Alternative options considered for tailings disposal included: • Dry stacked tailings disposal • Temporary disposal in the existing valley-fill site and reclamation of this material at closure for disposal in the pit. • Direct in-pit disposal.	Mining Proposal REG ID 40542 included approval for a dry-stacked tailings facility in the WRD southwest of the then proposed underground mine and within the mine catchment. The decision to move from a dry-stacked to a (conventional) valley-fill TSF design was based on the following: • A number of significant changes to the proposed mine design which meant that the original disposal site was no longer practical. Such changes included construction of an open pit and a permanent WRD within the mine catchment. • Given the PAF nature of tailings, dust generation from dry stacked tailings, was considered to pose a high environmental risk. Dry stacking methodology also has the potential to lead to increased oxygen ingress and oxidation of sulphides (versus storage in a consolidated facility). • Dry-stacking tailings involves dewatering tailings prior to discharge of a high-density slurry or paste to the TSF. While this includes less pore water than conventional slurried tailings, once the conventional tailings have consolidated, the amount of pore water after closure is similar. Given the increased potential for oxidation of PAF tailings within dry stacked tails, pore water quality under this scenario is predicted to be significantly poorer than for a conventional TSF. The option of reclaiming tailings as part of the Option 2 (above) valley-fill location at closure and partially backfilling the pit void was investigated as a means to reduce post-closure risks to receptors in the Minnieritchie Creek catchment. The option presented some advantages and disadvantages in terms of environmental risk which are not expanded upon in this document in light of relocation of the TSF to the pit sub-catchment (Option 3). In pit disposal of tailings remains an option for further study.

Activity	Alternative Technologies or Options Considered	Environmental Outcome(s)
TSF Closure Cover Design	Conceptual TSF cover options considered by O'Kane Consultants (O'Kane 2017) and Knight Piésold (KP 2017, KP 2018a, KP 2018b) included the following: • Store and release. • Water shedding. • Enhanced store and release, utilising a combination of the water shedding concept and the moisture store and release concept. • Use of alkaline materials (such as calcined magnesia (CSIRO 2019), organic material and crushed limestone).	Climatic conditions in the Sulphur Springs area would be conducive to a store and release cover. The PAF nature of the tailings and short lag time for acidification to commence also necessitate limiting net percolation into the tailings mass. Therefore, an enhanced store and release cover system that also utilises the water shedding concept, was selected for the Proposal. The water shedding feature is designed to handle less frequent high intensity rainfall events, which exceed the infiltration and storage capacity of the cover system. The moisture store-and-release concept is included to handle more frequent, less intense rainfall events, where incident rainfall is captured and stored within the cover system profile for subsequent release via evapotranspiration to the atmosphere (O'Kane 2017).
Concentrate Transport	• Transport in sealed half-height sea containers as opposed to covered trailers.	Around 50,000 tonnes of copper concentrate and 70,000 tonnes of zinc concentrate per annum will be transported from Sulphur Springs to Port Hedland. The following bulk transport and handling options were considered: • Half height containers on quad road-trains, with discharge of containers directly into the ship's hold at port. • Sheeted bulk transport in vessels such as tipping trailers covered by flexible tarpaulins, bulk storage of concentrate in a shed at port and transfer into the ship's hold via conveyor. While sheeted bulk transport is a lower cost option, the use of half height containers was selected to minimise potential fugitive dust emissions during both transport and ship loading. This option also represents current industry best practice.
Process Water	A source of make-up water will be required for ongoing operations. Potential options included: • Development of a new borefield in the region. • Use of water from mine dewatering.	Predicted dewatering volumes are likely to exceed make-up water requirements for the processing plant in the first five years of operation (AECOM 2020a, Appendix 16). Field and laboratory test programs have confirmed water in the vicinity of the orebody is low in pH but could be treated with lime to make it suitable for use in the processing plant. Use of mine water for this purpose avoids construction of a new borefield and assists with management of surplus water thereby reducing demand on local groundwater resources. Water from mine dewatering has therefore been selected as the primary processing water supply.
Water Management	Hydrogeological modelling (Appendix 16) indicates the site will have a positive water balance as a result of mine dewatering. • Construction of a dedicated evaporation pond for this purpose (as approved under REG ID 40542). • Construction of two storage ponds to facilitate use of this water in the processing plant and provide excess holding capacity. • Discharge of surplus water to Sulphur Springs or Minnieritchie Creeks. • Re-injection of surplus dewatering water into an aquifer. • Use of the TSF as an evaporation cell.	The current Proposal incorporates two water storage ponds for the management of excess mine dewater in preference to surface discharge, aquifer re-injection or discharge to the tailings surface. As the prior TSF design for this location demanded the highest standard in seepage control, the TSF was considered suitable for temporary water storage. No excess water will be discharged to the TSF under the current design, to provide for the earliest consolidation of tailings. An evaporation pond, similar to that approved under REG ID 40542, was considered for management of the excess dewatering water for an earlier location of the TSF (Option 2).

2.4 LOCAL AND REGIONAL CONTEXT

The Proposal is located within the Shire of East Pilbara, the largest shire in Australia covering approximately 372,571 km^2. Mining dominates the shire's economic landscape, followed by pastoral grazing and to a lesser extent tourism. The majority of the Proposal, including the mine area, TSF, WRD and ore processing footprint, is on Unallocated Crown Land, with the northern section of the Site Access Road and accommodation village on the Panorama and Strelley Pastoral leases (Figure 6).

The nearest mine is Atlas' Abydos iron ore mine, located approximately 9.5 km west of the proposed accommodation village. The mine is now under care and maintenance. Where practicable, the Proposal has been designed to utilise existing infrastructure associated with the Abydos mine. Nominally this will include communication infrastructure, accommodation infrastructure from the Abydos village and roads (the Abydos Link).

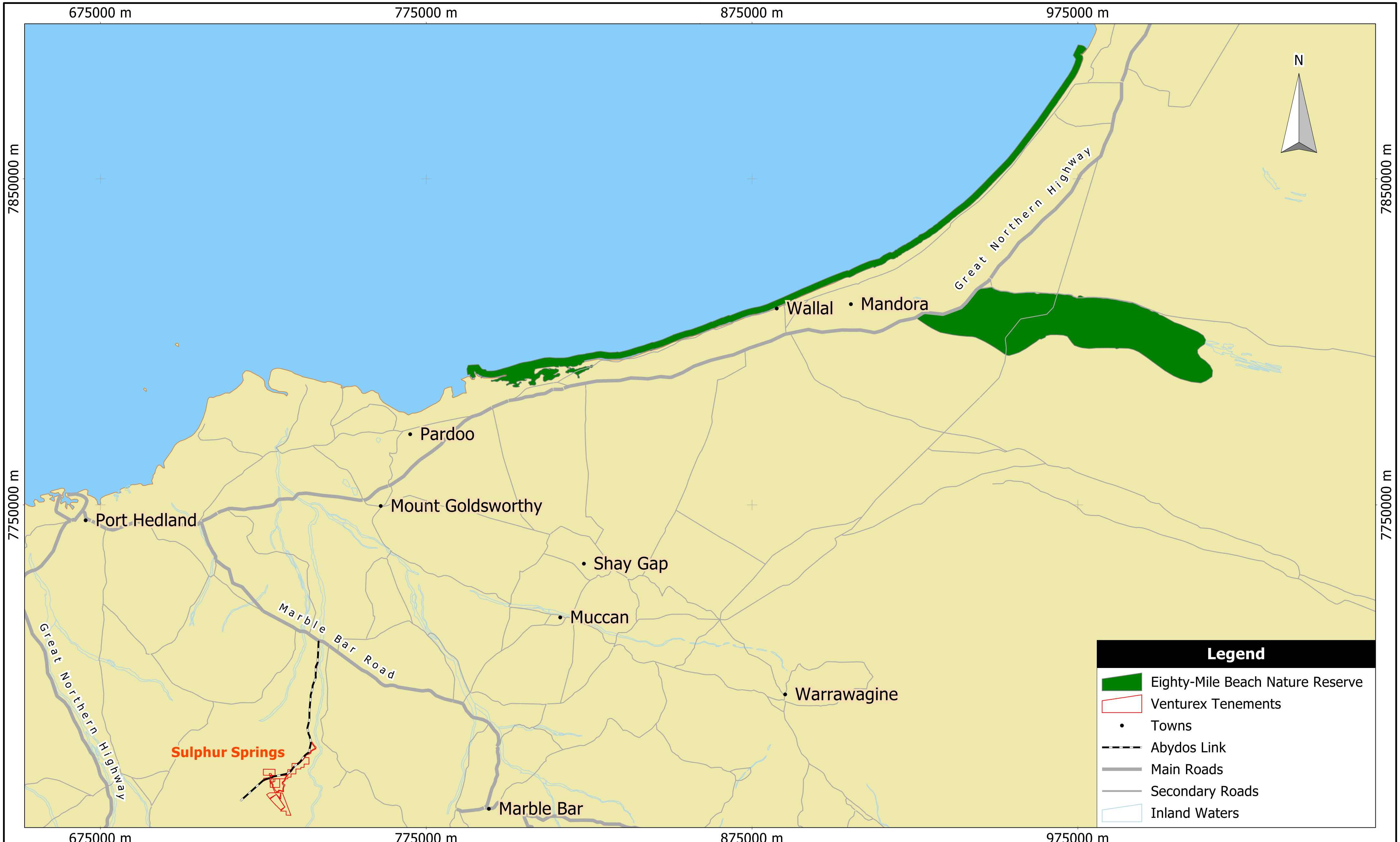
The area surrounding the site is sparsely populated. The closest regional centre, Port Hedland, is 110 km northwest of the site and has a population of 13,651 (ABS 2018). Marble Bar, the closest town, is approximately 57 km east of the site, with a population of 634 (ABS 2018).

There are no Nature Reserves, National Parks or Ramsar wetlands within 100 km of the Proposal. The nearest conservation park is Eighty Mile Beach Nature Reserve, located approximately 141 km north of the Proposal, on the WA coast between Port Hedland and Karratha (Figure 14). Eighty Mile Beach Nature Reserve is also the closest Ramsar Wetland.

The Proposal lies largely within an area of determined Native Title held by the Nyamal people. An agreement between Venturex and the Nyamal people provides for regular consultation and participation in the provision of cultural awareness training, site clearances, direct employment and provision of contract service to the Proposal. It also includes payment of a net smelter royalty to the Nyamal people.

The Proposal is in the Chichester subregion of the Pilbara bioregion. This subregion is generally rugged and hilly with elevations up to 1,250 m above sea level, hard alkaline red soils on plains and pediments and shallow and skeletal soils on ranges. The basalt plains host a shrub steppe of *Acacia inaequilatera* over *Triodia* spp. hummock grasslands, while tree steppes of *Eucalyptus leucophloia* occur on the ranges. The climate is arid to subtropical with an average rainfall of approximately 360 mm per annum, typically occurring during the wet season between December and March.

The Proposal footprint is predominantly in the Strelley River catchment, with a minor part of the proposed plant area in the Shaw River catchment. Both these rivers are ephemeral and characteristically flow in the lower courses through extensive floodplains, while upper reaches traverse deep gorges. Waterholes within low lying stretches of the drainage lines may persist for much of the year, but most are dry from May to November. Groundwater and surface water flow systems in the area are complex, variable and linked (AECOM 2020a, Appendix 16). There are strong correlations with topography, geology and structure (such as faults and thrusts), with groundwater recharge occurring in upland areas and groundwater discharges to valley floor domains and associated watercourses.



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Sulphur Springs Project

Figure 14

Sulphur Springs Project and Eighty Mile Beach Nature Reserve

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W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Location Plan.map 24/01/2020 F14 Sulphur Springs Project and Eighty Mile Beach Nature Reserve Layout

3. STAKEHOLDER ENGAGEMENT

3.1 KEY STAKEHOLDERS

Key stakeholders for the Proposal are summarised in Table 19.

Table 19: Key Stakeholders for Sulphur Springs

Stakeholder Sector	Organisation	Interest
State Government Departments and Agencies	Environmental Protection Authority (EPA)	• Administers *EP Act*. • Part IV (*EP Act*) Environmental Impact Assessments.
	Department of Planning, Lands and Heritage (DPLH)	• Indigenous and Native Title requirements. • Heritage, cultural, ethnographic and archaeological sites. • Risk management on unallocated Crown Land
	Department of Mining, Industry Regulation and Safety (DMIRS) Mine Safety Inspectorate	• Administers *Mining Act 1978* (*Mining Act*) and Regulations. • Tenement conditions. • Mining proposals, programs of work. • Mining rehabilitation fund. • Rehabilitation standards. • Safety in resource sector.
	Department of Water and Environmental Regulation (DWER)	• Provision of licences to take and abstract water. • Groundwater quality and quantity. • Administers Part V (*EP Act*), Industry Regulation and Licensing and *Contaminated Sites Act 2003*.
	Department of Biodiversity Conservation and Attractions (DBCA)	• Administers *Biodiversity Conservation Act 2016* (*BC Act*). • Flora, fauna and habitat conservation. • Interest in projects that are located on DBCA managed land. • Baseline surveys and licences to take flora and fauna.
	Department of Fire and Emergency Services (DFES)	• Fire breaks. • Provision of emergency services.
	Department of Health (DoH)	• Environmental health, building and planning compliance.
	Pastoral Lands Board (PLB)	• Pastoral leases, stations.
	Main Roads Western Australia (MRWA)	• Use of public roads, including RAV network.
Federal Government Departments	Department of Environment and Energy (Commonwealth, Territories and Assessment Branch) (DoEE)	• Part 7 (Referral) and Part 8 (Assessment) environmental impact assessments of matters of national environmental significance.
Indigenous Groups	Native Title Claimant Group (Nyamal Group)	• Access to and use of Traditional Owner land. • Cultural heritage values. • Native Title rights.

Stakeholder Sector	Organisation	Interest
Local Government Authorities	Shire of East Pilbara Town of Port Hedland	• Benefits to local economy and community. • Safety of locals and passers-by. • Use of public roads and infrastructure. • Compliance with building, health, sewage and other local government regulation.
Pastoral Stations	Panorama Pastoral Lease Strelley Pastoral Lease	• Land management (weeds, feral animals, fire). • Air and noise emissions at mine site. • Interaction with pastoral activities, including livestock safety on roads. • Post mining land use.
Adjacent Tenement Owners	Atlas Iron Limited	• Land access approvals/agreements use of minor infrastructure.
Others	Pilbara Ports Authority	• Storage and ship loading of concentrates and products.
	Pilbara Development Commission	• Job creation and promotion of economic and social development within the region.
Environmental Interest Groups	Wildflower Society of Western Australia Conservation Council of Western Australia (CCWA)	• Potential interest in baseline surveys and significance of data.

3.2 STAKEHOLDER ENGAGEMENT PROCESS

Venturex has, and will continue to, engage with stakeholders, government and the broader Pilbara community. Stakeholders have been engaged early in the planning process, primarily in the interests of achieving a collaborative approach and to ensure that local knowledge is considered in the design and management of the Proposal. A stakeholder register and records of engagement are maintained.

The objective of Venturex's consultation program is to enable individuals, groups and agencies with an interest in the Proposal to have access to current, relevant information regarding Sulphur Springs, provide a means for stakeholders to raise any concerns, and provide Venturex with the means to respond to feedback.

Venturex consulted with neighbours, pastoralists, representatives of interested parties and regulatory agencies during the Feasibility Study and permitting of a prior proposal between 2012 and 2014. This has continued throughout the current Proposal assessment. Presentations and information sessions were held to provide stakeholders with an overview of the Proposal as well as information on potential impacts and how they will be managed.

Venturex will maintain a program of engagement throughout the construction, operation and decommissioning phases of the project. Consultation will be aimed at developing relationships that are mutually beneficial to both parties.

A summary of stakeholder consultation completed for the Proposal is provided in Appendix 10.

4. ENVIRONMENTAL PRINCIPLES

Table 20 outlines how *EP Act* principles have been considered in relation to the Proposal.

Table 20: *EP Act* Principles

Principle Consideration	Principle Considerations
1. The precautionary principle Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: • Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • An assessment of the risk-weighted consequences of various options.	• A large number of technical investigations have been completed to provide accurate and comprehensive baseline data that has enabled detailed impact assessment and confidence in modelling outcomes. Studies undertaken for the Proposal are outlined in Sections 6 and 7. • A risk-based approach has been applied in the design of the Proposal. Amendments to avoid environmental impacts, or risk of impact, have been implemented and management measures adopted to minimise residual impacts. • This is demonstrated by adjustment of the Site Access Road and accommodation village to avoid impact on heritage site buffers determined via consultation with Traditional Owners, adjustment to the location of mine site infrastructure to avoid *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) and relocation of the TSF to minimise post-closure risks. • Relevant environmental factors were scoped through the Environmental Scoping Document process for the Proposal and involved consultation with EPA and Decision Making Authorities regarding Proposal details, potential impacts and associated risks.
2. The principle of intergenerational equity The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	• Agreement on post-mining land uses with relevant stakeholders. • The project has been designed and will be implemented to ensure that, with exception of the open pit, cleared land will be rehabilitated. Closure strategies to achieve this have been developed and are detailed in Appendix 8. • A Conceptual MCP has been prepared for the Sulphur Springs Project. This will be regularly updated in consultation with regulatory authorities, Traditional Owners, pastoral leaseholders and other stakeholders to ensure that post mining land use is consistent with agreed stakeholder objectives and that rehabilitation can be progressively implemented. • During the life of the project, measures will be implemented to minimise the risk, scale and intensity of environmental impacts as far as possible. Management measures are documented for each preliminary key environmental factor and other environmental factors or matters in Sections 6 and 7, respectively.
3. The principle of the conservation of biological diversity and ecological integrity Conservation of biological diversity and ecological integrity should be a fundamental consideration.	• Biological diversity has been investigated in detail for this Proposal. Numerous flora and fauna surveys have been carried out for the Development Envelope and surrounds and a detailed assessment of the extent and significance of impacts has been completed. The scope of the studies was determined through project scoping, risk assessment and stakeholder consultation. • Conservation significant species, including the Northern Quoll, Pilbara Leaf Nosed Bat, Ghost Bat and *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) are present in the region and additional targeted survey work has been carried out to determine the likely impacts on these species as detailed in Sections 6.1 and 7.1.

<table>
<tr><td></td><td>The Proposal design is unlikely to affect biodiversity, or the conservation status of any species.</td></tr>
<tr><td>4. Principles relating to improved valuation, pricing and incentive mechanisms
Environmental factors should be included in the valuation of assets and services.
The polluter pays principle – those who generate pollution and waste should bear the cost of containment, avoidance or abatement.
The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.
Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.</td><td>Venturex understands that environmental factors should be included in the valuation of assets and services and commits to doing this where appropriate.
Venturex recognises the polluter pays principle and management and mitigation measures as specified in this ERD aim to reduce the risk of pollution. Venturex commits to ongoing mitigation and management measures for the life of the project.
Venturex recognises the need to provide sufficient capital and operating funds to ensure environmental management measures are implemented throughout the project life. Provision has also been made for costs associated with closure and decommissioning and these costs form part of the cost of production.</td></tr>
<tr><td>5. The principle of waste minimisation
All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.</td><td>All reasonable and practicable measures to minimise the generation of waste and its discharge to the environment will be taken. Venturex will implement an ‘avoid, reduce, re-use, reprocess, recycle, recovery and dispose’ hierarchy of waste management approach across all components and phases of the project, in accordance with the objectives of the Waste Avoidance and Resource Recovery Act 2007.</td></tr>
</table>

5. IMPACT ASSESSMENT METHODOLOGY

In addition to identifying preliminary key environmental factors and defining the form and content of the ERD, the ESD set out a scope of work to be completed and reported in the ERD. This includes the detailed assessment of potential impacts, and identification of mitigation and management measures, for each of the preliminary key environmental factors.

5.1 RISK ASSESSMENT

A whole-of-project risk assessment was used to initially assess the risks of impact from the Proposal, based on an assessment of the likelihood and consequence of a potential impact. The approach generally aligned with processes outlined in Australian Standard/New Zealand Standard (AS/NZS) ISO 31000:2009 Risk Management and Handbook 203:2012 Managing Environment-related Risk. Table 21 lists and defines risk assessment terms used throughout this document.

Table 21: Risk Assessment Term Definitions

Term	Definition
Consequence	The implication of the potential impact on an environmental or socio-economic factor.
Direct impact	Impacts that arise directly from the project e.g. loss of vegetation due to land disturbance.
Factor	Environmental factors include physical environmental resources that are valued by society for their ecological, social or economic value and may be impacted by an aspect of a project.
Hazard	A potential source of harm, or situation with a potential to cause loss or adverse effect.
Indirect impact	Impacts that occur as a result of direct project impacts e.g. a reduction in viability of wildlife populations following removal of habitat.
Inherent risk	Risk of impact before the application of proposed mitigation and management measures.
Likelihood	The probability of a stressor impacting on an environmental factor.
Local/localised	Includes Development Envelope and adjacent or surveyed areas associated with the Proposal.
Long term	Longer than 10 years.
Medium term	Longer than two years, but fewer than 10 years.
Permanent	Impacts that arise from irreversible changes in conditions caused by the project, such as alteration of the landscape by mining.
Potential impact	Interaction of a stressor with an environmental or socio-economic factor that can reasonably be expected or is likely to occur in the lifetime of the project.
Regional	Includes a broader land area within the East Pilbara.
Residual risk	Risk remaining after the application of proposed mitigation and management measures.
Short term	Fewer than two years.
Stressor	A source of potential harm, or a situation with a potential to cause loss or adverse effects.

5.1.1 Consequence of Potential Impacts

A number of aspects were considered in determining the consequence of each potential impact, including:

- Type of impact (direct or indirect).
- Geographic extent, size and scale.
- Duration, frequency, reversibility of the potential impact.

- Whether the potential impacts are from planned or unplanned events.
- Sensitivity and the value of the receptor/resource.

Definitions for these aspects are described in Appendix 11.

The consequence ratings varied from Insignificant, through Minor, Moderate and Major, to Severe (refer Appendix 12).

5.1.2 Likelihood of Potential Impacts

Likelihood is the probability of a stressor impacting on an environmental factor. Where practicable, likelihood was attributed based on quantitative information or data. Definitions for likelihood are presented in Table 22.

Table 22: Likelihood Definitions

Descriptor	Explanation
Rare	Highly unlikely but may occur in exceptional circumstances (would be considered highly unusual); may occur in the next 30 to 40 years (<5% per year).
Unlikely	Not likely to occur; may occur within the next 10 to 20 years (5 to 10% probability).
Possible	May occur within 5 to 10 years (10 to 50% probability).
Likely	Known to occur or has occurred in the past; is likely to occur in the next 24 to 36 months (50-80% probability).
Almost Certain	Expected to occur in the next 12 to 24 months (80-100% probability).

5.1.3 Inherent and Residual Risk

Inherent risks were determined by assessing the likelihood and consequence of an impact before the application of mitigation or management measures.

The residual risks were determined taking into account the application of mitigation and management measures. The level of risk (both inherent and residual) was determined using the matrix shown in Table 23.

Where medium or high inherent risks were identified, mitigation options were determined in consultation with the project team to ensure adequate measures could be implemented to reduce the residual risk to be within acceptable levels. No extreme risks were identified for the Proposal.

Table 23: Risk Assessment Matrix

Likelihood	Impact Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Rare	Low	Low	Medium	Medium	High
Unlikely	Low	Low	Medium	High	High
Possible	Low	Medium	Medium	High	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Almost Certain	Medium	Medium	High	Extreme	Extreme

Residual risks derived from use of this matrix are used in decision making according to the following categories:

- **'Low' residual risks** are not considered to be of concern for decision making.
- **'Medium' residual risks** are not considered to require specific attention in the decision on approval of the project and adequate mitigation is considered achievable using reasonable mitigation and management measures. Monitoring may be needed to confirm that impacts do not exceed predicted levels.
- **'High' residual risks** are considered to require careful attention in decision making and specific mitigation and monitoring measures should be identified to ensure adverse impacts are as low as reasonably practicable or the likelihood of occurrence is significantly reduced or that beneficial impacts are delivered.
- **'Extreme' residual risks** occur when a significant change from baseline is predicted that exceeds legal limits and accepted standards. These warrant substantial consideration, when compared with other environmental, social or economic costs and benefits in making decisions on whether or not to allow a project to go ahead. Specific mitigation measures and monitoring should be identified to ensure risks of impact are well managed and the likelihood of occurrence is reduced.

If the risk assessment process has been successful, the majority of residual risks should be rated as no more than 'medium'. High or extreme residual risks should only arise where there are special circumstances preventing their mitigation, and management measures should aim to reduce the likelihood of these events occurring. Ordinarily, there should be no residual risks rated as extreme and any such eventuality would demand the application of offsets.

The project risk assessment is provided in Appendix 12 and potential impacts related to preliminary key environmental factors and other factors or matters are discussed in detail in Sections 6 and 7.

5.2 SCREENING OF IMPACTS

During the impact assessment completed to support this ERD, a number of potential impacts were determined to have a low inherent risk (i.e. prior to implementation of any mitigation measures) and/or a low residual risk following the consideration of standard industry-practice management measures.

These low risk impacts have been screened out to enable the detailed impact assessment to focus on potential impacts with inherent risks considered to be medium or above. The low risk impacts are discussed briefly in the following sections with rationale provided as to why they have been excluded from the more detailed assessment.

5.3 MITIGATION AND MANAGEMENT MEASURES

Risk assessments are designed to ensure that decisions on projects are made in full knowledge of potential impacts on the environment and society. A vital step within the process is the identification of measures that can be taken to ensure the risk of adverse impacts is as low as reasonably practicable and positive impacts are maximised. This is achieved by undertaking an assessment to identify where significant impacts could occur and then working with the wider project team to identify technically and financially feasible ways of mitigating and reducing the associated risk of these potential impacts.

When developing the mitigation and management measures for this Proposal, the following hierarchy of controls was considered:

- **Avoid**: Measures that avoid an impact.
- **Minimise**: Measures that minimise or reduce an impact (examples include storing hydrocarbons in impermeable storage areas or implementing measures to reduce dust emissions from vehicle travel on unsealed roads).
- **Rehabilitate**: Measures that rectify, repair, rehabilitate or restore an impact.

- **Offset:** Required in the event that significant residual environmental impacts remain following the application of the above measures.

Environmental Management Plans will include monitoring programs to verify impact predictions and the effectiveness of the mitigation and management measures. An adaptive management framework will exist during implementation, and plans will be updated as required according to new information or changing circumstances, experiences and lessons.

5.4 DEALING WITH UNCERTAINTY

Risk assessments often include a level of uncertainty, which exists due to a number of factors, including the complexity and interdependencies of natural systems and limited data sets. The risk assessment for the Proposal involved subject matter experts and was based on current knowledge and data informed with modelling where possible and appropriate. An inherently conservative approach (i.e. worst case or tending to overestimate likelihood and/or consequence) was applied to ensure uncertainties in the risk assessment are unlikely to lead to a shortfall in corresponding mitigation and management measures.

6. PRELIMINARY KEY ENVIRONMENTAL FACTORS

6.1 PRELIMINARY KEY ENVIRONMENTAL FACTOR 1 – FLORA AND VEGETATION

6.1.1 EPA Objective

The EPA objective for flora and vegetation is 'To protect flora and vegetation so that biological diversity and ecological integrity are maintained' (EPA 2016c).

6.1.2 Policy and Guidance

Flora and vegetation are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
- *Biodiversity Conservation Act 2016* (WA).
- *Environmental Protection Act 1986* (WA).

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in the impact assessment for flora and vegetation:

- EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b).
- EPA Environmental Factor Guideline – Flora and Vegetation (EPA 2016c).
- EPA Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment (EPA 2016d).

6.1.3 Receiving Environment

A number of vegetation and flora surveys have been undertaken for the Proposal and regional area as summarised in Table 24. Earlier botanical survey work was conducted with reference to *Guidance Statement No. 51: Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004a), however the latest report was consistent with the *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016d).

The Proposal is situated within the Fortescue Botanical District, which is within the Pilbara region (Beard 1990). Under the Interim Biogeographical Regionalisation for Australia (IBRA), the Proposal is located within the Chichester (PIL1) subregion of the Pilbara bioregion (DoEE 2018).

According to Beard (1990), the vegetation is predominantly characterised by tree and shrub steppe communities with *Eucalyptus* trees, *Acacia* shrubs, *Triodia pungens* and *Triodia wiseana*. Some mulga occurs in valleys and there are short grass plains on alluvial areas (Beard 1990).

The Chichester IBRA subregion (PIL1) covers the northern part of the Pilbara Craton and is geologically characterised by undulating Archaean granite and the basalt plains include areas of basaltic ranges. The plains predominately support a shrub steppe characterised by *A. inaequilatera* over *T. wiseana* hummock grasslands and *E. leucophloia* tree steppes generally occur on ranges (Kendrick and McKenzie 2001).

Table 24: Summary of Flora and Vegetation Surveys

Survey Date	Consultant	Description
April 2001	M. E. Trudgen and Associates	General flora collection survey conducted with 81 quadrats established and recorded along the proposed access road and around the proposed mine and processing areas (including Kangaroo Caves and Bernts areas).
October 2001	M. E. Trudgen and Associates	Vegetation survey of the Proposal area (including Kangaroo Caves and Bernts areas) and additional flora collections.
April 2006	M. E. Trudgen and Associates	Rare flora survey of the Proposal area.
May 2006	M. E. Trudgen and Associates	Rare flora survey focussing on proposed element locations and a vegetation survey of the previously proposed camp site.
May 2007	M. E. Trudgen and Associates	Vegetation and flora survey of new Proposal areas, around the plant site, that were not covered by previous surveys.
June 2007	M. E. Trudgen and Associates	Vegetation and flora survey of new Proposal areas, including the airstrip and camp that were not covered by previous surveys.
2007	Mattiske Consulting Pty Ltd	Review of the flora and vegetation survey data and an assessment of GDEs. Remapping of vegetation associations prepared by Trudgen (2002, 2006, 2007a, 2007b).
2012	Ecologia	*Pityrodia* sp. Marble Bar Targeted Flora Survey. Unpublished report by Ecologia Environment for Fortescue Metals Group Ltd. Ecologia Environment.
2013	Outback Ecology	Level 1 Vegetation and Flora survey of the Proposal area to review the previous vegetation mapping and search for conservation significant species.
2016	Ecologia	*Pityrodia* sp. Marble Bar Regional Survey 2015. Unpublished report by Ecologia Environment for FMG Iron Bridge (Aust) Pty Ltd. Ecologia Environment.
2018	Mattiske Consulting Pty Ltd	A Review of the Flora and Vegetation – Sulphur Springs Zinc Copper Project. Unpublished report prepared for Venturex Resources Ltd.

6.1.3.1 Local Context

Flora and vegetation surveys conducted for the Proposal cover 12,520 ha (Mattiske 2018, Appendix 13). The survey area is far larger than the Development Envelope (889.2 ha) due to the long history of the Proposal and the different options previously considered. About 11,631 ha, more than 13 times the size of the Development Envelope, have been surveyed outside the Development Envelope. The full extent of vegetation communities and flora species of conservation significance mapped are shown in Figure 15 and within the Development Envelope in Figure 16.

6.1.3.2 Flora

A total of 360 vascular plant taxa, representative of 139 genera and 48 families, were recorded within the flora survey area. The majority of taxa recorded were representative of the Fabaceae (77 taxa), Poaceae (60 taxa) and Malvaceae (37 taxa) families. Within the Development Envelope, a total of 185 vascular plant taxa, representative of 84 genera and 35 families were recorded. The majority of the taxa recorded were widespread both locally and more broadly within the associated biogeographical subregion (Appendix 13). Earlier survey mapping by Trudgen (2002) is also provided in Appendix 14.

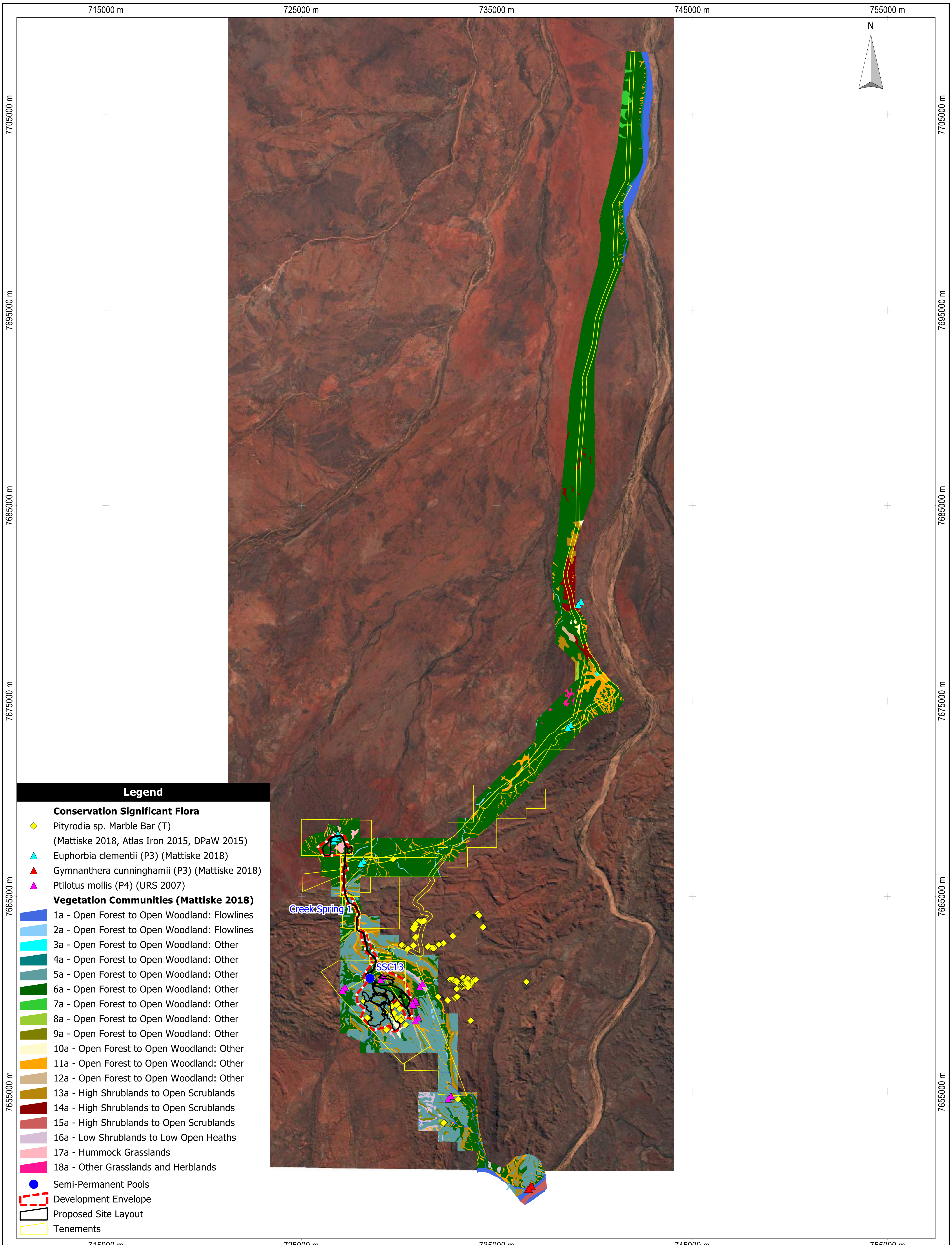

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Image source: Copernicus Sentinel Data 2018
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Figure 15

Conservation Significant Flora and Vegetation Communities Within the Survey Area

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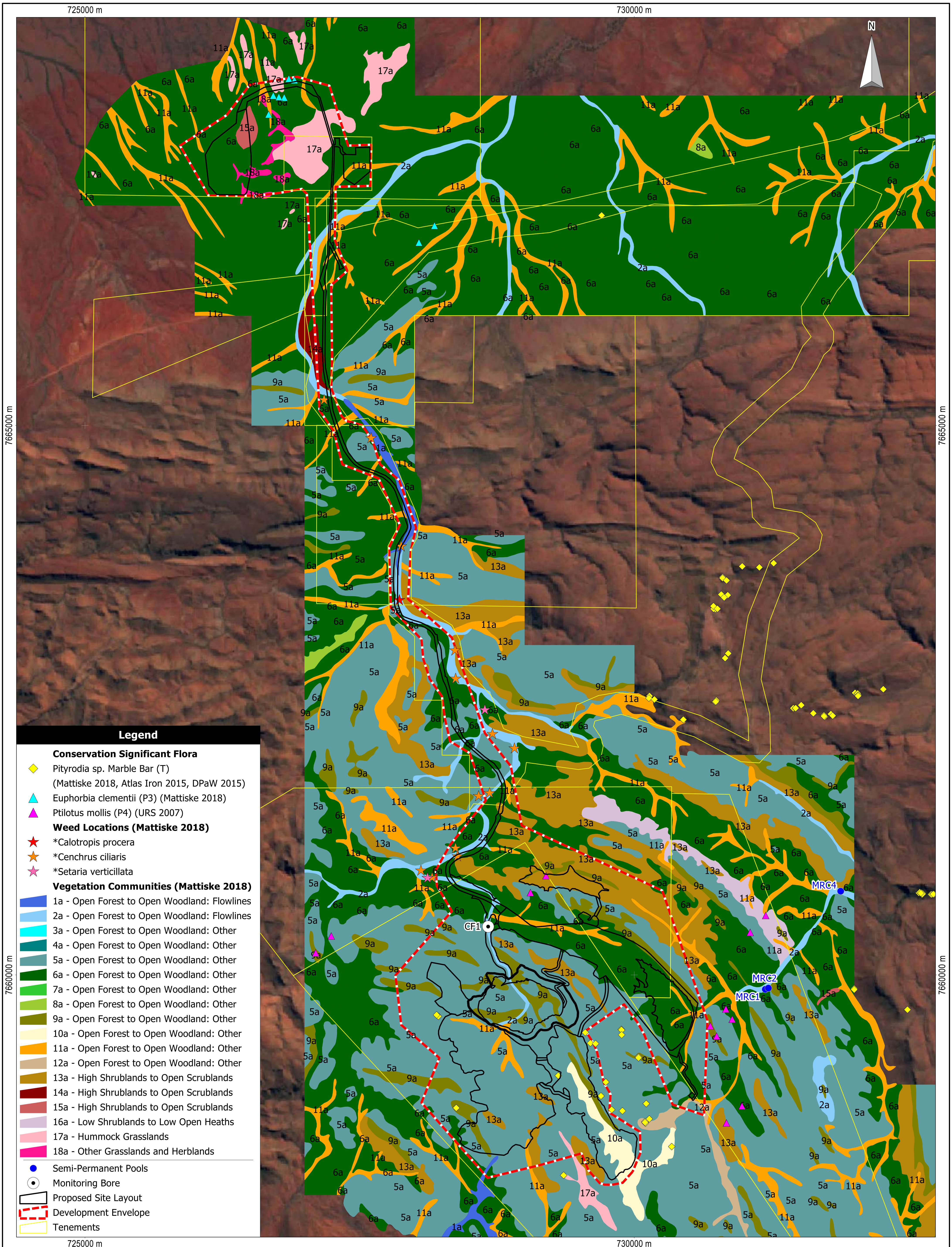

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Figure 16

Conservation Significant Flora and Vegetation Communities Within the Development Envelope

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6.1.3.3 Conservation Significant Species

One Threatened flora taxa, *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) listed as Endangered under both the *EPBC Act* and the *BC Act*, was recorded during flora surveys. *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) was recorded both within and outside of the Development Envelope (Figure 15, Figure 16). The Environmentally Sensitive Area (ESA), a 50 m radius around the plants, is shown in Figure 17.

Two Priority flora taxa, *Euphorbia clementii* (P3) and *Ptilotus mollis* (P4), as listed by DBCA, were recorded within the Development Envelope, in the accommodation village area and in the North Pond area respectively (Figure 16). A third Priority flora taxa; *Gymnanthera cunninghamii* (P3), was recorded in the local area, outside the Development Envelope (Appendix 13) (Table 25).

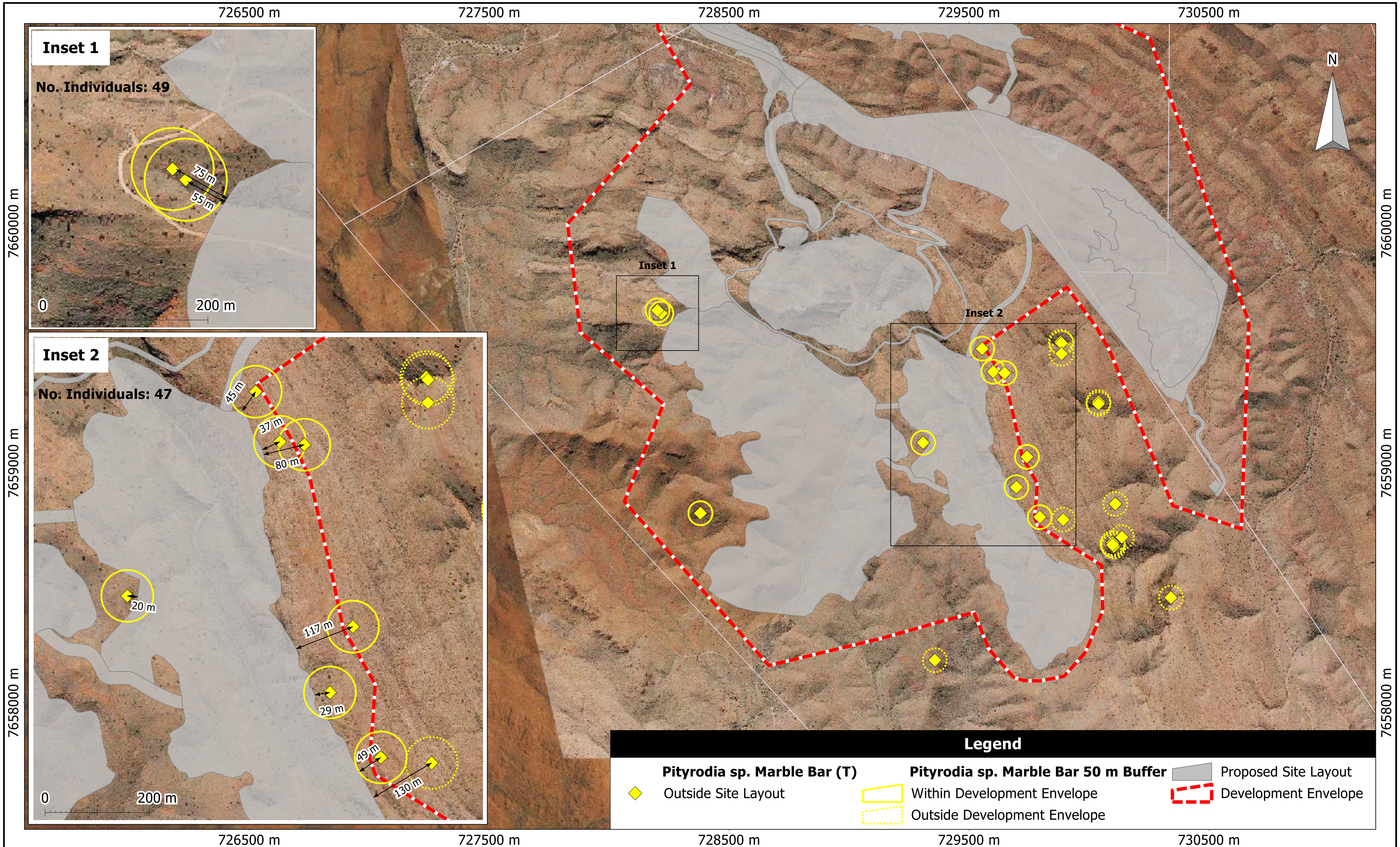
Table 25: Conservation Significant Species Recorded in the Proposal Area

Species	CC	Habitat	Recorded	Impacts
Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4)	T(E)	Occurs on sandstone hill slopes with skeletal sandy loams. Favours steep, rocky areas with a southerly or easterly aspect within the Capricorn Land System.	Recorded within and around wider Proposal area.	No direct impact. Elevated risk of indirect impact to individuals (8 plants).
Euphorbia clementii	P3	Occurs on gravelly hillsides and stony grounds.	Recorded along access road and in vicinity of airstrip.	None
Gymnanthera cunninghamii	P3	Occurs on sandy clay loams and sands. Commonly found on sandplains and drainage lines.	Recorded to the south of mining area.	None
Ptilotus mollis	P4	Occurs on stony hills and screes, common on ironstone ridges but can also occur on siltstone and chert.	Recorded in mining area and to the south.	Direct impact to one plant.

Legend:

CC = Conservation Code *T(E) = Threatened (Endangered) under the EPBC Act and BC Act* *P3 = Priority 3* *P4 = Priority 4*

Pityrodia sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is highly endemic and is only recorded in the Chichester IBRA subregion. It is a member of the Lamiaceae family and is a shrub that grows up to 2 m tall with predominately grey, densely hairy leaves and pink flowers that appear from July to September. *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is very distinctive in the surrounding landscape and can readily be identified from a distance, including from helicopters during regional surveys (Ecologia 2016). *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) at Sulphur Springs is shown in Plate 7. It has previously been recorded from sandstone hill slopes with skeletal brown sandy loam. *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) favours steep, rocky areas with a southerly or easterly aspect within the Capricorn Land System (Ecologia 2016).



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Source: Landgate Locate Mosaic
Air Photo Date: 2019
Grid: MGA94(50)

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Figure 17

Location of Pityrodia sp. Marble Bar ESAs

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Plate 7: *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) (Grey Plant in Foreground) at Sulphur Springs to the West of Proposed WRD

Two colour variants have been observed, a 'green' (less frequent) variant and a 'grey' (more common) variant. 'Grey' individuals appear to have an indumentum almost entirely of white hairs, whereas the stem and leaf of 'green' individuals have yellow hairs and sepal hairs are pink. The inflorescence structure may also be more open in 'green' plants, with possibly a later, albeit overlapping flowering period (Ecologia 2016). Taxonomic studies are currently being conducted to further assess the variants, but at present, assessment will assume they are the one species.

As part of the requirements of Ministerial Statement 993 for the FMG Iron Bridge (Aust) Pty Ltd North Star Magnetite Project, a Regional Survey of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) was undertaken by Ecologia (2016). Ecologia (2016) reported that there are an estimated 9,848 individuals of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) within 67 populations known to occur in the Pilbara. Ecologia (2016) report that the actual number of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is likely to be larger as some areas were surveyed by helicopter and some areas were surveyed at a distance from tracks rather than detailed transect traverses typical of a Targeted Flora Survey. *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) occurs predominately in the Capricorn Land System, with only six records recorded in the Rocklea Land System.

Several surveys pertinent to *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) have been conducted across Venturex tenements. A total of 59 *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals have been recorded within the Development Envelope in seven clusters as shown in Figure 16 and Figure 17, and detailed in Table 26. A further three clusters (49 m, 80 m and 117 m, respectively, east of proposed TSF) representing 13 individuals were recorded outside the Development Envelope but the 50 m ESA for these was intersected by the Development Envelope (Table 26). The Proposal footprint intersects the 50 m ESA for five clusters, representing eight individuals.

Table 26: Distribution of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) Within or Near to the Development Envelope

Location	ESA Intersected by Proposal Footprint	Number of Plants
Within the Development Envelope		
20 m west of proposed TSF	Yes	4
29 m east of proposed TSF	Yes	1
37 m east of proposed TSF	Yes	1
45 m east of proposed TSF	Yes	1
55 m west of proposed WRD	No	20
75 m west of proposed WRD	No	29
155 m west of proposed WRD	No	3
Outside the Development Envelope but ESA Intersected		
49 m east of proposed TSF	Yes	1
80 m east of proposed TSF	No	1
117 m east of proposed TSF	No	11

6.1.3.4 Vegetation Communities

Eighteen (18) vegetation communities have been defined and mapped during flora surveys with 13 of these occurring within the Development Envelope (Appendix 13).

The vegetation communities are shown in Figure 16 with details provided in Table 27.

6.1.3.5 Threatened and Priority Ecological Communities

No TECs as defined by the *EPBC Act 1999* (Commonwealth) or the *BC Act 2016* occur within the Development Envelope or adjacent areas.

No Priority Ecological Communities (PECs), as listed by DBCA (2018), occur within the Proposal area (Appendix 13).

Table 27: Vegetation Communities

Code	Description	Total Mapped (ha)	Total Within Development Envelope (ha)
1a	Open forest to open woodland of *Eucalyptus camaldulensis, Melaleuca argentea* and *Eucalyptus victrix* with scattered tall shrubs of *Indigofera monophylla* over *Schoenus falcatus, Cyperus vaginatus* and *Triodia longiceps* sedgeland/grasslands in riverbeds.	458.0	5.0
2a	*Eucalyptus victrix* scattered trees to open woodland which may include *Melaleuca glomerata* and *Melaleuca linophylla* over open to closed scrub in creek beds and low slopes.	177.7	27.7
3a	*Corymbia aspera* scattered low trees to low open woodland in creek beds.	4.8	0.0
4a	*Acacia tumida* high shrubland to low open forest in creeklines.	58.5	0.0
5a	*Eucalyptus leucophloia* scattered low trees over patches of *Acacia* shrubs over hummock grasslands of *Triodia* species, including *T. brizoides, T. wiseana* and *T. epactia* on ridge slopes.	2,253.4	343.4
6a	*Corymbia hamersleyana* scattered low trees to low open woodland over tall shrubs to open shrubland of *Acacia* spp. and *Grevillea wickhamii* over hummock grasslands on creek banks, flood banks and distributing fans.	7,285.8	279.7
7a	*Corymbia zygophylla* and *Corymbia hamersleyana* scattered low trees over hummock grasslands on sandplains.	66.8	0.0
8a	*Terminalia canescens* scattered low trees to low woodland on creek banks.	26.1	0.0
9a	*Atalaya hemiglauca, Acacia pruinocarpa, Ehretia saligna* var. *saligna, Acacia tumida, Eucalyptus ferriticola* subsp. *ferriticola* and *Ficus platypoda* scattered low trees over high open shrubland on steep, rocky gorge walls.	258.6	56.7
10a	Shrubland to open scrubland of *Acacia* species including *A. tumida, A. acradenia* and *A. orthocarpa* over hummock grasslands on upper and steep slopes.	43.2	13.4
11a	Shrubland to closed scrubland of *Acacia* species, including *A. acradenia, A. pyrifolia* and *A. tumida* along small creeklines and on the adjacent parts of valley floors and distributing fans.	818.4	34.7
12a	*Acacia inaequilatera* scattered tall shrubs to high open shrubland over *Triodia brizoides* hummock grasslands on ridge slopes and low hills.	36.7	1.0
13a	*Acacia inaequilatera* scattered tall shrubs to high shrubland over *Triodia wiseana* hummock grasslands occurring mainly on gentle lower slopes.	569.4	87.3
14a	*Acacia ancistrocarpa* high open shrubland to open scrub.	222.4	2.9
15a	*Acacia trachycarpa* high open shrubland to high shrublands.	44.8	5.1
16a	Low shrublands to low open heath on gentle slopes and undulating plains.	101.2	0
17a	Hummock grasslands on slopes and ridges.	55.1	24.2
18a	Cracking clay alliance on gentle sloping plains and seasonal damplands.	39.6	8.1
	Total	**12,520.5**	**889.2**

6.1.3.6 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are ecosystems that require groundwater in order to maintain their species composition, ecological processes and ecosystem services (SKM 2001). Many ecosystems rely purely on rainfall for their water requirements, but GDEs rely on additional input from groundwater. Changes in the timing, quantity, quality or distribution of groundwater may result in negative impacts on growth and health of vegetation of a GDE and ultimately lead to plant deaths and changes in ecosystem composition (Eamus 2009, Murray *et al.* 2003). Phreatophytes (plants dependent upon groundwater) can be divided into two types:

- Obligate phreatophytes rely on groundwater sources for maintenance of some part or all of their ecosystem function. This reliance can be continual, seasonal or episodic. These species are highly sensitive to reduced availability of groundwater.
- Facultative phreatophytes only require access to groundwater in some landscapes, but in other landscapes they can utilise alternate sources of water to maintain ecosystem function. The presence or absence of groundwater is not critical in determining the occurrence of these ecosystems (Eamus *et al.* 2006).

Astron Environmental Services (2008) conducted a search of FloraBase on species associated with creeks, depressions, drainage lines, floodplains, seasonally wet areas, swamps and watercourses in the Pilbara. It was anticipated that these types of habitat were more likely than others to support obligate and facultative phreatophytes (as well as non-groundwater dependent species). This resulted in a list of 368 species (trees, shrubs, climbers, herbs and grasses), including trees that characterise the creeks, rivers, banks and floodplains of the Pilbara region: *Eucalyptus camaldulensis*, *Eucalyptus victrix*, *Corymbia candida*, *Corymbia hamersleyana*, *Melaleuca argentea* and several *Acacia* species. These species were reviewed in detail in order to determine their reliance on groundwater and subsequent potential to act as indicators of the groundwater dependency of vegetation communities.

No known GDEs are present within the Development Envelope or surrounds as inferred from the National Groundwater Dependent Ecosystem Atlas (Appendix 13). The majority of the Sulphur Springs site is on the Groundwater Dependent Ecosystem Atlas, showing a low or moderate potential of occurrence of terrestrial GDEs (Appendix 13). There are three unclassified aquatic GDEs in close proximity to the Development Envelope identified by regional studies by the Department of Water associated with the De Grey river system. The GDEs are approximately 200, 600 and 800 m respectively from the boundary of the Development Envelope (Appendix 13).

Mattiske (2007) identified GDEs according to the presence of likely groundwater dependent flora species (floristic), structure and position (habitat) of the vegetation community in the landscape. Groundwater dependent flora species identified from Trudgen (2002) in the survey area included *E. camaldulensis, E. victrix, Melaleuca linophylla, Melaleuca glomerata, C. hamersleyana, Acacia tumida* var. *pilbarensis* and *Terminalia canescens*. A site visit in August 2007 indicated that *E. camaldulensis* and *E. victrix* are the main groundwater dependent flora species and *C. hamersleyana, A. tumida* var. *pilbarensis* and *T. canescens* are more widespread in occurrence in the survey area (Mattiske 2007).

A site visit in 2017 by Mattiske investigated seven sites within these communities. All sites had *E. victrix* as the dominant indicator tree species, while the midstorey and understorey was largely similar between sites (Appendix 13). Characteristics of the site (vegetation type, key species, presence of persistent water bodies, indicator tree species size and indicator tree species health) were scored in a matrix to produce a GDE likelihood score, with all seven sites scoring within the moderate likelihood range. Based on this study, Mattiske (2018) inferred that vegetation communities 1a and 2a had a moderate likelihood of being a GDE. The total mapped area of vegetation communities 1a and 2a within the Development Envelope totals 32.7 ha or 5.1% of the overall area.

6.1.3.7 Other Significant Flora

There are a number of species that could be considered significant flora as they have ranges significantly outside their current distribution (range extensions). These species include *Cymbopogon procerus*, *Cyperus viscidulus*, *Tephrosia spechtii, Mallotus ?dispersus, Sida* sp. A Kimberley Flora (P.A. Fryxell & L.A. Craven 3900) and *T. canescens*. The aforementioned species are species that mostly occur in the Kimberley region of Western Australia. Trudgen (2002) did not voucher any of these specimens with the Western Australian Herbarium and due to taxonomic changes over time, it is difficult to confirm these taxa with a great deal of certainty (Appendix 13).

Other species that have minor range extensions (under 100 km) include *Ehretia saligna* var. *saligna, Eriachne tenuiculmis, Polygala isingii* and *Pterocaulon sphaeranthoides*. These species are known to occur at other locations within the Pilbara bioregion.

6.1.3.8 Introduced Species

Weeds were recorded over the same area as the 2017 flora and vegetation survey by Mattiske (2018). A total of three introduced (weed) species were recorded as shown in Figure 16. One of these, **Calotropis procera* (Rubber Bush), is a Declared Pest Organism pursuant to Section 22 of the *Biosecurity and Agriculture Management Act 2007* (*BAM Act*). **Calotropis procera* is categorised as 'exempt', requiring no permit or conditions for keeping.

The remaining two weed species, **Cenchrus ciliaris* (Buffel Grass) and **Setaria verticillata* (Whorled Pigeon Grass), are permitted under Section 11 of the *BAM Act*. These species are currently not assigned to any control category for local government areas. All weed species were noted to be restricted to the main access road drainage line; however, this assessment of distribution was likely a reflection of the survey scope (Appendix 13).

6.1.3.9 Survey Limitations

Table 28 provides a general assessment of the Mattiske 2018 survey against a range of factors that may have limited the outcomes and conclusions of the report. Based on this assessment, it was concluded that the survey was not subject to constraints which would affect its thoroughness and the conclusions which have been formed (Appendix 13).

Table 28: Potential Limitations of Mattiske Survey Findings (Appendix 13)

Potential Survey Limitation	Impact on Survey
Availability of contextual information at a regional and local scale	Not a limitation: Reference resources such as Beard's mapping and historical survey data in the vicinity of the survey area, together with online flora and vegetation information, has provided an appropriate level of information for the current survey.
Competency/experience of team carrying out survey; experience in the bioregion surveyed	Not a limitation: All botanists had extensive experience working in a range of botanical districts across the State. The majority of plants observed in the field were collected for formal identification and were compared with specimens at the Western Australian State Herbarium where required.
Proportion of flora collected and identification issues	Potential limitation: The field survey was conducted after the peak flowering period for the Pilbara area. Whilst the late November period was not ideal, identification of Threatened and Priority flora species was not impacted due to some species still retaining fruit or identifications being able to be made on sterile material collected.
Effort and extent of survey (Was the appropriate area surveyed for the type of survey (reconnaissance / targeted / detailed))	Not a limitation: The intensity of the survey effort of the Sulphur Springs Project was considered to be sufficient. Resources, in terms of equipment, support and personnel were adequate.
Access restrictions within survey area	Not a limitation: Vehicle access to gorge and rocky slopes in the Sulphur Springs Project was at times difficult. However, foot traverses were sufficient to allow access to the entirety of the survey area.
Survey timing, rainfall, season of survey	Potential limitation: The EPA (2016d) recommends that flora and vegetation surveys in the Eremaean Botanical Province be conducted 6 – 8 weeks post wet season (March – June). The Mattiske survey was conducted in late November which falls outside of this period. Rainfall in the six months preceding the survey was slightly below average; however, the wet season (Jan – Mar) experienced above average rainfall with 487.2 mm compared to 255.9 mm. Although these factors may affect the completeness of the species list, they are not expected to have a significant effect on mapping reliability or on the identification of Threatened and Priority species in the area as the majority were perennial species. Specifically, the timing of the field survey would be unlikely to affect the ability to accurately identify the Threatened taxon, *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4), as this taxon is readily identifiable based on vegetative features that persist perennially. Identifying other conservation significant flora, such as *Euphorbia clementii* (P3), *Acacia levata* (P3), *Eragrostis crateriformis* (P3), *Fimbristylis sieberiana* (P3), *Heliotropium murinum* (P3), *Heliotropium muticum* (P3), *Triodia basitricha* (P3), *Bulbostylis burbidgeae* (P4) and *Ptilotus mollis* (P4) may be moderately influenced by the timing of the recent studies. However, in view of the previous extensive foot traverses undertaken by Trudgen (2002, 2006, 2007a, 2007b) across the Proposal area, additional occurrences of these Priority species are unlikely to be substantial.
Disturbances (fire/flood/clearing)	Not a limitation: The Sulphur Springs Project exhibits negligible levels of disturbance from agricultural and mining activities.
Data and statistical analysis	Not a limitation: Introduced species, annual species and singletons were excluded from the data set prior to analysis. Data collected was sufficient for delineation of vegetation communities based on statistical analysis.

6.1.4 Potential Impacts

Potential direct and indirect impacts to flora and vegetation, with inherent risks specified in brackets, include:

- Direct loss of native vegetation, including conservation significant species (high inherent risk).
- Indirect impacts to native vegetation from modification of surface water or groundwater quality due to spills (medium inherent risk).
- Indirect impacts to vegetation communities 1a and 2a due to overtopping of pit lake at closure (medium inherent risk).
- Indirect impacts to native vegetation in the Sulphur Springs Creek catchment from contamination of groundwater due to seepage from the TSF, WRD or pit (medium inherent risk).
- Indirect impacts to native vegetation due to dust emissions (medium inherent risk).
- Introduction and/or increased spread of weeds (medium inherent risk).
- Indirect impacts to vegetation communities in the Minnieritchie Creek and Six Mile Creek catchment areas from contamination of groundwater due to seepage from the TSF (low inherent risk).
- Indirect impacts to vegetation communities in the Minnieritchie or Sulphur Springs Creek catchment areas from contamination of groundwater due to seepage from storage ponds (low inherent risk).
- Indirect impacts to GDEs due to mine dewatering (low inherent risk).
- Indirect impacts to native vegetation from contamination of groundwater due to seepage from low grade stockpile or ROM pad (low inherent risk).
- Altered fire regime impacting vegetation health and condition (low inherent risk).
- Indirect impacts to native vegetation from modification of groundwater flows and/or groundwater levels (low inherent risk).
- Erosion of mine waste landforms resulting in sediment discharge and smothering of plants (low inherent risk).
- Vehicle movements off designated roads and tracks resulting in loss or reduced health and condition of native vegetation (low inherent risk).
- Habitat fragmentation or modification for conservation significant species (low inherent risk).
- Seepage from the TSF causing groundwater mounding and indirect impacts to vegetation health and condition (low inherent risk).
- Indirect impacts to native vegetation due to overtopping of storage ponds (low inherent risk).
- Indirect impacts to native vegetation from modification of surface water flows (low inherent risk).
- Direct or indirect impacts to other significant flora (low inherent risk).

Potential cumulative impacts of the Proposal are outlined in Section 6.1.6.

6.1.5 Assessment of Potential Direct and Indirect Impacts

Potential impacts of project development on flora and vegetation were assessed in accordance with the approach outlined in Section 5. Findings of surveys conducted within the Proposal area and the broader region in accordance with EPA policy and guidance, were utilised in conjunction with preliminary project design to inform the impact assessment. This assessment and resultant inherent risk ratings (i.e. prior to mitigation and management measures) are provided in Appendix 12.

Potential impacts assessed as 'low' risk and screened out from a further detailed assessment within the following sub-sections, are briefly discussed in Table 33. The remaining inherent 'moderate' risk impacts are discussed in the following sections. No inherent 'high' risk impacts are anticipated.

6.1.5.1 Direct Loss of Native Vegetation, Including Conservation Significant Species

Up to 313.6 ha of vegetation will be cleared for the Proposal. All vegetation communities proposed to be cleared are common in the wider region and present outside the Development Envelope. There are no TECs or PECs within or adjacent to the Development Envelope.

Total areas and relative percentages of clearing for each vegetation community are presented in Table 29. The majority of vegetation within the Development Envelope comprises open forest to open woodland vegetation communities 5a (38.6%) and 6a (31.5%). These vegetation communities are characterised by scattered to low open woodlands of *Eucalyptus/Corymbia* over *Acacia* shrubs over hummock grasslands. Vegetation community 5a occurs on ridge slopes and community 6a occurs on creek banks, flood banks and distributing fans. Approximately 28% of vegetation community 10a in the survey area will be cleared. For all other vegetation communities, less than 8% of each mapped by project surveys will be cleared. The majority of clearing will occur in vegetation communities 5a (129.8 ha or 5.8% of the total mapped area) and 6a (106.1 ha or 1.5% of the total mapped area).

One Threatened (Endangered) flora species, *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4), and two Priority flora species (*Euphorbia clementii* (P3) and *Ptilotus mollis* (P4)) have been recorded in the Development Envelope (Table 25, Figure 16). All of these species have also been recorded outside the Development Envelope. The placement of infrastructure in relation to *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is shown in Figure 17. No direct loss of individuals of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) will occur.

All vegetation communities proposed to be cleared are common in the wider region and present outside the Development Envelope. However, populations of conservation significant flora do exist in close proximity to and within the Development Envelope. Without any mitigation measures in place to manage clearing, the inherent risk of loss of biological diversity and conservation significant species is considered to be 'high'. Appropriate mitigation measures to address this potential impact are presented in Table 37.

Table 29: Direct Impacts on Vegetation Communities

Code	Description	Total Mapped* (ha)	Total Mapped in Development Envelope (ha)	Proposed Clearing Area (ha)	Percentage Cleared of Total Mapped (%)
Open Forest to Open Woodland: Flowlines					
1a	Open forest to open woodland of *Eucalyptus camaldulensis*, *Melaleuca argentea* and *Eucalyptus victrix* with scattered tall shrubs of *Indigofera monophylla* over *Schoenus falcatus*, *Cyperus vaginatus* and *Triodia longiceps* sedgeland/grasslands in riverbeds.	458.0	5.0	1.4	0.3%
Open Forest to Open Woodland: Other					
2a	*Eucalyptus victrix* scattered trees to open woodland which may include *Melaleuca glomerata* and *Melaleuca linophylla* over open to closed scrub in creek beds and low slopes.	177.7	27.7	8.3	4.7%
3a	*Corymbia aspera* scattered low trees to low open woodland in creek beds.	4.8	0.0	0.0	0.0%
4a	*Acacia tumida* high shrubland to low open forest in creeklines.	58.5	0.0	0.0	0.0%
5a	*Eucalyptus leucophloia* scattered low trees over patches of *Acacia* shrubs over hummock grasslands of Triodia species, including *T. brizoides*, *T. wiseana* and *T. epactia* on ridge slopes.	2,253.4	343.4	129.8	5.8%
6a	*Corymbia hamersleyana* scattered low trees to low open woodland over tall shrubs to open shrubland of *Acacia* spp. and *Grevillea wickhamii* over hummock grasslands on creek banks, flood banks and distributing fans.	7,285.8	279.7	106.1	1.5%
7a	*Corymbia zygophylla* and *Corymbia hamersleyana* scattered low trees over hummock grasslands on sandplains.	66.8	0.0	0.0	0.0%
8a	*Terminalia canescens* scattered low trees to low woodland on creek banks.	26.1	0.0	0.0	0.0%
9a	*Atalaya hemiglauca*, *Acacia pruinocarpa*, *Ehretia saligna* var. *saligna*, *Acacia tumida*, *Eucalyptus ferriticola* subsp. *ferriticola* and *Ficus platypoda* scattered low trees over high open shrubland on steep, rocky gorge walls.	258.6	56.7	20.4	7.9%
High Shrublands to Open Scrublands					
10a	Shrubland to open scrubland of *Acacia* species including *A. tumida*, *A. acradenia* and *A. orthocarpa* over hummock grasslands on upper and steep slopes.	43.2	13.4	12.1	28.0%
11a	Shrubland to closed scrubland of *Acacia* species, including *A. acradenia*, *A. pyrifolia* and *A. tumida* along small creeklines and on the adjacent parts of valley floors and distributing fans.	818.4	34.7	15.9	1.9%

Code	Description	Total Mapped* (ha)	Total Mapped in Development Envelope (ha)	Proposed Clearing Area (ha)	Percentage Cleared of Total Mapped (%)
12a	*Acacia inaequilatera* scattered tall shrubs to high open shrubland over *Triodia brizoides* hummock grasslands on ridge slopes and low hills.	36.7	1.0	0.002	<0.1%
13a	*Acacia inaequilatera* scattered tall shrubs to high shrubland over *Triodia wiseana* hummock grasslands occurring mainly on gentle lower slopes.	569.4	87.3	14.4	2.5%
14a	*Acacia ancistrocarpa* high open shrubland to open scrub.	222.4	2.9	0.2	0.1%
15a	*Acacia trachycarpa* high open shrubland to high shrublands.	44.8	5.1	2.8	6.2%
Low Shrublands to Low Open Heaths					
16a	Low shrublands to low open heath on gentle slopes and undulating plains.	101.2	0.0	0.0	0.0%
Hummock Grasslands					
17a	Hummock grasslands on slopes and ridges.	55.1	24.2	1.0	1.8%
Other Grasslands and Herblands					
18a	Cracking clay alliance on gentle sloping plains and seasonal damplands.	39.6	8.1	1.3	3.2%
	Total	**12,520.5**	**889.2**	**313.6**	**2.5%**

* *Mapped area shown in Figure 15*

6.1.5.2 Indirect Impacts to Native Vegetation from Modification of Surface Water or Groundwater due to Spills

Indirect impacts to native vegetation may result from contamination of surface water or groundwater due to spills of the following:

- Hydrocarbons, reagents and other chemicals used in mining and ore processing. Diesel will be used as fuel for the mining fleet and refuelling will occur from a purpose built fuel facility.
- Process slurries. Handling of most process slurries will largely be restricted to the processing plant area. Overland pipeline/s will be installed for transfer of tailings slurry from the processing plant to the TSF. Tailings slurry will be alkaline (pH of approximately 8), with the potential to generate acidity if exposed to oxygen and water.
- Mine water. Mine water will be transferred to a water treatment plant and used for ore processing or pumped to a storage pond (North Pond or South Pond) via overland pipelines. In the early stages of the project, mine water quality will be similar to existing groundwater, with low pH and elevated metal and metalloid concentrations.
- TSF decant water. Water recovered from the TSF decant will be returned to the processing plant area via an overland pipeline/s. This water has the potential to be acidic, saline and contain elevated concentrations of metal and metalloids.

Spills or failure of pipelines, material containment or equipment malfunction may result in discharge of these materials into the wider environment. The inherent risk of contamination or flora and vegetation death due to spills is therefore considered to be 'medium'. Appropriate mitigation measures to address this potential impact are presented in Table 37.

6.1.5.3 Indirect Impacts to Vegetation Communities 1a and 2a due to Overtopping of Pit Lake at Closure

Pit Lake Level

A conceptual hydrological model for the pit at closure is included in Figure 18. Once mining is complete, the mine void will slowly fill. The rate of flooding will decrease once the water level reaches the pit floor (having first filled the underground mine voids) as the void volume per metre rise will increase significantly, and evaporation from the pit lake surface becomes significant (Appendix 16). Seepages from both the TSF and the portion of the WRD within the pit catchment area will drain to the water table and express from the pit walls below the valley floor. Modelling of the pit lake included the following inflows:

- Rainfall and surface water runoff. Annual rainfalls of 365 mm, 445 mm, 465 mm and 505 mm (compared with the current 30 year moving average for the site of 445 mm) were modelled to test the sensitivity of outcomes. Various catchment area scenarios were also modelled to inform modifications required to ensure the pit remains a hydraulic sink at closure. These modifications were outlined in Section 2.2.3.4.
- Native groundwater inflow, determined by hydrogeological modelling after dewatering ceases. Two inflow rates were considered: a base case and an alternative case (using lower host rock hydraulic conductivity and specific storage).
- Seepage from the TSF footprint. Seepage rates of 0%, 5% and 10% of annual rainfall were considered to test the sensitivity of outcomes.
- Seepage from the WRD footprint. A seepage rate of 10% of annual rainfall was assumed.

The pit lake level will fluctuate with the varying rates of groundwater, rainfall and surface runoff inputs and evaporative loss. The volume of surface runoff, governed by the amount of rainfall and upstream catchment area, is a dominant influence on the pit water balance and predicted equilibrium water level, where over the long term, inflows match evaporative losses. The predicted equilibrium and rainfall event-based pit lake levels have been modelled for a number of catchment scenarios and are summarised in Table 30 (Appendix 9). Without diversion of runoff from any of the sub-catchments, the pit lake will slowly fill over 90 – 100 years and is likely to overflow in the long term. With sub-catchment modifications proposed in Section 2.2.3.4, the pit lake level remains below the point of surface discharge (1,245 mRL) under all PMP and ARI scenarios associated with both the 20 and 30 year moving average rainfalls. Under the most extreme rainfall events modelled, the pit lake level is predicted to seep to groundwater on the downgradient side of the pit. The likelihood of these events is estimated to be in the order of 1 in 10 million years (AECOM 2020c, Appendix 17). On this basis it can be concluded that the mine pit will remain a groundwater sink.

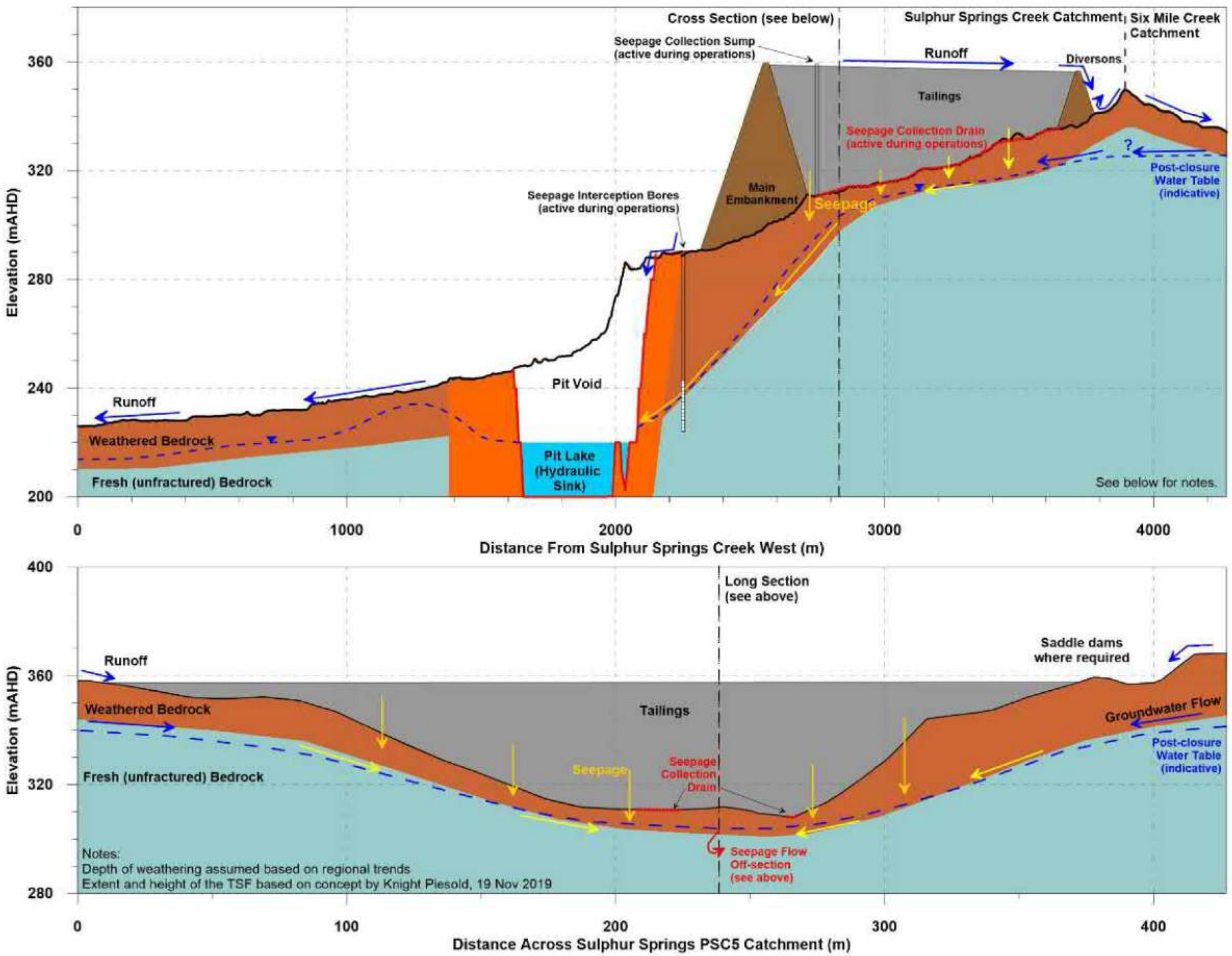
Assessment of inherent risk assumed no sub-catchment modifications. Under this scenario, the volume of pit overflow would depend on the annual rainfall. In dry years, there may be no discharge, while in wet years, it is considered more likely. An inherent likelihood of 'likely' has therefore been adopted.

Table 30: Simulated Pit Lake Water Levels for Average Annual Rainfall of 445 and 465 mm (Base Case)

Rainfall Scenario	Rainfall (mm)	Pit Water Level (mRL) with Pit Catchment Modified[1]	
		Annual Rainfall (mm)	
		445	465
Annual Rainfall		1,221	1,227
100 yr ARI 72 hr	376	1,224	1,230
1,000 ARI 72 hr	537	1,226	1,231
PMP 1 hr	590	1,226	1,232
PMP 3 hr	1,140	1,230	1,236
PMP 24 hr	1,530	1,233	1,239
PMP 48 hr	1,820	1,235	1,241
PMP 72 hr	2,300	1,239	1,244

Indicates seepage discharge from pit lake (> 1,235 mRL) (shaded cells: PMP 3 hr–72 hr at 465; PMP 48 hr and 72 hr at 445)

[1] *Modifications outlined in Section 2.2.3.4*



Not to Scale
Original Size: A4

Source: AECOM Sulphur Springs Project Groundwater Assessment 2020

Venturex Resources Limited
Sulphur Springs Project

Figure 18

Conceptual Groundwater Model for the Proposed Sulphur Springs Mine Area

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Pit Lake Water Quality

Baseline hydrological and hydrogeological models and tailings and waste rock leachate quality data (Appendix 3 and Appendix 9) were utilised to predict pit lake water quality (Table 31). This water body is predicted to become increasingly saline, with TDS values ranging from 5,259 mg/L (slightly saline) after 100 years to 26,609 mg/L (saline) after 1,000 years. Substantial (>50%) proportions of cadmium, nickel, selenium and zinc inputs are predicted to remain in solution following geochemical equilibration. Concentrations of nickel and selenium may exceed those in existing groundwater within the footprint. All other metal and metalloid concentrations are likely to remain similar to or below those in existing groundwater within the pit footprint (Table 31). Based on predicted TSF seepage water quality and alkalinity in the broader aquifer below the mine and TSF area, the pit lake water is expected to be circum neutral.

Table 31: Predicted Pit Lake Water Quality

Parameter	Guideline Value[1]	Existing Groundwater within Pit Footprint	Predicted Pit Lake Water
TDS (mg/L)	4,000	1,010 - 11,600	5,259 – 26,609
Cu (mg/L)	1	0.019 - 3.02	0.03
Ni (mg/L)	1	0.154 - 0.495	0.365 – 1.00
Zn (mg/L)	20	54 - 218	14.1 – 33.2
As (mg/L)	0.5	0.4 - 0.52	0.0001
Cd (mg/L)	0.01	0.0012 - 0.46	0.024 – 0.064
Se (mg/L)	0.02	<0.01 - <0.1	0.125 – 0.661

[1] ANZECC and ARMCANZ (2000): Livestock Drinking Water; NEPC (1999): Investigation levels for livestock; DER (2014): Non-potable groundwater use.

Vegetation Communities 1a and 2a Downstream of the Pit

Under a pit overtopping event, surface water quality impacts may be evident along Sulphur Springs Creek, as far downstream as the accommodation village. Vegetation communities 1a and 2a present along this path are shown in Table 32. Based on water quality data presented in Table 31, any consequences to these communities are predicted to be chronic, rather than acute and may include stunted growth or impaired recruitment.

Table 32: Vegetation Communities 1a and 2a Between Pit and SSWB36

Significant Vegetation	Total Area of Community (ha)
Vegetation Community 1a	1.48
Vegetation Community 2a	2.72

Taking a conservative approach (i.e. tending to overestimate impact), the inherent risk of indirect impacts to 2.72 ha of vegetation community 2a (representing approximately 1.5% of vegetation community 2a mapped in the Proposal area) and 1.48 ha of vegetation community 1a (representing approximately 0.3% of vegetation community 1a mapped in the Proposal area) due to overtopping the pit lake at closure is considered to be 'medium'.

Simulated pit lake levels demonstrate that the residual risk of this impact is reduced to 'low' with adoption of catchment management measures outlined in Section 2.2.3.4 and Table 37.

6.1.5.4 Indirect Impacts to Native Vegetation in the Sulphur Springs Creek Catchment from Contamination of Groundwater due to Seepage from the TSF, WRD or Pit

Indirect impacts to native vegetation in the Sulphur Springs Creek catchment may result from contamination of groundwater due to seepage from the TSF, WRD (operational and closure phases) or pit (closure phase).

Existing groundwater discharging to Sulphur Springs Creek in the vicinity of the proposed pit is naturally sulphidic with pH values ranging from 2 to 4. Baseline surface water and groundwater quality in the vicinity of the mineralised area (both upstream and downstream) currently exceed hardness modified trigger values (HMTVs) for 95% protection of freshwater species (ANZECC and ARMCANZ 2000) for some metals. Existing salt-scarring along a 450 to 500 m stretch of Sulphur Springs Creek, immediately downgradient of the proposed pit, provides an indication of the extent of existing and potential future groundwater discharges, should the pit become a groundwater seepage source. Based on this, it is anticipated that any surface expression of groundwater containing seepage that has originated from the TSF, WRD or pit area would extend to just upstream of CF1 (Figure 16). Approximately 0.27 ha of vegetation community 2a (mapped as 'potential GDE') lies outside the Proposal footprint between the pit and CF1 and may be indirectly impacted.

During the operational phase:

- TSF seepage will migrate vertically from the tailings and mix with native groundwater at the water table. Seepage and native groundwater will naturally focus at the invert of the steep sided valley and migrate downgradient within the PSC5 catchment towards the mine pit due to the underlying contours and stratigraphy. It will be intercepted by underdrains and downstream recovery bores, with any residual captured in drains in the pit (Appendix 16).
- Seepage from the northern portion of the WRD (encompassing PAF encapsulation areas as shown on Figure 10) will migrate downgradient towards the mine pit due to underlying contours and stratigraphy.
- Existing acidic discharges along Sulphur Springs Creek will cease once mine dewatering lowers the water table below the creek bed. Groundwater within the resulting cone of depression, including seepage from the WRD and TSF will be captured within the mine dewatering system. The quality of ephemeral surface water between the pit and CF1 is expected to slowly change to a magnesium-bicarbonate type. This is likely to be reflected in reduced sulphate concentrations, though no significant change in the alkalinity or hydrochemistry of metals/metalloids is expected. In the longer term, surface water is expected to trend towards the bicarbonate-dominant water type observed in adjacent catchments. No adverse impacts to vegetation health are predicted from what will essentially be an improvement in water quality.
- The inherent risk of impacts during operations is considered to be 'low'.

Figure 18 shows the conceptual model for the mine and TSF. Following closure:

- The drawdown cone around the mine void is predicted to extend under the entire TSF (Figure 10). Seepage from the TSF after closure is expected to remain within the PSC5 catchment and migrate towards the mine void where it will be captured in a terminal sink.
- Seepage from the northern portion of the WRD will migrate towards the mine void where it will also be captured in a terminal sink. This volume will be very minor compared to other inflows to the pit lake.
- Water in the pit lake is predicted to become increasingly saline, with TDS values ranging from 5,259 mg/L (slightly saline) after 100 years to 26,609 mg/L (saline) after 1,000 years (Table 31, Appendix 9). Substantial (>50%) proportions of cadmium, nickel, selenium and zinc inputs are predicted to remain in solution following geochemical equilibration.
- Simulated pit lake levels indicate that without appropriate designs for management of inflows to the pit, it is almost certain that the water level will rise above the point where groundwater seepage occurs (1,235 mRL) Table 30). The pit lake could then become a groundwater source for a period, pushing contained water into the Sulphur Springs Creek catchment, until evaporation causes the water level to fall below 1,235 mRL. The consequences of this impact are predicted to be chronic, rather than acute and may include stunted growth

or impaired recruitment. They will be limited to 0.27 ha of vegetation community 2a in the zone between the pit and CF1 which is currently exposed to natural acidic discharge and are considered to be 'minor'. Adopting a conservative approach, the inherent risk of indirect impacts is considered to be 'medium'. Simulated pit lake levels demonstrate that the residual risk of this impact is reduced to 'low' with adoption of catchment management measures outlined in Section 2.2.3.4 and Table 37.

6.1.5.5 Indirect Impacts to Native Vegetation due to Dust Emissions

Impacts to air quality with the potential to impact on native vegetation health may include the following:

- Particulate emissions from operational areas or site roads.
- Particulate emissions from the TSF surface.

Accumulation of dust particulates on leaf surfaces can affect the ability of plants to photosynthesise and transpire, causing a decline in health and potential mortality if not alleviated.

The Pilbara environment is naturally dusty, characterised by periodic 'dust storms' caused by large scale wind erosion of inland areas impacted by recent wildfires or following a prolonged dry period. Native vegetation is therefore expected to be reasonably tolerant to cycles of dust deposition imposed by existing climatic conditions.

Dust will be generated during the construction phase through land clearing, pre-stripping overburden and activities on exposed ground. During the operational phase, dust will be generated from light and heavy vehicle use, blasting, ore excavation and haulage, ore crushing and screening and rehabilitation activities such as spreading overburden and topsoil. Wind action on cleared areas may also generate dust across all phases of the Proposal. Impacts from dust deposition are likely to be limited to within 50 m of the generation point and will be managed using industry standard management methods. Without mitigation, dust deposition could impact on the health and condition of the following:

- Approximately 3.4 ha of vegetation community 1a and 10.8 ha of vegetation community 2a, located within 50 m of the site layout.
- Eight *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals are within 50 metres of the final design tailings surface. Dust exposure will arise from earthworks associated with site preparation, wind action on the tailings and also from rehabilitation activities in capping the completed TSF.

Given this, the inherent risk of impacts to the health and condition of the above flora and vegetation is considered to be 'medium', while the inherent risk of subsequent vegetation losses is considered to be 'low'. Appropriate mitigation measures to address this potential impact are presented in Table 37.

6.1.5.6 Introduction and/or Increased Spread of Weeds

Weeds may be introduced and spread around the Proposal area through vehicle use and earthmoving activities. Ground disturbance and altered localised soil moisture/water regimes (such as could arise from wastewater disposal and water/drainage) may also create a favourable environment for the establishment and proliferation of weeds.

Three weed species have been recorded within the Development Envelope and surrounds (Figure 16). One of these, **Calotropis procera*, is a Declared Pest Organism pursuant to Section 22 of the *BAM Act,* categorised as 'exempt', meaning no permit or conditions for keeping is required. The other two weed species (**Cenchrus ciliaris* and **Setaria verticillata*) are permitted under Section 11 of the *BAM Act*. Both are invasive grass species occurring widely throughout the region. These species were noted to be restricted to the main access road along the margins of Sulphur Springs Creek.

Weed infestations can smother and out-compete native vegetation causing a decline in condition. The inherent risk is rated as 'medium'. Measures to mitigate this potential impact are presented in Table 37.

6.1.5.7 Potential Low Risk Impacts

Potential impacts assessed as constituting a 'low' risk to flora and vegetation are shown in Table 33.

Table 33: Flora and Vegetation – Justification for Exclusion of Potential Low Risk Impacts

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Indirect impacts to vegetation communities in the Minnieritchie Creek and Six Mile Creek catchment areas from contamination of groundwater due to seepage from the TSF.	Operations and Closure	In addition to pit lake seepage assessed in Section 6.1.5.4, indirect impacts to native vegetation may result from lateral migration of TSF seepage into the Six Mile or Minnieritchie Creek catchment areas. Seepage flow outside the PSC5 catchment is not possible for the majority of the mine life and remains highly unlikely to occur at the end of the operational phase except under extreme circumstances. For this to occur, the decant pond needs to be at an elevation above the fresh bedrock interface under the surrounding ridgeline saddles and located for an extended period close to the edges of the tailings footprint. Even under these conditions, the seepage rate would be very low and constrained to creek lines in the adjacent catchments. This seepage will mix with native groundwater and disperse into seasonal surface water flows (Appendix 16). Overall, the risk of impacts to native vegetation within these catchments is considered to be low because: • The duration of any seepage would be limited to the period when the phreatic surface within the tailings is sufficiently high (late in the mine life and during the early years of rehabilitation works). • The portion of TSF seepage reporting to each of these catchments would be minor compared to the total predicted seepage rate (less than 6 m^3/day across the entire valley wall). • Any seepage volume would be significantly diluted by the underlying aquifer in each of these catchment areas. The Six Mile Creek and Minnieritchie Creek aquifers are also high in alkalinity (ranging from 154 mg/L to 526 mg/L) with a major ion composition reflecting generally calcium or magnesium-bicarbonate water types (Appendix 16) and are likely to provide significant assimilation capacity for any seepage.
Indirect impacts to vegetation communities in the Minnieritchie or Sulphur Springs Creek catchment areas from contamination of groundwater due to seepage from storage ponds.	Operations	Both ponds will be HDPE-lined and potential seepage rates will be very low. North Pond will be constructed within the valley to the north of the Processing Plant and within the Sulphur Springs Creek catchment, approximately 500 m to the east of the creekline. South Pond will be constructed within the Processing Plant area and within the Minnieritchie Creek catchment, approximately 428 m to the west of the creekline. The quality of water stored in these ponds will be variable. Early in the mine life, it may be brackish and low in pH if not treated. With time, the quality of dewatering discharge from the mine is likely to improve once the acidic groundwater within the orebody is removed. At closure, ponds will be decommissioned, and the footprints rehabilitated, therefore eliminating the potential for ongoing seepage during this phase. Due to very low seepage rates and distance to the creekline vegetation, the inherent risk of this impact is considered to be low.
Indirect impacts to native vegetation due to overtopping of storage ponds.	Operations	The South and North Ponds will be designed to contain runoff from a 1 in 100 year ARI. Given the distance to significant vegetation along Sulphur Springs and Minnieritchie Creek (500 m and 428 m, respectively), the consequences of an overtopping event are considered to be ‘minor’ and the resulting inherent risk ‘low’.

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Indirect impacts to GDEs due to mine dewatering	Construction and Operations	Mine dewatering will reduce groundwater levels in and around the mine pit. The cone of depression related to mine dewatering will be steep, with drawdown of 1 m likely to extend less than 1 km from the centre of the pit (Figure 26). Drawdown is unlikely to extend to any of the sites identified by Mattiske as having a 'moderate' likelihood of being a GDE (Appendix 13). Approximately 0.89 ha of vegetation community 2a lies outside the Proposal footprint, but within the 0.5 m drawdown zone. Given the limited extent of groundwater drawdown (both lateral and vertical) and the small area of vegetation community 2a remaining within this zone after clearing for project infrastructure, the inherent risk of impacts from dewatering is considered to be 'low'.
Indirect impacts to native vegetation from contamination of groundwater due to seepage from low grade stockpile or ROM pad	Operations	Ore temporarily stored on the low grade stockpile and ROM pad are predicted to be PAF. Any leachate from these freshly mined materials is predicted to be moderately acidic and contain slightly elevated concentrations of copper, lead, ferrous iron and zinc, with fresh to slightly brackish salinity. Typically, ROM pad ore will turn over in less than 1 week. The majority of any leachate will report as surface runoff to HDPE lined water management structures. The low grade stockpile and ROM pad will be within the cone of depression resulting from mine dewatering (Figure 26) and any seepage to groundwater is likely to be captured in this system. Given this restricted migration pathway and the fact that baseline conditions in the Sulphur Springs Creek catchment reflect a level of 'natural' acid drainage, the inherent risk of impacts to native vegetation due to seepage from the low grade stockpile or ROM pad is considered to be 'low'.
Altered fire regime impacting vegetation health and condition	Construction and Operations	Project specific impacts to fire regimes are not anticipated to adversely impact the environment given the low likelihood of occurrence (i.e. fire created by operational activities), open structure of the vegetation and widespread distribution of vegetation communities. The inherent risk of impacts of altered fire regimes is considered to be 'low'.
Indirect impacts to native vegetation from modification of groundwater flows and/or groundwater levels	Operations and Closure	Mine infrastructure and associated surface water management structures have the potential to reduce inputs to groundwater within and immediately surrounding the infrastructure footprint during the construction, operations and closure stages of the Proposal. This in turn may impact potential GDEs downgradient of infrastructure. A recent groundwater assessment for the Proposal considered baseline studies and Proposal design to predict that during the operational phase, other than the existing acidic groundwater exposures in the pit area, there are no other known groundwater discharge zones that will be affected by dewatering (Appendix 16). The infrastructure footprint occupies a relatively small proportion of the catchments upstream of potential GDEs along Minnieritchie Creek and Sulphur Springs Creek and the majority of project infrastructure is removed on closure, limiting the duration of impact on localised groundwater recharge. The inherent risk of indirect loss of vegetation and conservation significant species due to modification of groundwater levels and/or flows is considered to be 'low'.

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Erosion of mine waste landforms resulting in sediment discharge and smothering of plants	Construction, Operations and Closure	The inherent risk of localised transfer of relatively small volumes of sediment via erosion from landforms and infrastructure is considered to be 'low'. Landforms will be designed, constructed and rehabilitated to create a safe, stable, non-polluting landform and toe bunds may be constructed at the base of landforms to prevent erosion into the landscape post closure.
Vehicle movements off designated roads and tracks resulting in loss or reduced health and condition of native vegetation	Construction and Operations	The hilly terrain and rocky nature of the landscape provides a natural barrier to minimise off road vehicle movements. Vegetation communities are widespread and well represented regionally. Dust emissions from driving in off road areas are likely to be low given the typically skeletal nature of soils within the Development Envelope. The inherent risk of this impact is considered to be 'low'.
Habitat fragmentation or modification for conservation significant species	Construction	Clearing associated with the Proposal represents a localised loss of potential habitat for *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) in the Proposal area. Implementation of the Proposal will result in minor, limited fragmentation to undisturbed populations, but as no individual plants are proposed to be cleared, the indirect impacts are expected to be limited and are not expected to impact the overall health and viability of the local populations or the species as a whole (Figure 17). Significant populations of *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) also occur outside the Development Envelope.
Seepage from TSF causing groundwater mounding and indirect impacts to vegetation health and condition	Operations and Closure	The weathered bedrock, hosting the water table, forms a relatively permeable layer beneath the tailings. Seepage will migrate vertically from the tailings and mix with native groundwater at the water table. The water table will rise as a result of the seepage and may in some locations, rise to the base of the saturated tailings (Appendix 16). The steep sided valley in which the TSF is to be established limits the risk of any groundwater mounding below the invert of the valley impacting on peripheral native vegetation which is on elevated terrain. Any potential mounding would also be localised and contained within the catchment of the mine pit during the operations and post-closure phases. Based on this, the inherent risk of seepage from the TSF causing groundwater mounding and impacting vegetation health and condition is considered to be 'low'.

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Indirect impacts to native vegetation from modification of surface water flows	Construction, Operations and Closure	Small to medium scale, localised catchment changes to surface water flows are likely to result from construction and operation of mining infrastructure. Changes in surface water flow regimes may impact vegetation that is no longer receiving adequate resources to support growth, or vegetation may become inundated through ponding of stormwater, or failure of pipelines or other water infrastructure. Inundation causes stress and plant death when prolonged in those species not adapted to flooded conditions by decreasing oxygen levels within soils and impeding root respiration. Assessment of stream flows as a result of project infrastructure (AECOM 2020b, Appendix 21) indicates the Proposal may result in: • A relatively small reduction in Sulphur Springs Creek stream flow during the operational phase, compared to the naturally highly variable stream flow characteristics. The reduction in flow will progressively diminish downstream as flows from tributaries unaffected by the Proposal make up an increasingly greater portion of the stream flow in Sulphur Springs Creek. Pit catchment modification at closure will result in a significant reduction in stream flow immediately downstream of the pit. The flows are expected to decrease to about 88% of baseline at SSC13, with the change diminishing progressively downstream to an indistinguishable 96 % of baseline close to Creek Spring 1 (Figure 16). These predicted changes remain relatively small compared to the naturally highly variable stream flow characteristics. • A relatively small change in the naturally highly variable stream flow characteristics along Minnieritchie Creek during the operational phase. The reduction in stream flow volumes will progressively diminish further downstream as flows from tributaries unaffected by the Proposal make up an increasingly greater portion of the stream flow in Minnieritchie Creek. At closure, reinstatement of the runoff contribution from the processing plant area and the additional surface water runoff from a portion of the rehabilitated TSF area will result in a small increase in overall surface water runoff, still within the bounds of existing highly variable stream flow characteristics • A negligible change in the naturally highly variable stream flow characteristics along Six Mile Creek downstream of the project infrastructure during the operational phase. At closure, relatively small increases in stream flow in the upper reaches are expected due to additional runoff from a portion of WRD in the Sulphur Springs Creek catchment that is diverted into the Six Mile Creek catchment and the additional runoff from a portion of the rehabilitated TSF area. Based on this assessment, the inherent risk of impacts to native vegetation due to a change in surface water flows is considered to be 'low'.
Direct or indirect impacts to other significant flora	Construction, Operations and Closure	Based on findings presented by Mattiske (Appendix 13), the inherent risk of impacts to other significant flora is considered to be 'low'.

6.1.6 Assessment of Potential Cumulative Impacts

Pastoral leases excepted; the nearest other material ground disturbance is associated with Atlas' Abydos iron ore mine approximately 7 km to the northwest. Two other significant resource developments, Pilgangoora Lithium-Tantalum and North Star Magnetite occur within 35 km of the Proposal. Cumulatively, these disturbance footprints constitute less than 10,000 ha, or 0.02%, of the area within 35 km of the Proposal.

Available information for these sites has been reviewed to assess the cumulative impact of the Proposal on significant flora and vegetation with respect to the following:

- *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4).
- Groundwater Dependent Ecosystems.
- Vegetation Associations.
- Weeds.

As outlined in Table 33, the inherent risk of direct and/or indirect impacts to native vegetation from modification of groundwater or surface water flows, habitat fragmentation, mine dewatering or altered fire regime is considered to be 'low'. These impacts are insignificant on a local scale and so are unlikely to have any material effect on cumulative impacts at the regional scale. Consequently, these have not been considered further.

6.1.6.1 Pityrodia sp. Marble Bar

Data for *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) occurring within the development envelope of projects in the region is summarised in Table 34. In the highly unlikely, worst case circumstance where all plants within the Sulphur Springs Development Envelope or within 50 m of the TSF were lost (60 in total), overall regional impact on this taxon would increase by 0.6% (from 5.4% to 6.0%). Loss of the eight plants within 50 metres of the TSF (considered a 'low' inherent risk in Section 6.1.5.5) would increase the cumulative impact by 0.08% (from 5.4% to 5.5%). On this basis, the risk of increase to regional impacts on *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) is not considered to be significant.

Table 34: *Pityrodia* sp. Marble Bar Population

Proposal Development Envelope	Individuals Intersected by Development Envelope	
	Number	% of Known Population[1]
Approved Proposals in Region		
North Star Mine	158[3]	1.6
North Star Water Corridor	225[2,3]	2.3
Atlas	143[3]	1.5
Pilgangoora	0	0
Total		**5.4**
Sulphur Springs Proposal		
Sulphur Springs	60[4,5]	0.6
Cumulative Potential Impact		**6.0**

[1] *Pityrodia sp. Marble Bar known population is 9,848 individuals (Ecologia 2016)*

[2] *Proponent has committed to avoiding these individuals where possible.*

[3] *EPA 2014a*

[4] *Project infrastructure has been sited to avoid all known individuals.*

[5] *Total includes individuals within Development Envelope and individuals within 50 m of Proposal footprint.*

6.1.6.2 Groundwater Dependent Ecosystems

Two vegetation communities have a moderate likelihood of GDE presence in the Proposal area (Appendix 13):

- 1a – Open forest to open woodland of *Eucalyptus camaldulensis*, *Melaleuca argentea* and *Eucalyptus victrix* with scattered tall shrubs of *Indigofera monophylla* over *Schoenus falcatus*, *Cyperus vaginatus* and *Triodia longiceps* sedgeland/grassland in riverbeds.
- 2a – *Eucalyptus victrix* scattered trees to open woodland which may include *Melaleuca glomerata* and *Melaleuca linophylla* over open to closed scrub in creek beds and low slopes.

There is no publicly available data for potential GDEs in the region, although it was noted by Mattiske (2018) that vegetation present at potential GDE sites at Sulphur Springs is consistent with typical creekline vegetation of the Pilbara bioregion. On a local scale, within the immediate vicinity of the site, 635.7 ha of vegetation communities 1a and 2a have been mapped (Table 35).

Table 35: Sulphur Springs Vegetation Communities 1a and 2a

Significant Flora	Total Area Mapped[1] (ha)	Direct Impacts due to Clearing (ha)	Potential Indirect Impacts[2] (ha)		Total Direct and Potential Indirect Impacts (ha)	
			Sulphur Springs Creek Catchment	Minnieritchie Creek Catchment	ha	%
Vegetation Community 1a	458	1.4	1.48[3]	0	2.88	0.63
Vegetation Community 2a	177.7	8.3	2.99[3]	0	11.29	6.35
TOTAL	**635.7**	**9.7**	**4.47**	**0**	**14.17**	**2.23**

[1] Mapped area shown in Figure 15.

[2] Areas where inherent risk of vegetation loss is considered to be 'medium' or above.

[3] Sourced from Table 32 and Section 6.1.5.4 ('medium' inherent risk of a reduction in health and condition).

There is a 'medium' or 'high' inherent risk of direct and indirect impacts to approximately 14.2 ha of these communities, representing approximately 2.2% of that which is present locally. Therefore, potential cumulative impacts of the Proposal on potential GDEs at a regional scale are expected to be substantially lower than 2.2% and not considered significant.

6.1.6.3 Vegetation Associations

The two vegetation associations identified at Sulphur Springs (Appendix 13) remain relatively intact (99.87% remaining) across the greater Chichester subregion, relative to the pre-European extent (Table 36). Vegetation clearing associated with the Proposal equates to approximately 0.01% of the pre-European extent of these vegetation associations. Approximately 13,424 ha of vegetation association 93 in the Abydos Plain – Chichester system is protected for conservation. On this basis, implementation of the Proposal will not have a significant impact on the extent of vegetation associations within the Chichester subregion.

Table 36: Extent of Impact on pre-European Vegetation Associations in the Chichester IBRA Subregion

System	Vegetation Association[1]	Statewide Pre-European Extent[2] (ha)	% Remaining[2]	Area of Pre-European Vegetation Intersected by DE		Area of Pre-European Vegetation Intersected by Proposal Footprint	
				ha	%	ha	%
Georges Ranges	82 (hummock grasslands, low tree steppe; snappy gum over *T. wiseana*)	317,182	99.90	773.3	0.24	286.4	0.09
Abydos Plain - Chichester	93 (hummock grasslands, shrub steppe; kanji over soft spinifex)	2,476,378	99.86	115.9	0.005	27.3	0.001
TOTAL		**2,793,560**	**99.87**	**889.2**	**0.03**	**313.6**	**0.01**

[1] Mattiske 2018 *[2] Government of WA 2018*

6.1.6.4 Weeds

Historically, weeds in the Pilbara region have been introduced through pastoral activities or domestic purposes. As at 2010, 103 species of weeds were established in the Pilbara, comprising 6.3% of the region's flora species (Keighery 2010).

Of the three weed species identified at Sulphur Springs, **Calotropis procera* is considered to pose more risk to the region. This species is established along the De Grey River system but had not previously been recorded elsewhere in the Pilbara (Keighery 2010). More recently, it has been identified at other mining areas in the vicinity of Sulphur Springs including the North Star Mine (FMG 2013), Wodgina DSO mine (Atlas 2012), Corunna Downs Intersection (Woodman 2017) and the Nullagine Iron Ore mine (Strategen 2013). With limited available information, the potential cumulative impacts of this species in the region are difficult to quantify. Implementation of measures in Table 37 will limit the risk of any increase in the abundance or distribution of this weed species at a local scale and consequently will ensure the risk posed at a regional scale is not significant.

6.1.7 Mitigation

Table 37 lists key measures to be implemented at Sulphur Springs to address potential impacts on flora and vegetation.

Table 37: Proposed Mitigation Measures for Flora and Vegetation

Potential Impact Requiring Management	Mitigation Measures
Direct loss of native vegetation, including conservation significant species	**Measures to avoid:** • Project infrastructure has been located away, as far as practicable, from identified *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) individuals and the associated 50 m buffer area surrounding them. • Known locations of conservation significant species will be included in the site's GIS to ensure locations are avoided during any future activities. • Pre-clearance surveys undertaken prior to land clearing to erect clearly demarcated exclusion zones around *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) populations. • Land clearing to be conducted in accordance with internal Ground Disturbance Procedure. **Measures to minimise:** • Land disturbance will be kept to the minimum necessary for development of the Proposal. • A Flora and Vegetation Environmental Management Plan will be implemented (Appendix 18). • Ground disturbance procedures and an internal permitting system will be implemented. • Existing disturbed areas will be used wherever possible to minimise total ground disturbance. • The site induction program will provide written and verbal information on protection of vegetation, conservation significant flora and ground disturbance authorisation procedures. **Measures to rehabilitate:** • Further studies to confirm recoverable topsoil volumes and characteristics. • Progressive and early rehabilitation will be undertaken on disturbed areas where possible. • Monitoring of rehabilitated areas will be undertaken to track progress against short, medium and long-term objectives. • Local provenance seed collection will be undertaken throughout the project life for use in rehabilitation activities. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).
Indirect impacts to native vegetation from contamination of surface water or groundwater due to spills	**Measures to avoid:** • Chemicals, hydrocarbons and other environmentally hazardous materials will be stored and handled in accordance with the *Dangerous Goods Safety Act 2004* and associated regulations, including use of a bunded and sealed assembly area for hazardous chemicals (containerised) prior to offsite treatment/disposal by a licenced and authorised waste contractor. • Facilities containing hydrocarbons and/or chemicals have been designed within bunds to contain 110% of the contents of the material stored. • Pipelines containing chemical, hydrocarbons or tailings will either be double skinned or located within lined corridors to avoid any spills contacting soil, surface water or groundwater sources. **Measures to minimise:** • Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material. • Overland pipes will be installed within bunds with catchment sumps constructed at low elevation points as required to provide containment capacity in the case of a pipeline leak. • Flow/pressure sensors will be fitted along pipelines to enable detection of flow anomalies (i.e. pipeline leaks). • Isolation valves will be installed at appropriate intervals along pipelines. • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. **Measures to rehabilitate:** • Spills will be cleaned up and contaminated soils will either be remediated or removed from site by a licenced third party. Incident investigation will be undertaken as required to determine the cause of environmentally harmful spills/leaks and control measures identified to prevent future incidents. As required, spills will be reported to the relevant authorities. • Decommissioning and removal of all storages and pipelines. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).
Indirect impacts to native vegetation from contamination of surface and/or groundwater due to seepage from the TSF	**Measures to avoid:** None **Measures to minimise:** • Location of TSF upgradient of the mine pit in steep sided, confined valley • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. • Internal drainage collection and seepage monitoring and interception downstream of main embankment. • Saddle dams constructed with appropriate seepage prevention measures (low permeability cut off trench and embankment core, drainage collection on the upstream face). • Ongoing mine closure planning during the operational phase of the project, including TSF cover trials, to refine proposed designs. • pH amendment via lime addition conducted prior to final layers of tailings discharge to prevent the top surface of the tailings generating acid following sub-aerial deposition. **Measures to rehabilitate:** • TSF cover design to minimise infiltration. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Monitoring TSF seepage during operations for consideration in closure design. • Lysimeters and ion-specific probes will be utilised during the operational and short-term post-closure phases to validate TSF modelling assumptions. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure. • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions.

Potential Impact Requiring Management	Mitigation Measures
Indirect impacts to native vegetation from contamination of surface and/or groundwater due to seepage from the WRD or pit	**Measures to avoid:** • Storage of PAF waste rock and tailings within the catchment of the mine pit. • Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink. **Measures to minimise:** • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • Design of PAF cells in the WRD to minimise ingress of oxygen and water. • Diverting 'clean' surface water flows away from operational areas as far as practicable. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. • A standardised elemental suite will be included for all future waste rock, leachate and water analysis. **Measures to rehabilitate:** • WRD rehabilitation to a design to maximise surface stability and minimise infiltration around PAF areas. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Early rehabilitation of final outer slopes of WRD.
Indirect impacts to vegetation communities 1a and 2a downstream of pit due to pit overtopping	**Measures to avoid:** • Re-contouring of parts of the mine pit catchment (WRD and TSF landforms) to shed surface runoff to adjacent catchments so as to ensure the mine pit remains a hydraulic sink. **Measures to minimise:** • Further studies of potential additional measures for the diversion of runoff away from the mine pit. **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Review of the site surface water model during operations to refine/validate assumptions and pit water balance.
Indirect impacts to native vegetation from reduced air quality due to dust emissions	**Measures to minimise:** • Land disturbance will be kept to the minimum necessary for development of the Proposal. • A Flora and Vegetation Environmental Management Plan will be implemented (Appendix 18). • Existing disturbed areas will be used wherever possible to minimise total ground disturbance. • Dust suppression measures will be implemented. • Vehicle speed restrictions will apply. **Measures to rehabilitate:** • Progressive rehabilitation will be undertaken as disturbed areas become available. • Rehabilitation procedures to achieve surfaces that minimise susceptibility to wind erosion.
Introduction and/or increase spread of weeds from project activities	**Measures to avoid:** • Known locations of weeds will be avoided, where practicable, for the development of project infrastructure. • Weed control will be implemented on areas to be disturbed for infrastructure. **Measures to minimise:** • Locations of weeds identified during baseline surveys within the Proposal footprint will be targeted for application of appropriate management actions during construction and operations. • A weed hygiene system will be implemented to avoid the spread of existing populations and the establishment of new populations. • A Flora and Vegetation Environmental Management Plan will be implemented (Appendix 18). • Inspections targeting weeds will be conducted following significant rainfall, and depending on results, appropriate management actions will be implemented. **Measures to rehabilitate:** • Rehabilitation monitoring to include presence of weeds to enable appropriate management actions to be implemented.

6.1.8 Predicted Outcome

Clearing will result in the loss of flora and vegetation. The majority of proposed clearing is of communities that are common and widespread with all 13 vegetation communities directly impacted by the Proposal well represented outside of the clearing footprint and Development Envelope. The Proposal footprint overlies one individual of a Priority 4 taxa as listed by DBCA (*Ptilotus mollis*) but has been carefully designed to avoid all known *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) plants and minimise development within the 50 m ESA surrounding them. It presents a low residual risk to the health and condition of eight individual *Pityrodia* sp. Marble Bar (G. Woodman & D. Coultas GWDC Opp 4) located within 50 m of the TSF footprint. The loss of these individuals would have an insignificant impact on the viability of the species.

Incremental, potential indirect impacts arising from dust, weeds, modification of surface water flows and fire regimes will be minimised through project design and ongoing management and are unlikely to be significant at both a local and regional scale.

Impacts, if any, from dewatering to vegetation community 2a (a potential GDE) are predicted to be confined to immediately downstream of the mine pit. This vegetation community is well represented in the Proposal area and the potential impact is not considered significant.

With adoption of proposed mitigation measures, the pit lake will remain a hydraulic sink after closure and the residual risk to the condition of vegetation communities 1a and 2a downstream along Sulphur Springs Creek is consequently also considered to be low.

Overall, potential impacts to flora and vegetation can be adequately managed such that there are no significant residual impacts or significant cumulative impacts and the EPA objective for flora and vegetation (EPA 2016c) will be met.

6.2 PRELIMINARY KEY ENVIRONMENTAL FACTOR 2 – SUBTERRANEAN FAUNA

6.2.1 EPA Objective

The EPA objective for subterranean fauna is 'To protect subterranean fauna so that biological diversity and ecological integrity are maintained' (EPA 2016e).

6.2.2 Policy and Guidance

Subterranean fauna are protected under Commonwealth and State legislation, primarily governed by three Acts:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).
- *Biodiversity Conservation Act 2016* (WA).
- *Environmental Protection Act 1986* (WA).

In addition to Commonwealth and State legislation, the following policy and guidance statements were considered in the impact assessment for subterranean fauna:

- EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b).
- EPA Environmental Factor Guideline – Subterranean Fauna (EPA 2016e).
- EPA Technical Guidance – Sampling methods for Subterranean fauna (EPA 2016f).

- EPA Technical Guidance – Subterranean fauna survey (EPA 2016g).

6.2.3 Receiving Environment

A number of subterranean fauna surveys have been undertaken within the Proposal area and surrounds as summarised in Table 38.

Table 38: Summary of Subterranean Fauna Surveys

Survey Date	Consultant	Description
December 2006	Subterranean Ecology	Rapid reconnaissance survey across 30 sites to identify catchments and aquifers within the Proposal area where subterranean fauna were present. Sampling methods were consistent with current recommendations of the EPA *Technical Guidance – Sampling methods for Subterranean fauna* (EPA 2016f).
February 2007	Subterranean Ecology	Survey to resample known subterranean fauna locations and sample an additional 15 locations outside the Proposal area to determine the distribution and conservation status of recorded stygofauna species. Sampling methods were consistent with current recommendations of the EPA *Technical Guidance – Sampling methods for Subterranean fauna* (EPA 2016f).
February 2007	Subterranean Ecology	A desktop assessment and subsequent pilot survey to assess the likelihood of troglofauna occurrence in the Proposal area.
May to August 2007	Subterranean Ecology	Phase 1, 2 and 3 troglofauna surveys across the Proposal area and broader region, including areas within similar geological features (Kangaroo Caves and Bernts deposits) and nearby Outokumpu Camp and Dead Man's Hill. The aim of these surveys was to provide a better understanding of the composition and distribution of troglofauna communities in the wider region.
March 2018	Bennelongia Environmental Consultants	Desktop study to review and consolidate existing site-based and regional survey data and assess the likely presence and characteristics of subterranean fauna habitat. This report is provided in Appendix 19. The study was conducted with reference to the EPA's *Environmental Factor Guideline – Subterranean Fauna* (EPA 2016e).

6.2.3.1 Survey Results

The most recent desktop study (Bennelongia 2018) reviewed and consolidated findings of previous site-based and regional subterranean fauna surveys to provide a regional context for subterranean fauna in the Proposal area. The study also assessed the likely occurrence of subterranean fauna habitat in the vicinity of project elements. It is provided in Appendix 19 and findings are summarised in the following sections.

Habitat Prospectivity and Connectivity

The deposit is hosted in the Sulphur Springs Group of the Pilbara Supergroup in the East Pilbara Terrane. North east portions of the proposed mine pit are expected to intercept the Soanesville Group successions. Footwall rocks are predominantly formed of dacite/rhyodacite volcanics of the Kangaroo Caves Formation (Sulphur Springs Group). Hanging wall rocks include polymict breccias and upper chert beds of the Kangaroo Caves Formation and the overlying siltstone and quartz arenite of the Corboy Formation (Soanesville Group) (URS 2007a).

Groundwater and surface water flow systems in the area are complex, variable and linked. Flow is predominantly linked to fractures in bedrock and local geology has the potential to compartmentalise fractured rock aquifer systems and associated groundwater flow.

Stygofauna were recorded from colluvium and pebbly sandstone and conglomerate (De Grey Supergroup) geological units, both of which occur extensively beyond the Development Envelope. Polymict breccia, quartz, siltstone and rhyolite were sampled but did not return any stygofauna. Troglofauna (Blattodea sp. 1) was recorded from polymict breccia and quartzite units, both present beyond the Development Envelope.

Groundwater fauna of the Pilbara region of Western Australia show significant regional endemism. Oligochaetes and copepods, while hydrology plays a role in distribution, are not always confined to specific catchments. Studies suggest that intrinsic characteristics of oligochaetes in particular, such as body size, shape, reproductive strategy and ecological requirements, may have allowed them greater dispersal within the subterranean biome of the Pilbara. These fauna may occupy subterranean and surface waters, increasing their opportunities for dispersal (Brown *et al*. 2015). Two examples of species identified at Sulphur Springs with wider distributions across the greater region, include the oligochaete *Monophylephorus* n. sp. and the amphipod Melitidae n. sp. cf. Melitidae sp. 1. *Monophylephorus* n. sp., was collected from three bores over a linear range of approximately 22 km extending north from mid-way along the site access road. Melitidae n. sp. cf. Melitidae sp. 1 was collected from five bores covering more than 50 km (Appendix 19).

Stygofauna

Twenty seven species from 1,161 specimens have been recorded within the Proposal area and surrounds (Subterranean Ecology 2007a, Appendix 19). Species included Crustacea (amphipods, copepods, ostracods and isopods), Acariformes (aquatic mites), Nematoda (roundworms) and Oligochaeta (earthworms). The full list of species is provided in Appendix 19 and sample sites overlying geological mapping are shown in Figure 19 (regional) and Figure 20 (local).

Of the 27 species recorded, 24 were found within the zone of influence of mine dewatering (primarily in the vicinity of bores SSWB36, SSWB38 and SSWB40). Of these 24 species, 20 are known to occur outside the Development Envelope, either locally or throughout the broader Pilbara region (Subterranean Ecology 2007a). These species are not considered to be of conservation significance because their persistence will not be threatened by development of the Proposal. The remaining four species comprised:

- Two nematodes.
- Two oligochaetes (Phreodrilidae Gen. et sp. indet. and Tubificidae SS sp. 1).

Nematodes are routinely excluded from environmental impact assessments, as there is too little information to reliably identify to species level (EPA 2016e).

A single specimen of Phreodrilidae Gen. et sp. indet. was recorded at a surface spring in Sulphur Springs Creek, within unconsolidated alluvial sediments (the hyporheic zone). One specimen of Tubificidae SS sp. 1 was recorded at SSWB36 and a further 20 individuals were recorded approximately 2.9 km upstream, within Sulphur Springs Creek.

Troglofauna

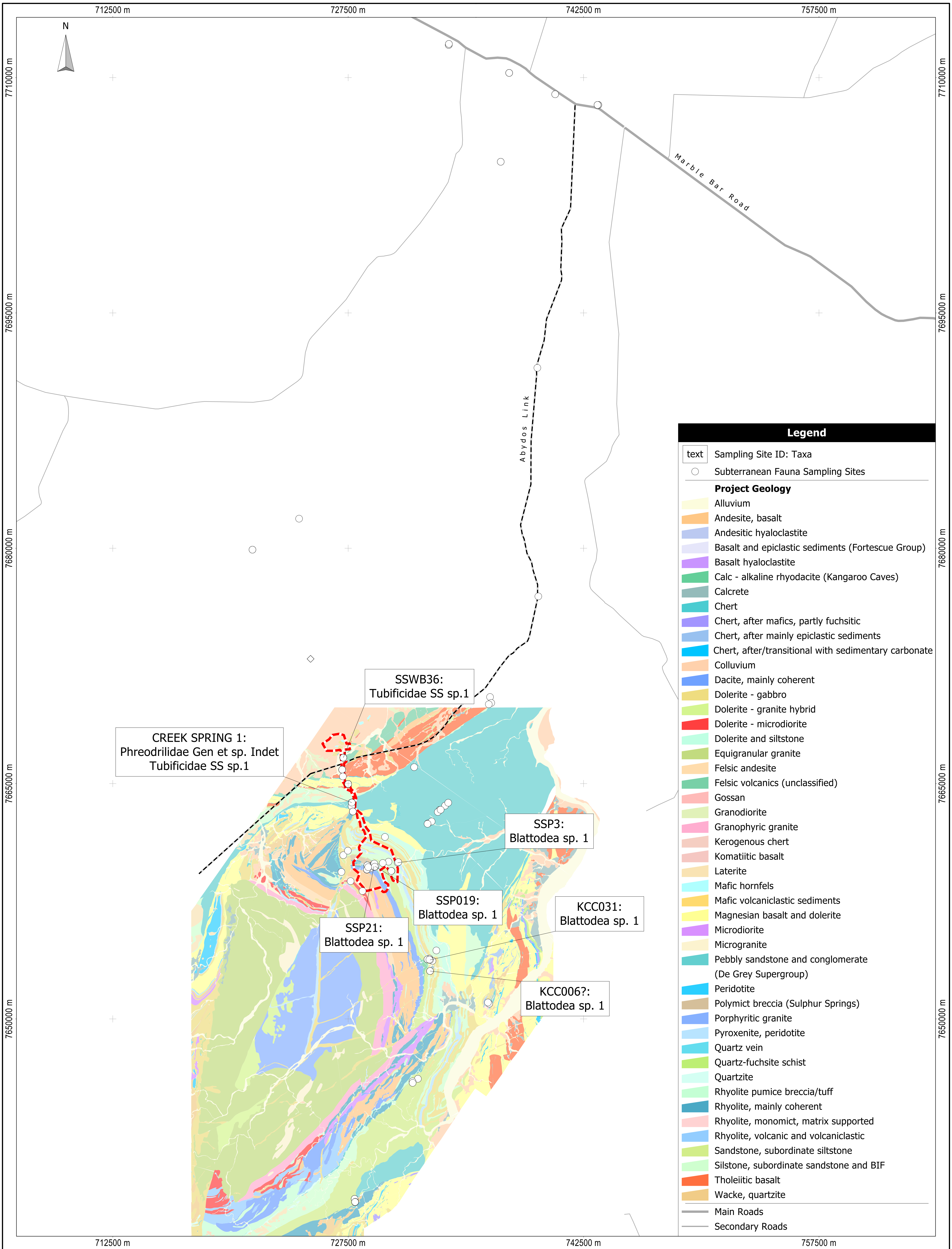
A pilot and first phase (Phase 1) survey for troglofauna was undertaken by Subterranean Ecology in July and November 2007 (Subterranean Ecology 2007a). Across both surveys, 23 morpho-species from 1,079 specimens were collected. The pilot survey in two drill holes collected 275 invertebrate specimens comprising 12 taxa belonging to Acarina (6 morpho-species), Collembola (3) and Diptera (1). All of the taxa collected in the pilot study, except one, were recollected during the Phase 1 survey. Only one species of cockroach (Blattodea sp. 1) displayed troglomorphic characteristics, including eye regression, depigmentation, and elongated appendages.

This troglomorphic cockroach was suspected to inhabit shallow subsurface habitats in the regolith surrounding the drill holes where it was collected (Subterranean Ecology 2007a). Potentially shallow subsurface habitats are well developed in the colluvium on slopes within the pit area and similar habitats occur extensively and continuously throughout the ranges within the wider region. It is considered likely that the distribution of collected fauna (including the cockroach) is not restricted to the proposed pit and occurs more widely in the region. Phase 2 and 3 surveys were conducted to provide more certainty on this issue.

The Phase 2 survey, completed to Level 2 survey standards, sampled locations outside the Proposal area that showed similar geomorphic terrain to that present at Sulphur Springs, with potential shallow subsurface habitats developed in colluvial slope regolith. Survey sites included the Kangaroo Caves and Bernts deposits. The Phase 2 survey collected 1,204 specimens (representing 18 taxa), including 10 individuals of the troglomorphic cockroach (Blattodea sp. 1) within regolith habitats at both the Kangaroo Caves and Bernts deposits (Subterranean Ecology 2007b), thus supporting the Phase 1 findings.

The Phase 3 regional sampling program, completed to Level 2 survey standards, included trapping in 24 holes located in six areas outside of the Sulphur Springs Proposal area including Bernts, Breakers, Jamersons and Kangaroo Caves deposits, and the Outokumpu Camp and Dead Man's Hill. The Phase 3 survey collected approximately 164,000 individuals, representing 41 species including 3 individuals of the troglomorphic cockroach (Blattodea sp. 1) (Subterranean Ecology 2007c, Appendix 20). The location of the survey sites overlying geological mapping are shown on Figure 20.

In the three phases of troglofauna sampling, one troglomorphic taxa (Blattodea sp. 1), was collected. Sampling showed that this species is locally widespread, and occurs within the Kangaroo Caves, Bernts and the Outokumpu Camp areas as well as within the Proposal footprint. The known distribution of this species and extensive and continuous regolith habitat in which it has been recorded indicates the species is widespread and not confined to the Sulphur Springs deposit area.



Scale: 1:210000
Original Size: A3
Grid: MGA94(50)

0 5 km

Venturex Resources Limited
Sulphur Springs Project

Figure 19

Regional Subterranean Fauna Survey Sites

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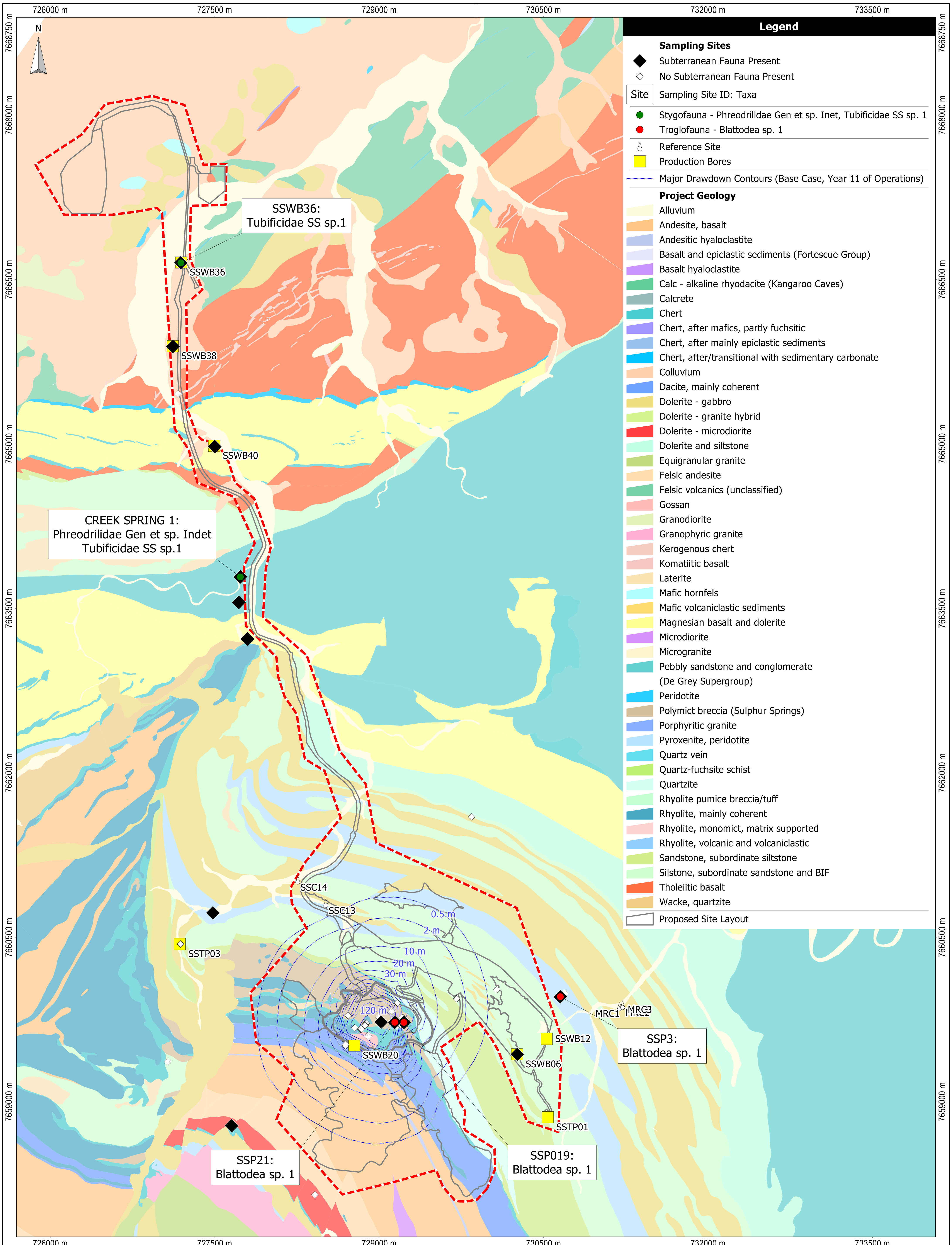

Scale: 1:30000
Original Size: A3
Source: Bennelongia 2018
Grid: MGA94(50)
0 1000 m

Venturex Resources Limited
Sulphur Springs Project

Figure 20

Local Subterranean Fauna Survey Sites

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W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Subterranean Fauna.map 24/01/2020 F20 Local Subterranean Fauna Survey Sites Layout

6.2.3.2 Limitations

Subterranean fauna surveys completed to date have not confirmed the distribution of Phreodrilidae Gen. et sp. indet. and Tubificidae SS sp. 1 outside the Proposal area. Stygofaunal oligochaetes in the Pilbara typically occupy several catchments and can generally be considered widespread, especially in relation to the size of borefield-related impacts (Appendix 19). Phreodrilidae Gen. et sp. indet. and Tubificidae SS sp. 1 occur in the hyporheic zone, where they are likely to be dispersed during flood events, and this increases the likelihood of a wide range (Appendix 19). Consequently, these species are not likely to be threatened by the Proposal and this knowledge gap has no substantial implication for the impact assessment.

In summary, there are no significant limitations to the work of Subterranean Ecology conducted between 2006 and 2007. Notwithstanding that the taxonomic framework for undescribed species has advanced in the last decade, stygofauna identifications for the Proposal were undertaken by recognised experts in the field and are considered likely to be sound in most cases (Appendix 19).

6.2.4 Potential Impacts

6.2.4.1 Potential Direct and Indirect Impacts

Potential impacts to significant subterranean fauna include:

- Degradation of subterranean fauna habitat due to seepage from the TSF, WRD or pit (medium inherent risk).
- Permanent loss of subterranean fauna habitat and individuals due to open pit development (low inherent risk).
- Loss of subterranean fauna habitat and individuals from groundwater drawdown due to mine dewatering or borefield groundwater abstraction (low inherent risk).
- Degradation of subterranean fauna habitat due to spills (hydrocarbons, reagents, chemicals or wastewater) (low inherent risk).
- Loss of subterranean fauna habitat and individuals due to increased sediment loads in hyporheic zone along Sulphur Springs Creek (low inherent risk).
- Degradation of subterranean fauna habitat and individuals downgradient of pit due to pit lake overtopping at closure (low inherent risk).
- Loss of subterranean fauna habitat due to altered groundwater flow regime (low inherent risk).
- Degradation of subterranean fauna habitat due to poor quality seepage from water storage ponds (low inherent risk).
- Loss of subterranean fauna habitat and individuals within the Minnieritchie Creek or Six Mile Creek catchments due to seepage from the TSF (low inherent risk).

6.2.4.2 Potential Cumulative Impacts

No potential cumulative impacts to subterranean fauna and/or subterranean fauna habitat have been identified. Atlas holds a Licence to Take Water (GWL 176408) from groundwater bores SSWB36, SSWB38 and SSWB40 (Figure 13). Under GWL 176408 and the associated Abydos Link road East Site Water Operating Plan, abstraction of up to 0.315 GL/yr is permitted from these bores. In consultation with Atlas, Venturex proposes to utilise SSWB36, SSWB38 and SSWB40 such that the total abstraction (from both parties) does not exceed 0.315 GL/yr. Abstraction under these conditions is sustainable and drawdown-related impacts are localised (Section 4 of Appendix 16).

6.2.5 Assessment of Impacts

Potential impacts of project development on subterranean fauna were assessed in accordance with the approach outlined in Section 5. Findings of surveys conducted within the Proposal area and the broader region in accordance with EPA policy and guidance, were utilised in conjunction with preliminary project design to inform the impact assessment. This assessment and resultant inherent risk ratings (i.e. prior to mitigation and management measures) are provided in Appendix 12.

The only potential impact considered to pose a 'moderate' risk was degradation of the subterranean fauna habitat due to seepage from the TSF, WRD or pit and this is discussed below. All other impacts were assessed as 'low' risk and screened from a further detailed assessment. These are briefly discussed in Table 39.

6.2.5.1 Degradation of Subterranean Fauna Habitat due to Seepage from the TSF, WRD or Pit

Indirect impacts to the health of stygofauna individuals may result from altered groundwater chemistry, principally increased acidity, salinity and metal and metalloid concentrations associated with seepage from the TSF or WRD (during both the operational and closure phases) or the pit lake that will form during the closure phase.

Baseline monitoring indicates groundwater from the proposed mine area currently discharges along a 450 to 500 m stretch of Sulphur Springs Creek. Groundwater up to 1.5 km downstream of the mineralised area is generally circum-neutral, relatively low in salinity, but contains elevated concentrations of aluminium, cadmium, copper, nickel, iron, manganese and zinc. Capture of subterranean fauna within this environment during field surveys demonstrates the capacity of species to survive in slightly modified groundwater quality conditions as a result of an upstream zone of acidic seepage. Thus, the local species are expected to be tolerant of minor changes in groundwater chemistry as a result of any low volume seepage from the TSF, WRD or pit. Species identified in these locations are expected to have a broader presence in the area/region.

During operations, TSF seepage will be intercepted by the seepage recovery and mine dewatering systems. Any WRD seepage will be intercepted by the mine dewatering system. The existing 'natural' acidic discharge from the pit area is also expected to cease because groundwater levels will be lowered by mine dewatering (Appendix 16). As a result, the inherent risk of impacts during this phase is considered to be 'low'.

At closure, cessation of mine dewatering will lead to the formation of a pit lake (Section 2.2.3.4). Inflows to the pit lake will include rainfall, surface water runoff (from WRD surface and the upstream catchment), seepage from the section of the WRD within the pit catchment, seepage from the TSF and local groundwater. As a result, water quality in the pit lake is predicted to become increasingly saline and contain higher concentrations of most solutes due to evaporation (Table 31, Appendix 9). Without appropriate surface water management measures, the addition of runoff from all of the surrounding catchment is likely to result in the pit becoming a persistent groundwater source rather than a hydraulic sink to downstream areas (Appendix 9). The inherent risk of impacts during this phase is considered to be 'medium'. Appropriate mitigation measures to address this potential impact are presented in Table 40.

6.2.5.2 Potential Low Risk Impacts

Potential risks assessed as posing a 'low' risk to subterranean fauna are shown in Table 39.

Table 39: Subterranean Fauna – Justification for Exclusion of Potential Low Risk Impacts

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Permanent loss of subterranean fauna habitat due to open pit development	Construction and Operations	All studies conducted to date indicate the proposed pit area does not provide prospective stygofauna habitat (Subterranean Ecology 2007a and b, Appendix 20 and Appendix 19). No stygofauna individuals have been captured in the vicinity and although the pit geology includes fractures and cavernous zones, existing groundwater is moderately-to-strongly acidic (pH 2.8 to 4.8) and poorly oxygenated (dissolved oxygen concentrations below 0.5 mg/L). The inherent risk of direct loss of subterranean fauna habitat due to pit development is therefore considered to be 'low'. Sampling recorded only one troglomorphic taxa (Blattodea sp. 1) in the Development Envelope and this taxon was also recorded from more distant areas including Kangaroo Caves, Bernts and the Outokumpu Camp areas. The presence of this species in several areas, combined with the extensive and continuous regolith habitat in which it has been located, indicates that this species is widespread throughout the region. While the likelihood of this impact may be 'likely', the consequence is considered to be 'insignificant' and the inherent risk of impact is therefore 'low'.
Loss of subterranean fauna habitat and individuals from groundwater drawdown due to mine dewatering		During operations, the cone of depression related to mine dewatering will be steep, with drawdown of 1 m likely to extend less than 1 km from the centre of the pit (Figure 21). Drawdown outside the existing zone of moderately to strongly acidic groundwater discussed above is predicted to be low (less than 0.5 m). Subterranean fauna sampling conducted at 31 sites within this cone of depression (Figure 20) returned species that occur outside the area that will be affected by mine dewatering (Subterranean Ecology 2007a). The inherent risk of indirect loss of subterranean fauna habitat or conservation significant species due to mine dewatering is therefore considered to be 'low'.
Loss of subterranean fauna habitat and individuals from groundwater drawdown due to borefield groundwater abstraction		GWL 176408 and the associated Abydos Link Road East Site Water Operating Plan permits abstraction of up to 0.315 GL/yr from bores SSWB036, SSWB038 and SSWB040. Atlas have been utilising these bores since 2013. Information from the 2017 monitoring report indicates groundwater levels in the abstraction bores fluctuated by 5 to 25 m, depending on whether or not abstraction was occurring. Drawdown fluctuations were not apparent in SSWB39 (Appendix 16), indicating the lateral extent of drawdown has been localised, tightly constrained in proximity to the transmissive structures. No groundwater quality triggers were breached as a result of abstraction and large rises in the water table occurred when larger and/or more frequent rainfalls were recorded. It is apparent that drawdown-related changes to the water table can be managed by changing the pumping rates and durations at these bores. Venturex is proposing to operate the same bores to perform the same function as Atlas (Appendix 16). There will be no change to abstraction volumes currently permitted under the *Rights in Water and Irrigation Act 1914* (GWL 176408). Standing water level triggers stipulated for these bores in the Abydos Link Road East Site Water Operating Plan will continue to apply and the rate of drawdown is expected to be similar to or less than currently being reported by Atlas. Abstraction under these conditions is sustainable and drawdown-related impacts are predicted to be localised (Appendix 16). A single specimen of Phreodrilidae Gen. et sp. indet. was recorded at a surface spring in Sulphur Springs Creek, within unconsolidated alluvial sediments (the hyporheic zone). The hyporheic habitat used by the species is likely to occur widely along drainage lines, at least in the local area, as a result of dispersal during flood events. Brown *et al.* (2015) suggested that oligochaetes utilising permanent groundwater-fed refugia in alluvial rivers during drought are likely to migrate upward or be flushed into surface water during episodic flooding, thus facilitating dispersal throughout and even between catchments. A regional-scale survey of stygofauna showed that the average minimum linear range in the Pilbara for species in the family Phreodrilidae is approximately 275 km, while oligochaete species from all recorded families occupied a median of 3 sub-catchments (Halse *et al.* 2014). Thus, this Phreodrilidae species is unlikely to be threatened by local impacts associated with abstraction from production water bores because of its anticipated wider occurrence, including outside the Proposal area (Appendix 19). One specimen of Tubificidae SS sp. 1 was recorded at SSWB36 and a further 20 individuals were recorded approximately 2.9 km upstream, within Sulphur Springs Creek. It appears likely that this species occurs in the regional fractured rock aquifer in which the production bore is slotted, as well as the shallow alluvial aquifer associated with Sulphur Springs Creek. While there may be drawdown in the immediate vicinity of SSWB36, the survey data confirms this species has a range extending at least 2.9 km to the south and outside the zone of impact. Furthermore, the population of Tubificidae SS sp. 1 in the hyporheic zone of the creekline is likely to be at least locally widespread. Thus, Tubificidae SS sp. 1 is unlikely to be threatened by proposed groundwater abstraction because of its wider occurrence outside the Proposal area (Appendix 19). The resulting inherent risk is considered to be low.
Degradation of subterranean fauna habitat due to spills (hydrocarbons, reagents, chemicals or wastewater)	Construction and Operations	Hydrocarbons, reagents and other chemicals will be used during mining and ore processing. Diesel will be used as fuel for the mining fleet and refuelling will occur within a purpose built, fully bunded, facility. All chemical reagents will be stored within tanks in appropriately bunded facilities whereby 110% of the largest vessel is contained and 25% of the total volume is contained according to Australian Standards AS1940 and AS1692. Stocks of reagents will be stored in a designated reagent shed, appropriately designed to comply with all relevant legislation. Treated effluent from the WWTPs will be irrigated to an assigned area to infiltrate or evaporate. This effluent will be treated to comply with the 'Extra Low' risk category under *Guidelines for the Non-Potable Uses of Recycled Water in Western Australia* (Department of Health 2011). The treated effluent irrigation area has been selected in accordance with the *Water Quality Protection Note (WQPN 22) Irrigation with Nutrient Rich Wastewater* (DoW 2008). The proposed sites are not permanently or seasonally inundated or waterlogged, need no artificial drainage or require natural watercourses to be diverted. There is no Sensitive Water Resource within 500 m of the WWTP facility. The location of the facility is not within a Public Drinking Water Source Area, a wetland with defined conservation value, Environmental Protection Policy Lakes, Waterways Management Areas or other wetland. Thus, the inherent risk of degradation of subterranean fauna habitat due to spills of hydrocarbons or wastewater is considered to be low.
Loss of subterranean fauna habitat and individuals due to increased sediment loads in hyporheic zone along Sulphur Springs Creek	Construction and Operations	Without mitigation measures, increased sediment loads in surface water may result due to runoff from disturbed areas. These sediments would to be transported along creeklines during peak flows and settle in existing pools as flows subside (Appendix 21). Migration of sediments from surface water into the hyporheic zone that form subterranean fauna habitat is likely to be very low and localised to such pools. Furthermore, all significant subterranean species identified in the hyporheic zone were also present in fractured rock aquifer habitat, where the likelihood sediment migration is considered to be 'rare'. The inherent risk of sedimentation impacting subterranean fauna health or habitat is therefore considered to be low.

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Loss of subterranean fauna habitat and individuals within the Minnieritchie Creek or Six Mile Creek catchments due to seepage from the TSF	Operations and Closure	In addition to pit lake seepage assessed in Section 6.2.5.1, indirect impacts to subterranean fauna may result from lateral migration of TSF seepage into the Six Mile or Minnieritchie Creek catchment areas. However, the risk of impacts to species within these catchments is considered to be low because: • The portion of TSF seepage reporting to each of these catchments would be minor compared to the total predicted seepage rate (less than 6 m^3/day across the entire valley wall). • Any seepage volume would be significantly diluted by the underlying aquifer in each of these catchment areas. The Six Mile Creek and Minnieritchie Creek aquifers are also high in alkalinity (ranging from 154 mg/L to 526 mg/L) with a major ion composition reflecting generally calcium or magnesium-bicarbonate water types (Appendix 16) and are likely to provide significant assimilation capacity. • Subterranean fauna surveys have identified only one troglofauna taxon (Blattodea sp. 1) and no significant stygofauna taxon in the vicinity of the TSF (Figure 20). As shown on Figure 19, Blattodea sp. 1 is locally widespread, also occurring within the Kangaroo Caves and Bernts geological formations. The presence of this species in several deposits across the region, combined with the extensive and continuous regolith habitat it is inferred to inhabit, means it is not of conservation concern for the Proposal (Appendix 20).
Degradation of subterranean fauna habitat due to poor quality seepage from water storage ponds.	Operations	Risk of impacts to subterranean fauna is considered to be low because: • Both North and South ponds will be HDPE-lined and potential seepage rates will be very low. • Subterranean fauna surveys have not identified any significant taxon in the vicinity of these ponds.
Degradation of subterranean fauna habitat and individuals downgradient of pit due to pit lake overtopping at closure	Closure	Modelling of the pit lake at closure has determined that with addition of runoff from the entire catchment upstream of the pit (i.e. runoff not diverted around the pit), the pit water level is expected to rise close to the rim and overflow on some occasions. The resultant surface water quality along Sulphur Springs Creek may, for intermittent periods, contain elevated concentrations of lead, zinc, selenium and cadmium. While some migration of these contaminants between surface water and subterranean fauna habitat may occur, predicted circum-neutral pH values at both SSC Creek Spring 1 and SSWB36 will limit their bioavailability. Furthermore, stygofauna species identified in these locations are expected to have a broader presence in the area/region. The inherent risk of this impact is therefore considered to be 'low'.
Loss of subterranean fauna habitat due to altered groundwater flow regime	Construction Operations and Closure	Mine infrastructure and associated surface water management features (including water storage ponds) have the potential to reduce inputs to groundwater within and immediately surrounding the infrastructure footprint during the construction, operations and closure stages of the Proposal. This in turn may lead to a loss of subterranean fauna habitat or individuals in affected areas. A recent groundwater assessment for the Proposal considered baseline studies and Proposal design to predict that during the operational phase, other than the existing acidic groundwater exposures in the pit area, there are no other known groundwater discharge zones that will be affected by dewatering (Appendix 16). The infrastructure footprint occupies a relatively small proportion of the catchments upstream of potential GDEs along Minnieritchie Creek and Sulphur Springs Creek and the majority of project infrastructure is removed on closure, limiting the duration of impact on localised groundwater recharge. Twenty stygofauna taxa have been recorded in proximity to the development footprint and within surrounding non-impact areas. Two species, Phreodrilidae Gen. et sp. indet and Tubificidae SS sp. 1, have been recorded within the Development Envelope, downstream of site SSC14 and while their broader presence in the area/region has not been confirmed, it is expected given the habitat they occupy. The Proposal footprint downstream of Site SSC14 represents a minor part (approximately 10%) of the total catchment area. The consequences of a change to groundwater flows from the mine area are expected to be negligible for this habitat. Based on the above, the inherent risk of loss of subterranean fauna habitat due to altered groundwater flow regime is considered to be 'low'.

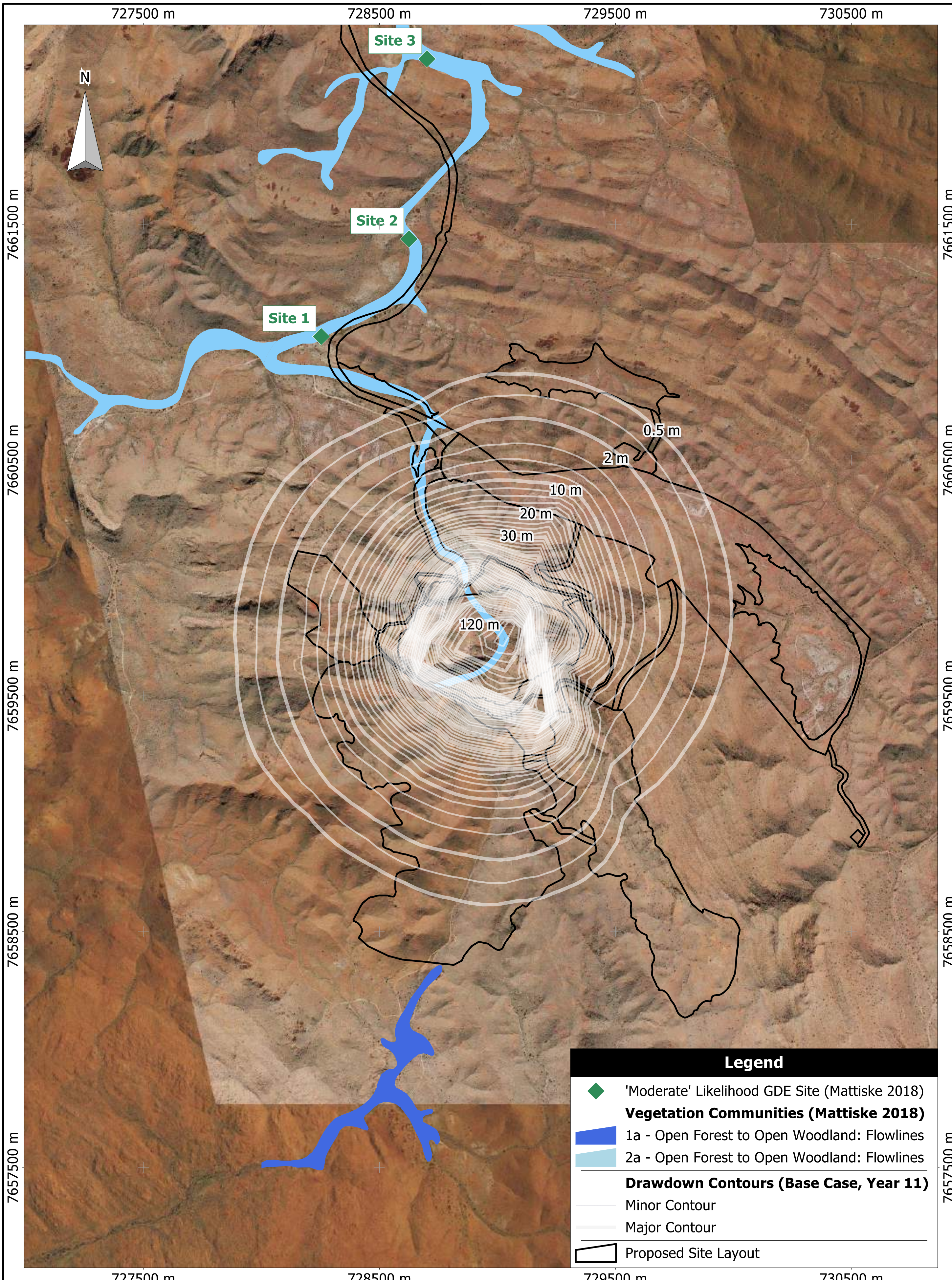

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Figure 21

Mine Dewatering Drawdown

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6.2.6 Mitigation

Table 40 lists key measures to be implemented at Sulphur Springs to address potential impacts on subterranean fauna.

Table 40: Proposed Mitigation Measures for Subterranean Fauna

<table>
<tr><th>Potential Impact Requiring Management</th><th>Mitigation Measures</th></tr>
<tr><td>Degradation of subterranean fauna habitat due to poor quality seepage from the TSF</td><td rowspan="2">Measures to avoid:
• Siting key proposal elements (WRD and TSF) adjacent to the mine pit to confine any seepage extent.
Measures to minimise:
• TSF location adjacent to the mine pit with minimised footprint.
• Siting of encapsulated PAF cells in the WRD within the pit catchment.
• Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management.
• Design of PAF cells in the WRD to minimise ingress of oxygen and water.
• Siting of other mine infrastructure and associated surface water management infrastructure to minimise impacts to catchment areas.
• Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions.
Measures to rehabilitate:
• WRD rehabilitation to a design to maximise surface stability and minimise infiltration around PAF areas.
• Shaping the final WRD and TSF landforms to shed surface runoff away from the mine pit to ensure the pit remains a hydraulic sink.
• Monitoring TSF seepage during operations for consideration in closure design.
• Review of the site surface water model during operations to refine/validate assumptions and pit water balance.
• Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure.
• Consideration of a reactive transport model for seepage quality and pit lake water quality predictions.</td></tr>
<tr><td>Degradation of subterranean fauna habitat due to poor quality seepage from the WRD or pit</td></tr>
</table>

6.2.7 Mitigation, Monitoring and Contingencies

The majority of mitigation measures proposed to minimise the risk of impacts to subterranean fauna relate to management of groundwater abstraction and surface water diversions. The effectiveness of these measures will be assessed via the following:

- A Groundwater Operating Strategy supplementing groundwater licence conditions for the site, developed in accordance with *Operational Policy 5.08 - Use of Operating Strategies in the Water Licensing Process* (DoW 2011).
- A project water management plan detailing:
  - Management measures for site activities including dewatering, stormwater and operation of the TSF.
  - Contingency actions for unwanted events such as equipment damage or failure, leaks/spills, excessive drawdown of aquifer, larger than predicted cone of dewatering drawdown or excess dewatering volumes (Section 6.2.2 of Appendix 17).
  - Provisional water quality trigger levels developed based on baseline monitoring. The purpose of these triggers is to identify whether changes to surface water or groundwater are significantly outside the normal range, thus necessitating a series of response actions to investigate the cause (Section 6.2.3 of Appendix 17).
  - Monitoring requirements, procedures, standards and reporting requirements.

6.2.8 Predicted Outcomes

Limited groundwater drawdown is predicted to result from mine dewatering and groundwater abstraction (water supply). The majority of stygofauna species recorded are confirmed to be well distributed beyond the potential impact area. The remaining stygofauna species are also believed based on habitat usage, to also be well represented beyond the impact area. Therefore, no significant impacts on stygofauna as a result of pit development, dewatering and groundwater abstraction (water supply) are expected.

The single troglofauna species recorded within the impact area is well represented beyond the Development Envelope and therefore no significant impacts on troglofauna from pit development are expected.

Groundwater and surface water modelling indicate that adoption of appropriate surface water diversions will ensure the pit lake becomes a hydraulic sink. Thus, no significant impacts to the groundwater quality in surrounding areas are expected (Appendix 9). Any seepage from encapsulated PAF cells in the WRD will be captured in the pit lake (Appendix 16), reducing the likelihood of significant impacts to groundwater quality in surrounding areas.

Taking into account the broad distribution of subterranean fauna beyond the impact area, the proposed mitigation measures including robust TSF and WRD design, development and implementation of a groundwater management plan and implementation of appropriate chemical storage and handling procedures, a significant impact on subterranean fauna as a result of degradation of habitat is not expected. Given this, it is believed that the EPA objective ‘to protect subterranean fauna so that biological diversity and ecological integrity are maintained’ (EPA 2016e) will be met.

6.3 PRELIMINARY KEY ENVIRONMENTAL FACTOR 3 – TERRESTRIAL ENVIRONMENTAL QUALITY AND INLAND WATERS ENVIRONMENTAL QUALITY

6.3.1 EPA Objectives

The EPA objective for terrestrial environmental quality is 'To maintain the quality of land and soils so that environmental values are protected' (EPA 2016h).

The EPA objective for inland waters environmental quality is 'To maintain the quality of groundwater and surface water so that environmental values are protected' (EPA 2016i).

6.3.2 Policy and Guidance

Terrestrial environmental quality and inland waters environmental quality are protected under State legislation:

- *Environmental Protection Act 1986* (WA).
- *Rights in Water and Irrigation Act 1914* (WA).
- *Country Areas Water Supply Act 1947* (WA).

In addition to State legislation, the following policy and guidance statements were considered in the impact assessment for terrestrial environmental quality and inland waters environmental quality:

- Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015).
- EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b).
- EPA Environmental Factor Guideline – Terrestrial Environmental Quality (EPA 2016h).
- EPA Environmental Factor Guideline – Inland Waters Environmental Quality (EPA 2016i).
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000 (Commonwealth) (ANZECC and ARMCANZ 2000).
- Water Quality Protection Guidelines No. 11, Mining and Mineral Processing, Mine Dewatering (WRC 2000a).
- Statewide Policy No. 5, Environmental Water Provisions Policy for Western Australia (WRC 2000b)
- National Water Quality Management Strategy (ANZECC and ARMCANZ 1994).
- Pilbara Regional Water Plan (DoW 2010).
- Guide to Departmental Requirements for the Management and Closure of Tailings Storage Facilities (DMP 2015).

6.3.3 Receiving Environment

A number of baseline surveys have been undertaken for the Proposal and regional area as summarised in Table 41.

Table 41: Summary of Soil, Hydrology and Hydrogeology Studies

Date	Consultant	Description
Soil		
2007	URS	Profiling and clay classification.
2013	Outback Ecology Services	Soil resource assessment in the Proposal area.
Hydrology		
2007	Golder Associates	Quality of the post-closure pit lake.
2007	URS	TSF flood risk study and climate change impact assessment.
2007	URS	Surface water characterisation of the Proposal area.
2009	URS	Design of mine surface water drainage control structures.
2013	URS	Studies into accommodation village flood risk assessment.
2013	URS	Surface water management in the Proposal area.
2016, 2017	Knight Piésold	Preliminary designs for the revised TSF.
2017	O'Kane Consultants	Conceptual design for the TSF cover.
2019	O'Kane Consultants	Conceptual cover design performance modelling and review of geochemical amendments.
2016	Venturex	Mine site water balance.
2018	AECOM	Surface water assessment in the Proposal area.
2018	AECOM	Sulphur Springs water addendum report.
2018	AECOM	Sulphur Springs water management plan.
2019	AECOM	Sulphur Springs second water addendum report.
2020b	AECOM	Surface water assessment in the Proposal area.
2020d	AECOM	Mine site water balance.
2020	Knight Piésold	Preliminary concept design for the revised TSF.
Hydrogeology		
2006, 2007	Golder Associates	Water supply exploration for the Proposal.
2007	URS	Water supply exploration for the Proposal.
2007	URS	Groundwater characterisation of the Proposal area.
2008, 2012	URS	Studies into the rates and impacts of TSF seepage.
2011, 2012, 2013	URS	Assessments for mine dewatering.
2012	URS	Water supply exploration for the Proposal.
2013	URS	Characterisation of groundwater in the Proposal area.
2013	URS	Water management in the Proposal area.
2018	AECOM	Groundwater assessment in the Proposal area.
2018	AECOM	Sulphur Springs water addendum report.
2018	AECOM	Sulphur Springs water management plan.
2019	AECOM	Sulphur Springs second water addendum report.
2020a	AECOM	Groundwater assessment in the Proposal area.
2020c	AECOM	Sulphur Springs water management plan.

6.3.3.1 Topography and Soils

Topography in the region is characterised by numerous rocky hills and small gorges that control the flow of surface water. Elevation ranges from around 200 mAHD in the alluvial flats and low hills to the north of the Proposal, to around 400 mAHD near the proposed pit. The Development Envelope has a diverse landscape, where the differential weathering of basement rocks has developed sharp local changes in relief (Plate 8 and Figure 22). In this landscape, the competent lithologies tend to form topographically high areas (such as ridge lines). In contrast, zones subjected to greater geological stress may preferentially weather and erode forming the valleys.

Plate 8: Typical Topography in Mine Area

The Proposal area sits within three land systems; Boolgeeda, Capricorn and Rocklea (Figure 23). Van Vreeswyk *et al.* (2004) have defined soil types of these land systems and determined their erodibility based on geological properties and landform (Table 42).

In general, soils of the granitic terrain and within the immediate vicinity of granite hills and outcrops across the site are red shallow sands. The hills give way to broad gently sloping plains with red sandy earths, red deep sands and red loamy earths (URS 2007b). Most soil types within the hills have significant to dominant proportions of stone throughout the soil profile and often have a very stony mantle and prominent rock outcrops. Other minor soils include red shallow loams with some red shallow sands. Soils become deeper downslope. In these areas, the dominant soils are stony surfaced red loamy earths. The land systems show no sign of degradation or erosion and the condition of perennial vegetation is generally good to very good (URS 2007b).

Topsoil development is localised and not extensive in the Proposal area. The proportion of coarse material (>2 mm) present within the soil is typically high (up to 81%), with the majority of soils assessed across the Proposal area having greater than 50% coarse material content (Appendix 22). Overall, project soils are considered to be ‘moderately stable’ to ‘stable’, from an erodibility perspective, prone to hard setting, moderately transmissive with low plant-available water, variable in pH, generally non-saline and non-sodic and contain low concentrations of plant available nutrients. Soil characteristics within specific infrastructure areas are presented in Table 42. Physical and chemical characteristics of soils across the Proposal area are further discussed in Appendix 22.

No landforms within the project tenements are listed on the Western Australian Geoheritage Sites database. The large number of baseline surveys conducted across the site (including heritage and ethnographic studies), have not identified any landforms within the project tenements that could be considered rare at a local, regional or national level.

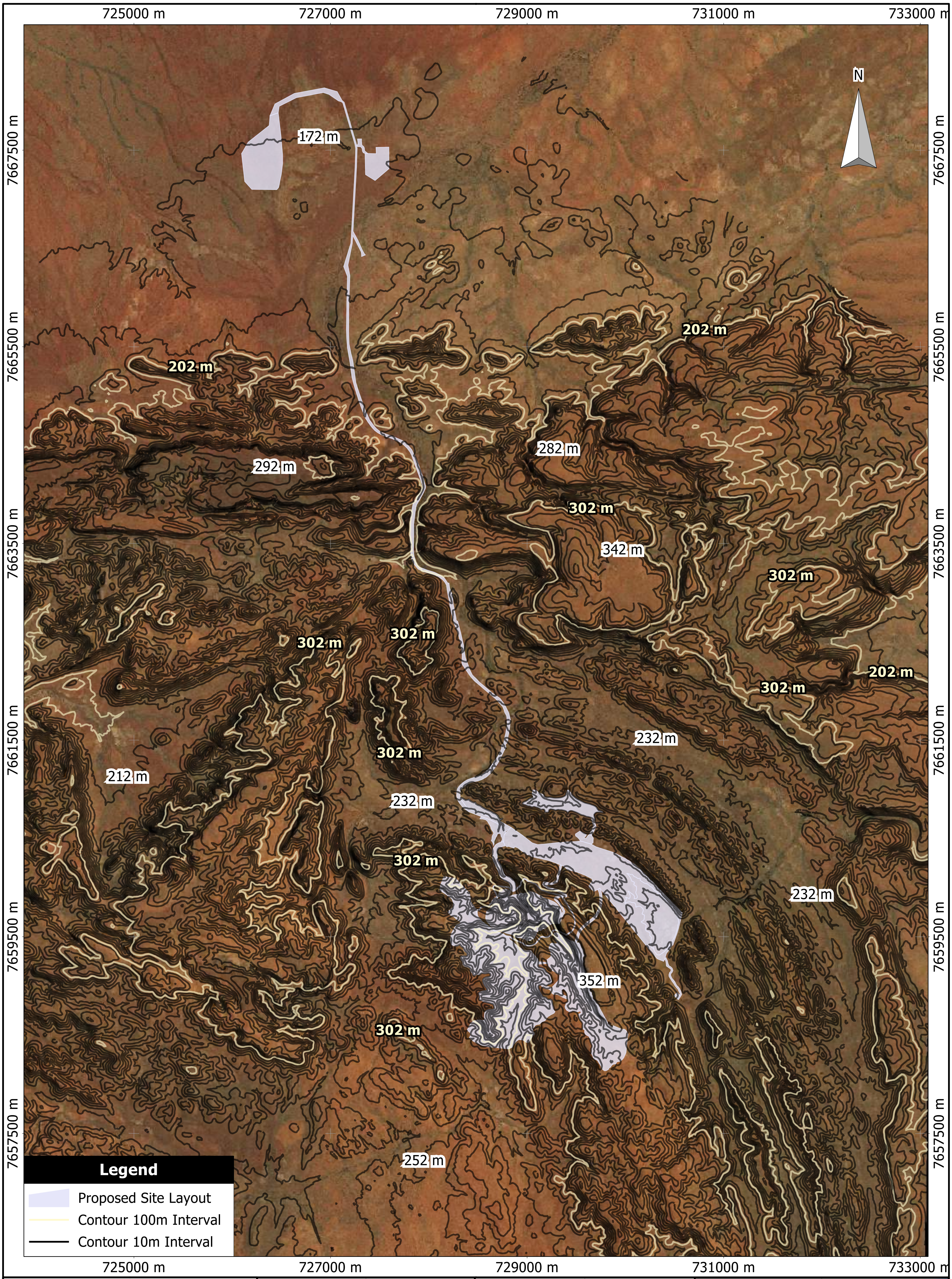

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Figure 22

Proposal Area Topography

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Table 42: Land Systems of Sulphur Springs

<table>
<tr><th rowspan="2">Proposal Infrastructure</th><th colspan="3">Regional data (Van Vreeswyk et al. 2004)</th><th colspan="2">Development Envelope (Outback Ecology 2013b)</th></tr>
<tr><th>Landform Types</th><th>Soil Types</th><th>Erosion Susceptibility</th><th>Soil Physical Characteristics</th><th>Soil Chemical Characteristics</th></tr>
<tr><td colspan="6">Boolgeeda Land System</td></tr>
<tr><td>• Southern half of accommodation village.
• Borrow pit near accommodation village.
• Northern section of Site Access Road.</td><td>Gently inclined Stony Slopes and Plains.</td><td>Bare rock, red shallow earth, deep red sands, and channels with riverbed soils.</td><td>Vegetation not prone to degradation.
Not susceptible to erosion.</td><td>• Sandy loam.
• Prone to structural decline as a result of clay dispersion.
• Generally not prone to hard setting.
• Low to medium plant-available water, considered typical of weathered surface soils in region.</td><td>• Moderately acidic (pH 4.8) to neutral (pH 7.0).
• Non-saline, non-sodic.
• Low plant available nitrogen and phosphorus.
• High plant available potassium.</td></tr>
<tr><td colspan="6">Capricorn Land System</td></tr>
<tr><td>• Majority of open pit.
• Small northwestern portion of WRD.
• Small northern portion of TSF</td><td rowspan="2">Hills and Ridges of sandstone and dolomite with steep rocky upper slopes.</td><td rowspan="2">Stony soils, red shallow loams, red shallow sands and riverbed soils.</td><td rowspan="2">Vegetation not prone to degradation.
Not susceptible to erosion.</td><td>• Sandy loam.
• Moderately stable in structure.
• <2 mm fractions prone to hard setting, but this is likely to be counteracted by higher content of coarse material (68%).
• Low to medium plant-available water, considered typical of weathered surface soils in region.</td><td>• Neutral pH (5.5).
• Non-saline.
• Non-sodic.
• Low plant available nitrogen and phosphorus.</td></tr>
<tr><td>• Processing Plant.</td><td>• Sandy loam, to loamy sand to sandy clay loam to clay loam.
• Structural stability generally moderately stable to stable.
• <2 mm fractions prone to hard setting, but this is likely to be counteracted by higher content of coarse material in most areas.
• Low to medium plant-available water, considered typical of weathered surface soils in region.</td><td>• Neutral to strongly alkaline pH (5.8 to 8.2)
• Generally non-saline, although some material adjacent to slopes in central area of plant identified as slightly saline.</td></tr>
</table>

Proposal Infrastructure	Regional data (Van Vreeswyk *et al.* 2004)			Development Envelope (Outback Ecology 2013b)	
	Landform Types	Soil Types	Erosion Susceptibility	Soil Physical Characteristics	Soil Chemical Characteristics
					• Generally non-sodic, although some material in the northwestern area of the site was sodic to highly sodic. • Low plant available nitrogen and phosphorus.
• Majority of Site Access Road.				• Sandy clay. • Moderately stable structure. • <2 mm fractions prone to hard setting, but this is likely to be counteracted by higher content of coarse material (>55%). • Moderate to moderately rapid hydraulic conductivity. • Low to medium plant-available water, considered typical of weathered surface soils in region.	• Neutral to moderately alkaline pH (6.6 to 7.1). • Moderately saline in upstream areas close to processing plant. • Non-saline in downstream areas. • Non-sodic. • Low plant available nitrogen and phosphorus.
Rocklea Land System					
• Majority of WRD. • Majority of TSF. • Small southern portion of open pit. • Northern half of accommodation village.	Basalt Hills, Plateaux, lower slopes and minor stony plains.	Stony soils and calcareous shallow loams, red shallow sandy duplex soils, shallow red/brown cracking clays, self-mulching cracking clays or the gilgai plains, channels with riverbed soils.	Vegetation not prone to degradation. Not susceptible to erosion.	• Sandy loam to sandy clay loam. • Structural stability ranging from moderately stable to unstable. • <2 mm fractions prone to hard setting, but this is likely to be counteracted by higher content of coarse material (>60%). • Low to medium plant-available water, considered typical of weathered surface soils in region.	• Neutral pH (5.6 to 6.9) • Generally non-saline. • Non-sodic. • Low plant available nitrogen and phosphorus. • High plant available potassium in some areas.

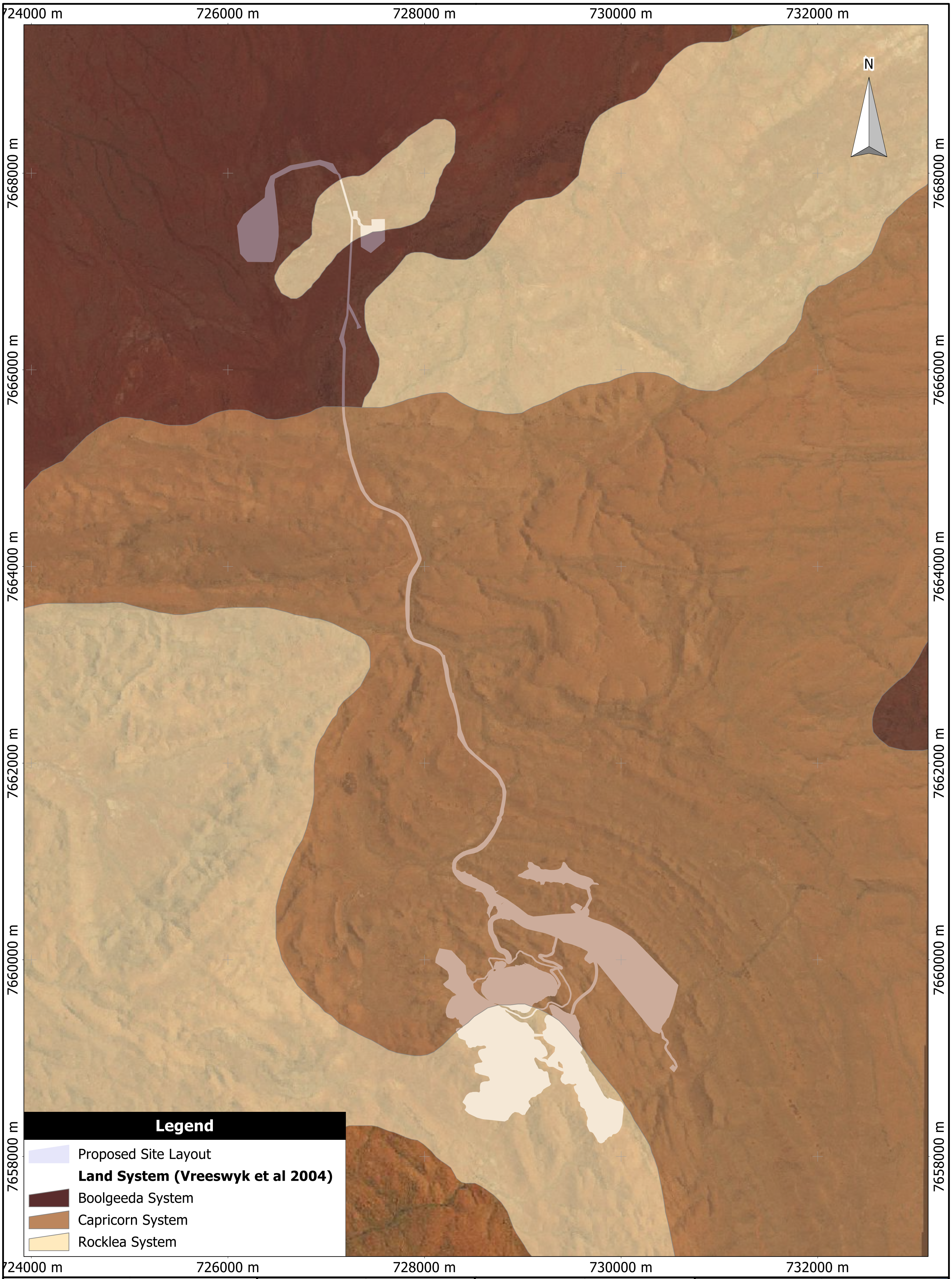

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Figure 23

Proposal Area Landforms

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6.3.3.2 Geology

Regional Geology

The Pilbara Craton comprises Archaean and paleo-Proterozoic rocks that outcrop in the Pilbara region of Western Australia. The Craton consists of a 250,000 km^2 ovoid segment of terranes and basins (URS 2007a).

The northern Pilbara Craton is divided into several types of tectonic domains (Van Kranendonk and Morant 1998). These include lithotectonic terranes, polyphase granitic complexes, individual granitic intrusions, greenstone belts (East Pilbara Terrane only) and sedimentary basins of the De Grey Supergroup (Van Kranendonk *et al.* 2006 and URS 2007a).

Sulphur Springs is located in the East Pilbara Terrane, the oldest component of the northern Pilbara Craton. The East Pilbara Terrane is a 'dome-and-basin' granite-greenstone domain in which ovoid granites are flanked by arcuate-shaped volcano-sedimentary packages. This terrane represents the nucleus of the Pilbara Craton, formed through a succession of mantle plumes (3,530 to 3,230 Ma) that produced a dominantly basaltic volcanic succession, known as the Pilbara Supergroup, on an older sialic basement. Granitic complexes in the East Pilbara Terrane are structural domes that are separated from one another by faults or intervening greenstone belts, or both. Each complex contains several different age components, but many of the components are common to several complexes (Van Kranendonk *et al.* 2006).

Project Geology

The Sulphur Springs Group of the Pilbara Supergroup in the East Pilbara Terrane is host to the deposit mineralisation. North east portions of the proposed pit are also expected to intercept the Soanesville Group successions, which dip 50º to 55º to the north east. Footwall rocks are predominantly formed of dacite/rhyodacite volcanics of the Kangaroo Caves Formation (Sulphur Springs Group). Sulphide mineralisation is strongly strata-bound on the contact between the footwall successions and overlying marker chert beds. Mineralisation is interpreted to occur in association with strata-bound shear zones that are concordant with the shear and foliation fabric of the marker chert. Hanging wall rocks include polymict breccias and upper chert beds of the Kangaroo Caves Formation and the overlying siltstone and quartz arenite of the Corboy Formation (Soanesville Group) (URS 2007a).

Sulphide mineralisation is dominated by massive pyrite, which contains enriched horizons of sphalerite and chalcopyrite. Galena is present in minor amounts. The sphalerite rich zone lies towards the top of the massive pyrite lenses. The copper rich zone of the deposit lies towards the base of the influence of the pyrite. The pyrite lenses have a gradational contact with the barren felsic volcanics beneath.

There are seven previously modelled faults which influence the distribution of both the local stratigraphic successions and mineralisation. Three of these faults are considered major (Main, Creek and Gorge faults) and four are considered minor. The Main and Creek faults appear to be localised in their alteration and brecciation halos, having a lower and in some instances indiscernible, impact on local ground conditions. The Gorge fault is believed to exist as a set of fault splays, with a greater level of brecciation of the surrounding rock. This fault impacts ground conditions to a much greater extent and is pervasive across three quarters of the orebody. Intersections are often ambiguous for the four minor faults. They are localised and minor in effect and interpreted to either be related to the major faults (as splays of extensions) or to be small, older thrust faults.

6.3.3.3 Hydrogeology

Conceptual hydrogeology for the Sulphur Springs area has been characterised through interpretations of the Archaean geology, catchment distributions, data obtained during exploratory drilling and groundwater investigation (URS 2007a and Appendix 16). Groundwater and surface water flow systems in the area are complex, variable and linked. There are strong correlations with topography, geology and structure (such as faults and thrusts) (Appendix 16).

Hydrogeological characteristics at Sulphur Springs include:

- Groundwater flow and water table gradients broadly reflect topography, surface water catchments and transmissive structures.
- Recharge takes place in upland areas and groundwater discharges to valley floor domains and associated watercourses.
- Geological units and structures such as faults and thrusts influence groundwater and surface water flow systems. Groundwater flow is predominantly linked to fractures in bedrock and local geology has the potential to compartmentalise fractured rock aquifer systems and associated groundwater flow, which may influence aquifer system limits, drawdown extents and local volumes of stored groundwater that is connected to the mine.
- Groundwater levels fluctuate in response to seasonal rainfall patterns. Generally, larger fluctuations in water level occur in elevated sections of the catchment. The steepest gradients are present along the slopes of valleys, and lowest along valley floors.
- The depth to water along Sulphur Springs Creek in the mine area is generally less than 2 m bgl. At some locations, it is observed that groundwater is slowly discharging from old mineral exploration drill holes. Combined with actively discharging groundwater along the creek bed, it is inferred that the water table is slightly above the creek bed level between SSC1 and SSC12 (Figure 8 of Appendix 16).
- The TSF site is in a groundwater flow system associated with the uppermost reaches of the Sulphur Springs Creek catchment. Based on data available within the WRD catchment and around the proposed pit area, the TSF site represents a groundwater recharge area and the shape of the water table approximates the local topography.
- Water quality in the Proposal area varies widely. Within the mineralised zone, solution cavities have formed through extensive oxidation of sulphide materials, resulting in groundwater that is equivalent to 'natural AMD' being low in pH and containing elevated concentrations of salinity, sulphate and metals/metalloids including aluminium, cadmium, copper, nickel, iron, manganese and zinc. Groundwater within this zone is known to discharge into Sulphur Springs Creek. Groundwater and surface water quality data indicate this mechanism has led to the development of acidic conditions and elevated metal concentrations in the creek system within the mineralised zone. Outside of the mineralised zone, surface water and groundwater are typically of near-neutral pH, low in salinity and contain lower concentrations of metals and metalloids. Baseline groundwater quality data is summarised in Table 43.

Table 43: Baseline Groundwater Quality (Appendix 16)

Parameter	Units	Mine Catchment	Mineralised Area
pH	pH units	6.1 – 8.4	2.8 – 6.9
TDS	mg/L	172 - 370	388 – 1,900
Alkalinity	mg/L	97 - 223	<1 - 91
Sulphate to Chloride Ratio	N/A	0.4 – 3.4	Up to 117
Major Ion Composition	N/A	Calcium or magnesium bicarbonate	Magnesium or sodium sulphate

6.3.3.4 Hydrology

Regionally, the Proposal footprint is predominantly in the Strelley River catchment, with a minor part of the proposed plant area in the Shaw River catchment. The Shaw and Strelley Rivers are ephemeral and characteristically flow in the lower courses through extensive floodplains while upper portions traverse deep gorges. Waterholes within low-lying stretches of the drainage lines may exist for much of the year, but most are dry from May to November. After heavy rains the rivers flood and often overflow their banks causing inundation of the coastal plain. Most of the rivers in the Pilbara region, including the Shaw and Strelley, have broad alluvial sands or zones of unconsolidated rock saturated with groundwater along their courses (URS 2013).

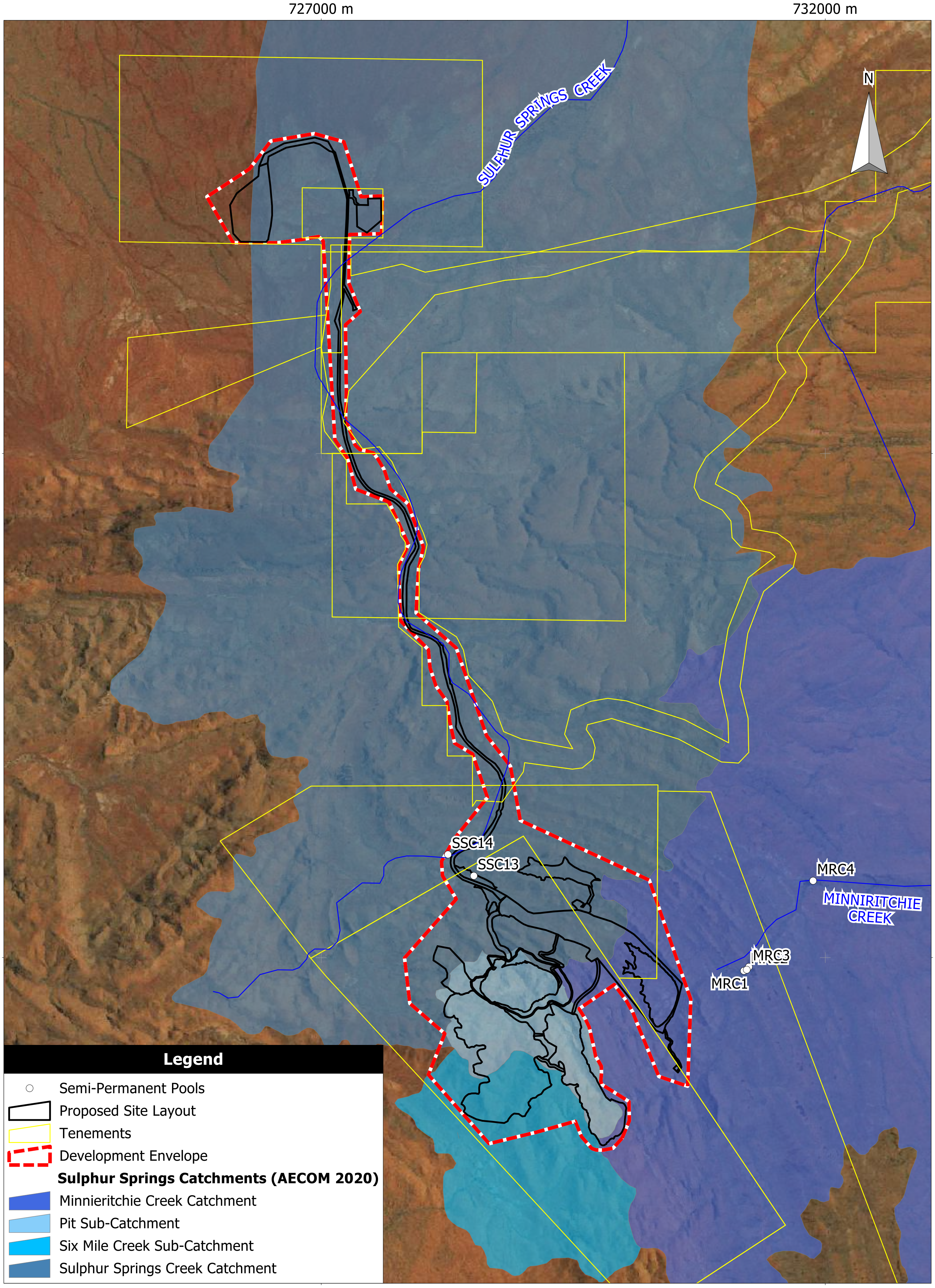
At a local scale, the Proposal lies within three catchments. The majority of the footprint is in the Sulphur Springs Creek catchment and lesser areas in the Six Mile Creek and Minnieritchie Creek catchments (Figure 24). Sulphur Springs Creek and Six Mile Creek flow to the Strelley River and Minnieritchie Creek flows to the Shaw River (AECOM 2020b, Appendix 21).

Surface water quality in the Development Envelope varies widely (Appendix 21). In the Sulphur Springs Creek catchment, perennial discharges of groundwater support surface water flows. These discharges come from mineralised bedrock with low pH and elevated concentrations of salinity, sulphate and metals/metalloids including cadmium, copper, nickel and zinc. Outside the mineralised zone, surface water generally has a close to neutral pH, low salinity and lower concentrations of metals and metalloids. Seasonal variations in concentrations of alkalinity occur as a result of evapoconcentration of solutes and biological activity in dry season pools.

Baseline water quality data is summarised in Table 44.

Table 44: Surface Water Quality (mg/L)

Parameter	Greater Region	Sulphur Springs Creek Catchment	Minnieritchie Creek Catchment	Six Mile Creek Catchment
TDS	194 - 1,330	194 - 1,910	1,050 - 1,500	250 - 340
pH	5.6 - 8.2	2.8 (near orebody) - 8.2	7.6 - 8.0	8.0 – 8.4
Arsenic	0.001 to 0.004	<0.001 to 0.007	<0.001 to 0.001	<0.001
Copper	0.001 to 0.012	0.006 to 4.29	0.001 to 0.002	0.001 to 0.004
Zinc	0.005 to 0.104	0.166 to 9.52	0.006 to 0.017	<0.005
Nickel	0.002 to 0.265	0.003 to 0.031	<0.001	<0.001
Lead	<0.001	0.002 to 0.02	<0.001	<0.001
Cadmium	<0.0001 to 0.007	0.0006 to 0.0482	<0.0001	<0.0001



Scale: 1:50000 Original Size: A4 Image source: Landgate Locate Mosaic Air Photo Date: 2012 Grid: MGA94(50) 0 — 1000 m	Venturex Resources Limited Sulphur Springs Project	**Figure 24** **Project Area Sub-Catchments**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD.map 28/01/2020 F24 Project Area Sub-catchments Layout

6.3.3.5 Surface Water and Ground Connectivity

The surface water and groundwater flow systems at Sulphur Springs are complex, variable and linked. There are strong correlations with topography, geology and structure in both the groundwater and surface water flow systems (Figure 25). Features relevant to links between the surface and groundwater include (Appendix 16):

- Groundwater flow and groundwater gradients broadly reflect the local topography.
- Groundwater discharge occurs in valley-floor domains and associated watercourses, including pools and springs.
- The occurrence of pools on valley floors indicates the shallow depth to groundwater, and that the local aquifer system becomes seasonally full.
- Geological structures such as faults and thrusts influence the link between surface water and groundwater.
- The local geology and structural settings have the potential to compartmentalise the fractured rock aquifer systems, associated groundwater flow, and discharges to surface water.
- Most of the valley-floor watercourses are aligned with known fractured-rock aquifer systems.

6.3.3.6 Existing Water Users

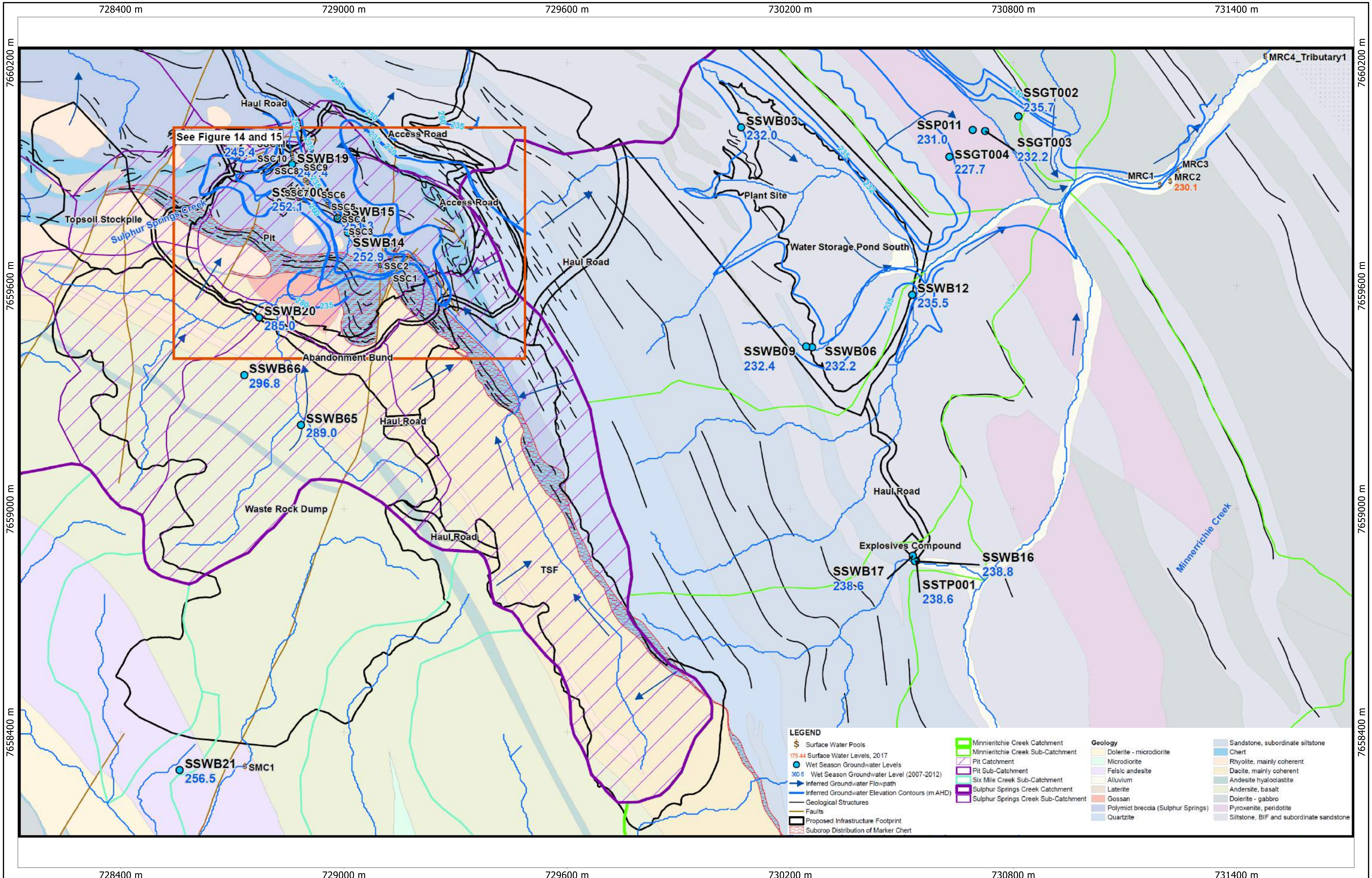
The Development Envelope is located within the Pilbara Surface Water Management Area proclaimed under the *Rights in Water and Irrigation Act 1914*, administered by DWER. The Development Envelope lies upstream of a proclaimed water reserve (a Priority 1 Drinking Water Source Area), which is located in the lower reaches of the De Grey River at least 100 km to the north (Appendix 16). Water resource objectives for this aquifer include:

- Preventing saltwater intrusion into the aquifer caused by abstraction.
- Maintaining water quality for the most beneficial use (potable water supply).
- Maintaining groundwater and pool levels within a target range to maintain aquatic habitat and riparian vegetation dependent on groundwater and protect values as listed in the Directory of Important Wetlands in Australia.

The closest other groundwater user to Sulphur Springs is Atlas which operates five water bores for mine dewatering and water supply to the Abydos Mine. These bores are located between 8 and 11 km west of Sulphur Springs in a tributary of Six Mile Creek (Appendix 16). Under a joint Water Management Plan between the two companies, Atlas also operates four bores (PAN60, SSWB36, SSWB38 and SSWB40 shown on Figure 13) that are owned by Venturex. These bores are used for dust suppression on the Abydos Link.

The Proposal lies predominantly within Unallocated Crown Land and there are no known users of surface water in any of the three catchments near the Proposal. The northern end of the Proposal footprint traverses parts of the Strelley and Panorama Pastoral Stations. There are ephemeral pools along the proposed Site Access Road on Sulphur Springs Creek on the Panorama Pastoral Station that may be frequented by wandering stock in the dry season. Ephemeral pools are also present along the upper reaches of Sulphur Springs and Minnieritchie Creeks within Unallocated Crown Land (Appendix 21).

No other future potential water users in the Proposal area are foreseen.



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Source: AECOM Sulphur Springs Project Groundwater Assessment 2020

0 200 m

Venturex Resources Limited
Sulphur Springs Project

Figure 25

Mine Site Hydrogeology (Wet Season)

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W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD.map 28/01/2020 F25 Mine Site Hydrogeology (Wet Season) Layout

6.3.4 Potential Impacts

6.3.4.1 Potential Direct and Indirect Impacts

Proposal infrastructure and the predicted mine dewatering cone of depression are shown on Figure 26. The Proposal may result in the following direct impacts to terrestrial environmental quality and inland waters environmental quality:

- Contamination of soils or surface water due to overtopping of the pit lake at closure (high inherent risk).
- Contamination of soils, surface water or groundwater due to spills (medium inherent risk).
- Contamination of soils, surface water or groundwater due to a TSF embankment failure (high inherent risk).
- Contamination of soils, surface water or groundwater due to overtopping the TSF (medium inherent risk).
- Contamination of surface and/or groundwater due to seepage from the TSF, WRD or pit (medium inherent risk).
- Contamination of soils or surface water due to overtopping of surface water storages (medium inherent risk).
- The TSF becomes listed as a contaminated site under the *Contaminated Sites Act 2003* (medium inherent risk).
- The WRD or pit becomes listed as a contaminated site under the *Contaminated Sites Act 2003* (medium inherent risk).
- Contamination of soils due to particulate emissions from the TSF surface (medium inherent risk).
- Contamination of groundwater due to seepage from storage ponds (low inherent risk).
- Loss of topsoil and/or viability due to erosion, compaction or inappropriate handling and storage regime (low inherent risk).
- Contamination of groundwater due to seepage from low grade stockpile or ROM pad (low inherent risk).

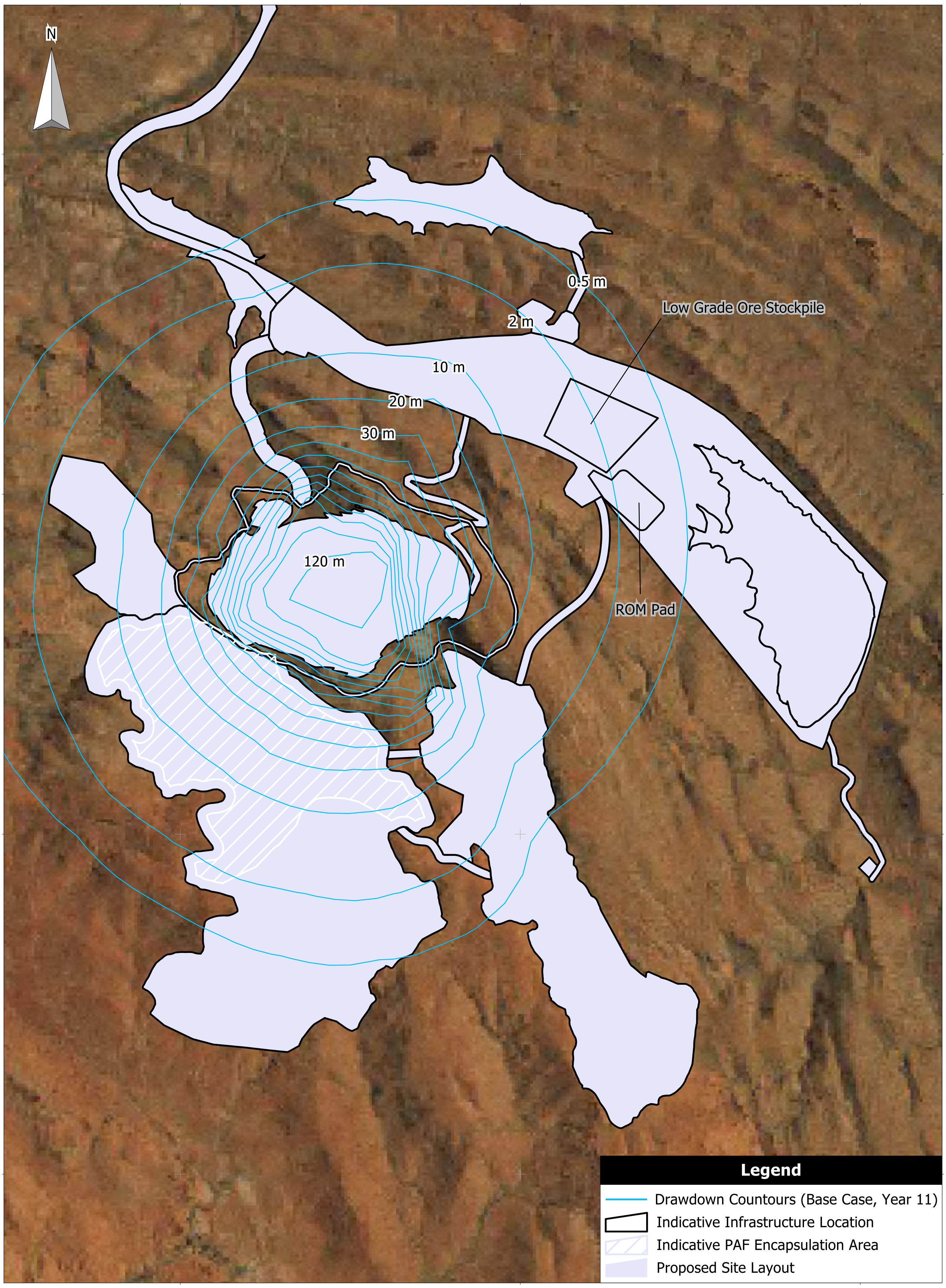
6.3.4.2 Potential Cumulative Impacts

No material risk of a cumulative impact on the quality of the terrestrial environment and water resources has been identified for the project. Overall the risks posed by the Proposal to the terrestrial environment and water quality are local in scale. The nearest development to the project site is 8 km to the west (Abydos iron ore mine, not currently in operation) and any project related impact is unlikely to contribute significantly to any cumulative impact at the broader catchment scale.

6.3.5 Assessment of Impacts

Potential impacts of implementation of the Proposal on terrestrial environmental quality and inland waters environmental quality were assessed in accordance with the approach outlined in Section 5. Findings of surveys conducted within the Proposal area and the broader region in accordance with EPA policy and guidance, were utilised in conjunction with preliminary project design to inform the impact assessment. This assessment and resultant inherent risk ratings (i.e. prior to mitigation and management measures) are provided in Appendix 12.

Potential impacts assessed as 'low' risk and screened from further detailed assessment are briefly discussed in Table 47. Inherent 'moderate' and 'high' risk impacts are addressed in the following sections.



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Sulphur Springs Project

Figure 26

Proposed Infrastructure and Mine Dewatering Cone of Depression

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6.3.5.1 Contamination of Soils or Surface Water due to Overtopping of the Pit Lake at Closure

As outlined in Section 6.1.5.3, without diversion of runoff from any of the sub-catchments, the pit lake is likely to slowly fill over 90 – 100 years and overflow in the longer term. With sub-catchment modifications proposed in Section 2.2.3.4, the pit lake level remains below the point of surface discharge (1,245 mRL) under all rainfall scenarios.

Assessment of inherent risk has assumed no sub-catchment modifications. Under this scenario, the volume of pit overflow would depend on the annual rainfall. In dry years, there may be no discharge, while in wet years, it is considered more likely. Following a pit overtopping event, surface water quality impacts may be evident along Sulphur Springs Creek. An inherent likelihood of 'likely' has therefore been adopted.

Pit lake water quality is predicted to become increasingly saline, with TDS values ranging from 5,259 mg/L (slightly saline) after 100 years to 26,609 mg/L (saline) after 1,000 years. Substantial (>50%) proportions of cadmium, nickel, selenium and zinc inputs are predicted to remain in solution following geochemical equilibration. Concentrations of nickel and selenium may exceed those in existing groundwater within the footprint. All other metal and metalloid concentrations in the pit lake are likely to remain similar to or below those in existing groundwater (Table 31). The consequences of this impact are considered to be 'moderate'.

Adopting a conservative approach, the inherent risk of indirect impacts to surface water in the Sulphur Springs Creek catchment is considered to be 'high'. Simulated pit lake levels demonstrate that the residual risk of this impact is reduced to 'medium' with adoption of catchment management measures to ensure the pit remains a hydraulic sink, as outlined in Section 2.2.3.4 and Table 48.

6.3.5.2 Contamination of Soils, Surface Water or Groundwater due to Spills

Contamination may result due to spills of the following:

- Hydrocarbons, reagents and other chemicals used in mining and ore processing. Diesel will be used as fuel for the mining fleet and refuelling will occur from a purpose built fuel facility.
- Process slurries. Handling of most process slurries will largely be restricted to the processing plant area. Overland pipeline/s will be installed for transfer of tailings slurry from the processing plant area to the TSF. Tailings slurry will be alkaline (pH of approximately 8), with the potential to generated acidity if exposed to oxygen and water.
- Mine water. Mine water will be transferred to a water treatment plant and used for ore processing or pumped to a storage pond via overland pipelines. In the early stages of the project, mine water quality will be similar to existing groundwater, with low pH and elevated metal and metalloid concentrations.
- TSF decant water. Water recovered from the TSF decant will be returned to the processing plant area via an overland pipeline/s. This water has the potential to be acidic, saline and contain elevated concentrations of metal and metalloids.

Spills or failure of pipelines, material containment or equipment malfunction may result in discharge of these materials into the wider environment. The inherent risk of contamination of soils, surface water or groundwater due to spills is considered to be 'medium'. Appropriate mitigation measures to address this potential impact are presented in Table 48.

6.3.5.3 Contamination of Soils, Surface Water or Groundwater due to a TSF Embankment Failure

The risk of TSF embankment failure, during the operational and closure phases was addressed via the following two modelling strategies:

- A dam breach assessment of potential consequences of a TSF embankment failure during the operational period when tailings are not fully consolidated (worst case scenario).

- Landform evolution modelling to identify likely long-term erosion patterns and review mitigation scenarios (over 1,000 years).

Dam Breach Assessment

The consequence of a TSF embankment failure was assessed at a high level by Knight Piésold (Appendix 4) drawing on previous detailed work for the prior TSF location undertaken in accordance with the *Code of Practice, Tailings Storage Facilities in Western Australia* (DMP 2013) and *Guidelines on the Consequence Categories for Dams* (ANCOLD 2012). The TSF is rated as a 'High B' consequence category facility and will be designed to criteria applicable for this category under ANCOLD (ANCOLD 2019).

Dam break modelling is based on the assumption that a dam fails and does not consider the likelihood of such a failure occurring. The identified flow paths were used to determine the Population at Risk, the severity of damage and loss, and hence the consequence category of the facility.

Any tailings release resulting from failure of the main embankment will be contained by the mine pit. Failure of a saddle dam, which are smaller structures, would result in lower volumes release of tailings and/or water to Six Mile Creek or Minnieritchie Creek catchments. The extent and magnitude of any release is dependent on the location of the breach, scale and the cause. Potential consequences of a major breach of the embankments (worst case scenario) are summarised in Table 45 (Appendix 4).

Table 45: Potential Consequences of a TSF Embankment Breach

Embankment	Potential Consequences of Major Breach
Main Embankment	• Tailings flow slide into the mine pit.
South Saddle Embankment	• Tailings flow slide predominantly to the east towards Minnieritchie Creek • Subject to failure point, there is a risk of lower volume tailings release into the Six Mile Creek catchment.

Landform Evolution Modelling

Long term (1,000 years) Landform Evolution Modelling using the SIBERIA software developed by Telluric Research for landform modelling was conducted to assess the behaviour and performance of the TSF landform (embankments and tailings cover) (Appendix 23). The modelling was undertaken based on the conceptual TSF cover design for the TSF in a prior location. As the cover design is unchanged (with the exception of the removal of a HDPE liner between 2-3 m depth), the outcomes of the modelling are considered applicable to the current proposal (Appendix 4). This includes:

- A pattern of rilling and sheet flow erosion on the tailings cover surface is likely to occur during the closure phase. The modelled depth of erosion over 1,000 years ranged from 0.15 m to 0.4 m. Deeper erosion is likely to occur where concentration of runoff develops. This erosion is consistent with expectations. Given the design thickness of cover is 2 – 3 m, the risk of exposure of the tailings is considered to be low.
- Erosion is predicted to commence early in the closure phase and development of mechanical stability in the surface of the cover system will therefore be critical to promote surface stability until a vegetative cover is sufficiently developed to maintain long term surface stability. Establishment of vegetation on the cover consistent with the current vegetation materials is viable (based on site investigations) and will reduce erosion rates in the order of 50%-60%.
- Review of the design and/or retention at closure of a berm to be established in the downstream face of the main embankment as per existing embankment construction guidelines, but which acts as a focal point for erosion post-closure.

The rehabilitation design for the cover of the TSF will be progressively refined during the operational phase (in keeping with the required revisions and updates of the Mine Closure Plan). This will include consideration of additional NAF material in the capping to achieve required surface slopes to direct runoff in a southerly direction, away from the mine pit on closure. Further landform evolution modelling will be undertaken as part of the process to define the final cover design.

The potential consequence of a breach of the southern saddle dam on surface water and land quality in the upper parts of the Minnieritchie Creek and Six Mile Creek catchments could necessitate medium to long term management and remediation. The inherent risk of contamination of soils, surface water, groundwater or flora and vegetation due to a TSF embankment failure is therefore considered to be 'high'. Appropriate mitigation measures to address this potential impact are presented in Table 48.

6.3.5.4 Contamination of Soils, Surface Water or Groundwater due to Overtopping the TSF

Depending on management practices and rainfall, water on the TSF may be acidic, alkaline and/or contain elevated concentrations of metals, metalloids and TDS. Overtopping the main TSF embankment could result in contamination of soils in the zone between this embankment and the pit. Overtopping the south saddle embankment could result in contamination of soils, surface and groundwater within the upper reach of Minnieritchie Creek and Six Mile Creek catchments.

Without adequate design and mitigation measures, the inherent risk of contamination of soils, surface water or groundwater in the Minnieritchie Creek catchment area due to overtopping the TSF is considered to be 'medium'. The inherent risk of contamination of soils in the Sulphur Springs Creek catchment area is considered to be 'low'. Measures to mitigate this potential impact are presented in Table 48.

6.3.5.5 Contamination of Surface and/or Groundwater due to Seepage from the TSF, WRD or Pit

Indirect impacts to groundwater (and surface expressions of this flow) in the Sulphur Springs Creek catchment may result from seepage from the TSF, WRD (operational and closure phases) or pit (closure phase).

Existing groundwater discharging to Sulphur Springs Creek in the vicinity of the proposed pit is naturally sulphidic with pH values ranging from 2 to 4. Baseline surface and groundwater water quality in the vicinity of the mineralised area (both upstream and downstream) currently exceeds HMTVs for 95% protection of freshwater species (ANZECC and ARMCANZ 2000) for some metals. Existing salt-scarring along a 450 to 500 m stretch of Sulphur Springs Creek, immediately downgradient of the proposed pit provides an indication of the extent of existing and potential future groundwater discharges, should the pit become a groundwater seepage source. Based on this, it is anticipated that any surface expression of groundwater that includes seepage from the TSF, WRD or pit area would extend to just upstream of CF1 (Figure 10).

During the operational phase:

- TSF seepage will migrate vertically from the tailings and mix with native groundwater at the water table. Seepage and native groundwater will naturally focus at the invert of the steep sided valley and migrate downgradient within the PSC5 catchment towards the mine pit due, to the underlying contours and stratigraphy. It will be intercepted by underdrains and downstream recovery bores, with any residual captured in drains in the pit (Appendix 16).
- Seepage from the northern portion of the WRD (encompassing PAF encapsulation areas as shown on Figure 10) will migrate downgradient towards the mine pit due to underlying contours and stratigraphy.
- Existing acidic discharges along Sulphur Springs Creek will cease once mine dewatering lowers the water table below the creek bed. Groundwater within the resulting cone of depression, including seepage from the WRD and TSF will be captured within the mine dewatering system. The quality of ephemeral surface water between the pit and CF1 is expected to slowly change to a magnesium-bicarbonate type, similar to existing groundwater outside of the immediate pit area. This is likely to be reflected in reduced sulphate concentrations, though no significant change in the alkalinity or hydrochemistry of metals/metalloids is

expected. In the longer term surface water is expected to trend towards the bicarbonate-dominant water type observed in adjacent catchments, essentially representing an improvement in water quality.

- The inherent risk of impacts during operations is considered to be 'low'.

During the closure phase:

- The drawdown cone around the mine void is predicted to extend under the entire TSF (Figure 10). Seepage from the TSF after closure is expected to remain within the PSC5 catchment and migrate towards the mine void where it will be captured in a terminal sink.
- Seepage from the northern portion of the WRD will migrate towards the mine void where it will also be captured in a terminal sink. This volume will be very minor compared to other inflows to the pit lake.
- Water in the pit lake is predicted to become increasingly saline, with TDS values ranging from 5,259 mg/L (slightly saline) after 100 years to 26,609 mg/L (saline) after 1,000 years (Table 31, Appendix 9). Substantial (>50%) proportions of cadmium, nickel, selenium and zinc inputs are predicted to remain in solution following geochemical equilibration.
- Simulated pit lake levels indicate that, without appropriate designs for management of inflows to the pit, the pit water level will rise above the point where groundwater seepage occurs (1,235 mRL) (Table 30). The pit lake may then become a groundwater source until evaporation reduces the water level below 1,235 mRL and pushing contained water into the Sulphur Springs Creek catchment. The consequences of this impact are considered to be 'minor' and limited to the zone between the pit and CF1, which is currently exposed to natural acidic discharge.
- Adopting a conservative approach (i.e. tending to overestimate), the inherent risk of indirect impacts to groundwater (and surface expressions of this flow) is considered to be 'medium'. Simulated pit lake levels demonstrate that the residual risk of this impact is reduced to 'low' with adoption of catchment management measures outlined in Section 2.2.3.4 and Table 48.

6.3.5.6 Contamination of Soils or Surface Water due to Overtopping of Surface Water Storages

Depending on the purpose of the pond, contained waters may be acidic, alkaline and/or elevated in concentrations of metals, metalloids, salinity and sediments.

Without mitigation, overtopping of these ponds could lead to low level land contamination and/or a low level decline in surface water quality. The inherent risk of contamination of soils or surface water due to overtopping of surface water storages is therefore considered to be 'medium'.

6.3.5.7 The TSF, Permanent WRD or Pit Becomes Listed as a Contaminated Site Under the Contaminated Sites Act 2003

The *Contaminated Sites Act 2003* defines 'contaminated' as, 'in relation to land, water or a site, means having a substance present in or on that land, water or site at above background concentrations that presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value'. Classification requires a presence above background concentrations and that it has a pathway or potential pathway for release to receptors in order to pose a risk.

Table 46 provides a preliminary ecological risk assessment based on findings in this ERD. Without mitigation:

- The inherent risk of a reduction in health and condition to 0.27 ha of vegetation community 2a along Sulphur Springs Creek as a result of seepage from the pit is considered to be 'medium' and is restricted to the zone between the pit and site CF1. It is noted that acidic groundwater from the mineralised zone naturally discharges to this zone.

- The inherent risk of a reduction in health and condition to 1.48 ha of vegetation community 1a and a further 2.72 ha of vegetation community 2a along Sulphur Springs as a result of the pit overtopping is considered to be 'medium'. The extent of this impact is limited to the zone between the pit and SSWB36.
- The inherent risk of a decline in condition or disruption to reproductive cycle of livestock, native animals and birds as a result of the pit overtopping is considered to be 'medium'. The extent of this impact is likely to be limited to within the Development Envelope.

Proposed catchment modifications (Section 2.2.3.4) will substantially reduce the likelihood and the residual risk of these impacts is considered to be to 'low'.

Environmental monitoring during the operational period will provide data to test the validity of assumptions of the solute transport modelling (such as seepage rate, hydrogeological modelling and seepage water quality) and inform adaptive management options for mine closure. Nickel, selenium and other metals/metalloids are expected to be attenuated to varying degrees in the fractured rock aquifer, mainly by surface adsorption to hydrous iron oxides formed by partial weathering of fracture zone by oxygenated groundwater. Dissolved metals are expected to be further attenuated by interaction with particulate and dissolved organic matter. Seepage volume and quality can be controlled by TSF cover design (material selection, compaction and thickness) and adaptive measures such as lime-dosing tailings in the final stages of processing or use of alkali in the TSF cover applied, if required. Alkaline tailings cover layers have proven effective for reducing acid mine drainage by preventing acid generation in deep tailings layers by soluble oxidants such as ferric (Fe^{3+}) ions and forming a low permeability gypsum crust at the tailings surface.

6.3.5.8 Contamination of Soils due to Particulate Emissions from the TSF Surface

There is potential for particulate emissions from the TSF if the tailings surface is allowed to dry. The likelihood of this occurring will be greatest during the period between cessation of operations and installation of the TSF cover at closure. Isolated zones of dry material along the tailings beach may also form during the operational phase, or during raising of the embankments.

Impacts from particulate emissions are likely to be limited to within 50 m of the generation point and will be restricted by the steep sided valley walls. Without mitigation, these emissions could lead to low level land contamination, largely restricted to the pit catchment area by the valley walls. The inherent risk of contamination of soils due to particulate emissions from the TSF is therefore considered to be 'medium'.

Table 46: Preliminary Ecological Risk Assessment

<table>
<tr><th>Source</th><th>Potential Contaminants</th><th>Primary Potential Pathway</th><th>Receptor/s</th><th>Comment</th><th>Inherent Risk</th></tr>
<tr><td>Process tailings in TSF</td><td rowspan="6">• Acidity – proton and mineral acidity (Fe, Al and Mn).
• Salinity, mainly in the form of sulphate salts (primarily magnesium, but also calcium).
• Base metal toxicants – primarily copper, nickel and zinc.
• Metalloids - although the sulphidic mine wastes are geochemically enriched in arsenic, antimony and selenium, these elements are mainly present in insoluble forms, with selenium identified as the metalloid most likely to report in seepage to groundwater in potentially environmentally significant concentrations.
• Toxic rare elements including cadmium, thallium and tellurium. These elements are also are geochemically enriched in Sulphur Springs mine waste and may report in low, but detectable, concentrations to pit water and groundwater beneath mine waste landforms.</td><td>TSF Seepage - Groundwater from the TSF valley discharges to the pit.</td><td>None identified between TSF and pit.</td><td>-</td><td>Low
(Seepage considered likely, but no significant receptors identified in zone between TSF and pit).</td></tr>
<tr><td>PAF waste rock in WRD</td><td>WRD Seepage - groundwater beneath the PAF storage in the WRD will report to the pit</td><td>None identified between WRD and pit.</td><td>-</td><td>Low</td></tr>
<tr><td rowspan="4">Poor quality water in pit lake</td><td rowspan="2">Seepage from the pit.</td><td>0.27 ha of vegetation community 2a between pit and site CF1 (Figure 16).</td><td rowspan="4">During the operational phase of the project, existing acidic discharges from the mineralised zone will cease once mine dewatering lowers the water table below the creek bed. The resultant risks during this phase are considered to be low.

During the closure phase and without appropriate designs for management of inflows to the pit, it is possible that it will become a persistent groundwater source, pushing contained water into the Sulphur Springs Creek catchment. If this were to occur, groundwater acidity in the zone between the pit and CF1 is unlikely to be any higher than current baseline conditions. It is possible that concentrations of dissolved metals and TDS in this zone will increase over the longer term.

Without measures to address pit inflows at closure, the mine pit is predicted to gradually fill over 90 to 100 years and eventually overtop (Appendix 9.

Concentrations of lead, zinc, selenium and cadmium at SSC Creek Spring 1 and SSEB36 may increase for intermittent periods.

Based on available ecotoxicity data, the risk to livestock, native animals and birds is considered to be 'medium'. Impacts (primarily related to selenium concentrations) are predicted to be chronic rather than acute, leading to a decline in condition or disruption to reproductive cycle.</td><td>Low (operations)
Medium (closure)</td></tr>
<tr><td>Fauna accessing surface water between pit and site CF1.</td><td>Low (operations and closure)</td></tr>
<tr><td rowspan="2">Overtopping of the pit.</td><td>1.48 h of vegetation community 1a between pit and SSWB36.
2.72 ha of vegetation community 2a between pit and SSWB36.</td><td>Medium</td></tr>
<tr><td>Fauna accessing surface water between pit and Accommodation Village.</td><td>Medium</td></tr>
</table>

6.3.5.9 Potential Low Risk Impacts

Potential impacts assessed as posing a 'low' risk to terrestrial and inland waters environmental quality are shown in Table 47.

Table 47: Terrestrial and Inland Waters Environmental Quality – Justification for Exclusion of Potential Low Risk Impacts

Potential Low Risk Impact	Project Phase	Justification for Exclusion
Contamination of groundwater due to seepage from storage ponds	Operations	Ponds will be HDPE lined and potential seepage rates will be very low. North Pond will be constructed within the valley to the north of the Processing Plant and within the Sulphur Springs Creek catchment, approximately 500 m to the east of the creekline. South Pond will be constructed within the Processing Plant area and within the Minnieritchie Creek catchment, approximately 400 m west of the creekline. The quality of water stored in these ponds will be variable. Early in the mine life, it may be brackish and low in pH. With time, the quality of dewatering discharge from the mine is likely to improve as acidic groundwater within the orebody, and the orebody are removed. At closure, both ponds will be decommissioned, and the footprints rehabilitated, eliminating the potential for ongoing seepage post-closure. Due to low seepage rates, likely dilution from the greater catchment and the distance to sensitive receptors, the inherent risk of this impact is considered to be low.
Loss of topsoil and/or viability due to erosion, compaction or inappropriate handling and storage regime.	Construction, Operations and Closure	Topsoil development in the Proposal area is localised and not extensive. Soils typically contain a high proportion (up to 81%) of coarse material, which protects the surface soils from excessive wind and water erosion. While some minor erosion and compaction is likely to occur as a result of mine development, the consequences of this are expected to be insignificant.
Contamination of groundwater due to seepage from low grade stockpile or ROM pad	Operations	Ores stored on the low grade stockpile and ROM pad are predicted to be PAF. Leachate from these freshly mined materials is predicted to be moderately acidic, saline and contain slightly elevated concentrations of copper, lead, ferrous iron and zinc, with fresh to slightly brackish salinity (Appendix 2). The low grade stockpile and ROM will be within the cone of depression resulting from mine dewatering for much of the project life (Figure 26). Resulting seepage is likely to be contained in the mine dewatering system. Given this restricted migration pathway and the fact that the Sulphur Springs Creek catchment exhibits 'natural' acidic drainage, the inherent impact of contamination of groundwater due to seepage from the low grade stockpile or ROM pad is considered to be low.

6.3.6 Mitigation

Table 48 lists key measures to be implemented at Sulphur Springs to address potential impacts on terrestrial environmental quality and inland waters environmental quality.

Table 48: Proposed Mitigation Measures for Terrestrial Environmental Quality and Inland Waters Environmental Quality

Potential Impact Requiring Management	Mitigation Measures
Contamination of soils or surface water due to overtopping of the pit lake at closure	**Measures to avoid:** • Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink. **Measures to minimise:** • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Review of options for further reduction in pit surface water catchment. **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Early and progressive rehabilitation of final landform surfaces (TSF and WRD) where practicable.
Contamination of soils, surface water or groundwater due to spills	**Measures to avoid:** • Chemicals, hydrocarbons and other environmentally hazardous materials will be stored and handled in accordance with the *Dangerous Goods Safety Act 2004* and associated regulations. • Facilities containing hydrocarbons and/or chemicals have been designed within bunds to contain 110% of the contents of the material stored. • Pipelines containing chemical, hydrocarbons or tailings will either be double skinned or located within lined corridors. **Measures to minimise:** • Refuelling and fuel delivery inlets will be located on concrete or HDPE-lined pads to contain any drips and spills. The pads will drain to a sump to allow removal of collected material. • Overland pipes will be installed within bunds with catchment sumps constructed at low elevation points as required to provide containment capacity in the case of a pipeline leak. • Flow/pressure sensors will be fitted along pipelines to enable detection of flow anomalies (i.e. pipeline leaks). • Isolation valves will be installed at appropriate intervals along pipelines. • Spill kits will be located at strategic locations throughout the project area and employees trained in their use. • Spills will be cleaned up and contaminated soils will either be remediated or removed from site by a licenced third party. **Measures to rehabilitate:** • Decommissioning and removal of all storages and pipelines. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).
Contamination of soils, surface water or groundwater due to a TSF embankment failure	**Measures to avoid:** • Location of the TSF immediately upgradient of the mine pit. • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • TSF design to include extreme storm storage volume equivalent to a 1 in 1,000 year AEP 72 hour duration storm with no release, evaporation or decant. • TSF design to accommodate wave run-up associated with a 1:50 AEP wind velocity with an additional freeboard of 0.5 m. • OBE and MDE design earthquake loadings of 1 in 1,000 AEP and 1 in 5,000 AEP, respectively. • Construction supervised by Dams Engineer and Specialist (where relevant) to ensure the TSF is constructed as per design with as-built drawings. • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Routine inspections of the TSF by operations personnel. • Implementation of a TSF operating manual. **Measures to minimise:** • Any material issues identified during routine inspections of the TSF will be rectified. **Measures to rehabilitate:** • TSF closure design which includes a water shedding, erosion resistant cover. • Shaping edges of the TSF cover around the valley sides such that they integrate into the hillside face. • Routine inspections by a Dams Engineer during the first five years of the closure phase. • Preparation and regular update of an MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).

Contamination of soils or surface water due to overtopping the TSF	**Measures to avoid:** • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • TSF design to include extreme storm storage volume equivalent to a 1 in 1,000 year AEP 72 hour duration storm with no release, evaporation or decant. • TSF design to accommodate wave run-up associated with a 1:50 AEP wind velocity with an additional freeboard of 0.5m. **Measures to minimise:** • Location of the TSF immediately upgradient of the mine pit. • Implementation of a TSF operating manual. • Routine inspections of the TSF by operations personnel. **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • TSF spillway included in closure design with capacity for a 1 in 100,000 year AEP and freeboard allowance. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance.
Contamination of surface and/or groundwater due to seepage from the TSF	**Measures to avoid:** • Location of the TSF immediately upgradient and within the catchment of the mine pit. **Measures to minimise:** • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • Comprehensive inspection of the TSF by Dams Engineer and Specialist (where relevant) after first year of operation, then every two years. • Intermediate inspection of the TSF by Dams Engineer annually. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions • Internal drainage collection and seepage monitoring and interception downstream of main embankment. • Embankments constructed with appropriate seepage prevention measures (low permeability cut off trench and embankment core, drainage collection on the upstream face). • Monitoring at potential seepage points and seepage recovery implemented where warranted. • Ongoing mine closure planning during the operational phase of the project, including TSF cover trials, to refine proposed designs **Measures to rehabilitate:** • TSF cover design to minimise infiltration. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Monitoring TSF seepage during operations for consideration in closure design. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • Lysimeters and ion-specific probes will be utilised during the operational and short-term post-closure phases to validate TSF modelling assumptions. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure. • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions.
Contamination of surface and/or groundwater in the wider Sulphur Springs Creek area due to seepage from the WRD or pit	**Measures to avoid:** • Consideration of PMP and PMF scenarios in project infrastructure and closure designs to contain any potential seepage from PAF cells in the WRD in the pit lake catchment. • Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink • Encapsulation of PAF waste rock within the WRD and within the catchment of the mine pit. **Measures to minimise:** • Multi-element analysis of representative samples of each waste rock lithology will be conducted during future resource definition drilling programs to consolidate the value of the existing waste rock database. • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • A standardised elemental suite will be included for all future waste rock, leachate and water analysis. • Design of PAF cells in the WRD to minimise ingress of oxygen and water. • Subject to geological assessment, installation of one monitoring bore to assist in characterising the hydrological characteristics of the fault beneath the design floor of the pit and another upstream of the pit, close to surface water monitoring site MCI.

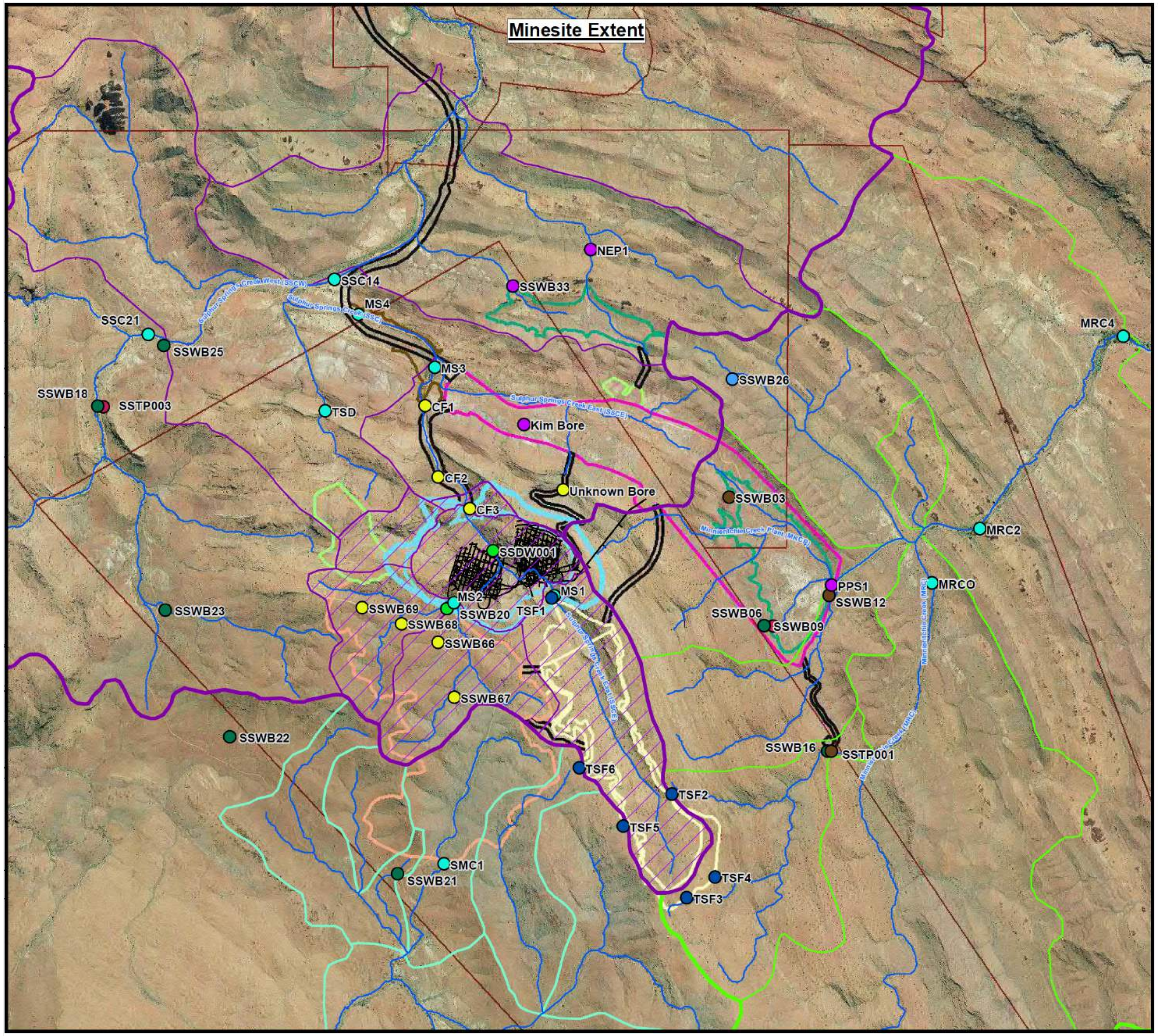
	Measures to rehabilitate: • WRD rehabilitation to a design to maximise surface stability and minimise infiltration around PAF areas. • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Early rehabilitation of final outer slopes of WRD where practicable. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure.
Contamination of soils or surface water due to overtopping of surface water storages	**Measures to avoid:** • Designs and operational practice to ensure sufficient freeboard for a 1 in 100 year 72 hour rainfall event. **Measures to minimise:** • Sediment ponds downstream of the processing area will include an engineered spill point to minimise damage from overflow during an extreme rainfall event. **Measures to rehabilitate:** • Removal of all surface water storages during the decommissioning and rehabilitation stages of the project.
Loss of topsoil availability and/or viability due to erosion, compaction or inappropriate handling and storage regime	**Measures to avoid:** • All available topsoil will be stored for use in future rehabilitation. • Topsoil will be stored in low stockpiles no higher than 2 m to optimise retain the viability of seeds. **Measures to minimise:** • The duration that topsoil is stockpiled will be minimised as far as practicable, and where possible, topsoil will be returned directly to areas that are ready to be rehabilitated. • All topsoil stockpiles will be located away or protected from stormwater flows, minimising potential losses via erosion. • Where practicable, topsoil will not be handled when wet to avoid damaging soil structure and composition. • A series of sediment traps will be installed in zones where surface water modelling has indicated concentrated flows may result around infrastructure. This will reduce flow energy and remove sediment from stormwater. • Vehicle movements will be restricted to authorised roads and tracks. • Project induction to contain information about not driving out of designated areas. **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).
The TSF, Permanent WRD or Pit becoming Listed as a Contaminated Site Under the *Contaminated Sites Act 2003*	**Measures to avoid:** • Consideration of PMP and PMF scenarios in project infrastructure and closure designs to contain any potential seepage from PAF cells in the WRD in the pit lake catchment. • TSF design to meet or exceed criteria applicable to High B consequence category facility under ANCOLD risk rating (ANCOLD 2019). • Comprehensive inspection by Dams Engineer and Specialist (where relevant) after first year of operation, then every 2 years. • Intermediate inspection by Dams Engineer annually. • During operations, underground PAF waste rock that cannot be immediately disposed in underground workings will be stored in the pit and within the mine dewatering cone of depression and either returned to the underground void or retained in the base of the pit where it will be covered by the pit lake post closure. • Encapsulation of PAF waste rock within the WRD and within the catchment of the mine pit. **Measures to minimise:** • Closely spaced grade control drilling and trained ore spotters to identify PAF material as part of selective material management. • Design of PAF cells to minimise ingress of oxygen and water. • Diverting 'clean' surface water flows away from operational areas as far as practicable. • Siting of other mine infrastructure and associated surface water management infrastructure to minimise impacts to catchment areas. • Implementation of a project water management plan incorporating groundwater monitoring levels and quality and contingency actions. • Internal drainage collection and seepage monitoring and interception downstream of TSF main embankment. • TSF embankments constructed with appropriate seepage prevention measures (low permeability cut off trench and embankment core, drainage collection on the upstream face). **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015). • Consideration of a reactive transport model for seepage quality and pit lake water quality predictions. • Review of the site surface water model during operations to refine/validate assumptions and pit water balance. • TSF closure design which includes a water shedding, erosion resistant cover designed to minimise infiltration.

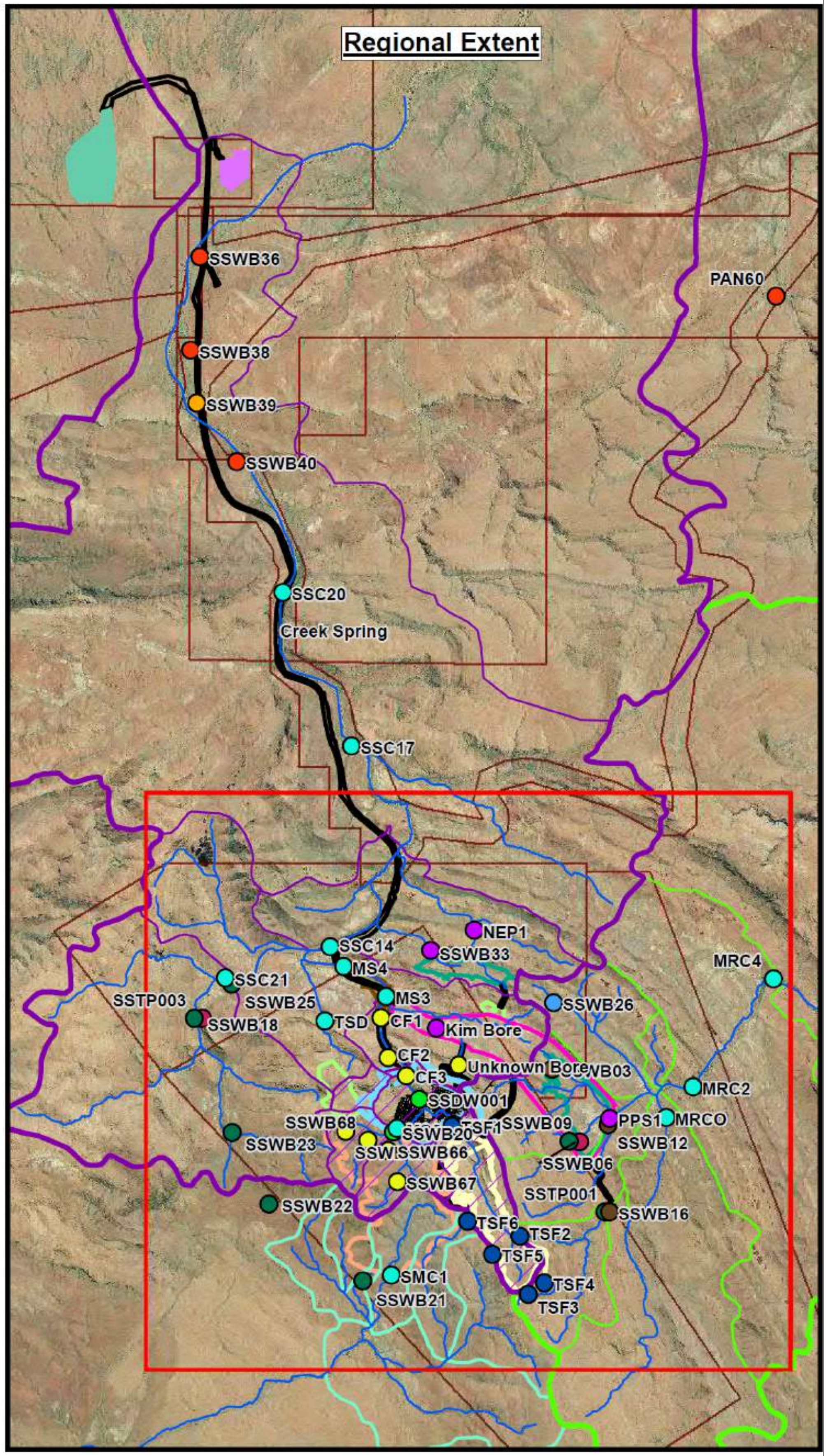
	• Re-contouring of parts of the mine pit catchment to shed surface runoff to adjacent catchments, to ensure the mine pit remains a hydraulic sink. • Review of the merit and effectiveness of use of alkaline materials to buffer pH changes in tailings post-closure.
Contamination of soils, surface water or groundwater due to particulate emissions from the TSF surface	**Measures to minimise:** • Maintaining a wetted tailings surface during operations. • Adoption of additional dust suppression measures for the TSF surface (such as binding agents or water spray) during embankment raises and the period between cessation of operations and installation of a TSF cover. • Implementation of a TSF operating manual. • Routine inspections by operations personnel. **Measures to rehabilitate:** • Preparation and regular update of a MCP consistent with *Guidelines for Preparing Mine Closure Plans* (DMP and EPA 2015).

6.3.7 Mitigation, Monitoring and Contingencies

The effectiveness of mitigation measures designed to minimise the risk of impacts to terrestrial and inland waters environmental quality will be assessed via the following:

- Implementation of a Groundwater Operating Strategy supplementing groundwater licence conditions for the site, developed in accordance with *Operational Policy 5.08 - Use of Operating Strategies in the Water Licencing Process* (DoW 2011).
- Extension of the baseline water data set through monitoring in advance of implementation of the Proposal.
- Additional groundwater and surface water monitoring during the pre-operational (construction) phase of the project. It is intended that this monitoring will capture 12 to 18 months (one additional seasonal cycle) of data prior to large-scale dewatering and TSF operation (Appendix 17).
- A project water management plan that includes:
  - Groundwater and surface water monitoring locations, monitoring parameters and monitoring frequency (preliminary details are provided in Figure 27 and Table 49).
  - Management measures for site activities including dewatering, stormwater and operation of the TSF.
  - Contingency actions for the management of unacceptable adverse trends.
  - Water quality trigger levels developed based on baseline monitoring. The purpose of these triggers is to identify whether changes to surface water or groundwater are significantly outside the normal range, thus necessitating a series of response actions to investigate the cause (Section 6.2.3 of Appendix 17).
  - Monitoring requirements, procedures, standards and reporting requirements.
- Implementation of a TSF operating manual, developed in accordance with *Guidelines on the Development of an Operating Manual for Tailings Storage* (DME 1998).
- Comparison of operational water abstraction, use and storage volumes with the site water balance (Appendix 9).
- Other internal site checks and procedures including chemical and reagent stocktakes, process mass balance, calibration of instrumentation and routine inspections.





Not to Scale
Original Size: A3

Source: AECOM Sulphur Springs Project Water Balance Assessment 2020

Venturex Resources Limited
Sulphur Springs Project

Figure 27

Proposed Surface Water and Groundwater Monitoring Locations

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MBS ENVIRONMENTAL

W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD.map 28/01/2020 F27 Recommended Monitoring Locations

Table 49: Water Monitoring Program

Monitoring Site	Parameter	Analytes	Pre-Operational Frequency	Operational Frequency
Sulphur Springs Site	Climate	Rainfall and evaporation	Hourly (rainfall), daily (evaporation)	
All operating abstraction bores (SSDW001, SSWB03, SSWB06, SSWB12, SSWB20, SSTP001, SSTP003) Pit sump discharge line Underground dewatering discharge line Selected underground groundwater inflow zones.	Groundwater abstraction	Quantity (kL)	Monthly	Monthly
	Groundwater level	Depth below ground level (m)		
	Groundwater quality	Field: pH, EC and temp Lab: pH, EC, TDS, acidity, total alkalinity, hardness, Na, K, Ca, Mg, HCO_3, CO_3, Cl, SO_4, NO_3, Si, Al, As, Cd, Cr (tot), Cu, Fe, Pb, Mn, Ni, Se, Te, Tl and Zn.	Monthly Annually	Monthly Annually
All operating abstraction bores Monitoring bores SSWB66, SSWB67, SSWB68, SSWB69, Unknown, CF1, CF2, CF3, SSWB26, TSF1, TSF2, TSF3, TSF4, TSF5, TSF6, Kim Bore, PPS1, NEP1, SSWB33, SSWB18, SSWB21, SSWB22, SSWB23, SSWB25.	Groundwater level	Depth below ground level (m)	Monthly	Monthly
	Groundwater quality	Field: pH, EC, DO, redox and temp Lab: pH, EC, TDS, acidity, total alkalinity, hardness, Na, K, Ca, Mg, HCO_3, CO_3, Cl, SO_4, NO_3, Si, Al, As, Cd, Cr (tot), Cu, Fe, Pb, Mn, Ni, Se, Tl, Te and Zn.	Annually Quarterly for TSF and Processing area bores (increased to monthly if any triggers are breached)	Annually Quarterly for TSF and Processing area bores (increased to monthly if any triggers are breached)
Minnieritchie Creek: MRC2 Sulphur Springs Creek: MS1, MS2, MS3, MS4, SSC14, SSC20. Six Mile Creek: SMC1	Surface water level	Depth above the datum (m)	Hourly	Hourly
Minnieritchie Creek: MRC2 Sulphur Springs Creek: MS4, SSC14. Six Mile Creek: SMC1	Surface water flows	Flow rate (L/s)	Hourly	Hourly
Minnieritchie Creek: MRC2 Sulphur Springs Creek: MS1, MS2, MS3, MS4, TSD, SSC14, SSC17, SSC20. Six Mile Creek: SMC1 Background: MRC0, SSC21	Surface water quality	Field: pH, EC, DO, redox and temp Lab: pH, EC, TDS, acidity, total alkalinity, hardness, Na, K, Ca, Mg, HCO3, CO3, Cl, SO4, NO3, Si, Al, As, Cd, Cr (tot), Cu, Fe, Pb, Mn, Ni, Se, Tl, Te and Zn, TPH, BTEX (MS3, MS4, SSC14 and MRC2 only)	Monthly (when water present) Event-based at MRC0 and SSC21	Quarterly (when water present) Event-based at MRC0 and SSC21

6.3.8 Predicted Outcome

The majority of inherent higher risk impacts associated with the Proposal arise from construction of waste landforms containing PAF materials (TSF and WRD) and surface water management. Extensive study of baseline geotechnical, soils, hydrological and hydrogeological conditions, together with geochemical characterisation of materials, has provided a higher level of certainty in the assessment of potential impacts.

The placement of PAF material and tailings within the catchment of the mine pit, such that any seepage is taken up by the mine dewatering system (operational phase) or reports to the pit (closure phase) significantly reduces the risk of degradation of land or water quality outside of the Proposal footprint. Design and operation of containment infrastructure to required regulatory standards will minimise the risk of overtopping or inadequate storage of hazardous materials. Operational procedures will ensure loss of containment of process reagents or hydrocarbons is contained and affected ground remediated.

On this basis, no changes beyond minor, local scale, changes to soil, surface water or groundwater quality are predicted. The Proposal can be implemented without compromising the EPA objective 'to maintain the quality of land, soils, groundwater and surface water so that environmental values are protected'.

7. OTHER ENVIRONMENTAL FACTORS OR MATTERS

Other relevant environmental factors for the Proposal include:

- Terrestrial fauna.
- Social surroundings.
- Hydrological processes.
- Air quality.

Evaluation of the risks to these factors used the same approach as that applied to the preliminary key environmental factors. These other factors are discussed below.

7.1 TERRESTRIAL FAUNA

7.1.1 EPA Objective

The EPA objective for terrestrial fauna is 'To protect terrestrial fauna so that biological diversity and ecological integrity are maintained' (EPA 2016j).

7.1.2 Policy and Guidance

Terrestrial fauna are protected under Commonwealth and State legislation, primarily governed by the following three Acts:

- *Biodiversity Conservation Act 2016* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

In addition to Commonwealth and State legislation, the following policies and guidance were considered in the design of fauna surveys and in the impact assessment:

- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).
- EPA Guidance Statement No. 20, Short Range Endemic Invertebrate Fauna (EPA 2009).
- EPA Guidance Statement No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment (EPA 2004b; revised 2016).
- EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b).
- EPA Environmental Factor Guideline – Terrestrial Fauna (EPA 2016j).
- EPA and DEC Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA and DEC 2010; revised 2016).
- EPA Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA 2016k).
- EPA Technical Guidance – Sampling methods for Terrestrial vertebrate fauna (EPA 2016l).
- Survey Guidelines for Australia's Threatened Bats (DEWHA 2010).
- *EPBC Act* referral guideline for the endangered Northern Quoll *Dasyurus hallucatus* (DoE 2016).
- Survey Guidelines for Australia's Threatened Mammals (SEWPAC 2011a).
- Survey Guidelines for Australia's Threatened Reptiles (SEWPAC 2011b).

- Conservation Advice for species listed under the *EPBC Act* (e.g. Pilbara Leaf-nosed Bat, Ghost Bat and Northern Quoll).

7.1.3 Receiving Environment

7.1.3.1 Terrestrial Fauna and Habitat Surveys

A large number of terrestrial fauna and habitat surveys have been undertaken within the Sulphur Springs area and across the broader region since 2001. Surveys most relevant to this Proposal are summarised in Table 50.

Table 50: Sulphur Springs Local and Regional Fauna Surveys

Survey Date	Consultant	Description
Local Surveys		
June and September 2001	Bamford Consulting Ecologists	Level 2 fauna survey (two phase) of Proposal area and immediate surrounds.
August to September 2006	Biota Environmental Sciences Pty Ltd	A Level 1 targeted fauna survey along the Abydos Link route. A Level 2 terrestrial fauna survey of the Site Access Road. A targeted survey for possible short range endemic (SRE) fauna within the Proposal area and immediate surrounds.
June 2007	Molhar	Targeted fauna assessment for conservation significant bats.
2011	Outback Ecology	Level 1 fauna (reconnaissance survey) and habitat mapping for Proposal area.
November 2012	Outback Ecology	Terrestrial vertebrate fauna impact assessment following the 2011 desktop study and Level 1 survey (above).
January 2012	Outback Ecology	Targeted terrestrial SRE invertebrate fauna assessment.
December 2017	Kingfisher Environmental Consulting	Targeted fauna assessment within Proposal area and immediate surrounds.
Regional Surveys		
2008	Bamford Consulting Ecologists	Level 2 fauna survey conducted approximately 5 km west of Sulphur Springs.
2010	Outback Ecology	Level 2 fauna survey conducted approximately 5 km west of Sulphur Springs.
2011	Ecologia	Level 2 fauna survey conducted 20 km west of Sulphur Springs.
2012	Ecologia	Level 2 fauna survey conducted 20 km west of Sulphur Springs.
2017	Stantec Australia Pty Ltd	Northern quoll monitoring survey for Abydos DSO Project.

The most recent surveys, by Kingfisher Environmental Consulting (Kingfisher) and Outback Ecology, are provided in Appendix 24, Appendix 25 and Appendix 26. The survey by Kingfisher in 2017 was a targeted fauna assessment within the Proposal area and also provides a summary of previous studies relevant to the proposed project (Kingfisher 2017, Appendix 24).

7.1.3.2 *Fauna Habitat*

Five broad fauna habitats relevant to vertebrates were identified in the Proposal area. Identification of these habitats was based on location, landform, substrate, vegetation community, degree of disturbance (e.g. mining and fire) and the type of habitat that they offer (Outback Ecology 2012a, Appendix 25). These habitats are:

- Spinifex Stony Plains.
- Rocky Foothills.
- Scree Slopes.
- Drainage Lines.
- Rocky Ridges and Gorges.

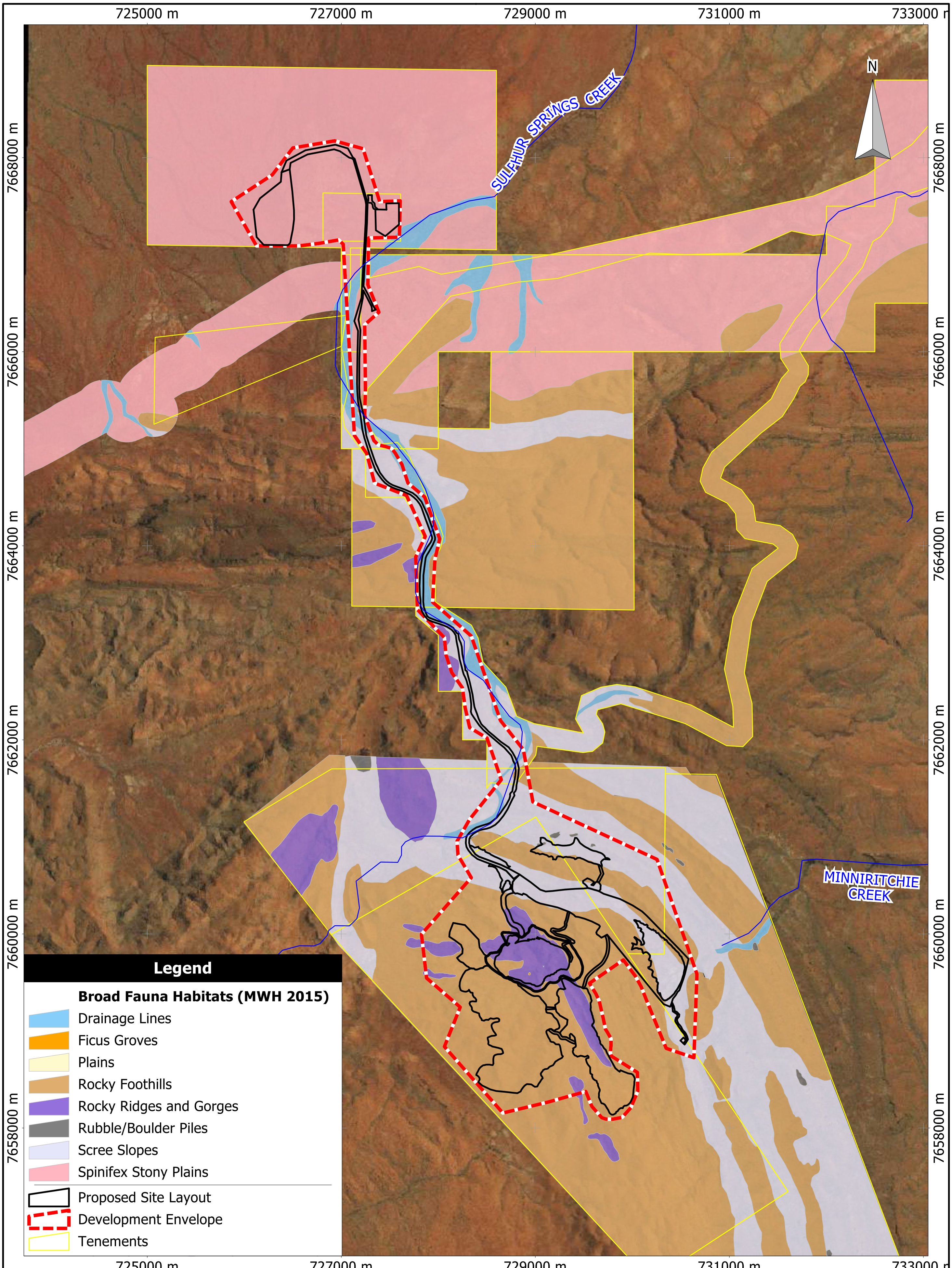
An additional two fauna habitats of limited extent were identified:

- Rubble/Boulder Piles.
- Ficus Groves.

All habitat types identified are considered typical of the Pilbara bioregion. They are varied in their potential to support vertebrate assemblages and conservation significant fauna species. Of the habitat types observed, Spinifex Stony Plains, Rocky Foothills and Scree Slopes are widespread throughout the landscape. Table 51, Figure 28 and Figure 29 show fauna habitats within the Proposal footprint, Development Envelope and existing land use.

Table 51: Fauna Habitats of the Sulphur Springs Proposal Area

Habitat	Regional Context	Total Mapped Area (ha)	Area Within Proposal Footprint		Area Within Development Envelope	
			(ha)	**% of Total Mapped**	**(ha)**	**% of Total Mapped**
Spinifex Stony Plains	Widespread throughout the surrounding landscape. Well represented in the region.	3,064.2	38.8	1.3	154.6	5.0
Rocky Foothills	Widespread throughout the surrounding landscape. Well represented in the region.	2,487.3	160.4	6.4	400.6	16.1
Scree Slopes	Widespread throughout the surrounding landscape. Well represented in the region.	1,042.0	70.0	6.7	228.3	21.9
Drainage Lines	Limited in the surrounding landscape but well connected. Well represented in the region.	215.2	4.7	2.2	36.9	17.1
Rocky Ridges and Gorges	Limited in the surrounding landscape but well connected. Not well represented in the region.	210.7	39.7	18.8	67.7	32.1
Rubble/Boulder Piles	Limited in the surrounding landscape.	13.1	0.1	0.9	1.1	8.2
Ficus Groves	Limited in the surrounding landscape.	<0.1	<0.1	72.8	0.1	72.8



Scale: 1:51000
Original Size: A4
Image source: Landgate
Air Photo Date: 2012
Grid: MGA94(50)
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Sulphur Springs Project

Figure 28

Fauna Habitats over Conceptual Site Layout

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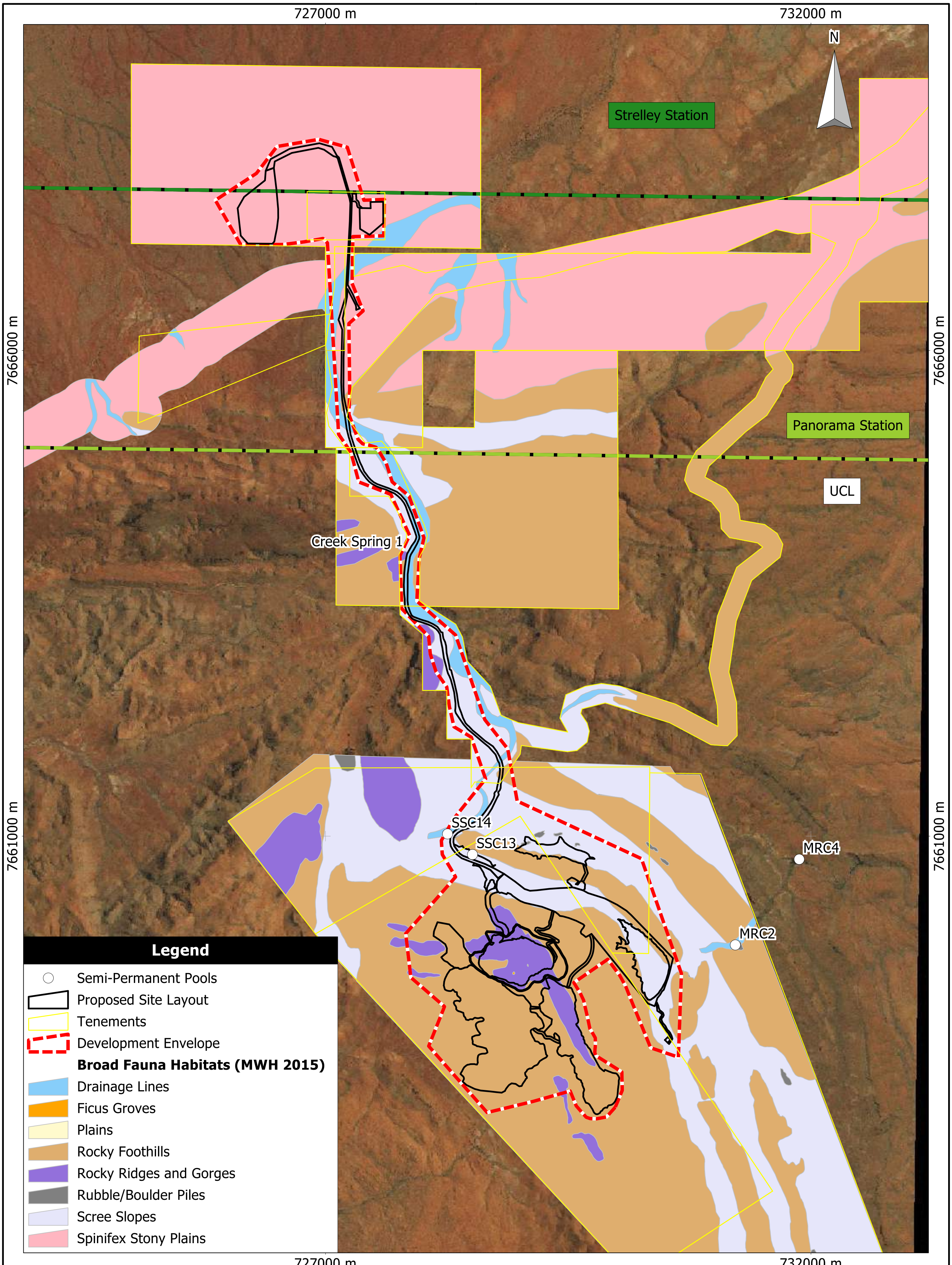
W:\Venturex Resources\Sulphur Springs\Projects\2018 ERD\Drawings\Sulphur Springs ERD.map 28/01/2020 F28 Fauna Habitats Layout



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Sulphur Springs Project

Figure 29

Fauna Habitats Over Conceptual Site Layout and Land Use

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7.1.3.3 Species of Conservation Significance

Several conservation significant fauna species were recorded within the Development Envelope (Figure 30):

- Northern Quoll (*Dasyurus hallucatus*).
- Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*).
- Long-tailed Dunnart (*Sminthopsis longicaudata*).
- Western Pebble-mound Mouse (*Pseudomys chapmani*).
- Rainbow Bee-eater (*Merops ornatus*).

Conservation significant species recorded from the wider study area include:

- Ghost Bat (*Macroderma gigas*).
- Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*).
- Brush-tailed Mulgara (*Dasycercus blythi*).
- Pilbara Olive Python (*Liasis olivaceus barroni*).

The conservation status of these species is shown in Table 52 and study findings for each are summarised in the following sections. Since the submission of earlier revisions of this ERD, the *Wildlife Conservation Act 1950* has been replaced by the *BC Act*. The conservation status of species presented in Table 52 has been updated to reflect current listings under the *BC Act* and, as a such, may vary from those presented in Kingfisher (2017).

Table 52: Conservation Significant Fauna Recorded or Expected in the Sulphur Springs Proposal Area (Appendix 24)

Species	Conservation Status			Local Records	Suitable Habitat Within Proposal Area	Likely to Occur in Proposal Area
	EPBC Act	*BC Act S19(1)*	DBCA Priority			
Woma *(Aspidites ramsayi)*	-	-	P1	Regional records	Minimal	No
Pin-striped finesnout Ctenotus *(Ctenotus nigrilineatus)*	-	-	P1	Regional records	Minimal	No
Pilbara Olive Python (*Liasis olivaceus barroni*)	VU	T(VU)	-	Abydos	Yes - rocky hills, outcrops, drainage lines	Yes
Peregrine Falcon *(Falco peregrinus)*	-	OS	-	Regional records	Yes, minimal breeding habitat	Visitor
Grey Falcon *(Falco hypoleucos)*	-	T(VU)	-	Regional records	Yes, minimal breeding habitat	Vagrant
Rainbow Bee-eater (*Merops ornatus*)	MG	-	-	Sulphur Springs	Yes - recorded within study area	Migrant
Night Parrot *(Pezoporus occidentalis*)	EN	T(CR)	-	None	Expected as vagrant only	Vagrant
Brush-tailed Mulgara (*Dasycercus blythi*)	-	-	P4	Sulphur Springs	Yes - northern plains	Yes
Northern Quoll (*Dasyurus hallucatus*)	EN	T(EN)	-	Sulphur Springs	Yes - rocky hills, outcrops, drainage lines	Previously recorded
Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*)	-	-	P4	Sulphur Springs	Minimal, recorded on northern plains	Potential visitor
Lakeland Downs Mouse *(Leggadina lakedownensis)*	-	-	P4	Regional records	Minimal, patchy distribution across Pilbara	No
Bilby *(Macrotis lagotis)*	VU	T(VU)	-	Greater area	Minimal, recent records from region	No
Ghost Bat (*Macroderma gigas*)	VU	T(VU)		Sulphur Springs	Yes - rocky hills, outcrops, drainage lines	Recorded
Pilbara Leaf-nosed Bat *(Rhinonicteris aurantia*)	VU	T(VU)	-	Sulphur Springs	Yes - rocky hills, outcrops, drainage lines	Recorded
Western Pebble-mound Mouse (*Pseudomys chapmani*)	-	-	P4	Sulphur Springs	Recorded within study area	Recorded
Long-tailed Dunnart (*Sminthopsis longicaudata*)	-	-	P4	Sulphur Springs	Recorded within greater area	Yes

Status Codes: EPBC Act: EN = Endangered, VU = Vulnerable, MG = Migratory.

BC Act: T(CR) = Threatened Species Critically Endangered, T(EN) = Threatened Species Endangered, T(VU) = Threatened Species Vulnerable, OS = Other specially protected fauna, P1 – P4 = DBCA Priority Species 1 – 4.

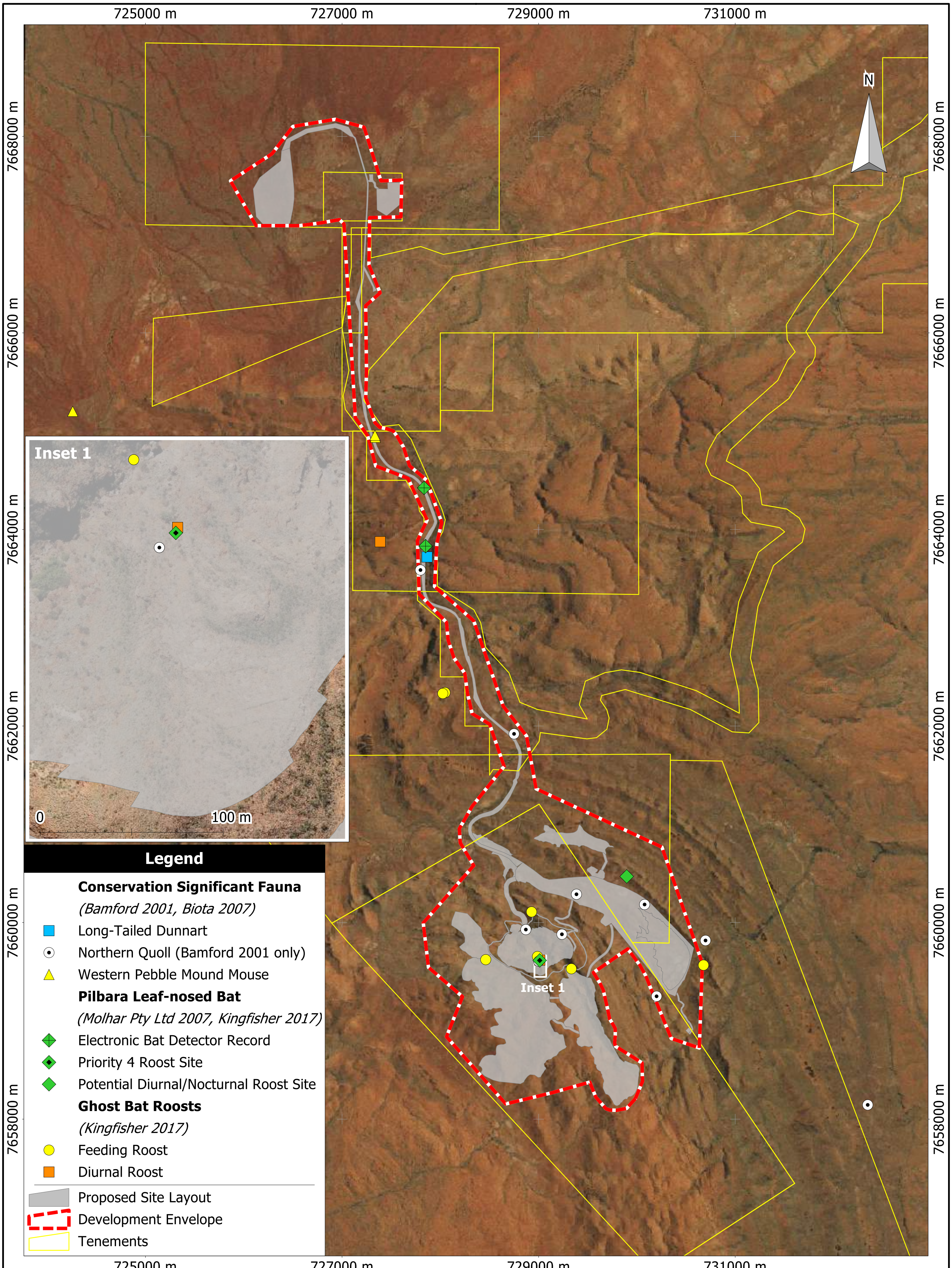

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Figure 30

Location of Fauna Species of Conservation Significance

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Northern Quoll

The Northern Quoll (*Dasyurus hallucatus*) is listed as Endangered under both the *EPBC Act* and the *BC Act*. Optimal habitat for the Northern Quoll consists of dissected rocky escarpments which provide shelter such as rock crevices and caves and support higher densities of Northern Quolls than habitats such as *Eucalyptus* woodlands and human settlements (Van Dyck and Strahan 2008). Adult male home ranges are over 100 hectares and overlap with female home ranges (King 1989).

Northern Quolls were observed within the Proposal footprint and Development Envelope in 2001 (Bamford 2001). No individuals have been recorded in subsequent surveys in 2011, 2012 or 2017 (Appendix 24). The 2017 survey comprised over 500 camera nights, with motion cameras positioned in locations deemed the most suitable habitat. The Proposal area is therefore considered unlikely to be a significant population refuge, although the species is considered to occur in low and fluctuating numbers in response to resource pulses. As suitable habitat for this species is extensive outside the Proposal area and throughout the surrounding rocky uplands, the Northern Quoll population is unlikely to be dependent on refuge within the Sulphur Springs area (Appendix 24).

Pilbara Leaf-nosed Bat

The Pilbara Leaf-nosed Bat (*Rhinonicteris aurantia*) is classified as Vulnerable under both the *EPBC Act* and the *BC Act*. This species is subject to several threatening processes including flooding and human impacts such as mining. The Pilbara Leaf-nosed Bat has specific habitat requirements occupying warm, very humid roost sites in caves and mines (Molhar 2007, Van Dyck and Strahan 2008). This enables the species to persist in arid temperatures by limiting water loss and energy expenditure. The Pilbara Leaf-nosed Bat is sensitive to human disturbance and the best method of detection is through recording echolocation calls while it flies from roost sites or forages within gorges (Van Dyck and Strahan 2008).

The Pilbara Leaf-nosed Bat has been recorded in the rocky uplands that extend well beyond the Sulphur Springs Proposal area. The species has been recorded at Abydos (Bamford 2009; Outback Ecology 2012b) and significant diurnal roosts have been recorded at Lalla Rookh Mine and at North Star (J. Turpin pers. obs.).

Locally, evidence of Pilbara Leaf-nosed Bats was recorded during a number of site surveys (Bamford 2001, Biota 2007, Molhar 2007 and Appendix 24). The most recent targeted survey (Appendix 24) concluded that the species is likely to forage extensively throughout the Proposal area, particularly along drainage lines, but roosting sites appear limited. One Priority 4[1] nocturnal refuge was recorded within the Proposal footprint (Figure 30). No maternity roosts were recorded within the Development Envelope or its surrounds.

Long-tailed Dunnart

The Long-tailed Dunnart (*Sminthopsis longicaudata*) is classified as a Priority 4 species by DBCA. This species lives in arid rocky areas and has been recorded from flat topped hills, plateaus, granite outcrops and rocky scree slopes. In the winter, the Long-tailed Dunnart feeds entirely on arthropods and under cold conditions this species may utilise torpor as a strategy to conserve energy (Van Dyck and Strahan 2008).

Habitat assessed as suitable for this species occurs within the Proposal area and wider region. A single record has been recorded in the area; at Wodgina, approximately 30 km to the south (Appendix 25).

Western Pebble-mound Mouse

The Western Pebble-mound Mouse (*Pseudomys chapmani*) is listed as a Priority 4 species by DBCA. This mouse constructs mounds out of small pebbles that can cover 0.5 to 9.0 m² (Van Dyck and Strahan 2008). Breeding for this species can occur throughout the year. Females may produce several litters per year of up to four young (Van Dyck and Strahan 2008).

[1] A Priority 4 refuge is described as a nocturnal refuge occupied or entered at night for resting, feeding or other purposes, with perching not a requirement. Excludes overhangs. Not considered critical habitat but are important for persistence in a local area (Threatened Species Scientific Committee 2016).

Suitable habitat for the species is patchy. Populations are widespread throughout the ranges of the central and southern Pilbara (Van Dyck and Strahan 2008). Evidence of the mouse has been frequently recorded within the region surrounding the study area (Outback Ecology 2012b; How and Cooper 2002, How *et al.* 1991).

The Western Pebble-mound Mouse and various mounds were recorded in the Proposal area during surveys in 2001 and 2007 (Bamford 2001, Biota 2007). This species has not been identified in subsequent surveys.

Rainbow Bee-eater

The Rainbow Bee-eater (*Merops ornatus*) is listed as Migratory under the *EPBC Act*. It is protected under the Japan-Australia Migratory Bird Agreement (JAMBA). The Rainbow Bee-eater prefers open or lightly timbered areas, often near water. This species has been recorded in dry open sclerophyll forest, open woodlands and shrublands, including mallee, spinifex tussock grassland with scattered trees, chenopod shrubland with scattered trees and riparian or littoral assemblages. It is often seen around disturbed areas such as quarries, road cuttings and mines where exposed bare soil provides suitable breeding sites (Marchant and Higgins 1993). The Rainbow Bee-eater will move north from the southern areas of Australia during winter (Johnstone & Storr 1998).

The Rainbow Bee-eater was recorded in three separate surveys of the Proposal area (Bamford 2001, Biota 2007 and Appendix 24) and is common in the surrounding region. Based on the transient nature of this species and the amount of habitat available in and surrounding the Development Envelope, this species is expected to occur in the Development Envelope.

Ghost Bat

The Ghost Bat (*Macroderma gigas*) is listed as Vulnerable under both the *EPBC Act* and the *BC Act*. The species is Australia's only carnivorous bat and is known to feed on a variety of vertebrate species including large insects, frogs, lizards, small mammals and other bats. Ghost bats occupy a variety of habitats from the arid Pilbara to the rainforests of Northern Queensland (Van Dyck and Strahan 2008).

The preferred roosting habitats of Ghost Bats in the Pilbara are deep, complex caves beneath bluffs of low rounded hills composed of Marra Mamba geology, Brockman Iron Formations, granite rockpiles and abandoned mines (Armstrong and Anstee 2000). Elsewhere, Ghost Bats have been known to roost in large colonies in sandstone caves, under boulder piles and in abandoned mines (Churchill 2008).

Regionally, Ghost Bats occur in the series of rocky uplands extending well beyond the Sulphur Springs area, with adjacent areas known to support a significant Ghost Bat population. The species has been recorded at Abydos, Wodgina and North Star (5 – 50 km west of Sulphur Springs, J. Turpin pers. obs.; Outback Ecology 2012b, Bamford 2009), as well as North Pole (20 km north east of Sulphur Springs, Armstrong and Anstee 2000), and a large maternity roost supporting hundreds of individuals is known from Lalla Rookh Mine (15 km north of Sulphur Springs, J. Turpin pers. obs., Armstrong and Anstee 2000).

Locally, evidence of Ghost Bats has been recorded during a number of site surveys (Bamford 2001, Biota 2007, Molhar 2007 and Appendix 24). The most recent targeted survey (Appendix 24) concluded that the species is likely to forage widely throughout the area and the greater region. During the survey 10 roosts were identified, three diurnal and seven feeding. One diurnal roost was recorded within the Proposal footprint, one diurnal roost was recorded outside the Development Envelope (445 m west of the access road) and a third was recorded beyond the Proposal area (Figure 31). Of the feeding roosts, two were located within the Proposal footprint, two within the Development Envelope and three outside of the Development Envelope (two 245 m west of access road and the third just outside the Development Envelope south east boundary). No maternity roosts were recorded within the Development Envelope or surrounds.

Pilbara Olive Python

The Pilbara Olive Python (*Liasis olivaceus barroni*) is listed as Vulnerable under both the *EPBC Act* and the *BC Act*. This species inhabits rocky escarpments, deep gullies and gorges within the Pilbara region and is often recorded near water holes and riverine habitats (Wilson and Swan 2008). Radiotelemetry has found that the Pilbara Olive

Python occupies a distinct home range, but males travel long distances during their breeding season from June to July, to locate females (Appendix 25).

The Pilbara Olive Python was not recorded during surveys within the study area (Bamford 2001, Biota 2007). The species has been recorded at Abydos and North Star (Appendix 24), 10 – 20 km from the Proposal and there is anecdotal evidence of the species at a pool on Minnieritchie Creek approximately 1 km east of the Proposal footprint. Given suitable habitat occurs within the Development Envelope, the presence of the Pilbara Olive Python is considered possible.

Spectacled Hare-Wallaby

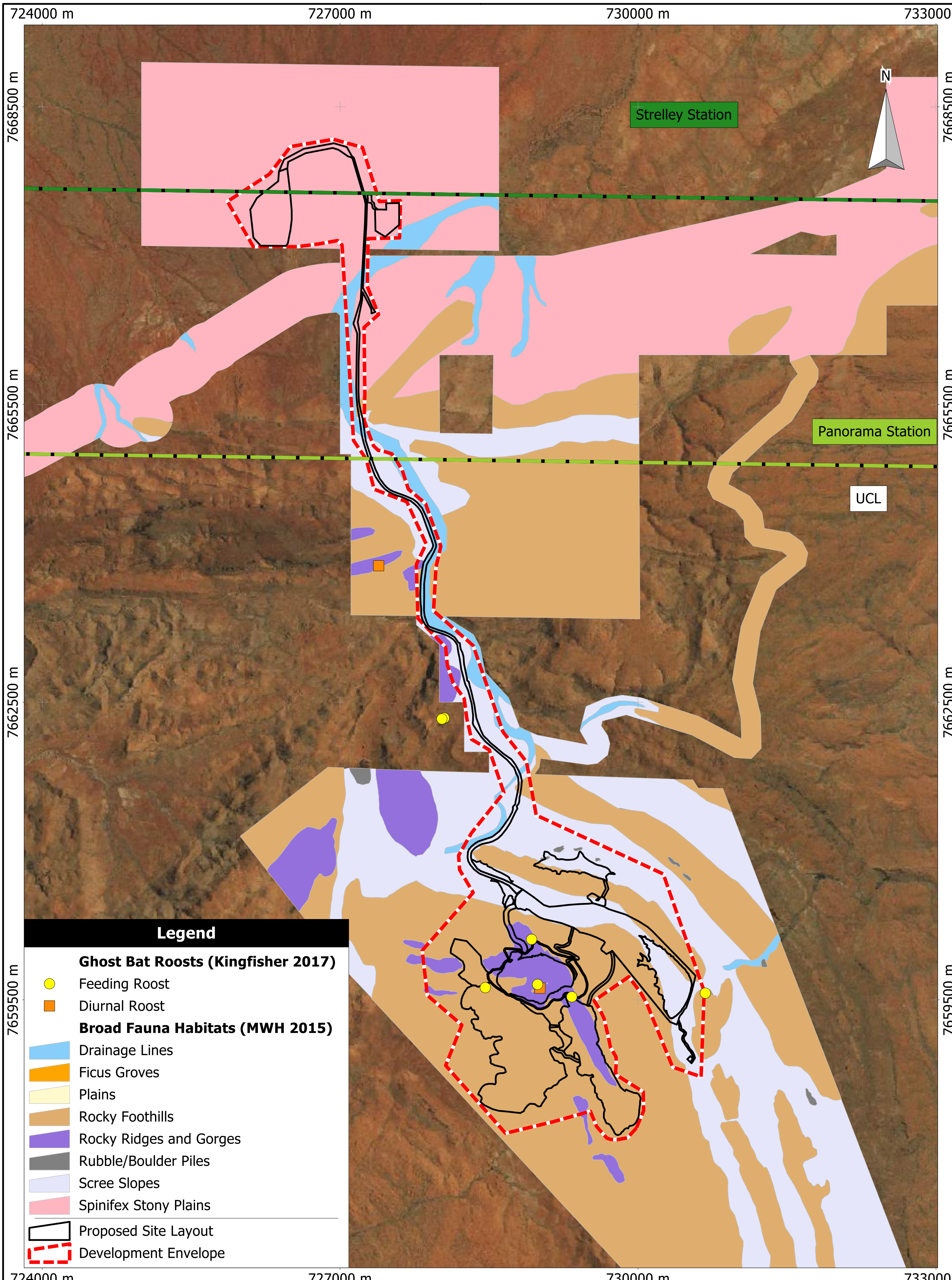
The Spectacled Hare-Wallaby (*Lagorchestes conspicillatus*) is listed as a Priority 4 species by DBCA. This species inhabits *Triodia* hummock grasslands and *Acacia* shrublands and has declined dramatically within the Pilbara region, possibly due to fox predation and altered fire regimes which have prevented the development of large tussock grasslands required for adequate shelter (Van Dyck and Strahan 2008). The Spectacled Hare-Wallaby has been recorded near the study area at Pilgangoora in 1994 (Appendix 25 and Outback Ecology 2012a).

Unconfirmed records of the Spectacled Hare-Wallaby were detailed in a survey by Bamford (Bamford 2001); however, no confirmed sighting has occurred within the Development Envelope. It is considered to be a potential visitor to the Proposal area (Appendix 24).

Brush-tailed Mulgara

The Brush-tailed Mulgara (*Dasycercus blythi*) is listed as a Priority 4 species (taxa in need of regular monitoring) by DBCA. The species prefers spinifex grasslands on sandy soils, constructing burrows on the flats between sand dunes (Van Dyck and Strahan, 2008). Cattle grazing, altered fire regimes and predation by cats and foxes have contributed to the population decline of this species (Maxwell *et al.* 1996, Van Dyck and Strahan 2008).

The Brush-tailed Mulgara has not been identified in the Proposal footprint but has been recorded during surveys in the surrounding area. There is potential for small numbers of individuals to occur on plains in the northern section of the Proposal area (Appendix 24).



Scale: 1:50000 Original Size: A4 Air Photo Date: 2012 Grid: MGA94(50) 0 1000 m	Venturex Resources Limited Sulphur Springs Project	**Figure 31** **Location of Ghost Bat Records**	Martinick Bosch Sell Pty Ltd 4 Cook St West Perth WA 6005 Ph: (08) 9226 3166 Fax: (08) 9226 3177 info@mbsenvironmental.com.au www.mbsenvironmental.com.au MBS ENVIRONMENTAL

7.1.3.4 Short Range Endemics

Targeted short range endemic (SRE) fauna surveys within the Proposal area and immediate surrounds have been undertaken by Biota (Biota 2007) and Outback Ecology (Outback Ecology 2012c, Appendix 26). Together, the studies encompassed a 27,425 ha parcel of land that surrounds the Proposal.

Five drainage habitats were identified within the study areas, namely Gorge, Creekline, Riverine, Drainage Line and Floodplain (Figure 32). Results yielded a total of 153 invertebrate specimens from 15 different species. Terrestrial snails were the most numerous group collected, followed by aquatic snails, millipedes, slaters, pseudoscorpions and mygalomorph spiders.

Based on current scientific knowledge, four species collected are considered potential SRE species. These are:

- *Antichiropus* 'DIP005'.
- *Antichiropus* 'DIP034'.
- *Buddelundia* sp. 11.
- *Feaella* 'PSE007'.

Table 53 details the potential SRE species and the habitat within which they were recorded. Figure 32 shows recorded locations.

Table 53: Potential SRE Species of the Sulphur Springs Project

Species	Common Name	Habitat	Location
Antichiropus 'DIP005'	Millipede	Creekline, Gorge and Riverine	Both outside and inside Development Envelope, but outside proposed footprint
Antichiropus 'DIP034'	Millipede	Riverine	Both outside and inside Development Envelope, but outside proposed footprint
Buddelundia sp. 11	Slater	Creekline and Gorge	Outside Development Envelope
Feaella 'PSE007'	Pseudoscorpion	Creekline	Outside Development Envelope

Outback Ecology (2012c) concluded that Gorge and Creekline habitats have the highest potential to support SRE species (Appendix 26). The remaining three habitats are considered to be extensive both within and outside the study area.

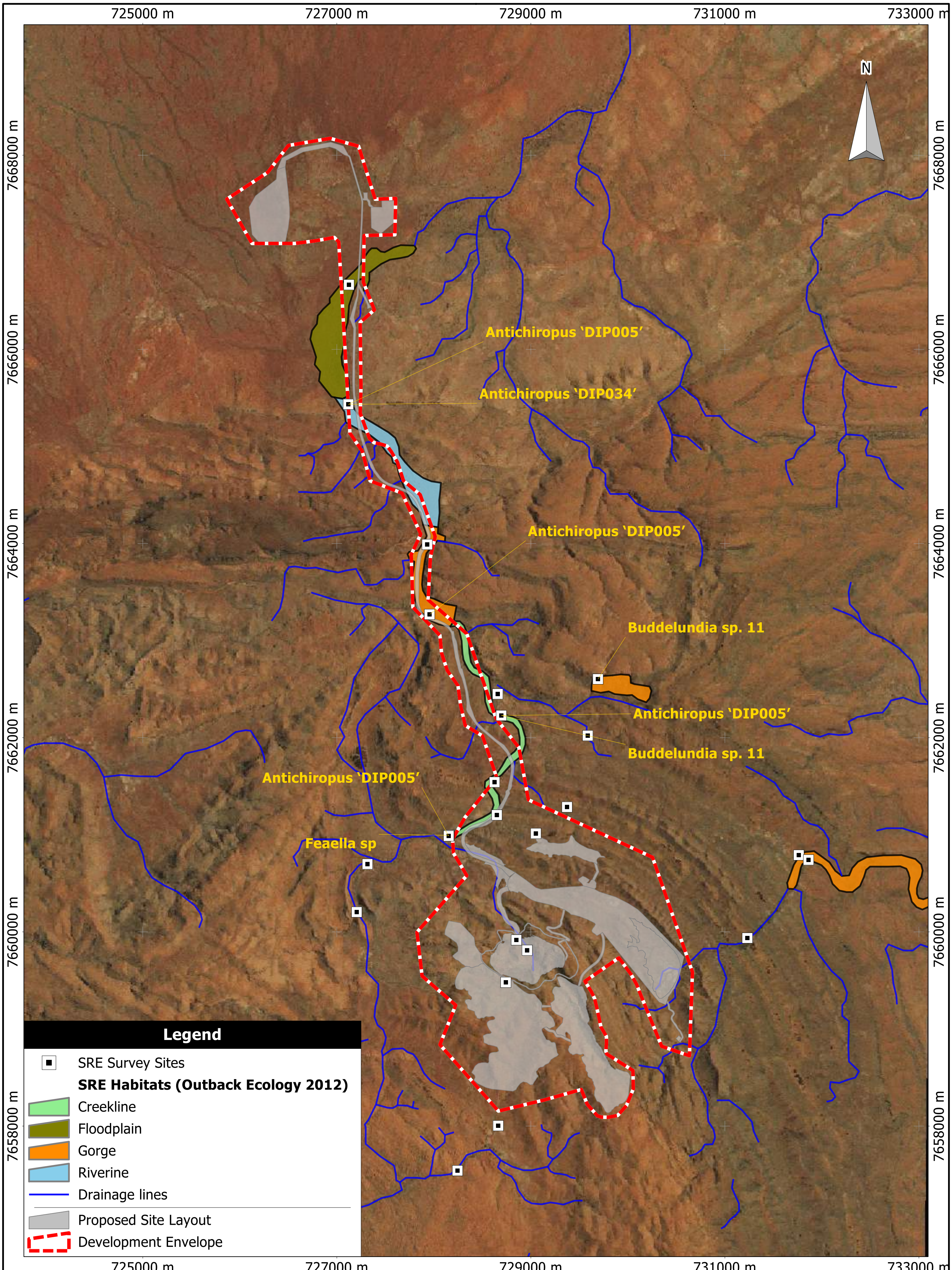


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Image source: Landgate Locate Mosaic
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Figure 32

Potential Short Range Endemic Habitat in the Study Area

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7.1.4 Potential Impacts, Mitigation Measures and Predicted Outcome

Potential impacts, mitigation measures and the predicted outcome for terrestrial fauna are summarised in Table 54.

Table 54: Terrestrial Fauna Potential Impacts, Mitigation Measures and Predicted Outcomes

Potential Impacts	Mitigation Measures	Predicted Outcome
Terrestrial Fauna • Removal and/or fragmentation of habitat. • Loss of conservation significant fauna due to reduced surface water quality. • Light spill impacts on conservation significant fauna. • Mortality of conservation significant fauna due to interaction with vehicles and equipment. • Degradation of fauna habitat due to altered fire regime. • Degradation or loss of fauna habitat (potential GDEs) due to poor quality seepage from TSF, WRD or pit lake. • Reduced access to suitable drinking water (due to changes in water quality or levels in semi-permanent pools along Sulphur Springs or Minnieritchie Creeks). • Degradation or loss of fauna habitat due to pit overtopping. • Reduced health and conditions of conservation significant fauna (birds and bat species) due to interaction with pit lake. • Mortality of conservation significant fauna due to interaction with pit lake.	**Measures to avoid:** • As far as is practicable, project elements will be sited to avoid or minimise potential denning sites for Northern Quoll. • As far as is practicable, project elements will be sited to avoid or minimise disturbance to important bat roosts identified by Kingfisher (Appendix 24).Appendix 24 • Artificial lights will be positioned to avoid directly illuminating bat roosts, with shielding installed as appropriate. • Barbed wire fences will not be used to avoid injury or death to bat species. **Measures to minimise:** • Clearing bat foraging habitat, particularly along drainage lines, will be minimised as far as practicable. • The use of insect repelling lighting will be considered to reduce the likelihood of bats being attracted to the area. • Clearing activities will be managed to ensure clearing is strictly limited to that necessary for operations. • Implementation of a project water management plan. • Siting of other mine infrastructure and associated surface water management infrastructure to minimise impacts to catchment areas. • Where practicable, access to known/suspected bat roosts within Development Envelope will be restricted. • Speed limits will be implemented. • Vehicle traffic will be confined to defined roads and tracks. • Pre-clearance surveys for conservation significant fauna will be conducted. If any such fauna are identified and where practicable, individuals will be relocated to similar habitats outside the Development Envelope within the region. • The site induction program will provide information on fauna of conservation significance including their appearance and habitats. Training will also discuss standard operating procedures in the event of fauna interactions. • Borrow pits will be designed, constructed and rehabilitated to minimise surface water ponding after rehabilitation. • Feral animal control will be undertaken as required, in co-operation with regional control programs. • The project site induction will include information on the prevention and management of fires. • Firefighting equipment will be located on site and in all mine vehicles and personnel will be trained in fire response. • A Hot Work Permit system will be developed and implemented. • Venturex will work with the pastoralist, Traditional Owners and DFES to undertake prescribed burns and install and maintain firebreaks, if required. • Grade control drilling will be conducted prior to mining each bench to enable PAF material to be identified and segregated based on total sulphur concentration, lithology and degree of weathering. • Storage of PAF waste rock from the pit in the WRD within the cone of depression resulting from mine dewatering. • Design of PAF cells to minimise ingress of oxygen and water. • Use of monitoring and pump back bores around the TSF as required. **Measures to rehabilitate:** • Disturbed areas will be rehabilitated as they become available. • Access to the pit lake will be restricted by establishment of an abandonment bund at closure. • The final pit profile will include steep slopes, a hard substrate and no shallow areas, making it unattractive to avifauna for foraging. • TSF closure design incorporates a multiple layer, low infiltration, erosion resistant, water shedding cover. • WRD closure design incorporates an engineered cover, designed to minimise ingress of air (oxygen) and water to the encapsulated PAF area. • Preparation and regular update of a Mine Closure Plan consistent with Guidelines for Preparing Mine Closure Plans (DMP and EPA 2015).	Water in the pit lake is expected to become increasingly saline with elevated concentrations of metals and metalloids. It will eventually become unpalatable to fauna. The steep pit walls will prevent access to the pit lake by most fauna species, restricting the risk to avifauna and bats. Based on modelled pit lake concentrations, potential impacts to these individuals due to ingestion and/or bioaccumulation are predicted to be chronic rather than acute and limited to the period that the pit lake water remains palatable. There are numerous alternative semi-permanent water sources both locally and across the region and the residual risk of toxicity due to ingestion is therefore considered to be low. Given TSF seepage is predicted to remain within the PSC5 catchment and migrate towards the pit, the residual risk to livestock and native fauna accessing surface water at Minnieritchie Creek is also considered to be low. SRE species *Antichiropus* 'DIP005', *Antichiropus* 'DIP034' and *Buddelundia* sp. 11 are all known to have a distribution which extends outside of the footprint of the Proposal. The Proposal is unlikely to pose a long term conservation risk to these species (Appendix 26). The proposed project will not impact the collection location of *Feaella* 'PSE007'. Given that impacts to the creekline habitat will be limited, the Proposal is unlikely to pose a long term residual risk to *Feaella* 'PSE007'. With adoption of proposed mitigation measures: • The Proposal is unlikely to lead to a decrease in the Pilbara Northern Quoll population, given the proportional loss of potential habitat is low and the species is considered unlikely to be dependent on marginal habitat within the disturbance footprint. • The Proposal is unlikely to result in significant impact to bat populations given the area is primarily used for foraging rather than roosting and similar habitat exists locally outside of the disturbance footprint and widely across the region. • Proposed clearing is not expected to adversely affect the conservation status of species potentially occurring in the Development Envelope, given that none of the habitats recorded are restricted to the Proposal area or considered unique to the local area. • Indirect impacts to potential GDEs are not expected to adversely affect the conservation status of species potentially occurring in the Development Envelope, given that none of the habitats recorded are restricted to the Proposal area or considered unique to the local area. • All residual risks to terrestrial fauna are considered to be 'low'. Based on the above, the EPA objective 'to protect terrestrial fauna so that biological diversity and ecological integrity are maintained' will be met.

7.2 SOCIAL SURROUNDINGS

7.2.1 EPA Objective

The EPA objective for social surroundings is 'To protect social surroundings from significant harm' (EPA 2016m).

7.2.2 Policy and Guidance

Social surroundings are protected under the following Commonwealth and State legislation:

- *Aboriginal Heritage Act 1972* (WA).
- *Environmental Protection Act 1986* (WA).
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

The following guidance was considered in the impact assessment for social surroundings:

- EPA Guidance Statement No. 41, Assessment of Aboriginal Heritage (EPA 2004c).
- EPA Environmental Factor Guideline – Social Surroundings (EPA 2016m).

7.2.3 Receiving Environment

7.2.3.1 Amenity

Sulphur Springs is remote from communities and other sensitive receptors (including scenic lookouts). The closest community, Marble Bar, is located approximately 57 km to the west of Sulphur Springs. The visual landscape of the region is mainly natural in appearance, with localised pockets of highly modified areas associated with mining.

7.2.3.2 Heritage and Culture

To determine the presence of items or sites of State, National or Aboriginal heritage, searches of the following databases were also undertaken (3 April 2018):

- Australian Heritage Places Inventory.
- Government of Western Australia Heritage Council's inHerit database.
- Shire of Port Hedland Municipal Inventory.
- Department of Aboriginal Affairs (DAA) Heritage Inquiry System (DAA 2018).

A large number of archaeological, ethnographic and heritage surveys have been undertaken within the Sulphur Springs area since 1993. Surveys most relevant to this Proposal are summarised in Table 55. The combined coverage of these surveys has enabled a detailed understanding of the values and distribution of heritage sites in the region.

Table 55: Sulphur Springs Heritage Surveys

Survey Date	Consultant	Description
April 1993	R. O'Connor	Ethnographic survey conducted within the Proposal area.
June 1993	G.S. Quartermaine and C.J. Mattner	Archaeological survey conducted within the Proposal area.
June 2001	Pilbara Native Title Service	Ethnographic heritage survey conducted within the Proposal area.
March 2007	R. & E. O'Connor	Aboriginal heritage survey of former Sulphur Springs tenement; L45/153.
July 2007	SJC Heritage Consultants Pty Ltd	Archaeological survey of nominated areas of Sulphur Springs current tenements; M45/653, M45/494, and former tenement; E45/2308.
May 2019	Terra Rosa Consulting	Archaeological survey of nominated areas of Sulphur Springs tenements; M45/1254

One registered Aboriginal Heritage Site (site 6046) in the local area is outside of the proposed disturbance areas (Figure 33). Seven sites of Aboriginal heritage significance have been recorded in the vicinity of the Proposal. These sites will not be directly impacted by the Proposal. Venturex has committed to implementing a 30 m exclusion zone surrounding each site for protection from ground disturbing activities, as agreed with the Nyamal Traditional Owners. The Proposal area is not used by the Nyamal Traditional Owners for the purposes of sourcing bush tucker. This was confirmed in a meeting between Venturex and the Nyamal Traditional Owners at the site on 7 June 2017 (Appendix 10).

No European heritage sites were identified.

7.2.4 Potential Impacts, Mitigation Measures and Predicted Outcomes

Potential impacts, mitigation measures and predicted outcome for social surroundings are summarised in Table 56.

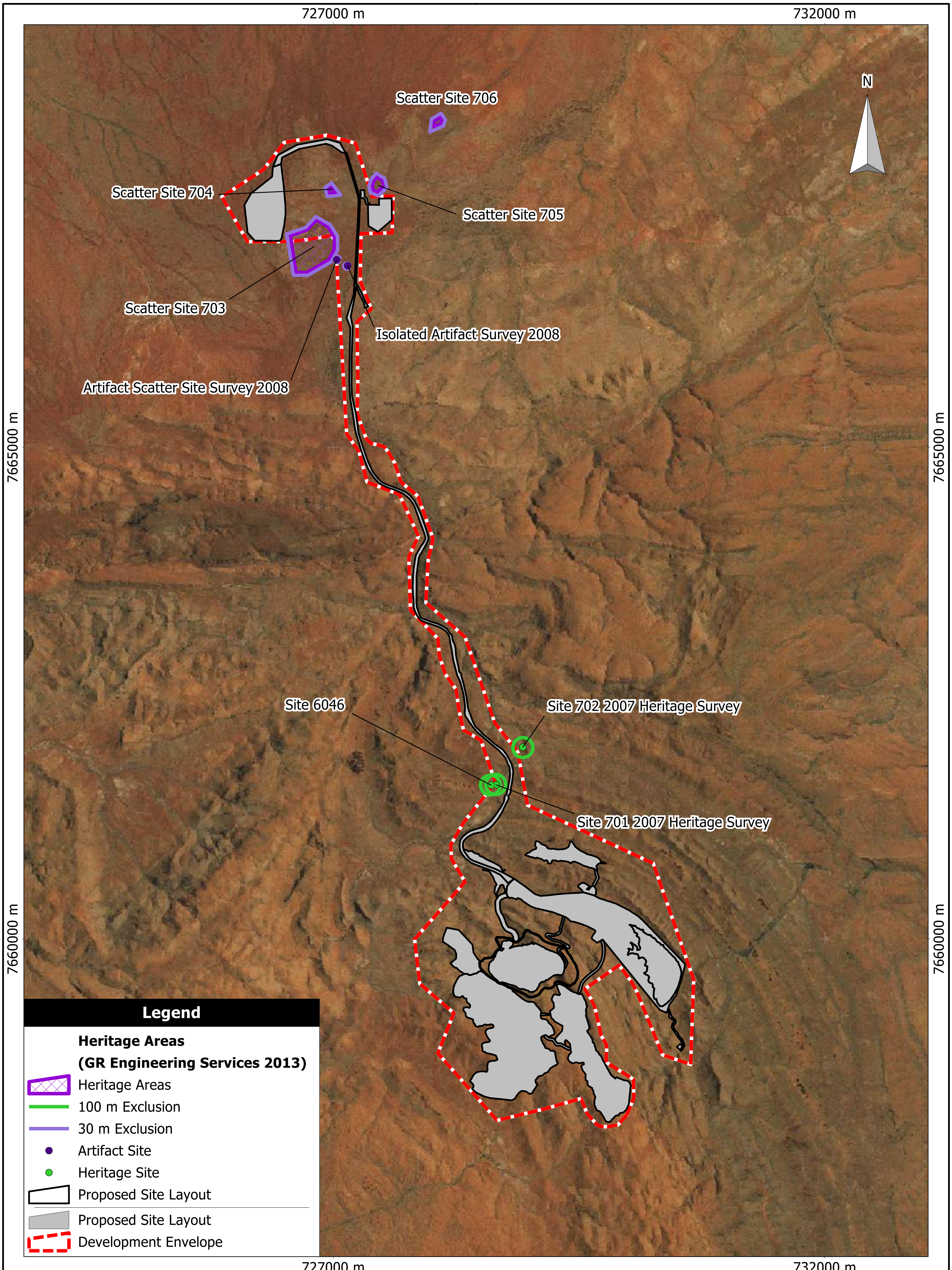

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Image source: Landgate
Air Photo Date: 2012
Grid: MGA94(50)
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Figure 33

Aboriginal Heritage Sites of Significance

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Table 56: Social Surroundings Potential Impacts, Mitigation Measures and Predicted Outcome

Potential Impacts	Mitigation Measures	Predicted Outcome
Amenity • Particulate emissions may impact visual amenity. • Noise and vibration from mining, processing or vehicle movements have the potential to impact sensitive premises (accommodation village).	**Measures to avoid:** • Mining and processing sites are located over 6.7 km away from the nearest sensitive receptor. **Measures to minimise:** • Land disturbance will be kept to the minimum necessary for development of the Proposal. • Vehicle traffic will be confined to defined roads and tracks. • Where practical, machinery movements will be confined to defined roads and tracks. • Vehicles will be required to travel at safe operating speeds on unsealed roads. • Dust will be managed by watering unsealed roads with a water cart or fixed sprays. • Occupational hygiene requirements for dust will be complied with in operational areas. • Fixed and mobile equipment will be maintained and serviced to manufacturer's specifications to ensure efficient running with minimal noise or vibration emissions. **Measures to rehabilitate:** • Disturbed areas will be rehabilitated upon completion of mining activities or where progressively able to do so. • Cleared vegetation will be, where practicable, directly placed in areas undergoing rehabilitation. Where this is not practicable, it will be stockpiled and retained for use on rehabilitated areas.	Potential impacts to social surroundings are limited because the Proposal is remote from communities and other sensitive receptors. With implementation of mitigation measures, the residual risk is considered to be low. With respect to amenity, the EPA objective 'to protect social surroundings from significant harm' will be met.
Heritage and Culture • Disruption to traditional use of the land and loss of access to sites of cultural significance. • Disturbance of heritage sites due to uncontrolled vehicle movements.	**Measures to avoid:** • Active engagement with Traditional Owners will be maintained. • Venturex has committed to implementing a 30 m exclusion zone surrounding each known heritage site for protection from ground disturbing activities, as agreed with the Traditional Owners. • Access to heritage sites present near the accommodation village will be restricted (via means such as fencing and signage as agreed with Traditional Owners).	No identified heritage sites will be directly impacted by this Proposal. With respect to heritage, the EPA objective 'to protect social surroundings from significant harm' will be met.
Human Health • Impacts to human health as a result of cultural activities such as bush tucker consumption.	**Measures to avoid:** • Contamination of soils, surface water and groundwater, and hence the risk of contamination of bush tucker, will be avoided through: – Project design, by locating PAF material placement adjacent to, and within the catchment of the mine pit. – Diversion of surface catchment to ensure the mine pit remains a hydraulic sink. – Environmental monitoring and remedial action in the event of any adverse trends or spills. **Measures to minimise:** • Minimisation of disturbance footprint. • Site induction will address the values and significance of heritage sites. • Site induction will address reporting protocols for personnel if a new site of potential cultural significance is encountered. • Ongoing communication with Traditional Owners will be recorded in Stakeholder Engagement Register. **Measures to rehabilitate:** • Early and progressive rehabilitation. • Use of local provenance seeds. • Recovery and storage of topsoil and vegetative material within disturbed areas.	With respect to human health, the EPA objective 'to protect social surroundings from significant harm' will be met.

7.3 HYDROLOGICAL PROCESSES

7.3.1 EPA Objective

The EPA objective for hydrological processes is 'To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected' (EPA 2016n)

7.3.2 Policy and Guidelines

Groundwater and surface water are protected under the following State legislation:

- *Environmental Protection Act 1986.*
- *Country Areas Water Supply Act 1947.*
- *Rights in Water and Irrigation Act 1914.*

In addition to State legislation, the following policies and guidance were considered in the impact assessment for hydrological processes:

- EPA Position Statement, Environmental Protection of Wetlands (EPA 2004d).
- EPA Statement of Environmental Principles, Factors and Objectives (EPA 2016b).
- EPA Environmental Factor Guideline – Hydrological Processes (EPA 2016n).
- Statewide Policy No. 5: Environmental Water Provisions Policy for Western Australia (Water and Rivers Commission 2000).
- Pilbara Water in Mining Guideline (DoW 2009).
- Western Australian Water in Mining Guideline (DoW 2013a).
- Strategic Policy 2.09: Use of Mine Dewatering Surplus (DoW 2013b).

7.3.3 Receiving Environment

A large number of groundwater and surface water hydrological and hydrogeological surveys have been undertaken within the Sulphur Springs area between 2002 and present. Surveys most relevant to this Proposal are summarised in Table 41. The combined coverage of these surveys has enabled a detailed understanding of hydrological processes within the Proposal area and interactions across the broader region. The most recent hydrogeological assessment for the Proposal is included in Appendix 16.

7.3.3.1 Sulphur Springs Creek

<u>Hydrological Processes</u>

The hydrological regime of Sulphur Springs Creek is discussed in Section 6.3.3. The occurrence of pools on valley floors indicates shallow depth to the water table in these settings and that the local aquifer systems are seasonally full. Shallow water table zones are commonly linked with the occurrence of potential GDEs. In the Sulphur Springs Creek catchment, surface water flows are supported by year-round discharges of groundwater from mineralised bedrock that is of low pH, low to moderate salinities and contains elevated concentrations of metals including cadmium, copper, nickel and zinc. As a result, natural acid drainage is occurring within Sulphur Springs Creek.

Ecological Communities

Potential water dependent ecosystems associated with Sulphur Springs include:

- Potential GDEs along Sulphur Springs Creek. These have been addressed in Section 6.1 and will not be considered further under this factor.
- Acidophiles: These are microorganisms that survive in highly acidic conditions. Such species have developed networked cellular adaptations to maintain their intracellular pH to around neutral. These adaptations allow the organism to restrict the rate at which protons can migrate into the cytoplasm and/or remove excess protons that reach the cytoplasm (Mirete *et al.* 2017). It is understood that these adaptations give acidophiles the flexibility to survive in low pH environments, rather than restricting them to such environments. Given the low pH water within the pit footprint, it is possible that acidophiles are present in Sulphur Springs Creek. These microorganisms have been documented in a range of locations around the world including geothermal waters, sulphide-rich geologies in cold environments such as Antarctica, and in caves, sewer systems, the human stomach and mining environments affected by AMD. There is no evidence to suggest acidophiles at Sulphur Springs, or in any other part of the world, should be considered conservation significant.

7.3.3.2 Minnieritchie Creek

Hydrological Processes

The hydrological regime of Minnieritchie Creek is discussed in Section 6.3.3. Surface water flows from the eastern part of the Proposal area into Minnieritchie Creek via numerous small ephemeral creeks. Groundwater discharges to the creek as part of a topographically-driven flow system. In low-lying locations along the creek line groundwater is exposed as pools where the water table is at or above ground level. Two such pools (possibly perennial) are located downstream of the proposed TSF (at sites MRC2 and MRC4, Figure 24). Surface water is typically circum-neutral with low background concentrations of metals and low to moderate salinities.

Ecological Communities

Potential GDEs are present along Minnieritchie Creek. These have been addressed in Section 6.1 (Table 33) and are not considered further under this factor.

7.3.4 Potential Impacts, Mitigation Measures and Predicted Outcome

Potential impacts, mitigation measures and predicted outcome for hydrological processes are summarised in Table 57.

Table 57: Hydrological Processes Potential Impacts, Mitigation Measures and Predicted Outcomes

Potential Impacts	Mitigation Measures	Predicted Outcome
• Groundwater abstraction results in a reduction in downstream water availability in Sulphur Springs Creek. • Surface water management infrastructure results in a reduction in downstream water availability in Sulphur Springs Creek. • Mine dewatering and/or groundwater abstraction lowers groundwater levels, impacting on health of potential GDEs in Sulphur Springs Creek.	**Measures to avoid:** • None **Measures to minimise:** • All groundwater abstraction will be conducted in accordance with the *Rights in Water and Irrigation Act 1914*. A site groundwater licence operating strategy, meeting requirements under this Act, will be developed and implemented to ensure sustainable use of groundwater resources. • Groundwater abstraction volumes will be limited to that required for the Proposal. The mine dewatering regime will consider rate of groundwater drawdown and location of impact of drawdown. • A project water management plan, incorporating monitoring of groundwater levels, surface water flows and water quality to identify any changes beyond those predicted and trigger management actions (Appendix 17). • Clean surface water flows will be diverted around operational areas as far as practicable to minimise impacts to downstream flows in the catchment. • Where necessary, suitable floodways, drains and culverts will be installed to transfer flow past infrastructure and return it to its natural flow path. • Disturbance of watercourse banks by construction and/or operational activities will be kept to the minimum necessary for development of the Proposal. **Measures to rehabilitate:** • Revision of the site surface water model during operations to further refine assumptions and water quality predictions and inform closure designs and strategies.	Groundwater modelling (Appendix 16) has confirmed that: • Other than the existing acidic groundwater exposures in the pit area, there are no other known groundwater discharge zones that will be affected by mine dewatering. • Due to the proximity of the WRD to the pit, the main body of the WRD is not expected to have any impact on the groundwater system outside of the mine site. With the implementation of mitigation measures, the Proposal is not expected to have any impact on environmental values associated with hydrological regimes of the groundwater and surface water and the EPA objective for this factor can be met.

7.4 AIR QUALITY

7.4.1 EPA Objective

The EPA objective for air quality is 'To maintain air quality and minimise emissions so that environmental values are protected' (EPA 2016o). In the context of this factor and objective, the primary focus is maintaining air quality and minimising emissions for human health and amenity. Potential impacts of poor air quality on flora and vegetation are addressed in Section 6.1.5.

7.4.2 Policy and Guidance

Impacts to air quality are managed primarily under the following legislation:

- *National Environment Protection Council Act 1994 (Cth).*
- *National Environment Protection Council (Western Australia) Act 1996 (WA)*.

In addition to above legislation, the following policy and guidance were considered in the impact assessment for air quality:

- Air Quality Modelling Guidance Notes (DEC 2006).
- A Guideline for Managing the Impacts of Dust and Associated Contaminants from Land Development Sites, Contaminated Sites Remediation and Other Related Activities (DEC 2011).
- EPA Guidance Statement No. 3, Separation Distances Between Industrial and Sensitive Land Uses (EPA 2005).
- EPA Environmental Factor Guideline – Air Quality (EPA 2016o).
- Environmental Protection Bulletin Number 24, Greenhouse Gas Emissions and Consideration of Projected Climate Change Impacts in the EIA Process (EPA 2015).
- *National Environment Protection Measure for Ambient Air Quality 1994* as amended 2003 (NEPC 2003).

7.4.3 Air Quality Aspects

7.4.3.1 Particulates

Proposed activities with the potential to cause emissions to air, predominantly in the form of particulate matter (dust) include:

- Vegetation clearing, topsoil clearing and re-spreading.
- Vehicle movements.
- Mining activities (blasting, earthmoving and dumping).
- Materials handling and processing activities including crushing of ore and filtration of concentrate.
- Concentrate loading and haulage from the plant site to Port Hedland and delivery to the storage facility at the port.
- Wind erosion from disturbed ground and exposed areas.

The risk to native vegetation posed by dust emissions is addressed in Section 6.1.5.5.

Given the absence of a community or townsite in proximity to the Development Envelope, the principal receptors sensitive to dust emissions are site workers. Exposure to dust will be managed through minimising dust emissions and use of protective equipment where relevant, in accordance with required workplace standards.

The prospect geology including the rock types, structure, metamorphic grade and mineralogy coupled with the lack of ultramafic and banded iron formations renders the presence of asbestiform minerals unlikely at Sulphur Springs. No asbestiform minerals have been reported during exploration programs on the leases surrounding Sulphur Springs and exploration drilling did not encounter any deleterious fibrous minerals. There is no record of asbestiform minerals being encountered during routine geological activities including field geological mapping and drilling at the site.

7.4.3.2 Greenhouse Gases

Greenhouse gas emissions will be produced during construction and operation of the project with main sources being the combustion of natural gas (power generation) and diesel (vehicles, power generation) as well as drilling and blasting. Vegetation clearing will also make a minor contribution to greenhouse gas emissions.

Annual diesel consumption for the project will be approximately 10,000 kL (predominantly mining fleet) and annual consumption of natural gas will be approximately 657,000 GJ. Using the National Greenhouse and Energy Reporting (NGER) threshold calculator (Australian Government Clean Energy Regulator 2018), this equates to emissions of approximately 54,600 tonnes of greenhouse gases per year (measured as CO_2 equivalent) which is in the order of 0.06 % of the net emissions for Western Australia in 2013-2014 (EPA 2016o).

Impacts related to greenhouse gas emissions include the potential to contribute to the result of climate change, including changes in global temperature, rainfall, and wind patterns, shifts in climate zones, and rising sea levels.

7.4.4 Potential Impacts, Mitigation Measures and Predicted Outcomes

Potential impacts, mitigation measures and predicted outcome for hydrological processes are summarised in Table 58.

Table 58: Air Quality Potential Impacts and Mitigation Measures

Potential Impacts	Mitigation Measures	Predicted Outcome
Particulate Matter • Particulate emissions from materials transport (aggregate and other construction materials) impacting human health. • Particulate emissions due to plant and power station operation impacting receptors (human health). • Concentrate emissions from containers during transport impacting human health.	**Measures to avoid:** • Mining and processing sites are located over 6.7 km away from the nearest sensitive receptor. • Heavy machinery operators will work in air-conditioned cabins and Personal Protective Equipment (PPE) will be used as required. **Measures to minimise:** • Land disturbance will be kept to the minimum necessary for development of the Proposal. • Vehicle traffic will be confined to defined roads and tracks. • Where practical, machinery movements will be confined to defined roads and tracks. • Vehicle hygiene measures to be adopted for the concentrate storage shed (including enclosed shed and wheel wash on exit). • Imposition of speed limits for vehicle traffic. • Dust minimisation measures will be implemented using water carts and fixed sprays. **Measures to rehabilitate:** • Disturbed areas will be progressively rehabilitated where possible.	Implementation of the Proposal will not significantly impact air quality or any sensitive receptors. The EPA objective for air quality 'to maintain air quality and minimise emissions so that environmental values are protected' will be met.
Greenhouse Gases • Gaseous emissions from vehicles, earthmoving equipment and power station resulting in air pollution. • Gaseous emissions from vehicles, earthmoving equipment and power station impacting human health.	**Measures to minimise:** • Substitution of diesel with natural gas for the majority of required power generation. • Energy efficiency and greenhouse gas emissions will be considered as part of equipment selection and purchase. • Identify and implement cleaner production initiatives to increase energy efficiency where practicable. • Appropriate emission control mechanisms will be selected to ensure that emissions comply with statutory requirements and acceptable standards. • Regular maintenance of diesel combustion equipment. • Diesel engines will be regularly serviced to maintain efficiency and minimise harmful combustion products.	Greenhouse gas emissions will be managed under Part V of the *EP Act*, the *Clean Energy Act 2011* and reported under the *National Greenhouse and Energy Reporting Act 2007*. Predicted greenhouse gas emissions for Sulphur Springs are low, representing approximately 0.06% of Western Australia's total greenhouse gas emissions.

8. OFFSETS

Environmental offsets are 'actions that provide environmental benefits which counterbalance the significant residual environmental impacts or risks of a project or activity' (Government of WA 2014).
The assessment and potential application of offsets for the Proposal has been undertaken with consideration of the following:

- *WA Environmental Offsets Policy* (Government of WA 2011).
- *WA Environmental Offsets Guidelines* (Government of WA 2014).

To determine whether offsets were required, residual environmental impacts were reviewed following the application of the nominated mitigation measures (see Table 37, Table 40, Table 48, Table 54, Table 56, Table 57 and Table 58). The mitigation measures were developed and applied based on the mitigation hierarchy, which involves:

- Avoidance.
- Minimisation.
- Rehabilitation.
- Offsets.

Outcomes of the assessment are summarised in Table 59. Offsets are applied for significant residual environmental impacts remaining after mitigation measures have been implemented. After applying these mitigation measures, it is believed that there will be no significant residual environmental impacts from the Proposal, and that the EPA objective for each of the preliminary key factors and other environmental factors can be met. Thus, no offsets are proposed.

Notwithstanding this conclusion, which is based solely on the characteristics of this Proposal, Venturex acknowledges the risks associated with cumulative environmental impacts across the Pilbara IBRA bioregion as set out by the EPA in the report *Cumulative Environmental Impacts of Development in the Pilbara Region* (EPA 2014b). Consistent with the recommendations of the EPA for many proposals in the Pilbara over the last seven years or so, Venturex acknowledges the possibility of a recommended condition of implementation requiring a contribution to the Pilbara Environmental Offset Fund, based on the extent of disturbance of native vegetation in good to excellent condition, and other higher value habitat (limited) within the Proposal footprint.

Table 59: Sulphur Springs Assessment Against Significant Residual Impacts for Part V Clearing Principles

Clearing Principle	Significant Residual Impacts that will Require an Offset	Significant Residual Impacts that may Require an Offset
Rare Flora*	None – no proposed impacts to or removal of buffers or other areas necessary to maintain ecological processes and functions for species declared as Threatened under the *BC Act* or the *EPBC Act.*	None – the Proposal will not result in a species being listed as Threatened under the *BC Act* or the *EPBC Act.*
TECs	None – No TECs in vicinity of the Proposal.	None – No TECs in vicinity of the Proposal.
Remnant Vegetation	None – More than 30% of pre-clearing vegetation within the Chichester subregion remains intact. State-wide vegetation statistics (Government of WA 2018) indicate 99.84% of pre-European vegetation in the Chichester subregion remains intact. 2017 DBCA dataset (Government of Western Australia 2018) indicates active Clearing Permits overlie 329,120 ha (3.9%) of the Chichester subregion and Clearing Permit proposals, a further 41,102 ha (0.5%). Proposed clearing for the Proposal (313.6 ha) equates to less than 0.004% of the Chichester subregion.	None – clearing will not result in high degree of fragmentation or impact on ecosystem services.
Wetlands and Waterways	None – no conservation significant wetlands present.	None – no damplands or floodplains present.
Conservation Areas	None – no conservation areas present in vicinity of the Proposal.	None – no ecological linkages between conservation areas identified within or near the Proposal.
High Biological Diversity	None – no nationally or internationally recognised biodiversity hotspots in the Proposal area.	None – no impacts to communities or species that are representative of high biodiversity.
Habitat for Fauna	None – no habitat necessary to maintain conservation significant species identified in the Proposal area.	None – the Proposal will not result in a species being listed as Specially Protected under *BC Act* or Threatened under *EPBC Act.*

** Since re-classified as Threatened flora under the BC Act.*

9. HOLISTIC IMPACT ASSESSMENT

This ERD provides a detailed assessment of the potential environmental impacts from the Sulphur Springs Zinc-Copper Project on the preliminary key and other environmental factors or matters. Potential impacts have been considered against the relevant EPA objectives, as defined in the *Statement of Environmental Principles, Factors and Objectives* (EPA 2016b).

This ERD also identifies the proposed environmental management strategies to minimise these impacts. Venturex has applied the mitigation hierarchy as presented in the *WA Environmental Offsets Guidelines* (Government of WA 2014) as follows:

- **Avoid:** Avoidance is the preferred strategy for managing potentially significant impacts to the environment. This Proposal has been designed to avoid potentially significant impacts to the environment.
- **Minimise:** After avoidance strategies have been considered (and implemented where practical), mitigation measures to minimise the remaining significant impacts (if any) are investigated and implemented to reduce remaining significant impacts to an acceptable level. This Proposal has been designed to minimise the remaining potentially significant impacts to the environment.
- **Rehabilitate:** After practicable avoid and minimise measures have been considered or implemented; rehabilitation will be undertaken to reduce remaining impacts.
- **Offset:** Required in the event that significant residual environmental impacts remain following the application of the above measures.

After applying these mitigation measures, Venturex is confident there will be no significant residual environmental impacts from the Proposal, and that the EPA objective for each of the preliminary key factors and other environmental factors can be met, as outlined below.

9.1 FLORA AND VEGETATION

Taking into account the:

- EPA Statement of Environmental Principles, Factors and Objectives.
- Environmental Factor Guidelines: Flora and Vegetation.
- WA Environmental Offsets Policy and Guidelines.
- Application of mitigation hierarchy to minimise flora and vegetation clearing.
- Limited extent of groundwater drawdown.
- Predicted surface and groundwater quality downgradient of the TSF, pit and WRD.
- Absence of direct impacts to Threatened flora.
- Wider representation of the vegetation communities present within the Development Envelope; and
- Proposed management measures including appropriate siting of infrastructure, the minimisation of the development footprint, measures to minimise the risk of indirect impacts and the implementation of a flora and vegetation management plan (Appendix 18).

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for flora and vegetation, that the impacts to this factor are manageable and would not represent a significant impact.

9.2 SUBTERRANEAN FAUNA

Taking into account the:

- Environmental Factor Guideline: Subterranean Fauna.
- Application of the mitigation hierarchy to avoid and minimise disturbance of habitat.
- Potential alteration of groundwater chemistry, principally increased acidity, salinity and metal and metalloid concentrations associated with seepage from the TSF during both the operational and closure phases.
- Occurrence of a single, widely distributed, troglofauna species.
- Occurrence of 24 stygofauna taxa in proximity to the development footprint, of which 20 are known to occur within surrounding non-impact areas.
- Occurrence of four stygofauna taxa (two Phreodrilidae Gen. et sp. indet. and two Tubificidae SS sp. 1) within the Development Envelope, but lack of confirmed presence in the broader area/region.
- Limited loss of subterranean fauna habitat relative to local habitat extent.
- Mine pit acting as a hydraulic sink and placement of PAF material within the catchment of the mine pit.
- Appropriate design, construction and operation of the WRD and TSF; and
- Implementation of an operational surface and groundwater management plan.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for subterranean fauna, that the impacts to this factor are manageable and would not represent a significant impact.

9.3 TERRESTRIAL ENVIRONMENTAL QUALITY AND INLAND WATERS ENVIRONMENTAL QUALITY

Taking into account the:

- EPA Statement of Environmental Principles, Factors and Objectives.
- Environmental Factor Guidelines: Terrestrial Environmental Quality and Inland Waters Environmental Quality.
- Mine pit acting as a hydraulic sink and placement of PAF material within the catchment of the mine pit.
- Appropriate design, construction and operation of the WRD and TSF; and
- Implementation of a project water management plan.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for terrestrial environmental quality and inland waters environmental quality, that the impacts to these factors are manageable and would not represent a significant impact.

9.4 OTHER ENVIRONMENTAL FACTORS OR MATTERS

9.4.1 Terrestrial Fauna

Taking into account the:

- EPA Statement of Environmental Principles, Factors and Objectives.
- Environmental Factor Guidelines: Terrestrial Fauna.
- WA Environmental Offsets Policy and Guidelines.

- Application of mitigation hierarchy to minimise flora and vegetation clearing.
- Representation of fauna habitats recorded within the development footprint across the wider area.
- Significant fauna recorded widely from the surrounding areas and not limited to within or adjacent to the Development Envelope; and
- Proposed management measures including appropriate siting of infrastructure to avoid potential higher value habitat for Northern Quoll and bat species.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for terrestrial fauna, that the impacts to this factor are manageable and would not represent a significant impact.

9.4.2 Social Surroundings

Taking into account the:

- Environmental Factor Guideline: Social Surroundings.
- Large number of archaeological, ethnographic and heritage surveys undertaken within the Sulphur Springs area since 1993.
- Avoidance of impact on the seven sites of Aboriginal heritage significance that have been recorded in the region; and
- Commitment to a 30 m exclusion zone surrounding each Aboriginal heritage site for protection from ground disturbing activities, as agreed with the Nyamal Traditional Owners.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for social surroundings, that the impacts to this factor are manageable and would not represent a significant impact.

9.4.3 Hydrological Processes

Taking into account the:

- EPA Statement of Environmental Principles, Factors and Objectives.
- Environmental Factor Guideline: Hydrological Processes.
- Large number of groundwater and surface water hydrological and hydrogeological surveys undertaken within the Sulphur Springs area since 2002.
- Natural discharge of low pH groundwater with elevated concentrations of metals emanating from mineralised bedrock; and
- Proposed management measures including suitable floodways, drains and culverts, appropriate siting of infrastructure and the preparation and implementation of a project water management plan.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for hydrological processes, that the impacts to this factor are manageable and would not represent a significant impact.

9.4.4 Air Quality

Taking into account the:

- EPA Statement of Environmental Principles, Factors and Objectives.
- Environmental Factor Guideline: Air Quality.
- Scale of greenhouse gas emissions (approximately 54,600 tonnes of greenhouse gases per year measured as CO_2 equivalent).

- No sensitive receptors (human) within at least 6.7 km; and
- Proposed dust management measures.

Venturex considers, having regard to the relevant *EP Act* principles and environmental objective for air quality, that the impacts to this factor are manageable and would not represent a significant impact.

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