YANGIBANA RARE EARTHS PROJECT

Environmental Review Document

Assessment number 2115
EPBC 2016/7845

	Document Status			
Rev	Author	Reviewer	Approved	Date
A	Lara Jefferson	OEPA prelim. review		05/01/17
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3	Lara Jefferson	EPA Services & DMAs	Stefan Wolmarans	31/08/18
4	Lara Jefferson	EPA Services	Stefan Wolmarans	06/09/18

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this proposal.

Hastings Technology Metals Limited is proposing to develop the Yangibana Rare Earths Project (the Proposal), located approximately 270 km east-northeast of Carnarvon, in the Upper Gascoyne region of Western Australia (WA). The Proposal will involve mining above and below the groundwater table, on-site processing of ore, water abstraction, and transport via road to Geraldton or Fremantle port for export. The Environmental Review Document has been prepared in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The ERD is a report prepared by the proponent on their environmental review which describes this proposal and its likely effects on the environment.

The ERD is available for a public review period of 4 weeks from 1 October 2018, closing on 28 October 2018.

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

Why write a submission?

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

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992*.

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the Environmental Review Document.

When making comments on specific elements in the ER document:

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

What to include in your submission

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

- Your contact details – name and address.
- Date of your submission
- Whether you want your contact details to be confidential.
- Summary of your submission, if your submission is long.
- List points so that issues raised are clear, preferably by environmental factor.

- Refer each point to the page, section and if possible, paragraph of the ERD.
- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: 28 OCTOBER 2018

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

SCOPING CHECKLIST

Required work	ERD Section
Flora and vegetation	5
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 5.3
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 5.3.3 Figure 5-4
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) in a 'worst case' scenario. • The total area (in ha) of each significant vegetation unit to be impacted (directly or indirectly) in 'worst case' scenario. • Identification of vegetation units which may represent a component of Threatened or Priority Ecological Communities. Analysis of impacts on flora to include: • Identification of any significant flora present or likely to be present. • The number of plants, and the number of populations of plants, to be impacted (directly and indirectly) in a 'worst case' scenario. • The total 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.	Section 5.3.1 and 5.3.2 Table 5-1 and 5-2 Section 5.5.2 Table 5-4 Section 5.5.1 Table 5-3
4. Provide tables and figures of the proposed direct impact or predicted extent of loss of vegetation 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 new flora.	Section 5.5
5. Discuss and quantitate the potential exposure to flora and vegetation to radiation through deposition of dust during mining and seepage from the Tailings Storage Facility (TSF).	Section 5.5.3
6. Assess potential radiation impacts on flora and vegetation using the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) tool. Australian specific data should be used where available.	Section 5.5.3
7. 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	Section 5.5.4

Required work	ERD Section
water quality, spread of weeds, fragmentation of vegetation, altered fire regime and dust.	
8. Discuss and determine significance of, potential direct, indirect (such as dust and downstream impacts) and cumulative impacts to flora and vegetation as a result of the proposal at a local and regional level.	Section 5.7.1
9. Discuss management measures, outcomes/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted.	Section 5.6
10. 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 5.6
11. Provide Flora and Vegetation management plan to address significant residual impacts to flora and vegetation. 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 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 offset (if applicable).	Appendix 1-5
12. 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 6 Section 5.6 under "Rehabilitation" heading
13. Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to flora and vegetation.	Section 5.6
14. Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	Section 5.7.1
15. Create an offsets position following application of the 'mitigation hierarchy'.	Section 5.7.2
16. Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 5.7.3
Subterranean fauna	7
17. 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 7.3
18. Conduct Level 2 surveys inside and outside areas subject to direct and indirect impacts, following Environmental Protection Authority Environmental Factor Guideline - *Subterranean Fauna* (2016), *Technical Guidance - Subterranean Fauna Survey* (2016) and *Technical Guidance - Sampling Methods for Subterranean Fauna* (2016).	Section 7.3.3

Required work	ERD Section
19. 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 hydrology predicted to support subterranean fauna habitats (including its extent outside the development envelope).	Section 7.3.3
20. Discuss habitat prospectivity and demonstrate habitat connectivity within and outside the proposed disturbance area.	Section 7.3.3.4
21. Determine the extent of and map the aquifers that have direct hydraulic connection to the Gifford Creek Calcrete PEC.	Section 7.3.2.1 Figures 7-1 and 7-2
22. 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 quality	Section 7.5
23. 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 7.5
24. Identify any limitations associated with the survey data or existing knowledge and discuss their implications for the impact assessment.	Section 7.3.3.3
25. Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to subterranean fauna.	Section 7.6
26. Discuss proposed management objectives, measures, and outcomes sought to ensure residual direct and indirect impacts are not greater than predicted.	Section 7.6
27. Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	Section 7.7.1
28. Create an offsets position following application of the 'mitigation hierarchy'.	Section 7.7.2
29. Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 7.7.3
Terrestrial Environmental Quality	8
30. Include rationale for site selection of WRLs and TSFs (i.e. favourable meteorological, geological and geographical characteristics).	Section 8.3.7
31. Present a baseline soil quality assessment of the development envelope.	Section 8.3.4 Appendix 5-2
32. Include in the ERD, figures of the mapped soil units.	Figure 8-1 and 8-2
33. Conduct chemical and physical characterisation of the waste materials, including characterisation of tailings pore water.	Section 8.3.5
34. Determination of waste rock volumes above 1 Bq/g, associated lithologies and strategies to manage these materials.	Section 8.3.4.1 Appendix 5-11 Waste Rock Management Plan
35. Assess the mineralogy for likelihood of asbestiform minerals occurring.	Section 8.3.5.1

Required work	ERD Section
36. Conduct long term (1000 years) Landform Evolution Modelling of behaviour and performance of landforms associated with containment systems including TSFs, modelled under a range of climatic events. Include the modelling of the appropriate Probable Maximum Precipitation (PMP) and associated Probable Maximum Flood (PMF) scenarios.	Section 8.5.2.4
37. For the each tailings stream, identify: - Geochemical properties (e.g. NAF, strongly gypsiferous etc.) - Radionuclide levels at each stage - If radionuclides will be water soluble - Any issues with drainage and tailings consolidation	Section 8.3.5.2
38. Assess impacts on surrounding environment if there was failure of TSF integrity.	Sections 8.3.9 and 8.5.2.4
39. Assess potential radiation impacts on surrounding soils/land using the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) tool. Australian specific data should be used where available.	Section 8.3.6
40. Demonstrate conformance with internationally recognised design criteria for TSF design and describe measures to minimise the risk of environmental exposure to as low as reasonably achievable/possible (ALARP). Include a conceptual design of the TSF 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 DMP as part of the Mining Proposal.	Section 8.3.9
41. Provide a graphical conceptual representation of the final TSFs.	Section 8.3.9 Figure 8-10
42. Provide details of stability of the site from a geotechnical and geochemical perspective. Noting that more detailed reports will be provided to the DMP as part of the Mining Proposal.	Sections 8.3.8 and 8.3.5
43. Determine and document if any of the TSFs are likely to be listed as contaminated sites under the *Contaminated Sites Act 2003* (WA).	Section 8.5.3
44. Described 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/lands/receiving environment. This description should contain recommendations for soil handling to minimise erosion of stockpiled soils.	Section 8.6 under the heading 'Management'
45. Provide a Mine Closure Plan. Rehabilitation and closure management and mitigation measures should be described in the plan. A Mine Closure Plan should be provided as an appendix to and discussed in the ERD. The Mine Closure Plan should be prepared in accordance with the Guidelines for Preparing Mine Closure Plans jointly prepared by the DMP and the EPA.	Section 8.6 under the heading 'Rehabilitation' Appendix 6 Preliminary Mine Closure Plan
46. Provide a Radioactive Waste Management Plan as an appendix to the ERD to describe the high-level management to be implemented to mitigate the risks associated with radioactive waste.	Appendix 5-7 and Section 8.6 under the heading 'Management'

Required work	ERD Section
47. Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Section 8.6 under the heading 'Management'
48. Demonstrate and document in the ERD how the EPA's objective for this factor can be met.	Section 8.7
Hydrological Processes and Inland Waters Environmental Quality	6
49. Characterise the baseline hydrology and hydrogeological regimes and water quality, both in a local and regional context, including but not limited to, water levels, water chemistry, stream flows, flood patterns, catchment boundaries and water quantity and quality. This is to include a detailed description of the geological framework within the zone to be impacted by groundwater abstraction and any interdependence between surface and groundwater features/bodies. Include, where relevant influences on water availability.	Section 6.3
50. Provide a detailed description of the design and location of the proposal with the potential to impact surface water or groundwater. A Figure should be provided in the ERD document which depicts the predicted location of the wetting front.	Section 6.5.3.2
51. 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 6.3.5 Figures 6-4 and 6-8
52. Identify a suitable water source and discuss the potential direct and indirect impacts. Identify contingency options discuss the impact of each option.	Section 6.3.7
53. Assess the age of groundwater and evaluate the recharge potential and sustainability of groundwater abstraction. It is recommended that this is done using isotopes Tritium, C13/14 and Deuterium.	Sections 6.3.5.1 and 6.5.3.2 under the headings isotopic analysis
54. Provide a conceptual mine water balance over the life of the proposal and discuss the capacity to reuse surplus mine dewater.	Section 6.3.7
55. 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.	Section 6.5.1
56. Discuss predicted impacts on GDEs.	Section 6.5.1
57. 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 onsite water and the characterisation of the leaching potential of all waste materials under a range of pH conditions and varying solid-liquid ratios.	Section 6.3.8
58. Document and include any potential pathways for contamination including but not limited to: - dust from the ROM pad, processing plant (processing reagents, chemicals) and TSFs; - seepage of tailings water; - operational leaks and spills; - failure of TSF integrity; - seepage from sewage treatment plants;	Section 6.5.3

Required work	ERD Section
- erosion of WRL surfaces; and - saline final void pit lakes contaminating surrounding ground water.	
59. Discuss the potential environmental impacts and benefits of identified surplus water management options (i.e. use of excess mine dewater, reuse on site, local water supply, aquifer recharge etc.) and discuss the most appropriate water management strategy for the proposal.	Section 6.3.7
60. Analyse, discuss and assess surface water and groundwater impacts. The analysis should include but not be limited to: - changes in groundwater levels and changes to surface water flows associated with the proposal; - the nature, extent, and duration of impacts; - The impact of changing water quality on environmental values; and - Cumulative impacts with other projects and referred proposals, for which relevant information is publicly available.	Section 6.5
61. Demonstrate application of the mitigation hierarchy to avoid and minimise impacts to Hydrological Processes and Inland Waters Environmental Quality.	Section 6.6
62. Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015) which addresses the development of completion criteria to maintain of the hydrological regimes and the quality of groundwater and surface water so that environmental values are maintained post closure.	Appendix 6
63. Provide a description of monitoring, management, closure and rehabilitation arrangements and attach a management plan.	Section 6.6
64. Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Section 6.6
65. Demonstrate and document in the ERD how the EPA's objectives for these factors can be met.	Section 6.7
Human Health	9
66. Establish an appropriate baseline for model input, including natural variation.	Section 9.3 Appendix 5-4
67. Define the radiation exposure pathways. Conduct and summarise a radiological exposure assessment and modelling of radiation exposure risk to the public and workers (including transport workers), both during operation and post closure, including a radiological dose assessment. Include characterisation of expected levels of radioactivity associated with each stage of the process, including transportation of the final product.	Section 9.4 Sections 9.5.1 – 9.5.7
68. Modelling of dust emission sources, particularly in relation to near surface mineralisation and dispersion modelling to predict radionuclide activities in airborne and deposited dust.	Section 9.3.3.2 Appendix 7-1 and 7-2
69. Consider and discuss appropriate conversion factors and modelling of absorbed doses.	Section 9.5.2

Required work	ERD Section
70. Include management measures to reduce radiological impacts during transport (from pit to processing plant) of ore, and if appropriate include measures to limit risk of spills in the event of a transport accident.	Section 9.6
71. Justify and provide details of the containment used for the product for loading, transport and unloading at the Port facility.	Section 9.6
72. Include management measures that would be implemented to minimise emission of radionuclide-containing dust and radon decay products.	Section 9.6
73. Include monitoring, management and contingency procedures to reduce exposure.	Section 9.6
74. Prepare a Mine Closure Plan consistent with DMP and EPA *Guidelines for Preparing Mine Closure Plans* (2015) which addresses the development of completion criteria to protect human health from significant harm so that environmental values are maintained post closure.	Appendix 6 Section 9.6
75. Outline the outcomes/objectives, trigger and contingency actions to ensure impacts (direct and indirect) are not greater than predicted.	Section 9.6 Appendix 5-8
76. Conduct a health risk assessment, using evidence based information for health impacts.	Section 9.5.7
77. Describe the residual impacts for the proposal and analyse these impacts to identify and detail any that are significant.	Section 9.7.1
78. Demonstrate and document in the ERD how the EPA's objectives for these factors can be met.	Section 9.7.2
Other: Terrestrial Fauna	Chapter 10
The assemblages and habitats present, including information on the conservation value of each habitat type from a local and regional perspective;	Appendices 1-4 and 2-1
Comprehensive mapping of fauna habitats;	Section 10.3.1
Habitats, populations/records and mapping of conservation significant species in relation to the proposed disturbance and areas of impact;	Figure 10.1
Quantitative analyses for conservation significant fauna, of the likely extent of loss of individuals, population(s) and amount of habitat (Information, including maps, must also differentiate habitat on the basis of use (e.g. breeding habitat, migration pathways, foraging/feeding/dispersal habitat);	Section 10.3.1 Table 10.1 Figure 10.2
Descriptions and maps of expected direct, indirect and cumulative impacts;	Section 10.5 Table 10.1 Table 10.2
An ecotoxicity assessment	Appendix 2-2
An assessment of potential radiation impacts on fauna using the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) tool. Australian specific data should be used where available	Appendix 5-6 Section 10.5.5
Impacts to State and Commonwealth-listed significant species in particular	Sections 10.4 and 10.5 Table 10.2
Evidence of application of the mitigation hierarchy	Section 10.6

Required work	ERD Section
Discussion of the proposed management, monitoring and mitigation methods	Section 10.6
Management plans to ensure impacts are not greater than predicted, produced in accordance with Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA, 2016).	Section 10.6 Appendix 2-3
Other – Social surroundings	11
Present and discuss the results of the heritage surveys	Section 11.3
Assessment of risks to human health from cultural activities in the region, including bush tucker consumption, in the region from radiological sources and other contaminants.	Section 11.5
Matters of National Environmental Significance	12
Summary from supporting sections 8 and 9	12.1-12.7

Executive Summary

Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal; **Table ES-1**), located in the Upper Gascoyne region of Western Australia (WA; **Figure ES-1**).

Table ES-1 Summary of the Proposal

Proposal Title	Yangibana Rare Earths Project
Proponent Name	Hastings Technology Metals Limited
Short Description	Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal), located approximately 270 km east-northeast of Carnarvon, in the Upper Gascoyne region of Western Australia (WA). The Proposal will involve mining above and below the ground water table, on-site processing of ore, water abstraction, and transport via road to Geraldton port for export.

REE will be mined from four deposits. During mining the REE ore will be taken to the ROM pad in preparation for processing, whereas waste rock will be deposited in a waste rock landform, alongside each respective pit. A processing plant, consisting of a beneficiation process and a hydrometallurgical process, will produce a REE concentrate product. Tailings will be disposed in three TSFs. Support infrastructure will include, but is not limited to, power, water, accommodation facilities, airstrip and linear infrastructure.

Figure ES-1 and **Table ES-2** provides a summary of the location and proposed extent of physical and operational elements of the Proposal, respectively.

Table ES-2 Location and proposed extent of physical and operational elements

Element	Location	Proposed Extent
Physical elements		
Mine and associated infrastructure	Figure 2	Clearing of no more than 1,000 Ha within a development envelope of 13,373 Ha
Operational elements		
Mining	Figure 2	Mining from 4 pits
Water abstraction, including dewatering from pits	Figure 2	Abstraction of no more than 2.5 GL/a of groundwater
Ore processing (waste)	Figure 2	Tailings disposal of no more than: • 9.336 Mt into TSF1 • 484,000 t into TSF2 • 638,000 t into TSF3
Transport	Figure 1	Transport of packaged product to port via trucks on existing roads. Storage of packaged product at an existing port facility. Loading of product on existing container ships.

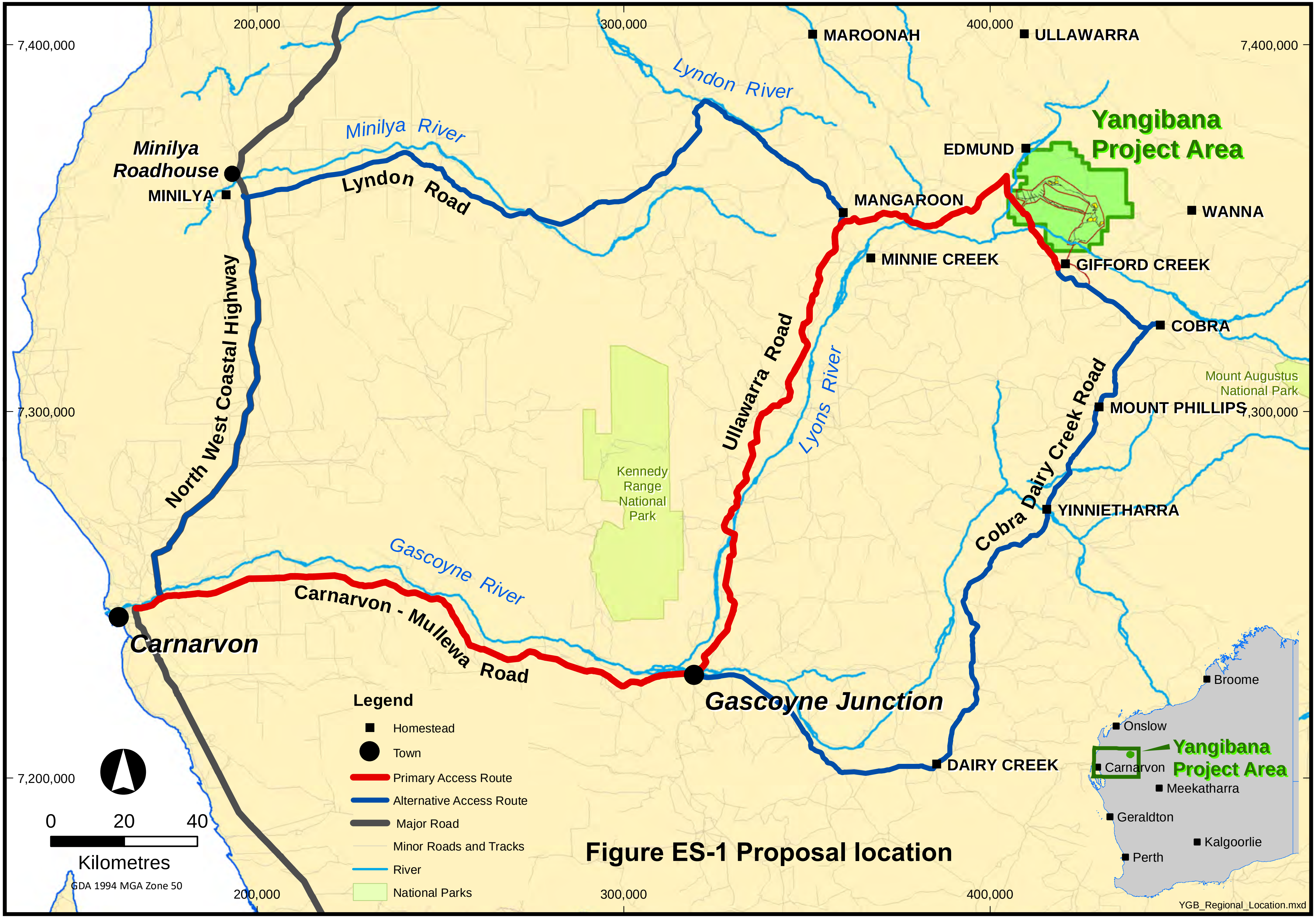
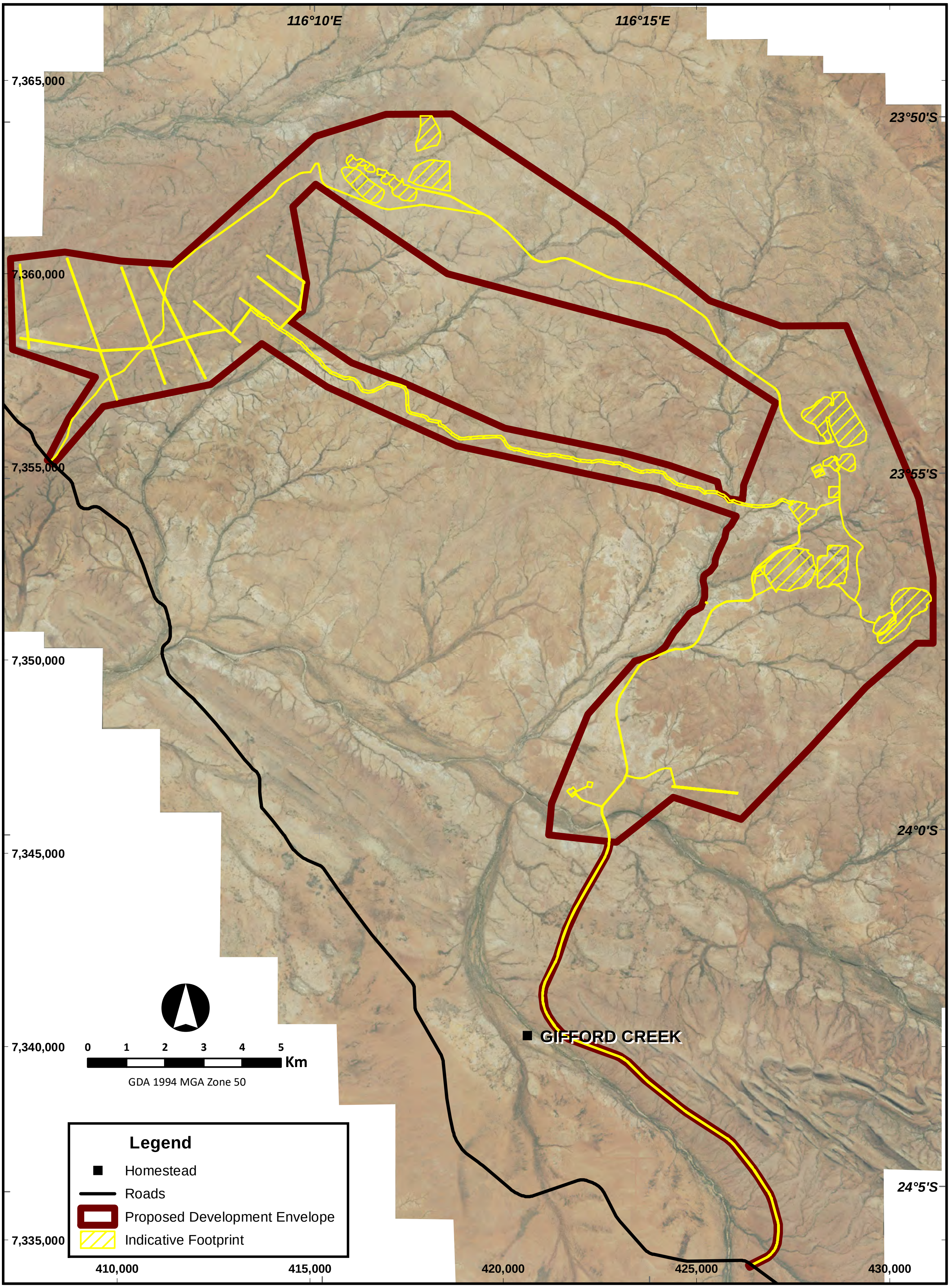


Figure ES-1 Proposal location



HASTINGS Technology Metals Limited

YANGIBANA RARE EARTHS PROJECT

PER_F1-2_Envelope_Footprint.mxd
22 June 2018

Figure ES-2 Development Envelope and Indicative Footprint

Hastings has consulted with the following key stakeholders for the proposal:

1. Commonwealth government:
    - Department of the Environment and Energy (DoEE)
2. State Government:
    - Department of Mines, Industry Regulation and Safety (DMIRS), formerly Department of Mines and Petroleum (DMP)
    - Radiological Council
    - Department of Health (DoH)
    - Department of Water and Environmental Regulation (DWER), formerly the Department of Environment Regulation (DER), the Department of Water (DoW) and the Office of the Environmental Protection Authority (OEPA)
    - Department of Planning, Lands and Heritage (DPLH), formerly the Department of Aboriginal Affairs (DAA)
3. Local Government:
    - Shire of Upper Gascoyne
    - Shire of Carnarvon
4. Native Title claimants
    - combined Thin-Mah Warianga, Tharrikari, Jiwarli (TMWTJ) native title claimants (WC2016/003; WAD464/2016), represented by the Yamatji Marlpa Aboriginal Corporation (YMAC)
5. Pastoralist
    - Bagden Pty Limited, Wanna and Gifford Creek Stations

Section 4A of the *Environmental Protection Act 1986* (WA; EP Act) describes the principles of environmentally sustainable development. These principles have been considered in the context of the Proposal. Environmental impact assessment of five key environmental factors is summarised in Table ES-3.

Table ES-3 Summary of the environmental review

Key Environmental Factor 1: Flora and vegetation	
EPA objective	*To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*
Policy and guidance	Laws and regulations relevant to the consideration of flora and vegetation include: *Agricultural and Related Resources Protection Act 1976* (WA) *Biosecurity and Agriculture Management Act 2007* (WA) *Bush Fires Act 1954* (WA) *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) *Environmental Protection Act 1986* (WA) *Wildlife Conservation Act 1950* (WA) Relevant guidelines include: EPA (2016n) Technical Guidance - Flora and vegetation surveys for environmental impact assessment; and EPA (2016e) Environmental Factor Guideline: Flora and vegetation.
Potential impacts	• The proposal includes clearing of up to 1,000 ha of native vegetation. • Clearing of vegetation units considered to have high local significance such as Ground Dependent Ecosystems (GDE), and riparian vegetation. • Removal and disturbance to conservation significant flora and vegetation. • Increased risk (altered fire regime) for fire resulting in vegetation loss or change. • Radiation exposure to flora and vegetation • Changed hydrology (quality and quantity of surface water) negatively impacting downstream vegetation. • Introduction and spread of weeds that outcompete native vegetation. • Loss of the native seed bank from the areas cleared.
Mitigation	**Avoid** • Minimise land disturbance to meet operational requirements only. • Progressive rehabilitation, where possible. • Design, construction and operation of TSFs in accordance with relevant standards and guidelines. • Detailed engineering design of linear infrastructure to ensure surface drainage is not obstructed. • Bald Hill (BH) pit size has reduced to a BH West and BH East (satellite pit).

<table>
<tr><td></td><td><u>Minimise</u>

Groundwater abstraction from fractured rock aquifers is self-limiting.
Water reuse to reduce the water requirements of the Proposal.
Water harvesting in pit voids will reduce water required from SipHon Well Borefield over the medium-long term.
Practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the development envelope including:

Development envelope has been refined and reduced at the location of the access road;
The disturbance area of the Waste Rock Landforms (WRLs) have been reduced by designing them to be taller (without compromising their integrity or resulting in erosion).

<u>Rehabilitation</u>
Preliminary Mine Closure Plan (Appendix 6) including the following considerations:

Topsoil and subsoil storage and locations in preparation for progressive rehabilitation.
Progressively shape, contour and spread suitable soils on WRLs.
Establish diversion drains at the toe of the WRLs.
Rehabilitation of auxiliary roads that are no longer in use.
Rehabilitation with vegetation composed of native species of local provenanceRehabilitation of drill pads that are no longer in use including capping of holes, sumps backfilled, soil ripped and reseeded.
</td></tr>
<tr><td>Outcomes</td><td><u>Residual Impact</u>
No impacts to rare flora or threatened species will occur. Direct impact to two priority flora species is considered insignificant: Only 1.2 % and 0.7 % of Acacia curryana and Rhodanthe frenchii plants, respectively. Application of the mitigation hierarchy will ensure indirect impacts are a low risk.

There are no Threatened Ecological Communities present nor Priority Ecological Communities (as defined by vegetation associations). No regional vegetation associations will be cleared below the ‘threshold level’ of 30% of its pre-clearing extent.

<u>Offsets</u>
No offsets are required.</td></tr>
<tr><td colspan="2">Key Environmental Factor 2: Subterranean fauna</td></tr>
<tr><td>EPA objective</td><td>To protect subterranean fauna so that biological diversity and ecological integrity are maintained.</td></tr>
</table>

Policy and guidance	Laws and regulations relevant to the consideration of subterranean fauna include: *Environmental Protection Act 1986* (WA) Relevant guidelines include: EPA (2016k) Environmental Factor Guideline: Subterranean fauna; EPA (2016o) Technical Guidance - Subterranean fauna survey; and EPA (2016s) Technical Guidance - Sampling Methods for Subterranean Fauna.
Potential impacts	• Loss or alteration of habitat, assemblage and loss of individuals from groundwater abstraction and groundwater drawdown due to dewatering activities. • Loss or alteration of habitat, assemblage and loss of individuals from stockpiling, mine pit excavation, infrastructure construction and other ground disturbance. • Spills of hydrocarbons or wastewater, seepage from the TSF and other contamination may degrade subterranean habitats. • Potential change to Gifford Creek Calcrete Priority Ecological Community subterranean fauna assemblage due to direct and indirect impacts.
Mitigation	**AVOID** Hastings has avoided potential impacts by: • No groundwater abstraction from the Gifford Creek calcrete aquifers. • No significant groundwater abstraction from an aquifer with direct hydraulic connection to the Gifford Creek Calcrete PEC. **MINIMISE** Hastings will minimise potential impacts as follows: • Limit groundwater abstraction to meet operation requirements only. • Water collection and re-use from processing plant, where possible. • Processing plant, evaporation pond and TSFs located outside of the flood plain. **REHABILITATE** • Cessation of water abstraction activities at closure will result in the rebound of the water table towards pre-mining levels, reintroduction of natural geohydrology patterns and return of subterranean fauna habitat. • A Preliminary Mine Closure Plan (Appendix 6) include closure strategies and ‘next steps’ identified (where possible), specific to subterranean fauna.

Outcomes	<u>**RESIDUAL IMPACT**</u> The direct impacts to the subterranean fauna community involve the mining of the resource body. As a result of mining of the four deposits (Bald Hill, Frasers, Yangibana North and Yangibana West), there will be a loss of 116 Ha of low value subterranean fauna habitat. This represents less than 0.05% of the Gifford Creek PEC footprint. It is considered unlikely that dewatering, excavation and other mine-related activities at the Project will have any substantial impacts on the conservation values of stygofauna communities or the persistence of any individual species. <u>**OFFSETS**</u> No offsets are required.
Key Environmental Factor 3: Terrestrial environmental quality	
EPA objective	*To maintain the quality of land and soils so that environmental values are protected.*
Policy and guidance	Laws and regulations relevant to the consideration of terrestrial environment quality include: *Australian Radiation and Nuclear Safety Act 1998* (Commonwealth) *Contaminated Sites Act 2003* (WA) *Dangerous Goods and Safety Act 2004* (WA) *Environmental Protection Act 1986* (WA) *Health Act 1911 (WA)* *Mines Safety and Inspection Act 1994* (WA) *Mining Act 1950* (WA) *Radiation Safety Act 1975 (WA)* *Soil and Land Conservation Act 1945 (WA)* Relevant guidelines include: ANCOLD (2012) Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure; ANCOLD (2012) Guidelines on the Consequence Categories for Dams; ARPANSA (2005) Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (the Mining Code); Australian Government Department of Industry, Tourism and Resources (2007) Tailings Management: Handbook in the Leading Practice Sustainable Development Program for the Mining Industry Series; DER (2014) Assessment and Management of Contaminated Sites: Contaminated Sites Guidelines;

	DMP (1998; prev. DME) Guidelines on the Development of an Operating Manual for Tailings Storage; DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM 4.1 Controlling NORM – dust control strategies; DMP (2010) Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM-4.2 Controlling NORM – management of radioactive waste. Resources Safety, Department of Mines and Petroleum; DMP (2013) Code of Practice - Tailings storage facilities in Western Australia. Resources Safety and Environment Divisions; DMP (2013) Guidelines on the Safe Design and Operating Standards for Tailings Storage; DMP (2015) Guide to the Preparation of a Design Report for Tailings Storage Facilities; DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans; DoW (2009) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs; EPA (2016l) Environmental Factor Guideline: Terrestrial Environmental Quality; and IAEA (2006) Storage of Radioactive Waste: Safety Guide.
Potential impacts	• Dispersion of saline, sodic and alkaline soils, which will reduce the soil quality and local provenance native species seedbanks. • Potential contamination of surrounding soil and land as a result of: o Dust (including dust with elevated radiation levels) from the Run-Of-Mine pad, processing plant (processing reagents, chemicals) and TSFs. o Seepage of tailings water. o Operational leaks and spills. o Failure of TSF integrity. o Seepage from sewage treatment plants. o Drainage and associated erosion of WRL surfaces.
Mitigation	**AVOID** • On-going characterisation and management of waste rock to ensure erosive materials are not used on surface slopes of waste rock landforms.

	• Avoid using Plains topsoils as a growth medium for rehabilitation of disturbed areas.
	
	• Location of processing plant, evaporation pond and TSFs outside of the flood plain.
	
	<u>Minimise</u>
	• Minimise dust generation during operations using water sprays, where possible.
	
	• Store concentrate in enclosed facilities during maintenance and repairs to the processing plant.
	
	• Minimise potential for spills through personnel training and awareness.
	
	• Contractor management, including:
	    • Environmental compliance requirements in contracts.
	    • Environmental Specification for Contractors (to be developed) will include:
	        ▪ requirement for site-specific and activity-specific EMP;
	        ▪ roles and responsibilities;
	        ▪ provision of Hastings relevant management plans, procedures, licence conditions;
	        ▪ provision of Hastings environmental policy;
	        ▪ ensuring each contractor has adequate resourcing for environmental management of their activities relative to the level of risk;
	        ▪ requirement for activity based and task specific environmental risk assessment; and
	        ▪ environmental performance reporting requirements.
	    • Coordination of waste segregation, recycling and management.
	    • Training and awareness.
	    • Audits and inspections.
	• Radiation Waste Management Plan
	• Land Management Plan (to be developed) will include the following considerations:
	    • Application of waste management hierarchy.
	    • Containment bunding, silt and oil traps will be established where necessary to remove sediments or pollutants from runoff before water enters local drainage.
	    • Spill clean-up procedures
	    • Visual monitoring will be undertaken of diversion channels and downstream drainage lines, and the condition of vegetation in the diversion channels.
	    • Reference to water quality monitoring in a Water Management Plan (to be developed).
	    • Visual monitoring of dust generation
	    • Contingency measures for excessive dust generation

	• Waste management for general domestic and office waste, industrial waste, landfill, hydrocarbons, tyres, and sewage. • Management measures for dangerous goods and hazardous materials. • Hazard and incident reporting. • Pastoral activities and associated protocols. • Reference to procedures in the Cultural Heritage Management Plan (in draft). • Waste Rock Management Plan includes the following considerations: • waste rock characterisation and segregation program during operations; • use of saprolites, pegmatites and other clay rich lithologies for TSF embankment lifts and low infiltration covers; • WRL batters to consist only of benign, competent durable fresh waste rock; • use of concave slopes on WRLs to reduce potential for erosion; and • waste rock with elevated radionuclide levels is to be distributed/diluted with waste rock containing low radionuclide levels in the WRL. **REHABILITATE** A Preliminary Mine Closure Plan (Appendix 6) and Radiation Waste Management Plan (Appendix 5-7) include closure strategies and 'next steps' identified (where possible), specific to terrestrial environmental quality
Outcomes	**RESIDUAL IMPACT** The mining operations, process plant and TSFs occur at the higher elevation locations in the local water catchment. In addition, much of the disturbance footprint occurs over the benign Hill's soils. There are evident risks where infrastructure intersects Plains soils, the presence of waste rock lithologies that are not competent for landform surfaces, and where radionuclides become elevated and concentrated in the tailings materials, particularly TSF 3. The implementation of the mitigation hierarchy and management plans, described in Section 8.6, ensures risks will be as low as reasonably possible and the surrounding environment will not be significantly impacted. Due to the storage and containment of tailings with elevated radionuclides above background levels, TSF 2 and 3 are considered potentially contaminating activities. In addition, sensitive environmental receptors occur within the Development Envelope. However, any credible pathway of exposure has been eliminated via the TSF design. Construction and operation in accordance with the design criteria and mitigation measures ensures that the TSFs are not contaminated sites as defined under the *Contaminated Sites Act 2003* (WA) and associated regulations (2007). **OFFSETS** No offsets are required.

Key Environmental Factor 4: Inland waters environmental quality	
EPA objectives	*To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.* *To maintain the quality of groundwater and surface water so that environmental values are protected.*
Policy and guidance	Laws and regulations relevant to the consideration of inland waters environmental quality include: *Country Areas Water Supply Act 1947* (WA) *Environmental Protection Act 1986* (WA) *Rights in Water and Irrigation Act 1914* (WA) *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) *Mining Act 1950* (WA) *Waterways Conservation Act 1976 (WA)* Waterways Conservation Regulations 1981 (WA) Relevant guidelines include: ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality; DFAT (2016) Water Stewardship - Leading Practice Sustainable Development Program for the Mining Industry; DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans; DoW (2009a) Hydrogeological reporting associated with a groundwater well licence; DoW (2009b) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs; DoW (2011) Use of operating strategies in the water licencing process; DoW (2013a) Western Australian Water in Mining Guideline; DoW (2013b) Use of mine dewatering surplus; DoH (2013) System compliance and routine reporting requirements for small community water providers; EPA (2016g) Environmental Factor Guideline: Hydrological processes; EPA (2016h) Environmental Factor Guideline: Inland waters environmental quality; Johnson and Wright (2003) Mine void water resource issues in Western Australia, Hydrogeological Record Series HG9;

	NHMRC and ARMCANZ (1996). Australian drinking water guidelines; and WRC (2000) Water Protection Guidelines No. 11 Mining and Mineral Processing: Mine dewatering.

Potential impacts	• Drawdown from water abstraction and dewatering pits resulting in deaths of stygofauna and vegetation supporting GDEs.
	• Decreased water flow or increased movement of sediments to nearby water bodies (i.e. semi-permanent pools, nearby creeks and rivers) from the alteration of surface water flows through the development envelope.
	• Potential contamination of surrounding surface water and groundwater as a result of:
	    • dust from the ROM pad, processing plant (processing reagents, chemicals) and TSFs;
	    • seepage of tailings' water, decant and evaporation ponds;
	    • operational leaks and spills;
	    • failure of TSF integrity;
	    • seepage from sewage treatment plants;
	    • increased salinity and radionuclides as a result of pit lakes; and
	    • drainage from associated erosion of WRL surfaces.

Mitigation	**AVOID** • Infrastructure has been located out of the flood plain, where possible. • Exclusion of disturbance within 150 metres of Yangibana and Fraser Creeks, with the exception of road crossings. • Locate soil stockpiles away from drainage lines and flood zones. • Design the Proposal layout so that mining landforms are located outside the Yangibana and Fraser Creeks flood zones. • Exclusion of groundwater abstraction from calcrete aquifers. **MINIMISE** • Design and locate infrastructure to minimise potential impacts associated with flood events. • Linear infrastructure has been moved to reduce the number of crossings of creeks and drainage channels thus reducing the risk of obstructing surface water flow during heavy rainfall events. • Water reuse and recycling has been incorporated into the design of the processing plant to reduce groundwater demands for the proposal. • Waste Rock Management Plan • Radiation Waste Management Plan • Water Supply Operating Strategy (to be developed for 5C licence). • TSF Operating Manual including: • short and long term range of readings that are anticipated for all monitoring instruments, monitoring bores, underdrain flows, and open channel flows, throughout the life of the TSF; and

	- actions to be followed in the event that readings are recorded outside an anticipated envelope of measurements should be stipulated in the Operating Manual. - Drinking Water Quality Management Plan (to be developed) - Water Management Plan (to be developed) to summarise and describe inter-relationships of water quality management and monitoring actions determined by the: - RWMP, - Water Supply Operating Strategy, - TSF Operating Manual, and - Drinking Water Quality Management Plan, and - ensure any gaps not covered in the above plans are addressed. **<u>REHABILITATE</u>** - Natural surface drainage to be considered post-closure; and - Bunding to prevent erosion of landforms post-closure - A Preliminary Mine Closure Plan (Appendix 6) include closure strategies and 'next steps' identified (where possible), specific to hydrological processes and inland waters environmental quality
Outcomes	**<u>RESIDUAL IMPACT</u>** The Proposal occurs within the Gascoyne River Catchment in a landscape that has been historically and significantly impacted by pastoral activities. The local catchment, however, is in a relatively good condition. The Proposal mining operations, process plant and TSFs occur at the higher elevation locations in the local water catchment. In addition, much of the disturbance footprint occurs over the benign Hill's soils. There are evident risks where infrastructure intersects Plains soils, where linear infrastructure occurs at 90 degrees to the sheet flow of surface water, the presence of waste rock lithologies that are not competent for landform surfaces, storage of chemicals, and where radionuclides become elevated and concentrated in the tailings solids, particularly TSF 3. Water drawdown also has the potential to impact groundwater dependent ecosystems. The implementation of the mitigation hierarchy and management plans, described in Section 6.6, ensures risks will be as low as reasonably possible and the hydrological processes and inland waters environmental quality will not be significantly impacted. Due to the storage and containment of tailings with elevated radionuclides above background levels, TSF 2 and 3 are considered potentially contaminating activities although the radionuclides are strongly tied to the solids component and concentrations are negligible in the tailings pore water. However, any credible pathway of exposure has been eliminated via the TSF design. Construction and operation in accordance with the design criteria and mitigation measures ensures that the TSFs are not contaminated sites as defined under the *Contaminated Sites Act 2003* (WA) and associated regulations (2007).

	<u>Offsets</u> No offsets are required.
Key Environmental Factor 5: Human health	
EPA objective	*To protect human health from significant harm.*
Policy and guidance	Laws and regulations relevant to the consideration of human health include: *Mines Safety and Inspection Act 1994* (WA) *Occupational Safety and Health Act 1984 (WA)* *Radiation Safety Act 1975* (WA) The primary radiation protection related guideline documents are: Western Australian Department of Mining and Petroleum guidelines on managing naturally occurring radioactive material (NORM) in mining and mineral processing - guideline (2nd edition) (also known as the NORM Guidelines) (DMP 2010) National Code of Practice & Safety Guide: Radiation protection and radioactive waste management in mining and mineral processing; known as "the Mining Code" (ARPANSA 2005) National Safety guide: Management of naturally occurring radioactive material (ARPANSA 2008) National Fundamentals: Protection against ionising radiation (ARPANSA 2014a) National Code of Practice: Safe transport of radioactive material (ARPANSA 2014b) Western Australian EPA Environmental Factor Guideline: Human health (EPA 2016f)
Potential impacts	• Gamma irradiation and absorption, from a person being in close proximity to material with elevated radioactive levels. • Inhalation of radon decay products (RnDP) and thoron decay products (TnDP). • Inhalation of radionuclides in dust. • Ingestion of animals or plants that have come in contact with emissions. • Radiation exposure to members of the public on the rehabilitated landform.

Mitigation	**<u>Avoid</u>**
	• Locating TSF 2 and 3, and evaporation pond to avoid potential risk of contamination of water courses:
	    • Distance from rivers and creeks;
	    • Geotechnical considerations i.e. situated on impermeable granites; and

	• Elevations where surface water from flood events is minimal.
	• Designing a wet process and TSF 2 and 3 will be maintained as 'wet' to prevent dust emissions during operations.
	
	MINIMISE
	
	• Establishment of detailed design requirements for the processing plant in order to minimise dust emissions and exposure to gamma radiation. Mandatory controls include:
	  • Covering and/or misting on conveyor belts, where used;
	  • Ensuring wet processes are used, where possible; and
	  • Barriers between ore and humans.
	• Spill management procedures and bunding to ensure spilt ore or concentrate is contained quickly.
	• Removal of radionuclides in product to as low as reasonably achievable thus minimising risk along the transport route.
	• The Radiation Management Plan (Appendix 5-8) is the primary document for the management and monitoring of potential impacts to human health and safety and will form a component of the Safety Management System.
	
	REHABILITATE
	
	A Preliminary Mine Closure Plan (Appendix 6) and Radiation Waste Management Plan include decommissioning considerations, specific to human health.

Outcomes	**RESIDUAL IMPACT** Taking into account the 'system of dose limitation', the predicted outcomes are discussed in context of the three key elements as follows: • Justification – naturally occurring radionuclides are associated with the target rare earths ore body. During processing they become concentrated in two of the three tailings streams. It is not possible to avoid mining and concentrating the radionuclides. However, an impact assessment to determine dose demonstrated that occupational and public doses are well below the dose limit. • Optimisation – exposure to doses are reduced to As Low As Reasonably Achievable (ALARA), by maintaining a 'wet' processing plant and 'wet' tailings in TSF 2 and 3 to reduce potential dust generation. Considerations during design, operations and closure also consider reducing doses to ALARA as described in the RMP and RWMP. Encapsulation of the tailings waste and capping of TSF 2 and 3 at closure will also ensure doses are reduced to ALARA and are representative of the background gamma levels. A TSF operating manual will also ensure the TSFs are constructed in accordance with design specifications and will describe monitoring of the integrity of each TSF structure to be conducted during the operations phase.

	• Limitation – the impact assessment determined that doses will not exceed the prescribed dose limits for the workforce or members of the public. Development and implementation of a safety management system, establishment of a safety culture, and implementation of the mitigation hierarchy will ensure human health is protected from exposure pathways. A precautionary approach will be maintained commensurate with the level of risk. Therefore, residual impacts from radiation to workers and the public are low. **OFFSETS** No offsets are required.

Consideration of other environmental factors in this environmental impact assessment include:

- Terrestrial fauna
- Social surroundings

Laws and regulations relevant to the consideration of Matters of National Environmental Significance include:

- *Environment Protection and Biodiversity Conservation Act 1999* (C'th; EPBC Act)
- EPBC Regulations 2000 (C'th)

Relevant guidelines include:

- DEWHA (2009) Matters of National Environmental Significance. Significant impact guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999

The proposal was deemed a 'controlled action' under the EPBC Act. The 'nuclear action' was deemed the controlling provision that required assessment as per section 21 and section 22A of the EPBC Act. As defined in clause 22(1)(e) of the EPBC Act and clauses 2.02(1)(c) and 2.02(2) of the EPBC Regulations 2000 (Cwth), the Proposal may be considered a nuclear action due to two tailings storage facilities (TSFs) being considered "large scale facilities for the disposal of radioactive waste".

Radionuclides concentrate in different process streams, particularly the beneficiation regrind and flotation circuit, and the hydrometallurgical circuit. Tailings will be disposed into three distinct TSFs, each with different uranium and thorium concentration ratios relative to the ore. Tailings in TSF 1 will be <1 Bq/g. TSF 2 and TSF 3 will have average concentrations of 4 Bq/g and 32 Bq/g, respectively. TSF 2 and TSF 3 tailings represent less than 9% of the tailings generated by the ore processing plant. TSF 2 and TSF 3 trigger the "nuclear action" criteria specified in the EPBC Act and EPBC Regulations.

No other MNES triggered the requirement for assessment.

While the radiation impact assessment (Chapter 10 Human Health, section 10.5.7) indicated that anticipated doses to workers and members of the public would be low and well below the annual dose limits, a health risk assessment was then undertaken to determine potential exposure situations where doses may be higher than expected. Activities associated with potential exposure situations were identified and an assessment of the likelihood and consequence was made. Where necessary, mitigation measures were also identified.

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INTRODUCTION

Chapter 1

1 INTRODUCTION

Hasting Technology Metals Limited (Hastings) is an Australian Stock Exchange (ASX) listed exploration and development company. Hastings proposes to develop the Yangibana Rare Earths Project (the Proposal) in the Upper Gascoyne Region of Western Australia. The Proposal will produce a Mixed Rare Earth Carbonate (MREC) rich in Neodymium (Nd) and Praseodymium (Pr). Nd -Pr are critical materials of permanent magnets, which in turn are important components of many new technology products such as Electric Vehicles (EV), renewable energy, wind turbines and electrical consumer products.

The Proposal establishes Hastings as an important future supplier of critical rare earths to the high growth EV and renewable energy sectors. Following government agreements at the Paris Climate Conference in 2015, a great deal of emphasis has been placed on the reduction of fossil-fuels in transportation and energy generation. Several countries, most notably Norway, India, United Kingdom and France, have recently announced policy targets to transform the use of fossil-fuel vehicles to electric over the next one or two decades. China is also expected to make similar policy announcements soon, having flagged its intention to do so in September 2017. At the same time, innovation in electric motors utilising permanent magnets has resulted in lighter and more efficient EV, which are increasingly in demand from consumers around the world. In 2016, it was estimated that two million EVs were on the road. The International Energy Agency estimates the number of EVs will increase to between 120 – 200 million by 2030. Hastings anticipates that these trends will underpin the solid demand for Nd-Pr.

The Proposal will come online at a time when demand for the currently emerging permanent magnet market is expected to enter a significant growth phase due to increased demand for EV and market penetration of large scale renewable energy wind turbines.

1.1 PURPOSE AND SCOPE

This purpose of this Environmental Review Document (ERD) is to:

- provide a comprehensive formal environmental impact assessment of the Proposal in consultation with relevant stakeholders, and
- satisfy requirements under Part IV of the *Environmental Protection Act 1986* (WA) and *Environment Protection and Biodiversity Conservation Act 1999* (C'th).

Specifically, this ERD is structured to provide detailed information on:

- the Proposal description (section 2),
- stakeholder engagement (section 3),
- consideration of environmental principles (section 4)
- an assessment of the Proposal activities on the key environmental factors taking into consideration survey findings, relevant policies and guidelines, the EPAs objectives for the factor and assessing impacts and mitigation to determine a predicted outcome (section 5-9),
- consideration of other environmental factors (section 10-11),
- consideration of Matters of National Environmental Significance (section 12), and

- concludes with a holistic impact assessment (section 13).

This document has been prepared in accordance with the:

- Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA 2016a),
- Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual 2016 (EPA 2016b), and
- requirements set out in the Environmental Protection Authority (EPA) "Instructions on how to prepare an Environmental Review Document".

1.2 PROPONENT

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1.3 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The Proposal was considered a significant proposal requiring a formal environmental impact assessment under Part IV, Section 38 of the *Environmental Protection Act 1986* (WA; EP Act). In addition, the proposal triggered a 'controlled action' under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth; EPBC Act).

The delegate of the Commonwealth Minister for Environment and Energy has assigned the assessment approach under section 87 of the EPBC Act as an accredited process under the EP Act.

The Western Australian Environmental Protection Authority (EPA) Services then developed the Environmental Scoping Document (ESD) in consultation with Hastings and other relevant stakeholders. The purpose of the Environmental Scoping Document (ESD) is to define the form, content, timing and procedure of the environmental review as required by section 40(3) of the EP Act. The ESD was approved by the EPA Board on the 18th May 2017.

This ERD has been prepared to meet the requirements of the ESD and to the satisfaction of the EPA Services and in consultation with Decision Making Authorities (DMAs). This ERD will then undergo a 4-week public review period. Hastings will respond to any comments received from DMAs and the public. The EPA will prepare an assessment report taking account of the comments received from DMA's, the public and Hastings. The assessment report will make recommendations to the Commonwealth Minister for the Environment and the Western Australian Minister for the Environment.

1.4 OTHER APPROVALS AND LEGISLATION

The Proposal is located within tenure granted under the *Mining Act 1978* (WA), comprising of exploration leases, mining leases and miscellaneous leases. Mining activities will occur within the following mining leases (M): M09/157, M09/158, M09/159, M09/160, M09/161, M09/162. Miscellaneous Leases (L) and General Purpose Leases (G) have been obtained for associated infrastructure: L09/66, L09/67, L09/78, L09/79, L09/80, G09/13, G09/14, G09/16. Grants for additional tenure or conversion of tenure will be required in the future for other infrastructure including the water bore field and associated pipeline.

Coexisting *Land Administration Act 1997* (WA) land tenure is pastoral lease, with the Proposal overlying Gifford Creek and Wanna Stations (both stations are owned by the same leaseholder, Bagden Pty Limited and were previously the one Wanna Station).

On the 7th of October 2016, the combined Thin-Mah Warianga, Tharrikari, Jiwarli (TMWTJ) People submitted a native title claim (WC2016/003) (WAD464/2016) over the Proposal area and beyond. The Native Title claim has been accepted as a valid claim but not yet been determined. Regardless, Hastings and the TMWTJ People ratified a Native Title Agreement on the 14th November 2017.

Other approvals and legislation identified for this Proposal are listed in **Table 1-1**.

Table 1-1 Other approvals and regulation

Proposed activities	Land tenure/access	Type of approval	Legislation regulating the activity
Clearing of native vegetation	*Mining Act 1978:* all mining tenure	Native Vegetation Clearing Permit	*Environmental Protection Act 1986*
Mining	*Mining Act 1978:* Mining lease	Mining Proposal	*Mining Act 1978*
Closure and rehabilitation	*Mining Act 1978*: all mining tenure	Approval of Preliminary Mine Closure Plan	*Mining Act 1978*
Construction of well, water abstraction, dewatering	*Mining Act 1978*: Mining leases and miscellaneous leases	26D and 5C licenses	*Rights in Water and Irrigation Act 1914*
Handling of naturally occurring radioactive materials, radiation safety	*Mining Act 1978*: all mining tenure	Approval of Radiation Management Plan and Radiation Waste Management Plan	*Mines Safety and Inspection Act 1994* *Radiation Safety Act 1975*
Buildings	*Mining Act 1978*: all mining tenure	Building licenses	*Local Government Act 1995*
Construction and operation of prescribed waste premises i.e. processing facilities and associated tailings storage facilities, landfill, sewage treatment plant	*Mining Act 1978*: all mining tenure	Works Approvals and Operating Licenses	*Environmental Protection Act 1986*

The Decision Making Authorities (DMAs), as listed in Table 5 of the EPA approved ESD, are:

- Department of the Environment and Energy (Commonwealth)
- Minister for Environment
- Minister for Water
- Minister for Aboriginal Affairs
- Minister for Mines and Petroleum’
- Executive Director, Environment Division (Department of Mines, Industry Regulation and Safety (DMIRS), formerly Department of Mines and Petroleum)
- Chief Dangerous Goods Officer, DMIRS
- State Mining Engineer, DMIRS

- Radiological Council
- Chief Health Officer (Department of Health)
- Director General, Department of Water and Environment Regulation (DWER, formerly Department of Environmental Regulation)
- Chief Executive Officer (Shire of Upper Gascoyne)

PROPOSAL

Chapter 2

2 PROPOSAL

2.1 BACKGROUND

The Proposal was referred to the:

- Western Australian Environmental Protection Authority (EPA) on the 30th January 2017.
- Commonwealth Department of the Environment and Energy (DoEE) on the 15th December 2016.

The EPA determined to assess the Proposal on 2nd of March 2017, and subsequently set the level of assessment as Public Environmental Review with a review period of four weeks.

The DoEE determined the Proposal was a 'controlled action' on the 14th of March 2017, and requires assessment using an accredited assessment approach.

Hastings has received approval from the EPA Chairman under section 41A of the *Environmental Protection Act 1986* (WA; EP Act) to conduct minor or preliminary works. These include an access road and exploration accommodation village (and associated infrastructure i.e. water bore, borrow pits) and a satellite exploration camp and laydown area at the process plant area.

There have been modifications to the proposal since the time of referral under section 43A of the EP Act including:

- Relocation of the airstrip (following consultation with the pastoralist)
- increased capacity of the tailings storage facilities; and
- a bore field and water pipeline corridor.

2.2 JUSTIFICATION

2.2.1 International considerations

Market demand for Rare Earth Elements (REE) is ever increasing as economies move towards 'green energy' technologies. The Proposal ore body has one of the highest Neodymium and Praseodymium (Nd- Pr) content in the world at 41% Total Rare Earth Oxides (TREO). Neodymium and Praseodymium are referred to as the elemental twins, as they are difficult to separate and possess a multitude of special properties. Neodymium is the critical material for a neodymium-iron-born magnet, the strongest type of permanent magnet, which are most widely used in electric motors of hybrid electric vehicles and electric vehicles, wind turbine generators, high-speed rail, robotics, medical devices, and electric motors, to name a few. In combination with Neodymium, Praseodymium is predominantly used in Neodymium magnets, which are used in a growing arena of high-tech applications.

However, while the end-use of the Nd-Pr product is promoted as environmentally beneficial, it is widely acknowledged that the mining and processing of rare earth elements has a poor reputation when it comes to environmental impacts. This is the result of illegal and irresponsible practices in China. Given most rare earth mines to-date have been established in China where environmental regulation is in its infancy and currently being developed. The process used to concentrate the mixed rare earth carbonate is similar to that of other processing plants widely used today such as nickel, lithium, and cobalt process plants.

Most countries do not have the 'red tape' or duplication of approvals processes that Australia has in place. The formal environmental impact assessment and level of public scrutiny in Australia ensures that this Project provides our international stakeholders with a higher level of certainty that the mining and processing of the ore body is conducted in an environmentally responsible manner that will not significantly impact the surrounding environment. In addition, Western Australian regulators are familiar with the processing activities associated with gold, nickel, and cobalt, and thus environmental impact assessment considerations will be similar.

When considering the sustainability of REE, it is important to consider the full lifecycle of the material, from extraction through to waste disposal and recycling. Hastings are developing a supply chain platform using blockchain technology to trace and track its product from the Yangibana Rare Earths Project to the customer. The ability to be transparent in tracking the REE from mine to product aims to provide confidence to consumers that the REE end use product meets ethical and environmentally responsible standards of production. The International Standardisation Organisation (ISO) is also developing several standards (ISO/TC298) specific to rare earths and recycling of products containing rare earths. The reputation and environmental performance of the mine site will be reflected in the sale of the product. Hastings is so confident that it can meet the ethical and environmentally responsible standards due to the reputation of Australian environmental regulatory requirements, that it has invested in the development of blockchain technology to gain a competitive advantage in the international market.

2.2.2 Proposal location considerations

Tailings storage facilities

During the Pre-Feasibility Study an options study was undertaken with up to six locations and two designs considered for a Tailings Storage Facility (TSF). The location of the processing plant and associated TSF were guided by:

- location of the resource,
- methods of tailings handling and discharge (thickened versus un-thickened),
- economics of ore haulage from four open cut pits located over approximately 7 km,
- geotechnical study outcomes for landform stability and seepage analysis,
- surface water drainage patterns,
- cultural heritage surveys,
- wind direction, and
- pastoralist consultation.

Disposal of all three tailings streams in one TSF has also been considered. However, radionuclide concentrations will still be elevated and thus require a higher level of management. Given that less than 10% of tailings have elevated levels of radionuclides, a greater management focus can be provided when tailings are disposed in separate TSFs. This also significantly reduces the footprint of those TSFs with elevated levels of radionuclides.

Mine Voids

Backfilling of mine voids has also been considered, but not implemented, as the target ore body continues at depth. The current mining depth of the pits is based on 2017 commodity prices. Market demand for REE is predicted to increase in the future, therefore the depth at which the target resource can be mined economically may increase in the future. Backfilling will potentially sterilise future ore deposits.

Linear infrastructure

Locations of linear infrastructure, the accommodation village and airstrip have taken into consideration pastoral values and surface hydrology. The water levels of seasonal flood events, location of the Gifford Creek homestead and future potential mining areas were considered in the determination of road alignments. The proximity of land with high levels of pastoral value and future potential mining areas have resulted in changes to the location of the airstrip.

Water

Reuse and optimisation of water usage in the processing plant has reduced water requirements for the Proposal. All water from pit dewatering will also be used in the processing plant reducing wastage associated with water disposal.

The Proposal's water source has taken account of the calcretes of the Gifford Creek Priority Ecological Community. Every effort has been made to source water from areas not associated with the PEC habitat, with options explored in order of preference:

- Pit dewatering
- Fractured rock aquifers associated with the ore body
- Regional water bearing structures within granite (e.g. faults)
- Palaeochannel aquifers outside the PEC boundary
- Palaeochannel aquifer tributaries
- Gifford Creek paleochannel aquifer

An integrated water source option was determined for the Project, which includes a combination of pit dewatering, fractured rock aquifers and a palaeochannel aquifer tributary. Pit dewatering and fractured rock aquifers alone proved to be an unsustainable source of water. Targeted water bearing structures within the regional granite complex did not provide a feasible supply of water. A palaeochannel aquifer to the north of the Project and outside of the PEC boundary was close to the Edmund Station homestead with most of the target area occurring outside of tenement areas. As a result, this option was not pursued further. The paleochannel tributary selected for the project water source is located within the project tenement area and situated such that there are no adverse drawdown impacts on the superficial calcrete aquifers.

2.3 PROPOSAL DESCRIPTION

Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal), located in the Upper Gascoyne region of Western Australia (WA). **Table 2-1** provides a summary of the Proposal.

Table 2-1 Summary of the Proposal

Proposal Title	Yangibana Rare Earths Project
Proponent Name	Hastings Technology Metals Limited
Short Description	Hastings Technology Metals Limited (Hastings) proposes to develop the Yangibana Rare Earths Project (the Proposal), located approximately 270 km east-northeast of Carnarvon, in the Upper Gascoyne region of Western Australia (WA). The Proposal will involve mining above and below the ground water table, on-site processing of ore, water abstraction, and transport via road to Geraldton port for export.

Rare Earths Elements (REE) will be mined from four deposits (section 2.3.1). During mining, the REE containing ore will be taken to the Run of Mine (ROM) pad in preparation for processing, whereas waste rock will be deposited in waste rock landforms, adjacent to each respective pit (section 2.3.2). An on-site processing plant, consisting of a beneficiation process and a hydrometallurgical process, will produce a mixed rare earth carbonate (MREC) product. Tailings will be disposed in three tailings storage facilities (TSFs; section 2.3.3). Support infrastructure will include, but is not limited to, power generation, water, accommodation facilities, airstrip and linear infrastructure (section 2.3.4). Trucks will transport the bagged product, stored in containers, to Fremantle port via existing roads (section 2.3.4). The development envelope and indicative footprint are shown in **Figure 2-2**.

Table 2-2 provides a summary of the location and proposed extent of physical and operational elements of the Proposal.

Table 2-2 Location and proposed extent of physical and operational elements

Element	Location	Proposed Extent
Physical elements		
Mine and associated infrastructure	Figure 2	Clearing of no more than 1,000 Ha within a development envelope of 13,373 Ha
Operational elements		
Mining	Figure 2	Mining from 4 pits[1]
Water abstraction, including dewatering from pits	Figure 2	Abstraction of no more than 2.5 GL/a of groundwater
Ore processing (waste)	Figure 2	Tailings disposal of no more than: • 9.336 Mt into TSF1 • 484,000 t into TSF2 • 638,000 t into TSF3
Transport	Figure 1	Transport of packaged product to port via trucks on existing roads. Storage of containerised product at an existing port facility. Loading of product on general cargo container ships, operating on existing routes and ports.

[1] Mine pit optimisation from the four pits may result in smaller satellite pits within the same deposit footprint.

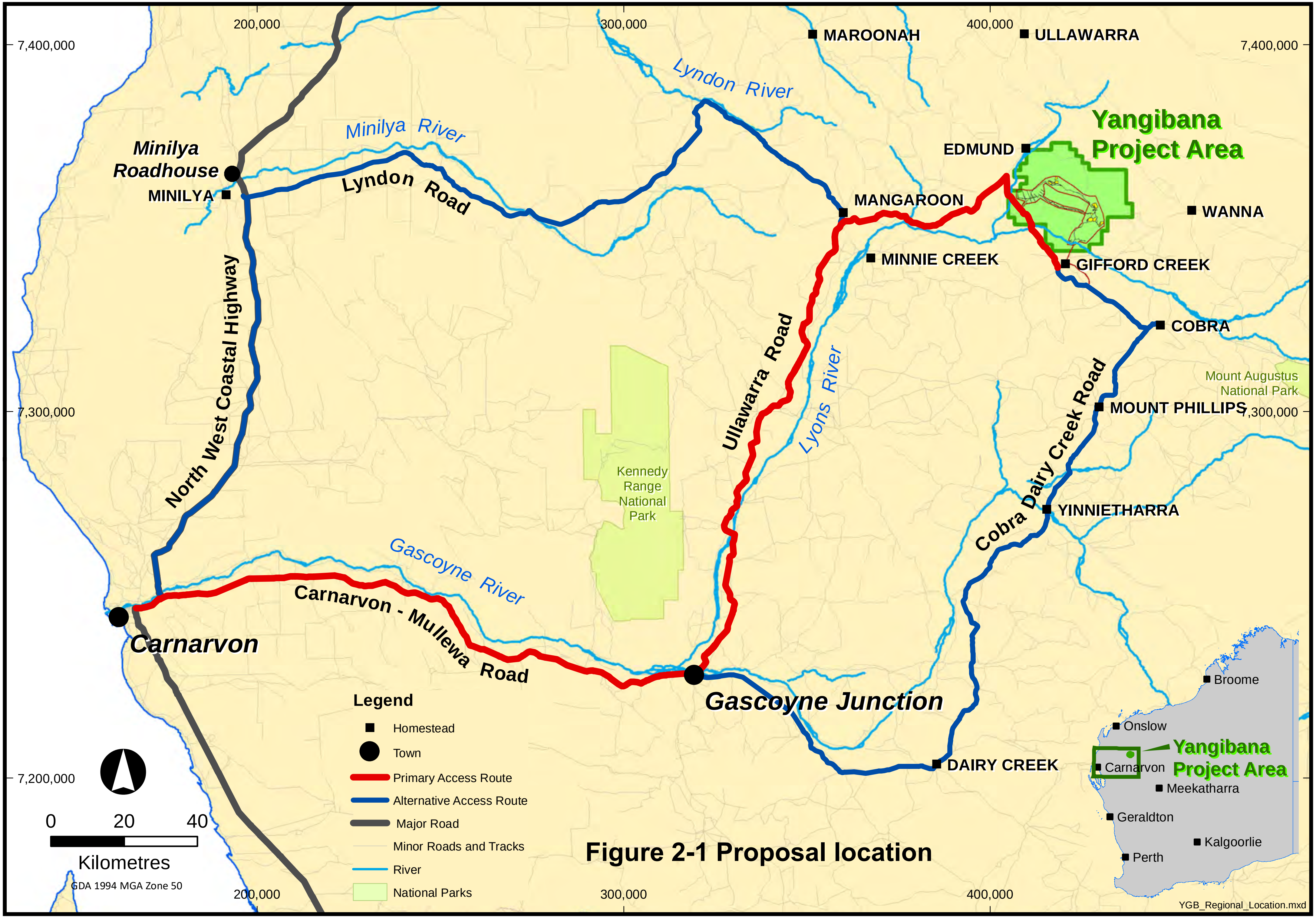
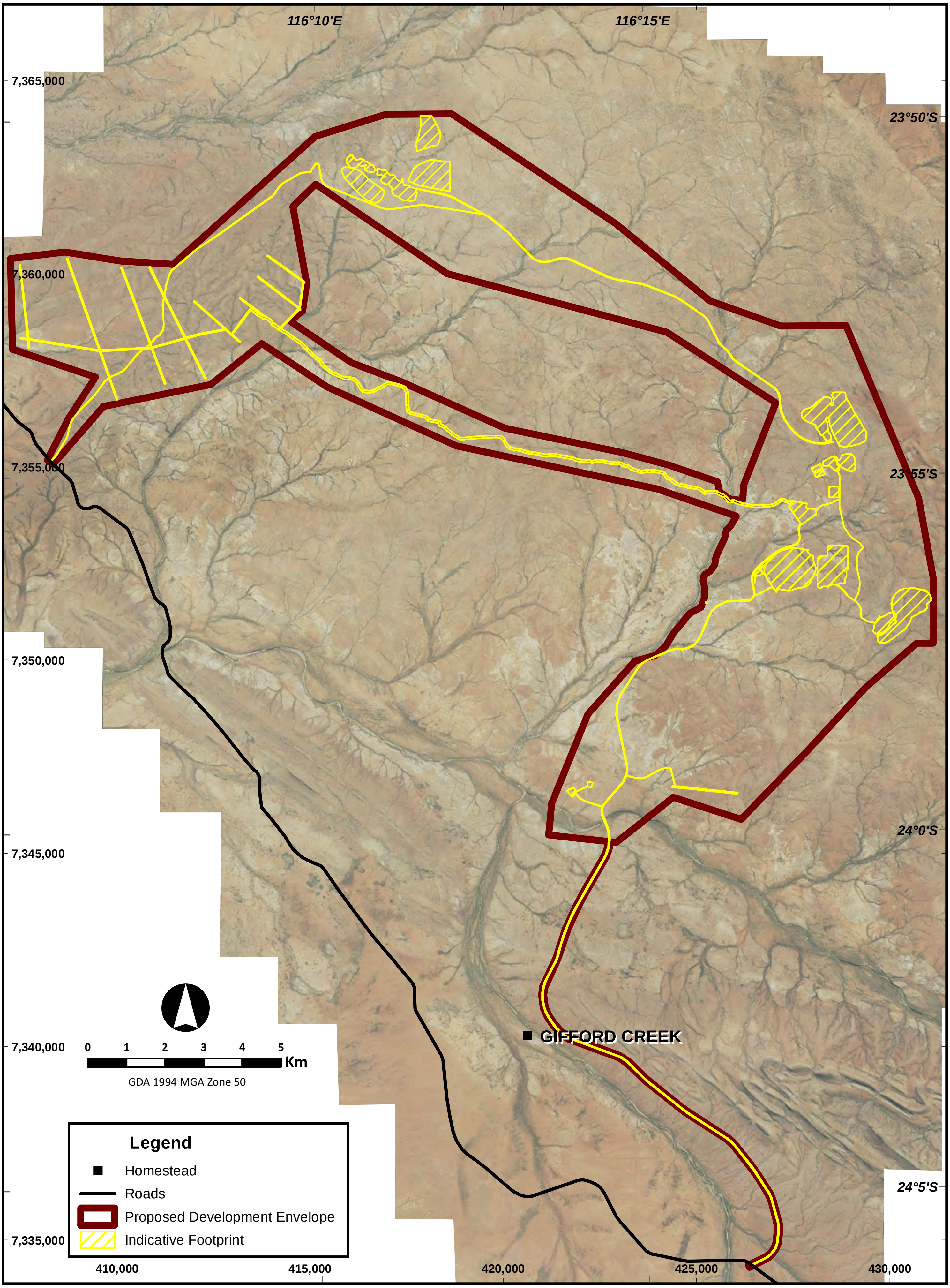


Figure 2-1 Proposal location



HASTINGS Technology Metals Limited

YANGIBANA RARE EARTHS PROJECT

PER_F1-2_Envelope_Footprint.mxd
22 June 2018

Figure 2-2 Development Envelope and Indicative Footprint

2.3.1 Mineral resource

There are four deposits (Yangibana North, Yangibana West, Bald Hill and Fraser's) within the Proposal area containing economic quantities of rare earth elements (REE) in a monazite ore. The monazite is rich in REE, of which neodymium, praseodymium, dysprosium and europium are most valuable.

2.3.2 Mining

The ore bodies will be mined using conventional open cut pit methods of drill and blast, load and haul. Proposed depths of open cut pits range from 70 metres below ground level (mBGL) at Bald Hill, and 95 mBGL at Yangibana and Fraser's. The largest deposit will be Yangibana, which comprises of Yangibana North and Yangibana West deposits.

Deposits will require dewatering prior to mining below the groundwater table. Depth to groundwater within deposits is 30 mBGL on average.

Mine waste rock will be generated throughout the mining phase of operations. The strip ratio of ore to waste rock will vary depending on the deposit and the depth of mining, with more waste rock produced as the depth of pits increase. The average strip ratio for all four pits combined is 1:7 ore:waste. Waste Rock Landforms (WRL) will be constructed adjacent to each open pit. WRLs will be reshaped during the rehabilitation phase of the operation to meet final landform design parameters. The proposed maximum height of WRLs is up to 30-40 metres above the natural surface.

2.3.3 Processing

Beneficiation

The initial phase of processing occurs within the beneficiation plant (**Figure 2-3**). This consists of conventional processes to remove economic materials and produce a REE concentrate. This process includes:

- Run of Mine (ROM) ore receival;
- crushing and screening;
- grinding;
- flotation; and
- tailings handling.

The beneficiation mineral concentrate will represent approximately 3-5% of the incoming ore mass. The remaining 95-97% of the mass, comprising barren material, will be disposed of in two Tailings Storage Facilities (TSFs). The majority of water used in the beneficiation process will be recovered and reused. The beneficiation concentrate will undergo further processing in the hydrometallurgical plant.

Key reagents used in the beneficiation process include:

- Sodium hydroxide;
- Sodium silicate;
- Fatty acid collector;
- Quick lime;

- Flocculant; and
- Depressant Rinkalore F410.

Hydrometallurgy

The hydrometallurgical plant will continue processing the concentrate to remove residual materials such as iron, phosphate, aluminium, uranium and thorium (and their decay products) and produce a mixed rare earth carbonate (**Figure 2-3**). Approximately 13-15,000 tonnes per annum (tpa) of mixed rare earth carbonate will be produced. The process includes:

- Acid bake rotary kiln: Acidification and roasting of the mineral concentrate to crack the mineral structure;
- Acid bake rotary kiln off-gas treatment;
- Water leaching to bring metals into solution;
- Purification and ion exchange to remove impurities;
- Precipitation of rare earths carbonate product; and
- Neutralisation of waste streams prior to disposal in a TSF.

The key reagents required for the hydrometallurgical plant include:

- Sulphur to make sulphuric acid;
- Ammonium or sodium bicarbonate;
- Quick lime slaked to hydrated lime;
- Limestone;
- Magnesium oxide;
- Sodium hydroxide (caustic soda);
- Ferric Sulphate;
- Hydrogen Peroxide; and
- Flocculant.

The process water generated from the hydrometallurgical plant cannot be reused in the plant due to reagent solutes (i.e. ammonium), and as such disposal of this water (~470,000 to 480,000 m^3/annum) to an evaporation pond will be required.

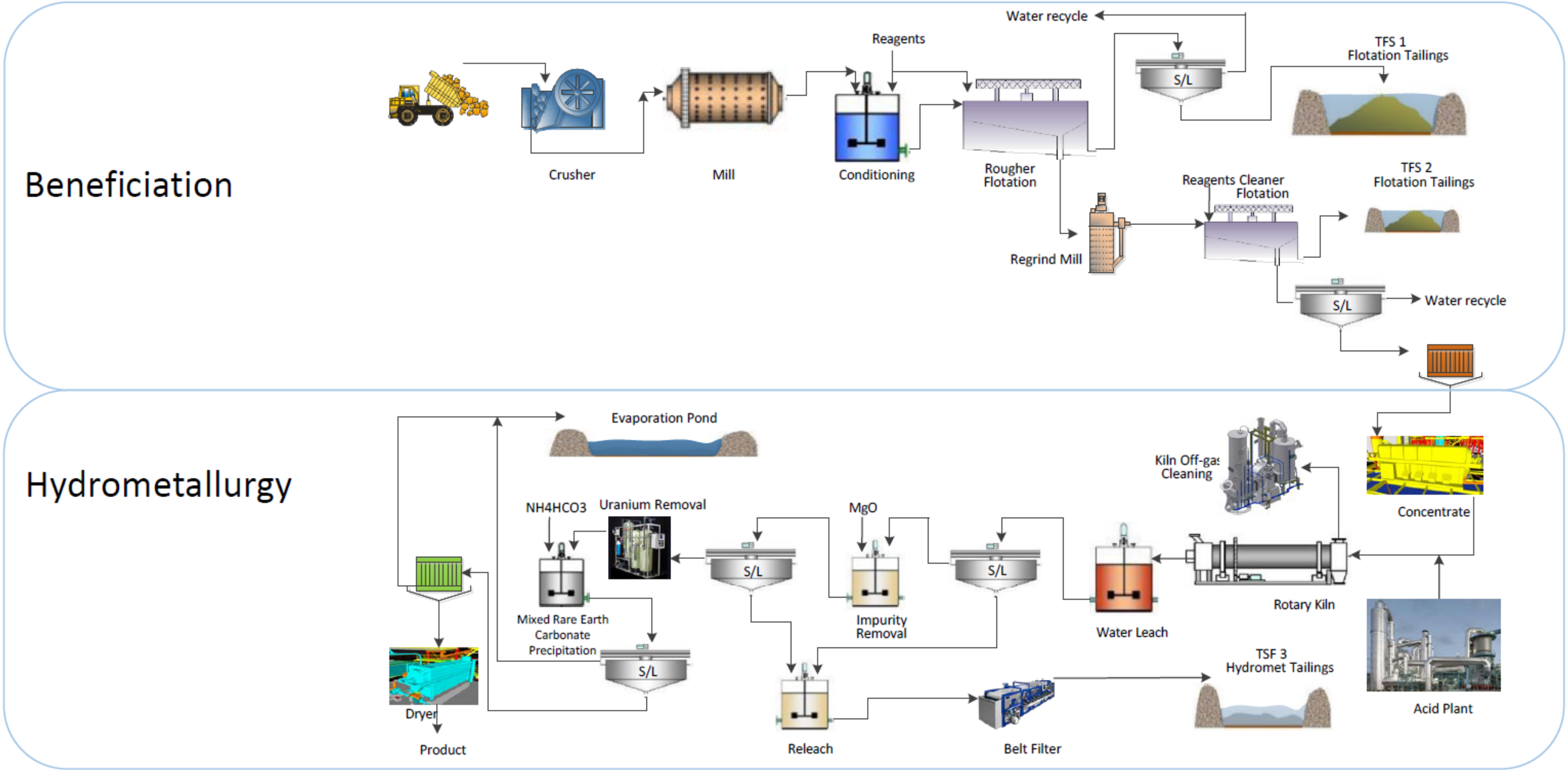


Figure 2-3 Process flowsheet

Tailings disposal and storage

The three separate processing tailings streams will be disposed in distinct TSFs. **Table 2-3** summarises chemical and physical characteristics, source and disposal location of each tailings stream.

The majority of tailings (94%) are generated from the beneficiation process, which involves crushing and milling the ore and use of floatation agents over 2 cycles: rougher (TSF 1) and cleaner circuits (TSF 2). The second circuit produces a finer tailings material after crushing and milling for the second time. The particle size is similar to clay and tends to remain suspended in liquids for a longer period of time. The levels of radionuclides are elevated in a small portion (3.7%) of tailings solids but not the tailings pore water from the cleaner circuit.

The remainder of tailings (6%) are generated from the hydrometallurgical process. These tailings solids have elevated levels of radionuclides (~33 Bq/g), however levels remain less than 1 Bq/g in the liquid portion.

Table 2-3 Source, disposal and general characteristics of tailings streams

Processing source	Tailings mass (%)	Annual rate (tpa)	Physical processing	Chemical properties	Radionuclide Concentration (head of chain)	Disposal
Beneficiation	94%					
1. Rougher circuit	91.0%	933,600	Crushed and milled ore, flotation	Trace flotation reagents; pH 10-11.5	Solids<1 Bq/g Liquids <1Bq/g	TSF 1
2. Cleaner circuit	3.7%*	48,400*	Crushed and milled ore, flotation	Trace flotation reagents; pH 10-11.5	Solids~ 9 Bq/g Liquids <1Bq/g	TSF 2
Hydrometallurgical	6.0%	63,800	Acid Heating Water leach Neutralisation and waste removal Thickening	Trace sulphuric acid; U and Th; Iron phosphates Aluminium; Gypsum Metal hydroxides; pH 7-8	Solids ~33 Bq/g Liquids <1Bq/g	TSF 3
TOTAL	**100%**	**1,036,100**				

*Note: An opportunity is being considered to mix tailings from TSF1 into TSF2 at a ratio of 80:20 to increase the settling rate of cleaner tailings in TSF2. This figure will be lower should mixing of TSF1 tailings with those of TSF 2 not be deemed feasible.

All three TSFs are designed for the long-term closure of the facility to provide for the safe containment of tailings and maintain the integrity of TSFs beyond the extent of institutional control i.e. 1000 years. Specific landform closure specifications to be implemented during design, construction, operations and closure phases have been identified to ensure the integrity of the TSFs over the long-term. TSF 3, which will contain the hydrometallurgical plant tailings with elevated radionuclides and magnesium sulphate, will be lined with a bituminous geomembrane. TSF 1 and TSF 2 will not be lined although the superficial clayey sand soils will be proof compacted. The embankment design has taken account of foundation, construction material, and maximum seismic events. The heights of the respective embankments were designed to ensure sufficient freeboard under a 1:100 Annual Exceedance Probability, 72-hour runoff rainfall event with additional contingency included in line with international standards (**Table 2-4**).

Table 2-4 Summary of proposed TSF design features

Design feature	TSF1	TSF2	TSF3
Proportion of tailings	89 - 91%	3.7 – 4.7%	6%
Maximum height (m)	8 metre perimeter embankments; Tailings stack 15 metres	11 metre perimeter embankments	11 metre perimeter embankments
Area (approx. Ha)	100 Ha	7 Ha	11 Ha
Number of cells	1	1	1
Construction	Downstream perimeter embankment raising	Downstream perimeter embankment raising	Downstream perimeter embankment raising
Discharge method	Central Thickened Discharge (CTD)	Perimeter spigots	Perimeter spigots
Lining	Proof compacted basal clayey sand layer	Proof compacted basal clayey sand layer	Proof compacted basal clayey sand layer Bituminous geomembrane
Encapsulation	Nominal capillary break / erosion protection; growth medium (soil and rock armour)	Compacted clayey sand base; Compacted Clay Liner (CCL) engineered capping with growth medium (soil and rock armour). Design and construct in accordance with relevant standards and long-term landform evolution specifications to provide safe containment of tailings and integrity of TSFs beyond the extent of institutional control	Bituminous liner/ compacted clayey sand base; CCL engineered capping with growth medium (soil and rock armour). Design and construct in accordance with relevant standards and long-term landform evolution specifications to provide safe containment of tailings and integrity of TSFs beyond the extent of institutional control
Leak detection	Downstream groundwater monitoring bores	Downstream groundwater monitoring bores	Downstream groundwater monitoring bores; Underdrain detection above bituminous geomembrane with lined sump
Closure capping	500 mm durable waste rock 100 mm topsoil	500 mm durable waste rock 100 mm topsoil	HDPE liner welded to the bituminous geomembrane 0.8-1 m durable waste rock 100 mm topsoil
Embankment closure	2 m durable waste rock	2 m durable waste rock	2 m durable waste rock

2.3.4 Support infrastructure

Power supply

Anticipated annual power requirement across mining, processing and support infrastructure will be 12 Megawatt (MW). Power requirements to the processing plant and associated infrastructure are anticipated to be in the order of 10 MW per annum, predominantly supplied through diesel/CNG fuelled generator sets. Power supply for the accommodation facilities will be supplied by diesel generator sets located adjacent to the accommodation facilities.

Water supply

An estimated annual water demand for the Proposal of up to 2.5 gigalitres (GL) per year (79.3 L/sec), the majority of which will be supplied by groundwater.

WATER BALANCE

The majority of the water demand will come from ore processing, with minor volumes required for dust suppression, fire protection, equipment washdown and potable uses across the Proposal. Water reuse will primarily occur within the processing plant (TSF 1 and TSF 2 decant water). The Proposal's water balance is provided in **Figure 2-4**. The water balance shows an estimated water consumption of 2.1GL/annum, which is within the requested 2.5GL/annum.

Of the water for processing, the beneficiation component of the project comparatively requires the most water, and thus water recovery and recycle is incorporated into the design to improve the efficiency of project water requirements (i.e. approx. 78% of beneficiation water is recycled representing approx. 50% of total water demand). All water required by the hydrometallurgical component of the process will need to be disposed of, and therefore does not contribute to the recycled water system. Water disposal will occur in an evaporation pond and TSF 3.

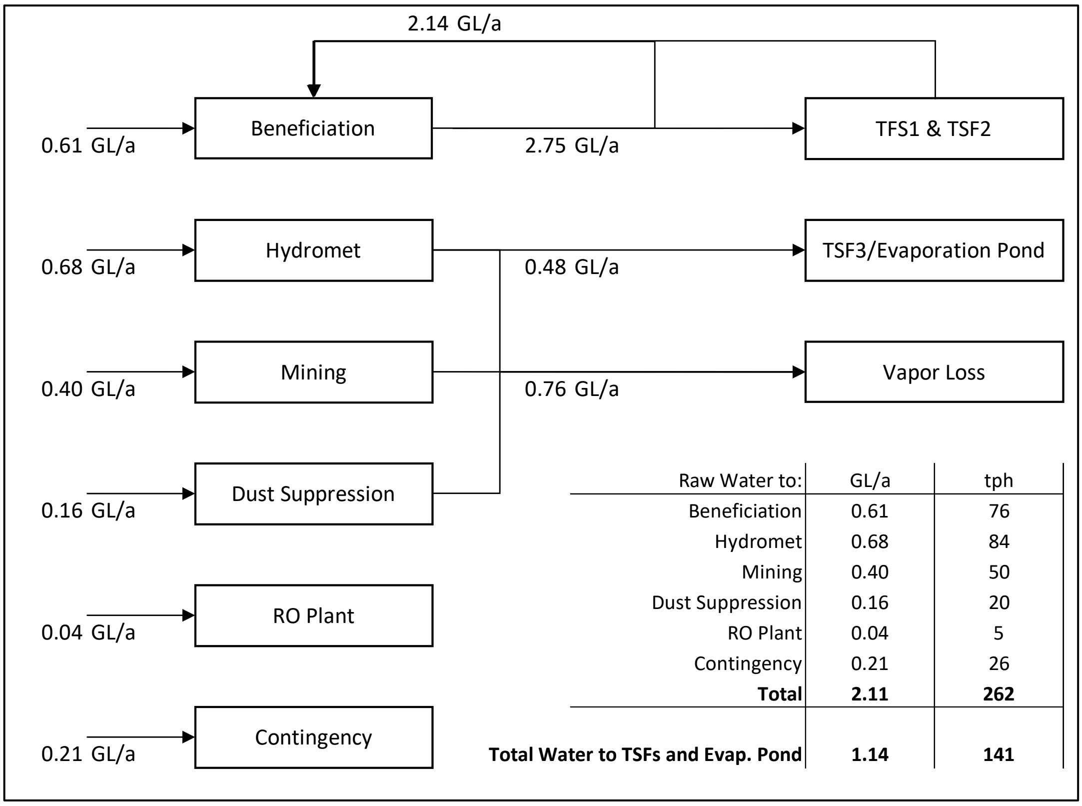


Figure 2-4 Water balance

<u>Water source</u>

Groundwater will be abstracted via groundwater production bores, and where possible from in-pit sumps, into transfer dams prior to being distributed to different storage locations around the Proposal for use in ore processing, dust suppression and potable water uses. Raw water will undergo necessary water treatment through a Reverse Osmosis (RO) plant to meet potable water quality parameters.

Pit dewatering, including the two existing production bores, is expected to satisfy approximately 20% of this demand in the initial stage of the project, increasing to 90% towards the end of the mine life. The remainder of the demand is expected to be met by a network of water supply bores located in a palaeochannel tributary, named the SipHon Well Borefield.

Transport Corridor and Port Facility

Access to the mine site will be via the Cobra-Gifford Creek Road and Ullawarra Road. Works to upgrade some sections of Shire of Upper Gascoyne roads (Cobra - Dairy Creek Road) will be required to establish a safe and reliable route for transport of reagents, fuel and other consumables to site, and transport of the product to port for export. Borrow pits, laydown areas and a water supply will be required for road works during the construction stage and for ongoing road maintenance.

The product is slightly radioactive (~1.3 Bq/g) although Class 7 placarding is not required because radionuclide concentrations in the product are below the values stated in the Western Australian Transport Regulations and IAEA Regulations for safe transport of product containing NORM. Therefore, the product can be shipped as general cargo. Existing container facilities at the port will be used for the storage of the product.

Fremantle is the recommended export port. MREC product will be bulk bagged at site, backloaded in tautliner (curtainsider trailers) consolidated to store and packed to 20' Shippers owned lined containers and exported on a weekly basis. This 'Just-In-Time' (JIT) approach will limit the volume of cargo in transit and storage.

Other infrastructure

An aerodrome and accommodation facilities will be located approximately 10 km south-southwest of the processing plant. In accordance with Civil Aviation Safety Authority's Manual of Standards Part 139 - Aerodromes, the aerodrome will have a Code 3C runway, 30 m wide and 1,800 m long (Commonwealth of Australia 2012). The accommodation facilities will allow for an estimated peak workforce of up to 350 people during construction, and 200 people during operations. Single storey accommodation blocks are proposed, with laundry, mess and recreational facilities.

Additional infrastructure includes administration facilities, first aid and emergency response facilities, workshops, parking areas, a landfill for putrescible and industrial waste, contaminated waste facility, wash down bay, bioremediation area, sewage treatment plant, water transfer infrastructure, communications facilities, power infrastructure, surface water drainage infrastructure, LPG and CNG gas storage, bulk diesel tank farm and an explosives magazine.

2.4 Timing and Staging

The Proposal will have a life of mine of approximately ten years, however this may be extended subject to outcomes of on-going mineral exploration and economic conditions. This Proposal represents a 'greenfield' development. Mining of additional resource areas may represent expansion projects and would be subject to future Approvals considerations.

Construction of minor or preliminary works is planned to commence in the third quarter (Q3) of 2018. Commissioning is planned for Q1/Q2, 2020.

2.5 LOCAL AND REGIONAL CONTEXT

The proposal is located 10 km north of the Lyons River, approximately 150 km northeast of Gascoyne Junction and approximately 150 km southeast of the mining hub of Paraburdoo (Figure 1).

There are no other mining developments within 100km of the Proposal in the local Shire of Upper Gascoyne. While potential mineral deposits are known to occur in the Gascoyne Region, the only mining operations underway are salt production at Useless Loop in the Shire of Shark Bay and at Lake MacLeod near Cape Cuvier, north of Carnarvon.

Mount Augustus National Park is approximately 80km south east of the Proposal and the north eastern corner of the Kennedy Range National Park is approximately 100km south west of the Proposal.

STAKEHOLDER ENGAGEMENT

Chapter 3

3 STAKEHOLDER ENGAGEMENT

3.1 KEY STAKEHOLDERS

Key stakeholders for the proposal include:

6. Commonwealth government:
    - Department of the Environment and Energy (DoEE)
7. State Government:
    - Department of Mines, Industry Regulation and Safety (DMIRS), formerly Department of Mines and Petroleum (DMP)
    - Radiological Council
    - Department of Health (DoH)
    - Department of Water and Environmental Regulation (DWER), formerly the Department of Environment Regulation (DER), the Department of Water (DoW) and the Office of the Environmental Protection Authority (OEPA)
    - Department of Planning, Lands and Heritage (DPLH), formerly the Department of Aboriginal Affairs (DAA)
8. Local Government:
    - Shire of Upper Gascoyne
    - Shire of Carnarvon
9. Native Title claimants
    - combined Thin-Mah Warianga, Tharrikari, Jiwarli (TMWTJ) native title claimants (WC2016/003; WAD464/2016), represented by the Yamatji Marlpa Aboriginal Corporation (YMAC)
10. Pastoralist
    - Bagden Pty Limited, Wanna and Gifford Creek Stations

The DMIRS are the assigned lead agency for this proposal and provide on-going Approvals advice in relation to government processes and play a role in ensuring issues associated with government Approvals are resolved.

3.2 STAKEHOLDER ENGAGEMENT PROCESS

Hastings has implemented an external and community relations strategy since 2016, and developed the methodology for ongoing social assessment, engagement, community investment and community consultation.

A Stakeholder Engagement Management Plan has been developed to provide a framework for Hastings to engage in structured, meaningful and effective stakeholder engagement and management. The framework comprises a series of work plans, which together form the company's comprehensive external relations plan for the period 2016 to 2021, including key milestones such as feasibility study completion, Proposal financial investment decision, construction, commissioning, and first shipment.

Hastings is committed to ongoing stakeholder communication, engagement and consultation through the planning and approval phase, and through the construction and operational phases of the Project. The Stakeholder Engagement Management Plan strives to provide access to government, to facilitate community partnering, to enable access to land, and a myriad of other objectives to develop and protect the company's reputation.

Hastings can demonstrate, through research and community consultation, that the company has developed and maintains strong relations with the shires and local communities and, utilising an external relations program, that these relationships will continue to be enhanced for the mutual benefit of the Project and relevant stakeholders.

Hastings has adopted principles from the Ministerial Council on Mineral and Petroleum Resources (MCMPR) *Principles for engagement with communities and stakeholders* (2005):

- Communication: Open and effective engagement involves both listening and talking:
    - Two-way communication
    - Clear, accurate and relevant information
    - Timeliness
- Transparency: Clear and agreed information and feedback processes:
    - Transparency
    - Reporting
- Collaboration: Working cooperatively to seek mutually beneficial outcomes.
- Inclusiveness: Recognise, understand and involve communities and stakeholders early and throughout the process.
- Integrity: Conduct engagement in a manner that fosters mutual respect and trust.

3.3 Stakeholder Consultation

On-going proactive stakeholder consultation has been underway since 2015 (**Table 3-1**).

Table 3-1 Stakeholder consultation

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Commonwealth government			
Dept of Industry, Innovation and Science	6 October 2016	Roundtable discussion of rare earths and lithium mining in Australia	Provision of information
Commonwealth Government – Minister for Environment	26 June 2017	Overview of the Project in regards with approvals status	Noted
DoEE	1 December 2016	Pre-referral meeting. Draft referral provided prior to the meeting. DoEE raised specific aspects that required additional information	Referral documentation revised based on DoEE advice
DoEE	14 March 2017	Assessment outcome • Nuclear action • Accredited assessment	Work with the state EPA to proceed with the environmental impact assessment process
DoEE	17 August 2017	Environmental discussions with regards to combining tailings of TSF 1 and TSF 2	Noted
DoEE	12 October 2017	S156 request for Stage 1 – Access road and accommodation village	Noted
DoEE	27 March 2018	S156 request for Stage 2 – Access Road Extension and Process Plant earth works	Noted
State government			
DMP	4 February 2015	Briefing on the Proposal	Noted
DMP	11 March 2015	Project update and DER advice	Noted
DMP	1 December 2015	Briefing on Proposal, outline of potential environmental impacts. Seeking advice from DMP	Noted
DMP and DSD	20 October 2016	Overview of Proposal status, schedule, environmental studies and comparison with Browns Range EIA. Advice received from DMP	Hastings will ensure these requirements are addressed in the Mining Proposal. A

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		regarding water balance and source, surface water mitigation, heritage sites, TSF design, and WRL to sit outside of pit zone of instability. DMP, as lead agency, to be the first point of contact.	water source will be developed for the state Referral to the EPA.
DMP	26 October 2016	DMP was invited to attend environmental risk assessment workshops (held as a series of workshops). DMP declined to attend due to schedule conflicts but would provide feedback on the risk assessment.	Risk assessment to be provided to DMP for review.
DMP	25 January 2017	Project overview with the focus on radiation safety	Hastings to meet again to discuss the project in greater detail for the Project Management Plan and the Mining Proposal
DMP	19 April 2017	Tenure, sterilisation drilling clarification, tenure purpose, infrastructure layout, closure of TSFs, diversion drain	Discussion following TSF design reports and geochemical characterisation
DMP	19 May 2017	TSF design overview including radiation impact assessment, geotechnical assessment, and closure aspects. Discussion topics included control of lateral seepage, settlement of tailings for closure, decant pond embankment at closure (to be removed), PMP for flood impact.	Discussion topics to be considered in TSF design report
DMP	21 June 2017	Water source program update	Noted.
DMIRS	18 July 2017	DMIRS have approved and confirmed that the water exploration works is considered investigative works	Noted.
DMIRS	19 July 2017	PoW within the development envelope and requirements to consult with the OEPA & Department of Water (DoW)	Hastings to identify all PoW's, Reg ID within the development envelope.
DMIRS	10 January 2018	Updates with regards to the meetings with EPA and DWER. Topics included: • Water studies • Stygofauna assessment	Further meeting to be arranged to discuss more detail around the mining proposal and further information about the proposed borrow pits

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		• Radon assessment • Secondary S41A application submission • Mining Proposal • Tenure	
DMIRS	30 January 2018	Phil Boglio reviewed and made suggestions to Hastings Mining Proposal – Early works. Needed to include: • Description of the borrow pits environmental surroundings • Where are the stockpiles to be kept/ disposed/ rehabilitated • Dust and Noise considerations • Clearing permits • Radionuclide management • Description of the hydrology	Hastings to address the outcomes from the meeting immediately.
DMIRS EPA	7 February 2018	Informing EPA Services of DMIRS concern with Plain Soil management.	Plain soils will be initially stored as per topsoil management action. Plain soils are to be labelled. The borrow pit will be covered with subsoil (initially collected and stored alongside the borrow pit) and then Hill soils.
DMIRS	11 May 2018	Review and comments are made on the Hastings TSF Feasibility design report.	Hastings to address comments.
DMIRS	15 May 2018	Project updates – topics concerning: • Status of approvals • Project Timing • Radon monitoring update	Jim Hondras confirmed cumulative impacts of water for dust suppression will have no impact

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		• Uranium in water – concerns of cumulative impacts of uranium when using water for dust suppression. • Safety – Considerations of facilities for emergency management. • Risk assessments.	
DMP, Resources Safety	30 October 2016	Outcomes of radionuclide studies and monitoring to-date. DMP raised the following considerations: Cross-reference TSF designs with landfill specifications, combination of clay liner and membrane liner to ensure leaching of TSF doesn't occur, capping and drainage system, use of analogue sites in closure planning, keen to see holistic approach to waste characterisation with heavy metal assessment as well as radionuclide assessment, on-going waste characterisation with commitment to update RWMP annually, and note that rare earths have radionuclides that mainly emit Beta radiation.	Advice from DMP noted and provided to TSF design consultants. Focus on gamma baseline studies as the more intense form of radiation. Gamma baseline studies and monitoring has been undertaken which will inform closure planning. Radionuclides considered within the waste characterisation report to provide holistic approach.
DMP, Resources Safety	25 January 2017	Change of DMP staff, briefing on proposal and aspects relating to radiation.	Preliminary advice received.
Radiological Council*	4 February 2015	Briefing on proposal.	Preliminary advice received.
DAA	9 May 2016	Advice sought on the selection of heritage survey participants.	Advice received, (noting that there was no native title claim over the area at the time).
DAA	23 January 2017	Overview of the proposal and summary of heritage survey work undertaken to date.	Advice from DAA on s18 approval process.
DER	17 March 2015	Briefing on proposal, preliminary advice received.	
DER	14 December 2016	Briefing on proposal.	Next meeting to be held for scoping of Part V approvals at the end of the EIA process.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
DoW	6 October 2016	Overview of the proposal. Briefing on water requirements for the proposal. Advice received: Consider doing isotope analysis to further understand age of water source and potential for recharge; likely that more but brackish water exists closer to the Lyons River. Better quality water is likely available with distance from the River but at lower volumes; and TSF location appeared such that water would not flow into creeks or rivers except after heavy rainfall events.	Isotopic analysis is underway. DoW advice communicated to consultants.
DoW	13 October 2016	Requirement for 5C licence for test pumping to determine drawdown contours in each pit.	Project description and test pumping details provided to DoW, Geraldton. No 5C licence required.
DWER, Water Division	17 July 2017	Assessment of 26D licence on tenements with JV holder, Mojito Resources – Request for Agreement that Hastings will conduct water investigations.	
DWER, Water Division	18 July 2017	Technical discussion of water investigations: • Quality and quantity of water from fractured rock aquifers versus palaeochannel aquifers. • Groundwater recharge and catchment size • Isotopic analysis	Isotopic analysis is underway based on previous advice (7mths since submitting samples to lab for analysis)
DWER, Water Division	13 February 2018	Update of the water status	Strong focus needed to be emphasised on: • Knowing the source of the water • Sustainability of the water
DWER, Water Division	13 February 2018	Water source investigations progress updates. DWER - is there water at location, where is it coming from and is it sustainable? Include this info in hydrogeological report.	Noted.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		Has stygofauna sampling been completed? Hastings -sampling was conducted before Christmas. No stygofauna species had been found. Another round of stygofauna sampling to be planned for Q2.	
DWER, Environmental Regulation Division	4 May 2018	Works application – WWTP (Category 85) and Screening Plant (Category 12) Process Plant.	Hastings to submit works approval, and provide the TSF design report, plume study SoW and leach testing proposal.
DWER, Environmental Regulation Division	11 May 2018	Recommended a list of analytes for leach testing, length of leach testing to occur over a minimum 20-week period, use of the LEAF method.	Noted. Advice provided to consultants for consideration.
DWER, EPA Services and Water Division	12 February 2018	Update of water exploration.	With regards to second S41A: • Hastings should follow same process as per first S41A application, i.e. S156A • Further information required for borrow pits (process of clearing and mitigation hierarchy) • Resubmit revised S41A #2
DPaW	2 April 2015	Preliminary advice on flora and fauna survey requirements and design from DPaW.	Noted.
DPaW	30 September 2016	Overview of environmental survey outcomes, subterranean fauna assessments and on-going studies, consultation requirements with DPaW.	No further consultation required unless EPA formally request DPaW input. No subterranean fauna expertise in DPaW, so they would request input from WA Museum if required.
OEPA	10 September 2015	Overview of Proposal, presentation of available environmental data particularly flora and fauna, hydrology and radiation assessments.	

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
OEPA	10 March 2016	Briefing on Proposal, outline of potential environmental impacts.	
OEPA	12 October 2016	Concern raised about whether or not referral of the Proposal could be given a level of assessment during the governments 'caretaker phase'. The OEPA officer seemed to think this was likely and recommended a pre-referral meeting ASAP.	Pre-referral meeting with OEPA was then scheduled for 19 October 2016. Plans to refer in mid-November.
OEPA	19 October 2016	Pre-referral meeting. Briefing on proposal, API level impact assessment requirements and timing of referral during caretaker phase. OEPA officers advised that the EPA could provide proponents with a level of assessment during caretaker phase. Key requirements: all studies to be completed with no information gaps, adequate stakeholder consultation with low community interest, high quality documentation.	Delay of referral to ensure all necessary studies have been completed.
OEPA	13 January 2017	OEPA requests for Hastings to do F&F survey of the access road.	Hastings to comply and commence survey.
OEPA	23 January 2017	Preliminary feedback re referral information included: inclusion of port and transport corridor in proposal, water drawdown impacts to GDE to be determined, height of waste rock landforms, risks associated with flora along access road, minor revisions to form and ERD.	Address OEPA feedback in final referral form and ERD.
OEPA	15 February 2017	Requirement for flora and fauna survey of the access road.	Flora and fauna survey to be undertaken.
OEPA	9 March 2017	Basis for level of assessment: • Nuclear action • New geographic area (no previous mining development in Upper Gascoyne region) Discussion of additional scope of works and advised of long lead items.	Noted.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
OEPA	8 May 2017	Insufficient information provided by Hastings on how to source water.	Hastings to undertake hydrology program to demonstrate water source.
OEPA	8 June 2017	Water source investigation outcomes, subterranean fauna study requirements.	Consultation with DPaW required.
OEPA/DPaW	29 June 2017	Water source options and subterranean fauna sampling requirements.	Development of Stygofauna Sampling Plan for OEPA approval.
CASA	31 October 2016	Registration requirements and details for notification of an airstrip. CASA then provided a brief overview of their requirements highlighting the importance of have the correct consultants do the design and ensuring it is constructed to design specifications. No environmental issues were raised.	Noted. A formal letter was then sent showing the location of the airstrip, runway code and timeframes for construction.
AirServices Australia	7 November 2016	Location and overview of airstrip design intent was provided in a letter. AirServices noted that the airstrip was in a good location from a safety perspective. No environmental issues were raised.	Noted.
Local Government			
Shire of Upper Gascoyne	26 May 2016	Project overview and update on project status. Discussed access road options. The Shire provided information on council maintenance operations of the Dairy-Creek Road and requirements during project operations. Briefing on status of engineering and option study for access road.	Shire provided MRWA road assessment information.
Shire of Upper Gascoyne	25 October 2016	Logistics for community forum and advertising. The Shire noted that the Gassy News was the best form of advertising in remote areas, pastoralists and everyone in town will be informed. Advertisement will be distributed as per the Gassy News to pastoralists as well as those in town. Briefing on status of engineering and option study for access road.	Advertisement prepared and distributed.
Shire of Upper Gascoyne	30 November 2016	Briefing on the Proposal, non-committal until they know that Project will go ahead. Interest in future maintenance	Hastings to keep the Shire updated of progress.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		requirements to maintain good road condition with additional vehicle movements to and from the proposal.	
Shire of Upper Gascoyne	13 February 2017	Local government approvals for exploration camp expansion incl. waste water, water source	Noted.
Shire of Upper Gascoyne	27-28 June 2017	Project update. Description of minor or preliminary works. Shire road upgrade requirements.	Noted.
Shire of Upper Gascoyne	27 November 2017	Project update. Discussions were made with regards to fire hazards and road access agreements. Request for Hastings to present at the Shire Council meetings.	Noted. Hastings will present at the Shire council meeting on the 15 Dec 2017.
Shire of Upper Gascoyne	15 December 2017	Project update to the Shire Council. Discussion of access road location and road maintenance.	Noted.
Shire of Upper Gascoyne	29 May 2018	Confirmation of information to be included in the Construction EMP and Environmental Induction for Minor or Preliminary works program. Road closure during rainfall events (localised and regional) and RAV 6 rating of Ullawarra Road.	Noted and included in documentation.
Shire of Carnarvon	13 June 2018	Proposal overview.	Noted.
Gascoyne Development Commission (GDC)	30 November 2016	Overview of Proposal, approvals status and requirements, environmental aspects. GDC discussed development initiatives in the Gascoyne region.	Hasting to keep GDC updated of progress and provide a copy of the presentation.
Gascoyne Development Commission (GDC)	14 December 2017	Proposal update.	Noted.
Carnarvon Chamber of Commerce and Industry	14 December 2017	Proposal update. Introduction to potential local businesses that would help benefit the project and community.	Noted.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Traditional Owners			
Traditional owners field visits	2-4 August 2016 and 21 September 2016	Location of proposed mine areas, processing plant and associated infrastructure visited by TOs. TO's highlighted importance of story line associated with the Lyons River and its tributaries. Concerns raised to protect the River.	Refer to Appendix 8.2 report. Hastings has put a 150m exclusion buffer on either side of the Lyons river, Fraser Creek and Gifford Creek. Hastings has been able to avoid significant heritage sites identified to-date.
YMAC	9 May 2016	Advice sought on the selection of heritage survey participants	Advice received, (noting that there was no native title claim over the area at the time)
YMAC	1 December 2016	Introductory meeting and outline of likely future tenure requirements and engagement.	YMAC to seek instructions from the combined Thin-Mah Warianga, Tharrikari, Jiwarli (TMWTJ) native title (NT) claimants
YMAC	16 February 2017 10 March 2017	Hastings request to consult with the TMWTJ NT claimants.	Meeting to be arranged.
YMAC	14 March 2017	Response to Hastings request to consult. YMAC met with combined TMWTJ on the 9/3/2017. TMWTJ requests to meet with Hastings to commence negotiation	Noted
YMAC and TMWTJ NT claimants	11 Apr 2017	Discussion of Hastings intent to negotiate a Mining Agreement with the TMWTJ NT claimants despite no legal requirement to do so. Discussion of process going forward.	Development of heritage agreement to do surveys. Initiate negotiation process.
YMAC and TMWTJ NT claimants	23 May 2017	Mining agreement negotiations.	Development of heritage agreement for infrastructure activities. Draft Mining Agreement.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Traditional owners field visits	25 to 26 May 2017	Aboriginal heritage survey of exploration areas. Several avoidance areas were identified by the TO's.	Refer to Appendix 8.2 report. Hastings has been able to avoid significant heritage sites identified to-date.
YMAC and TMWTJ NT claimants	11 July 2017	Mining agreement negotiations.	The terms of a possible project wide agreement are substantially progressed.
Traditional owners field visits	13 to 15 July 2017	Aboriginal heritage survey of proposed infrastructure areas. Several avoidance areas were identified by the TO's.	Refer to Appendix 8.2 report. Hastings has been able to avoid significant heritage sites identified to-date.
Traditional owners field visits	6 August 2017	Aboriginal heritage survey of proposed water bores and access. No sites were identified.	Refer to Appendix 8.2 report.
YMAC and TMWTJ NT claimants	22 August 2017	Mining agreement negotiations.	Agreement reached in principle.
YMAC	September - October 2017	Agreement drafting, numerous meetings.	Agreement reached in principle.
YMAC and TMWTJ community	9 November 2017	Community meeting in Carnarvon to consider the proposed voluntary mining agreement between the TMWTJ native title claimants and Hastings.	Agreement endorsed and executed.
YMAC	4 May 2018	Meeting to discuss heritage survey requirements, agreement implementation and next meeting with the TMWTJ group	Heritage surveys to be progressed. Next meeting with TMWTJ scheduled for 12 June
YMAC and TMWTJ agreement implementation committee	12 June 2018	Inaugural mining agreement implementation committee meeting in Carnarvon.	
Wanna Station	12 May 2017	Comprehensive land access agreement has been concluded between Hastings and Bagden Pty Ltd that covers all infrastructure of the project, including the access road and accommodation village.	Hastings to provide 21 days-notice of commencement of construction activities
Wanna Station	20 November 2017	Hastings discussing future business opportunities:	Bill Biggs provided a draft agreement for use of the RFDS airstrip.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
		• Use of airstrip • Access road construction • Possible mining of dry calcrete (limestones) All improvements to the Royal Flying Doctor Service (RFDS) airstrip requires pastoralist's consent.	Hastings to respond.
Wanna Station	15 December 2017	Project update.	Hastings to continue providing project updates.
Community			
Gascoyne Junction	30 November 2016	Community forum held at community resource centre in Gascoyne Junction. Environmental fact sheet summarising environmental issues, proposal overview and invite to provide comment.	Despite advertising the event, the only two attendees raised no issues. The community resource centre will ensure residents are sent a copy of the environmental fact sheet and will maintain copies on display at the centre.
Conservation Council	19 October 2016	Letter sent informing of the proposal and invite to meet if further information is required. Invite to meet if further information is required.	No response received.
Conservation Council	24 May 2017	Notification of Public Environmental Review level of assessment. Invite to meet if further information is required.	No response received.
Conservation Council	8 June 2018	Notification of completion of studies and expected submission of the PER document.	No response received.
Wilderness Society	19 October 2016	Letter sent informing of the proposal and invite to meet if further information is required.	No response received.
Wilderness Society	24 May 2017	Notification of Public Environmental Review level of assessment via letter. Invite to meet if further information is required.	No response received.

Stakeholder	Date	Issues/topics raised	Proponent response/outcome
Wilderness Society	8 June 2018	Notification of completion of studies and expected submission of the PER document via letter. Invite to meet if further information is required.	No response received.

ENVIRONMENTAL PRINCIPLES

Chapter 4

4 ENVIRONMENTAL PRINCIPLES

This section was guided by the *Statement of Environmental Principles, Factors and Objectives* (EPA 2016r) as the basis for the environmental impact assessment.

Section 4A of the *Environmental Protection Act 1986* (WA; EP Act) describes the principles of environmentally sustainable development. These principles are considered in the context of the Proposal (**Table 4-1**).

Table 4-1 Environmental Protection Act 1986 (WA) Principles

Principle	Consideration
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 the application of the precautionary principle, decisions should be guided by:* *a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* *b) an assessment of the risk-weighted consequences of various options.*	Hastings recognises the importance of minimising environmental impacts to ensure the company's longevity, success, growth and positioning in domestic and global markets. This will be achieved by successful mitigation of potential risks to the environment. An overarching Environmental Management System (EMS) will be implemented to ensure risks associated with all proposed activities with the potential to impact the environment are mitigated to as low as reasonably practicable (ALARP). Consideration of risk has involved completing comprehensive biological and physical baseline surveys and assessments to identify key environmental factors. Risk of impact to key environmental factors from implementing the Project has then been considered. Where there are information gaps or a lack of scientific certainty, a conservative approach has been taken to assess risk. Careful evaluation has been made of options to avoid or minimise any potential impacts to the environment. The Proposal will use best practice design and management to reduce risk, where practicable. The Proposal has then considered management and rehabilitation of potential impacts to key environmental factors.
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.*	The Proposal presents the Western Australian economy with the opportunity to diversify its mineral exports, thus providing a more resilient employment environment. The rare earths concentrate is used to create products, namely magnets that are utilised in the renewable energy markets i.e. wind turbines, hybrid cars. This contributes to health, diversity and productivity of the global environment

Principle	Consideration
	by reducing our dependence on fossil fuels, thus creating a more sustainable environment for future generations. The biological surveys conducted to-date have broadened our knowledge of the local environment, ensuring that we can mitigate potential risks and thus maintain the health, diversity and productivity of the local environment.
3. Principles relating to improved valuation, pricing and incentive mechanisms *(1) Environmental factors should be included in the valuation of assets and services.* *(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.* *(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *(4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive 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.*	The Proposal will be subject to a Preliminary Mine Closure Plan prepared in accordance with the *Guidelines for Preparing Preliminary Mine Closure Plans* (DMP and EPA, 2015). The Mine Closure Plan will be a dynamic document, which having identified post-mining land use objectives, consulting with key stakeholders and conducting on-going studies or research to fill information gaps, will be reviewed and updated. Addressing closure objectives throughout all phases will ensure a cost-effective way to reduce liabilities and risks associated with mine closure. A Radiation Waste Management Plan, prepared in accordance with the *NORM guideline 4.2* (DMP, 2010), and a Tailings Storage Facilities Operations Manuals, prepared in accordance with *Guidelines on the Development of an Operating Manual for Tailings Storage* (DMP, 1998) will ensure that tailings are contained and encapsulated in accordance with industry best practice and to the highest standards and guidelines. Hastings is developing blockchain technology to trace and track its product from the Yangibana Rare Earths Project to the customer. The transparent tracking provides confidence to consumers that the REE product meets ethical and environmentally responsible standards of production. This will also ensure that the company is ready for the future implementation of the ISO/TC298 standards. As a result, the reputation and environmental performance of the Proposal will be reflected in the product valuation mechanisms.
4. The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	Conservation of biological diversity and ecological integrity is fundamental to Hastings approach to environmental management and is a major environmental consideration for the Proposal. Biological assessments have been conducted over an extensive study area to identify conservation significant species and ecosystems. The Proposal has been designed to avoid or minimise potential impacts to preliminary key environmental factors.

Principle	Consideration
5. The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	Waste management of the Proposal involves minimising generation of wastes through: • Avoid and reduce at source • Reuse and recycle, including salvage • Treat and/or dispose. In doing so, mine planning aims to minimise strip ratios to reduce the amount of mine waste rock. Water from the processing plant will be recycled and reused, where possible. Contractor management (i.e. contracts, audits, coordination of waste segregation and disposal) will ensure waste is recycled, where possible.

FLORA AND VEGETATION

Chapter 5

5 KEY ENVIRONMENTAL FACTOR 1: FLORA AND VEGETATION

5.1 EPA OBJECTIVE

The EPA objective for flora and vegetation is:

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

5.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of flora and vegetation include:

Agricultural and Related Resources Protection Act 1976 (WA)

Biosecurity and Agriculture Management Act 2007 (WA)

Bush Fires Act 1954 (WA)

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Environmental Protection Act 1986 (WA)

Wildlife Conservation Act 1950 (WA)

Relevant guidelines include:

EPA (2016n) Technical Guidance - Flora and vegetation surveys for environmental impact assessment; and

EPA (2016e) Environmental Factor Guideline: Flora and vegetation.

5.3 RECEIVING ENVIRONMENT

The following studies have informed this section:

- Flora and Vegetation Report (Ecoscape 2015; Appendix 1-1)
- Flora and Fauna Memo (Ecoscape 2017; Appendix 1-2)
- GDE Memo (Ecoscape 2017; Appendix 1-3)
- Flora and Fauna Survey (Ecological 2017; Appendix 1-4)
- Environmental Risk for Ionising Contaminants Assessment (ERICA; in JRHC Enterprises 2016; Appendix 5-6)

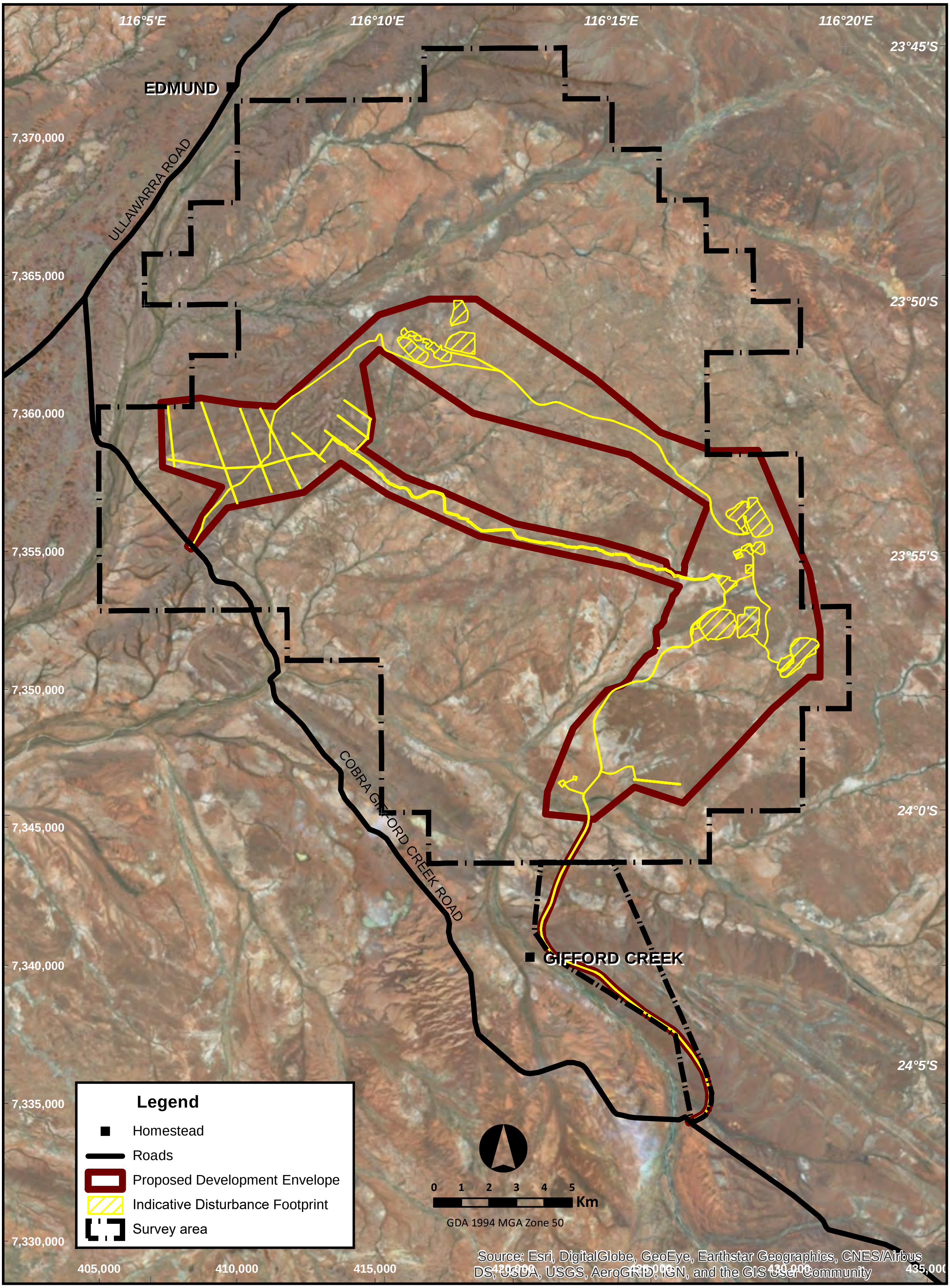
Flora and vegetation surveys[1] have been conducted in accordance with the standards of *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016n), where possible. Limitations of the surveys are as follows:

- Every intention was made by Ecoscape to ensure two quadrats per vegetation unit was collected during the time of the field survey. However, when the data was collated, and floristic analysis undertaken, the results showed additional vegetation units compared to those identified during field observations. In this case (i.e. Ecoscape 2015), four vegetation units have only one quadrat (i.e. AaSaEs, ApAsEp, AsFh and Fs). Two vegetation units do not occur within the impact area and thus only provide context to the assessment. Only 20% of AaSaEs and 72% of Fs occurs within the development envelope.
- The Ecological Australia (2018) survey was conducted as a Reconnaissance Survey (Level 1) in agreement with EPA Services. Since this time, the following approvals have been granted for minor or preliminary works (i.e., the access road) within this survey area, i.e., a Section 41A, Mining Proposal and a Native Vegetation Clearing Permit.

The detailed surveys occur over areas that have potential to be directly or indirectly impacted from the proposal.

The historical land use has been pastoral, and evidence of degradation along drainage lines occurs where hooved mammals and weeds are present. Other minor areas are classified as degraded from pastoral activities and exploration tracks and pads (to be rehabilitated at completion of exploration programme). Despite this, the majority (~71%) of the survey area (**Figure 5-1**) is in Excellent condition with native vegetation largely intact (Ecoscape 2015; Appendix 1-1).

1 Note that the flora and vegetation report completed by Ecoscape (2015) was conducted prior to the release of the new standard (EPA 2016n), however, the methodology utilised to conduct the surveys aligns with the standards.



YANGIBANA RARE EARTHS PROJECT

PER_F5-1_SurveyArea.mxd
12 June 2018

HASTINGS Technology Metals Limited

Flora and Vegetation Survey Area

Figure 5-1

5.3.1 Flora

A total of 472 vascular flora taxa were recorded in the survey area (50,600 Ha; **Figure 5-2**). No threatened flora listed under the EPBC Act (Cwth) and *Wildlife Conservation Act 1950* (WC Act; WA) were recorded in the study area. One undescribed species (*Elacholoma sp.* 'Showy Flowers') was recorded in the survey area but outside of the Proposal development envelope.

Priority Flora

Eight priority flora (Department of Biodiversity Conservation and Attractions (DBCA) listed, formerly the Department of Parks and Wildlife (DPaW)) were recorded in the study area (**Table 5-1**). Four of these species occur within the Development Envelope, namely *Acacia curryana*, *Rhodanthe frenchii, Wurmbea fluviatilis,* and *Sporobolus blakei*.

Table 5-1 Number of conservation significant plants within the study area and the development envelope

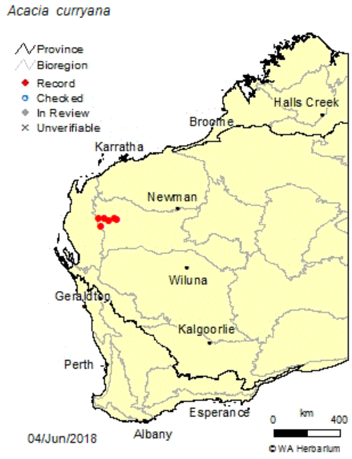
Priority Flora Species	Regional (Study area)	Local (Development Envelope)
Acacia curryana (Priority 1 - P1)	7,754	4,015
Rhodanthe frenchii (P2)	1,690	504
Solanum octonum (P2)	325	0
Wurmbea fluviatilis (P2)	126	10
Gymnanthera cunninghamii (P3)	5	0
Sporobolus blakei (P3)	666	2
Goodenia berringbinensis (P4)	1,525	0
Goodenia nuda (P4)	1	0

The state-wide distribution of these species is as follows:

Acacia curryana **(Priority 1)**

Acacia curryana is a rounded shrub that grows up to 2.5 m tall and typically occurs on low granite hills in skeletal soils (Maslin 2014 in Ecoscape 2015; FloraBase, WAH 1998-2015). Six records are listed on NatureMap and all are located to the southwest of the Proposal.

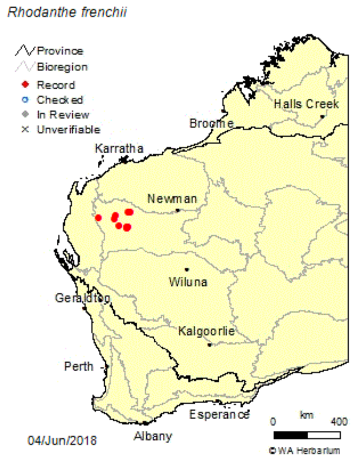
The 30+ populations recorded within the study area therefore represent a range extension of up to 50 km.



Rhodanthe frenchii **(Priority 2)**

Rhodanthe frenchii is an erect herb with yellow flowers and recorded as growing to 35 cm tall (recorded up to 50-60 cm tall in the Proposal area). This taxon is typically known from stony hills or rocky river banks (FloraBase, WAH 1998-2015). There are 16 records for this taxon listed on NatureMap (DPaW 2007-2018), from the Gascoyne, Pilbara and Carnarvon bioregions.

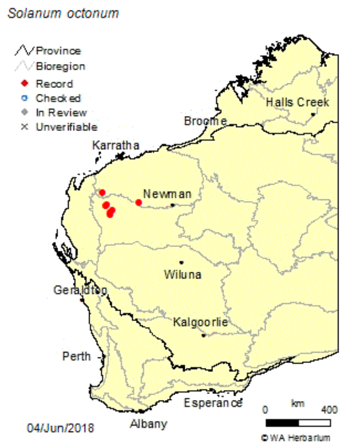
Fifteen populations occur within the Proposal study area.



Solanum octonum **(Priority 2)**

Solanum octonum is an erect shrub with purple flowers that grows to a height of to 1.5 m high. The taxon is known from a variety of habitats including riparian areas, gorges and steep hillslopes (Bean 2013 in Ecoscape 2015; FloraBase, WAH 1998-2015). There are seven records for this taxon listed on NatureMap (DPaW 2007-2018), all located to the north of the study area.

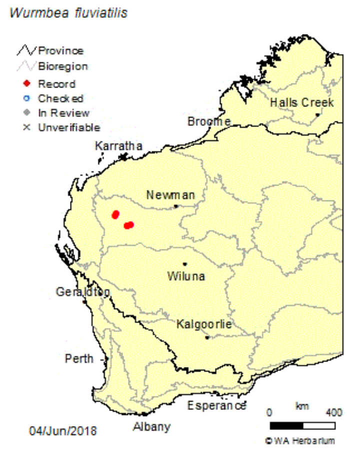
The seven populations recorded within the Proposal area represent a minor southern range extension of 20-30 km (Ecoscape 2015).



***Wurmbea fluviatilis* (Priority 2)**

Wurmbea fluviatilis is pink flowering herb to 55 cm tall. This taxon is typically known from damp soils of riparian habitats (Macfarlane & Case 2011 in Ecoscape 2015; FloraBase, WAH 1998-2015). There are six records for this taxon listed on NatureMap (DPaW 2007-2018), representing two distinct locations, both to the southeast of Mt Augustus.

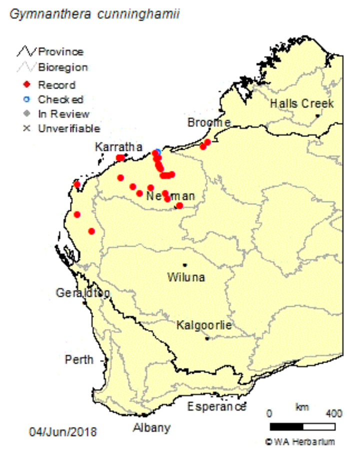
The nine populations recorded within the study area represent a north-western range extension of approximately 100 km (Ecoscape 2015).



***Gymnanthera cunninghamii* (Priority 3)**

Gymnanthera cunninghamii is a shrub to 2 m high occurring in sandy soils (FloraBase, WAH 1998-2015). There are 66 records for this taxon listed on NatureMap (DPaW 2007-2018), predominantly within the Pilbara and Carnarvon bioregions. *Gymnanthera cunninghamii* is also known from the Northern Territory and Queensland (ALA 2015a in Ecoscape 2015).

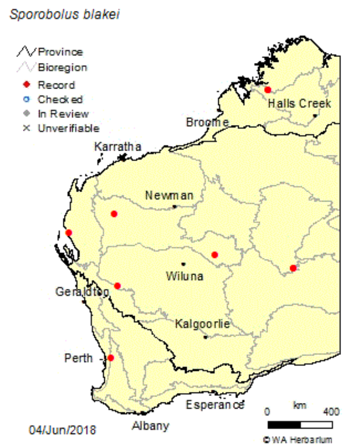
This species has not previously been recorded from the Gascoyne bioregion and therefore fills a range gap, at least 150 km from the nearest known record (Ecoscape 2015). A single population of five individuals was recorded in the Proposal study area.



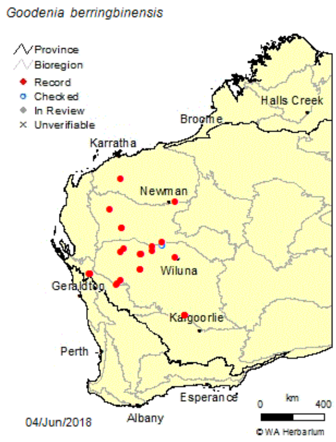
***Sporobolus blakei* (Priority 3)**

Sporobolus blakei is a perennial grass to 0.6 m high (Plate 12, Plate 13), typically recorded from creeks (FloraBase, WAH 1998-2015). It is known from 11 scattered records listed on NatureMap (DPaW 2007-2018), though it is also recorded from Northern Territory, South Australia, Queensland and New South Wales (ALA 2015a in Ecoscape 2015).

The records within the study area fills a range gap for the species; the closest known record is 270 km away (Ecoscape 2015). Eight populations were recorded in the study area and one population occurs within the development envelope.



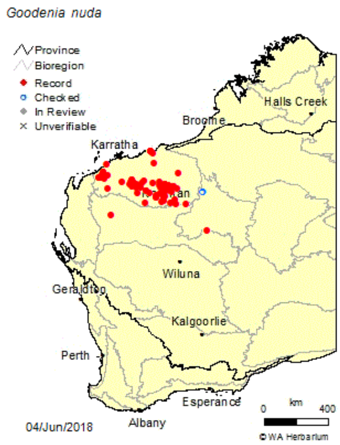
***Goodenia berringbinensis* (Priority 4)**



Goodenia berringbinensis is a yellow flowering herb to 30 cm tall. This taxon is typically known from riparian habitats (FloraBase, WAH 1998-2015). There are 33 records for this taxon listed on NatureMap (DPaW 2007-2018).

The nearest record is located more than 100 km from the study area and as such the 9 populations within the study area fill a range gap (Ecoscape 2015). Four populations were located outside the Development Envelope, in proximity to the access road during a second survey (EcoLogical 2017).

***Goodenia nuda* (Priority 4)**



Goodenia nuda, a herb to 50 cm high with yellow flowers, is known from a variety of habitats (FloraBase, WAH 1998-2015). There are 116 records for this taxon listed on NatureMap (DPaW 2007-2018), almost exclusively within the Pilbara bioregion.

The record within the study area represents a significant southern range extension, approximately 150 km south of the nearest known population.

A single plant was recorded in the southern section of the study area south of Lyons River and outside of the proposed development footprint.

Range extensions

There has historically been a distinct lack of flora surveys in the Upper Gascoyne region. As a result, 57 taxa were recorded as having significant range extensions (>100 km) or filling substantial range gaps in species distribution (**Table 5-2**). The extension to the known distribution range of taxon recorded in the Study Area (Ecoscape 2015) have been categorised as follows:

1. Range extension: The taxon has previously been recorded within the Gascoyne Interim Biogeographical Regionalisation of Australia (IBRA) region.
2. Bioregional extension: The taxon has not previously been recorded within the Gascoyne IBRA region.
3. Range gap: The recorded location of respective taxon in the study area is situated between widely separated populations of that species.

Five of the 57 taxa are Priority flora species*:* *Goodenia berringbinensis* (Priority 4), *Goodenia nuda* (Priority 4), *Gymnanthera cunninghamii* (Priority 3), *Sporobolus blakei* (Priority 3) and *Wurmbea fluviatilis* (Priority 2). Five of the 57 taxa are alien to Western Australia, namely *Cucumis myriocarpus, Echinochloa colona, Eragrostis amabilis, Lolium multiflorum* and *Portulaca pilosa.* The greatest bioregional extension of 1160km was *Eragrostis amabilis* (alien to Western Australia), which has previously only been recorded in the Northern Kimberley IBRA region. The extension of the known distribution of 19 species were categorised as bioregional extensions, however of these, 14 species were recorded in the Pilbara IBRA region (noting that the Proposal is located close to the Pilbara border).

Table 5-2 Taxa recording in the study area that represent range extensions

#	Taxon	Type of record	Distance from nearest record	# locations within the study area	# WA Herbarium locations
1	*Abutilon malvifolium*	Bioregional extension	210 km southwest of nearest known location in the Pilbara IBRA region	1	26
2	*Acacia craspedocarpa*	Range extension	260 km north of nearest known location within the Gascoyne IBRA region	1	134
3	*Blumea tenella*	Range extension	130 km southwest of nearest known location in the Gascoyne IBRA region	1	108
4	*Bonamia media*	Range extension	150 km southwest of nearest known location in the Gascoyne IBRA region	1	91
5	*Bonamia pilbarensis*	Bioregional extension	150 km south of nearest known location in the Pilbara IBRA region	1	39
6	*Calotis porphyroglossa*	Range gap	100 km of nearest known location in the Gascoyne IBRA region	15	17
7	*Corchorus sidoides* subsp. *sidoides*	Bioregional extension	220 km south of nearest known location in the Pilbara IBRA region	1	100

#	Taxon	Type of record	Distance from nearest record	# locations within the study area	# WA Herbarium locations
8	*Corchorus tridens*	Bioregional extension	140 km southwest of nearest known location in the Pilbara IBRA region	13	94
9	*Cucumis myriocarpus**	Range extension	240 km northwest of nearest known location in the Gascoyne IBRA region	1	42
10	*Cullen graveolens*	Range gap	180 km of nearest known location in the Gascoyne IBRA region	2	29
11	*Dodonaea pinifolia*	Range extension	270 km north of nearest known location in the Murchison IBRA region	1	322
12	*Echinochloa colona**	Bioregional extension	170 km south of nearest known location in the Pilbara IBRA region	10	135
13	*Elacholoma hornii*	Range gap	280 km southwest of nearest known location in the Gascoyne IBRA region	2	16
14	*Eragrostis amabilis**	Bioregional extension	1160 km southwest of nearest known location in the Northern Kimberley IBRA region	1	12
15	*Eremophila latrobei subsp. filiformis*	Bioregional extension	120 km south of nearest known location in the Pilbara IBRA bioregion	1	62
16	*Eremophila platycalyx subsp. pardalota*	Range extension	100 km west of nearest known location in the Gascoyne IBRA region	2	20
17	*Eriochiton sclerolaenoides*	Range extension	240 km northwest of nearest known location in the Gascoyne IBRA region	1	261
18	*Euphorbia coghlanii*	Range gap	160 km of nearest known location in the Gascoyne IBRA region	1	148
19	*Goodenia berringbinensis* (Priority 4)	Range gap	130 km of nearest known location in the Gascoyne IBRA region	9	33
20	*Goodenia maideniana*	Range extension	320 km north of nearest known location in the Gascoyne IBRA region	3	44
21	*Goodenia nuda* (Priority 4)	Range extension	160 km southeast of nearest known location in the Gascoyne IBRA region	1 plant	129
22	*Gymnanthera cunninghamii* (Priority 3)	Range gap Bioregional extension	170 km of nearest known location in the Carnarvon IBRA region	1 plant	68
23	*Hibiscus sturtii var. grandiflorus*	Range gap	240 km of nearest known location in the Gascoyne IBRA region	2	49

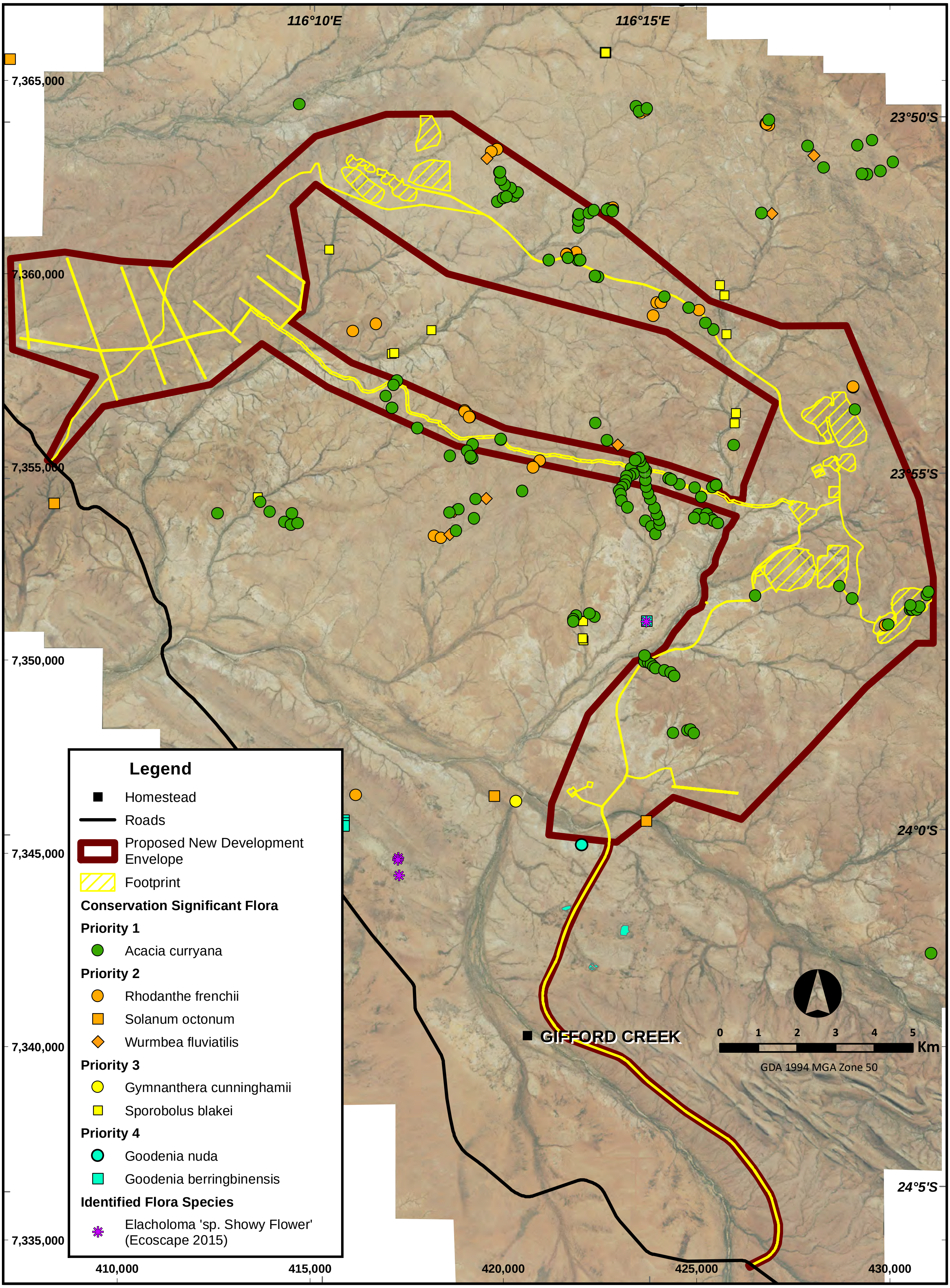
#	Taxon	Type of record	Distance from nearest record	# locations within the study area	# WA Herbarium locations
24	*Hibiscus verdcourtii*	Bioregional extension	200 km southwest of nearest known location in the Pilbara IBRA region	1	14
25	*Hypericum gramineum*	Bioregional extension	200 km northwest of nearest known location in the Murchison IBRA region	1	123
26	*Ipomoea coptica*	Bioregional extension	170 km southeast of nearest known location in the Pilbara IBRA region	3	103
27	*Ipomoea plebeia*	Bioregional extension	160 km southwest of nearest known location	1	38
28	*Ipomoea polymorpha*	Bioregional extension	220 km south of nearest known location in the Pilbara IBRA region	2	108
29	*Lolium multiflorum**	Range extension	180 km west of nearest known location in the Gascoyne IBRA region	1	29
30	*Lysiana exocarpi*	Range extension	150 km northeast of nearest known location in the Gascoyne IBRA region	1	17
31	*Melhania oblongifolia*	Bioregional extension	220 km south of nearest known location in the Pilbara IBRA region	5	302
32	*Menkea sphaerocarpa*	Range extension	350 km northwest of nearest known location in the Gascoyne IBRA region	1	77
33	*Najas tenuifolia*	Bioregional extension Range gap	190 km of nearest known location in the Pilbara IBRA region	1	62
34	*Notoleptopus decaisnei*	Bioregional extension	140 km southwest of nearest known location in the Pilbara IBRA region	8	97
35	*Oldenlandia galioides*	Range gap	150 km of nearest known location in the Gascoyne IBRA region	2	132
36	*Podolepis kendallii*	Range extension	160 km north of nearest known location in the Gascoyne IBRA region	1	124
37	*Portulaca intraterranea*	Bioregional extension	170 km southwest of nearest known location in the Pilbara IBRA region	17	173
38	*Portulaca pilosa**	Range extension	180 km southwest of nearest known location in the Pilbara IBRA region	1	133
39	*Ptilotus auriculifolius*	Range extension	120 km southwest of nearest known location in the Pilbara and Gascoyne IBRA region	1	145
40	*Scaevola tomentosa*	Range extension	180 km northeast of nearest known location in the Carnarvon	1	179

#	Taxon	Type of record	Distance from nearest record	# locations within the study area	# WA Herbarium locations
			IBRA region (and also found further away in the Gascoyne IBRA region)		
41	*Schoenoplectus laevis*	Range extension	170 km southwest of nearest known location in the Pilbara (and also occurs further away in the Gascoyne IBRA region)	1	9
42	*Setaria surgens*	Range gap	250 km of nearest known location in the Gascoyne IBRA region	1	67
43	*Sida sp.* Supplejack Station (T.S. Henshall 2345)	Bioregional extension	210 km southwest of nearest known location in the Pilbara IBRA region	1	10^
44	*Sida* sp. verrucose glands (F.H. Mollemans 2423)	Range extension	160 km southwest of nearest known location in the Gascoyne IBRA region	8	51^
45	*Sida spinosa*	Range extension	180 km southwest of nearest known location in the Gascoyne IBRA region	2	91
46	*Sporobolus blakei* (Priority 3)	Range gap	270 km of nearest known location in the Gascoyne IBRA region	8	15
47	*Swainsona longipilosa*	Range gap	130 km of nearest known location in the Gascoyne IBRA region	4	2
48	*Swainsona oroboides*	Range extension	260 km northwest of nearest known location in the Gascoyne IBRA region	1	54
49	*Swainsona rotunda*	Range extension	100 km northwest of nearest known location in the Gascoyne IBRA region	2	7
50	*Triglochin hexagona*	Range gap	280 km of nearest known location in the Gascoyne IBRA region	1	20
51	*Urochloa occidentalis var. ciliata*	Range gap	170 km of nearest known location in the Gascoyne IBRA region	2	21
52	*Urochloa subquadripara*	Range extension	250 km west of nearest known location in the Gascoyne IBRA region	1	63
53	*Vigna lanceolata*	Range extension	150 km south of nearest known location in the Pilbara IBRA region	2	79
54	*Vigna sp.* Hamersley Clay (A.A. Mitchell PRP 113)	Bioregional extension	190 km south of nearest known location in the Pilbara IBRA region	1	24
55	*Wurmbea fluviatilis* (Priority 2)	Range extension	100 km northwest of nearest known location in the Gascoyne IBRA region	9	11

#	Taxon	Type of record	Distance from nearest record	# locations within the study area	# WA Herbarium locations
56	*Zygophyllum aurantiacum subsp. aurantiacum*	Range extension	160 km north of nearest known location in the Gascoyne IBRA region	1	82
57	*Zygophyllum eichleri*	Range extension	110 km west of nearest known location in the Gascoyne IBRA region	3	122

*Alien to Western Australia

^Specific identities of the respective Sida sp were not listed on Naturemap, and thus total locations are based on information extrapolated from the respective Naturebase map.



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Priority Flora

PER_F5-2_Priority_Flora.mxd
25 June 2018

Figure 5-2

5.3.2 Vegetation

The tenement area is located within the Gascoyne IBRA region that consists of three major subregions: Ashburton, Augustus and Carnegie (Thackway and Cresswell 1995 in Ecoscape 2015; Appendix 1). The development envelope occurs in the Augustus subregion, described in the 2002 Biodiversity Audit of Western Australia's 53 Biogeographical Subregions (Desmond et al. 2001 in Ecoscape 2015) as:

> *Rugged low Proterozoic sedimentary and granite ranges divided by broad flat valleys. Also includes the Narryera Complex and Bryah Basin of the Proterozoic Capricorn Orogen (on northern margin of the Yilgarn Craton), as well as the Archaean Marymia and Sylvania Inliers. Although the Gascoyne River System provides the main drainage of this subregion, it is also the headwaters of the Ashburton and Fortescue Rivers. There are extensive areas of alluvial valley-fill deposits. Mulga woodland with Triodia occur on shallow stony loams on rises, while the shallow earthy loams over hardpan on the plains are covered by Mulga parkland. A desert climate with bimodal rainfall. The subregional area is 10,687,739 Ha.*

Ten land systems occur within the surveyed tenement areas. All land systems are well represented beyond the development envelope. The James System occupies the greatest area, i.e. 31.2% of the tenement areas, which represents 8.24% of its total extent in the Gascoyne bioregion, followed by the Phillips System occupying 21.7% of the tenement areas, which represents 1.43% of its total extent.

Four pre-European vegetation associations occur within the tenement areas:

- 18 Low woodland; mulga (*Acacia aneura*);
- 165 Low woodland; mulga and snakewood (*Acacia eremmaea*);
- 166 Low woodland; mulga and *Acacia victoriae;* and
- 181 Shrublands; mulga and snakewood scrub.

4.42% of vegetation association 165 occurs within the tenement areas, with 100% of its pre-European extent remaining in the Gascoyne bioregion. Less than 1% of the total extent of the other three vegetation associations occur within the tenement areas (Ecoscape 2015).

Twenty-eight vegetation types were recorded from the study areas by Ecoscape (2015) and Ecological (2017) (

Figure 5-3), with the following 23 vegetation types found within the development envelope:

1. AaEpDr: *Acacia aptaneura* low open woodland over *Eremophila phyllopoda subsp. obliqua, Acacia tetragonophylla* and *Dodonaea petiolaris* mid open shrubland over *Dysphania rhadinostachya, Bulbostylis barbarta* and *Gomphrena cunninghamii* low open forbland/sedgeland

2. AaSaEs: *Acacia aptaneura* low open woodland over *Senna artemisioides subsp. oligophylla* low sparse shrubland over *Eragrostis setifolia and Eragrostis tenellula* low tussock grassland

3. AaAcTSS: *Acacia aptaneura* and *Acacia cuthbertsonii* subsp. *cuthbertsonii* tall sparse shrubland over *Eremophila cuneifolia* and *Senna artemisioides* subsp. *oligophylla* sparse shrubland over *Ptilotus obovatus* var*. obovatus* low sparse shrubland over *Aristida contorta* and *Sporobolus australasicus* sparse grassland over *Cleome viscosa* sparse forbland

4. AcAc: *Acacia curryana, Senna artemisioides* subsp. *helmsii* and *Eremophila exilifolia* mid sparse shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *dominii* low grassland

5. AcAsCc: *Acacia citrinoviridis* and *Eucalyptus victrix* low open woodland over *Acacia sclerosperma* subsp. *sclerosperma* and *A. cuthbertsonii* subsp. *cuthbertsonii* tall sparse shrubland over **Cenchrus ciliaris* and **C. setiger* mid tussock grassland

6. AcApTSS: *Acacia citrinoviridis, Acacia cyperophylla* var. *cyperophylla* and *Acacia pruinocarpa* tall sparse shrubland over *Aristida contorta* sparse grassland over **Bidens subalternans* var. *simulans* sparse forbland

7. AcEt: *Acacia cyperophylla* var. *cyperophylla* low open woodland over *Eragrostis tenellula*, *Eragrostis cumingii* and *Eriachne aristidea* low tussock grassland

8. ApEeTSS: *Acacia paraneura* and *Eremophila exilifolia* tall sparse shrubland over *Tribulus suberosus* low sparse shrubland over *Bulbostylis barbata* sparse sedgeland

9. ApGbTSS: *Acacia pruinocarpa* and *Grevillea berryana* tall sparse shrubland over *Acacia tetragonophylla* and *Eremophila phyllopoda* sparse shrubland over *Ptilotus obovatus* var. *obovatus, Solanum lasiophyllum* and *Tribulus suberosus* low sparse shrubland over *Bulbostylis barbata* sparse sedgeland over *Aristida contorta* sparse grassland

10. ApSgAc: *Acacia pruinocarpa* and *Grevillea berryana* low open woodland over *Senna glutinosa* subsp. x *luerssenii* and *Eremophila phyllopoda* subsp. *obliqua* mid sparse shrubland over *Aristida contorta* and *Eriachne pulchella* subsp*. dominii* low grassland

11. ArPc: *Acacia ramulosa* var. *linophylla, A. aptaneura* and *A. pruinocarpa* low woodland over *Paspalidium clementii* and *Dysphania rhadinostachya* low grassland/forbland

12. AsAtEcSs: *Acacia synchronicia, Acacia tetragonophylla* and *Eremophila cuneifolia* sparse shrubland over *Ptilotus nobilis subsp. nobilis* low sparse shrubland over *Stemodia grossa* sparse forbland

13. AtGc: *Acacia tetragonophylla, Dodonaea petiolaris* and *Eremophila latrobei* subsp. *latrobei* mid open shrubland over *Gomphrena cunninghamii*, *Aristida contorta* and *Cymbopogon ambiguus* low open forbland/grassland

14. AxEcAc: *Acacia xiphophylla*, *A. synchronicia* and *A. macraneura* low open woodland over *Eremophila cuneifolia, Senna artemisioides* subsp. *oligophylla, S. glutinosa* subsp. x *luerssenii* mid open shrubland over *Aristida contorta* and *Enneapogon caerulescens* low sparse tussock grassland

15. AxTSS: *Acacia xiphophylla* tall sparse shrubland over *Acacia synchronicia, Eremophila cuneifolia* and *Senna artemisioides* subsp. *oligophylla* sparse shrubland over *Sclerolaena cornishiana* chenopod shrubland over *Stemodia grossa* sparse forbland

16. EcBp: *Eremophila cuneifolia* and *Scaevola spinescens* mid sparse shrubland over *Brachyachne prostrata* and *Sclerolaena eriacantha* low sparse grassland/chenopod shrubland

17. EcMgCc: *Eucalyptus camaldulensis* mid woodland over *Melaleuca glomerata* and *Acacia coriacea subsp. pendens* tall shrubland over **Cenchrus ciliaris* mid tussock grassland

18. EeAc: *Eremophila exilifolia*, *Acacia tetragonophylla* and *A. kempeana* mid open shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *dominii* low sparse tussock grassland

19. EfAc: *Eremophila flaccida, Acacia tetragonophylla* and *E. phyllopoda* mid sparse shrubland over *Aristida contorta, Calandrinia* sp. The Pink Hills (F. Obbens FO19/06), *Eriachne pulchella* subsp. *dominii* low grassland/forbland

20. EpAc: *Eremophila phyllopoda* subsp. *obliqua, Acacia tetragonophylla* and *Senna artemisioides* subsp. *helmsii* mid open shrubland over *Aristida contorta*, *Eriachne pulchella* subsp. *dominii* and *Portulaca oleracea* low grassland/forbland

21. EvCc: *Eucalyptus victrix* and *Acacia citrinoviridis* mid open forest over **Cenchrus ciliaris* and **C. setiger* mid tussock grassland

22. Fs: *Frankenia setosa, Sclerolaena medicaginoides* and *Maireana georgei* low open shrubland

23. Mp: *Maireana polypterygia*, *Lawrencia densiflora* and *Eremophea spinosa* low open chenopod shrubland/forbland

Ecological (2017) noted that some vegetation types recorded in the 2017 survey were similar to Ecoscape's (2015) vegetation types as described in **Table 5-3**.

Table 5-3 Similar vegetation types

Ecological (2018) Vegetation type and associated landform	Description	Similar Ecoscape (2015) Vegetation type and associated landform	Description
AsAtEcSS Rocky hardpan plain	*Acacia synchronicia*, *Acacia tetragonophylla* and *Eremophila cuneifolia* sparse shrubland over *Ptilotus nobilis* subsp. *nobilis* low sparse shrubland over *Stemodia grossa* sparse forbland	AsFh Flat	*Acacia synchronicia* and *Eremophila cuneifolia* mid sparse shrubland over *Frankenia hispidula* and *Aristida contorta* low open shrubland/ grassland
AxTSS Calcrete	*Acacia xiphophylla* tall sparse shrubland over *Acacia synchronicia*, *Eremophila cuneifolia* and *Senna artemisioides* subsp. *oligophylla* sparse shrubland over *Sclerolaena cornishiana* chenopod shrubland over *Stemodia grossa* sparse forbland	AxEcAc Flat, low-lying	*Acacia xiphophylla*, *A. synchronicia* and *A. macraneura* low open woodland over *Eremophila cuneifolia*, *Senna artemisioides* subsp. *oligophylla*, *S. glutinosa* subsp. x *luerssenii* mid open shrubland over *Aristida contorta* and *Enneapogon caerulescens* low sparse tussock grassland
VfSS Clay pans	**Vachellia farnesiana* sparse shrubland over *Eriachne flaccida* and *Sporobolus australasicus* grassland over *Alternanthera nodiflora*, *Marsilea hirsuta* and *Stemodia viscosa* sparse forbland	EcBp Flat, low-lying	*Eremophila cuneifolia* and *Scaevola spinescens* mid sparse shrubland over *Brachyachne prostrata* and *Sclerolaena eriacantha* low sparse grassland/chenopod shrubland
AaAcTSS Drainage lines and fringing clay pans	*Acacia aptaneura* and *Acacia cuthbertsonii* subsp. *cuthbertsonii* tall sparse shrubland over *Eremophila cuneifolia*	AaSaEs Minor depression	*Acacia aptaneura* low open woodland over *Senna artemisioides subsp. oligophylla* low sparse shrubland over

Ecological (2018) **Vegetation type and associated landform**	**Description**	**Similar** **Ecoscape (2015)** **Vegetation type and associated landform**	**Description**
	and *Senna artemisioides* subsp. *oligophylla* sparse shrubland over *Ptilotus obovatus* var. *obovatus* low sparse shrubland over *Aristida contorta* and *Sporobolus australasicus* sparse grassland over *Cleome viscosa* sparse forbland		*Eragrostis setifolia and Eragrostis tenellula* low tussock grassland
ApGbTSS Rocky lower slopes	*Acacia pruinocarpa* and *Grevillea berryana* tall sparse shrubland over *Acacia tetragonophylla* and *Eremophila phyllopoda* sparse shrubland over *Ptilotus obovatus* var. *obovatus*, *Solanum lasiophyllum* and *Tribulus suberosus* low sparse shrubland over *Bulbostylis barbata* sparse sedgeland over *Aristida contorta* sparse grassland	ApSgAc Flat	*Acacia pruinocarpa* and *Grevillea berryana* low open woodland over *Senna glutinosa* subsp. x *luerssenii* and *Eremophila phyllopoda* subsp. *obliqua* mid sparse shrubland over *Aristida contorta* and *Eriachne pulchella* subsp. *dominii* low grassland
AcApTSS Minor drainage	*Acacia citrinoviridis*, *Acacia cyperophylla* var. *cyperophylla* and *Acacia pruinocarpa* tall sparse shrubland over *Aristida contorta* sparse grassland over **Bidens subalternans* var. *simulans* sparse forbland	AcEt Creek	*Acacia cyperophylla* var. *cyperophylla* low open woodland over *Eragrostis tenellula*, *Eragrostis cumingii* and *Eriachne aristidea* low tussock grassland

To maintain a conservative approach, these vegetation types have not been combined and are considered individually.

One vegetation type (EcMgCc) represents a Groundwater Dependent Ecosystem (GDE) being characterised by the presence of *Eucalyptus camaldulensis*. Vegetation types, EvCc, EvReMg, AcEt and AcAsCc, represent potential GDEs due to the presence of *Eucalyptus victrix*. This species is dominant in EvCc and EvReMg vegetation types and sometimes present in AcEt and AcAsCc vegetation types.

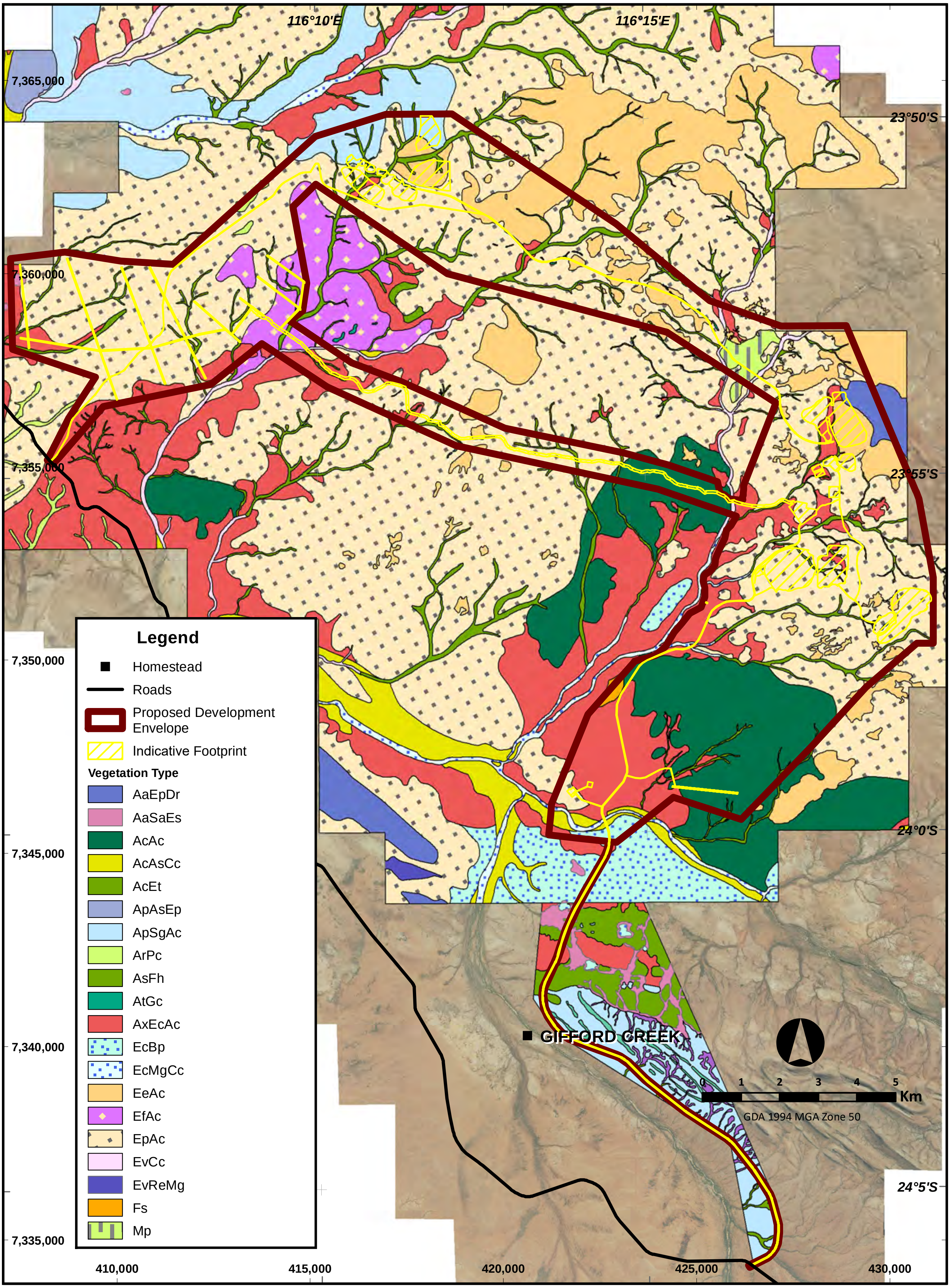
The extent of each vegetation type on a regional and local scale was determined (**Table 5-4**).

No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC), characterised by a vegetation type, were recorded within the study area, and none are listed for the Gascoyne bioregion.

Table 5-4 Regional and local extent of each vegetation type

Vegetation type	Regional (Study area) Ha	Local (Development envelope) Ha	Relative occurrence (%) in the development envelope within the regional extent
AaEpDr	517	99	19
AaSaEs	44	9	20
AaAcTSS	192	2	1
AcAc	3,337	1,578	47
AcAsCc	1,588	62	4
AcApTSS	33	4	12
AcEt	1,967	4	<1
ApAsEp	159	0	0
ApEeTSS	126	5	4
ApGbTSS	876	53	6
ApSgAc	2,649	233	9
ApTSS	72	0	0
ArPc	211	20	9
AsAtEcSs	487	8	2
AsFh	27	0	0
AtGc	22	15	68
AxEcAc	8,079	1,714	21
AxTSS	231	6	3
EcBp	1,063	67	6
EcMgCc	448	47	10
EeAc	4,175	1,162	28
EfAc	2,499	322	13
EpAc	25,723	7,017	27
EvCc	686	47	7

Vegetation type	Regional (Study area) Ha	Local (Development envelope) Ha	Relative occurrence (%) in the development envelope within the regional extent
EvReMg	43	0	0
Fs	29	21	72
Mp	279	113	41
VfSS	20	0	0



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PER_F5-3_Vegetation.mxd
12 June 2018

Vegetation Types

Figure 5-3

5.3.3 Introduced species

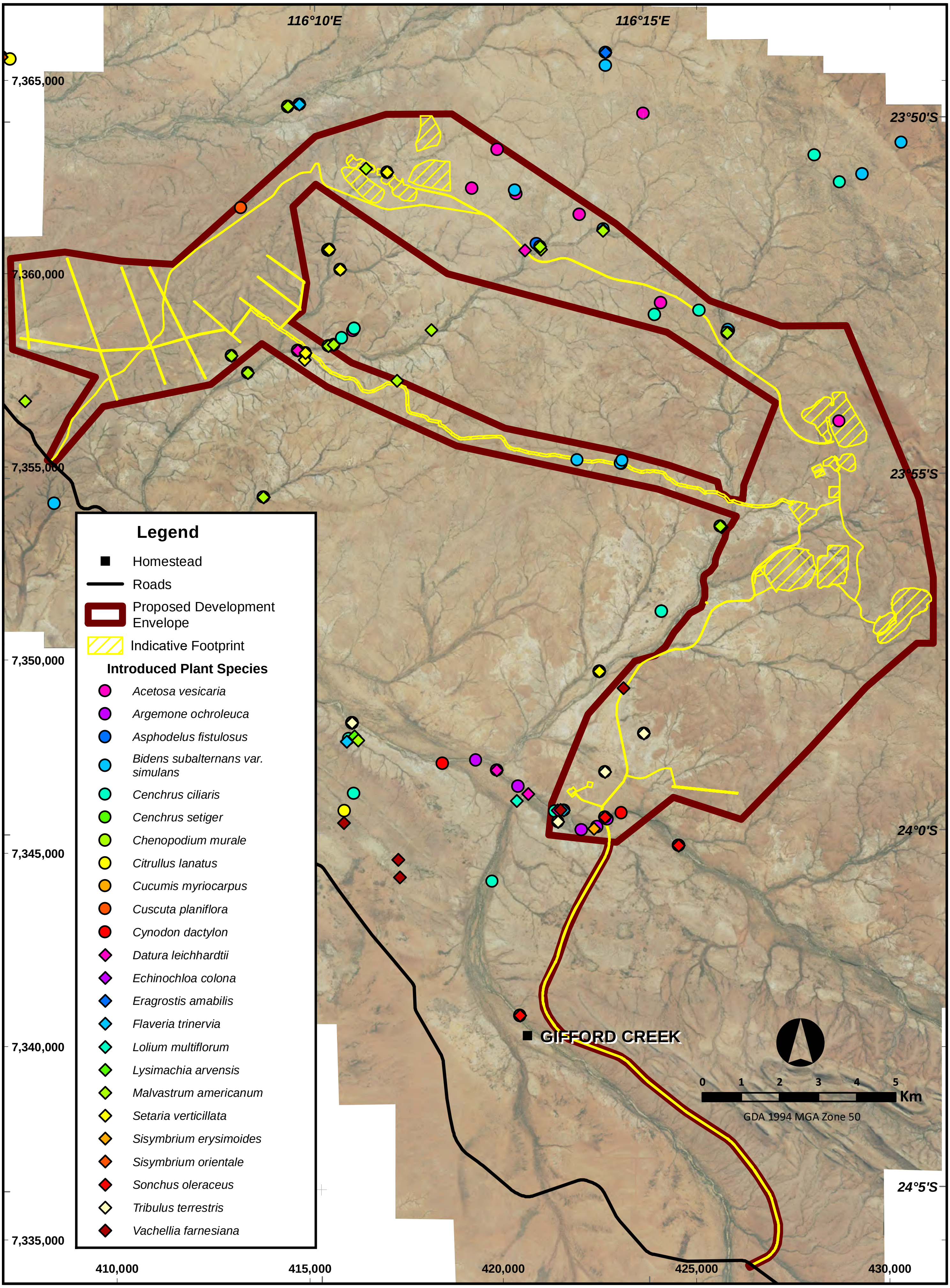
Baseline mapping of weed affected areas over the regional study area (including the development envelope) was conducted (**Figure 5-4**). The weed assessment did not include the homestead area. The homestead area is the likely distribution point for 24 weed species recorded and mapped over the survey area. Given the homestead area is close to the Lyons River and Gifford Creek, and the on-going movement of station vehicles to and from the homestead and across the Proposal area, and the degraded nature of the land from historical and current cattle grazing, it is expected that any weeds would likely have already established and been recorded. However, Hastings will in future assess the area immediately surrounding the homestead for weed species (with permission from Bagden Pty Ltd). The access road (as requested by Badgen Pty Ltd) has also been designed to avoid the immediate homestead area during the construction and operations phase, which will in turn reduce the risk of spreading weed species that occur within the immediate vicinity of the homestead as a result of Hastings activities. In addition, Hastings will not be utilising station equipment during the construction and operations phases due to the scale of the Proposal activities and will have its own fleet. Twenty-four introduced plant species exist in the study area:

- *Acetosa vesicaria* (Ruby Dock)
- *Argemone ochroleuca* (Mexican Poppy)
- *Asphodelus fistulosus* (Onion Weed)
- *Bidens subalternans* var. *simulans*
- *Cenchrus ciliaris* (Buffel Grass)
- *Cenchrus setiger* (Birdwood Grass)
- *Chenopodium murale* (Nettle-leaf Goosefoot)
- *Citrullus lanatus* (Pie Melon)
- *Cucumis myriocarpus* (Prickly Paddy Melon)
- *Cuscuta planiflora*
- *Cynodon dactylon* (Couch)
- *Datura leichhardtii* (Native Thornapple)
- *Echinochloa colona* (Awnless Barnyard Grass)
- *Eragrostis amabilis* (Awnless Barnyard Grass)
- *Flaveria trinervia* (Speedy Weed)
- *Lolium multiflorum* (Italian Ryegrass)
- *Lysimachia arvensis* (Pimpernel)
- *Malvastrum americanum* (Spiked Malvastrum)
- *Setaria verticillata* (Whorled Pigeon Grass)
- *Sisymbrium erysimoides* (Smooth Mustard)
- *Sisymbrium orientale* (Indian Hedge Mustard)
- *Sonchus oleraceus* (Common Sowthistle)
- *Tribulus terrestris* (Caltrop)
- *Vachellia farnesiana* (Mimosa Bush)

Two species are listed as Declared Pests under the WA *Biosecurity and Agriculture Management Act 2007* (BAM Act): *Argemone ochroleuca* (Mexican Poppy); and *Datura leichhardtii* (Native Thornapple) are classified as C3 (management) for the Upper Gascoyne. Under the BAM Act, C3 organisms should have some form of management applied that will alleviate the harmful impact, reduce the numbers or distribution, or prevent/contain the spread of the pest.

None of the introduced species recorded in the study area are included on any of the weed lists maintained by the Department of the Environment and Energy, nor Weeds Australia.

Only one introduced species, *Malvastrum americanum* (Spiked Malvastrum), rates above 'moderate' according to the *Weed Prioritisation Process for DPaW (WA) Midwest rankings summary* (DPAW 2013 quoted in Ecoscape 2015). The Spiked Malvastrum is classified as 'very high'.



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PER_F5-4_Weeds.mxd
12 June 2018

Introduced Plant Species

Figure 5-4

5.4 POTENTIAL IMPACTS

Potential impacts include:

- The proposal includes clearing of up to 1,000 ha of native vegetation.
- Clearing of vegetation units considered to have high local significance such as Ground Dependent Ecosystems (GDE), and riparian vegetation.
- Removal and disturbance to conservation significant flora and vegetation.
- Increased risk (altered fire regime) for fire resulting in vegetation loss or change.
- Radiation exposure to flora and vegetation
- Changed hydrology (quality and quantity of surface water) negatively impacting downstream vegetation.
- Introduction and spread of weeds that outcompete native vegetation.
- Loss of the native seed bank from the areas cleared.

5.5 ASSESSMENT OF IMPACTS

5.5.1 Significant flora and vegetation

Consideration of significant flora or vegetation, as defined in the EPA's Environmental Factor Guideline for Flora and Vegetation (2016) includes:

Flora

- Flora being identified as threatened or priority species: Hastings has identified eight Priority flora species within the survey area.
- Flora that are locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems): There is one Groundwater Dependent Ecosystem (GDE) and two potential GDEs (as defined by the presence of *Eucalyptus vitrix*) within the survey area.
- New species or anomalous features that indicate a potential new species: One undescribed species (*Elacholoma sp.* 'Showy Flowers') was recorded in the survey area but outside of the Proposal development envelope.
- Representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range): Of the 58 species considered to be range extensions, four were Priority flora species (*Acacia curryana*, *Solanum octonum*, *Wurmbea fluviatilis*, and *Goodenia nuda*). Ecoscape (2015) highlight that the high number of range extensions is likely due to the lack of flora surveys within the Gascoyne Region.
- Unusual species, including restricted subspecies, varieties or naturally occurring hybrids: No unusual species were recorded.
- Relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape: No species were identified to have a relictual status.

Vegetation

- Being identified as threatened or priority ecological communities: No vegetation type was identified as a threatened or priority ecological community within the survey area.
- Restricted distribution: No vegetation type was identified with a restricted distribution.

- Degree of historical impact from threatening processes: The vegetation condition of the majority of the survey area (71%) was considered to be in excellent despite large scale land degradation from pastoralism in the Gascoyne Region. There are no other mining projects within 100 km of the Proposal and thus cumulative impacts have not been considered.
- A role as a refuge: Rivers and creeks, characterised by the GDE vegetation types, are considered important refuge to fauna.
- Providing an important function required to maintain ecological integrity of a significant ecosystem: GDE vegetation types are considered important to maintain the ecological integrity of the river and creek ecosystems.

The following sections focus on impacts to significant flora and vegetation, specifically priority flora (section 5.5.3) and vegetation types that represent groundwater dependent ecosystems (section 5.5.4), respectively.

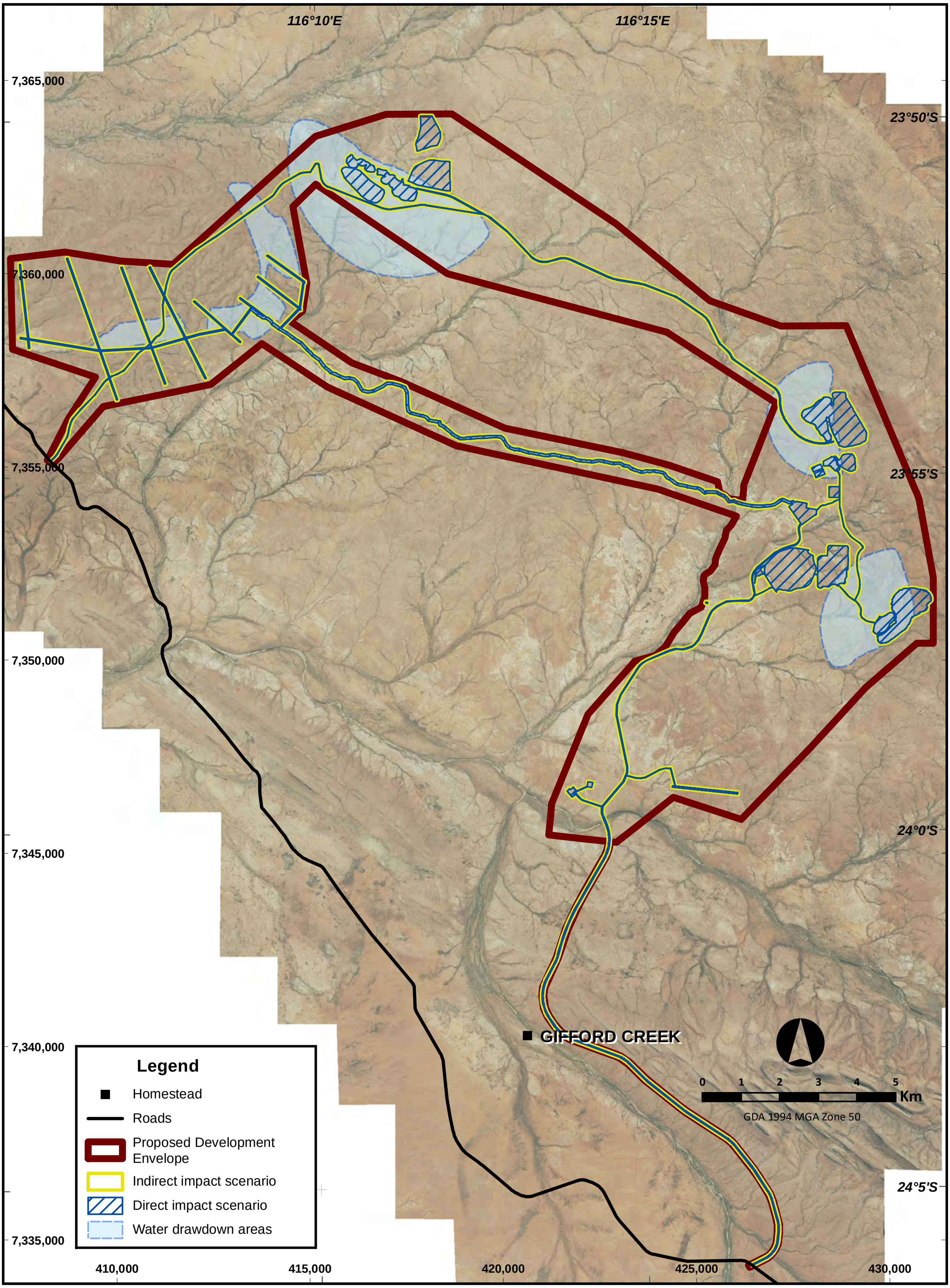
5.5.2 Approach

Hastings has maintained a conservative assessment of potential impacts listed above. The 'worst case' impact scenario includes the following considerations:

- Direct impacts associated with the disturbance footprints
- Indirect impacts assume a 20m buffer around disturbance footprints for:
    - no proactive avoidance of Priority flora during clearing or pipe laying activities;
    - no active management to prevent, manage or monitor weed species allowing introduction of and initial establishment of weed species. Weed species are likely to occur on disturbed areas within the Proposal area without any form of mitigation;
    - minor incidents associated with 'unauthorised' clearing or driving on undisturbed ground;
    - dust deposition on areas immediately surrounding roads;
    - minor hydrocarbon spills; and
    - localised and unanticipated erosion events that require remediation activities involving ground disturbance.
- Possible water drawdown impacts to potential Groundwater Dependent Ecosystems (GDEs) within the drawdown contours of pit dewatering and water abstraction activities. There is a level of uncertainty as to whether water drawdown will impact the potential GDEs, and thus a conservative approach assumes an impact will occur.

While Hastings intent is to mitigate the likelihood of the occurrence of indirect impacts, the above-listed indirect impacts are common to mine sites in Western Australia and acknowledged with the inclusion of a 20m buffer in this assessment.

The area of impact under a worst-case scenario is shown in **Figure 5-5**.



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Impact scenarios

PER_F5-5_Impact_Scenario.mxd
27 August 2018

Figure 5-5

5.5.3 Flora

The Proposal will not impact any threatened flora species or threatened ecological community. Furthermore, the Proposal will not change the conservation status of the four Priority flora species occurring within the Development Envelope (**Table 5-5**).

A total of 1,245 *Acacia curryana* (P1) individuals occur within the disturbance footprint under a worst-case scenario. A total of 7,754 plants were recorded in approximately 34 populations within the study area. Under a worst-case scenario, the Proposal may impact 1,245 individuals in 14 populations representing 16% of the total recorded number in the study area. Of these, 950 *A. curryana* individuals (12%) occur within the water pipeline corridor – direct impacts can be avoided and the access track will only be used to service the bore field during operations and thus indirect impacts can be easily managed.

A total of 12 *Rhodanthe frenchii* (P2) individuals from three populations occur within the disturbance footprint under a worst-case scenario. A total of 1,690 plants were recorded within the broader study area. Under a worst-case scenario, the Proposal may impact 0.7% (12) of individuals in the study area.

While eight and nine populations of *Sporobolus blakei* (P3) and *Wurmbea fluviatilis* (P2), respectively, occur within the survey areas, only one population of each species occurs within the Development Envelope, and none occur within the disturbance footprint under a worst-case scenario. No individuals of these species will be impacted by the Proposal.

Table 5-5 The number of plants, and the number of populations of plants, to be impacted (directly and indirectly) in a 'worst case' scenario

	Acacia curryana	*Rhodanthe frenchii*
# individual plants		
Number in study area	7,754	1,690
Worst case scenario		
Direct impact	95	12
Indirect impact	1,150	0
Total	1,245	12
# populations~		
Number in study area	34	19
Worst case scenario		
Direct impact	7	1
Indirect impact	7	0
Total	14	1

~ Populations were defined as plants less than 500 m apart as per the *Threatened and Priority Flora Report Form – Field Manual* (DEC 2010). Some populations are only partially impacted.

5.5.4 Vegetation

None of the vegetation types recorded in the study area represent a component of a Priority Ecological Community or Threatened Ecological Community.

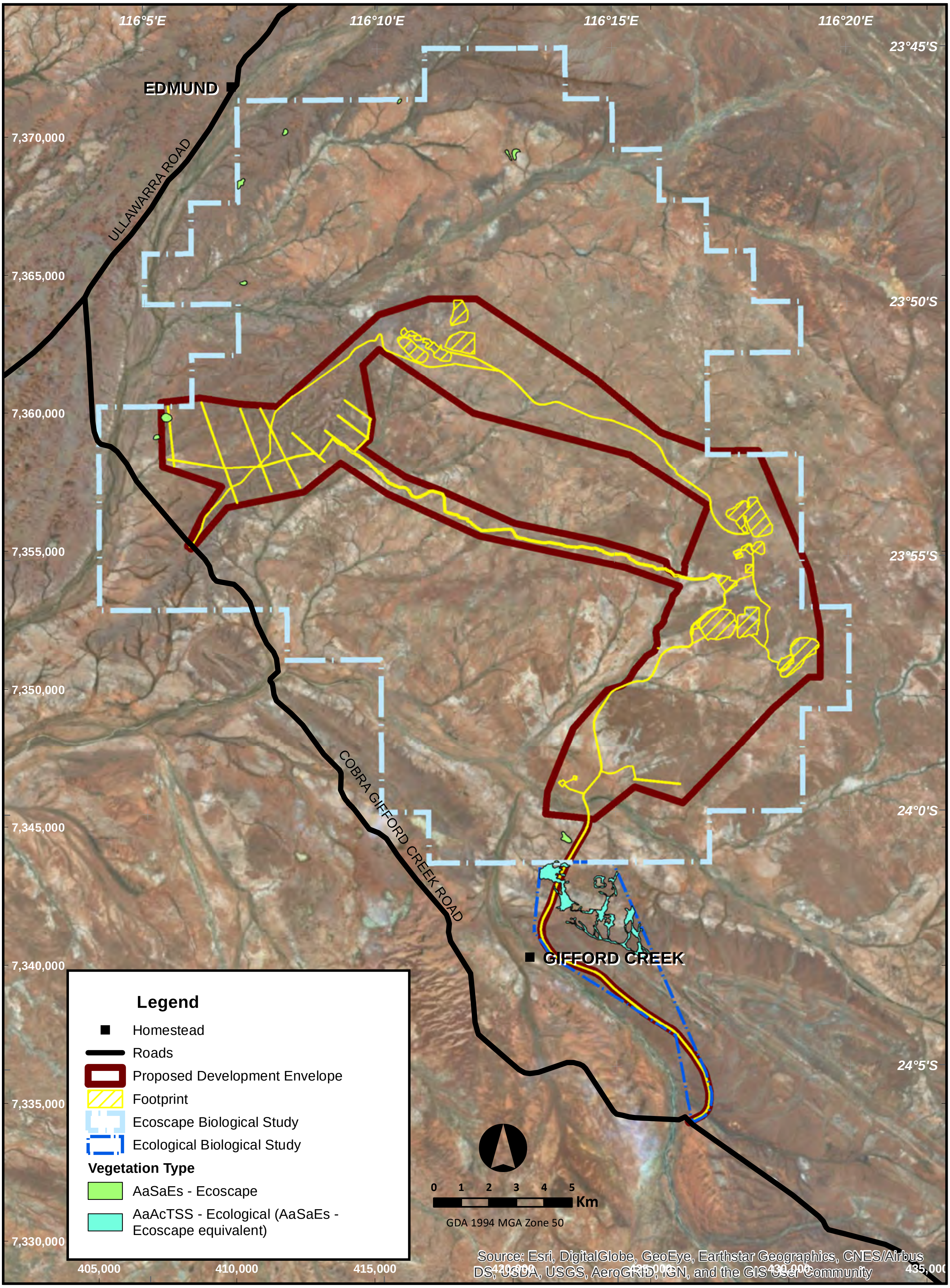
None of the mapped vegetation types are restricted to the proposed development footprint. Vegetation type AtGc has the highest proportion of its total extent within the worst-case scenario impact footprint (9 ha; 42%), followed by EfAc (333.2 ha; 13.3%), and AcApTSS (4.3 ha; 13.1%) (**Table 5-6**). Approximately 25% (5.6 ha) of vegetation type AtGc is directly impacted by the Proposal, however, 17% (3.6 ha) of this vegetation type occurs within the 20m buffer. Furthermore, this vegetation type is not specifically representative of the habitat of any conservation significant flora or fauna species.

Table 5-6 Impacts to vegetation types under a 'worst case' scenario

Vegetation type	Total area (ha) in the study area	Worst case scenario			
		Direct Impact (ha)	Indirect Impact (ha)	Total Impact (ha)	% impact
AaEpDr	517	4.3	1.1	5.4	1.0
AaSaEs	44	0.8	1.1	1.8	4.2
AaAcTSS	192	1.1	1.6	2.7	1.4
AcAc	3,337	27.1	24.7	51.8	1.6
AcAsCc	1,588	0.4	0.6	1	0.1
AcApTSS	33	1.8	2.5	4.3	13.2
AcEt	1,967	35.6	160.2	195.8	10.0
ApAsEp	159	0	0	0	0
ApEeTSS	126	2.1	3.1	5.2	4.1
ApGbTSS	876	24.8	35.2	60.0	6.8
ApSgAc	2,649	37.3	114.9	152.2	5.7
ApTSS	72	0	0	0	0
ArPc	211	0	19.7	19.7	9.4
AsAtEcSs	487	3.6	5.0	8.6	1.8
AsFh	27	0	0	0	0

Vegetation type	Total area (ha) in the study area	Worst case scenario			
		Direct Impact (ha)	Indirect Impact (ha)	Total Impact (ha)	% impact
AtGc	22	5.6	3.6	9.2	42.0
AxEcAc	8,079	99.8	166.0	265.8	3.3
AxTSS	231	2.7	3.9	6.6	2.9
EcBp	1,063	5.1	7.2	12.3	1.2
EcMgCc	448	0.5	0.8	1.3	0.3
EeAc	4,175	158.2	148.7	306.8	7.3
EfAc	2,499	0.0	333.2	333.2	13.3
EpAc	25,723	577.3	2049.3	2626.6	10.2
EvCc	686	1.2	1.3	2.5	0.4
EvReMg	43	0	0	0	0
Fs	29	0	0.1	0.1	0.2
Mp	279	2.3	4.5	6.8	2.4
VfSS	20	0	0	0	0

As noted in section 5.3, two vegetation types were categorised using only one quadrat instead of two quadrats. Only 20% of AaSaEs (Ecoscape 2015) and 1% of the equivalent AaAcTSS (Ecological 2018) occur within the development envelope (**Figure 5-6**). The Proposal will impact (direct and indirect) 4.2% and 1.4% of the extent of AaSaEs and AaAcTSS vegetation types, respectively. In addition, 72% of the Fs vegetation type (Ecoscape 2015) occurs within the development envelope with only a minor impact (direct and indirect) of 0.2% of its extent (**Figure 5-7**).



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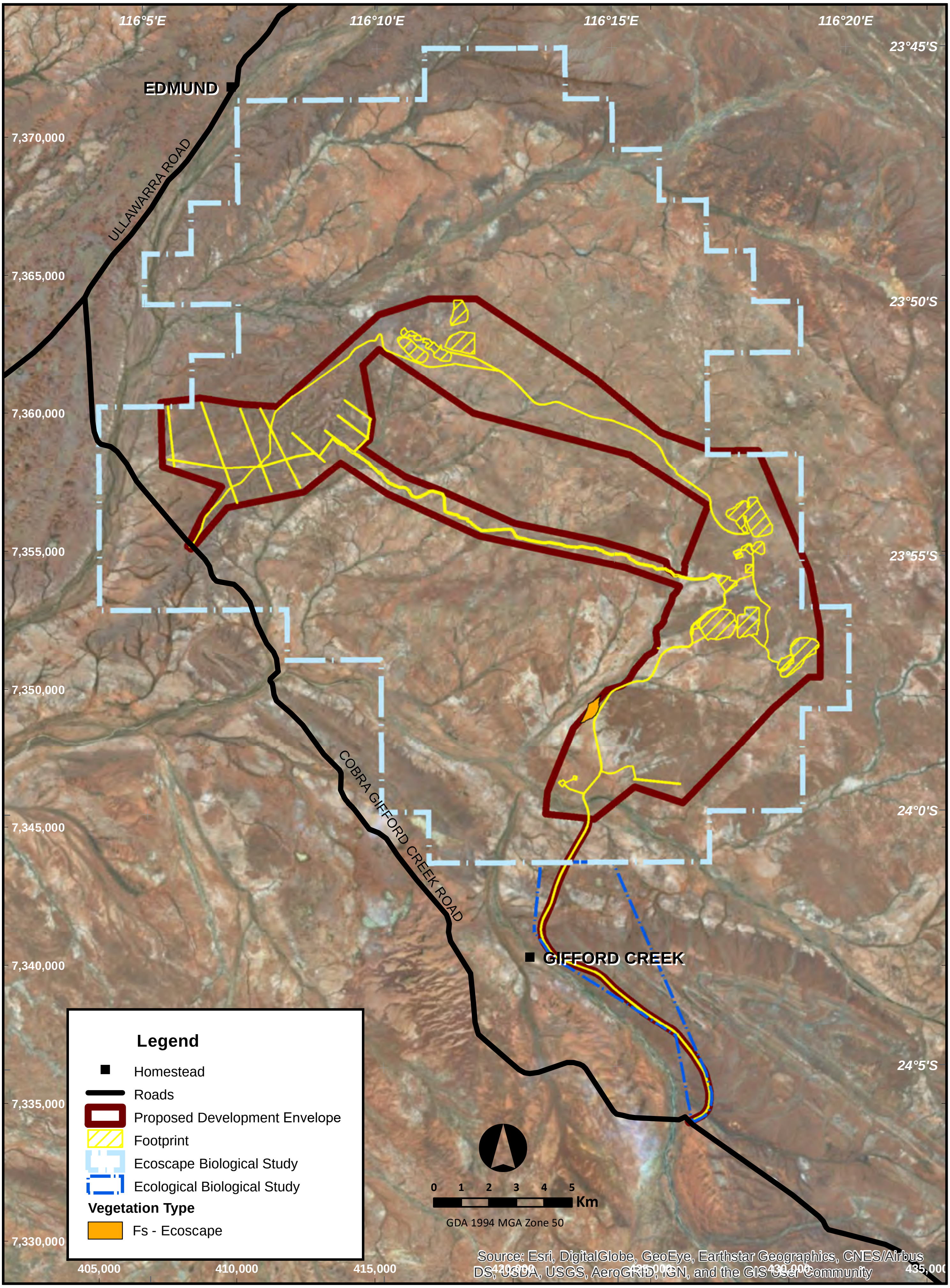
PER_F4_Veg_AaSaEs.mxd
07 September 2018

AaSaEs Vegetation Type

Figure 5-6



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PER_F4_Veg_Fs.mxd
07 September 2018

Fs Vegetation Type

Figure 5-7

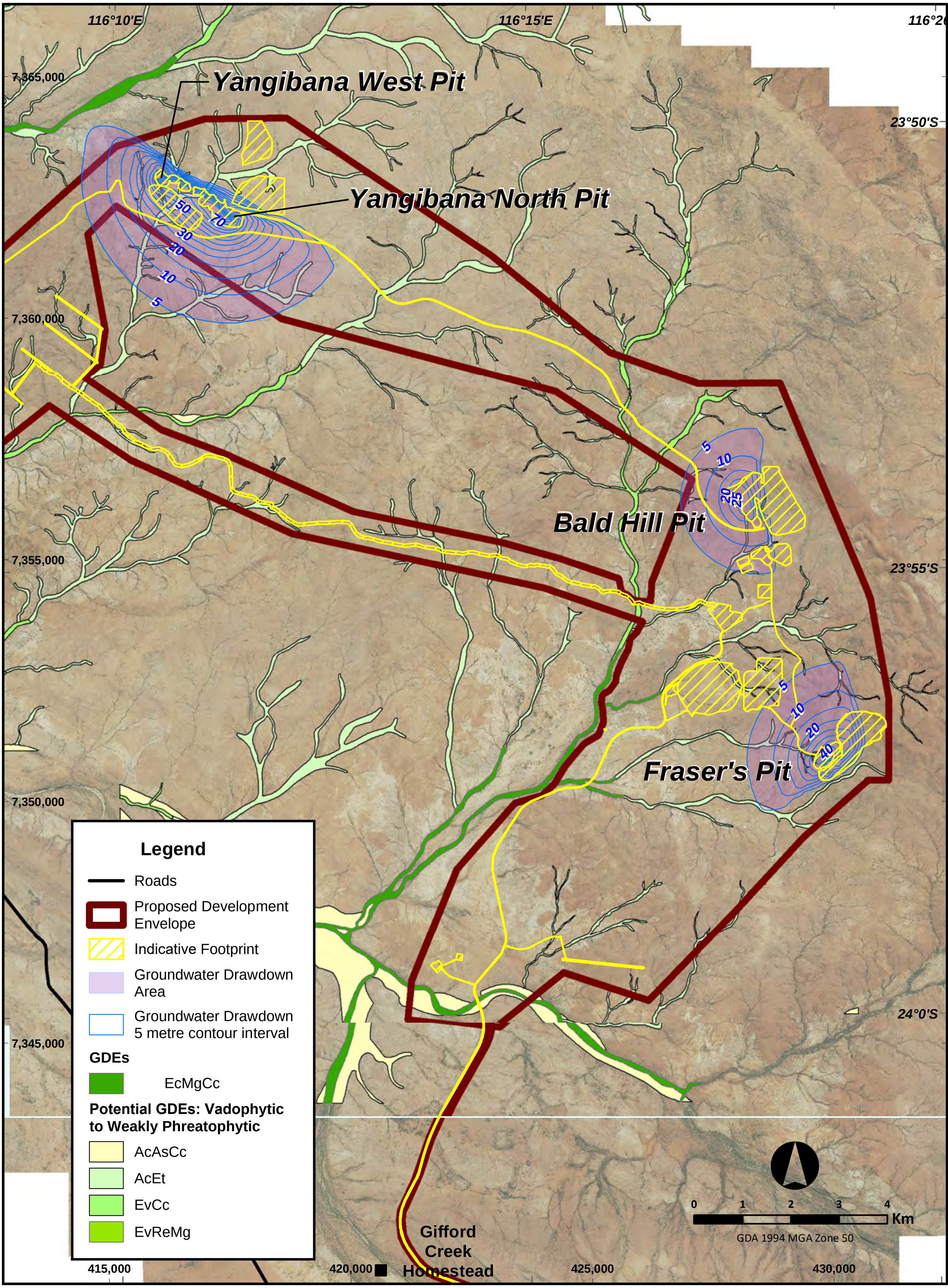
The one vegetation type (EcMgCc), which represents a Groundwater Dependent Ecosystem (GDE), is minimally impacted as a result of direct and indirect impacts (1.3 ha; 0.3%) and while protected by a 150m heritage exclusion buffer on either side of the Lyons River and Frasers Creek, there are locations where two roads and the water pipeline cross the river and creek. This vegetation type will not be impacted by water drawdown from the borefield or pit dewatering. The Lyon's River crossing represents a direct impact of 0.1% (0.5ha) and an indirect impact of 0.13% (0.5ha) to the EcMgCc vegetation type.

A 'worst case' scenario impact (direct and indirect) of 0.4% (2.55 ha) and 10% (195.8 ha) may occur to two vegetation types, EvCc and AcEt, that represent potential GDEs (due to the presence of *Eucalyptus vitrix*, respectively. Only 1.2 Ha of the total mapped extent (686 Ha) of EvCc will be directly impacted, whereas 1.3 Ha may be indirectly impacted. EvCc does not occur within the drawdown contours from water abstraction neither at the borefield nor pit dewatering.

Thirty-five hectares (1.9%) of the total mapped extent (1,967 Ha) of AcEt will be directly impacted. Potential indirect water drawdown impacts from pit dewatering and water abstraction at the borefield may occur to AcEt (160.2 ha or 8.1%), which intersects the modelled post mining drawdown in the immediate surrounds (**Figure 5-8** and **Figure 5-9)**. The extent of the post-mining drawdown occurs over an area of 433 ha at Bald Hill (19.0 Ha of AcEt), 514.5 ha at Frasers (20.1 Ha of AcEt) and 1241.5 ha at Yangibana (99.2 Ha of AcEt) resource areas and 514 ha at the SipHon Well Borefield (21.9 Ha of AcEt). Ecoscape (2017; Appendix 1-3) reports:

> *The AcEt vegetation type is primarily dominated by Acacia cyperophylla which is not known or considered to be a groundwater dependant species. This vegetation type was only occasionally observed to contain scattered or isolated individuals of Eucalyptus victrix; more commonly this species was absent. Therefore, it is considered unlikely that the AcEt vegetation type represents a groundwater dependant ecosystem, at least in most cases. The potential impact of post mining groundwater drawdown on GDE's is therefore considered likely to be negligible or nil.*

Ecoscape's conclusions also apply to drawdown from the SipHon Well Borefield, which also contains the AcEt vegetation type.



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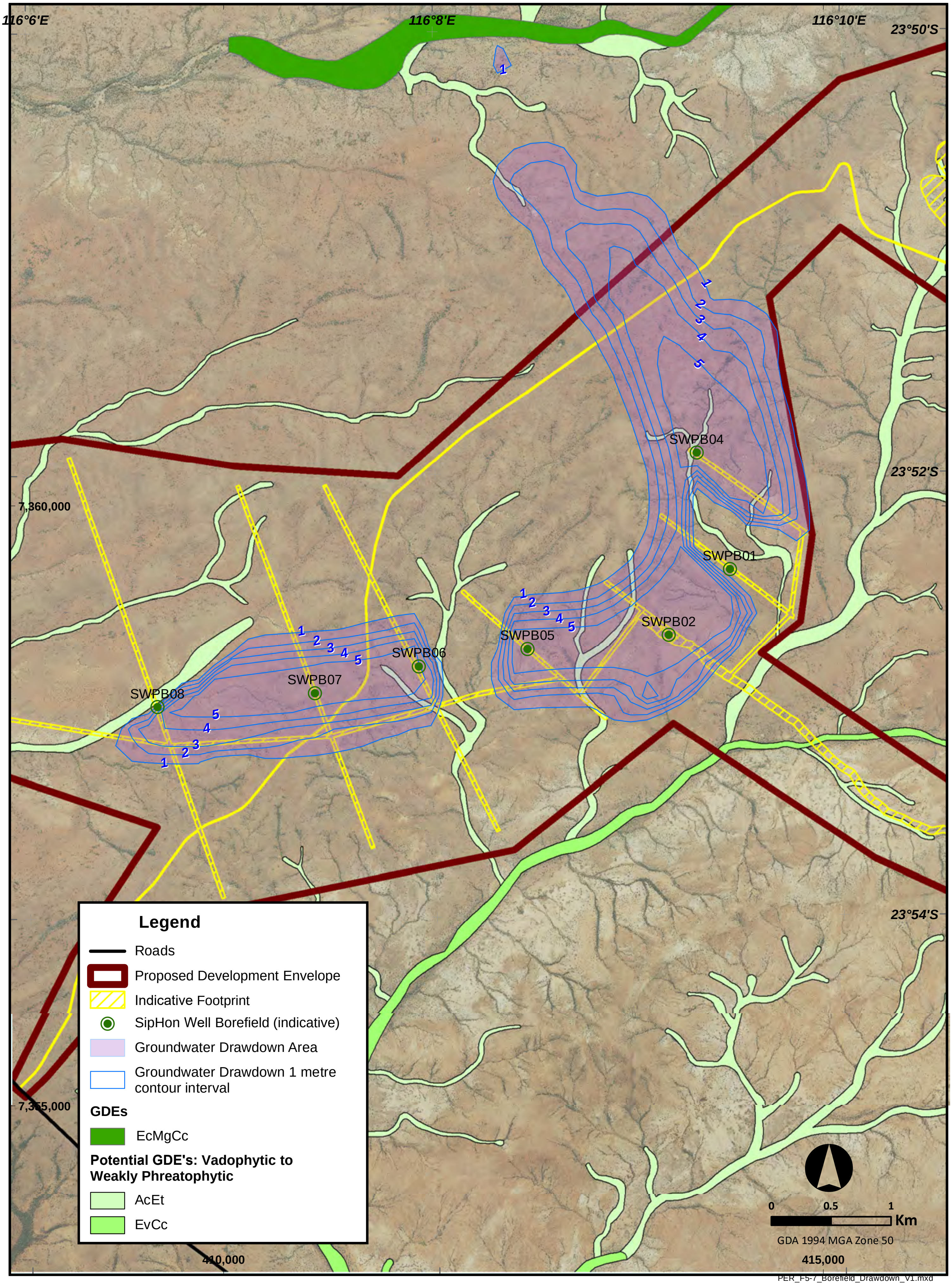
PER_F5-6_BH-F-Y_Pits_Drawdown.mxd
12 June 2018

Fraser's, Bald Hill, Yangibana West and North Pits dewatering drawdown contours (life of mine)

Figure 5-8



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YANGIBANA RARE EARTHS PROJECT

Siphon Well Borefield End dewatering drawdown contours (life of mine)

Figure 5-9

5.5.5 Radiological assessment

The ERICA Software Tool is used for assessing radiological impacts to plants and animals. The software uses the change in media radionuclide concentrations and concentration ratios in species, derived from studies, to provide a measure of radiological impact to reference species. The intake of radionuclides is a function of the quantity of radionuclides in the soil and the rate of uptake. For this ERICA assessment (JRHC 2016; Appendix 5-6), the maximum media concentration was used, and a Tier 2 level assessment was undertaken.

All dust emissions conservatively assume the source is mineralised dust, which has an average uranium concentration of 27 parts per million (ppm) and average thorium concentration of 450 ppm. In practice, a significant proportion of the emitted dust will be non-mineralised. At these concentrations, there will be approximately 0.3 Bq/g of each radionuclide from the uranium decay chain (U238) and 2 Bq/g of each long-lived radionuclide in the thorium decay chain.

The radionuclides are in secular equilibrium (as they are naturally) and remain in secular equilibrium for all waste streams except those tailings to be stored in TSF 3 and the evaporation pond (Appendix 5-5). The radionuclides are closely tied to the minerals/tailings material and levels of radionuclides in tailings pore water are below 1 Bq/g, i.e. they are not classified as radioactive in all waste streams. It can safely be assumed that all TSFs will leak to some degree, however, additional design controls such as lining the facilities with clay (all TSFs) and liners (i.e. bituminous for TSF 3 and HDPE liner for the evaporation pond) will prevent seepage (Appendix 6-3, Section 9.5 and Appendix 5-9). Therefore, flora and vegetation will not be exposed to seepage water.

The focus of the ERICA assessment is, therefore, on fugitive mineralised dust emissions. The two important inputs for an ERICA assessment are:

- Operationally derived changes in media concentration, which is the additional radionuclide concentration in either soils or waters attributable to the operation and is in units of Bq/kg or Bq/l; and
- Radionuclide concentration ratios, which are the ratios of radionuclide concentrations in the media and concentrations in flora and fauna.

A level 2 ERICA assessment was conducted to determine radiological impacts to flora and vegetation. The assessment method produces a dose rate, which is compared to a 'screening level', i.e., the level below which no effects would be observed. The default ERICA level is set at 10 µGy/h (ARPANSA 2010). The output of the assessment showed that a 10 µGy/h screening level was not exceeded. The level of exposure for grasses and herbs was 0.005 µGy/h and trees were less than 0.001 µGy/h. Therefore, the ERICA assessment indicated that there will be no radiological risk of impact on reference plants from potential emissions from the Proposal.

5.5.6 Cumulative impacts

In the region, there are no other mining activities within a 100 km radius of the Project area. Locally, it is not specifically known what impact the underlying land use of pastoralism has had on the land, other than to cause widespread degradation of the semi-arid landscape in general through the introduction of weeds and overgrazing by introduced ungulates. However, 71% of the Project area is classified as 'excellent' during botanical surveys and thus historical land management could be considered as sound in the survey area.

Land clearing of tracks and pads has also occurred for exploration and feasibility studies required to define the Proposal, specifically mineral and water exploration activities. Clearing of up to 1000 ha will directly impact flora and vegetation as result of implementing the Proposal. However, previously cleared tracks and pads are utilised, where possible. For example, the water pipeline corridor will utilise an existing track and the water borefield was also partially implemented as a component of water exploration studies.

In addition, indirect impacts to flora and vegetation (assuming no application of a mitigation hierarchy) have the potential to occur due to the proposal activities:

Altered drainage

Annual flood events occur over the proposal area with water draining into Fraser Creek and then the Lyon's River. Linear infrastructure is known to obstruct water flow, without the correct engineering controls in place, often causing a 'shadow effect' on one side and inundation on the other side. Loss of flora and vegetation will often occur where there is a 'shadow effect'.

The Proposal access road currently has a Bed and Banks Permit to cross the Lyon's River and drainage lines. A condition of the Bed and Banks Permit is "*The permit holder is to comply with designs and specifications submitted to the department with the application...*" Detailed engineering designs of drainage crossings were submitted to the DWER and approved as a component of the Bed and Banks Permit for the access road. It is assumed the same condition of Bed and Banks Permits will be applied for the remainder of the Proposal areas. However, despite this Permit condition, sheet flow will likely be obstructed by linear infrastructure.

In addition, the presence of 'plains' soils indicate that there are components of the Proposal that are susceptible to erosion. Due to the highly degraded nature of the Gascoyne River catchment in general (as described by Wadell et al 2012), **Table 5-7** lists land types according to their susceptibility to erosion. Much of the Project footprint occurs on low hills and stony plains, although there are areas such as the Lyon's River crossing where the land type is classified as river plains or alluvial plains. These areas generally correspond to those areas mapped as the 'Plains' soil type.

Table 5-7 Land type susceptibility to accelerated erosion in the Gascoyne River catchment

Susceptibility to accelerated erosion	Land type
Major	Mesas and breakaways
	Wash plains on hardpan
	Alluvial plains
	River plains
Moderate	Low hills
	Stony plains
	Calcrete platforms
Minor	Hills and ranges
	Sandy plains, sandplains and occasional dunes
	Coastal plains, cliffs, dunes, mudflats and beaches

(Wadell et al 2012)

Changes in water quality

Chemical use and hydrocarbons may potentially be spilt in small quantities, which have the potential to impact soil and water quality. In addition, pit void lakes often become saline post-closure due to lack of water flow and high evaporation rates resulting in a saline water. Furthermore, seepage from TSFs also have the potential to change the water quality, specifically for TSF 3, which contain tailings from the hydrometallurgy process. Site selection for the TSF's have targeted a area that is underlain by competent granite bedrock of very low permeability. Seepage modelling, based on data and parameters measured from detailed site investigation, demonstrates vertical seepage will not occur through the bedrock to the groundwater table and lateral seepage does not extend beyond the toe of the return water pond (discussed further in Chapters 6 and 8).

Spread of weeds

Weeds are often distributed by humans (although this depends on the weed species and how their seeds are dispersed i.e. wind, water, animals). For example, most weeds are first observed along road corridors. Seeds carried to site in mud and crevices on vehicles or equipment will be distributed by vehicle and mobile plant movement. While 24 existing weed species occur in the survey area, presumably introduced by historical pastoral activities, there is the potential to introduce new species. Ground disturbance and clearing, and storage of topsoil, also provide suitable habitat that promotes germination and establishment of weed species (new and existing), and thus has the potential for a greater abundance of weed species on-site.

Fragmentation of vegetation

Where cumulative and intense development occurs, or where there are limited areas of certain vegetation types, clearing activities can cause fragmentation of vegetation. This is not the case for this proposal. There are no other mining developments in the near vicinity, and no vegetation types are specifically restricted to the Development Envelope.

Altered fire regime

It is well known that the Australian landscape is adapted for infrequent bush fires, often caused naturally by lightning strikes. However, the frequency of fire may increase because of human activities, e.g. cigarette butts, hot exhaust pipes, and hot works, during construction and operation of the Proposal. The impact of an increased frequency in fire may result in a change in the structure and composition of vegetation types because some species respond favourably to fire while others do not. Regardless, impacts are likely to be localised and minimal due to safety precautions which form standard practice in mining.

Dust

Ambient dust is common in this environment. Fugitive dust generation from mining activities (i.e. blasting, movement of ore, crushing of ore) is inevitable. Many plant species have adapted to cope with dust deposition on their leaf surfaces, however there is a limit to the dust loading that plants will tolerate before adverse impacts occur (i.e. blocking of stomata preventing photosynthesis and resulting in death of the plant). Impacts of dust loading are often observed in areas immediately alongside roads where there is frequent vehicle movement.

5.6 Mitigation

Hastings commits to the following mitigation of potential impacts:

Best Practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- Minimise land disturbance to meet operational requirements only.
- Progressive rehabilitation, where possible.
- Design, construction and operation of TSFs in accordance with relevant standards and guidelines.
- Detailed engineering design of linear infrastructure to ensure surface drainage is not obstructed.
- Bald Hill (BH) pit size has reduced to a BH West and BH East (satellite pit).

Avoidance

Hastings will avoid potential impacts by:

- Avoid clearing populations and individual plants of Priority flora species and GDE's, where possible.
- 150 m exclusion zone on either side of Fraser Creek and Lyons River.
- Hastings has utilised proposed mining areas for borrow pits for minor or preliminary works i.e. access road construction and process plant earthworks.
- Existing exploration tracks have been utilised where possible i.e. access along water pipeline, access to borrow pits.

Minimisation

Hastings will minimise potential impacts as follows:

- Groundwater abstraction from fractured rock aquifers is self-limiting.
- Water reuse to reduce the water requirements of the Proposal.
- Water harvesting from pit sumps during the operational phase will reduce water required from the SipHon Well Borefield over the medium-long term.
- Practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the development envelope including:
    - development envelope has been refined and reduced at the location of the access road; and
    - the disturbance area of the Waste Rock Landforms (WRLs) have been reduced by designing them to be taller (without compromising their integrity or resulting in erosion).

Management

The following management plans and associated documentation will be implemented to mitigate potential risks of impact to flora and vegetation:

- The groundwater operating strategy (as a component of water licence applications) for the borefield will include consideration of:
    - monitoring water abstraction;
    - water quality monitoring;
    - groundwater level monitoring;
    - monitoring bores;
    - GDE health monitoring; and
    - contingency planning.
- Topsoil stockpile management to retain viability of local provenance native seedbank.
- Flora and vegetation management plan, including:
    - management of existing weeds and prevention of the introduction and establishment of weed species (not currently present in the development envelope);
    - ground disturbance procedure to ensure delineation of clearing boundaries and topsoil management;
    - dust suppression;
    - chemical and hydrocarbon management, with reference to storage and spill clean-up in the Land Management Plan; and
    - fire prevention, with reference to bush fire management procedures in the Emergency Response Plan.

Rehabilitation

Implementation of progressive rehabilitation will occur, where possible, during the operational phase of the Project. While progressive rehabilitation and closure will be prioritised, the relatively short life of mine and sequential nature of mining deposits will limit these opportunities to exploration activities, Waste Rock Landforms (WRLs), final voids and associated disturbance, following the cessation of mining activity in each area. Disturbance associated with exploration activities also represents opportunities for progressive rehabilitation.

Progressive rehabilitation will enable opportunities to undertake trials, reduce the Project's financial liability under the Mining Rehabilitation Fund (MRF), and demonstrate to key stakeholders Hastings commitment to meet the social and environmental licence to operate.

Progressive rehabilitation will be implemented as determined in the Preliminary Mine Closure Plan (Appendix 6) including the following considerations:

- Topsoil and subsoil storage and locations in preparation for progressive rehabilitation.
- Progressively shape, contour and spread suitable soils on WRLs.
- Establish diversion drains at the toe of the WRLs.

- Rehabilitation of auxiliary roads that are no longer in use.
- Rehabilitation with vegetation composed of native species of local provenance, including:
    - seed collection from representative species in the surrounding vegetation;
    - determine seed treatment methods to break seed dormancy (e.g. burial, smoke, temperature) and/or seed enablement technologies (e.g. coating, pelleting);
    - preparation of site for rehabilitation (e.g. erosion controls, topsoil application, fertiliser application);
    - implementation of the rehabilitation procedure, including sowing when moisture availability is at its highest; and
    - monitoring of rehabilitation success and lessons learned.
- Rehabilitation of drill pads that are no longer in use including capping of holes, sumps backfilled, soil ripped and reseeded.

5.7 PREDICTED OUTCOME

5.7.1 Residual impacts

Following the mitigation of potential impacts, it is expected that no more than 1000 Ha of vegetation will be cleared. Risks of indirect impacts are mitigated as shown above using the mitigation hierarchy.

No impacts to rare flora or threatened species will occur. Direct impact to two priority flora species is considered insignificant: Only 1.2 % and 0.7 % of *Acacia curryana* and *Rhodanthe frenchii* plants, respectively. Application of the mitigation hierarchy will ensure indirect impacts are a low risk.

There are no Threatened Ecological Communities present nor Priority Ecological Communities (as defined by vegetation associations). No regional vegetation associations will be cleared below the 'threshold level' of 30% of its pre-clearing extent.

5.7.2 Offsets position

Application of the residual impact significance model (EPA 2014), outlining how significance will be determined and when an offset is or may be required, in relation to flora and vegetation, includes consideration of relevant clearing principles in Schedule 5 of the EP Act:

- Clearing Principle (c) Rare flora: There are no rare flora. Therefore, residual impacts are not significant.
- Clearing Principle (d) Threatened ecological communities: There are no TECs. Therefore, residual impacts are not significant.
- Clearing Principle (e) Remnant vegetation: There is no remnant vegetation. Therefore, residual impacts are not significant.
- Clearing Principle (f) Wetlands and waterways: There are no conservation significant wetlands or waterways, however the proposal occurs relatively close to the Lyon's River where there are Groundwater Dependent Ecosystems (GDEs). There will not be significant impacts to GDEs. Therefore, residual impacts are not significant.

- Clearing Principle (h) Conservation areas: There are no conservation areas near the Proposal. Therefore, residual impacts are not significant.
- Clearing Principle (a) High biological diversity: There are no areas recognised as having high biological diversity. Therefore, residual impacts are not significant.

In conclusion, no offsets are required for the key environmental factor, flora and vegetation.

5.7.3 EPA objective

Due to an understanding of the existing environment through flora and vegetation surveys, identification and assessment of potential impacts and application of the mitigation hierarchy, it is concluded that the EPA's objective has been met for this environmental factor:

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

HYDROLOGICAL PROCESSES AND INLAND WATERS ENVIRONMENTAL QUALITY

Chapter 6

6 KEY ENVIRONMENTAL FACTOR: HYDROLOGICAL PROCESSES AND INLAND WATERS ENVIRONMENTAL QUALITY

6.1 OBJECTIVE

The EPA objective for hydrological processes is:

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

The EPA objective for inland waters environmental quality is:

To maintain the quality of groundwater and surface water so that environmental values are protected.

6.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of inland waters environmental quality include:

Country Areas Water Supply Act 1947 (WA)

Environmental Protection Act 1986 (WA)

Rights in Water and Irrigation Act 1914 (WA)

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

Mining Act 1950 (WA)

Waterways Conservation Act 1976 (WA)

Waterways Conservation Regulations 1981 (WA)

Relevant guidelines include:

ANZECC and ARMCANZ (2000) Australian and New Zealand guidelines for fresh and marine water quality;

DFAT (2016) Water Stewardship - Leading Practice Sustainable Development Program for the Mining Industry;

DMP and EPA (2015) Guidelines for Preparing Preliminary Mine Closure Plans;

DoW (2009a) Hydrogeological reporting associated with a groundwater well licence;

DoW (2009b) Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs;

DoW (2011) Use of operating strategies in the water licencing process;

DoW (2013a) Western Australian Water in Mining Guideline;

DoW (2013b) Use of mine dewatering surplus;

DoH (2013) System compliance and routine reporting requirements for small community water providers;

EPA (2016g) Environmental Factor Guideline: Hydrological processes;

EPA (2016h) Environmental Factor Guideline: Inland waters environmental quality;

Johnson and Wright (2003) Mine void water resource issues in Western Australia, Hydrogeological Record Series HG9;

NHMRC and ARMCANZ (1996). Australian drinking water guidelines; and

WRC (2000) Water Protection Guidelines No. 11 Mining and Mineral Processing: Mine dewatering.

6.3 Receiving environment

The following studies have informed this section:

- Soils Assessment Report (Landloch 2016; Appendix 5-2)
- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment Fractured Rock Aquifers II (GRM 2018a; Appendix 4-2)
- Hydrogeological Assessment Paleochannel (GRM 2018b; Appendix 4-2)
- Surface Water Assessment Report (JDA 2016; Appendix 4-3)
- Geotechnical Assessment (ATC Williams 2017; Appendix 5-9)
- Leach Testwork Assessment (Trajectory and Graeme Campbell and Associates 2018; Appendix 5-12)

The Proposal is located on the upland areas of the regional Gascoyne River catchment, which occurs within the Gascoyne Surface Water Proclamation Area and the Gascoyne Groundwater Proclamation Area under the *Rights in Water and Irrigation Act 1914* (WA).

6.3.1 Sensitive receptors

There are no wetlands of international importance within the development envelope nor near the Proposal.

The sensitive receptors in the near vicinity of the Proposal area are, ecosystems associated with surface and groundwater and pastoral bores, as follows:

- Riparian vegetation specifically groundwater dependent ecosystems (GDEs) characterised by the presence of *Eucalyptus camaldulensis*.
- Ephemeral pools.
- A network of shallow calcrete aquifers, which provide habitat to a stygofauna community of the Gifford Creek Priority Ecological Community.
- Three pastoral bores near to Proposal activities, namely Fraser Bore, Yangibana Bore and Edmund Bore.

6.3.2 Geology

The Project is located within the Gascoyne Province of the Capricorn Orogen, bounded by the Archean Yilgarn Craton to the south, the Archean Pilbara Craton to the north, and the Phanerozoic Carnarvon Basin to the west (Martin *et al.* 1994 in GRM 2018).

The predominant lithology in the area is the Durlacher Supersuite granites, which comprise the Pimbyana Granite, the Dingo Creek Granite, the Yangibana Granite and several other un-named units. The suite mainly consists of monzogranite and granodiorite, with lesser syenogranite and minor amounts of tonalite and rare gabbro. Within the Project area, the granites contain rafts of older sedimentary rocks, and intrusive dykes. The primary mineralisation occurs in narrow, regionally extensive ferrocarbonatite/ironstone veins (GRM 2018).

The dykes carry anomalous rare earths within the monazite mineralisation. The dykes are a younger intrusive phase, which has cross cut slightly older ferrocarbonatite dykes, possibly leaching and upgrading rare earths minerals (and base metals). The carbonatite dykes (which form the Gifford Creek Carbonatite Complex), along with associated fenitic alteration, are likely sourced from a carbonatite intrusion at depth (GRM 2018).

Large, extensive palaeodrainage networks incise the bedrock and are comprised of thick sequences of fluvial clay and sand. The palaeovalleys are no longer functional surface water systems and are typically overlain by Quaternary alluvium, which also includes the sediment of the modern drainages. As a result, the palaeovalleys generally occur beneath the river and creek systems, although often do not occur in the exact same locations. The Quaternary alluvium includes calcrete deposits, which typically occur on the flanks of the modern drainage systems (GRM 2018).

The majority of the palaeodrainage valleys across Australia were formed during the Permian continental glaciation. They were then further developed at the end of the Cretaceous when Australia was rifted from Antarctica. Then an associated epeirogeny uplift resulted in the development of inset-valleys within the precursor Permian valleys. The palaeodrainage systems of today are the remnant Early Cenozoic inset valleys with an Early to Middle Tertiary sedimentary infill, overlain by a thin Quaternary cover (Magee 2009 in GRM 2018).

6.3.3 Climate

The semi-arid to arid transitional climate in the Gascoyne Region is affected by winter (June to July) and summer rainfall (January to March). Rainfall in the Gascoyne region occurs from two types of meteorological events:

- Rare and high intensity rainfall resulting from tropical cyclonic activity.
- Frequent, lower intensity rainfall resulting from low pressure systems, localised thunderstorms or tropical upper air disturbances.

Inland climatic conditions are more extreme than those experienced near the coast. However, rainfall is unreliable from year to year and extremely variable and successive years with below average rainfall occur frequently (Wadell et al 2012).

The Bureau of Meteorology (BoM) climate mapping provides an overall indication of the historical climate conditions across Australia. This mapping has been utilised to provide an overview of the expected climatic description for the Project area and summarised in **Table 6-1**.

Figure 6-1 Climate summary

Mapping	Description
Major seasonal rainfall zone – climate class	Arid, low rainfall
Climate zone based on temperature and humidity	Hot dry summer, mild winter
Average annual rainfall	200-300 mm
Average annual pan evaporation	2800-3000 mm

The nearest weather station has been installed (2015 -) at the Proposal, specifically 10 km northeast of the accommodation village. The site is subject to northern monsoon influences over the summer and early autumn period, and southern frontal influences in late autumn and winter. There are two periods of higher rainfall from January to April and June to July, and a drier period from August to December (**Figure 6-1**).

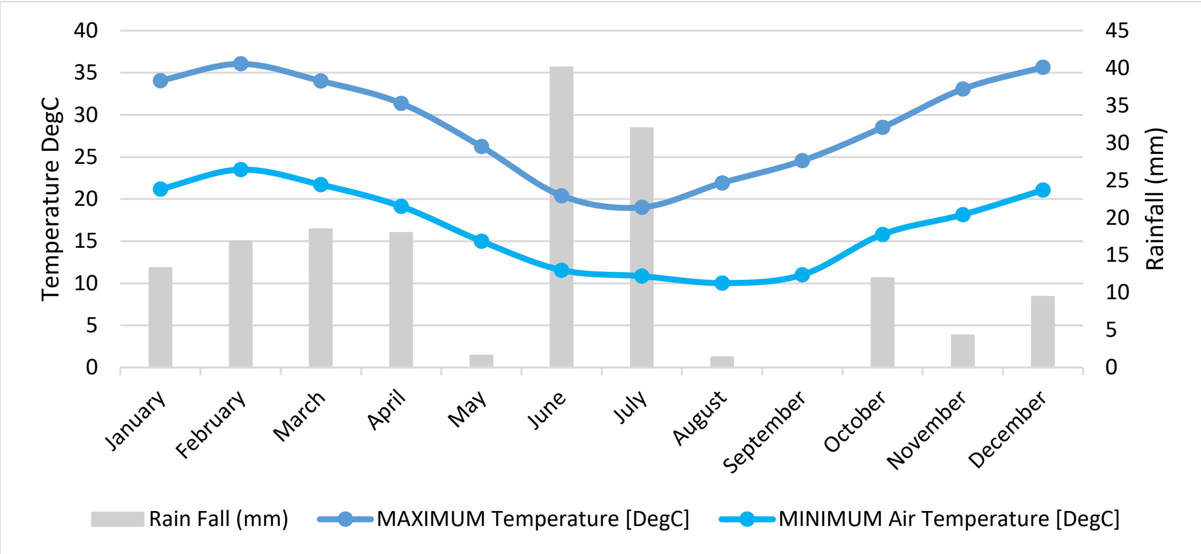


Figure 6-2 Monthly rainfall and daily maxima and minima for the Yangibana Project (2017)

The Yangibana weather station received above average annual rainfall in 2017 of 308 mm although average annual rainfall for the region is between 210 and 278 mm. February has the highest temperatures with a mean maximum of 40.5°C and mean minimum of 26.4°C. July temperatures are the lowest ranging from a mean maximum of 21.3°C to a mean minimum of 11.3°C.

The nearest registered Bureau of Meteorological (BoM) weather station with long-term data is Wanna (station number 7028), located approximately 12 km south of the Project (GRM 2018b). The station has a 98% complete data set for the 63-year period between the 1st of January 1946 and the 31st of October 2009. Mean monthly rainfall data from Wanna (station number 7028), is provided in **Table 6-2**. The data from Wanna indicates that the average annual rainfall is around 240 mm, with the highest rainfall occurring from January to March, closely followed by May and June rainfall events.

Evaporation data were recorded at Paraburdoo (station number 7178), located 160 km north east of the Project, and Learmonth Airport (station number 5007), 290 km north west of the Project. The data from Paraburdoo and Learmonth has been scaled, based on distance to the Project, to develop an estimate of average monthly evaporation for Yangibana (**Table 6-2**). The pan evaporation exceeds mean monthly rainfall in all months of the year, with the total annual evaporation being well over an order of magnitude higher than the annual rainfall.

Figure 6-3 Long Term Average Rainfall (63 year period) derived from Wanna and Evaporation Data recorded from Paraburdoo (scaled for the Yangibana Project)

Month	Wanna (BoM station 7028)	Paraburdoo (BoM station 7178) adjusted
	Mean Monthly Rainfall (mm)	**Mean Monthly Pan Evaporation (mm)**
January	32.5	411
February	59.0	365
March	32.3	335
April	18.1	272
May	25.3	187
June	32.0	137
July	18.9	147
August	10.1	191
September	2.7	261
October	3.0	346
November	3.3	396
December	7.7	427
Annual Total	**240.2**	**3,475**

6.3.4 Hydrology

6.3.4.1 Catchments

The Proposal is located within a regional Gascoyne River catchment (80,400 km^2). The Lyon's River is its most prominent tributary, which drains the northern part of the catchment, and joins to the Gascoyne River just east of the Kennedy Range. The Proposal is situated at the base of the Lyon's River catchment (11,000 km^2; JDA 2016).

The Gascoyne River catchment is generally in poor condition, as characterised by a loss of plant cover, few perennial plants and ongoing soil loss. The poor condition rating has been in effect at least since the 1960s and possibly the 1930s due to historical overgrazing by pastoral activities (Waddell et al. 2012).

The Lyons River, a tributary of the Gascoyne River, is associated with the southern portion of the study area and flows in a north-westerly direction (**Figure 6-2**). The Edmund River, a tributary of the Lyons River, traverses the western edge of the Proposal area and flows in a southerly direction. Both rivers are ephemeral, and only flow after rainfall. Semi-permanent pools occur along their length. Several tributaries of these rivers traverse the study area: Yangibana Creek and Fraser Creek are the main tributaries of the Lyons River, which occur within the Proposal area and flow in a southerly direction.

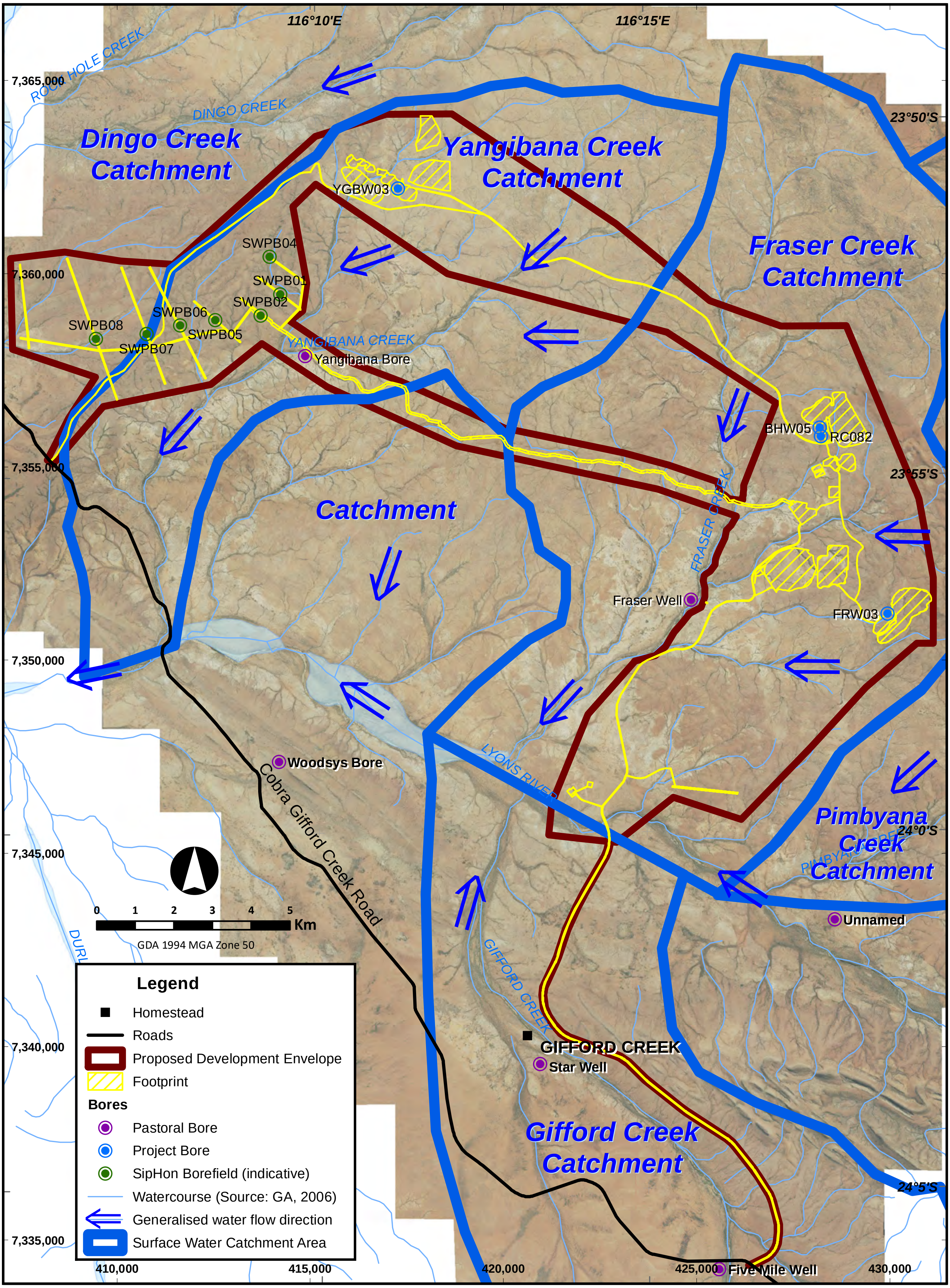
The soils of the local catchment areas are predominantly shallow sandy loams overlying weathered granite or clayey loams (Landloch 2016). This limits the capacity for rainfall infiltration into the soil and with a lack of vegetation cover is prone to erosion.

The Proposal is situated within several smaller catchments, which form components of the larger Lyons River catchment. The Proposal access road crosses the Lyons River, which itself is located about 10 km south of the Project mining areas. The Lyons River flows south-westward, ultimately discharging into the Gascoyne River. Several smaller creeks, including Fraser Creek and Yangibana Creek cross the Project site in a roughly north to south direction, discharging into the Lyons River (GRM 2018).

The proposed Fraser's and Bald Hill pits are located within the Fraser Creek Catchment, which covers an area of just over 150 km^2. The proposed Yangibana North and Yangibana West pits are located within the Yangibana Creek Catchment (to the west of the Fraser Creek Catchment), which is slightly larger, covering an area of almost 200 km^2 (GRM 2018).

The Edmund River, located to the west of the Project comprises several smaller catchments, including Dingo Creek Catchment (344.4 km^2), Rock Hole Creek Catchment (85.6 km^2) and the Upper Edmund Creek Catchment (830.3 km^2). The Edmund River discharges to the Lyons River (GRM 2018).

The river and creeks are ephemeral and only flow following rainfall although semi-permanent pools occur along their lengths. Two semi-permanent pools occur within 5-10 km of the Proposal.



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Water catchments and water flow direction

PER_F6-2_Water_Flow.mxd
18 June 2018

Figure 6-2

6.3.4.2 Peak flows

Under a 100-year annual return interval (ARI) rainfall event, the peak flow in the Lyons River was modelled to be 747.2 m^3/s and the maximum velocity was modelled to be 2.7 m/s (**Table 6-3**).

Figure 6-5 Predicted peak flows in the Lyon's River based on the Annual Exceedance Probability (AEP) and the Annual Return Interval (ARI)

AEP (%)	ARI (year)	Peak flow (m^3/s)	Maximum velocity (m/s)
18	5	23.6	0.7
10	10	32.0	0.8
5	20	155.1	1.9
2	50	454.8	2.6
1	100	747.2	2.7

(JDA 2016)

The road crossings at the Lyons River and Fraser Creek will be constructed as floodways across the natural streambed inverts. As a result, during the 1% Annual Exceedance Probability (AEP; 100-year ARI), a road closure period of up to 68.4 hours across the Lyon's River (labelled as FW2) is predicted for light and heavy vehicles. Of all crossings assessed by JDA (2016), the Lyons River crossing is likely to be inundated for the longest duration (2.5 days) following events exceeding the 18% AEP (5-year ARI; JDA 2016).

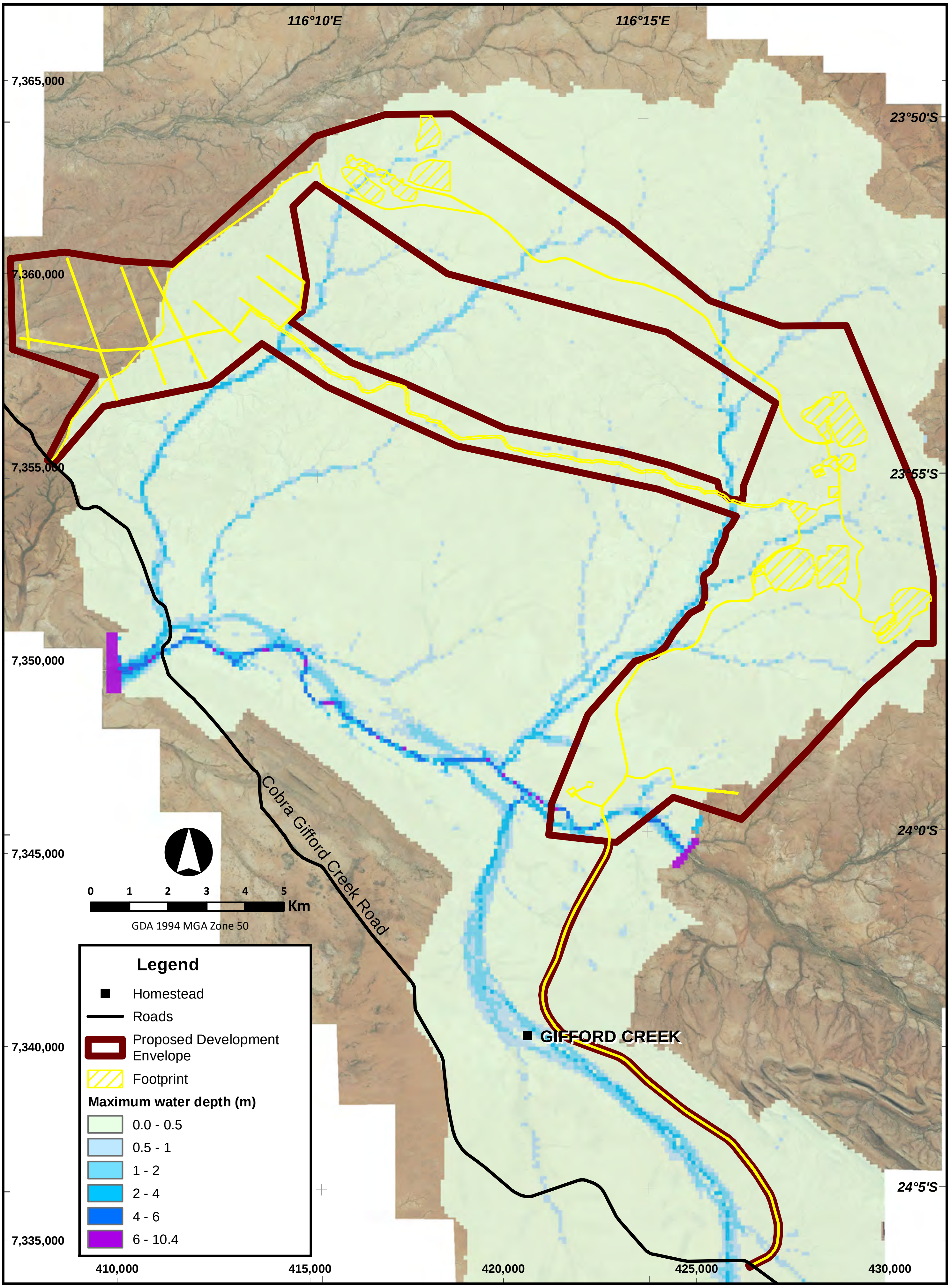
The majority of infrastructure (processing plant, ROM pad, TSFs) occurs on the upland side of the Fraser Creek catchment near FW4. At this location, a small tributary of the Frasers Creek bisects the process plant and the Tailings Storage Facilities (TSFs). The process plant and TSF's are in areas that is well outside the influence of flooding from the Frasers Creek or its tributaries. The flow in the Frasers Creek tributary during a 100-year ARI event is predicted to be 129.7 m^3/s with a maximum velocity of 1.1 m/s (JDA 2016).

6.3.4.3 Flood modelling

A detailed hydrological model has been developed for Fraser, Yangibana and Gifford Creeks, as well as the Lyons River adjacent to the study area, to assess flood conditions that will likely impact on the proposed mine infrastructure (JDA 2016). Peak flows for the 18% to 1% AEP; 5, 10, 20, 50, 100-year ARI events and the probable maximum precipitation (PMP) were estimated for the Proposal and for the Lyons River Catchment using a two-dimensional (2D) hydrodynamic flood model (MIKE21FM) rain on grid approach. The detailed model allowed for accurate delineation of flood extent, depth (i.e. drying depth, flooding depth and wetting depth), flow rates and velocities. **Figure 6-3** shows flood mapping for the 100-year ARI event. The modelling resulted in the following conclusions:

- Most mining areas and infrastructure occur in locations outside of flood impact areas.
- The linear infrastructure traverses the alignment of minor ephemeral drainage courses.
- Flood waters from Yangibana Creek, Frasers Creek and Lyons River traverse either the main access road or the haul road. Floodways' will be constructed relatively flush with the natural creek invert resulting in road closure during flood events.

- No notable drainage paths are located within the processing plant or TSF’s areas.
- The Yangibana West mining area footprint occurs in the upper reaches of Yangibana Creek within minor tributaries. Surface water flows occur within ephemeral drainage lines in south-west direction. The waste rock landforms and open pits are exposed to surface water flow from a natural drainage line. Diversion of this drainage line is required to protect the integrity of proposed waste rock landforms and to prevent flooding of the open pits.



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Flood mapping for a 100-year Annual Return Interval rainfall event

PER_F6-3_100yr_ARI_Rainfall.mxd
18 June 2018

Figure 6-3

6.3.5 Hydrogeology

The Proposal area and surrounds is located within the Bangemall/Capricorn Groundwater subarea of the Gascoyne Groundwater area. Groundwater resources within the subarea comprise alluvium, calcrete, palaeochannel and fractured rock aquifers (Global Groundwater 2016).

The hydrogeology of the area is characterised by a westerly draining system, consistent with the surface water regime. Superficial sediment cover is typically thin, with thicker sequences confined to the creek beds and drainage systems. Calcrete units up to about 30 m thick can occur along the major drainage lines (Global Groundwater 2016).

Groundwater occurrences within the area predominantly occur as fractured bedrock aquifers, whereby permeability in the natural rock is enhanced by fracturing, dissolution and chemical weathering. Away from the fractures permeability in the bedrock is low. Modest supplies can also occur in calcrete aquifers, where the calcrete units are sufficiently thick to extend below the water table. Small amounts of groundwater can occur in alluvium associated with the larger drainage systems. However away from the larger drainage systems the alluvium is typically of insufficient depth to extend below the water table (Global Groundwater 2016).

Large, extensive palaeodrainage networks incise the bedrock, comprising thick sequences of fluvial clay and sand. Palaeovalleys' are no longer functional surface water systems. They are, however often overlain by Quaternary alluvium, which includes the sediment of the modern drainages. The Quaternary alluvium includes calcrete deposits, which typically occur on the flanks of the modern drainage systems (GRM 2018).

The nature of rainfall in the region produces periods of high runoff to creeks and rivers. This in turn produces sporadic recharge to permeable units (e.g. permeable alluvium and calcrete along the drainages or where fractured basement rocks contact surface drainage lines, in areas where the runoff is concentrated). Groundwater recharge by direct infiltration of rainfall over the superficial units or fractured outcropping rocks will likely be minor (Global Groundwater 2016).

Field investigations were undertaken by GRM since 2017 to estimate the dewatering requirements for the proposed pits and assess a water supply potential from fractured rock aquifers (GRM 2018a), as well as a palaeochannel tributary (SipHon Well Borefield; GRM 2018b). The calcrete aquifers associated with the Gifford Creek PEC were not assessed as a potential water source.

6.3.5.1 Fractured rock aquifers

The fractured rock aquifers form a component of the vuggy ironstone which hosts the target ore body. The fractured rock component of the Proposal comprises:

- A pit dewatering assessment.
- Pit lake modelling post-closure.
- A fractured rock water supply investigation was undertaken to target fractured rock aquifers away from the pit areas, at Auer North and the Western Belt. The Western Belt lies between Bald Hill and Yangibana and comprises an area of approximately 12 km of ironstone strike length. Targets were identified along the Western Belt using Electrical Resistivity Imaging (ERI) to define cross cutting structural features along the ironstone. One test production bore was installed, and test pumped which reported low yields (1 to 2 L/s). The focus of the water supply investigation was then shifted to target palaeochannel aquifers (Section 6.3.5.2 below).

Field investigations comprised:

- Six exploration drill-holes.
- 12 airlift recovery tests.
- The installation and test pumping of two test production bores.

The production bores installed at Fraser's and Bald Hill deposits targeted a thickened sequence of ironstone, which will be suitable as a construction and operational water supply for the project. The bores were test pumped for a period of 48 hours. The analysis of the test pumping data indicates a yield of 6 L/sec and 8 L/sec for the Fraser's and Bald Hills bores, respectively.

The field investigation indicates that the depth to groundwater in the pit areas are approximately 309 mRL at Fraser's, 316 mRL at Bald Hills and 323 mRL at Yangibana.

Modest groundwater inflows are likely, which will be associated with an aquifer unit comprising the vuggy ironstone veins which host the orebody. The ironstone veins strike in a north south direction in Fraser's and Bald Hills, swinging to a north-west south-east direction at Yangibana. The ironstone veins dip steeply to the west (or south west at Yangibana), extending above the water table on the up-dip side. The veins are thought to extend down dip and along strike from each of the pits.

The permeability away from the ironstone structures is low to very low. Analysis of the airlift recovery data indicates the hydraulic conductivity of the aquifer averages about 2.5 m/day at Fraser's to 5 m/day at Bald Hill and Yangibana. The thickness of the aquifer varies from 1 m to over 10 m thick, with an average thickness of about 5 m at Fraser's and 4 m at Bald Hills and Yangibana.

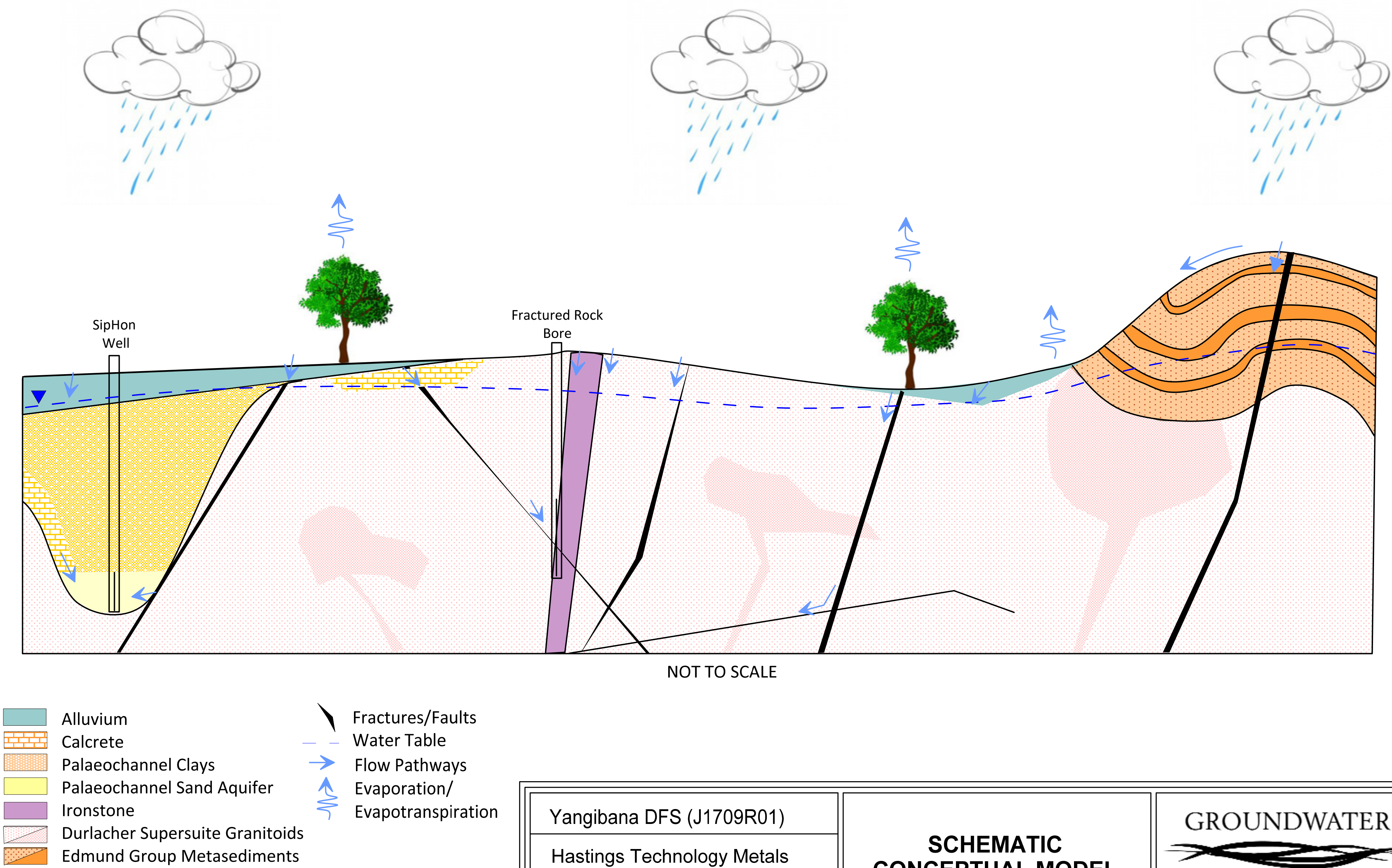
A conceptual model of the fractured rock aquifer is provided in **Figure 6-4**.

Pit dewatering

Pit dewatering requirements were estimated based on the hydrogeological data collected during field investigations and the revised mining schedule and pit geometry inputs provided by Hastings mining consultants, Snowden Group (Snowden). The static water levels are 308 m RL at Fraser's, 316 m RL at Bald Hill and 323 mRL at Yangibana north and west deposits. Pit dewatering will be initiated in year 3 of mining at Frasers and Bald Hill and year 5 at Yangibana (west and north deposits; GRM 2018a).

Pit dewatering will be best achieved by a combination of sump pumping and ex-pit dewatering bores. Dewatering bores would need to be located such that they intercept any potential high yielding structural features, which extend beyond the pit perimeter (GRM 2018a).

Average dewatering rates for each pit at yearly increments have been estimated using the Thiem equation for unconfined flow (GRM 2018a) and are provided in **Table 6-4**.



Yangibana DFS (J1709R01)		
Hastings Technology Metals		
KM	Nov 17	**FIGURE 6-4**

SCHEMATIC CONCEPTUAL MODEL

GROUNDWATER RESOURCE MANAGEMENT

FILE://Jobs17/J1709_YangibanaFS/figures/surfer/conceptual cross section.srf

Figure 6-8 Dewatering estimates

Quarter	Dewatering Estimates (L/s)				
	Fraser's	Bald Hill	Yangibana North	Yangibana West	Total
9	2.9	-	-	-	2.9
10	3.0	-	-	-	3.0
11	3.2	15.8	-	-	19.0
12	3.6	13.3	-	-	16.9
13	6.8	13.0	-	-	19.8
14	8.3	15.2	-	-	23.4
15	10.2	15.7	-	-	25.9
16	8.0	16.0	-	-	24.0
17	7.9	16.2	-	-	24.1
18	-	16.3	-	-	16.3
19	-	16.5	-	-	16.5
20	-	17.0	7.5	-	24.4
21	-	24.6	7.5	-	32.0
22	-	25.0	7.5	-	32.5
23	-	28.4	7.5	-	35.9
24	-	28.1	19.6	7.1	54.8
25	-	26.2	19.6	7.1	52.9
26	-	22.7	19.6	7.1	49.4
27	-	22.6	19.6	7.1	49.3
28	-	-	21.1	15.7	36.8
29	-	-	21.1	15.7	36.8
30	-	-	21.1	15.7	36.8
31	-	-	21.1	15.7	36.8
32	-	-	20.8	16.7	37.5
33	-	-	20.8	16.7	37.5
34	-	-	20.8	16.7	37.5
35	-	-	20.8	16.7	37.5

(GRM 2018a)

Modelling of pit dewatering drawdown of fractured rock systems has limitations due to the modelling code being designed for porous media, which requires the use of bulk hydraulic properties to simulate fracture flow (refer to GRM 2018a for specific details of modelling parameters). Despite recommendations by GRM

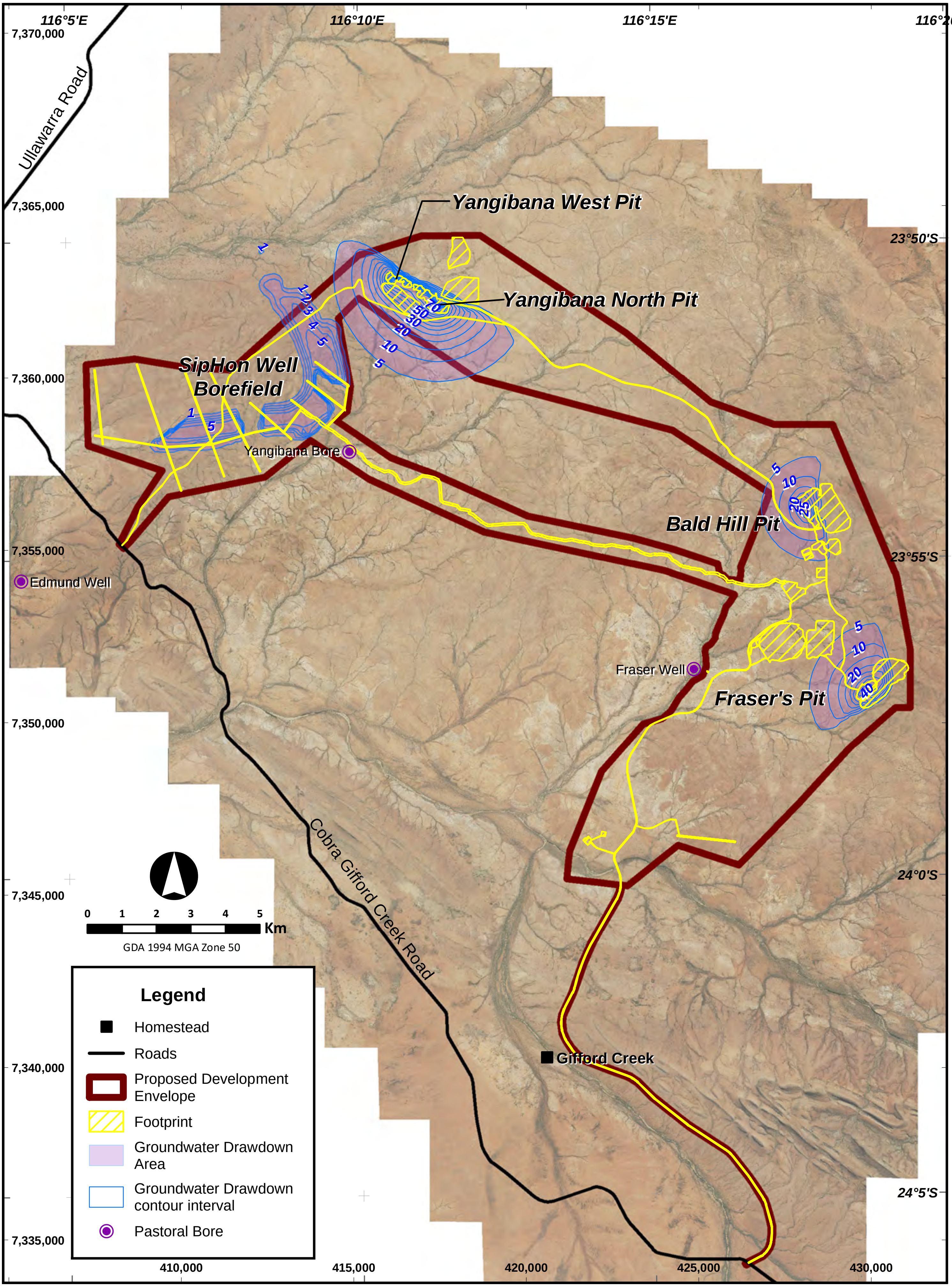
(2018a; based on recommendations by the Department of Water and Environmental Regulation, Water Division to use analytical methods instead) not to model the pit dewatering due to the type of aquifer system, Hastings requested GRM conduct modelling to assess groundwater drawdown to enable a worst-case scenario assessment of potential impacts to the surrounding environment. These drawdown contours are considered for assessment of environmental factors, flora and vegetation (Section 5) and subterranean fauna (Section 7) and other groundwater users (i.e., pastoral bores).

Modelling of groundwater drawdown of each deposit was undertaken using the MODFLOW 3D finite-difference code PMWIN pre-processor. Sensitivity analyses were run to further understand the implications of varying hydraulic conductivities (*K*; GRM 2018a).

Groundwater recharge was not included in the model given the low hydraulic conductivity of the fresh bedrock and the short project life. This is a conservative approach with respect to drawdown impacts, which will be reduced under recharge conditions (GRM 2018a).

The predicted groundwater level drawdown for the baseline runs at the end of mining are presented as contour plots in **Figure 6-5**. The plot shows the following:

- The asymmetrical drawdown reflects the geometry of the aquifer, with the steep hydraulic gradient corresponding to the ironstone extending above the water table, whilst the drawdown propagates along strike and down-dip of the ironstone aquifer.
- At the end of mining the predicted 5 m drawdown contour extends up to 1.5 km from the pit perimeter at Fraser's, 1.8 km from the pit perimeter at Bald Hill and 2 km from the pit perimeter at Yangibana.
- Steep hydraulic gradients are predicted in the fresh basement (HU3) beyond the outcropping ironstone, with the 5 m contour extending only about 500 m from the pit perimeter.
- The groundwater drawdown contours suggest that other groundwater users in the area are not expected to be impacted by dewatering. The nearest identified other groundwater user (Yangibana Bore) is located 2.7 km from the predicted 5 m drawdown contour.



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PER_F6-5__Pits_Drawdown_Bores.mxd
18 June 2018

Water drawdown contours at end of mine life

Figure 6-5

Pit lake modelling

The depth of mining occurs below the ambient ground water level. Pit dewatering will occur during the operations phase of the Project. Pit lake modelling was undertaken to assess pit lake conditions after mine closure. The main drivers influencing pit lake water levels include inflow of groundwater (supplemented by sporadic rainfall events) and evaporation. Evaporation far exceeds rainfall in the Gascoyne Region (**Table 6-2**). The models were run over a period of 500 years under both average and wet climatic conditions. Sensitivities analyses were undertaken to account for high rainfall events to assess impact under a worst-case scenario.

The results indicate a rapid pit lake level rise over the initial 10 years when groundwater inflow rates exceed evaporation due to a high groundwater hydraulic gradient and a comparatively small lake area for evaporation. The rate of rise reduces between 10 and 15 years after cessation of dewatering due to the increased area available for evaporation, before reaching a state of equilibrium after 20 years, when inflows (i.e. groundwater and rainfall) balance evaporative losses. The models indicate that both pits act as groundwater sinks (i.e. no groundwater throughflow) under worst-case scenario's assessed by sensitivity analysis (GRM 2018a). By the end of the 500-year model run, the pit lakes have stabilised with minor seasonal variation in response to rainfall and temperature.

For the baseline condition, the final predicted pit lake levels are 302.7 mAHD in Frasers, 310.2 mAHD in Bald Hill, 304.8 mAHD in Yangibana North and 296.0 mAHD in Yangibana West pits. This provides a residual drawdown range of 6.3, 5.8, 18.2 and 27 m at Frasers, Bald Hill, Yanagibana West and Yangibana North pits, respectively. As a result, all pits act as groundwater sinks under baseline conditions. Under a worse-case scenario, i.e. wet conditions, the residual drawdown ranges from 4.3 to 25 m, indicating that pits continue to act as groundwater sinks.

The pit lake model also provides an estimate of salinity concentrations post-closure, based upon an evaporative concentration in the pit lakes. The results indicate a rise in pit lake water salinity over a period of 500 years to approximately 34,000 mg/L TDS in all pits (GRM 2018a).

Isotopic analysis

Groundwater samples were collected from Fraser's, Bald Hill and Yangibana West for isotopic analysis to assist in assessing whether modern recharge exists in the fractured rock aquifer. Samples were collected at the start and end of the 48-hr constant rate test at Fraser's and Bald Hill, and at the end of test pumping at Yangibana.

The samples were sent to Australian Nuclear Science and Technology Organisation (ANSTO) Laboratory, in Sydney and analysed for Tritium concentrations. Tritium is a short-lived isotope (half-life of 12.43 years) and can be used for determining whether modern recharge exists in groundwater. Tritium is produced naturally by cosmic radiation, and until the 1950's concentrations were consistent in the atmosphere and rainfall. However, since the early 1950's, as a result of thermonuclear testing, additional Tritium was introduced into the atmosphere. In 1963 Tritium concentrations reached two to three orders of magnitude higher than natural background levels.

The only sample to record measurable Tritium, above the lower limit of detection was the sample collected from FRW03 at the commencement of test pumping. The late sample from FRW03 did not report measurable Tritium, nor did any of the other samples collected from BHW05 and YGW03.

These results suggest that:

- The FRW03 bore is screened over both younger and older groundwater, and the bore is primarily drawing from the older groundwater, which likely has higher permeability.
- BHW05 and YGWB03 indicate that these groundwaters are not modern (i.e. greater than 60 years old) and no recent groundwater recharge has occurred.

Aquifer storage

Aquifer storage within the fractured rock is expected to be limited. Aquifer storage in fractured rock systems is a function of the open void space associated with the fracturing, and the degree of connection between the fractures. The test pumping data indicated barrier boundary conditions at both the Fraser's and Bald Hill bores indicative of limited storage.

The limited recharge to the fractured rock aquifer and possible storage limitations indicate that bore yields and dewatering rates may diminish during the life of the Project.

6.3.5.2 Palaeochannel tributary

The SipHon Well Borefield is situated in a palaeovalley tributary to the larger Lyons River palaeodrainage system. The Lyons palaeodrainage is relatively un-explored and little was known about the system (Magee 2009 in GRM 2018b) prior to this investigation. The Lyons palaeodrainage discharges to the larger Gascoyne palaeodrainage system, which ultimately discharges to the Indian Ocean near Carnarvon.

Physical extent

The SipHon Well Borefield palaeochannel is incised into metasediments and granites of the Proterozoic Durlacher Supersuite (GRM 2018b). Drilling within the study area has identified a steep palaeo-cliff forming the eastern boundary (and outer bend) of the palaeochannel. The palaeo-cliff is up to 100 m high, and likely represents the Permian precursor valley wall. The metasediments forming the palaeo-cliff show evidence of faulting, which presumably pre-date, and likely facilitated the development of the valley (GRM 2018b).

Whilst the drilling defined the outer bend of the valley, the drilling did not locate the valley wall on the inner bend (GRM 2018b). This finding is consistent with the WASANT Palaeovalley map (Geoscience Australia 2017), which indicates a 24 km wide valley. The paleochannel within the study area may represent one of several distinct palaeochannels' with overbank deposits located between, or it may represent the most eastern extent of a large braided network of channels (GRM 2018b).

A 3 km long section of palaeochannel sand aquifer was investigated in the study (GRM 2018b). The aquifer is up to 40 m thick, 150 m deep and approximately 1 km wide. Geophysical surveying has mapped the channel beyond the drilled area, providing a total of 12 km of mapped palaeochannel extent (GRM 2018b).

Lithology

The palaeochannel sand aquifer within the study area is overlain by up to 100 m of clay, which acts as an aquitard (GRM 2018b; **Figure 6-6** represents a typical cross-section). The sand aquifer is typically fine to medium grained with some coarser sands and gravels reported on the outer bend of the meander, which is consistent with a higher energy environment.

The sand sequence likely formed under wet climatic conditions of the Early Tertiary, was characterised by wide-spread rainforests (GRM 2018b). This is also evidenced by thin zones of carbonaceous sediment within the sand aquifer, with occasional wood fragments, possibly Callitris (pers. comm. Dr Pauline Grierson, University of Western Australia). The genus Callitris, commonly known as conifer trees, was widespread during the Tertiary period.

The overlying clay sequence likely represents a lower energy, lacustrine environment, formed during a drier climate (Magee 2009 in GRM 2018b). The sand aquifer is likely to be analogous to the Eocene Wollubar Sandstone of the well-studied Yilgarn region of Western Australia, with the overlying clay sequence the lateral equivalent of the Oligo-Miocene Perkolilli Shale (GRM 2018b).

Deep calcrete was intercepted on the inner bend to the north of the study area, overlying the basal sand (GRM 2018b). The deep calcrete, approximately 30 m thick, is overlain by approximately 70 m of clay. An adjacent drill-hole located approximately 1 km away also reported calcrete at a similar depth (as illustrated in **Figure 6-7**). Surface mapping (over a radius of 2 km) did not identify any nearby shallow calcretes.

Hydraulic conductivity

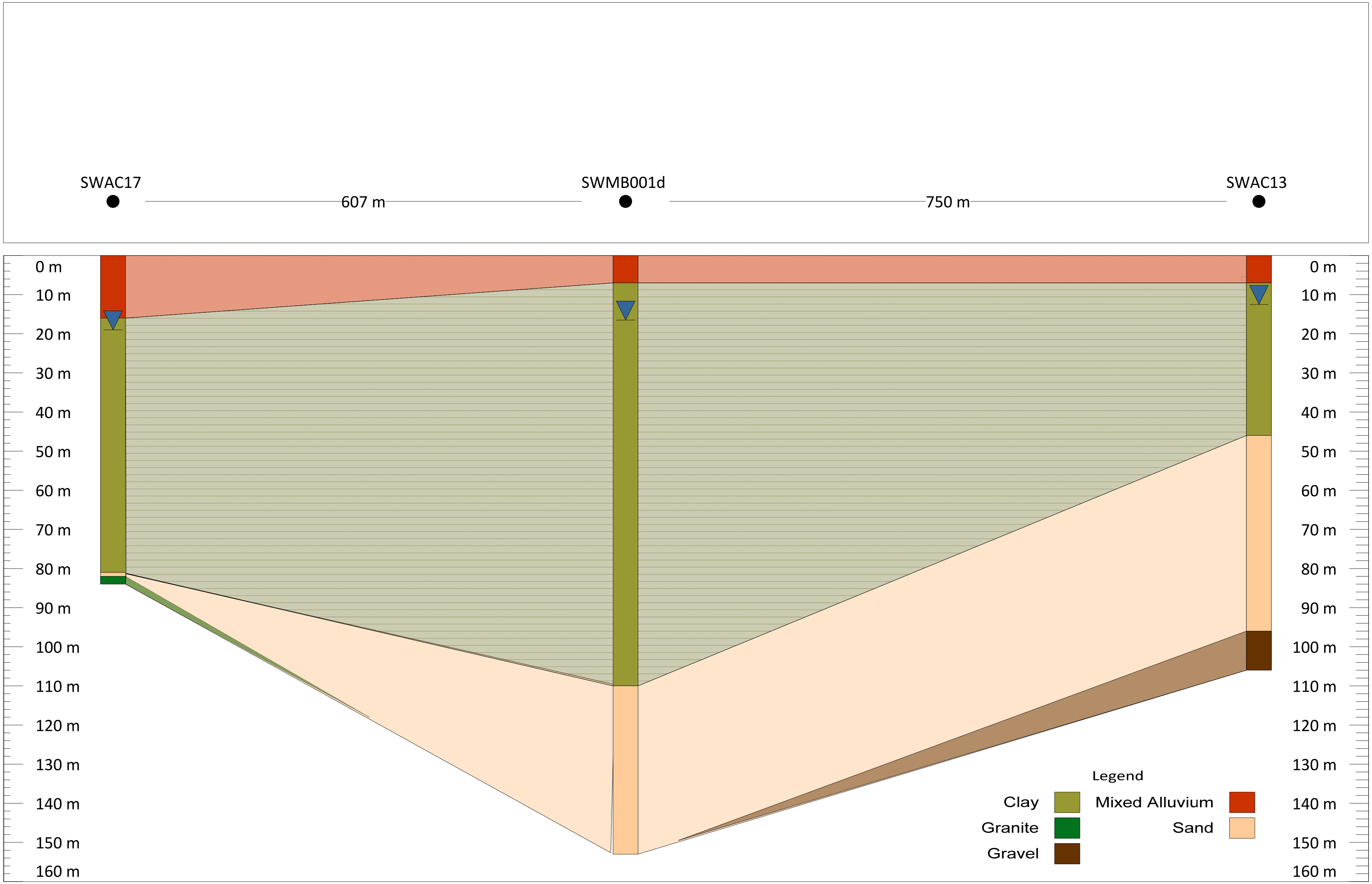
The test pumping data indicates a hydraulic conductivity of the sand aquifer of about 2.2 m/d (GRM 2018b). Test data indicates a hydraulic conductivity of the overlying clay aquitard of 0.003 m/d. However, the hydraulic conductivity is significantly lower than this in some areas of the channel as evidenced by shallow monitoring bores taking several months to achieve water level recovery after development.

A thin veneer of colluvium, laterite and till overlies the clay sequence (GRM 2018b). The static water level within the SipHon Well Borefield is consistently below the base of the alluvial veneer. The shallow groundwater environment is not considered an aquifer.

Recharge

At the SipHon Well Borefield, GRM (2018b) reports the deep sand aquifer is probably recharged from the fractured bedrock, specifically by the fracture that occurs in the palaeo-cliff on the outer bend. Furthermore, there may be minor slow leakage from overlying and adjacent sediments, but this will likely be minimal unless invoked by drawdown (i.e. pumping from the sand aquifer). The fractured bedrock is recharged via direct rainfall runoff to outcropping bedrock, or via leakage from overlying alluvium or calcrete.

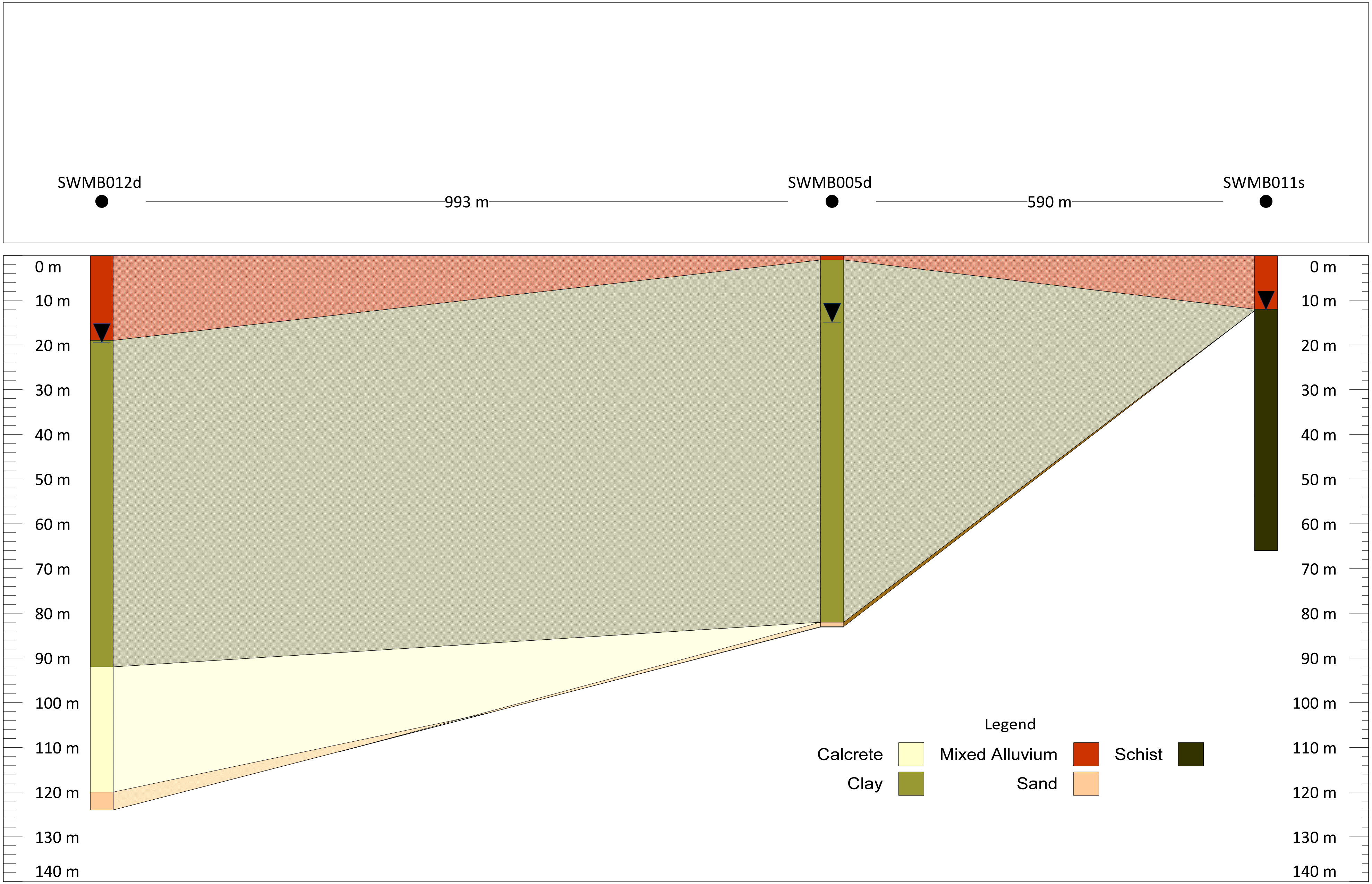
The shallow groundwater system will be recharged primarily following streamflow events via modern creek alluvium and calcrete (GRM 2018b). The study area straddles the current Dingo Creek, the Yangibana Creek and the Lower Edmund River surface water catchments and will likely receive recharge via these three systems. Surface water is likely to be subjected to evaporative loss under the current climate, prior to seepage to the underlying shallow environment, which may explain the higher reported salinity in the shallow groundwater environment compared to the underlying sand aquifer, which has water that is fresh to slightly brackish.



Yangibana Stage II PC (J1709R02)		
Hastings Technology Metals Ltd		
KM	May 18	**FIGURE 6-6**

SIPHON BOREFIELD CROSS SECTION TRANSECT 2

GROUNDWATER RESOURCE MANAGEMENT



Yangibana Stage II PC (J1709R02)		
Hastings Technology Metals Ltd		
KM	May 18	**FIGURE 6-7**

SIPHON BOREFIELD
CROSS SECTION
TRANSECT 1

GROUNDWATER RESOURCE MANAGEMENT

Isotopic analysis

Groundwater samples were collected from the SipHon Well Borefield for isotopic analysis to assist in assessing the recharge characteristics of the deep palaeochannel aquifer.

The samples were sent to the Institute of Geological and Nuclear Science Limited in New Zealand, and analysed for tritium, deuterium and radiocarbon. Deuterium and radiocarbon results have been received, whilst the tritium results are expected by July 2018.

The radiocarbon concentrations indicate an age of 37,000 (± 5,400) years. Groundwater from other palaeochannels across Australia has reported ages in the order of 80,000 to 100,000 years (Magee 2009). The slightly younger water in the SipHon Well Borefield, than other palaeodrainage systems is potentially a function of recharge from the fractured rock aquifer, which likely contains younger groundwater.

Given the radiocarbon results, tritium concentrations are not likely to be detected in the sample from the SipHon Borefield, and are not expected to add value to the hydrogeological assessment.

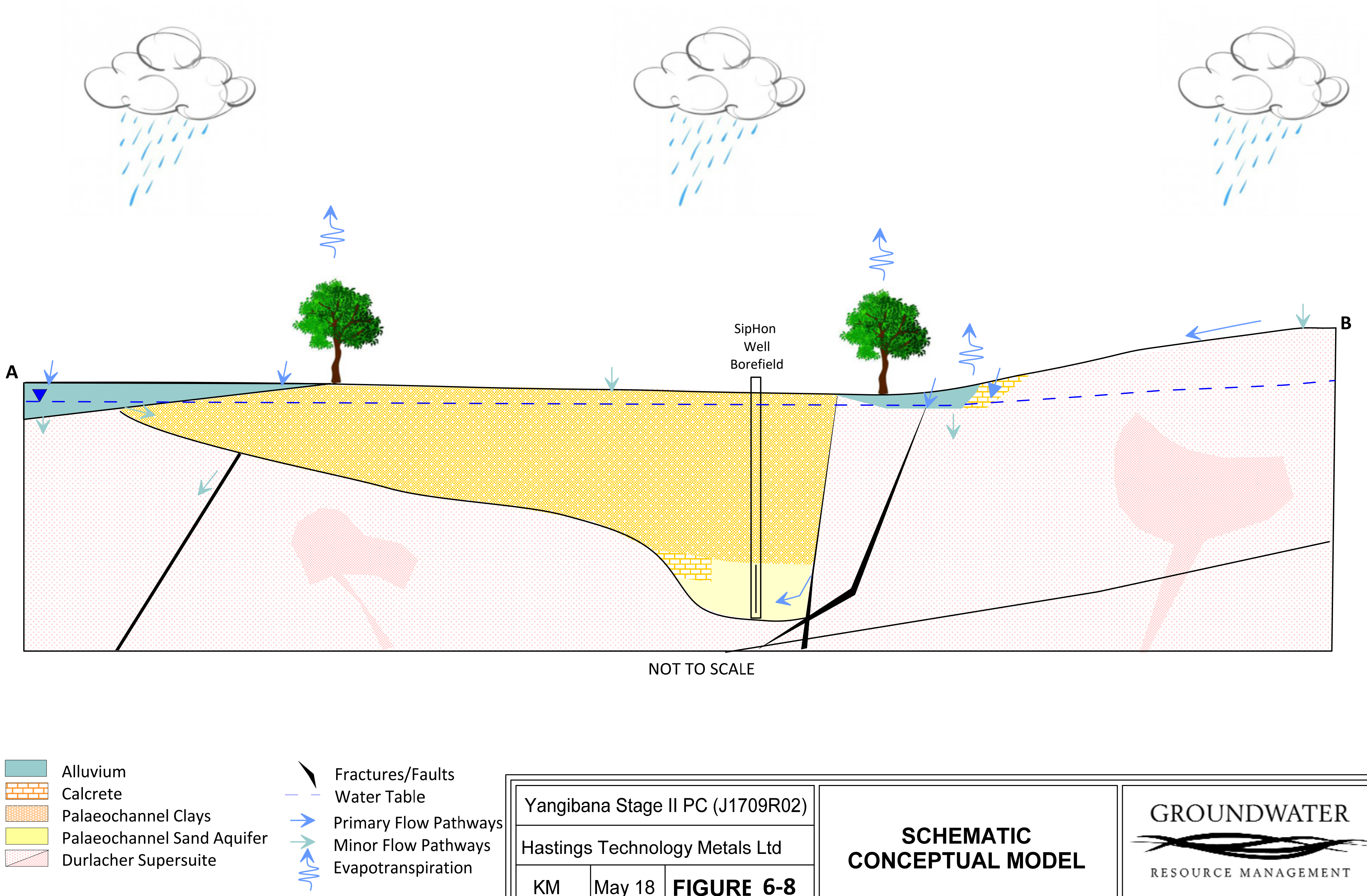
The conceptual hydrogeology of the SipHon Well Borefield is shown in **Figure 6-8**.

6.3.6 Water quality

Water quality analysis was undertaken for fractured rock aquifers associated with Frasers, Bald Hill and Yangibana deposits, SipHon Well borefield, eight pastoral bores, and two ephemeral pools (**Figure 6-9**). Where multiple sampling has been undertaken, the range is provided. All areas sampled tend to have alkaline water that is in the fresh to brackish range (**Table 6-5**). Pastoral bores and ephemeral pools are more likely to be influenced by seasonal variation. The on-going water monitoring program will likely reflect these seasonal changes.

Figure 6-12 Summary of pH and salinity parameters

Water Quality Parameters	Fractured rock aquifers	SipHon Well Borefield	Pastoral bores	Ephemeral pools
pH range	7.8 – 8.5	7.6 - 9.0	7.2 – 8.6	8.1 - 9.6
Salinity range (mg/L)	920 – 1,200	740 – 1,400	600 – 2,800	330 – 2,900



Yangibana Stage II PC (J1709R02)			**SCHEMATIC CONCEPTUAL MODEL**	GROUNDWATER RESOURCE MANAGEMENT
Hastings Technology Metals Ltd				
KM	May 18	**FIGURE 6-8**		

FILE://Jobs17/J1709_YangibanaFS/figures/surfer/palaeochannel/conceptual cross section.srf

6.3.6.1 *Fractured rock aquifers*

Groundwater samples were collected from each of the production bores at the end of the test pumping (GRM 2018). Water quality analyses of the samples indicates the groundwater is slightly alkaline, reporting a pH of 7.8 to 8.5; is fresh to slightly brackish, with a salinity range of 920 to 1,200 mg/L total dissolved solids (TDS) and is of sodium chloride type (**Table 6-6**). FRW03 is currently providing potable water for minor or preliminary works.

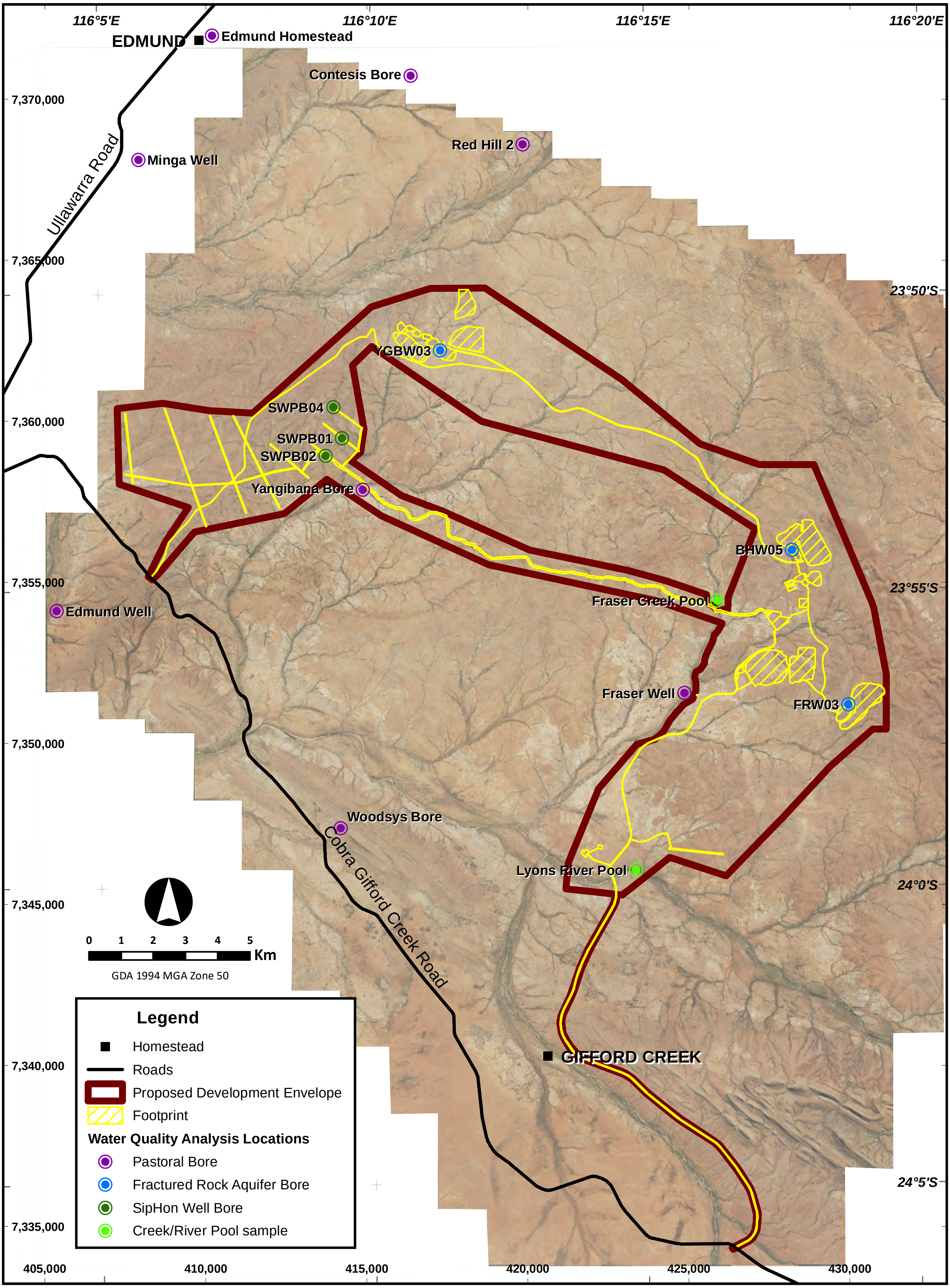
Figure 6-14 Groundwater quality of fractured rock aquifer water at Frasers (FRW03), Bald Hill (BHW05) and Yangibana (YGW03) deposits

Analyte	Unit	FRW03	BHW05	YGWB03
pH		8.5	8.0	7.8
Electrical Conductivity	µS/cm	2,100	1,900	1,500
Total Dissolved Solids	mg/L	1,200	1,000	920
Total Alkalinity	mg/L	-	-	270
Carbonate Alkalinity	mg/L	11	<1	<1
Bicarbonate Alkalinity	mg/L	280	<5	330
Chloride	mg/L	380	330	250
Fluoride	mg/L	2.4	2.2	2.5
Sulphate	mg/L	160	100	89
Nitrite	mg/L	<0.2	<0.05	<0.2
Nitrate	mg/L	9.1	65	63
Calcium	mg/L	72	81	85
Magnesium	mg/L	67	51	44
Molybdenum	mg/L	0.01	0.03	0.02
Potassium	mg/L	9.5	9.0	7.5
Silica, soluble	mg/L	52	72	91
Silicon	mg/L	-	34	43
Sodium	mg/L	230	240	180
Total Hardness	mg/L	460	410	390
Aluminium	mg/L	<5	<5	<5
Iron	mg/L	73	9	5
Manganese	mg/L	<1	<1	<1
Selenium	mg/L	4	7	6
Uranium	mg/L	0.011-0.016	<0.036-0.039	0.034
Radium 226	Bq/L	<0.05	<0.05	0.21
Radium 228	Bq/L	<0.08	<0.08	0.08

6.3.6.2 Pastoral bores

Pastoral stations, as the only other groundwater users near the Proposal, use water for domestic and stock purposes. The nearest pastoral bore (Frasers Bore) is approximately 2 km from the Proposal. Water quality parameters from eight pastoral station bores were variable depending on location. pH ranged from 7.3 to 8.3 and salinity ranged from 560 to 3,100 mg/L TDS (**Figure 6-9**).

Elevated levels of heavy metals were found in the tailings pore water i.e. Fluoride and Molybdenum. Hastings has since included these heavy metals in the suite of analytes to test in the water quality monitoring program for pastoral bores. **Table 6-7** provides a summary of the range of values for each respective analyte. A broader range of analytes were tested, however not all are presented here including, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Chromium, Copper, Cobalt, Lead, Nickel, Silver, Strontium, Thorium, Tin, Titanium, Vanadium and Zinc, in addition to those presented in **Table 6-7**. Most bores have been sampled on at least three occasions, with sampling occurring 3-4 months apart. Radium has only been tested on one sample from each bore sampled (upon advice from Jim Hondras, JRHC and Associates).



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YANGIBANA RARE EARTHS PROJECT

PER_F6-9_Water_Sample_Locs.mxd
18 June 2018

Water Quality Analysis Locations

Figure 6-9

Figure 6-16 Water quality analysis of pastoral bores

Analyte	Unit	Minga	Edmund HST	Contessis	Edmund	Fraser	Yangibana	Woodsys	Red Hill 2
pH		8.2-8.3	7.5-7.9	8.2	7.5-7.6	7.3-8.1	7.4-8.1	7.5-7.6	7.5-8.1
Total Dissolved Solids	mg/L	560-920	580-1400	530-600	1800-2200	1400-1600	1300-1600	1500-1800	2100-3100
Chloride	mg/L	91-110	75-270	81-95	700-810	510-700	510-530	590-620	710-890
Sulphate	mg/L	89-110	35-330	45-81	3310-350	170-190	180-200	230-270	700-1200
Fluoride	mg/L	1.3-2.3	1.3-1.4	2.5	1.9-2.9	2.4-3.0	1.7-2.2	1.1-1.3	4.0
Nitrate	mg/L	4.7-6.5	2.7-9.0	0.05-1.1	17-18	11-12	17-18	12-13	7.7-8.3
Calcium	mg/L	39-54	66-82	30-73	74-88	49-60	110-130	100-120	170-260
Magnesium	mg/L	46-58	40-90	48-51	94-100	41-53	65-83	93-110	98-150
Molybdenum	mg/L	0.01	<0.01	0.01	0.01	0.02	<0.01-0.01	<0.01	0.01
Potassium	mg/L	3.8-4.4	2.8-4.0	4.4-4.6	15-18	9.1-11	9.4-9.9	24-31	17-22
Silica, soluble	mg/L	36	32	30	23	24	23	26	31
Sodium	mg/L	88-150	26-280	37-70	450-750	420-770	200-430	310-500	410-670
Aluminium	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1-0.3	<0.1	<0.1	<0.1
Iron	mg/L	<0.01-0.02	0.02-0.07	<0.01-0.33	<0.01-0.05	<0.01-0.84	<0.01-0.05	<0.01-0.03	<0.01-0.19
Manganese	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.87
Selenium	mg/L	0.002-0.003	0.001-0.007	<0.001	0.003-0.005	0.005-0.008	0.005-0.008	0.003-0.004	<0.001-0.01
Uranium	mg/L	0.003-0.004	0.001-0.044	0.020-0.027	0.031-0.038	0.025-0.038	0.029-0.038	0.009-0.012	0.079-0.25
Radium 226	Bq/L	-	<0.05	<0.05		0.05	<0.05		<0.05
Radium 228	Bq/L	-	<0.08	<0.08		<0.08	<0.08		<0.08

6.3.6.3 Ephemeral pools

Water quality analysis was also conducted at two ephemeral pools (LC - Pool 800US and FR – Pool) on the Lyons River, located approximately 5-10 km from the proposed processing plant. These samples were collected at the end of the dry season and thus parameters measured (**Table 6-8**) will vary depending on time since last rainfall. Hastings has collected samples from Lyons River Pool on several occasions, however Fraser Creek Pool has only been sampled on one occasion. The Fraser Creek Pool is much smaller than the Lyons River Pool and dries out much faster.

Figure 6-17 Water quality analysis of two ephemeral pools in the Lyons River (LC-Pool) and Fraser Creek (FR-Pool)

Analyte	Unit	LC-Pool	FR-Pool
pH		9.0-9.6	8.1
Total Suspended Solids	mg/L	6-18	<5
Total Dissolved Solids	mg/L	1,200-2,900	330
Total Alkalinity	mg/L	140-320	190
Chloride	mg/L	430-1100	30
Fluoride	mg/L	1.3	0.2
Sulphate	mg/L	290-550	<1
Nitrate	mg/L	<0.01	<0.01
Calcium	mg/L	38	43
Manganese	mg/L	<0.01	<0.01
Magnesium	mg/L	88-210	17
Molybdenum	mg/L	<0.01	<0.01
Potassium	mg/L	23-69	22
Sodium	mg/L	290-630	23
Aluminium	mg/L	<0.1	<0.1
Iron	mg/L	0.08	0.45
Selenium	mg/L	<0.001-0.002	<0.001
Uranium	mg/L	<0.001	0.008
Radium 226	Bq/L		0.05
Radium 228	Bq/L		0.08

6.3.6.4 SipHon Well Borefield

Water quality analysis has been conducted for three production bores (SWPB01; **Table 6-9**). Samples were collected twice (GRM 2018 and Hastings in 2018) for SWPB01, and once (GRM 2018) for SWPB02 and SWPB04.

Figure 6-18 Water quality analysis at SipHon Well borefield

Analyte	Unit	SWPB01	SWPB02	SWPB04
pH		8.3 - 9.0	7.6	7.9
	µS/cm	1,900	2,400	1,600
Total Suspended Solids	mg/L	8	-	-
Total Dissolved Solids	mg/L	790-1,100	1,400	960
Total Alkalinity	mg/L	330	290	260
Hardness	mg/L	240	-	-
Hydroxide Alkalinity	mg/L	<5	<5	<5
Carbonate Alkalinity	mg/L	7	<1	<1
Bicarbonate Alkalinity	mg/L	390	360	320
Chloride	mg/L	370-410	480	250
Fluoride	mg/L	0.8-1.2	1.4	1.6
Sulphate	mg/L	71-99	200	130
Nitrate	mg/L	<0.01	-	-
Phosphorus	mg/L	0.16-1.2	<0.05	<0.05
Calcium	mg/L	27-92	140	81
Magnesium	mg/L	43-54	82	48
Molybdenum	mg/L	0.03-2	4	5
Potassium	mg/L	11	-	-
Sodium	mg/L	210-220	220	160
Aluminium	mg/L	<0.1	<5	<5
Iron	mg/L	3.1	28	<5
Selenium	mg/L	<0.001	-	-
Zinc	mg/L	<0.01	<5	22
Radium 226	Bq/L	<0.2	-	-
Radium 228	Bq/L	<0.2	-	-

Analyte	Unit	SWPB01	SWPB02	SWPB04
Gross alpha	Bq/L	0.10	-	-
Gross beta	Bq/L	0.25	-	-

6.3.7 Water source

The Proposal's water demand of 2.5Gl/annum will be met using an integrated approach (as illustrated in **Figure 6-10**) from the following water sources:

- Fractured rock aquifer for minor or preliminary works.
- Paleochannel aquifer with most water sourced from this aquifer during the first five years of operation.
- Pit dewatering will provide most of the water demand for the final five years of operation.

There will not be surplus water over the life-of-mine because Hastings will manage the supply of water by:

- Turning off pumps at bores in the SipHon Well Borefield.
- Allowing the respective pit lake to reach equilibrium when pits have been closed.

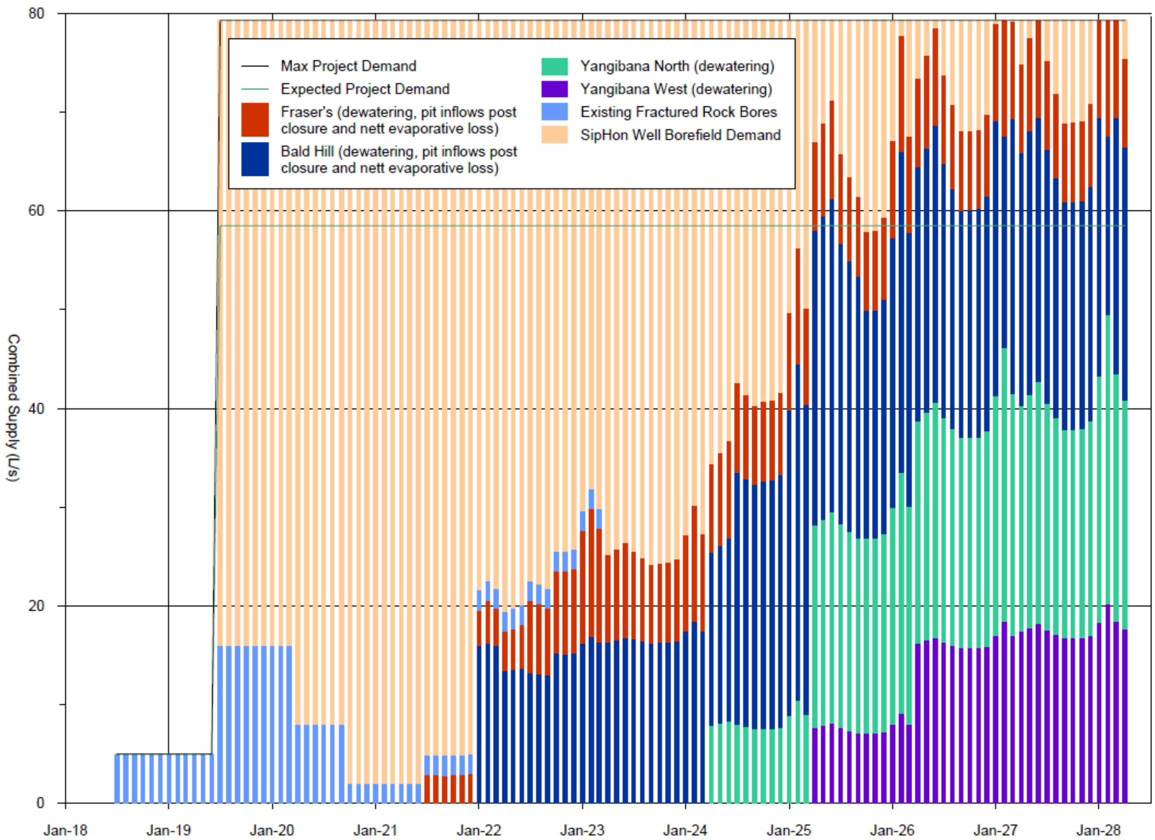


Figure 6-19 Water balance

6.3.8 Waste characterisation

Section 8.3.5 provides a detailed waste characterisation assessment. Specific to this section is the characterisation of tailings pore waters, summarised as follows:

Static testing

- The TSF 1 tailings solids and pore water will be benign geochemically (i.e. Non-Acid Forming [NAF]) (Trajectory and Graeme Campbell 2017; Appendix 5-1). There were slight enrichments of metals (i.e., Fluoride and Molybdenum) in both the tailings solids and contact waters that were analysed. Trace element concentrations are either below or close to those typically recorded for soils, rocks and sediments derived from non-mineralised terrain (Trajectory and Graeme Campbell 2017; Appendix 5-1). TSF 1 tailings characterisation have shown radionuclide readings of < 1 Bq/g (JRHC 2017; Appendix 5-5). The radionuclides in these tailings are not water soluble (JRHC 2017; Appendix 5-5).
- The second stream of beneficiation tailings (to be disposed in TSF 2) solids and pore water are benign geochemically (i.e. NAF; Trajectory and Graeme Campbell 2017; Appendix 5-1). Slight to moderate enrichments of metals (i.e., Fluoride and Molybdenum) were reported in both tailings solids and contact waters that were analysed. Trace element concentrations were either below or close to those typically recorded for soils, rocks and sediments derived from non-mineralised terrain (Trajectory and Graeme Campbell 2017; Appendix 5-1). Detailed characterisation of TSF 2 tailings solids show radionuclide levels of 4 Bq/g (JRHC 2017; Appendix 5-5). Radionuclides are not water soluble in these tailings, as reflected by the pore water analysis in the detailed characterisation assessment of tailings (JRHC 2017; Appendix 5-5).
- TSF 3 tailings-solids were found to be slightly acidic and NAF (Trajectory and Graeme Campbell 2017; Appendix 5-1). TSF 3 pore liquors have a pH that is circum-neutral, are saline, and have elevated magnesium and sulphate (as MgSO4), and Molybdenum levels (Trajectory and Graeme Campbell 2017; Appendix 5-1). Detailed characterisation studies report TSF 3 radionuclide levels at 32.4 Bq/g and are not water soluble (JRHC 2017a; Appendix 5-5).

Evaporation pond liquors were analysed. Radionuclide levels did not exceed 1 Bq/g, however $MgSO_4$ was elevated above Stock Water Quality Guidelines (Trajectory and Graeme Campbell 2017; Appendix 5-1).

Due to the elevated levels of $MgSO_4$, both TSF 3 and the evaporation pond will be lined with bitumen impregnated geofabric and HDPE liners, respectively.

Leach testing

Leach testing was then undertaken on TSF 1 and 2 tailings to determine the long-term leaching of fluoride and molybdenum using water sourced from fractured rock and paleochannel tributary aquifers, and deionised water. The results presented in Trajectory and Graeme Campbell and Associates (2018; Appendix 5-12) are the outcomes of the leach testing program over a period of 15 weeks.

TSF 1 tailings solids (generated by a pilot plant) showed that, upon leaching with either High Pressure Deionised Water (HPDW) or locally acquired groundwater under saturated conditions, soluble-F and soluble-Mo concentrations rapidly decreased and radionuclides concentrations continued to be negligible. Approximately 6-7 pore volumes were passed through the test columns over a period of 15 weeks. In the case of leaching with HPDW, the leachate-F and leachate-Mo concentrations were below the stock water quality guideline (ANZECC and ARMCANZ 2000) values of 2 mg/L and 150 µg/L, respectively. In the case of leaching with groundwater, the leachate-F concentrations matched that of the groundwater at 1-2 mg/L, and leachate-Mo concentrations were near the ANZECC guideline value. These findings confirmed that the recorded soluble-F and soluble-Mo elevations were mainly associated with tailings process water, and thus would diminish with flushing.

The results of the leach tests using TSF 2 tailings solids (generated by a pilot plant) have been generated at a much slower pace due to the very low permeability of the more clay-enriched TSF 2 solids and the consequent very slow rate of drainage / leaching. To-date, approximately 2-3 pore volumes have been passed through the test columns over a period of 15 weeks. The trajectory of the leachate-F and leachate-Mo concentrations are like the TSF 1 leach tests and radionuclide levels remained well below 1Bq/g. However, due to the slow nature of the leaching, F and Mo have not yet reached levels below the stock water quality guideline (ANZECC and ARMCANZ 2000), although the solubility trends clearly suggest that this will occur in time. This testing will continue until the soluble-F and soluble-Mo concentrations are stable or decrease below the stock water quality guidelines.

6.4 Potential Impacts

The following potential impacts may occur as a result of implementing the Proposal:

- Drawdown from water abstraction and dewatering pits resulting in deaths of stygofauna and vegetation supporting GDEs.
- Decreased water flow or increased movement of sediments to nearby water bodies (i.e. semi-permanent pools, nearby creeks and rivers) from the alteration of surface water flows through the development envelope.
- Potential contamination of surrounding surface water and groundwater as a result of:
  - dust from the ROM pad, processing plant (processing reagents, chemicals) and TSFs;
  - seepage of tailings' water, decant and evaporation ponds;
  - operational leaks and spills;
  - failure of TSF integrity;
  - seepage from sewage treatment plants;
  - increased salinity and radionuclides as a result of pit lakes; and
  - drainage from associated erosion of WRL surfaces.

6.5 Assessment of Impacts

6.5.1 Water drawdown

Pit dewatering, including the two existing production bores, is expected to satisfy approximately 20% of the water demand in the initial stage of the project, increasing to 90% towards the end of the mine life. The remainder of the demand is expected to be met by a network of water supply bores located in a palaeochannel tributary (named SipHon Well Borefield). There are no other existing water users abstracting water from the fractured rock or the palaeochannel tributary aquifers. There are no future users of these aquifers known to Hastings.

Dewatering rates have been estimated for the project, based on analytical techniques (GRM 2018). The rates are based upon sump pumping, augmented at Fraser's and Bald Hills by abstraction from the two existing production bores.

Model simulated drawdown contours at the end of mining have been provided both for the pit dewatering and borefield water abstraction. The drawdown contours show no impact to existing groundwater users (i.e. three pastoral bores in the near vicinity; **Figure 6-5**).

The drawdown impact associated with pit dewatering is considered minor due to the discrete fractured rock aquifers, low exposure of sensitive receptors (i.e. GDE, Gifford Creek PEC) in the near vicinity of water drawdown and relatively shallow pit depths. Consideration of impacts to groundwater dependent ecosystems and the Gifford Creek PEC are discussed in sections 5 and 7, respectively.

The pit lake modelling indicates that after mine closure the water level in the pits will rise for approximately 20 years, until equilibrium is reached. Equilibrium is achieved once evaporation equals the sum of rainfall and groundwater inflows. The modelling indicates that under all scenarios, the pit lake level will remain below the ambient groundwater level over the 500-year simulation period. This condition is termed a groundwater 'sink' and prevents water, which becomes concentrated in salts over time, from discharging to the down-gradient groundwater environment.

6.5.2 Surface Water flow

6.5.2.1 Flooding and shadow effects

Large sections of the mining area are unaffected by flooding, other than shallow, localised overland runoff. Based on JDAs assessment (2016), a combination of diversion channels, flood ways and culverts are required to mitigate impacts associated with surface water flows in specific areas of the Proposal.

The Project occurs in a proclaimed surface water catchment area under the *Rights in Water and Irrigation Act 1914*. As such, all river, creek and drainage channel crossings require a Bed and Banks Permit to ensure surface water flow is maintained. Due to this legal requirement, the impacts to rivers, creeks and drainage channels are unlikely.

Linear infrastructure does have the potential to obstruct sheet flow, which may result in shadow effects.

6.5.2.2 Erosion and sedimentation

Flow velocities at points where the road crosses the Lyons River, Yangibana Creek, or Frasers Creek are likely to exceed 1.9 m/s in events greater than 5% AEP (20-year ARI). Sedimentation and erosion are likely if mitigation is not implemented.

Design and location of infrastructure are unlikely to result in additional sediment loads during heavy rainfall events. A soils assessment report (Appendix 5-2) has highlighted plains topsoils are unsuitable for use in rehabilitation due to their saline and sodic nature and are highly erodible. These soils will not be harvested or stored.

6.5.3 Contamination

Potential contamination pathways include:

- Dust from the ROM pad, processing plant (processing reagents, chemicals) and TSFs.
- Seepage of tailings liquor.
- Overflow of water from evaporation ponds.
- Operational leaks and spills.
- Failure of TSF integrity;

- Seepage from sewage treatment plants.
- Erosion of WRL surfaces.
- Saline final void pit lakes contaminating surrounding ground water.

6.5.3.1 Dust

There is the potential for dust containing NORM to be released to the surrounding environment from mining to ROM pad and crushing. An ERICA assessment has deemed that concentrations are well below threshold limits and will not impact native plants or animals given dust management will occur in accordance with industry practice. The process of the ore is a wet process from beneficiation to hydrometallurgy. The product will be moist and put in 'bulka' bags at the end of the process, and then stored in preparation for transport.

Processing reagents and chemicals will be stored in enclosed containment areas or silos. Key processing reagents and chemicals that will be stored as solids and have the potential to generate dust will be contained as follows:

- Sulphur will be stored in a stockpile in the open and near the processing plant. The density of sulphur is 2 g/cm3 and will not readily generate dust. Sulphur is not water soluble and thus will not disperse during rainfall events. However, the sulphur will be maintained in a bunded facility to ensure it is contained as per industry practice. Water collection ponds from the bunded area will be managed.
- Ammonium bicarbonate or sodium bicarbonate will be stored in bags in a self-bunded chemical facility. This substance is a crystallised solid and unlikely to generate dust.
- Quick lime, lime and MgO are powders and will generate dust. These substances will be stored in bulka bags or containers. They will be handled within the process plant and will be added to the process in a loading system with dust collectors in place.
- The flocculant is a man-made chemical and presented as a solid in powder form. This substance will also be contained in bags. Material handling will occur within the process plant and not subject to windy conditions. There will be dust management systems within the process plant to manage dust.

Any other chemicals in solid form will be managed in accordance with industry practice.

6.5.3.2 Seepage of tailings liquor

Seepage from the tailings storage facilities is unlikely with the implementation of standard management and regulatory practices, and best practice design, construction and operations. Geotechnical studies demonstrate an impermeable granite bedrock. Seepage analysis shows no vertical seepage, although lateral seepage is possible. Mitigation to prevent seepage extending beyond the decant pond has been prescribed in the TSF design report (ATC Williams 2017; Appendix 6-3).

Waste characterisation studies of tailings solids and liquids have found the that while TSF 2 and 3 tailings have elevated levels of radionuclides, the tailings pore water in all three TSFs is well below 1 Bq/g. Fluoride and Molybdenum are elevated in the tailing pore water. Leach testing has demonstrated recorded soluble-F and soluble-F elevations were chiefly associated with tailings process water, and thus would diminish with flushing.

A seepage assessment has been conducted for TSF 1 and 2 liquids (ATC Williams 2017). TSF 1 tailings pore water is collected in the return water pond (RWP). Due to the low permeability of the basement rock, vertical seepage does not extend to the groundwater table. Lateral seepage does not extend beyond the footprint of the TSFs. The wetting front is shown after 10 years for the TSF2 and RWP in **Figure 6-20** and

Figure 6-21, respectively. The progression of the wetting front from the start of operations to closure is shown in ATC Williams Tailings Storage Design Report Appendix C (2017; Appendix 6-3).

6.5.3.3 Overflow of water from evaporation ponds

The decant pond and evaporation pond are designed with sufficient freeboard to ensure water is contained during heavy rainfall events (ATC Williams 2017). The heights of the respective embankments were designed to ensure sufficient freeboard under a 1:100 Annual Exceedance Probability, 72-hour runoff rainfall event with additional contingency included in line with international standards. It is therefore unlikely that contaminated water will be discharged from these facilities due to overflow.

6.5.3.4 Operational leaks and spills

Bunding and secondary bunding around chemical storage areas is standard practice. The entire process plant will be bunded and surface water ponds will ensure management of any contaminants via disposal in the evaporation pond or TSF 3. In addition, surface water will be contained in areas around the processing plant and tailings storage facilities, where runoff may become contaminated by operational leaks and spills. Therefore, it is unlikely that any major surface water contamination will occur due to chemical storage or operational leaks and spills.

6.5.3.5 Failure of TSF integrity

A landform evolution assessment (Trajectory 2017; Appendix 6-1) considered the behaviour and performance of TSFs over the long-term. The study assessed TSFs over a 1000 year period under a range of climatic events. Given the stage of the proposal, Trajectory prescribed the design processes required to meet the objective of:

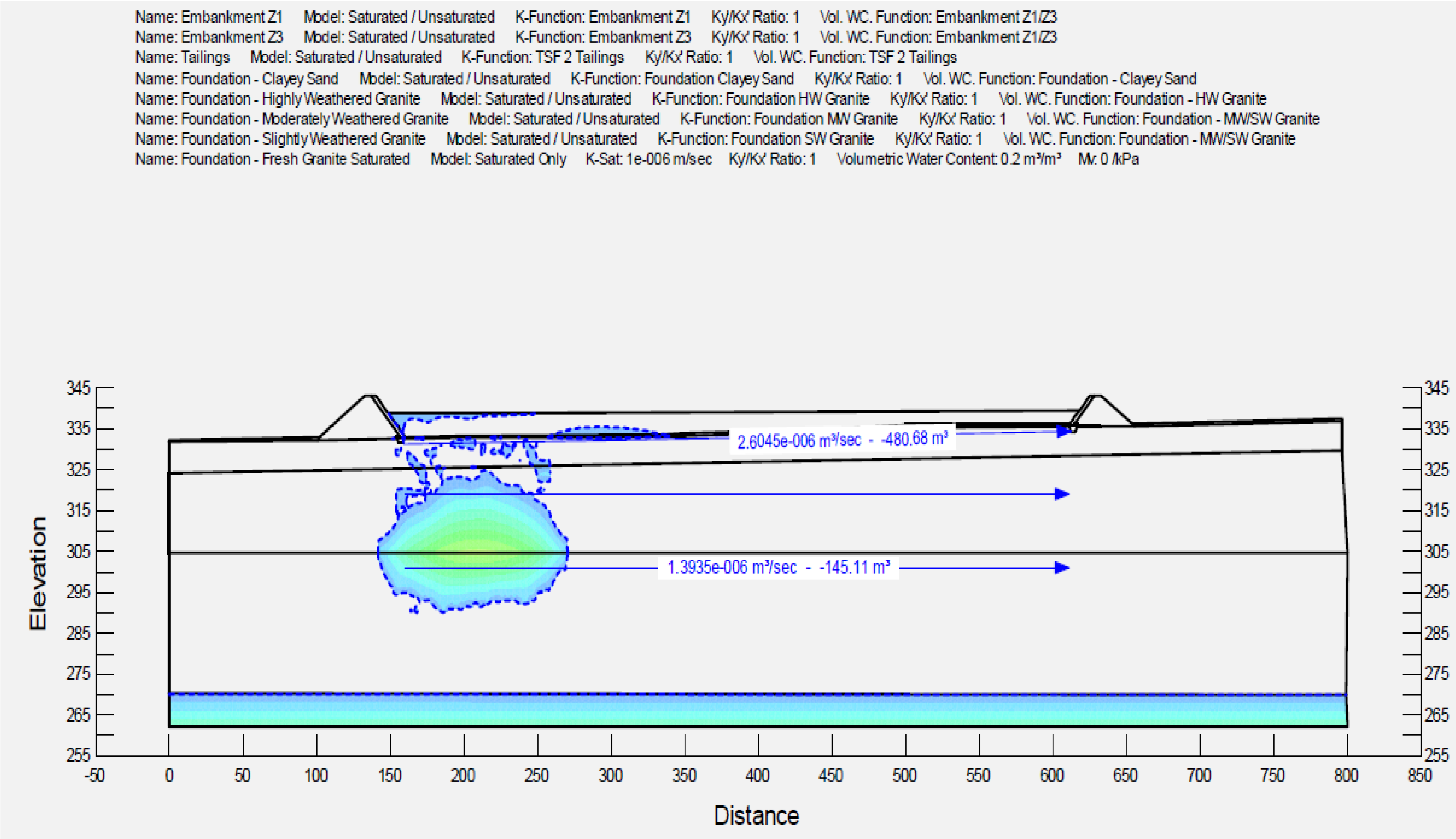
> *Generate, analyse and compare a range of credible alternative slope profile and treatment options such that the selection of landform profile shapes and treatments at individual locations across the Project landforms are technically justified as creating stable landforms (from an erosion perspective) over a 1000-year design period.*

In doing so, Trajectory not only considered erosion but was also cognisant of the following relevant factors:

- Slope profile: Consideration of three options, to determine durability and resilience over 500 and 1000 years, namely:
    1. single concave slope;
    2. traditional 20 degree slope with 5m berms; or
    3. wide berms on concave slope.
- Slope hydrology.
- Surface characteristics.
- Biological factors.

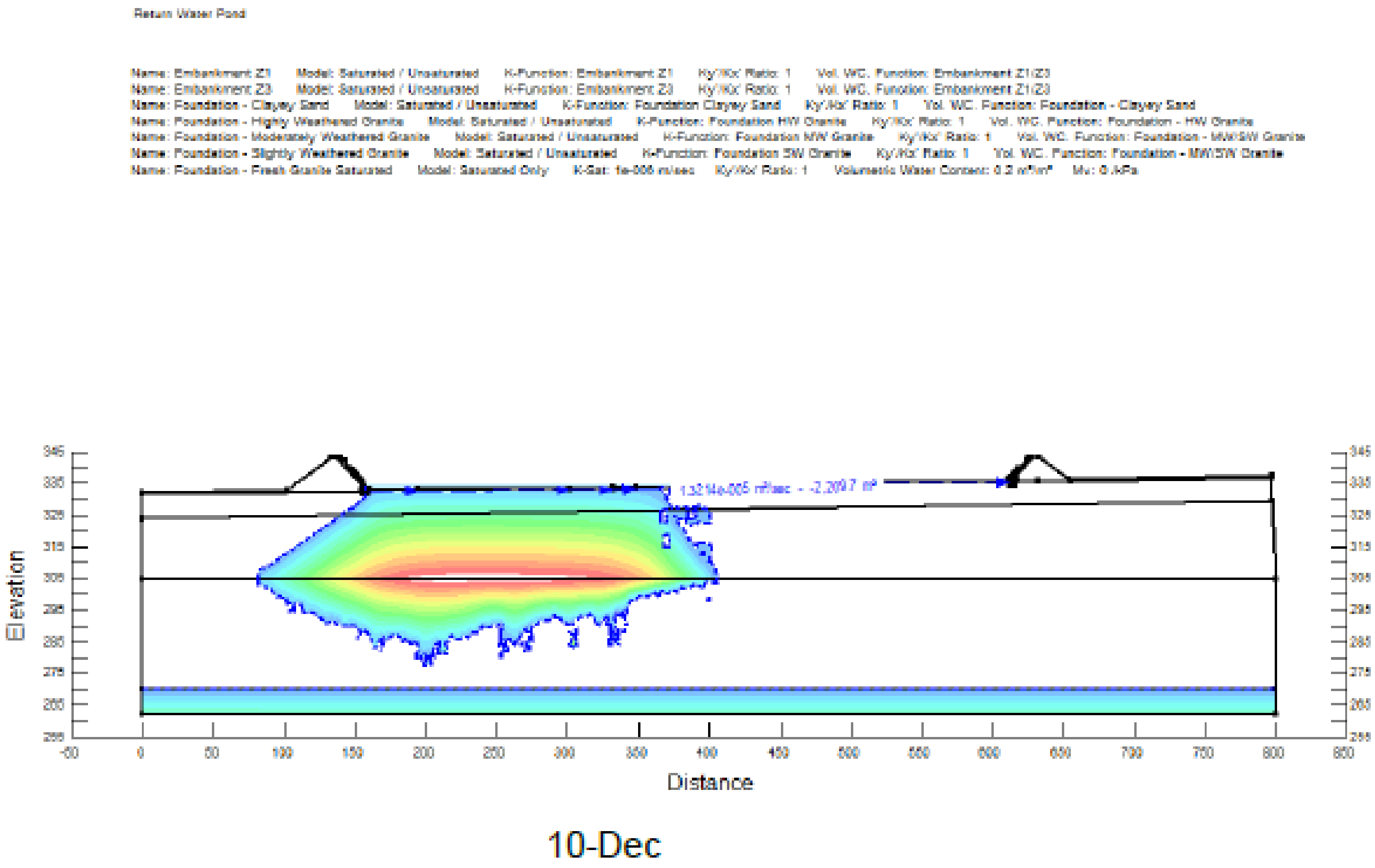
Due to this multi-faceted approach, Trajectory (2017; Appendix 6-1) demonstrated design factors that would compromise the TSF integrity over the long term and was also able to prescribe design criteria that demonstrated (over a 1000-year period) the TSF integrity could be maintained over the long term.

Further detail is provided in Section 8 Terrestrial Environmental Quality.



(ATC Williams 2017)

Figure 6-20 Wetting front of seepage from TSF 2 at end of mine life (year 10)



(ATC Williams 2017)

Figure 6-21 Wetting front of seepage from the Return Water Pond at end of mine life (year 10)

6.5.3.6 Seepage from sewage treatment plants

Discharge or leakage of water from sewage treatment plant(s) is unlikely. The construction and operations of prescribed facilities has strict regulatory controls under part V of the *Environmental Protection Act 1987* (administered by the Department of Water and Environmental Regulation (DWER)). This also applies to other prescribed facilities such as the landfill and processing plant (and associated tailings storage facilities).

6.5.3.7 Erosion of Waste Rock Landform surfaces

Surface and subsurface waste rock characterisation (see Section 8 Terrestrial Environmental Quality) identified certain materials that were highly erosive. The fresh waste rock and transitional rock components of the pits' lithology have a higher proportion of gravels, cobbles and larger clasts, and will therefore provide more suitable armouring and growth media layers. If waste rock material is not characterised during mining and if the erodible subsurface soils are used on the WRL surfaces' then the integrity of the surface structure will be compromised and likely to erode. The different materials are visually distinct and can be stored in separate stockpiles to ensure future WRL rehabilitation material is available that is fit for purpose.

6.5.3.8 Saline final void pit lakes contaminating surrounding ground water

Pit lake modelling of water levels and salinity over a 500-year period was undertaken by GRM (2018a) and a sensitivity analysis has taken into consideration high rainfall events and size of catchment (20% increase; see section 6.3.5.1). While the water in the pits will become increasingly saline over time, there will be no interaction between the saline water in the pit and groundwater i.e., the respective pits will act as groundwater sinks.

6.5.4 Cumulative impacts

There are no other Projects within 100 km of the Proposal, and as such no public information is available to consider cumulative impacts. Hastings currently has an active mineral exploration program that is assessing the feasibility of developing other deposits within the tenement area. The consideration of cumulative impacts from future expansion activities will be included in future approvals documentation.

6.6 MITIGATION HIERARCHY

Hastings commits to the following principles for the mitigation of potential impacts:

Best Practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- A hydrological model has been developed to identify specific areas where linear infrastructure may obstruct surface water movement.
- Diversion channels, flood-ways and culverts will be included in the detailed design of the proposal's infrastructure as per requirements under the *Rights and Water Irrigation Act 1914* Bed and Banks Permit.
- Hydrogeological modelling has been undertaken to determine the drawdown impacts to the surrounding environment and assess post closure pit void conditions at each location.
- Design and construct all hazardous materials storage areas to meet Australian Standards, including containment and impermeable bunding, as required.

- Design, construct and operate the landfill and waste water treatment plant to meet relevant statutory requirements.
- Design and construct TSFs, decant pond and evaporation pond in accordance with international best practice and land evolution modelling specifications (Trajectory 2017) to ensure a low risk of seepage and mass failure during operations or post-closure is achieved.
- Waste rock and soil management from mining operations to ensure that suitable cover material for closure purposes are stockpiled separately.

Avoidance

Hastings has avoided potential impacts by:

- Infrastructure has been located out of the flood plain, where possible.
- Exclusion of disturbance within 150 metres of Yangibana and Fraser Creeks, with the exception of road crossings.
- Locate soil stockpiles away from drainage lines and flood zones.
- Design the Proposal layout so that mining landforms are located outside the Yangibana and Fraser Creeks flood zones.
- Exclusion of groundwater abstraction from calcrete aquifers.

Minimisation

Hastings will minimise potential impacts as follows:

- Design and locate infrastructure to minimise potential impacts associated with flood events.
- Linear infrastructure has been moved to reduce the number of crossings of creeks and drainage channels thus reducing the risk of obstructing surface water flow during heavy rainfall events.
- Water reuse and recycling has been incorporated into the design of the processing plant to reduce groundwater demands for the proposal.

Management

The following management actions and associated documentation will be implemented to mitigate potential risks of impact to hydrological processes and inland waters environmental quality.

Surface water management plan (SWMP; to be developed)

OBJECTIVE(S)

To maintain the hydrological regimes and surface water quality so that environmental values are protected.

MANAGEMENT ACTIONS

The management of surface water includes:

- Maintain the existing cross-sectional area of creek to avoid accelerating water velocities and significantly altering pre-Proposal hydrology.
- Consideration of rip-rap protection upslope and downslope of the flood ways at river and creek crossings.
- Design and construct surface water management structures to:
  - divert overland flows around mining landforms to minimise erosion and sedimentation. Diversions shall return to the natural downstream drainage, where possible;
  - ensure linear infrastructure does not result in erosion and sedimentation;
  - protect the processing plant, evaporation pond and tailings storage facilities from surface water flows during heavy rainfall events; and
  - manage contaminated surface water runoff within processing plant, evaporation pond and TSF areas using water detention ponds.
- Detailed design of waste rock landforms to occur outside of drainage lines, where possible.
- Construct and progressively rehabilitate waste rock landforms with competent materials to prevent erosion (refer to Waste Rock Management Plan and Mine Closure Plan).
- Burial or raising of the water pipelines will be implemented to ensure sheet flow is not obstructed.
- Topsoil will be stored in designated areas and won't be used to form bunding on the side of roads.
- Maintenance of roads (i.e. grading) will ensure bunding alongside the roads is prevented and does not obstruct sheet flow.
- An oily water collection and treatment pond shall be designed, implemented and maintained.
- Hydrocarbons and chemicals shall be stored in accordance with the *Land Management Plan* and industry standards.

MONITORING

Construction phase

Monitoring of the construction process will occur to ensure infrastructure is built in accordance with design specifications as approved by DWER and the conditions of a Bed and Banks Permit.

Operations phase

Procedures will be developed as a component of the Hastings EMS to provide specific protocols for surface water monitoring including:

- Erosion monitoring
  - o WRL monitoring to ensure landform slopes are not eroding post heavy rainfall events;
  - o geotechnical inspections of diversion drains to assess performance following heavy rainfall events; and

    - post-flood or heavy rainfall event inspections of drainage and linear infrastructure.
- Water quality monitoring will include:
    - Lyons River and Fraser Creek ponds;
    - total suspended solids (TSS) shall be monitored upstream and downstream of Lyon's River road crossing following flood events;
    - maintenance inspections of process plant equipment, where chemicals are used, for leaks/drips;
    - treated effluent quality from the oily water separator;
    - maintenance inspections of oil water separator and ponds; and
    - waste water treatment plants' effluent monitoring.
- Hydrological processes:
    - monitoring of changes to vegetation composition and structure where linear infrastructure occurs at 90 degrees to surface water flow direction; and
    - inspections of drainage infrastructure prior to heavy rainfall events.
- Internal audits (in accordance with the Audits and Inspections Standard Operating Procedure) of the implementation of the SWMP.

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. The trigger limits and associated contingency actions include:

- Visible erosion or sedimentation events:
    - determine the cause;
    - repair damaged infrastructure;
    - stabilise area of erosion;
    - implement controls to prevent on-going or future erosion events (e.g. diffusion of kinetic energy); and
    - monitor the performance of the controls.
- Water quality exceedances beyond natural variation:
    - investigate cause; and
    - implement remedial action (e.g. installation of sediment traps, revise chemical storage/handling procedures, repair equipment.
- Significant change in flow regime impacting vegetation composition and structure upstream or downstream:
    - identify the cause (e.g. design, maintenance of drainage, damage);
    - determine management action (engineering design, drainage maintenance, repair); and
    - implement remedial actions.

Waste Rock Management Plan (WRMP; Appendix 5-11)

OBJECTIVES

The WRMP identifies the legal provisions that Hastings proposes to implement to meet the EPA objective for terrestrial environmental quality:

To maintain the quality of land and soils so that environmental values are protected.

Specific objectives of the WRMP are to ensure the effective characterisation, placement and configuration of waste rock, which meet closure objectives of being:

Safe: The waste rock landforms will, on average, have radionuclide levels below the proposed threshold of <1Bq/g. Landforms are geotechnically stable and safe to access on foot.

Stable: The waste rock landforms will have a durable, mixed fraction of waste rock exposed on the final surfaces such that erosion is minimised and the landforms are stable over the long-term.

Non-polluting: The waste rock landforms will not discharge unacceptable Acid and Metalliferous Drainage (AMD), neutral metalliferous or saline drainage to surface or groundwater.

Ecologically sustainable: The landforms, to the extent that the stabilising substrate allows, will be revegetated with local provenance species and ecological communities, which generally reflect the surrounding landscape.

MANAGEMENT ACTIONS

The following management actions will be implemented for each key aspect:

Dilution of waste rock with elevated radionuclide levels

- *Mining Schedule* to take into account waste rock movement and placement from source locations adjacent to ore body (i.e. waste rock most likely to have elevated levels of radionuclides).
- Areas of the WRLs with elevated radionuclide levels that exceed thresholds of 1Bq/g will be covered with benign rock materials.

Segregation and management of waste rock lithologies

- *Mining Schedule* to take into account waste rock movement and placement i.e. walls and surfaces of WRL to be comprised of fresh granite.
- WRL to be constructed in accordance with the respective WRL design specifications as detailed in the *WRL Design Report*.

Management of soils

- Plains soils will not be harvested in accordance with the *Land Clearing and Topsoil Stockpiling Work Instruction*.
- Topsoil delineation, harvesting and storage to be conducted in accordance with the *Land Clearing and Topsoil Stockpiling Work Instruction* includes instructions for:
  - mapping of soil types;
  - delineation of Plains versus Hills soils prior to clearing activities;
  - collection and disposal of Plains soils; and

- collection and storage of Hill soils.

MONITORING

The following monitoring activities detailed in the WRMP include:

- Re-profiled waste rock landform will be monitored for exceedances in radionuclide thresholds.
- Audit of construction of each WRL against the respective WRL design specifications.
- Annual audit of mining schedule to ensure segregation of waste types and placement of competent waste to ensure landform stability and prevention of surface erosion.
- Routine inspections of waste rock landforms to ensure that slope angle, berm width and cover material are according to design.
- Inspections of WRL surfaces following heavy rainfall events to establish competent materials are performing as determined by the geotechnical assessment.
- Audit of implementation of *Land Clearing and Topsoil Stockpiling Work Instruction*.

CONTINGENCY

Where the management target/s is not met or exceeded, Hastings will review and revise the risk assessment, review and revise management actions and identify additional management actions where necessary.

Hastings will implement adaptive management to learn from the implementation of mitigation measures, monitoring and evaluation against management target/s, to more effectively meet the environmental objective. The following approach will be followed:

- Monitoring data will be evaluated and compared to baseline and reference site data on an annual basis (or more frequently in some instances) in a process of adaptive management to verify whether responses to the impact are the same or similar to predictions.
- Address evaluation of assumptions and uncertainties listed.
- Annual review of the risk assessment and revision of risk-based priorities based on monitoring program information, incidences, verification of modelling outcomes and new information.
- Increased understanding of the ecological regime, best practice, new technologies.
- Revision through consideration of incidents and associated investigations, or when management actions are not as effective as predicted or as result of change management (e.g. construction versus operations phases).
- External changes during the life of the proposal (e.g. changes to the sensitivity of the key environmental factor, implementation of other activities in the area, etc.).
- Annual review of the WRMP as a component of the continual improvement process within the mining management system.

Groundwater operating strategy

OBJECTIVE(S)

The objective for groundwater abstraction is to:

To abstract groundwater so that environmental values are protected.

MANAGEMENT ACTIONS

Management actions for the abstraction of water from the SipHon Well Borefield include the

- Development and implementation of deep and shallow monitoring bores.
- Design larger bore field than required to allow for flexibility in localised water abstraction rates.
- Install flow meters.
- Install valves to provide flexibility in water bore usage and support maintenance activities.
- Maintenance of bore field infrastructure and equipment.

MONITORING

The groundwater operating strategy (as a component of water licence applications) will include monitoring of production bores, and shallow and deep monitoring bores:

- Water abstraction rates.
- Water quality analysis i.e. salinity, analytes.
- Groundwater level.
- Visual inspections of pipework, ponds and fittings to detect leaks.

Monitoring data will be compared to monitoring outcomes of Groundwater Dependent Ecosystems (GDE's). The monitoring data will also be used to validate the groundwater modelling (GRM 2018b).

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. The trigger limits and associated contingency actions include:

- Impacts to Groundwater Dependent Ecosystems i.e. vegetation or stygofauna determined:
  - turn off/reduce water abstraction from closest bore;
  - alternate to pit dewatering of closed pits, where possible; and
  - long-term considerations/investigations of alternate water source borefield.
- Validation of groundwater model shows smaller volume of water available for abstraction:
  - reduce reliance on SipHon Well Borefield, where possible; and
  - investigate alternate water source borefield.
- Water quality trigger level is exceeded for salinity or analytes:
  - initiate hydrogeological assessment to identify cause;
  - assess consideration of exceedance to process activities or potable water requirements and treatment, and environmental impact assessment;
  - reduce volumes of water abstracted; and
  - repeat monitoring and/or intensify water quality monitoring to determine trend.

Radiation Waste Management Plan (Appendix 5-7)

OBJECTIVE(S)

Ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations.

MANAGEMENT ACTIONS

The management of radioactive waste applies to the management of TSFs. Key considerations follow a risk based approach and include:

Detailed engineering phase

- Design of the TSFs will conform to relevant international standards.
- Key design features when considering elevated radionuclides include:
  - embankment stability taking account of site stability;
  - freeboard to accommodate severe weather events;
  - landform evolution modelling, specifications for long-term performance;
  - encapsulation and liners; and
  - leak detection.

Construction phase

- Preparation of a *TSF construction management plan* with quality assurance procedures will be developed and implemented to ensure that the TSF construction meets design specifications and tolerances.

Operations phase

- Preparation of a *TSF operating manual* with all pertinent information with respect to operation, rehabilitation and closure of the TSFs including:
  - deposition methodology;
  - water management;
  - seepage control (including drain details and requirements);
  - pipeline management;
  - all measures that should be followed during the operating phase to reduce the amount of work required at decommissioning;
  - planned measures to reduce impact(s) to the surrounding environment; and
  - planned measures for progressive rehabilitation during operations.

MONITORING

Construction phase

Monitoring of the construction process will occur to ensure the TSFs are built in accordance with design specifications. A competent person will be engaged to certify that the construction of the respective TSF meets design specifications and tolerances.

Operations phase

An *Environmental Radiation Monitoring Work Instruction*, a component of the Hastings EMS, will be developed to provide specific protocols for environmental radiation monitoring from the following sources:

- Direct gamma radiation: A survey of the perimeter of the Development Envelope to measure gamma radiation levels will be conducted on an annual basis.
- Radon decay products: Track etch monitors will rotate between off-site locations.
- Seepage into groundwater: A network of 5 monitoring bores will surround the TSFs (as per ATC Williams 2017) and downstream pastoral bores will be sampled and analysed for heavy metals including radionuclides, on a quarterly basis.
- Contamination of surface water run-off: Surface water sampling will be conducted opportunistically following significant rainfall events or on a quarterly basis.
- Contamination of potable water supply: Sampling and radiometric analysis will be conducted as detailed in the *Drinking Water Quality Management Plan* (to be developed and as required by the Department of Health).
- Dust containing long-lived alpha-emitting radionuclides: Dust deposition gauges and high volume samplers will collect dust samples at pre-determined locations for composite analysis on an annual basis and rotate between approved off-site locations, respectively.

Monitoring of controls for containment of radioactive waste will include:

- Weekly visual inspection of surface water management structures including bunds, drainage channels, tailings and water pipelines, and evaporation ponds.
- Weekly inspection of the walls of TSF 2 and 3 for erosion or other signs of potential compromise to the integrity of their structure, including signs of seepage of tailings or water from tailings into the environment immediately surrounding the TSFs.
- Inspections of management controls following major rainfall or extreme weather events.
- Annual inspection/audit by closure specialist to identify potential hazards, risks and opportunities for continual improvement, including aspects that require further investigation or research.
- Internal audits (in accordance with the Audits and Inspections Standard Operating Procedure) of the implementation of this RWMP.

Trigger values are based on authorised limits and/or baseline values of *NORM Guideline 6 Reporting Requirements* (DMP 2010). Exceedances of a trigger value will be considered an incident unless significant seasonal environmental variation of background levels are expected. In such instances, a trend of exceedances in trigger values will then be treated as an incident.

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. Contingency plans will form a component of the *Emergency Response Plan* (ERP). Where containment of radioactive waste fails, the ERP will include:

- Human health and safety first: response to exposure, evacuation, decontamination of the persons exposed to radiation.
- Stabilisation of the containment and prevention of impact to surrounding environmental receptors.
- Consideration of secondary containment and drainage.

- Clean-up procedures.
- Training of personnel on the Emergency Response Team to address radioactive waste containment failures.
- Identification of radiation specialists and TSF experts to review contingency plans.
- Suspension of operations (also considered in the Care and Maintenance section of the MCP).

Water Management Plan (Appendix 4-4)

OBJECTIVE(S)

Summarise and describe inter-relationships of water quality management and monitoring actions determined by the:

- *Radiation Waste Management Plan*
- *Groundwater Operating Strategy*
- *TSF Operating Manual*
- *Drinking Water Quality Management Plan.*

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

To maintain the quality of groundwater and surface water so that environmental values are protected.

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

MANAGEMENT ACTIONS

The following management actions will be implemented to manage **surface water**:

- A series of diversion drains will be installed to direct storm water around workshops, plant areas, hydrocarbon storages and other disturbed areas, discharging to the natural drainages.
- Infrastructure within the diversion drains, including the ROM and plant will be internally draining, discharging to sumps and then to a process pond for use within the plant.
- Oily water separators and sediment traps will be installed to manage runoff from contaminated and disturbed areas, respectively.
- Hydrocarbons and other chemicals will be stored in bunded facilities, which will comply with Australian Standards and licence conditions.
- An on-site bioremediation facility will be established and maintained, to treat hydrocarbon contaminated soil as per the Land Management Plan and managed in accordance with the Bioremediation Facility Work Instruction.
- Monitoring and inspection schedules, contingency and reporting requirements are developed to manage surface water upon commencement of the Project and are discussed in the following sections.

The following management actions will be implemented to address the **groundwater abstraction**:

- Groundwater abstraction from the SipHon Well Borefield will be distributed across the bores to manage impacts on groundwater levels and quality. A maximum permissible total allocation from the borefield, as well as recommended sustainable pumping rates for each bore, as per the Groundwater Operating Strategy.
- Each bore shall be equipped with a submersible pump, dip tube, flow meter and control box.
- Borefield details and pumping rates will be tabulated as per the Groundwater Operating Strategy.
- A network of monitoring bores will be installed to enable the drawdown impacts to be measured.

- Monitoring and inspection schedules, contingency and reporting requirements are discussed in the following sections.

The following management actions will be implemented to manage **potable water** usage:

- Potable water will be treated via an on-site RO treatment plant located either at the camp and/or at the process plant.
- The potable water will be further treated with a chlorinator or in-line UV treatment system.
- Waste potable water will be treated within the waste water treatment plant, before being discharged to an irrigation area. The irrigation area will be located on flat ground, bunded to prevent runoff and will be rested following periods of high rainfall to promote evaporation.
- Water usage within the camp will be monitored regularly to determine the relative water efficiency in the village and allow the assessment of ongoing water minimisation strategies implemented during the life of the Project.
- Monitoring and inspection schedules, and contingency and reporting requirements will be developed to manage the potable water supply upon commencement of the Project and are discussed in the following sections.

The following management actions will be implemented to manage **pit dewatering**:

- The dewatering bores should be constructed using 6" schedule 40 steel casing (7.1 mm wall thickness). The steel casing should be slotted across the main aquifer zone (as per the test bore construction), with the bore annulus gravel packed to just below the surface. The annulus will need to be sealed at the surface, with cement grout or bentonite, to prevent surface water ingress.
- Additional dewatering bores could be considered if higher than predicted inflow rates are observed during operations. The dewatering bores should be positioned into a thick (preferably greater than 10 m) sequence of ironstone, and located just outside the crest of the pits, on the down dip side.
- It is recommended the dewatering bores are installed at least 6 months prior to mining to achieve sufficient drawdown. However the bores can be operated prior to this, to provide additional make-up water to meet the Project demand if necessary, which will further aid mine dewatering.
- Sump pumping will require ongoing management during the operational life of the pits. Sumps should be strategically located at low points along the pit floor.
- All dewatering discharge will be transferred to a water storage pond, for use during the operation phase activities, for dust suppression and mineral processing. At the predicted dewatering rates there shall be no requirement to discharge mine water to the surrounding environment.
- A network of monitoring bores have been installed to assess the drawdown impacts from mine dewatering.
- Monitoring and inspection schedules, contingency and reporting requirements have been developed to manage dewatering upon commencement of the Project and are discussed in the following sections.

The Tailings Storage Facilities (TSFs) will be managed as detailed in the *TSF operating manual* follows:

- The TSFs will be constructed in accordance with the proposed design.
- TSF3 will be constructed with underdrain detection between the compacted clay and bitumen liners, and a sump.
- The storage ponds will be constructed with sufficient contingency for high rainfall events.

- A series of monitoring bores will be installed down hydraulic gradient from the TSFs to measure groundwater level and water quality.
- Monitoring and inspection schedules, contingency and reporting requirements have been developed to manage the storage receptors upon commencement of the Project and are discussed in the following sections.
- Trigger limits for the TSF monitoring bores have been identified to assist in early detection of seepage impacts (as described in the following section).

MONITORING

The Water Management Plan will include the following monitoring programs:

- Surface water quality testing will be conducted following the first heavy rainfall event of the season.
- Visual inspections of pipework, ponds and fittings to detect leaks.
- Groundwater quality monitoring of the fractured rock aquifer bores and SipHon Well Borefield, pastoral bores, and Frasers and Lyons River pools.
- Inspections of all infrastructure relevant to water sources including pit dewatering bores and in pit sumps, Siphon Well borefield and associated pipelines, potable water, and waste water including evaporation pond, return water pond, waste water treatment plant and irrigation field, storage ponds and sumps.
- Inspection of all surface water management infrastructure prior to and following heavy rainfall events including culverts, diversion drains and floodways.
- Water quality parameters of water from TSF monitoring bores.

Trigger levels for groundwater quality have been proposed for the Project, for all monitoring locations (including dewatering discharge, production bores, TSF monitoring bores and the regional stock water bores). The proposed trigger values have been set as follows:

- Exceedances of >25% beyond natural variability on 3 consecutive samples.
- Exceedances of ANZECC guidelines for fresh and marine water quality (2000) for livestock and Australian NHMRC and ARMCANZ (1996) Australian Drinking Water Guidelines for drinking water quality for elements that are not exceeded naturally.

CONTINGENCY

The SipHon Well Borefield has been designed to meet the maximum water demand of the Project i.e. 2.5 Gl/annum. This water balance shows that 2.1Gl/annum is required to meet the Project water demand. As a result, a larger borefield has been designed. This provides flexibility and contingency should trigger levels be exceeded, or early response indicators of GDE monitoring show potential impacts.

Rehabilitation

The closure objectives relevant to hydrological processes and inland waters environmental quality are:

> *Surface drainage structures will be constructed to an appropriate hydrology design standard to minimise erosion of permanent mining landforms and maintain ecosystem function.*
>
> *Impacts on the availability and quality of regional groundwater are minimised and do not limit the proposed post-mining land use.*

The completion criteria relevant to hydrological processes and inland waters environmental quality are:

> *Surface drainage to downstream environments is maintained.*
>
> *Pit water quality does not impact on areas beyond the immediate mining area.*
>
> *Any groundwater contamination will be confined to the immediate mining area and will not impact on surrounding groundwater resources.*
>
> *Groundwater levels of production bores will recover to pre-abstraction levels after mine closure.*

A Preliminary Mine Closure Plan (Appendix 6) include closure strategies and 'next steps' identified (where possible), specific to hydrological processes and inland waters environmental quality include:

Baseline studies and investigations:

- Closure research, investigations and trials:
  - progressive rehabilitation; and
  - water drawdown impacts on GDEs.
- On-going surface water and groundwater monitoring during operations:
  - tailings pore water characterisation and verification of laboratory-based findings;
  - TSF seepage monitoring during operations to verify seepage modelling;
  - verification that landforms were/are constructed in accordance with design specifications;
  - water availability, recycling and storage as per water balance; and
  - assess erosion performance of competent material used on slopes and batters of landforms.

Design and construction of landforms:

- TSF covers and / or encapsulation specific to each of the facilities:
  - TSF design reports to incorporate closure considerations; and
  - detailed design to incorporate closure considerations.
- Landforms are constructed as per design specifications:
  - waste rock landform design reports to incorporate closure considerations; and
  - detailed design to incorporate closure considerations.

Identification and management of site contamination:

- Areas of site (e.g. TSFs, hydrocarbon storage areas, workshops, chemical storage areas, process plant) with the potential for contamination will be assessed by an accredited contaminated site auditor at closure, in accordance with DWER requirements under the *Contaminated Sites Act 2003* (WA) and associated regulations.

- Develop and implement *Land Management Plan* and associated procedures for management of hydrocarbons, chemical use and storage, and spill response procedures, identification of areas at risk of contamination.
- Implement *Radiation Waste Management Plan.*
- Develop and implement *TSF operating manual.*

Rehabilitation of landforms:

- Progressive rehabilitation of landforms, where possible.
- Construction of pit abandonment bunds and surface water diversion bunds.

Post closure monitoring and maintenance:

- Landform monitoring of erosion, stability and rehabilitation success.
- Water levels and water quality monitoring in decommissioned production and monitoring bores at SipHon Well Borefield.
- Performance of permanent surface water diversion drains.

6.7 PREDICTED OUTCOME

6.7.1 Residual Impacts

The Proposal occurs within the Gascoyne River Catchment in a landscape that has been historically and significantly impacted by pastoral activities. The local catchment, however, is in a relatively good condition. The Proposal mining operations, process plant and TSFs occur at the higher elevation locations in the local water catchment. In addition, much of the disturbance footprint occurs over the benign Hill's soils.

There are evident risks where infrastructure intersects Plains soils, where linear infrastructure occurs at 90 degrees to the sheet flow of surface water, the presence of waste rock lithologies that are not competent for landform surfaces, storage of chemicals, and where radionuclides become elevated and concentrated in the tailings solids, particularly TSF 3. Water drawdown also has the potential to impact groundwater dependent ecosystems. The implementation of the mitigation hierarchy and management plans, described in Section 6.6, ensures risks will be as low as reasonably possible and the hydrological processes and inland waters environmental quality will not be significantly impacted.

Due to the storage and containment of tailings with elevated radionuclides above background levels, TSF 2 and 3 are considered potentially contaminating activities although the radionuclides are strongly tied to the solids component and concentrations are negligible in the tailings pore water. However, any credible pathway of exposure has been eliminated via the TSF design. Construction and operation in accordance with the design criteria and mitigation measures ensures that the TSFs are not contaminated sites as defined under the *Contaminated Sites Act 2003* (WA) and associated regulations (2007).

6.7.2 EPA Objective

Potential impacts will be mitigated as described in section 6.6 so that the Proposal meets the EPA objective:

> *To maintain the quality of groundwater and surface water so that environmental values are protected.*
>
> *To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.*

SUBTERRANEAN FAUNA

Chapter 7

7. KEY ENVIRONMENTAL FACTOR: SUBTERRANEAN FAUNA

7.1 EPA OBJECTIVE

The EPA objective for subterranean fauna is:

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

7.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of subterranean fauna include:

Environmental Protection Act 1986 (WA)

Relevant guidelines include:

EPA (2016k) Environmental Factor Guideline: Subterranean fauna;

EPA (2016o) Technical Guidance - Subterranean fauna survey; and

EPA (2016s) Technical Guidance - Sampling Methods for Subterranean Fauna.

7.3 RECEIVING ENVIRONMENT

The following studies have informed this section:

- Subterranean Fauna Report (Ecoscape 2016; Appendix 3-1)
- Regional Subterranean Fauna Report (Bennelongia 2017; Appendix 3-2)
- Conceptual Hydrogeological Assessment (Global Groundwater 2016; Appendix 4-1)
- Hydrogeological Assessment (GRM 2017 and 2018; Appendix 4-2 and 4-4)

Subterranean fauna are animals that have adapted to live underground. Living underground reduces the capacity of animals to disperse widely. Therefore, subterranean fauna species tend to have smaller geographic ranges. In the underground environment, subterranean fauna species are not exposed to light and thus lack eyes and pigmentation. There are two types of subterranean fauna, namely stygofauna and troglofauna.

Stygofauna are aquatic animals that live in groundwater whereas troglofauna are 'cave dwellers' at a micro scale, breathe air and are found in various lithologies from a metre or two below the surface down to just above the water table. While some of the best-known stygofauna species occupy lakes in subterranean caves, most stygofauna species occur in calcrete, alluvial, karstic or fractured rock aquifers. They occupy the interstitial spaces, vugs and fissures in these aquifers.

A desktop study revealed that the Proposal development envelope intersects the northern portion of a Department of Biodiversity Conservation and Attractions (DBCA) listed Priority Ecological Community (PEC):

Priority 1 (P1) Gifford Creek, Mangaroon, Wanna calcrete groundwater assemblage type on Lyons palaeodrainage on Gifford Creek, Lyons and Wanna Stations.

DBCA refer to the PEC as the "Gifford Creek Calcrete PEC" (**Figure 7-1**), which comprises unique assemblages of invertebrates (stygofauna) that have been identified in shallow calcrete aquifers.

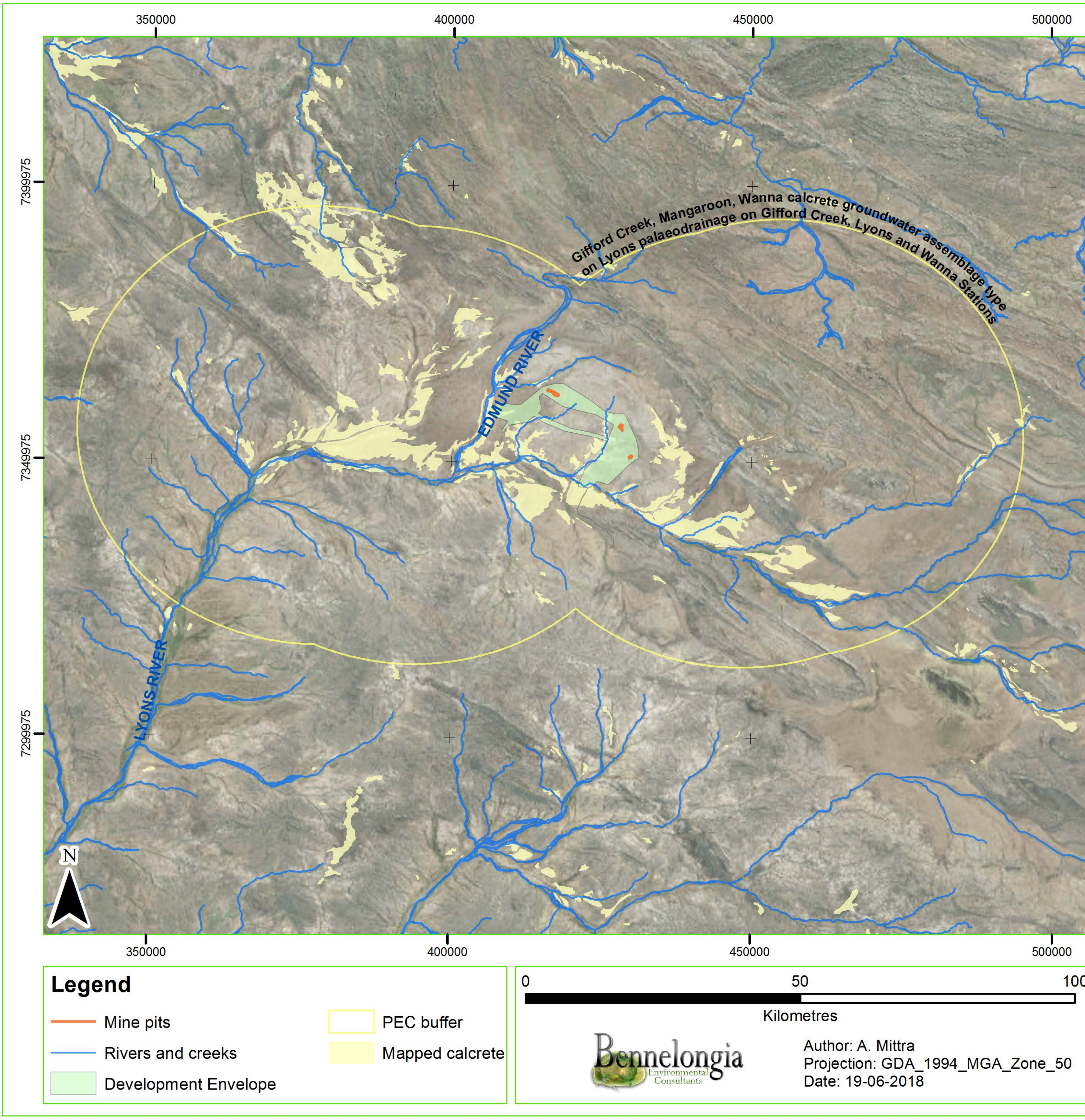


Figure 7-1

Distributions of calcrete Priority Ecological Communities, rivers and creeks relative to the Project

7.3.1 Geology

The Project is located within the Gascoyne Province of the Capricorn Orogen, between the Archaean Yilgarn Craton to the south, the Archaean Pilbara Craton to the north and Phanerozoic Carnarvon Basin sediments to the west (Global Groundwater 2016; Appendix 4-1).

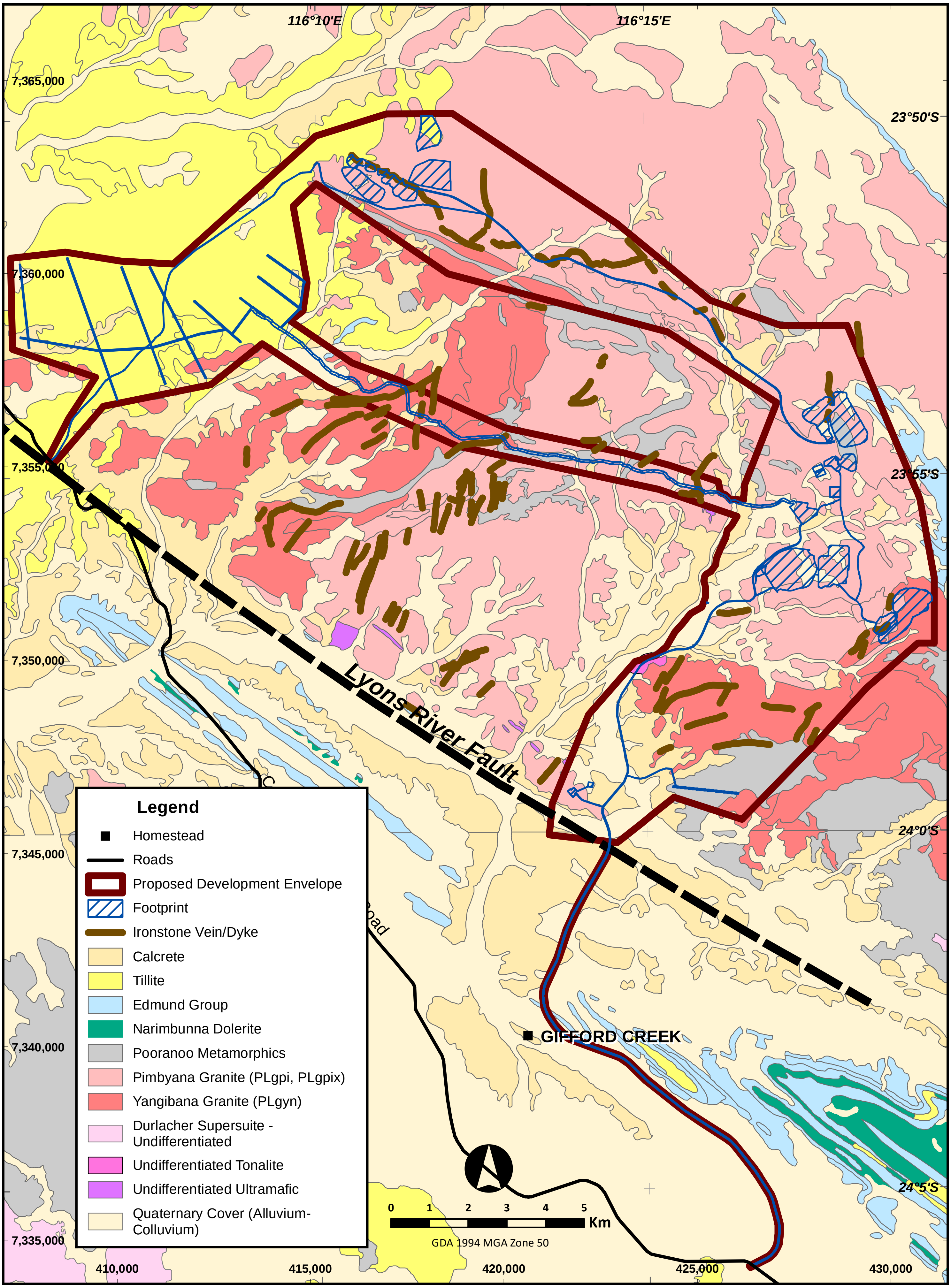
The majority of the Proposal area and surrounds is underlain mostly by Proterozoic metasedimentary basement rocks of the Pooranoo Metamorphics. The basement rocks consist of metamorphosed feldspathic sandstone and psammitic schist and calc-silicate rocks. These have been intruded by Proterozoic granitic rocks (specifically the Pimbyana and Yangibana Granites), which underlie the Proposal development envelope and the bulk of Yangibana tenements area. The granitic rocks are fresh to weathered (Global Groundwater 2016) and provide suitable habitat for troglofauna. Their extent is shown in **Figure 7-2**.

The earlier basement rocks have been intruded by later dolerite sills and dykes as well as veins of ferrocarbonatite, ironstone and quartz of the Gifford Creek Ferrocarbonatite Complex (GFC). The ironstone veins consist of magnetite, hematite, and supergene goethite and are locally weakly radioactive. Lenses and pods up to 10 m wide of massive to vuggy iron oxide are contained within the veins, which also provide suitable habitat for subterranean fauna. They host the rare earth element (REE) mineralisation of the Proposal and occur as sinuous pods and veins (Global Groundwater 2016). The known location (from mineral exploration) of these ironstone veins is shown in **Figure 7-2.** These pods and veins may also host fractured rock aquifers as described below in Section 7.3.2.

Cenozoic superficial strata cover much of the basement rocks in the study area. The superficial strata within the study area include: calcrete, colluvium and other transported and older residual units (excluding calcrete and saprolite), eluvium (saprolite), more recent alluvium and lake deposits. Of specific interest is the shallow calcrete geology associated with the Lyons River and Fraser and Yangibana Creek systems (**Figure 7-1**).

Fluctuating groundwater levels and resulting precipitation of carbonates along the internal palaeochannel river systems of many arid parts Western Australia have resulted in the formation of many calcrete aquifers (Humphreys 2001. Although classical karst formations are absent from the Western Australian landscape, calcretes display karstic characteristics and provide excellent habitat for stygofauna, as well as for troglofauna above the water table (Bennelongia 2018).

Dissected calcrete units occur scattered along the major drainage lines i.e. Lyons River, Fraser Creek and Yangibana Creek (Global Groundwater 2017). The calcrete units are characterised by a hard surface layer of brecciated and partly silicified calcrete underlain by softer more friable material. These units consist mostly of vuggy calcrete with irregular, lenticular, bedding parallel cavities. Veins and cavities can be filled by quartz cement, especially in upper parts of the calcrete profile. The calcrete can be 30 m thick and possibly up to 50 m thick and is commonly partly eroded and degraded (Global Groundwater 2017). The extent of this habitat is shown in **Figure 7-1**.



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PER_FX-X_Geology.mxd
28 August 2018

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Figure 7-2 Regional Surface Geology

Regional Geology source: © State of Western Australia (Department of Mines, Industry Regulation and Safety) 2017

7.3.2 Hydrogeology

7.3.2.1 Regional overview

Basement rocks (i.e. granite geologies) in the study area will, in the main, have very low permeability and may be regarded as effectively impermeable throughout much of the Proposal area, although some zones of very high permeability will occur. Permeability in basement rocks will be very high near bedding plane partings and fractures from faulting, folding, intrusives and where solution cavities and channels (vugs) have developed in ironstone veins. Large cavities were identified as a significant feature of the mineralised zone at depth at Fraser and Bald Hill deposits. Groundwater in fractured rock can be unconfined , although confinement can occur where clayey, weathered basement rock overlies either sandy, weathered strata above the fresh basement rocks or fractures within the basement rocks. This can often be the case in granitic basement rocks and appears to be the case at the ore body in the Proposal (Global Groundwater 2016).

Most superficial units within the study area will have low permeability and/or will be unsaturated (i.e. colluvium, eluvium and some alluvium). In general, only alluvium and/or calcrete aquifers occur in proximity to recharge along the main drainages (as can be seen in **Figure 7-1**). Both units would essentially act as one aquifer of variable extent, occasionally layered, and with highly variable permeability; highest where solution channels and cavities are present in calcrete, and lowest where the strata are clayey (Global Groundwater 2016).

The Gifford Creek Calcrete PEC underlies the Gifford Creek, Lyon's River, Frasers Creek, Yangibana Creek and Edmund River surface water systems (**Figure 7-1**) that are ephemeral and serve to recharge the shallow calcrete aquifers following heavy rainfall and flood events. The nature of rainfall in the region produces periods of high runoff to creeks and rivers. This in turn produces sporadic recharge to permeable units (e.g. permeable alluvium and calcrete along the drainages or where fractured basement rocks contact surface drainage lines, in areas where the runoff is concentrated).

The Gifford Creek PEC itself lies above the palaeochannel drainage systems, which are part of a deep and ancient river system developed at the end of the Cretaceous period when Australia was rifted from Antarctica. The extensive palaeovalley drainage system underlying the Gifford Creek PEC is deep and comprises thick sequences of fluvial clay and sand and incises the bedrock. The palaeovalleys themselves are no longer functional surface water systems and are typically overlain by Quaternary alluvium, which also includes the sediment of the modern drainages. The Quaternary alluvium includes calcrete deposits that typically occur on the flanks of the modern drainage systems (GRM 2018).

The shallow calcrete aquifers may interact with the palaeochannels to provide a recharge mechanism to the deeper aquifers, however this depends on the overlying lithology (**Figure 7-3**).

7.3.2.2 Fractured rock aquifers (Pit dewatering)

A low diversity of stygofauna and troglofauna occur within the proposed mineral deposits (Ecoscape 2015; Appendix 4-1). The proposed mineral deposits occur below the groundwater table and thus pit dewatering will be required. The field investigation indicated that the depths of groundwater in the pit areas are approximately 309 mRL at Fraser's, 316 mRL at Bald Hills and 323 mRL at Yangibana.

Modest groundwater inflows are likely in association with an aquifer unit comprising the vuggy ironstone veins which host the orebody. The ironstone veins strike in a north south direction in Fraser's and Bald Hills, swinging to a north-west south-east direction at Yangibana. The ironstone veins dip steeply to the west (or south west at Yangibana), extending above the water table on the up-dip side. The veins are thought to extend down dip and along strike from each of the pits.

The permeability away from the ironstone structures is low to very low. Analysis of the airlift recovery data indicates the hydraulic conductivity of the aquifer averages about 2.5 m/day at Fraser's to 5 m/day at Bald Hill and Yangibana. The thickness of the aquifer varies from 1 m to over 10 m thick, with an average thickness of about 5 m at Fraser's and 4 m at Bald Hills and Yangibana (north and west).

7.3.2.3 Palaeochannel tributary (SipHon Well borefield)

A water exploration program has identified a 3 km long section of palaeochannel sand aquifer, which is up to 40 m thick, 150 m deep and approximately 1 km wide. It is overlain by up to 100 m of clay, which acts as an aquitard. Geophysical surveying has mapped the channel extent over a length of 12 km. A thin veneer of unsaturated alluvium overlies the clay sequence and thus may represent a shallow ephemeral aquifer. The groundwater quality in the palaeochannel aquifer is fresh to slightly brackish.

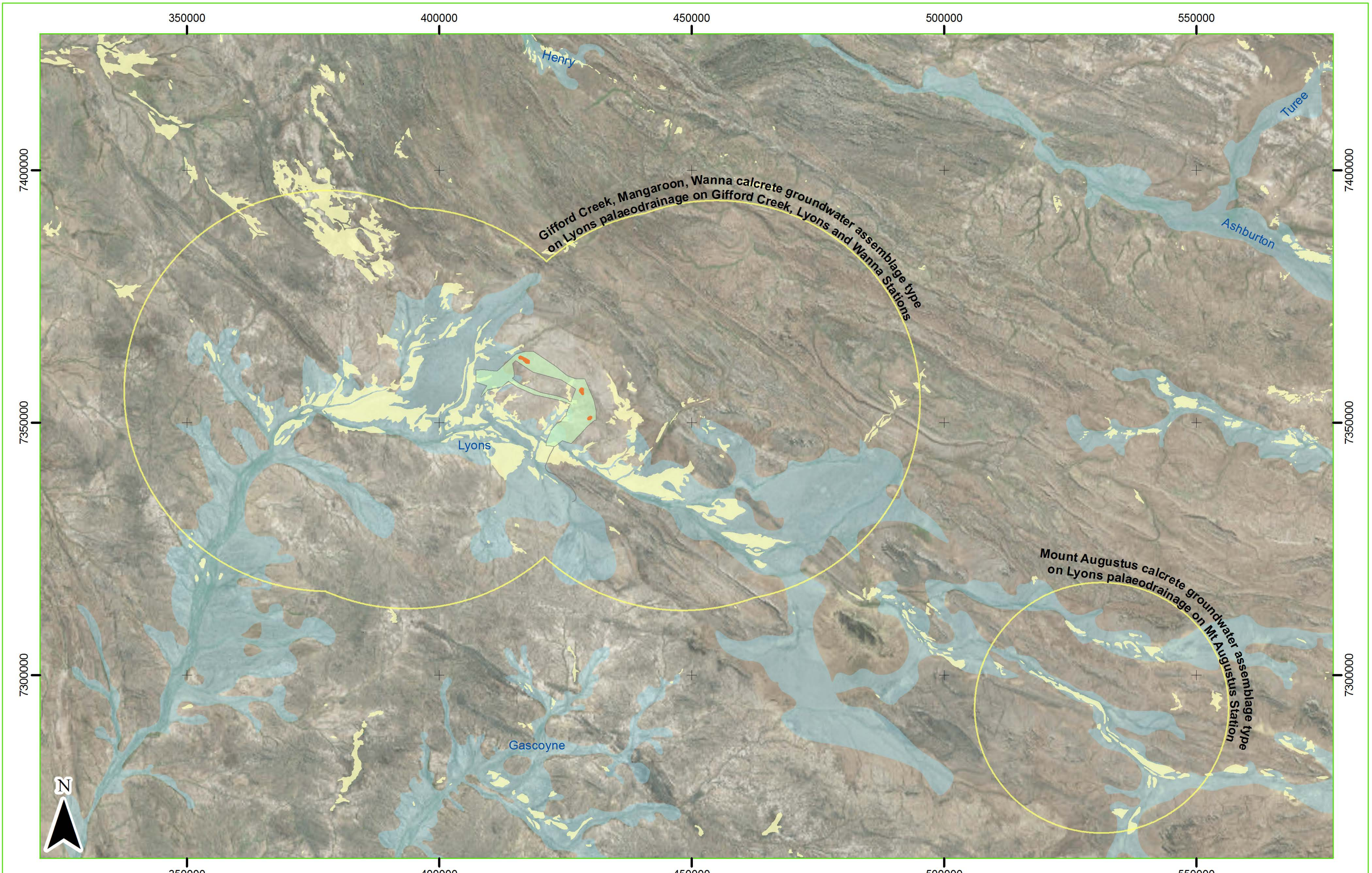
No stygofauna or troglofauna have been found within the SipHon Well Borefield (Bennelongia 2018; Appendix 3-3).

7.3.2.4 Water drawdown modelling

Pit dewatering, including two existing production bores, is expected to satisfy approximately 20% of the water demand in the initial stage of the Proposal, increasing to 90% towards the end of the mine life. The remainder of the demand is expected to be met by a network of water supply bores located in a palaeochannel tributary (i.e. SipHon Well Borefield).

Groundwater flow modelling was undertaken to estimate dewatering rates around the proposed pits (GRM 2017, 2018) and the rate of water abstraction from the SipHon Well Borefield (GRM 2018b). Water will be obtained by sump pumping, augmented at Fraser's and Bald Hills by abstraction from the two existing production bores, and by water abstraction from SipHon Well Borefield.

Sensitivity analysis was also conducted to provide a range of possible dewatering rates, by varying hydraulic parameters within likely ranges (refer to the GRM (2017, 2018a) reports for further details). For SipHon Well Borefield, sensitivity analysis was based on maximum abstraction, no recharge, hydraulic conductivity and aquifer storage. Model simulated drawdown contours at the end of mining were created for the pit dewatering and borefield water abstraction (**Figure 7-4**).



Legend

- Mine pits
- Development Envelope
- PEC buffer
- Mapped calcrete
- Palaeovalleys

0 50 100

Kilometres

Bennelongia Environmental Consultants

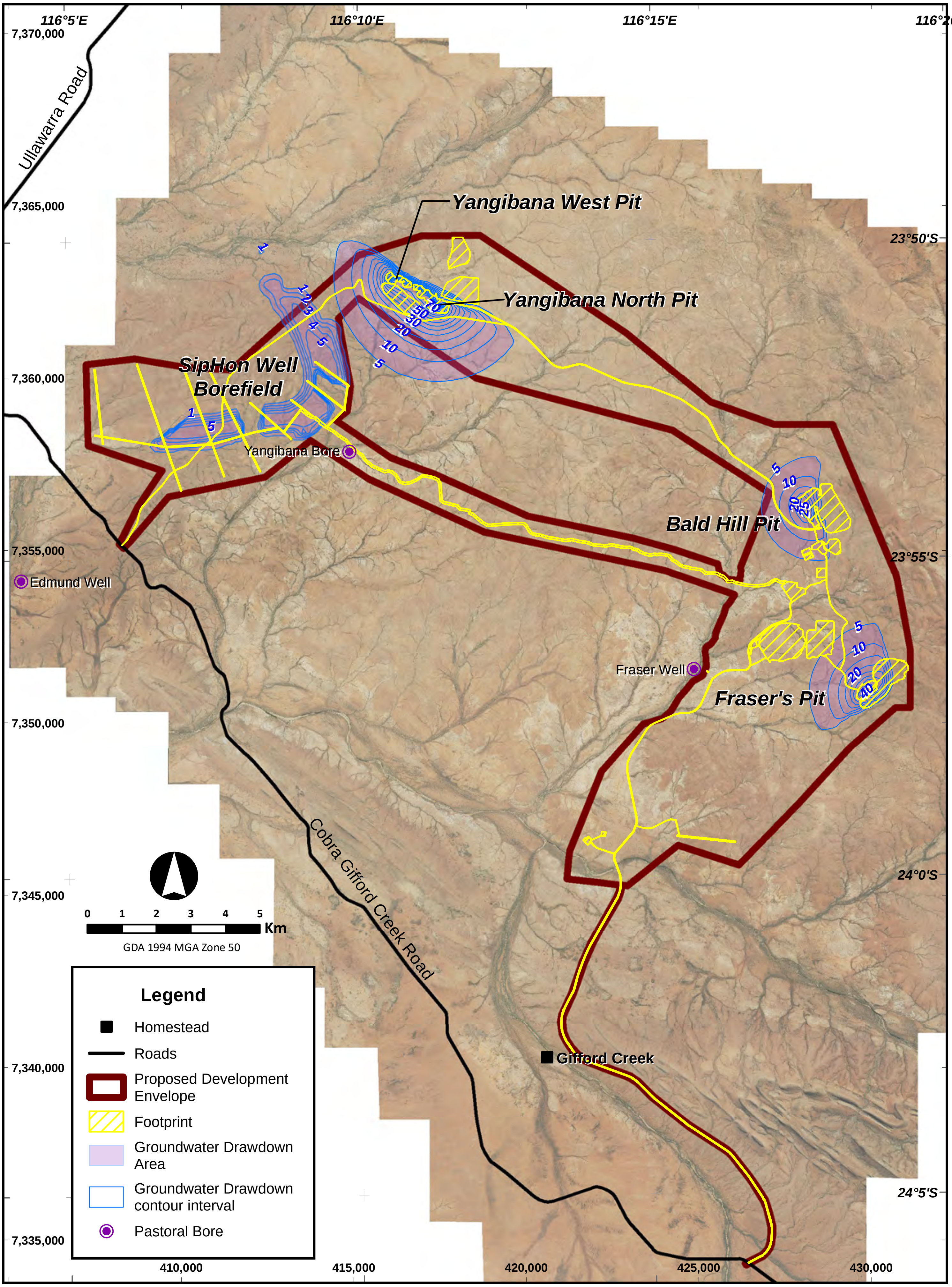
Author: A. Mittra

Projection: GDA_1994_MGA_Zone_50

Date: 19-06-2018

Figure 7-3

Distributions of calcrete Priority Ecological Communities, rivers and creeks relative to the Project



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PER_F6-5__Pits_Drawdown_Bores.mxd
18 June 2018

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Figure 7-4 Water drawdown contours at end of mine life

7.3.3 Subterranean fauna surveys

7.3.3.1 Stygofauna

Seven sampling events were undertaken in May and September 2015, October and December 2016, October 2017, December 2017 and May 2018 (**Table 7-1**). Stygofauna sampling methods conformed with *Technical Guidance Sampling for Subterranean Fauna* (EPA 2016). A total of 167 stygofauna samples were collected across the seven sampling events (Ecoscape 2016; Bennelongia 2018; **Table 7-1**). Of these 120 reference samples were taken and 47 impact samples were collected (**Table 7-1**). Some locations were sampled on more than one occasion.

Table 7-1 Number of stygofauna samples collected in 2015 - 2018

Location	Sample Type	2015		2016		2017		2018	Total
		May	Sept	Oct	Dec	Oct	Dec	May	
Regional	Reference	7	9	38	1	51			106
Eastern Belt*	Impact	4	7	10					21
Western Belt^	Impact	2	2	5			1		10
SipHon Well Borefield	Reference						5	9	14
SipHon Well Borefield	Impact						6	10	16
Total	Reference								120
	Impact								47
	Overall	13	18	53	1	51	12	19	167

*The Eastern Belt is Frasers and Bald Hill deposits.
^The Western Belt is Yangibana West and North deposits.

Ecoscape (2016) collected 236 stygofauna specimens from four families representing 10 discrete species. In addition, a total of 1400 specimens from 79 discrete species of stygofauna were recorded by Bennelongia (2018) from the Project and surrounding region during surveys conducted in 2016-2018. Reference sites yielded 1301 specimens from 79 species, while impact areas yielded 99 specimens from 6 species (**Table 7-2**). The total number of stygofauna species known from the broader Gifford Creek PEC study area is at least 81 (Bennelongia 2018; **Figure 7-5**). At least 50 species are new to science and are probably restricted to the Gifford Creek Calcrete PEC. Considering other extensively surveyed calcrete aquifers in Western Australia, the Gifford Creek Calcrete PEC is among the most diverse in terms of known species richness (Bennelongia 2018).

No stygofauna species were found within the palaeochannel tributary (i.e. SipHon Well Borefield) or Frasers deposit (Ecoscape 2016; Bennelongia 2018). Additional subterranean fauna surveys within the broader PEC area have found that a greater diversity and abundance of stygofauna species are represented within the calcretes of the PEC (Bennelongia 2018; Appendix 3-2), and probably focussed on a more vuggy and better wetter calcrete.

Major groups collected during stygofauna sampling program include flatworms (Turbellaria), earthworms (Oligochaeta), rotifers (Rotifera), nematode roundworms (Nematoda), ostracods (Ostracoda), copepods (Cyclopoida and Harpacticoida), amphipods (Amphipoda), isopods (Isopoda), aquatic mites (Arachnida: Acari) and beetles (Insecta: Coleoptera). Nine of the ten stygofauna species recorded in the previous Ecoscape (2016) survey were also recorded in the later surveys (Ameiridae gen. nov. sp. B04, *Diacyclops cockingi*, *Diacyclops humphreysi humphreysi*, *Orbuscyclops westaustraliensis*, Areacandona sp. BOS550, Paramelitidae sp. B49, Phreodrilidae sp. AP DVC B12, Enchytraeidae sp. 21 and Nematoda sp.), and only one species (*Phreodrilus peniculus*) were not recollected (Bennelongia 2018).

Table 7-2 Stygofauna species within and outside of impact areas

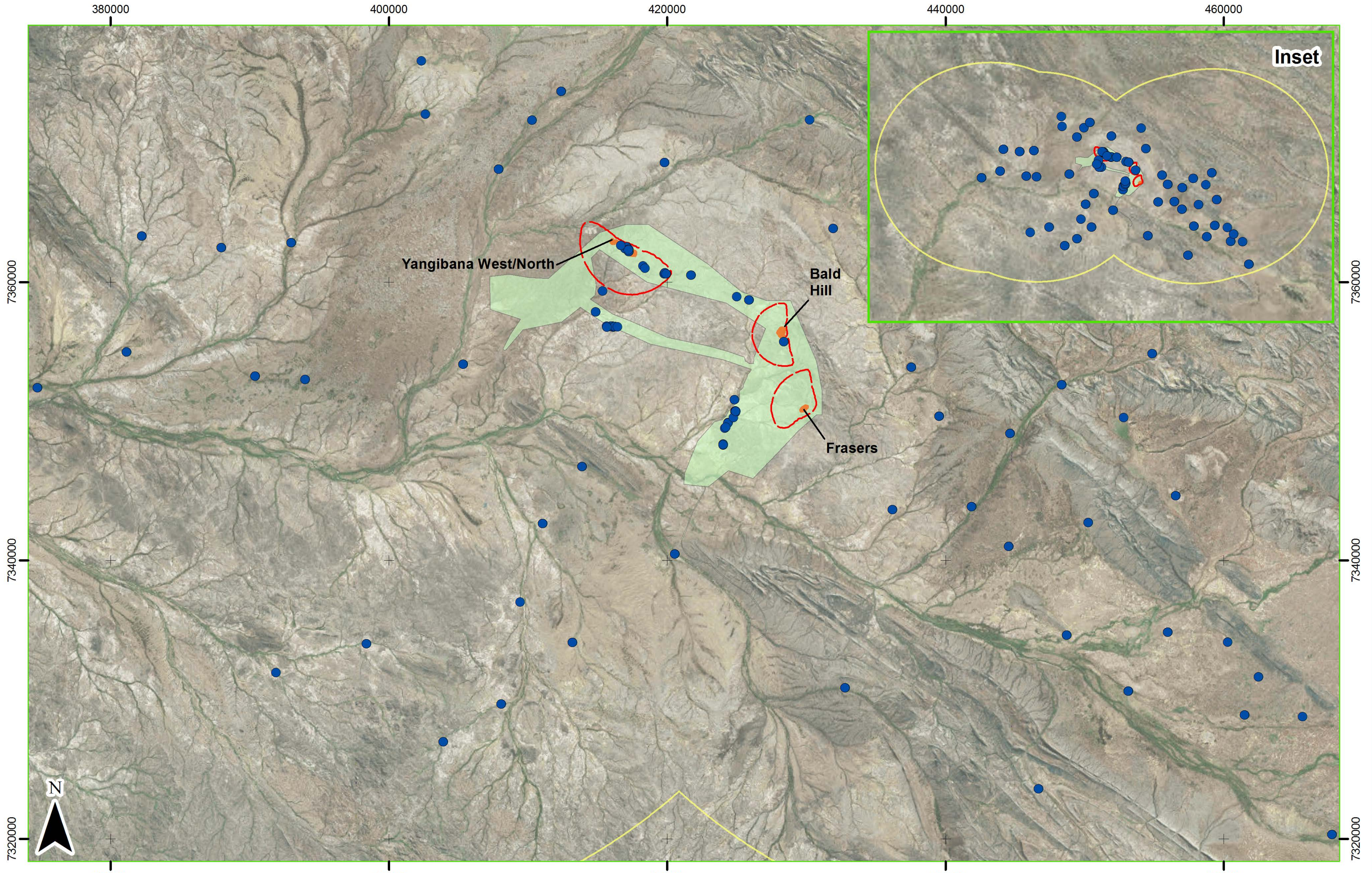
Higher Taxonomy	Lowest Identification	Abundance			Comments on Distribution
		Control	Impact	Grand Total	
Nematoda	Nematoda sp.	96	4	100	Not assessed in EIA.
Platyhelminthes					
Turbellaria	Microturbellaria sp.	3		3	Not assessed in EIA.
Rotifera					
Bdelloidea	Bdelloidea sp. 2:2	45		45	Not assessed in EIA.
	Bdelloidea sp. 3:3	5		5	Not assessed in EIA.
Monogononta					
Flosculariidae	Flosculariidae sp.	2		2	Not assessed in EIA.
Lecanidae	Lecane bulla	2		2	Not assessed in EIA.
Annelida **Aphanoneura** Aeolosomatidae	Aeolosoma sp.	8		8	Not identified to species level. Genus is widespread across WA.
Clitellata Enchytraeidae	Enchytraeidae sp. B20	2		2	New species, probably endemic to the prevailing PEC.
	Enchytraeidae sp. B21	4	10	14	New species, endemic to the prevailing PEC.
Naididae	Dero (Aulophorus) furcatus	5		5	Not restricted to the Project area
	Pristina aequiseta	7		7	Common throughout WA
	Pristina longiseta	92		92	Cosmopolitan (ABRS 2009).
Phreodrilidae	Phreodrilidae sp. AP DVC B12	35	6	41	New species, endemic to the prevailing PEC.
	Phreodrilidae sp. AP SVC B13	14		14	New species, endemic to the prevailing PEC.
Tubificidae	Tubificidae sp. B04	3		3	New species, endemic to the prevailing PEC.
Arthropoda **Arachnida** Piersigiidae	nr Stygolimnochares sp. B02	1		1	New species, endemic to the prevailing PEC.
Insecta Dytiscidae	Paroster sp. B02	4		4	New species, endemic to the prevailing PEC.
	Paroster sp. B03	1		1	New species, endemic to the prevailing PEC.
	Paroster sp. B04	1		1	New species, endemic to the prevailing PEC.
Malacostraca Bathynellidae	Bathynella sp. B31	3		3	New species, endemic to the prevailing PEC.
Bogidiellidae	Bogidiella sp. B06	1		1	New species, endemic to the prevailing PEC.
Eriopisidae	Nedsia sp. B06 (hurlberti group)	50		50	New species, endemic to the prevailing PEC.
Melitidae	Melitidae sp. 1 group (PSS)	1		1	Higher order identification
Microcerberidae	Microcerberidae sp.	1		1	Higher order identification from a juvenile specimen

Higher Taxonomy	Lowest Identification	Abundance			Comments on Distribution
Parabathynellidae	Atopobathynella sp. B30	3		3	New species, endemic to the prevailing PEC.
	Brevisomabathynella sp. B09	1		1	New species, endemic to the prevailing PEC.
	nr Atopobathynella sp. B21	5		5	New species, endemic to the prevailing PEC.
	nr Atopobathynella sp. B22	3		3	New species, endemic to the prevailing PEC.
Paramelitidae	Maarrka sp. B02	1		1	New species, endemic to the prevailing PEC.
	Paramelitidae sp. B49	18	10	28	Previously of conservation concern, now known from reference areas with a range of approximately 1,000 km2.
	Paramelitidae sp. B51	48		48	New species, endemic to the prevailing PEC.
	Paramelitidae sp. B52	4		4	New species, endemic to the prevailing PEC.
	Paramelitidae sp. B53	2		2	New species, endemic to the prevailing PEC.
	Paramelitidae sp. B54	1		1	New species, endemic to the prevailing PEC.
	Paramelitidae sp. B55	18		18	New species, endemic to the prevailing PEC.
Tainisopidae	Pygolabis sp. B11	6		6	New species, differs from nearby P. Gascoyne in male genital morphology. Endemic to the prevailing PEC.
Maxillopoda Ameiridae	Ameiridae gen. nov. sp. B04	15		15	New species, endemic to the prevailing PEC.
	Nitokra lacustris pacifica	6		6	Not restricted to the Project area
Canthocamptidae	Australocamptus sp. B16	5		5	New species, endemic to the prevailing PEC.
	Australocamptus sp. B17	4		4	New species, endemic to the prevailing PEC.
Cyclopidae	Australoeucyclops karaytugi	2		2	Australia-wide distribution (ABRS 2009).
	Diacyclops cockingi	72		72	Widespread throughout Pilbara and Yilgarn (Karanovic 2006).
	Diacyclops humphreysi humphreysi	50	62	112	Widespread throughout Pilbara and Yilgarn (Karanovic 2006).
	Diacyclops humphreysi unispinosus	1		1	Not restricted to the Project area
	Fierscyclops (Fierscyclops) fiersi	5		5	Widespread throughout Pilbara and Yilgarn (Karanovic 2004).
	Mesocyclops brooksi	24		24	Australia-wide distribution (ABRS 2009).
	Mesocyclops notius	85		85	Australia-wide distribution (ABRS 2009).
	Metacyclops 3442 sp. B06	56		56	New species, endemic to the prevailing PEC.
	Microcyclops varicans	128	7	135	Australia-wide distribution (ABRS 2009).
	nr Eucyclops (ngen?) sp. B01	8		8	New species, endemic to the prevailing PEC.

Higher Taxonomy	Lowest Identification	Abundance			Comments on Distribution
	Orbuscyclops westaustraliensis	1		1	Widespread species
Ectinosomatidae	Pseudectinosoma sp. B02	8		8	New species, endemic to the prevailing PEC.
Miraciidae	Schizopera sp. B25	4		4	New species, endemic to the prevailing PEC.
	Schizopera sp. B26	3		3	New species, endemic to the prevailing PEC.
	Schizopera sp. B27	2		2	New species, endemic to the prevailing PEC.
	Schizopera sp. B28	5		5	New species, endemic to the prevailing PEC.
	Schizopera sp. B29	2		2	New species, endemic to the prevailing PEC.
	Schizopera sp. B30	3		3	New species, endemic to the prevailing PEC.
Parastenocarididae	Parastenocaris sp. B37	25		25	New species, endemic to the prevailing PEC.
	Parastenocaris sp. B38	4		4	New species, endemic to the prevailing PEC.
Ostracoda Candonidae	Areacandona sp. BOS550	5		5	New species, endemic to the prevailing PEC.
	Areacandona sp. BOS675	8		8	New species, endemic to the prevailing PEC.
	Candonidae sp. BOS1108 (c. tenuis?)	9		9	New species, endemic to the prevailing PEC.
	Candonidae sp. BOS1110	12		12	New species, endemic to the prevailing PEC.
	Candonidae sp. BOS1113	13		13	New species, endemic to the prevailing PEC.
	Candonidae sp. BOS1116	8		8	New species, endemic to the prevailing PEC.
	Candonidae sp. BOS1121	2		2	New species, endemic to the prevailing PEC.
	Candonopsis sp. BOS1118	3		3	New species, endemic to the prevailing PEC.
	Candonopsis tenuis	70		70	Widespread outside study area (ABRS 2009).
	Deminutiocandona murrayi	3		3	Also known from Pilbara (Karanovic 2007).
	Humphreyscandona sp. BOS1124	2		2	New species, endemic to the prevailing PEC.
Cyprididae	Candonocypris novaezelandiae	5		5	Not restricted to the Project area
	Cypricercus sp. BOS908	3		3	New species, endemic to the prevailing PEC.
	Cyprinopsinae sp. BOS1112	4		4	New species, endemic to the prevailing PEC.
	Riocypris fitzroyi	78		78	Widespread in the Pilbara
	Sarscypridopsis aculeata s.l.	23		23	Probably a new species that is a member of a cosmopolitan complex
	Zonocypris sp.	6		6	Higher order identification
Limnocytheridae	Limnocythere dorsosicula	33		33	Widespread outside the study area (ABRS 2009; Bennelongia unpublished data).

Higher Taxonomy	Lowest Identification	Abundance			Comments on Distribution
Grand Total		1301	99	1400	

(Bennelongia 2018)



Legend

- Stygofauna records
- Mine pits
- Development Envelope
- Drawdown (2 m)
- PEC buffer

0 10 20
Kilometres

Bennelongia Environmental Consultants

Author: A. Mittra
Projection: GDA_1994_MGA_Zone_50
Date: 27-08-2018

Figure 7-5

Collection locations of stygofauna in the development envelope and wider study area.

Inset shows collection locations at a broader scale, including relative to the Gifford Creek PEC calcrete buffer zone.

7.3.3.2 Troglofauna

Ecoscape (2016) conducted two sampling events for troglofauna in May and September 2015 and Bennelongia (2018) also sampled for troglofauna in October 2016. The majority of troglofauna samples collected from each drill hole consisted of results of two separate collecting techniques, i.e. trapping and scraping. Troglofauna sampling methods conformed with *Technical Guidance Sampling for Subterranean Fauna* (EPA 2016).

Ecoscape (2016) conducted troglofauna sampling at 34 drill holes, 11 of which were sampled during both wet (May 2015) and dry season (September 2015) sampling. Overall, 43 traps were deployed in the Project area, with 18 and 25 traps deployed during wet and dry season survey, respectively. Additionally, troglofauna scraping was undertaken at 32 drill holes. This was then complemented with further sampling by Bennelongia in October 2016. A total of 20 troglofauna samples were collected consisting of scape and trap sampling methods. A scrape sample (totalling 0.5 of a standard troglofauna sample) was opportunistically sampled in October 2017 but did not yield any further troglofauna species, although a troglofauna species was recorded in a stygofauna sample in October 2017. Troglofauna samples comprised 31.5 reference samples and 27 impact sites from the combined sampling effort between 2015 and 2017 (Ecoscape 2016; Bennelongia 2018; **Table 7-3**).

Table 7-3 Number of troglofauna samples collected 2015-2017

Sample Area	Sample Site	Method	May-15	Sept-15	Oct-16	Oct-17	Total No of Complete Samples
Regional	Reference	Scrape				1	0.5
Eastern Belt	Reference	Scrape	3		9		15
		Trap	9		9		
Eastern Belt	Impact	Scrape	1	13	3		19.5
		Trap	6	13	3		
Western Belt	Reference	Scrape		10	6		16
		Trap		10	6		
Western Belt	Impact	Scrape	2	3	2		7.5
		Trap	3	3	2		
Total	Reference						31.5
	Impact						27
	Overall						58.5

*The Eastern Belt is Frasers and Bald Hill deposits.
^The Western Belt is Yangibana West and North deposits. Deposits West of Frasers Creek have been grouped as the Western Belt and those east of Fraser Creek are grouped as the Eastern Belt.

A total of 17 specimens representing 11distinct species of troglofauna were recorded across 20 drill holes in the study area in 2016-2017 (Bennelongia 2018). Five troglofaunal specimens from four species were collected in traps, eleven troglofaunal animals from 7 species were collected in stygofauna samples and one troglofaunal specimen was collected in a scrape sample (Bennelongia 2018).

Of the 34 drill holes sampled by Ecoscape (2016), troglofauna were collected from five drill holes across three areas (Frasers, Kanes Gossan and Bald Hill; **Figure 7-6**) in PLgpi geology (see extent in **Figure 7-2**). Note that Kanes Gossan is not planned for development or disturbance and does not form a component of the Proposal; refinement of the disturbance footprint has occurred since the time of the survey. Initial surveys recorded 11 troglofauna specimens from five orders representing at least five separate species:

- *Troglarmadillo* sp. B60 (isopod)
- *Projapygidae* sp. B19 (dipluran)
- *Trinemura* sp. B29 (thysanuran)
- *Geophilida* sp. (centipede)
- *Scutigerella* sp. B09 (symphylan).

Alignment of Ecoscape (2016) and Bennelongia (2018) data shows at least 14 species of troglofauna are known from the study area (**Table 7-4**), and including additional findings at Auer deposits and Gossan (**Figure 7-6**). The species comprise a palpigrade, three isopods, three centipedes, a millipede, a symphylan, two diplurans, a sciarid fly, a meenoplid bug and a silverfish. Six of these species are considered likely to be restricted to the study area, although assessments of endemism are limited by unresolved taxonomy in many groups. Two taxa recorded in the current survey may taxonomically align with previously recorded species and are not currently considered to represent discrete species: *Scutigerella* sp. may belong to *Scutigerella* sp. B09; and *Trinemura* sp. may belong to *Trinemura* sp. B29 (Ecoscape 2016). Overall, the Project appears to harbour a troglofauna community of low-to-moderate diversity (Bennelongia 2018).

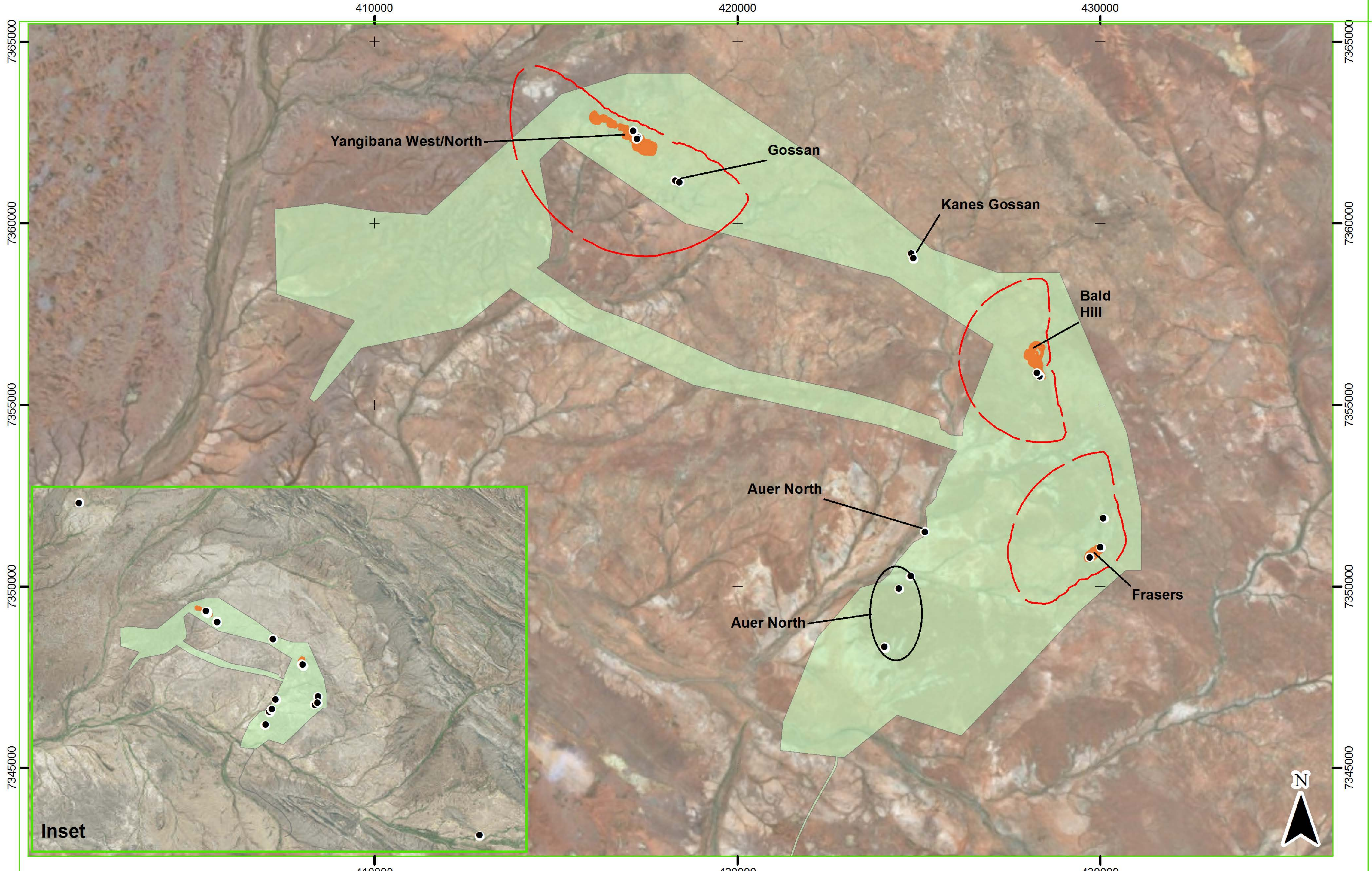
Table 7-4 Troglofauna species within and outside of impact areas

Higher Taxonomy	Lowest Identification	Number of Specimens			Comments on Distribution
		Control	Impact	Total	
Arthropoda	Palpigradi sp. B21	1		1	New species represented by a singleton from a reference site; possibly endemic. Median range[1] for troglofaunal palpigrades in Pilbara is 345 km[2], although group poorly studied.[2]
Chelicerata					
Arachnida					
Palpigradi					
Crustacea					New species represented by singleton from a reference site. Likely to be an SRE.[1, 3]
Malacostraca					
Isopoda					
Platyarthridae	Trichorhina sp. B29	1		1	
Stenoniscidae	Stenoniscidae gen. nov. sp. B07	1		1	New species, probably endemic to the area.
Hexapoda					Known linear range of 0.25 km; possibly endemic. Median range[1] for troglofaunal diplurans 16 km[2].
Entognatha					
Diplura					
Parajapygidae	Parajapygidae sp. B41		2	2	
Insecta					Widespread morphospecies frequently recorded across northwestern Australia.[6]
Diptera					
Sciaridae	Sciaridae sp. B01	1		1	
Hemiptera					Family widely recorded throughout WA7, median range[1] of 19,725 km[2] although family under review and species ranges likely smaller than estimated. [8]
Meenoplidae	Phaconeura sp.	2		2	
Thysanura					May be *Trinemura* sp. B29 recorded previously in study area[7]. Median range for troglofaunal silverfish 11 km[2]
Nicoletiidae	Trinemura sp.	1		1	
Myriapoda					Not identified to species level

Chilopoda					(partial specimen).Median range[1] for troglofaunal centipedes in Pilbara is 30 km^2.
Geophilida					
Chilenophilidae	Chilenophilidae sp.		1	1	
	Chilenophilidae sp. B09		1	1	New species, probably endemic to the area.
Schendylidae	Schendylidae sp.		2	2	Not identified to species level. Median range[1] for troglofaunal centipedes in Pilbara is 30 km^2.
Diplopoda					Likely to be *Lophoturus madecassus.*
Polyxenida					
Lophoproctidae	Lophoproctidae sp.		1	1	
	Lophoturus madecassus	2		2	Widely distributed troglophile frequently recorded across the Pilbara[4] and Yilgarn[5].
Symphyla					May be *Scutigerella* sp. B09 previously recorded in the Bald Hill reference area[7]. Median range[1] for troglofaunal Symphyla of 8.3 km^2.
Cephalostigmata					
Scutigerellidae	Scutigerella sp.		1	1	
Grand Total		**9**	**8**	**17**	

[1]Halse and Pearson 2014; [2]Barranco and Harvey 2008; [3]Javidkar 2014; [4]Bennelongia 2012; [5]Bennelongia 2008c; [6]Bennelongia 2014; [7]Ecoscape 2016; [8]Bennelongia unpublished data.

(Bennelongia 2018)



Legend

- Troglofauna
- Mine pits
- Development Envelope
- Drawdown (2 m)

0 5 10
Kilometres

Bennelongia Environmental Consultants

Author: A. Mittra
Projection: GDA_1994_MGA_Zone_50
Date: 27-08-2018

Figure 7-6

Collection locations of troglofauna within the development envelope.

Inset shows troglofauna collections across the broader study area.

7.3.3.3 Survey Limitations

A survey limitation, when conducting troglofauna sampling, is that the available sampling sites are restricted to mineral exploration drill holes. While this is one aspect of determining what the impacts will be, the lack of sampling sites outside of impact areas limits the ability to demonstrate that the species occur in non-impact areas. Most drill holes are located where the target mineralisation occurs and thus are within areas to be impacted. Due to limited sampling sites outside of the disturbance footprint, evidence of a species wider range is based on surrogate information (i.e. habitat connectivity and the ranges of related species). While this is not ideal, it is generally an accepted method of determining the significance of impacts to troglofauna species.

7.3.3.4 Habitat analysis

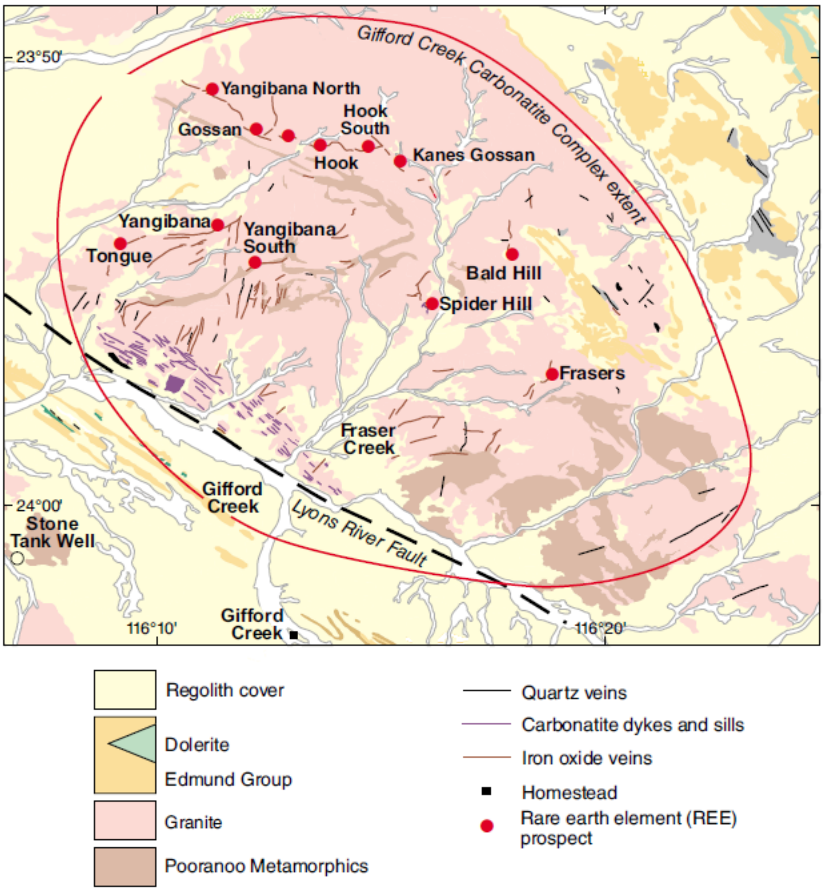
Stygofauna

Habitat analysis indicated that there is no obvious link between the preferred calcrete habitats of stygofauna as found in the PEC and the occurrence of stygofauna within the Proposal area (Ecoscape 2016). Geological drill logs and datasets have shown that calcrete is not present within the mineral exploration areas of the Proposal, indicating that subterranean fauna habitat is not typical of that recorded from PEC calcrete areas, although it may overlap and be representative of that on the fringes of the Gifford Creek PEC.

The SipHon Well Borefield does have calcrete present at depth i.e. approx. 90m. However, stygofauna species are rarely found at depth due to poor hydraulic conductivity with the surface. Hydraulic conductivity is an important factor dictating the movement of oxygen and carbon into and throughout ecosystems. Therefore, transmissive aquifers with large pore spaces allowing movement of oxygen and carbon tend to accommodate the most abundant and diverse stygofauna communities (Hose *et al*. 2015 in Bennelongia 2018). The lithology of the SipHon Well Borefield also lacks a significant shallow aquifer system (other than a shallow layer of unsaturated alluvium which may, if anything, represent a shallow ephemeral aquifer), with the surface environment primarily comprised of a clay aquitard (GRM 2018), which is probably not sufficiently porous to support a stygofauna community.

Troglofauna

Holes in three deposit areas yielded troglofauna – Frasers, Yangibana North and Yangibana West. Underlying geology of these deposits is largely granite and granitoid rock (PLgpi), with some unconsolidated ferruginous rubble and scree (C1f) present at Frasers (Ecoscape 2016). Troglofauna sampling were also conducted at the Bald Hill (impact) and Kanes Gossan (reference) areas by Ecoscape (2016) and Bennelongia (2018) but were not recorded there. Bald Hill geology comprises granites (PLgpi and PLgpix) and unconsolidated units (C1f), while geology at Kanes Gossan largely comprises granite (PLgpi) (Ecoscape 2016). Granite and granitoid units occur widely throughout the study area and may provide suitable habitat for troglofauna in areas that are not proposed for development (as shown in **Figure 7-7** and **Figure 7-2**).



Pirajno and Gonzalez-Alvarez, 2013

Figure 7-7 Simplified geology of the Gifford Creek Ferrocarbonatite Complex

7.4 POTENTIAL IMPACTS

Potential impacts include:

- Loss or alteration of habitat, assemblage and loss of individuals from groundwater abstraction and groundwater drawdown due to dewatering activities.
- Loss or alteration of habitat, assemblage and loss of individuals from stockpiling, mine pit excavation, infrastructure construction and other ground disturbance.
- Spills of hydrocarbons or wastewater, seepage from the TSF and other contamination may degrade subterranean habitats.
- Potential change to Gifford Creek Calcrete Priority Ecological Community subterranean fauna assemblage due to direct and indirect impacts.

7.5 ASSESSMENT OF IMPACTS

7.5.1 Direct impacts

7.5.1.1 Stygofauna

Pit dewatering

Records of stygofauna in impact areas included 11 specimens from two species at Bald Hill, 132 specimens from six species at Yangibana North and two specimens from one species at Yangibana West. No stygofauna species were found at Frasers pit.

Of the eight species recorded in impact areas, seven species (*Phreodrilus peniculus*, *Diacyclops cockingi*, *Diacyclops humphreysi humphreysi*, *Microcyclops varicans*, Phreodrilidae sp. AP DVC B12, *Enchytraeus* sp. 21 and Nematoda sp.) are common species that are widespread outside the study area. The remaining species, Paramelitidae sp. B49, is probably endemic to the local calcrete PEC. It was recorded in moderate abundance throughout the study area, including reference areas, and has a known range of approximately 1,000km^2 (Bennelongia 2018; **Figure 7-8**).

Water abstraction at SipHon Well Borefield

No stygofauna species were found at the SipHon Well Borefield.

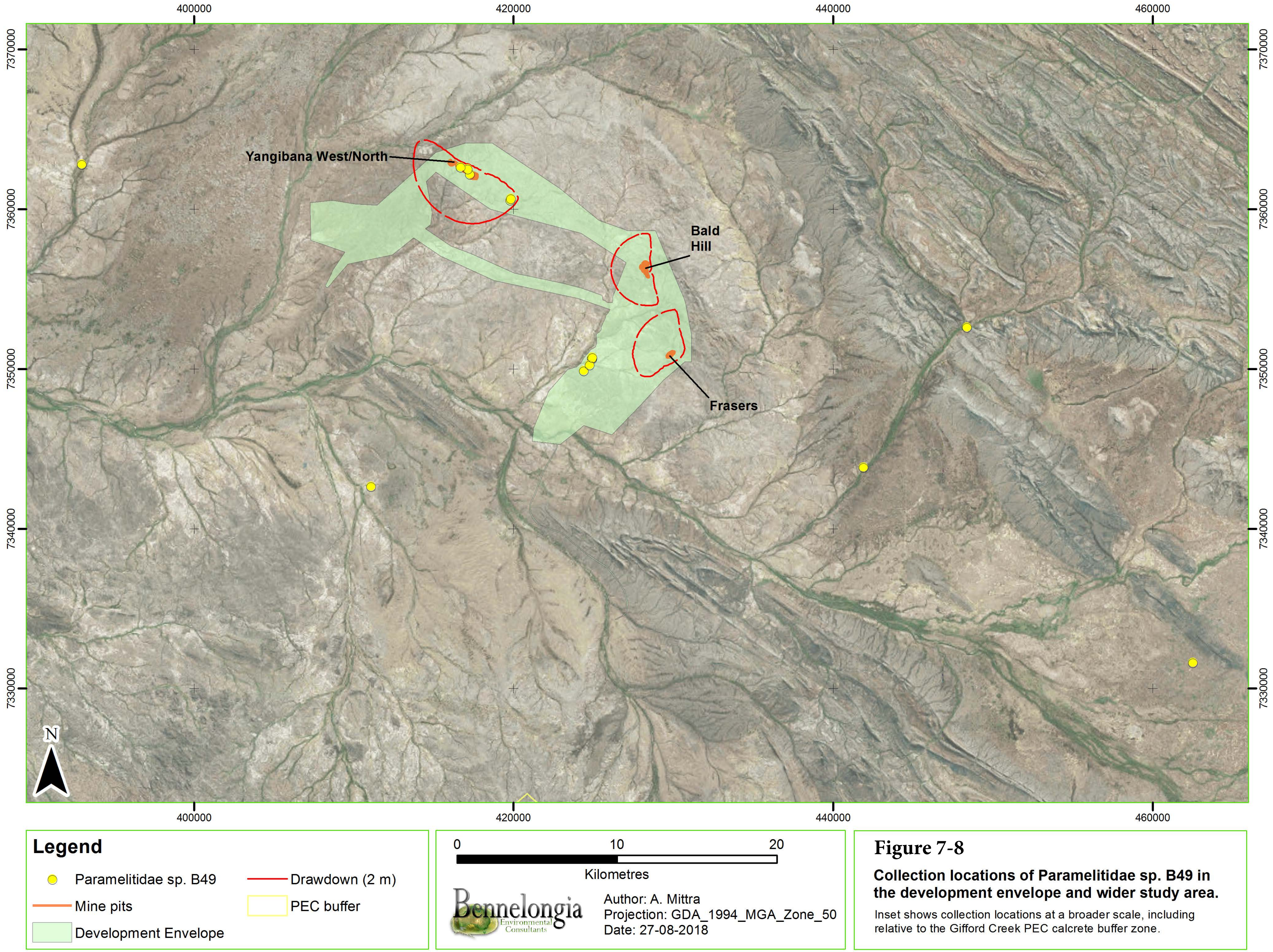


Figure 7-8

Collection locations of Paramelitidae sp. B49 in the development envelope and wider study area.

Inset shows collection locations at a broader scale, including relative to the Gifford Creek PEC calcrete buffer zone.

7.5.1.2 Troglofauna

The primary mine-related factor contributing to the loss of troglofauna habitat is mine pit excavation. In the case of proposed mining operations at the proposal, pit excavations are the only proposed operations that will result in significant loss of troglofauna habitat. Four of the 10 troglofauna taxa in the current survey were recorded within the pit boundaries, however as discussed below, it is considered likely that all four species are likely to occur outside the impact areas (**Figure 7-9**).

The centipede Chilenophilidae sp. B09 was recorded from a hole in the Frasers deposit while a confamiliar identification (Chilenophilidae sp.) was recorded as a partial specimen at Yangibana North. It is considered that the specimens probably represent the same species, in which case collections would indicate a minimum linear range of 17 km.

Similarly, the family-level identification Schendylidae sp. was recorded from partial or damaged specimens at both Frasers and Yangibana North and are considered likely to represent the same species. If so, collections would indicate a minimum linear range of approximately 17 km. The collection locations at Frasers and Yangibana North are surrounded by areas with similar granite geologies to collection locations (**Figure 7-2**). What is more, troglofaunal centipedes in the Pilbara are reported to have a median range of 30 km^2 (Halse and Pearson 2014) and together with the likely extent of suitable habitat this indicates that both chilenophilid and schendylid taxa at the Proposal are likely to have ranges larger than the proposed pits from which they were collected. Therefore, these centipede taxa are not currently considered to be of conservation concern.

The dipluran Parajapygidae sp. B41 and the isopod *Troglarmadillo* sp. B60, which are both considered likely to be short-range endemics, remain known only from inside proposed pit boundaries although it is considered they have wider occurrence. The granite and granitoid (PLgpi) geologies where these species were collected occur extensively in reference areas outside proposed development areas (**Figure 7-2**). The reason for not collecting the species more widely is, at least in part, the low yields associated with troglofaunal sampling. For example:

- Parajapygidae sp. B41 was collected from two holes in the Yangibana North deposit, where six impact holes and no reference holes were surveyed, and has a known linear range of approximately 0.25 km.
- *Troglarmadillo* sp. B60 was recorded as three individuals from a single hole in the Frasers deposit, where a total of 5 reference and 7 impact holes have been surveyed for troglofauna.

Both Parajapygidae sp. B41 and *Troglarmadillo* sp. B60 are considered likely to occur in reference areas because:

- The median range for species of Diplura (the order to which Parajapygidae sp. B41 belongs) in the Pilbara is reportedly 16 km^2 (Halse and Pearson 2014). More specifically, 11 species or morphospecies of Parajapygidae recorded by Bennelongia from at least two locations in northwestern Australia have a median linear range of 16.7 km (range 0.3–113.6 km; Bennelongia, unpublished data). Therefore, it is considered that Parajapygidae sp. B41 is likely to have a range extending beyond proposed pit from which it was collected.
- The median ranges of troglofaunal isopod species in the Pilbara is reportedly 2.5 km^2 (Halse and Pearson 2014). More specifically, 30 species or morphospecies of *Troglarmadillo* recorded by Bennelongia from at least two locations in northwestern Australia have a median linear range of 4.8 km (range 0.1–38.8 km; Bennelongia, unpublished data). Therefore, it is considered that *Troglarmadillo* sp. B60 probably has a range extending beyond the proposed pit from which it was collected.

- Granite and granitoid (PLgpi) geologies similar to those at collection locations occur extensively in reference areas outside proposed development areas (**Figure 7-2**). This suggests that habitat suitable for both species probably occurs in reference areas.
- The presence of troglofauna at Auer, Gossan and Kanes Gossan deposits, which are not currently proposed for development, shows that prospective troglofauna habitat occurs in granite units outside of proposed development areas (**Figure 7-6**).
- Yield rates for troglofauna sampling, including yields of troglofauna in stygofauna samples, were very low, suggesting either low troglofauna population densities, a high degree of sampling difficulty, or a combination of both these limiting factors. It is inferred that sampling effort was insufficient to collect further specimens of Parajapygidae sp. B41 or *Troglarmadillo* sp. B60.

Considering the distributions of other species collected from the same geologies as Parajapygidae sp. B41 and *Troglarmadillo* sp. B60 and range characteristics of related species, the risk to the conservation values of troglofaunal communities and species from operations at the Project is considered low (Bennelongia 2018).

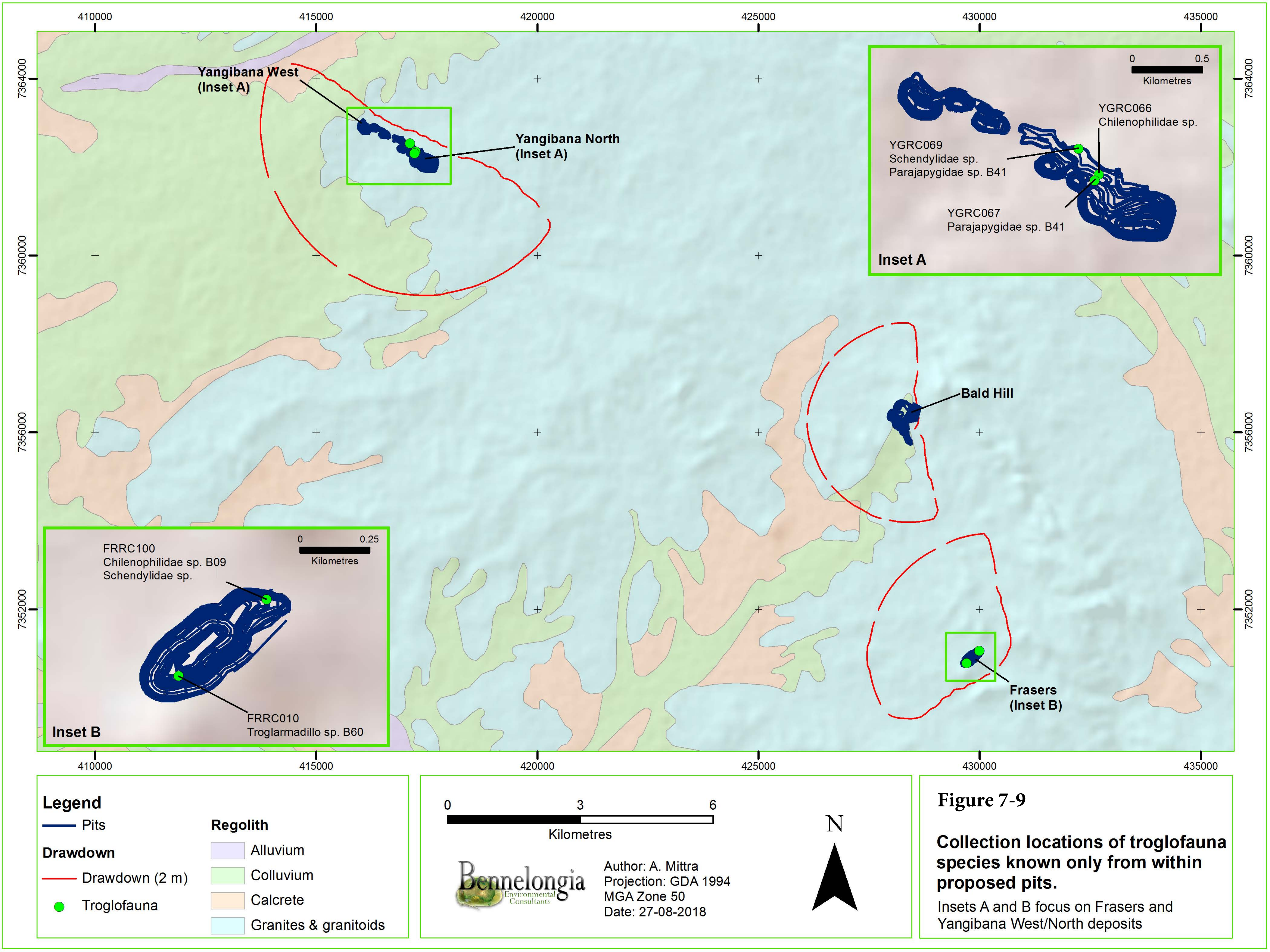


Figure 7-9

Collection locations of troglofauna species known only from within proposed pits.

Insets A and B focus on Frasers and Yangibana West/North deposits

7.5.2 Indirect impacts

7.5.2.1 Pit dewatering

All stygofauna species known from the Project area have been recorded in areas outside the 2 m drawdown contour inferred from hydrological modelling by GRM (2017, 2018; **Figure 7-10**). Two-metre drawdown contours associated with proposed developments were considered appropriate delineators between reference and impact areas because:

- The occurrence of calcrete near the proposed development areas is low, meaning that drawdown affecting calcrete aquifers will be relatively insignificant in the regional context.
- The likely depth and volume of calcrete aquifers near to proposed development areas means that substantial stygofauna habitat would remain intact outside the 2 m drawdown contour (Bennelongia 2018).

Geologies of the proposed excavation areas at the Bald Hill, Frasers, Yangibana North and Yangibana West largely comprise consolidated granite and granitoid units (PLgpi) that are generally unconducive to stygofauna. Sampling in impact areas yielded significantly fewer animals and species per sample than in reference areas (that for the most part coincided within calcrete aquifers). Furthermore, stygofauna species recorded in impact areas were also collected in reference areas, and are common species that are known to be widespread outside the study area (Bennelongia 2018; **Figure 7-6**).

In conclusion, it is considered unlikely that water abstraction from pit dewatering will have any impact on the conservation value of stygofauna communities or individual stygofauna species.

7.5.2.2 Water abstraction from SipHon Well borefield

Two-metre drawdown contours associated with proposed developments were considered appropriate delineators between reference and impact areas (as above). Water abstraction from the SipHon Well borefield will occur at a depth of approximately 100m. The overlying material is clay, which is not suitable stygofauna or troglofaunal habitat. The immediate borefield areas do not have a shallow water aquifer system. During rainfall events some water will permeate the surface, however, most surface water flows to drainage channels within the catchment area.

In conclusion, it is considered unlikely that water abstraction from the SipHon Well borefield will have any impact on the conservation value of stygofauna communities.

7.5.2.3 Stockpiling, pit excavation infrastructure construction and other ground disturbance

Geologies of the proposed excavation areas at the Bald Hill, Frasers, Yangibana North and Yangibana West largely comprise consolidated granite and granitoid units (PLgpi) that are generally unconducive to stygofauna (i.e. as reflected by significantly fewer animals and species per sample compared to the reference areas). Furthermore, stygofauna species recorded in impact areas were also collected in reference areas over the broader Gifford Creek PEC area and are common species that are known to be widespread outside the study area (Bennelongia 2017, 2018).

It is considered unlikely that excavation and other mine-related activities at the Proposal will have any impact on the conservation value of stygofauna communities or individual stygofauna species.

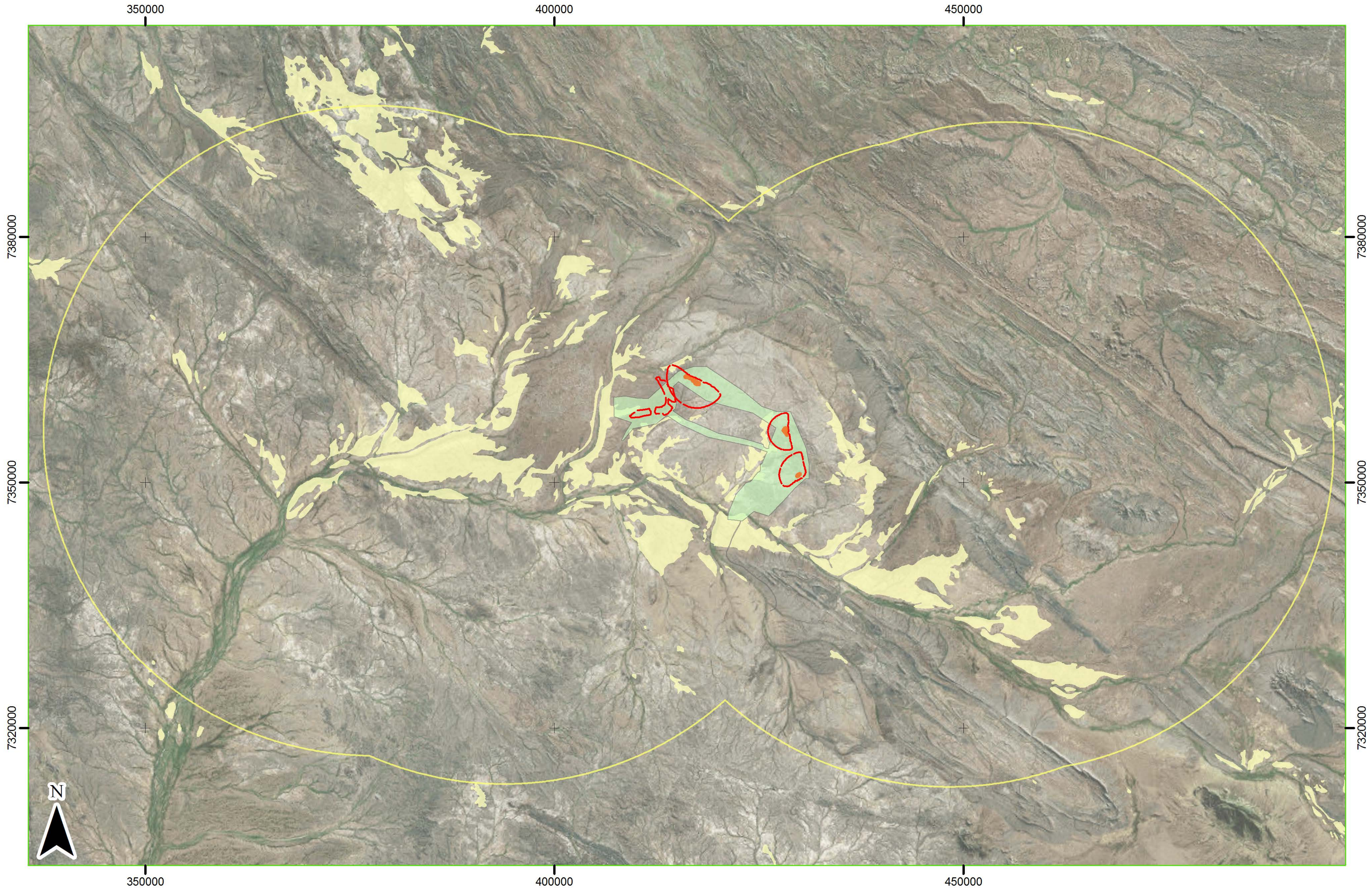
7.5.2.4 Hydrocarbons or wastewater spills, seepage from the TSF and other contamination

Due to the presence of hydrocarbons and other chemicals on-site, there is potential for localised contamination.

Tailings waste characterisation studies (summarised in further detail in Section 8) have highlighted that:

- Elevated radionuclides occur in TSF 2 and 3, although concentrations were negligible in tailings pore water.
- TSF 3 and the evaporation pond have elevated levels of magnesium sulphate.
- All TSFs have elevated levels of soluble-Fluoride and soluble-Molybdenum, with elevated levels an artefact of processing as shown by rapid decreases in concentration during leach tests using both deionised water and samples from SipHon Well Borefield and fractured rock aquifers.
- TSF 3 and the evaporation pond have a bituminous liner and a HDPE liner, respectively.
- Seepage of tailings pore water does not interact with groundwater and does not extend beyond the TSF footprint.

It is unlikely seepage from the TSF will impact subterranean fauna habitat beyond the immediate TSF footprints.



Legend

- Mine pits
- Drawdown (2 m)
- Development Envelope
- PEC buffer
- Mapped calcrete

0 30 60
Kilometres

Bennelongia Environmental Consultants

Author: A. Mittra
Projection: GDA_1994_MGA_Zone_50
Date: 19-06-2018

Figure 7-10

Water drawdown contours (2 m) relative to mapped areas of calcrete associated with the Gifford Creek PEC

7.6 MITIGATION HIERARCHY

Hastings commits to the following mitigation of potential impacts:

Best Practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- Site-wide water reuse
- Design, construction and operation of TSFs in accordance with policy and guidelines.

Avoidance

Hastings has avoided potential impacts by:

- No groundwater abstraction from the Gifford Creek calcrete aquifers.
- No significant groundwater abstraction from an aquifer with direct hydraulic connection to the Gifford Creek Calcrete PEC.

Minimisation

Hastings will minimise potential impacts as follows:

- Limit groundwater abstraction to meet operation requirements only.
- Water collection and re-use from processing plant, where possible.
- Processing plant, evaporation pond and TSFs located outside of the flood plain.

Management

The following management plans and associated documentation will be implemented to mitigate potential risks of impact to the subterranean fauna.

Land Management Plan (to be developed)

OBJECTIVE(S)

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To maintain the quality of water so that environment values or the health, welfare and amenity of people and land uses are protected, by meeting statutory requirements and acceptable standards.

MANAGEMENT ACTIONS

The following management actions will be implemented for each key aspect within the Land Management Plan:

Water management

- Diversion drains will be constructed to ensure water re-enters natural drainage lines at a velocity and depth that can be accommodated by the natural flow rate without increased scouring.
- Containment bunding, silt and oil traps will be established where necessary to remove sediments or pollutants from runoff before water enters local drainage.
- Measures to reduce water usage or re-use water will be implemented, where possible.
- WRL and TSFs will be designed to accommodate long-term weather events, as per specifications and performance measures recommended in Trajectory (2017; Appendix 6-1).
- Surface drainage around crushing and processing activities will be captured to ensure overflows, spillages or leaks are contained.
- Surface water will be managed near the landfill to minimise runoff entering the landfill.

Waste management

- Spill clean-up procedures, training and resources.
- Waste management for general domestic and office waste, industrial waste, landfill, hydrocarbons, tyres, and sewage (as per requirements of prescribed premises works approvals and operating licenses administered by the Department of Water and Environmental Regulation).

Chemical storage

- A *Hydrocarbon and Hazardous Substance Management Work Instruction* will be developed to provide instructions for transport and storage of hydrocarbons and hazardous substances, spill management and incident reporting.

MONITORING

Monitoring considerations to be included in the Land Management Plan are:

- Groundwater and surface water monitoring will be undertaken in accordance with the *Groundwater Operating Strategy*, and *Water Management Plan*
- Audits and inspections to ensure implementation of management measures in accordance with relevant laws, licence conditions, commitments and Hastings Environmental policy and management actions as per the Land Management Plan.

CONTINGENCY

Contingency measures for water quality monitoring are described in the respective management plans.

Radiation Waste Management Plan (Appendix 5-7)

OBJECTIVE(S)

Ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations.

MANAGEMENT ACTIONS

The management of radioactive waste applies to the management of TSFs. Key considerations follow a risk-based approach and include:

Detailed engineering phase

- Design of the TSFs will conform to relevant international standards.
- Key design features when considering elevated radionuclides include:
    - embankment stability taking account of site stability;
    - freeboard to accommodate severe weather events;
    - landform evolution modelling, specifications for long-term performance;
    - encapsulation and liners; and
    - leak detection.

Construction phase

- Preparation of a *TSF construction management plan* with quality assurance procedures will be developed and implemented to ensure that the TSF construction meets design specifications and tolerances.

Operations phase

- Preparation of a *TSF operating manual* with all pertinent information with respect to operation, rehabilitation and closure of the TSFs including:
    - deposition methodology;
    - water management;
    - seepage control (including drain details and requirements)
    - pipeline management;
    - all measures that should be followed during the operating phase to reduce the amount of work required at decommissioning;
    - planned measures to reduce impact(s) to the surrounding environment; and
    - planned measures for progressive rehabilitation during operations.

MONITORING

Construction phase

Monitoring of the construction process will occur to ensure the TSFs are built in accordance with design specifications. A competent person will be engaged to certify that the construction of the respective TSF meets design specifications and tolerances.

Operations phase

An *Environmental Radiation Monitoring Work Instruction*, a component of the Hastings EMS, will be developed to provide specific protocols for environmental radiation monitoring from the following sources:

- Seepage into groundwater: A network of 5 monitoring bores will surround the TSFs (as per ATC Williams 2017) and downstream pastoral bores will be sampled and analysed for heavy metals including radionuclides, on a quarterly basis.
- Contamination of surface water run-off: Surface water sampling will be conducted opportunistically following significant rainfall events or on a quarterly basis.

Monitoring of controls for containment of radioactive waste will include:

- Weekly visual inspection of surface water management structures including bunds, drainage channels, tailings and water pipelines, and evaporation ponds.
- Weekly inspection of the walls of TSF 2 and 3 for erosion or other signs of potential compromise to the integrity of their structure, including signs of seepage of tailings or water from tailings into the environment immediately surrounding the TSFs.
- Inspections of management controls following major rainfall or extreme weather events.
- Annual inspection/audit by closure specialist to identify potential hazards, risks and opportunities for continual improvement, including aspects that require further investigation or research.
- Internal audits (in accordance with the Audits and Inspections Standard Operating Procedure) of the implementation of this RWMP.

Trigger values are based on authorised limits and/or baseline values of *NORM Guideline 6 Reporting Requirements* (DMP 2010). Exceedances of a trigger value will be considered an incident unless significant seasonal environmental variation of background levels are expected. In such instances, a trend of exceedances in trigger values will then be treated as an incident.

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. Contingency plans will form a component of the *Emergency Response Plan* (ERP). Where containment of radioactive waste fails, the ERP will include:

- Human health and safety first: response to exposure, evacuation, decontamination of the persons exposed to radiation.
- Stabilisation of the containment and prevention of impact to surrounding environmental receptors.
- Consideration of secondary containment and drainage.
- Clean-up procedures.
- Training of personnel on the Emergency Response Team to address radioactive waste containment failures.
- Identification of radiation specialists and TSF experts to review contingency plans.
- Suspension of operations (also considered in the Care and Maintenance section of the MCP).

Surface water management plan (SWMP; to be developed)

OBJECTIVE(S)

> *To maintain the hydrological regimes and surface water quality so that environmental values are protected.*

MANAGEMENT ACTIONS

The management of surface water includes:

- An oily water collection and treatment pond shall be designed, implemented and maintained.
- Hydrocarbons and chemicals shall be stored in accordance with the *Land Management Plan* and industry standards.

MONITORING

Construction phase

Monitoring of the construction process will occur to ensure infrastructure is built in accordance with design specifications as approved by DWER and the conditions of a Bed and Banks Permit.

Operations phase

Procedures will be developed as a component of the Hastings EMS to provide specific protocols for surface water monitoring including:

- Water quality monitoring will include:
  - Lyons River and Fraser Creek ponds;
  - total suspended solids (TSS) shall be monitored upstream and downstream of Lyon's River road crossing following flood events;
  - maintenance inspections of process plant equipment, where chemicals are used, for leaks/drips;
  - treated effluent quality from the oily water separator;
  - maintenance inspections of oil water separator and ponds; and
  - waste water treatment plants' effluent monitoring.
- Hydrological processes:
  - inspections of drainage infrastructure prior to heavy rainfall events.
- Internal audits (in accordance with the Audits and Inspections Standard Operating Procedure) of the implementation of the SWMP.

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. The trigger limits and associated contingency actions include:

- Water quality exceedances beyond natural variation:
  - investigate cause; and
  - implement remedial action (e.g. installation of sediment traps, revise chemical storage/handling procedures, repair equipment).
- Significant change in flow regime impacting vegetation composition and structure upstream or downstream:
  - identify the cause (e.g. design, maintenance of drainage, damage);
  - determine management action (engineering design, drainage maintenance, repair); and
  - implement remedial actions.

Groundwater operating strategy

OBJECTIVE(S)

The objective for groundwater abstraction is to:

> *To abstract groundwater so that environmental values are protected.*

MANAGEMENT ACTIONS

Management actions for the abstraction of water from the SipHon Well Borefield include the:

- Development and implementation of deep and shallow monitoring bores.
- Design larger bore field than required to allow for flexibility in localised water abstraction rates.
- Install flow meters.
- Install valves to provide flexibility in water bore usage and support maintenance activities.
- Maintenance of bore field infrastructure and equipment.

MONITORING

The groundwater operating strategy (as a component of water licence applications) will include monitoring of production bores, and shallow and deep monitoring bores:

- Water abstraction rates.
- Water quality analysis i.e. salinity, analytes.
- Groundwater level.
- Visual inspections of pipework, ponds and fittings to detect leaks.

Monitoring data will be compared to monitoring outcomes of Groundwater Dependent Ecosystems (GDE's). The monitoring data will also be used to validate the groundwater modelling (GRM 2018b).

CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. The trigger limits and associated contingency actions include:

- Impacts to Groundwater Dependent Ecosystems i.e. vegetation or stygofauna determined:
  - turn off/reduce water abstraction from closest bore;
  - alternate to pit dewatering of closed pits, where possible; and
  - long-term considerations/investigations of alternate water source borefield.
- Validation of groundwater model shows smaller volume of water available for abstraction:
  - reduce reliance on SipHon Well Borefield, where possible; and
  - investigate alternate water source borefield.
- Water quality trigger level is exceeded for salinity or analytes:
  - initiate hydrogeological assessment to identify cause;
  - assess consideration of exceedance to process activities or potable water requirements and treatment, and environmental impact assessment;
  - reduce volumes of water abstracted; and
  - repeat monitoring and/or intensify water quality monitoring to determine trend.

Water Management Plan (Appendix 4-4)

OBJECTIVE(S)

Summarise and describe inter-relationships of water quality management and monitoring actions determined by the:

- *Radiation Waste Management Plan,*
- *Groundwater Operating Strategy,*
- *TSF Operating Manual,*
- *Drinking Water Quality Management Plan*

To maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.

To maintain the quality of groundwater and surface water so that environmental values are protected.

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

MANAGEMENT ACTIONS

The following management actions will be implemented to address **surface water**:

- A series of diversion drains will be installed to direct storm water around workshops, plant areas, hydrocarbon storages and other disturbed areas, discharging to the natural drainages.
- Infrastructure within the diversion drains, including the ROM and plant will be internally draining, discharging to sumps and then to a process pond for use within the plant.
- Oily water separators and sediment traps will be installed to manage runoff from contaminated and disturbed areas.
- Hydrocarbons and other chemicals will be stored in bunded facilities, which will comply with Australian Standards and licence conditions.
- An on-site bioremediation facility will be established and maintained, to treat hydrocarbon contaminated soil as per the Land Management Plan and managed in accordance with the Bioremediation Facility Work Instruction.
- Monitoring and inspection schedules, contingency and reporting requirements have been developed to manage surface water upon commencement of the Project and are discussed in the following sections.

The following management actions will be implemented to address the **groundwater abstraction from fractured rock aquifers**:

- Bore details and maximum pumping rate for each bore is provided in Table 3.2 below.
- Each bore shall be equipped with a submersible pump, dip tube, flow meter and control box.
- A network of five monitoring bores has been installed (KGRC019, KGRC022, LERC020, YWMB01, HYRC02 and HYRC03) have been installed to provide regional water level information in the fractured rock aquifer.
- Monitoring and inspection schedules, contingency and reporting requirements are discussed in the following sections.

The following management actions will be implemented to address the **groundwater abstraction from SipHon Well Borefield**:

- The Borefield will likely comprise seven production bores, at a spacing of approximately 1 km, with a sustainable duty rate of approximately 8 to 10 L/s per bore. Currently three bores have been installed. Bore details and maximum pumping rates for each bore are provided in Table 3.3 below.
- Groundwater abstraction from the SipHon Well Borefield will be distributed across the bores to manage impacts on the groundwater environment. A maximum permissible total allocation from the borefield, as well as recommended sustainable pumping rates for each bore, are provided in the Groundwater Operating Strategy.
- Each bore shall be equipped with a submersible pump, dip tube, flow meter and control box.
- Borefield details and pumping rates will be tabulated as per the Groundwater Operating Strategy.
- A network of monitoring bores has been installed to enable the drawdown impacts to be measured. Currently there are seven deep and ten shallow monitoring bores installed. Additional shallow and deep monitoring bore will be installed at each new production bore location for the four remaining bores, as well as two additional calcrete monitoring bores.
- Monitoring and inspection schedules, contingency and reporting requirements are discussed in the following sections.

The following management actions will be implemented to manage **pit dewatering:**

- Dewatering of the proposed pits will be best achieved using sump pumping, supplemented by dewatering bores as required. The inflow rates to the pits were estimated using analytical techniques (Thiem equation for unconfined flow) and do not allow for surface water runoff following high rainfall events, which can increase dewatering rates significantly.
- Sump pumping will require ongoing management during the operational life of the pits. Sumps should be strategically located at low points along the pit floor. All sump pumps will require flow meters to measure abstraction volume.
- The requirement for dewatering bores will be assessed on a pit by pit basis. The existing bores, FRW03 and BHW05, will aid dewatering to some extent, however they were constructed for testing purposes (i.e. using uPVC casing) and are unlikely to remain operational once mining of the respective pits commences.
- Any additional dewatering bores should be constructed into the target aquifer; the ironstone dyke cross cut by supplemental fracturing, on the down-dip side of the pit. Future dewatering bores will be installed at least 6 months prior to mining to achieve sufficient drawdown. The bores should be constructed using 6” schedule 40 steel casing (7.1 mm wall thickness). The steel casing should be slotted across the main aquifer zone with the bore annulus gravel packed to just below the surface. The annulus will need to be sealed at the surface, with cement grout, to prevent surface water ingress.
- All dewatering discharge will be transferred to a water storage pond. The discharge will be used predominantly for dust suppression at the respective pit, with additional water transferred to the process plant.
- At the predicted dewatering rates there shall be no requirement to discharge mine water to the surrounding environment.
- Monitoring and inspection schedules, contingency and reporting requirements have been developed to manage dewatering upon commencement of the Project and are discussed in the following sections.

The tailings storage facilities will be managed as follows:

- The TSFs will be constructed in accordance with the proposed design.
- TSF3 will be constructed with underdrain detection between the compacted clay and liners, and a sump.
- The storage ponds will be constructed with sufficient contingency for high rainfall events.
- A series of monitoring bores will be installed down hydraulic gradient from the TSFs to measure groundwater level and water quality.
- Monitoring and inspection schedules, contingency and reporting requirements have been developed to manage the storage receptors upon commencement of the Project and are discussed in the following sections.
- Trigger limits for the TSF monitoring bores will assist in early detection of seepage impacts (as described in the following section).

MONITORING

The Water Management Plan will include the following monitoring programs:

- Surface water quality testing will be conducted following the first heavy rainfall event of the season.
- Groundwater quality monitoring of the fractured rock aquifer bores and SipHon Well Borefield, pastoral bores, and Frasers and Lyons River pools.
- Inspections of all infrastructure relevant to water sources including pit dewatering bores and in pit sumps, Siphon Well borefield and associated pipelines, potable water, and waste water including evaporation pond, return water pond, waste water treatment plant and irrigation field, storage ponds and sumps.
- Inspection of all surface water management infrastructure prior to and following heavy rainfall events including culverts, diversion drains and floodways.
- Water quality parameters of water from TSF monitoring bores.

Trigger levels for groundwater quality have been proposed for the Project, for all monitoring locations (including dewatering discharge, production bores, TSF monitoring bores and the regional stock water bores). The proposed trigger values have been set as follows:

- Exceedances of >25% beyond natural variability on 3 consecutive samples.
- Exceedances of ANZECC guidelines for fresh and marine water quality (2000) for livestock and Australian NHMRC and ARMCANZ (1996) Australian Drinking Water Guidelines for drinking water quality for elements that are not exceeded naturally.

CONTINGENCY

The SipHon Well Borefield has been designed to meet the maximum water demand of the Project i.e. 2.5 Gl/annum. This water balance shows that 2.1Gl/annum is required to meet the Project water demand. As a result, a larger borefield has been designed. This provides flexibility and contingency should trigger levels be exceeded, or early response indicators of GDE monitoring show potential impacts.

Rehabilitate

The closure objectives relevant to subterranean fauna are:

> *Impacts on the availability and quality of regional groundwater are minimised and do not limit the proposed post-mining land use*

The completion criteria relevant to hydrological processes and inland waters environmental quality are:

> *Pit water quality does not impact on areas beyond the immediate mining area.*
>
> *Any groundwater contamination will be confined to the immediate mining area and will not impact on surrounding groundwater resources.*
>
> *Groundwater levels of production bores will recover to pre-abstraction levels after mine closure.*

A Preliminary Mine Closure Plan (Appendix 6) include closure strategies and 'next steps' identified (where possible), specific to subterranean fauna include:

Baseline studies and investigations

- Closure research, investigations and trials:
    - progressive rehabilitation; and
    - water drawdown impacts on GDEs, including subterranean fauna and the Gifford Creek PEC.
- On-going groundwater monitoring during operations:
    - tailings pore water characterisation and verification of laboratory-based findings;
    - TSF seepage monitoring during operations to verify seepage modelling;
    - verification that landforms were/are constructed in accordance with design specifications; and
    - water availability, recycling and storage as per water balance.

Design and construction of landforms

- TSF covers and / or encapsulation specific to each of the facilities:
    - TSF design reports to incorporate closure considerations; and
    - detailed design to incorporate closure considerations.
- Landforms are constructed as per design specifications:
    - waste rock landform design reports to incorporate closure considerations; and
    - detailed design to incorporate closure considerations.

Identification and management of site contamination

- Areas of site (e.g. TSFs, hydrocarbon storage areas, workshops, chemical storage areas, process plant) with the potential for contamination will be assessed by an accredited contaminated site auditor at closure, in accordance with DWER requirements under the *Contaminated Sites Act 2003* (WA) and associated regulations.
- Develop and implement *Land Management Plan* and associated procedures for management of hydrocarbons, chemical use and storage, and spill response procedures, identification of areas at risk of contamination.
- Implement *Radiation Waste Management Plan*.
- Develop and implement *TSF Operating Manual*.

Post closure monitoring and maintenance

- Water levels and water quality monitoring in decommissioned production and monitoring bores at SipHon Well Borefield.

7.7 Predicted Outcome

7.7.1 Residual Impacts

The direct impacts to the subterranean fauna community involve the mining of the resource body. As a result of mining of the four deposits (Bald Hill, Frasers, Yangibana North and Yangibana West) , there will be a loss of 116 Ha of low value subterranean fauna habitat. This represents less than 0.05% of the Gifford Creek PEC footprint.

Potential indirect impacts may occur from the presence of mining landforms, seepage from TSFs, minor chemical or hydrocarbon spills and water drawdown during pit dewatering or water abstraction. Most of the Proposal's water demand will be obtained from the SipHon Well Borefield, a deep palaeochannel tributary that does not host either stygofauna or troglofauna communities. Drawdown contours also show no indirect impact to the Gifford Creek PEC from pit dewatering or water abstraction. However due to the presence of both troglofauna and stygofauna within the pit footprint, it is likely drawdown contours from pit dewatering activities may reflect some indirect impact to subterranean fauna habitat over the life of mine. Given there is limited hydrogeological connectivity with the broader calcrete aquifer network of the Gifford Creek PEC, it is unlikely that impacts to groundwater quality and quantity have the potential to impact the diversity and ecological integrity of the PEC. The mitigation described above (section 7.6) will also ensure the Proposal will not indirectly impact the diversity and ecological integrity of the PEC.

It is considered unlikely that dewatering, excavation and other mine-related activities at the Project will have any substantial impacts on the conservation values of stygofauna communities or the persistence of any individual species.

7.7.2 Offsets Position

Application of the residual impact significance model (EPA 2014), outlining how significance will be determined and when an offset is or may be required, in relation to flora and vegetation, includes consideration of relevant clearing principles in Schedule 5 of the EP Act:

- Clearing Principle (a) High biological diversity:
    - Stygofauna: The Project area intersects the Gifford Creek Priority 1 PEC, which has a very high biological diversity of stygofauna species. Approx. 61 species were collected from the PEC making it one of the most speciose assemblages of stygofauna known from Western Australia. All stygofauna species that have been recorded in the study area, including those previously thought to be of conservation concern, are known from reference areas outside predicted 1 m drawdown contours associated with proposed developments. This provides evidence that the conservation values of stygal species and communities will not be threatened by mine-related activities at the Project. Therefore, residual impacts are not significant.
    - Troglofauna: The Project area hosts a low-moderate assemblage of troglofauna species. Four species are known to occur only within the Project footprint to be directly impacted due to survey limitations. Habitat connectivity and the ranges of related species was used as surrogate information to demonstrate that these species likely occur outside the Project footprint. Therefore, residual impacts are not significant.

- Clearing Principle (b) Habitat for fauna: The proposal area occurs on the northern fringes of the Gifford Creek PEC, which consists of a network of shallow calcrete aquifers covering an area of 296,142 ha. Loss of 112.75 Ha of subterranean fauna habitat will occur due to mining. This represents less than 0.05% of the Gifford Creek PEC footprint. Troglofauna species were not confined to any one geological unit and were not restricted to the target ore body. Their habitat is well represented outside of the Proposal areas. Therefore, residual impacts are not significant.

In conclusion, no offsets are required for the key environmental factor, subterranean fauna.

7.7.3 EPA Objective

Both troglofauna and stygofauna habitat occur well beyond the Proposal pit footprints and thus the Proposal will meet the EPA objective for this environmental factor:

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

TERRESTRIAL ENVIRONMENTAL QUALITY

Chapter 8

8 KEY ENVIRONMENTAL FACTOR: TERRESTRIAL ENVIRONMENTAL QUALITY

8.1 EPA OBJECTIVE

To maintain the quality of land and soils so that environmental values are protected.

8.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of terrestrial environment quality include:

Australian Radiation Protection and Nuclear Safety Act 1998 (Commonwealth)

Contaminated Sites Act 2003 (WA)

Dangerous Goods Safety Act 2004 (WA)

Environmental Protection Act 1986 (WA)

Health Act 1911 (WA)

Mines Safety and Inspection Act 1994 (WA)

Mining Act 1950 (WA)

Radiation Safety Act 1975 (WA)

Soil and Land Conservation Act 1945 (WA)

Waste Avoidance and Resource Recovery Act 2007 (WA)

Relevant guidelines include:

Guidelines on Tailings Dams - Planning, Design, Construction, Operation and Closure (ANCOLD 2012);

Guidelines on the Consequence Categories for Dams (ANCOLD 2012);

Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (the Mining Code; ARPANSA 2005);

Tailings Management: Handbook in the Leading Practice Sustainable Development Program for the Mining Industry Series (Australian Government Department of Industry, Tourism and Resources 2007);

Potentially Contaminating Activities, Industries and Land-uses. Contaminated Sites Management Series (Department of Environment 2004);

Assessment and Management of Contaminated Sites. Contaminated Sites Guidelines (DER 2014);

Identification, reporting and classification of contaminated sites in Western Australia. Contaminated Sites Guidelines (DER 2017);

Guidelines on the Development of an Operating Manual for Tailings Storage (DMP 1998);

Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM 4.1 Controlling NORM – dust control strategies (DMP 2010);

Managing naturally occurring radioactive material (NORM) in mining and mineral processing guideline (2nd edition). NORM-4.2 Controlling NORM – management of radioactive waste. Resources Safety, Department of Mines and Petroleum (DMP 2010);

Code of Practice - Tailings storage facilities in Western Australia. Resources Safety and Environment Divisions (DMP 2013);

Guidelines on the Safe Design and Operating Standards for Tailings Storage (DMP 2013);

Guide to the Preparation of a Design Report for Tailings Storage Facilities (DMP 2015);

Guidelines for Preparing Preliminary Mine Closure Plans (DMP and EPA 2015);

Water quality monitoring program design: A guideline for field sampling for surface water quality monitoring programs (DoW 2009);

Environmental Factor Guideline: Terrestrial Environmental Quality (EPA 2016l); and

Storage of Radioactive Waste: Safety Guide (IAEA 2006).

8.3 RECEIVING ENVIRONMENT

The following studies have informed this section:

- Waste Characterisation Report (Trajectory and Graeme Campbell 2016, 2017; Appendix 5-1)
- Soils Assessment Reports (Landloch 2016a, 2017; Appendix 5-2)
- Baseline Radiation Report (RadPro 2016a; Appendix 5-4)
- Radiation Waste Characterisation Reports (RadPro 2016b and JRHC Enterprises 2017a; Appendix 5-5)
- Radiation Impact Assessment (JRHC Enterprises 2016; Appendix 5-6)
- TSF Closure Design Considerations (JRHC Enterprises 2017b; Appendix 6-2)
- Geotechnical Assessment (ATC Williams 2017a; Appendix 5-9)
- Preliminary Landform Surface Erodibility Assessment (Landloch 2016b; Appendix 5-3)
- Long term Landform Evolution Assessment (Trajectory 2017; Appendix 6-1)
- TSF Design Report (ATC Williams 2017b; Appendix 6-3)
- Yangibana Geology Technical Note (Border 2016; Appendix 5-10)

8.3.1 Terrain

The Project occurs within the Augustus subregion, which is described as:

Rugged low Proterozoic sedimentary and granite ranges divided by broad flat valleys. Also includes the Narryera Complex and Bryah Basin of the Proterozoic Capricorn Orogen (on northern margin of the Yilgarn Craton), as well as the Archaean Marymia and Sylvania Inliers. Although the Gascoyne River System provides the main drainage of this subregion, it is also the headwaters of the Ashburton and Fortescue Rivers. There are extensive areas of alluvial valley-fill deposits. Mulga woodland with Triodia occur on shallow stony loams on rises, while the shallow earthy loams over hardpan on the plains are covered by Mulga parkland. A desert climate with bimodal rainfall. The subregional area for GAS3 is 10,687,739 ha (Desmond et al. 2001).

Global Groundwater (2016) describe the bulk of the Project area being *underlain by granitic rocks characterised by subdued topography with some broad open flats* (Figure 8-1) *and occasional rounded granitic hills with elevations to about 350 m AHD.*

Figure 8-1 Yangibana Rare Earths Project terrain

8.3.2 Land use

The predominant land use in the Upper Gascoyne region, and in the immediate vicinity of the proposed development envelope, is cattle grazing. Current impacts to the terrestrial environment exist from historic grazing and weed infestation, most evident along stream banks where cattle access water (Ecoscape 2015).

8.3.3 Geology

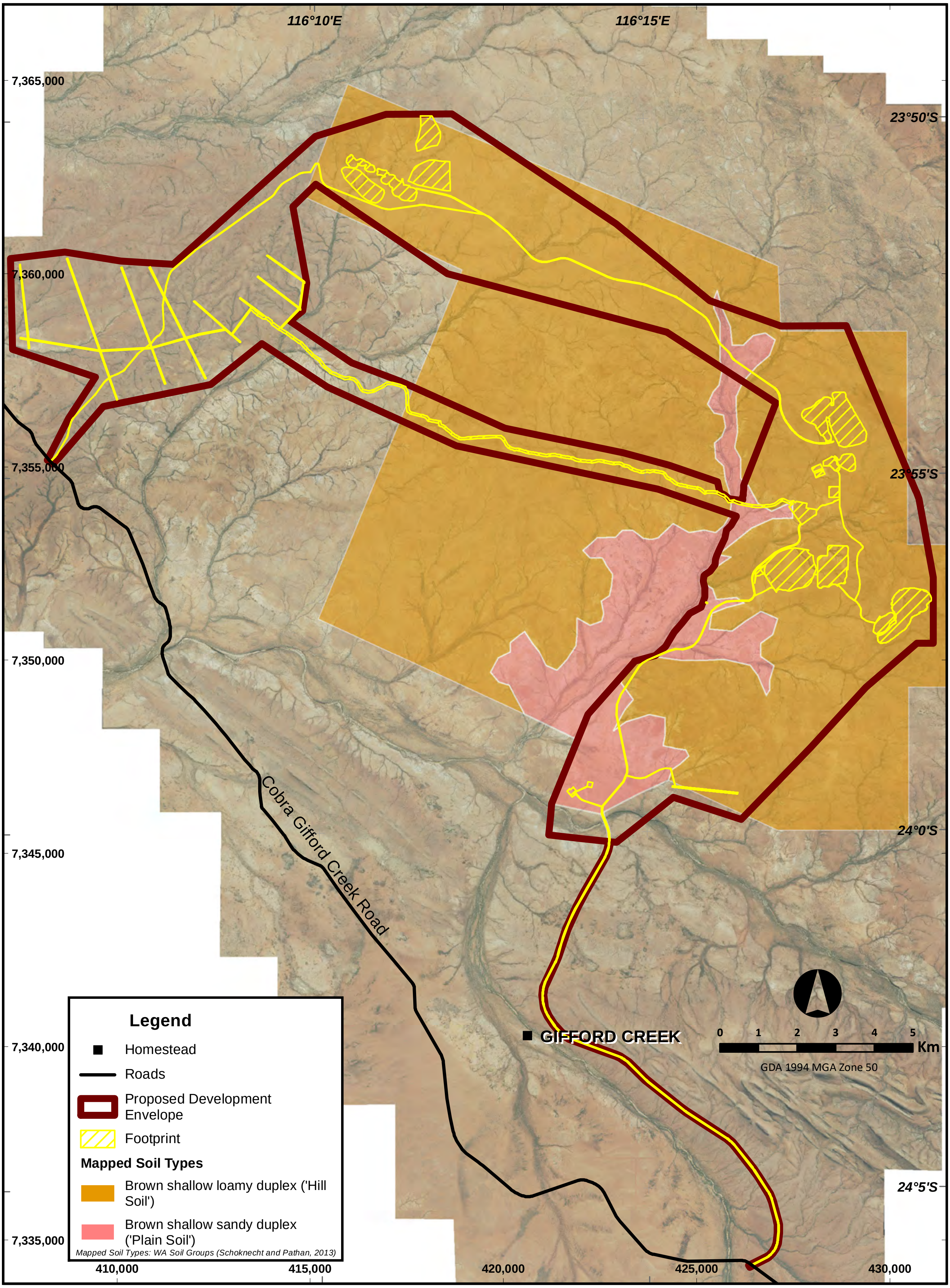
The Yangibana rare earths mineralisation is associated with rocks of the Gifford Creek Ferrocarbonatite Complex (GCFC; Border 2017; Appendix 5-10). The GCFC is a high-level, carbonatite-associated igneous intrusive suite. It is characterised by ferrocarbonatite dykes, veins and sills and surrounded by fenitised (due to wallrock metasomatism) country rocks, which are generally southeast to east-southeast trending. They consist of dolomite, ankerite and siderite with accessory minerals that include magnetite, hematite and the Rare Earth Element (REE)-bearing mineral phosphate monazite.

The geology of prospects within the proposed development envelope contain the phosphate mineral monazite which contains low levels of thorium and uranium and their decay progeny in approximate secular equilibrium. The presence of these elements is termed Naturally Occurring Radioactive Materials (NORM) as they are derived from a geological source associated with the granite bedrock and successive hydro-thermal emplacement of ferrocarbonatite (ironstone) dykes. The target ore body occurs within the ferrocarbonatite dykes (Border 2017; Appendix 5-10).

8.3.4 Soils

Two predominant soil types have been mapped within the Proposal development envelope area (Landloch 2016a, 2017; Appendix 5-2; Figure 8-2 and Figure 8-3), both of low fertility:

> Hill soils - associated with the granite low hills and rises of the site. Soil depths vary from shallow near hill tops (adjacent to rock outcrops or more sloping hills) to 40-50cm on lower hill flanks. Hill Soils are dark brown sandy duplex soils and con be divided into an A and B horizon that overlies a C horizon of decomposing granite. The Hill Soil has a neutral to slightly acidic pH, very low salinity levels (electrical conductivity initial value (ECi) <0.02dS/m) and a maximum exchangeable sodium percent (ESP) of 4.7%.
>
> Plain soils - associated with the low relief areas and flood plains of the drainage lines. A thin surface sandy loam topsoil overlies a silty loam subsoil. These soils are located in areas of recent deposition and will be influenced by the nature and frequency of past flooding events, and the character of the contributing catchment. The Plain Soils tend to be shallow (<30cm), but the depth of refusal and hence the reported soil depth is a function of the clay hardpan encountered. The Plain Soil is a dark brown sandy loam over clay loam. The soil has a massive structure (i.e. weak), strongly alkaline, saline (ECi 5 0.55 - 9.35dS/m), and sodic (ESP 2.85 - 33.96%).



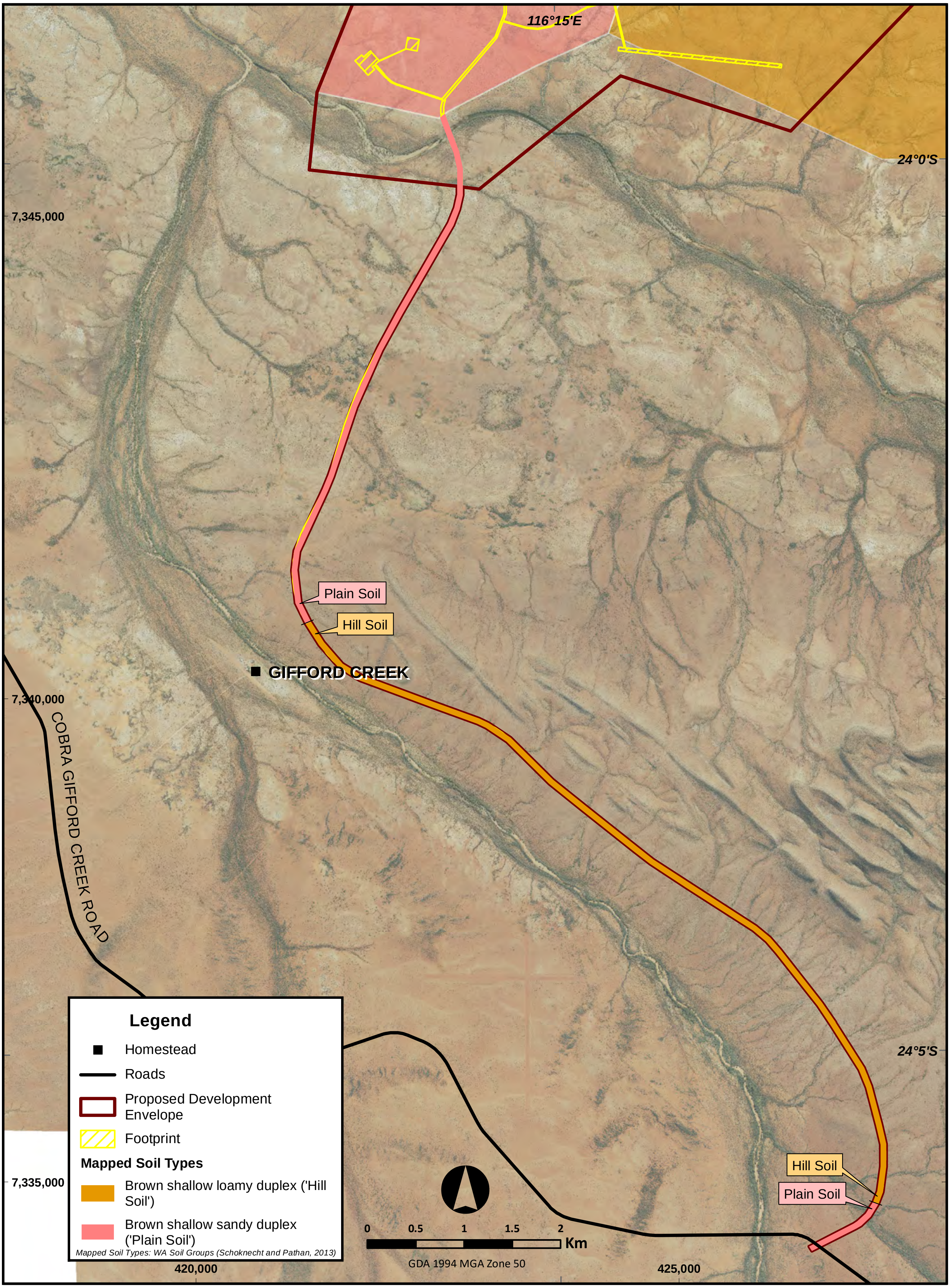
HASTINGS Technology Metals Limited

YANGIBANA RARE EARTHS PROJECT

PER_F8-2_Soil_Type.mxd
12 June 2018

Soil types at the Yangibana Rare Earths Project (Landloch 2017)

Figure 8-2



HASTINGS Technology Metals Limited

YANGIBANA RARE EARTHS PROJECT

PER_F8-3_Soil_Type_Access_Road.mxd
12 June 2018

Soil types of the access road at the Yangibana Rare Earths Project (Landloch 2017)

Figure 8-3

8.3.5 Waste characterisation

8.3.5.1 Waste rock

Chemical

The primary waste lithologies, which will be mined in large quantities and hence form part of the waste management and landform design strategy are ironstone, fresh granite, transitional granite/ironstone (saprock) and weathered granite (saprolite). All Project mine pit lithologies have been characterised geochemically and classify as Non Acid Forming (NAF; Trajectory and Graeme Campbell 2016; Appendix 5-1). Sulphide-S forms are consistently absent as indicated by Total-S values less than 0.1 % (and generally less than 0.01 %). Gypsum-S may occur locally within the range 0.1-1.5 % in the surficial colluvium and waste-saprolite-zone. However, this is 'benign-S' and the gypsum-Ca has the effect of suppressing clay dispersion. Enrichments in minor-elements are modest, reflective of the lack of sulphide-minerals (Trajectory and Graeme Campbell 2016; Appendix 5-1).

As a matter of course, Hastings has sampled the hanging wall (i.e. immediately above target ore body) and footwall (i.e. immediately below target ore body) units within 1-2 metres of the mineralisation in all holes at all targets tested (Border 2016; Appendix 5-10). In addition, limited random sampling of material was undertaken at Yangibana North and Bald Hill South to provide analyses of material in the hanging wall well away from the mineralised zones. All of the intersections were assayed for key radionuclides. A proportion of the waste rock inventory (approximately 8-9%) has slightly elevated naturally occurring radionuclide levels. Note the sampling program was heavily biased with the majority of samples collected in near proximity to the ore body and thus the proportion may well be much lower. However, these results do indicate an elevated level of thorium in samples containing higher REE concentrations, which is in fact the target ore body (Border 2016; Appendix 5-10).

Landloch (2016b; Appendix 5-3) undertook additional rock chip sampling, which was analysed for thorium and reported the following levels of thorium: Ironstone contained 188 ppm, surface granite contained 25.4 ppm and weathered granite contained 23.7 ppm of thorium. The zones containing elevated radionuclides occur primarily in the ironstone within two meters of the main target ore body. This area of 1-2m in the surrounding ironstone will more than likely, due to the size of the mining equipment, be considered a component of the target ore body. However, a conservative approach also assumes that some of this material will be transported to the respective waste rock landform.

The mineralogy of the project is not associated with asbestiform minerals (Trajectory and Graeme Campbell 2016; Appendix 5-1). In Western Australia, most fibrous minerals are serpentine or amphibole asbestiform minerals (e.g. chrysotile, crocidolite and actinolite). These are not associated with the Proposal’s ore body or surrounding waste rock.

Physical

The following physical parameters were used to define the durability of the waste rock (Landloch 2016b; Appendix 5-3):

1. Rock water absorption: Indicates the susceptibility for water to penetrate the rock
2. Rock particle densities: Indicate the strength of the rock
3. Slake durability: Indicates the durability of the rock to abrasive forces such as truck tipping and bull-dozer trafficking.

The rock water absorption and rock particle density of the weathered granite was poor i.e. water absorption was high and rock particle density was low indicating a lower durability in comparison to other waste types (Table 8-1). Both ironstone and surface granite has excellent rock particle density indicating their suitability for rock armouring. Ironstone had lower rates of water absorption indicating its greater durability whereas surface granite was marginal. The slake durability test showed relatively high levels of durability for all three waste rock types with ironstone (very high durability) performing best (Landloch 2016b; Appendix 5-3).

Table 8-1 Physical parameters measured on waste rock (ironstone, surface granite and weathered granite)

Physical parameter	Unit	Ironstone	Surface granite	Weathered granite
Rock water absorption	%	1.3	3.4	17.1
Rock particle density	g/cm^3	3.8	2.9	2.0
Slake durability	%	99.5	95.5	88.5

Erodibility parameters were determined for topsoils (i.e. plain soils and hill soils), ironstone, surface granite and weathered granite (Landloch 2016b; Appendix 5.3). The hills soils represent topsoil, which may be a suitable plant growth media. The ironstone, surface granite and weathered granite are representative of waste materials in the waste rock landform and collected from surface and subsurface areas. However, the majority of waste will be fresh granite, which is found at depth and this was not tested in the erodibility assessment due to its competent nature. The erosion potential of the soils tested showed that erosion reaches high rates at very short slope lengths, and then remains high as length of slope increases. Mixing soil and rock reduced the potential for erosion but were detachment limited i.e. potential for erosion remains low for a longer length of slope but then increases rapidly as water accumulation causes detachment of particles within rills (Landloch 2016b; Appendix 5-3).

8.3.5.2 Tailings

There will be three tailings streams generated from processing of the ore. Given a process plant has not yet been built, Hastings has characterised the tailings as part of the normal staged approach of metallurgical development of the process plant as follows:

- Modelling, based on geochemical analysis of ore body and initial process considerations.
- Tailings were then produced from bench scale process testing and these have undergone preliminary characterisation.
- As the next step of the metallurgical assessments, a pilot plant for the process has been developed and the resultant tailings have undergone more detailed characterisation (Trajectory and Graeme Campbell 2017; and JRHC 2017; Appendices 5-1 and 5-5, respectively)).

The following reports the outcomes from the latest metallurgical testing, which most accurately represents the tailings streams. The first stream of tailings from the beneficiation process are to be disposed in TSF 1. The tailings solids and pore water will be benign geochemically (i.e. Non-Acid Forming [NAF]) (Trajectory and Graeme Campbell 2017; Appendix 5-1). There were slight enrichments of metals (i.e., Fluoride and Molybdenum) in both the tailings solids and contact waters that were analysed. Trace element concentrations are either below or close to those typically recorded for soils, rocks and sediments derived from non-mineralised terrain. TSF 1 tailings characterisation have shown radionuclide readings of < 1 Bq/g (JRHC 2017; Appendix 5-5). The radionuclides in these tailings are not water soluble (JRHC 2017; Appendix 5-5).

The second stream of beneficiation tailings (to be disposed in TSF 2) solids and pore water are benign geochemically (i.e. NAF; (Trajectory and Graeme Campbell 2017; Appendix 5-1)). Slight to moderate enrichments of metals (i.e., Fluoride and Molybdenum) were reported in both tailings solids and contact waters that were analysed. Trace element concentrations are either below or close to those typically recorded for soils, rocks and sediments derived from non-mineralised terrain. Detailed characterisation of TSF 2 tailings solids show radionuclide levels of 4 Bq/g (JRHC 2017; Appendix 5-5). Radionuclides will not be water soluble in these tailings as reflected by the pore water analysis in the detailed characterisation assessment of tailings (JRHC 2017; Appendix 5-5). The facility will be maintained as a 'wet' facility during operations to control dust generation. At closure, the consolidation of tailings and drainage of water will occur. Given the size of the tailings particles, consolidation of tailings will require either a thickener or tailings from TSF 1 to reduce time taken to consolidate. Given the geochemical characteristics of TSF 2 are similar to TSF 1 other than radionuclide concentrations, there is the option to combine TSF 2 and 1. This has the following benefits:

- Radionuclide concentrations are diluted to approx. 0.9 Bq/g (although this may increase to 1.1 Bq/g due to variability in ore being processed).
- Blending of tailings will provide better closure outcomes (increased heterogeneity of tailings particle size will aid in drainage and consolidation of tailings).
- A reduced footprint (i.e., a smaller disturbance area).

However, the effectiveness of water recycling is significantly reduced during operations.

TSF 3 tailings-solids were found to be slightly acidic and NAF (Trajectory and Graeme Campbell 2017; Appendix 5-1). TSF 3 pore liquors have a pH that is circum-neutral, are saline, and have elevated magnesium and sulphate (as MgSO4), and Molybdenum levels (Trajectory and Graeme Campbell 2017; Appendix 5-1). Detailed characterisation studies report TSF 3 radionuclide levels at 32.4 Bq/g and are not water soluble (JRHC 2017a; Appendix 5-5).

Evaporation pond liquors were analysed. Radionuclide levels did not exceed 1 Bq/g, however $MgSO_4$ was elevated above Stock Water Quality Guidelines (Trajectory and Graeme Campbell 2017; Appendix 5-1).

8.3.6 Radionuclides

Naturally occurring radioactive minerals are associated with the ore body that is proposed to be mined.

Atoms that emit radiation such as radium and thorium are unstable. As a result of their instability, they decay and make new daughter atoms while giving up some of their excess energy as alpha, beta, and gamma rays. Alpha, beta and gamma rays have different penetration ranges in air, and in solid matter, and therefore affect biological tissue differently. Thus when gaining an understanding of the radionuclide levels in the receiving environment, measurements of gamma levels, airborne ambient dust that emits alpha radiation, and measures of radon and thoron provide an understanding of the naturally occurring radionuclides and their daughter products in the environment.

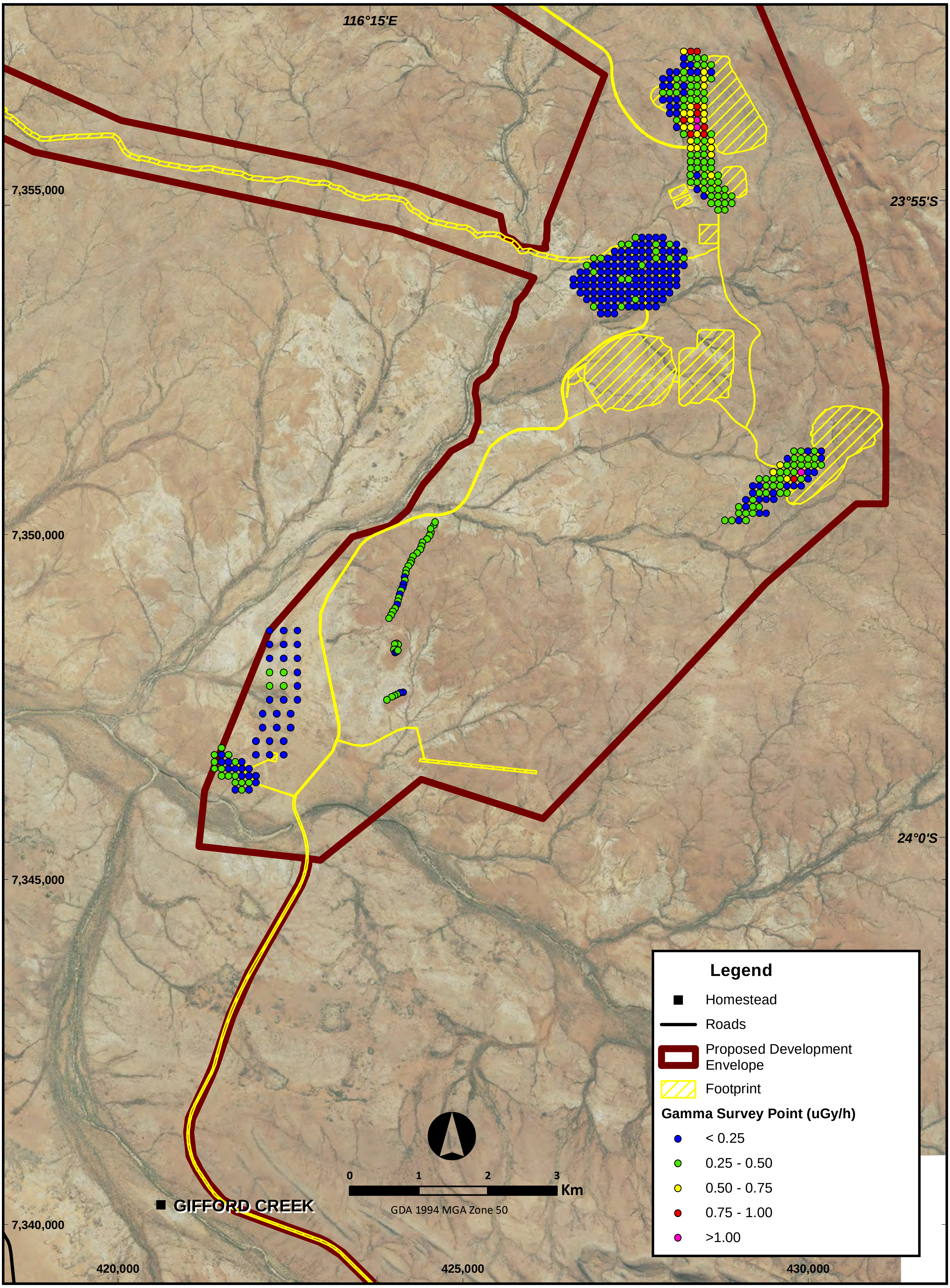
People are exposed to natural radiation sources as well as human-made sources on a daily basis. Natural radiation comes from many sources including more than 60 naturally-occurring radioactive materials found in soil, water and air. Radon, a naturally-occurring gas, emanates from rock and soil, and is the main source of natural radiation. The average annual radiation dose that humans are exposed to and come from all radiation sources is 2.4 mSv, with a range from 1.0 – 13 mSv per year (UNSCEAR 2008; reported in RadPro 2016a; Appendix 5-4).

Mining of ore containing naturally occurring radionuclides has the potential to concentrate the radionuclides during processing and change the levels of naturally occurring radionuclides in the receiving environment. As a result, internationally accepted radiation standards have been adopted into state regulatory processes and guidelines. The following summary of baseline radiation studies aligns with the *NORM Guideline 3.1 Pre-operational Monitoring Requirements* (DMP 2010). The baseline studies included:

- Gamma radiation.
- Radionuclides in dust particles.
- Radon and thoron gas concentrations.
- Radionuclides in soil.
- Radionuclides in groundwater and surface water (presented in Chapter 9 *Hydrological Processes and Inland Waters Environmental Quality*).

8.3.6.1 Gamma radiation

Baseline gamma levels have been determined via three methods: Handheld instrument gamma surveys, integrating monitors, and interpretation of an aerial radiometric survey (RadPro 2016a; Appendix 5-4). The results of all three methods were consistent and showed that gamma levels were elevated above mineralisation as expected, which is associated with the outcropping ironstone (as illustrated in Figure 8-4 and Figure 8-5, which are results from the handheld instrument gamma surveys). Average gamma dose rates are 0.23 $\mu Gy.h^{-1}$ in areas away from the outcropping mineralisation. Average gamma dose rates are 0.37 $\mu Gy.h^{-1}$ over the deposit areas and range up to 1.26 $\mu Gy.h^{-1}$ (RadPro 2016a; Appendix 5-4).



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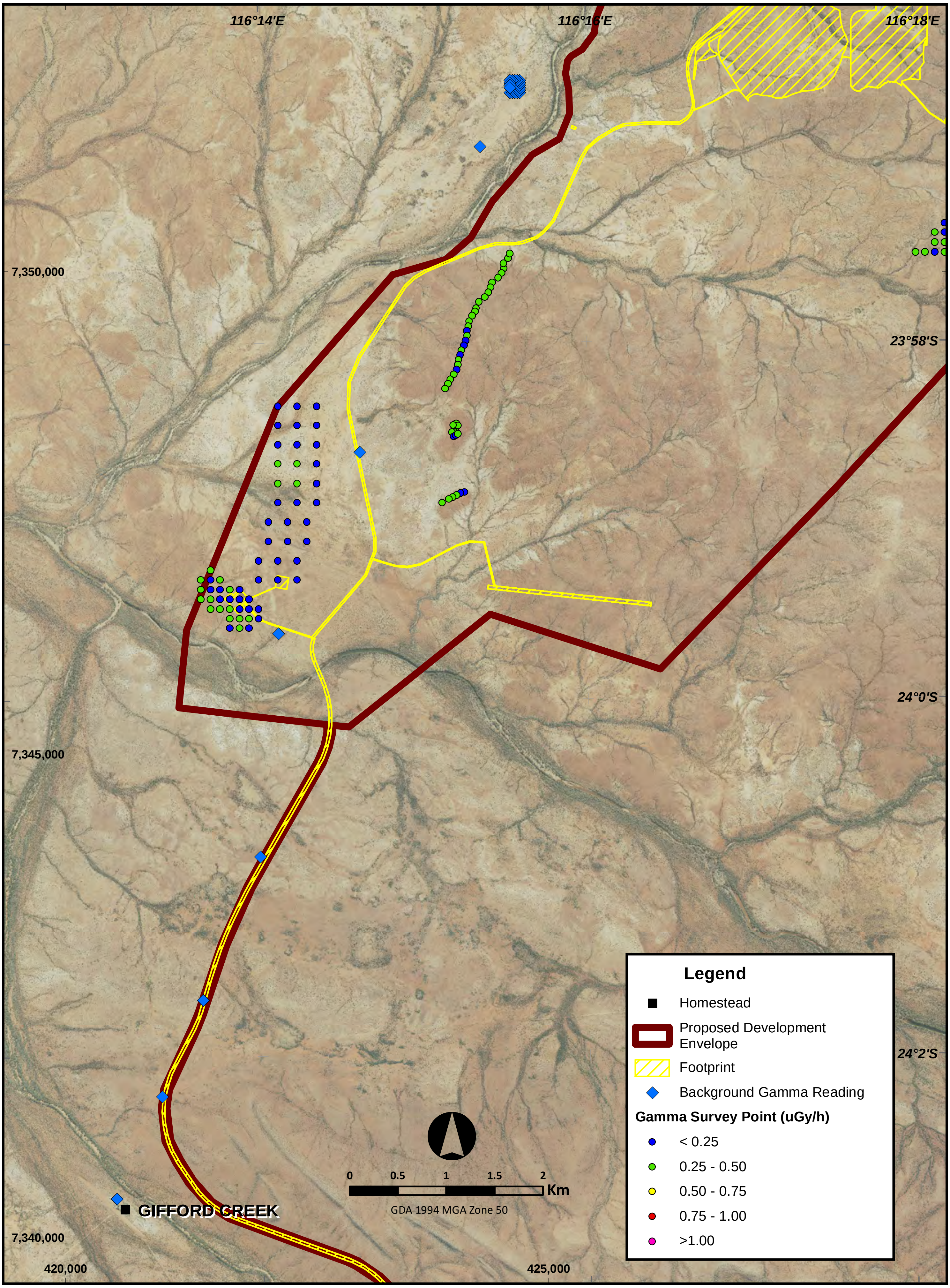
PER_F8-4_Gamma_Survey_overview.mxd
12 June 2018

Gamma survey results of Bald Hill Pit, Frasers Pit, ProcessingPlant and Accommodation Village

Figure 8-4



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PER_F8-5_Gamma_Survey_Accom-Access.mxd
12 June 2018

Gamma survey results of the northern section of the access road and accommodation village

Figure 8-5

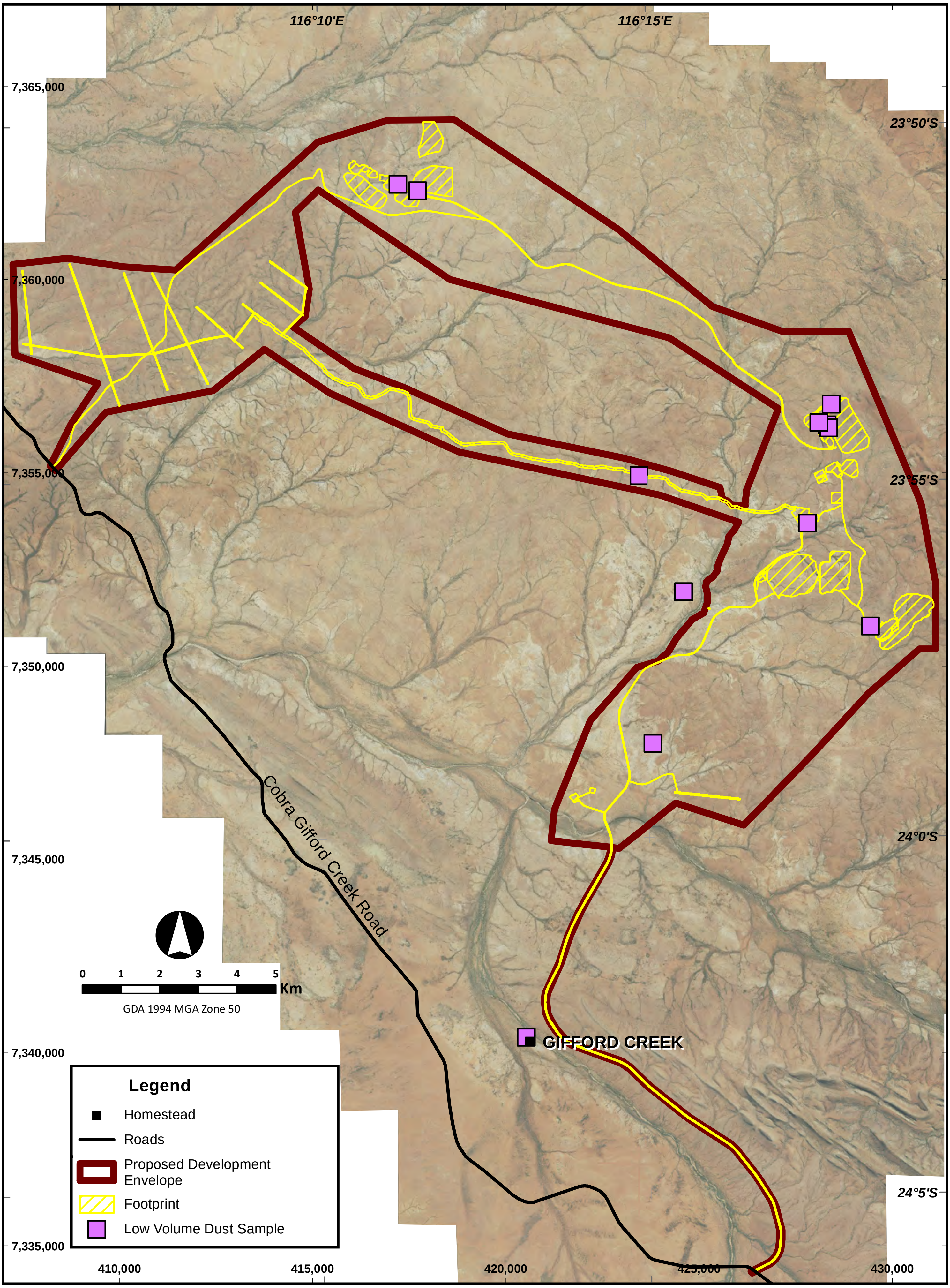
8.3.6.2 Radionuclides in dust particles

Baseline environmental dust sampling was conducted across the project area, from 2015 onwards, using low volume pumps (SKC AirLite and SKC Airchek 52) to collect samples over a period of at least four hours (RadPro 2016a; Appendix 5-4. Eleven locations were chosen: Fifteen samples were collected from six locations on the mineralisation and nine samples were collected from five locations in areas that were not associated with the mineralisation (Figure 8-6). Alpha activity levels in all samples were below Minimum Detection Limits (MDL). Airborne alpha activity concentrations are similar for all areas of the Proposal, both over the prospects and in areas away from radiologically enhanced mineralization. The average airborne activity on and off the deposit was 0.01 and 0.009 αdps[1].m^{-3}, respectively (Table 8-2).

Table 8-2 Airborne alpha activity levels at areas on the deposit and off the deposit

Location	Average (αdps.m^{-3})	Maximum (αdps.m^{-3})	Minimum (αdps.m^{-3})	Number of Samples
On Deposit	0.010	0.019	0.005	15
Off deposit	0.009	0.013	0.005	9

[1] αdps - alpha decays per second



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PER_F8-6_Low_Volume_Dust.mxd
12 June 2018

Low Volume Dust sampling locations

Figure 8-6

8.3.6.3 Radon and thoron gas concentrations

Baseline radon and thoron monitoring, commenced in 2015 using Landauer Radtrak devices, which were placed at four locations around the Project areas, with one pair measuring a background location at Gifford Creek Station Homestead, approximately 20 km south of the Project area (RadPro 2016a; Appendix 5-4; Figure 8-7). Monitors were placed in pairs, one measuring radon only and the other measuring radon and thoron. Twenty-four monitors were only measuring radon and 26 monitors measured radon and thoron. Monitors were replaced at intervals determined by access to site, and exposure periods have ranged from 144 days up to 173 days (RadPro 2016a; Appendix 5-4).

Fifteen of 24 radon-only monitors returned results below the minimum detection level (MDL) as opposed to one of the radon and thoron monitors that returned results below the MDL. For the estimation of values for radon and thoron concentrations, a conservative approach was adopted and assumed that any result below the MDL was equivalent to the MDL value (RadPro 2016a; Appendix 5-4; Table 8-3).

Table 8-3 Passive radon/thoron monitoring

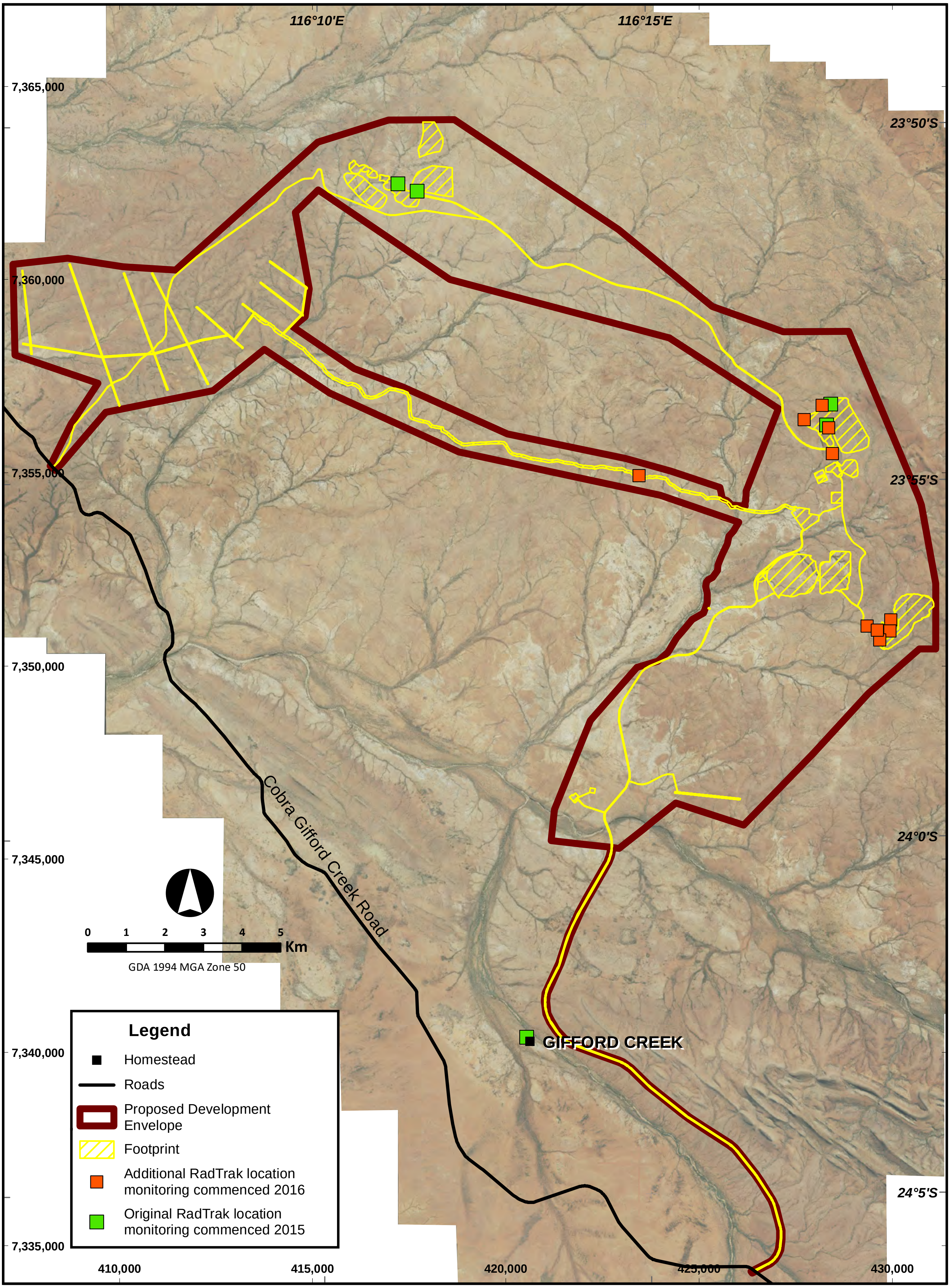
Location	Average Radon ($Bq.m^{-3}$)	Average Thoron ($Bq.m^{-3}$)
Bald Hill	9.9	24.6
Fraser's	9.9	29.1
Yangibana North	10.4	16.9
Gifford Creek H.S	9.1	15.5

Real time radon monitoring was also conducted using a portable radon detector (Durridge RAD7, 2010). The RAD7 was left in the field for five runs of approximately two days each, sampling the air every 30 minutes under a user-defined sampling protocol. Radon was elevated at the location of the accommodation facilities (Table 8-4). Given the ore body does not occur in the location of the accommodation facilities, the results are surprising. Additional real-time radon monitoring at the location of the accommodation facilities has since found that the values are much lower than previously found. Technical error or faulty equipment may account for the results, although this is not known. Hastings will continue to conduct additional radon monitoring at this location.

Table 8-4 Real time radon monitoring

Location	# Cycles	Run Start	Run Stop	Avg. Radon ($Bq.m^{-3}$)	Two-sigma Uncertainty*
Bald Hill South	99	08/13/16 16:01	08/15/16 17:33	14.6	1.8
Gifford Creek Homestead	97	08/17/16 15:57	08/19/16 16:23	5.04	1.1
Bald Hill Central	92	08/20/16 14:55	08/22/16 12:56	7.56	1.4

Accommodation Facilities Area	87	9/03/2016 16:45	09/05/16 12:05	43.8	3.4



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PER_F8-7_Passive-Rad-Thoron.mxd
12 June 2018

Passive radon/thoron monitoring locations

Figure 8-7

8.3.6.4 Radionuclides in soil

Subsurface soil samples were collected and analysed for uranium and thorium. Subsurface samples were taken from eight drill holes below the surface, within or immediately adjacent to mineralisation and were selected to be approximately representative of the Proposal target resource material (Figure 8-8). Samples were analysed for total uranium and thorium, and by gamma spectroscopy (ESR) for members of each decay chain.

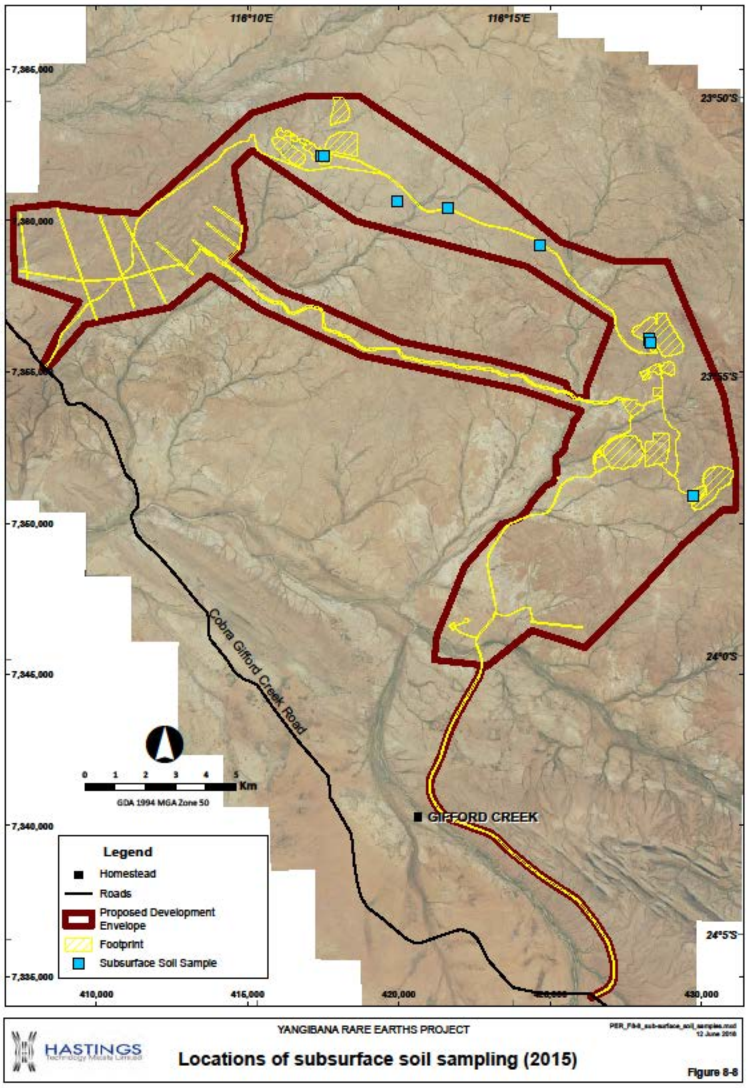


Figure 8-8 Locations of subsurface soil sampling (2015)

The outcomes from the analysis show that there are elevated concentrations of uranium and thorium associated with the ore body and that concentrations vary widely (Table 8-5). Comparison with the wider data set indicated that higher concentrations of radionuclides are found with the target REE in mineralised areas compared to surrounding granites and metamorphics (Border 2016; Appendix 5-10; and reported in RadPro 2016a; Appendix 5-4).

Table 8-5 Sample origin and lithology: Uranium and thorium content

Hole ID	Metre from	Metre to	Lithology Description (from Field Logs)	U (ppm)	Th (ppm)
BHRC007	21	22	Fenitic Granite (interburden between two ironstone lenses).	32.3	2520.7
BHDD027	14.5	14.9	Strongly weathered granite, immediate FW to Ironstone	10.9	1177.1
FRRC009	104	105	Ironstone	143.6	1309.2
KGRC005	71	72	Ironstone	50.2	1510.6
HKRC005	11	12	Fenetic Granite with 40% ironstone	5.2	1382.2
LERC007	9	10	Fenitic Granite, immediate HW to ironstone	15.8	1870.7
YGRC024	37	38	Ironstone	20.9	1245.5
YGRC028	39	40	Ironstone and quartz (10%).	62.2	2454.5

The uranium and thorium concentrations in topsoil were 0.368 mg/kg and 7.87 mg/kg, respectively, and confirmed their association with the ore body and not that of the surrounding soils (RadPro 2016a; Appendix 5-4; also confirmed by Landloch 2016a; Appendix 5-2).

In early 2015 Hastings undertook a limited programme of random sampling of material from the 2014 drilling programmes at its known deposits at Bald Hill, Frasers, Yangibana North and Yangibana West, and a mineral exploration area south of Bald Hill at Auer. These samples provide analyses of thorium oxide (ThO_2) and uranium oxide (U_3O_8) material in the ore body containing <0.1% or <0.2% rare earth oxides and hanging wall (HW) that is not in the mineralised zones (Table 8-6; Border 2016; Appendix 5-10).

Table 8-6 shows the number of samples taken from each area and the mean ThO_2 and U_3O_8 values derived from those analyses. Samples from drilling have been split into those that are immediately adjacent to the mineralisation (usually only 1-2m wide; i.e. waste <0.1% and waste<0.2%) and those slightly further from the mineralisation and carrying less than total rare earths oxides (i.e. HW samples) (Border 2016; Appendix 5-10).

Table 8-6 Number (No.) of samples collected, and mean thorium oxide (ThO_2) and uranium oxide (U_3O_8) (ppm) in waste rock sampled with < 0.1% rare earth elements (REE), < 0.2% REE and hanging wall rock (HW) at Bald Hill South, Fraser's, and Yangibana North and West, and the Auer prospect.

	Waste <0.1%			Waste <0.2%			HW samples		
	No.	ThO_2	U_3O_8	No.	ThO_2	U_3O_8	No.	ThO_2	U_3O_8
Bald Hill South	375	36	7	1645	81	10	10	33	11
Fraser's	234	30	8	480	57	10			
Yangibana North	185	25	6	497	78	9	54	24	6
Yangibana West	293	30	5	317	91	8			
Auer	20	41	4						

These results clearly indicate an increase in thorium levels within 1-2m of the mineralisation to means of 57 - 91 ppm ThO_2. This figure drops off rapidly away from the mineralisation to means of 24 - 41 ppm ThO_2 (Border 2016; Appendix 5-10).

Uranium levels are consistently low with means of 8-10 ppm U_3O_8 within 1 - 2m of the mineralisation and 4 - 8 ppm U_3O_8 slightly further away. A higher mean of 11 ppm U_3O_8 in the hanging wall samples from Bald Hill South relates to the background values of the granite (Border 2016; Appendix 5-10).

8.3.6.5 ERICA assessment of radiological dose exposure to flora and fauna

Given the elevated levels of radionuclides pose a risk of exposure to the surrounding flora and fauna values, a Tier 2 ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) was conducted (JRHC 2016; Appendix 5-6). ARPANSA (2010) recommend the ERICA software tool for assessing risk to Australian plants and animals. The availability of data, specifically for the Australian kangaroo, enable users to apply the tool for Australian operations at a Tier 2 level. Other flora and fauna utilise the ERICA default value.

The assessment method produces a dose rate, which is then compared to a 'screening level' set at 10 µGy/h (default ARPANSA 2010). If the dose rate is below the screening level then no impacts of radionuclides would be observed in the respective flora or fauna. The dose rates determined in the ERICA assessment are shown in Table 8-7. When compared to the screening level, the ERICA assessment indicates that there is no radiological risk to reference plants and animals (including kangaroos) from emissions from the proposal (JRHC 2016; Appendix 5-6).

Table 8-7 ERICA Assessment: Output (total dose rate) for each class of flora or fauna

Class of flora or fauna (ERICA default unless noted)	Total Dose Rate (µGy/h)
Amphibian	<0.001
Annelid	<0.001
Arthropod - detritivorous	<0.001
Bird	<0.001
Flying insects	<0.001
Grasses & Herbs	0.005
Lichen & Bryophytes	0.014
Mammal - large	<0.001
Mammal - small-burrowing	<0.001
Mollusc - gastropod	<0.001
Reptile	<0.001
Tree	<0.001
Kangaroo (user defined)	<0.001

8.3.7 Site selection

8.3.7.1 Waste rock landforms

Waste rock landforms will occur alongside each of the four respective pits. Sites were selected to ensure future resources were not being sterilised. The WRLs are also located as close to the source pit as possible. The source pits are generally located at the highest elevation within the Project and therefore the location of the WRLs are also located on the higher elevations within the local water catchment area.

During the Definitive Feasibility Study phase, the design of the WRL aimed to reduce the size of the disturbance footprint by maximising the height of the WRLs, while taking account the waste rock erodibility study outcomes (see section 8.3.5; Landloch 2016b; Appendix 5.3) to ensure closure objectives will be achieved.

8.3.7.2 Tailings storage facilities

Two types of tailings storage facility designs (TSF) were originally selected, namely thickened tailings in a central discharge facility, and thickened or unthickened tailings in a valley-fill facility. The site criteria for the central discharge facility were a flat location with a minimal upstream catchment. The site criteria for the valley-fill facility was to identify a valley catchment. The location also needed to take into consideration factors such as proximity to pit locations, a suitable location for a process plant adjacent to the TSFs, as well as, the water catchment for a probable maximum precipitation (PMP) event. One site was identified for each facility (Figure 8-9).

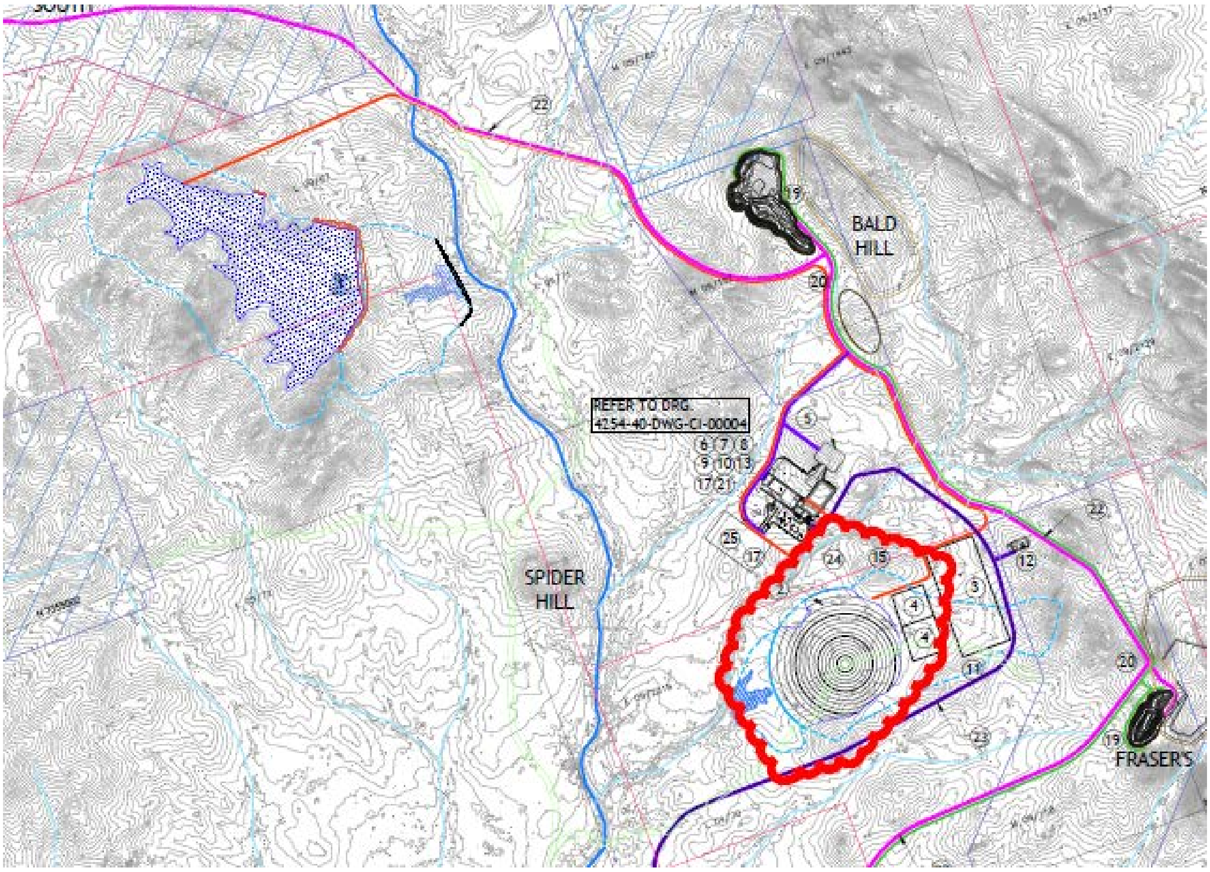


Figure 8-9 Location of central discharge tailings storage facility (red outline) and valley-fill tailings storage facility (purple grain fill) options. The water catchment of each is shown by a blue broken line.

A multi-criteria analysis using a sustainability approach was undertaken to identify a preferred facility. Environmental considerations included disturbance area, energy requirements and water balance. Social considerations included stakeholder perception, including pastoralists' inputs (Hastings has consulted with Mr Bill Biggs, pastoral owner of Gifford Creek and Wanna Stations). From an environmental perspective, the central discharge TSF was identified as the preferred option for the following reasons:

- Smaller disturbance footprint.
- Less water usage.
- Lower energy requirements.

From a social perspective, the central discharge TSF (1) was also the preferred option due to its distance from Fraser Creek and considered lower-valued grazing country (i.e. lower grass density).

In addition, two smaller paddock style TSFs (2 and 3) have since been identified for the containment of tailings with elevated levels of radionuclides. The location of these are at a higher elevation within the water catchment and outside of the flood zone for a PMP event (100 year ARI). The evaporation pond was also located alongside the TSFs.

8.3.8 Site stability

8.3.8.1 Seismicity

The peak ground acceleration in the area for a return period of 500 years has been estimated to be 0.07 g (Geoscience Australia earthquake hazard map: Figure 8-10); ATC Williams 2016). The earthquake hazard map shows the peak ground acceleration (response spectral period of 0.0s) on rock expected for a 500 year return period, in units of g[2] (i.e., the acceleration due to earth's gravity).

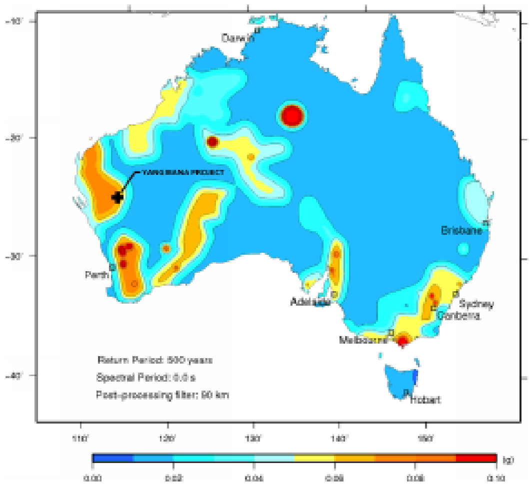


Figure 8-10 2013 Earthquake hazard map of Australia

The seismic rating for the area then informs the TSF design, which is considered in a stability assessment under dynamic loading conditions. Specific design considerations (as per internationally recognised ANCOLD guidelines) includes ensuring the facility is stable under:

- Operating Basis Earthquake (OBE) 1:100 Annual Exceedance Probability (AEP).
- Maximum Design Earthquake (MDE) 1:1000 AEP.
- Post Closure, Maximum Credible Earthquake (MCE).

The following conditions were considered in the stability analyses:

- Various structural loading conditions (i.e., static, pseudo-static and post-closure) caused by an earthquake.
- Soil and rock strength parameters: Shear strength estimation under seismic loading.
- Phreatic surface (i.e. water saturation zones).

The results of the analyses indicate satisfactory factors of safety (FOS; i.e., they meet the ANCOLD requirements) for operational conditions. However, at closure the TSF design (prior to capping and rehabilitation) did not meet the ANCOLD determined FOS. ATC Williams (2017b; Appendix 6-3) report "*the placement of up to 2 m of durable rock fill on the TSF embankments, which will increase the FOS to the required minimum for the MCE*".

[2] 1 g = 9.81 m/s^2

8.3.8.2 Geotechnical assessments

Pits

Preliminary geotechnical assessments of the pits were completed for the pre-feasibility study (Snowden 2015, 2016). Detailed reports will be presented as components of the Mining Proposal as required under the *Mining Act 1978* (WA) and regulations administered by the Department of Mines, Industry Regulation and Safety (DMIRS).

The pits are situated in a flat to shallow dipping topography with three waste geotechnical domains: Fresh granite, weathered granite and saprolite (Figures 8-11 – 8-13). The geotechnical drilling, logging and sampling program identified four geotechnical domains, namely fresh granite, weathered granite, saprolite and ore. The following summarises results of the study:

- Fresh granite will dominate the hanging wall and footwall of the deposits. This material is considered to be un-mineralised. It is expected that this unit will be the dominant material forming the pit slopes as mining goes deeper and is mostly composed of fresh and very strong rock. It has a very high average Rock Quality Designation (RQD) of 90%, and median Fracture Frequency of 3.2 fractures per metre;
- Overlying the weathered rock mass is a layer of soil-like saprolite. The base of this material has been modelled by Hastings and has an approximate depth of between 20 m and 70 m below surface for Bald Hill and around 10 m depth for Fraser's. This material may have originated from the surrounding Granite. Due to its recent deposition and non-indurated condition, this unit is considered to have the characteristics of an engineering soil. From logging, this material is described as a dense, clayey, silt and sand. Laboratory results classify this material as a sandy silt with a large percentage of fines of intermediate plasticity.
- Weathered granite will be exposed for several benches immediately below the saprolite material on the east and southwest walls of Bald Hill, while in Fraser's pit this material will only be exposed on two benches located on the northeast and southwest sector of the pit. The weathered granite material ranges from extremely to slightly weathered and is typically moderately weathered. Strength ranges from weak to strong and is typically medium strong rock. RQD is variable but is typically around 70% and six fractures per metre.
- Ore is modelled as a single domain cutting through the major stratigraphy of the deposits. In the initial mining stage, particularly at Bald Hill and Yangibana pits, the target mineralisation is mostly within the weathered zone. In this zone, the ore is likely to exhibit the characteristics of highly to moderately weathered material with strength ranging from very weak to strong and typically medium strong rock. It has an average RQD of 54% and median Fracture Frequency of 7.4 fractures per metre.

A geochemical assessment of these materials has been conducted as described in section 8.3.5.

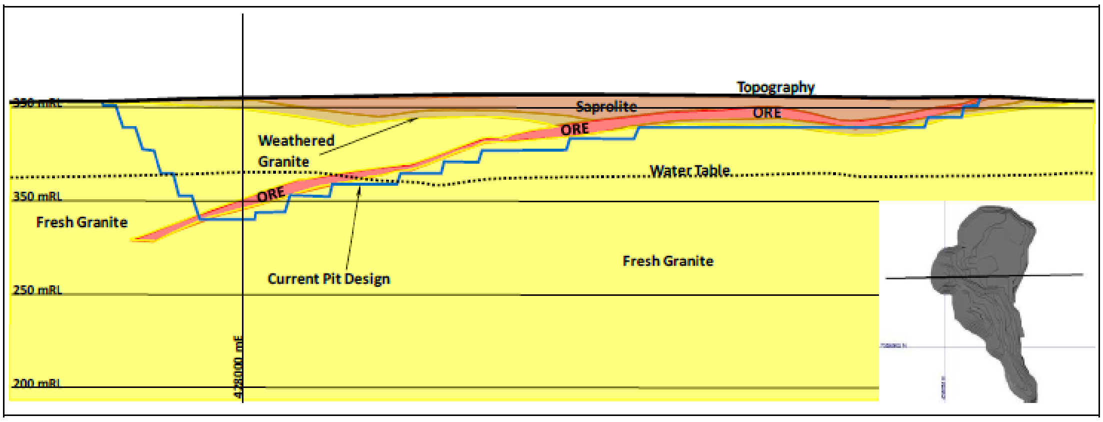


Figure 8-11 Cross-section of typical geology at Bald Hill pit (Snowden 2016)

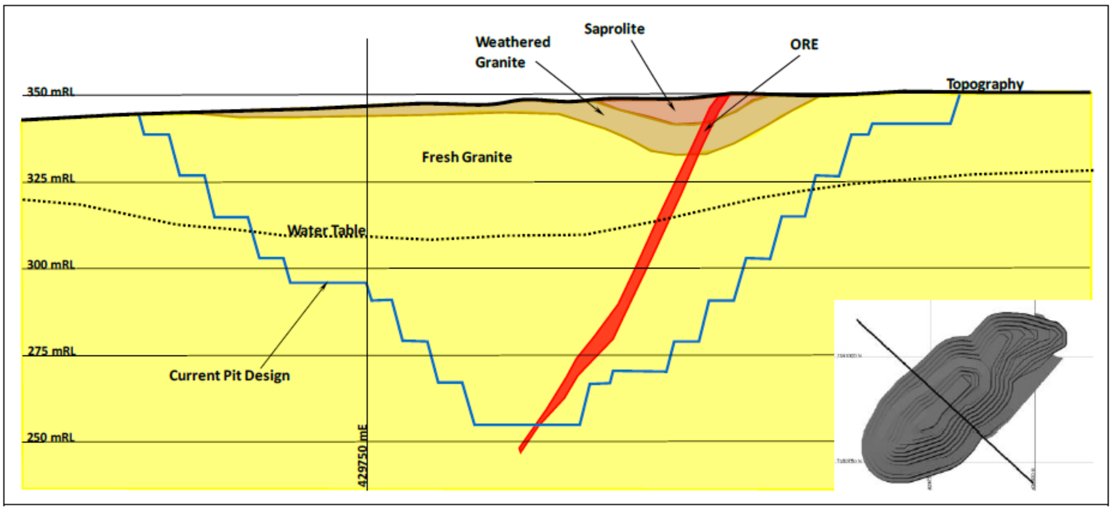


Figure 8-12 Cross-section of typical geology at Fraser's pit (Snowden 2016)

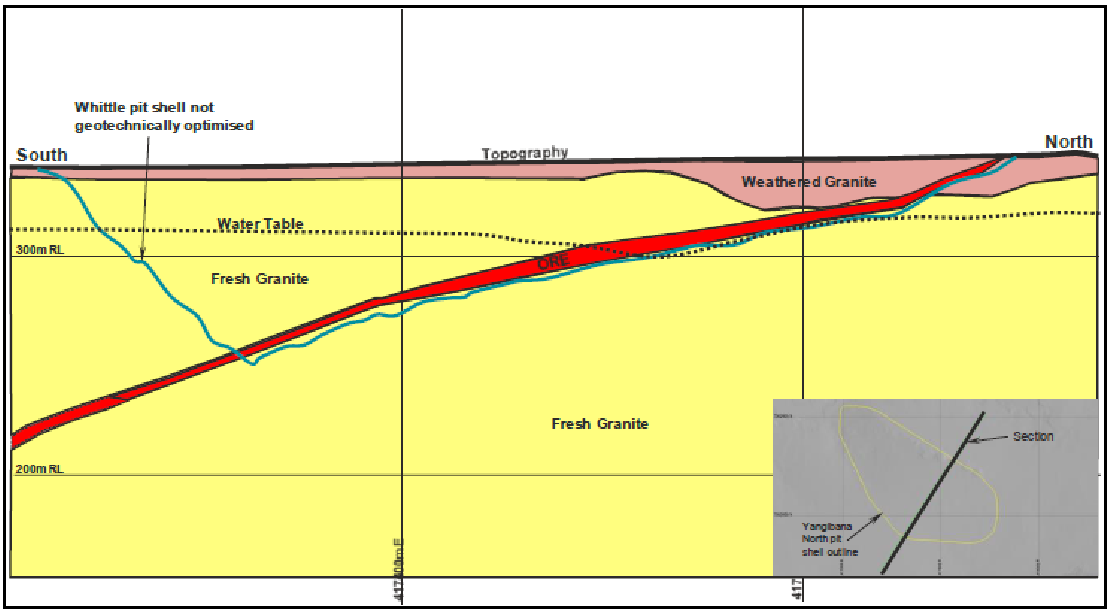


Figure 8-13 Cross-section of typical geology at Yangibana North pit (Snowden 2016)

Tailings storage facilities

A geotechnical assessment has been conducted over the return water pond, TSFs, and evaporation pond areas (ATC Williams 2017a):

- Return water pond: Bore holes were placed at the toe of TSF1 and in the return water pond areas. The soils in this location consisted of superficial soils (i.e. clay, clay gravel and clayey sand) up to 1.15 m below ground level (BGL), then highly weathered granites up to 3.4 to 9.5 m BGL and then fresh granite until termination depth. Water was encountered in two of the bore holes in this area.
- TSF 1: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.45 to 1.7 m BGL.
- TSF 2 and 3: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.4 to 1.9 m BGL.
- Evaporation pond: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of approximately 0.4 m BGL.

No groundwater was encountered within TSFs or evaporation pond areas.

Falling head *in-situ* permeability tests between 0.0 m and 11.9 m indicated relatively low permeability in the superficial soils and weathered rock (1.44×10^{-6} m/s to 7.91×10^{-8} m/s). *In-situ* permeability of between 3.73×10^{-6} m/s and 6.38×10^{-9} m/s were obtained from down borehole packer tests, performed in moderately to freshly weathered granite bedrock underlying the site. Vertical seepage rates will be very slow and it is unlikely that a hydraulic connection and fully saturated conditions between the decant water pond and groundwater will be established. However, there is potential for lateral seepage.

A geochemical assessment of the materials used to construct the TSFs has been conducted. Two key construction materials are representative of waste rock material characterisation, as summarised in Section 8.3.5:

- Near surface clayey sand deposits (i.e., saprolite material) will be used to construct the low permeability embankment zones and backfill to cut off trenches.
- Fresh granite waste rock from pit stripping operations will form the remainder of the structures: Downstream shoulder, crest and upstream erosion protection layers.

8.3.9 TSF design

The TSFs have been designed to comply with the *Code of Practice -Tailings Storage Facilities in Western Australia* issued by the Western Australian Department of Mines, Industry Regulation and Safety (DMIRS) (formerly Department of Mines and Petroleum (DMP; 2013)).

The design of the TSFs and the content of the TSF design report (ATC Williams 2017b; Appendix 6-3) also conforms to:

- DMP (2015) *Guideline to the preparation of a design report for tailings storage facilities (TSFs)*, which includes a requirement to justify the basis of the design and the parameters adopted for the engineering design, construction, operation, rehabilitation and closure of the TSF; and

- Australian National Committee on Large Dams (ANCOLD; 2012) *Guidelines on tailings dams - planning, design, construction, operation and closure*. ANCOLD prepares and issues guidelines, which represent best engineering practice, and are widely used across Australia and internationally. ANCOLD is an active member of the International Commission on Large Dams (ICOLD), which shares international practice and new techniques to advance all aspects of TSF engineering.

The development of a design concept took into consideration tailings storage capacity requirements, and the physical, geochemical and radiological properties of the various tailings streams, and ground (hydrogeology; geotechnical) and climatic conditions. The design concept (Figure 8-14) comprises of a stacked, thickened tailings deposit at TSF 1 with a centralised discharge point. TSF 2 and TSF 3 will be paddock type facilities with spigotted perimeter discharge lines. Provision of a composite geomembrane / compacted clay liner is proposed for TSF 3. At the time of referral of the proposal to the EPA (January 2017), Hastings had planned to also line TSF 2, however, ATC Williams (2017b; Appendix 6-3) have since determined this is not required based on recent geochemical analysis of tailings pore water and a seepage assessment.

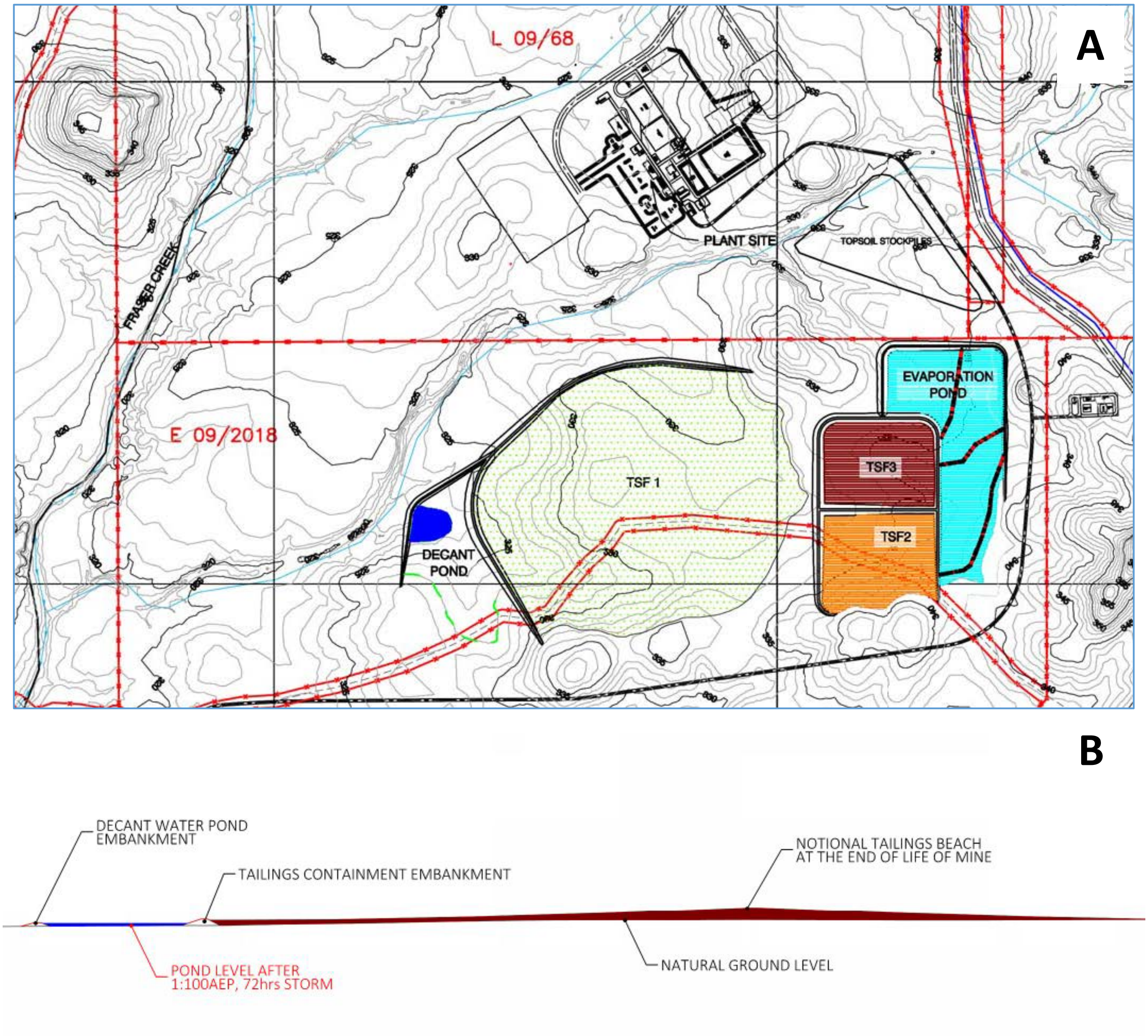


Figure 8-14 Aerial view (A) and cross-section (B) of the conceptual Tailings Storage Facility after 10 years (ATC Williams 2017b)

Specific design requirements for tailings dams are given by DMIRS (formerly DMP) and ANCOLD depending on the TSF type and category. In Western Australia, TSFs are classified as Category 1, 2 or 3 facilities based on their hazard rating and height of the TSF retaining structure and, in some circumstances, the location and depositional method (DMP 2015).

Determining the TSF category uses a risk based approach, which is primarily based on an assessment of the potential extent or severity of impacts due to embankment failure or uncontrolled release of tailings and/or water, should such events occur. This assessment is supplemented by consideration of embankment height (DMIRS) or the number of people likely to be impacted (ANCOLD).

The extent or severity of a tailings or water release is determined on a qualitative basis. However, ATC Williams (2017b; Appendix 6-3) has supplemented the assessment of impacts with a semi quantitative dam break assessment. The dam break assessments were based on an assumed volume of released material, estimated on the basis of embankment height, stored volume and amount of stored water on the TSF surface. Taking account of the maximum embankment heights and estimated release volumes, the estimated run out distances were approximately 7.2 km for TSF 1, 3.9 km for TSF 2 and 2.3 km for TSF 3. On this basis, the tailings would not reach the Lyons River (approximately 11 km away) but would reach Fraser Creek.

Based on the assessment of the potential impact of the release of tailings, water or seepage, and embankment structural failure, a hazard risk rating of 'Medium' was derived for TSF 1 and TSF 2, and a hazard risk rating of 'High' was derived for TSF 3 as a result of elevated radionuclide levels, metal concentrations and decant water salinity. Using DMP 2015 and ANCOLD 2012, specific design and operation requirements for various consequence categories are required, including stormwater retention, spillway capacity, seismic design, and facility operation and surveillance frequencies.

Based on the considerations of hazard rating and maximum embankment height, TSF 1 and TSF 2 are Category 2 facilities. TSF 3 is considered to be a Category 1 facility.

The specific design requirements resulting from the risk based categorisation of the TSFs are:

- Stormwater storage requirements include:
    - DMIRS – 1:100 Annual Exceedance Probability[3] (AEP), 72 hour runoff superimposed on normal operating pond plus 0.5 m total freeboard. A spillway is not necessarily required; although for cross valley embankments may be considered as an additional safety measure, provided they are located and constructed on natural ground.
    - ANCOLD – Design Storage Allowance of 1:10 AEP notional wet season run off plus extreme storage allowance of 1:100 AEP, 72 hour run off, plus 1:10 AEP wave run up plus 0.3 m contingency freeboard. Provision of an emergency spillway is considered good risk management practice. Operational spillways designed for a 1:1000 AEP flood plus 1:10 AEP wave run up.
- Seismic loading considerations (discussed in section 8.3.7) include:
    - DMIRS – ANCOLD guidelines are considered applicable; and
    - ANCOLD require:
        - Operating Basis Earthquake (OBE) 1:100 AEP

[3] AEP is defined as:

> The probability that a given rainfall total, accumulated over a given duration, will be exceeded in any one year.

- Maximum Design Earthquake (MDE) 1:1000 AEP
- Post Closure, Maximum Credible Earthquake (MCE)

The likelihood of containment failure is therefore very low since the consequences of such failure have been considered and ameliorated in the risk based design process thus minimising the risk of environmental exposure to as low as reasonably practicable (ALARP). In addition, the TSF design report addresses the above DMIRS and ANCOLD requirements, thus reducing the hazard rating to internationally acceptable levels. Based on the DMIRS and ANCOLD requirements, and geotechnical investigations of ground conditions, ATC Williams (2017b; Appendix 6-3) further refined the design concept for each TSF, taking into consideration the following:

- Construction materials and source.
- Water storage requirements and freeboard.
- Storm water storage events.
- Surface water management and drainage.
- Water balance.
- Embankment stability.
- Liquefaction assessment.
- Seepage assessment.

Two key construction materials are representative of waste rock materials (as characterised in Section 8.3.5):

- Near surface clayey sand deposits (i.e. saprolite material) will be used to construct the low permeability embankment zones and backfill to cut off trenches.
- Fresh granite waste rock from pit stripping operations will form the remainder of the structures: Downstream shoulder, crest and upstream erosion protection layers.

Specific details are provided in the TSF design report (ATC Williams 2017b; Appendix 6-3) and will be assessed as a component of the Mining Proposal, to be approved by the DMIRS.

8.4 POTENTIAL IMPACTS

Potential impacts include:

- Dispersion of saline, sodic and alkaline soils, which will reduce the soil quality and local provenance native species seedbanks.
- Potential contamination of surrounding soil and land as a result of:
    - dust (including dust with elevated radiation levels) from the Run-Of-Mine pad, processing plant (processing reagents, chemicals) and TSFs;
    - seepage of tailings water;
    - operational leaks and spills;
    - failure of TSF integrity;
    - seepage from sewage treatment plants; and

- o drainage and associated erosion of WRL surfaces.

8.5 ASSESSMENT OF IMPACTS

8.5.1 Dispersion of saline, sodic and alkaline soils

Plains soils have the potential to impact surrounding lands and soils (Landloch 2016a; Appendix 5-2). Hill soils are also erosive but do provide a suitable growth medium for rehabilitation of disturbed surfaces (Landloch 2016a; Appendix 5-2).

8.5.2 Contamination of surrounding soil and land

8.5.2.1 Dust

Dust generation from the 'wet' processing plant is unlikely. Should certain aspects of the process require maintenance or temporarily require repair, there is risk of the concentrate drying and generating dust.

TSF 2 and 3 will be maintained in a 'wet' state during operations. Containment embankments, elevated above the tailings, limit the potential for saltation across the surface. If saltation[4] does occur, it is anticipated that desiccation/shrinkage cracks on the tailings surface will trap particles and absorb their momentum (ATC Williams 2017b; Appendix 6-3). In addition, strong inter-particle forces, due to the extremely fine grain size and cohesive nature of the tailings, inhibit dust generation (ATC Williams 2017b; Appendix 6-3).

During decommissioning TSF 2 and 3 will be left to dry out and consolidate. During dewatering, TSF 3 will have the consistency of 'putty' (pers. comm. R. Haymont, 18 November 2017). To ensure dust is controlled from the small surface areas of TSF 2 and 3, Hastings will implement dust management measures (e.g. surface spraying or temporary cover measures) while allowing the tailings to consolidate. The TSFs will then be capped with benign waste rock and rehabilitated.

Dust generation from TSF 1 will be geochemically benign. Tailings will be deposited on the surface in a moist state and although some dust generation is likely, it will be geochemically benign.

Dust generation at the ROM pad has the potential to impact the surrounding lands and soils. Dust management measures, such as covers, surface sprays, sprinklers, will be used to prevent dust generation from the surface of the ore stockpiles.

8.5.2.2 Seepage

Elevated radionuclides occur in two of three tailings waste streams, however, the tailings pore water at all 3 TSFs do not contain elevated levels of radionuclides. A geotechnical assessment has been conducted over the return water pond, TSFs, and evaporation pond areas (ATC Williams 2017a; Appendix 5-9):

- Return water pond: Bore holes were placed at the toe of TSF1 and in the return water pond areas. The soils in this location consisted of surficial soils (i.e. clay, clay gravel and clayey sand) up to 1.15 m below ground level (BGL), then highly weathered granites up to 3.4 to 9.5 m BGL and then fresh granite until termination depth. Water was encountered in two of the bore holes in this area.

[4] Saltation is the leaping movement of sand or soil particles as they are transported in a fluid medium (e.g. wind) over an uneven surface.

- TSF1: Test pits and hand auger investigations found surficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.45 to 1.7 m BGL.
- TSF 2 and 3: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of 0.4 to 1.9 m BGL.
- Evaporation pond: Test pits and hand auger investigations found superficial soils occupied the subsurface layers, and granite layers were encountered at depths of approximately 0.4 m BGL.

No groundwater was encountered under TSFs or evaporation pond areas.

Falling head *in-situ* permeability tests between 0.0 m and 11.9 m indicated relatively low permeability in the superficial soils and weathered rock (1.44 x 10^{-6} m/s to 7.91 x 10^{-8} m/s). *In-situ* permeability of between 3.73 x 10^{-6} m/s and 6.38 x 10^{-9} m/s were obtained from down borehole packer tests, performed in moderately to freshly weathered granite bedrock underlying the site. Based on these results and hydrological characteristics of tailings from laboratory tests, a hydrogeological model was developed (Figure 8-15). Vertical seepage rates will be very slow and ATC Williams (2017b; Appendix 6-3) concluded that it is unlikely that a hydraulic connection and fully saturated conditions between the decant water pond and groundwater will be established.

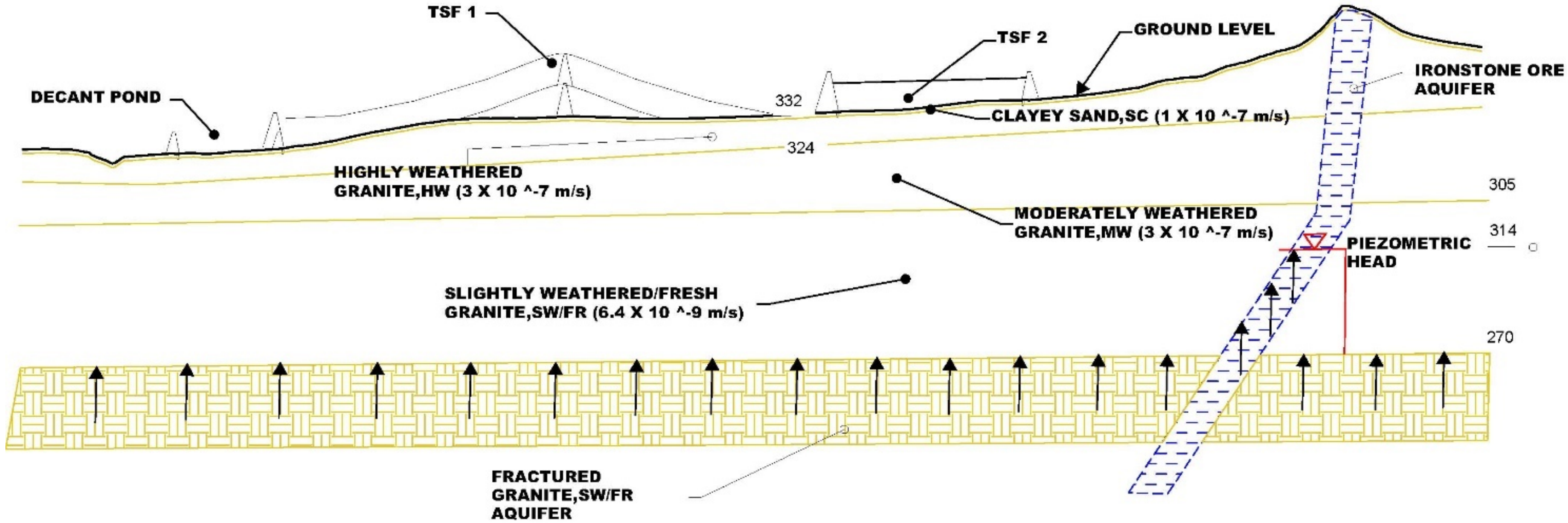
A transient analysis was undertaken by ATC Williams (2017b; Appendix 6-3) using SEEP/W software (GEO-SLOPE International 2017) to investigate the progress of a wetting front, over an 11-year period, through the unsaturated soil and rock profile beneath the TSFs. Specific details and parameters can be found in the TSF design report (ATC Williams 2017b; Appendix 6-3). The model shows that the likelihood of significant downward seepage of water contained in saturated, very low permeability tailings stored at the ground surface is considered to be very low.

However, at the return water pond, the modelling predicts that seepage rates will be very low through the base of the surficial soils for approximately the first six years of operations. Then the highly weathered rock mass beneath the pond begins to approach saturation, resulting in an increase in flux into this layer and development of a seepage plume. From year 8 onwards, the seepage plume reaches the slightly weathered rock at approximately 25 m depth. Due to the low permeability of this layer, the water plume begins to spread laterally in the overlying layers. At year 10, the extent of the wetting front is approximately coincident with the toe of the return water pond embankment (ATC Williams 2017b; Appendix 6-3) and thus remains within the disturbance footprint.

8.5.2.3 Operational leaks and spills

Potential operational leaks and spills will likely be minor although there may be a cumulative impact on surrounding lands and soils.

Surface water contamination may occur around the processing plant, evaporation pond or TSFs if not mitigated. This will in turn dilute contaminants and transport contaminants to downstream areas causing impact to the lands and soils.



ATC Williams 2017b

Figure 8-15 Hydrogeological model for seepage analysis

8.5.2.4 TSF integrity

The tailings storage facilities (TSFs) have been designed specifically to prevent the uncontrolled release of tailings and water (ATC Williams 2017b; Appendix 6-3). In addition, the facility location takes account of natural topographic containment, reduced exposure to flood levels and distance from sensitive environmental receptors. Contingency measures to cater for extreme floods and earthquakes have also been incorporated in the design.

A landform evolution assessment (Trajectory 2017; Appendix 6-1) considered the behaviour and performance of TSFs over the long-term. The study assessed TSFs over a 1000 year period under a range of climatic events. Given the stage of the proposal, Trajectory prescribed the design processes required to meet the objective of:

> *Generate, analyse and compare a range of credible alternative slope profile and treatment options such that the selection of landform profile shapes and treatments at individual locations across the Project landforms are technically justified as creating stable landforms (from an erosion perspective) over a 1000-year design period.*

In doing so, Trajectory not only considered erosion but was also cognisant of the following relevant factors:

- Slope profile: Consideration of three options, to determine durability and resilience over 500 and 1000 years, namely:
    1. Single concave slope,
    2. traditional 20 degree slope with 5m berms, or
    3. wide berms on concave slope,
- Slope hydrology.
- Surface characteristics.
- Biological factors.

As a result of this multi-faceted approach, Trajectory (2017; Appendix 6-1) demonstrated design factors that would compromise the TSF integrity over the long term and was also able to prescribe design criteria that demonstrated (over a 1000 year period) the TSF integrity could be maintained over the long term.

For example, when considering the slope profile of a traditional 20 degree slope with 5 m berms, Trajectory (2017; Appendix 6-1) demonstrated that the landform integrity would be compromised as shown in Figure 8-16. Erosion rates over a period of 1000 years were severe with an average overall loss of profile of nearly 3 m and gully depths of approximately 2 m. The narrow berms acted as energy stores, concentrating and then discharging volumes of flow. The water flow then escalated downslope resulting in local areas of failure, accumulation of batter catchment flows and more severe erosion.

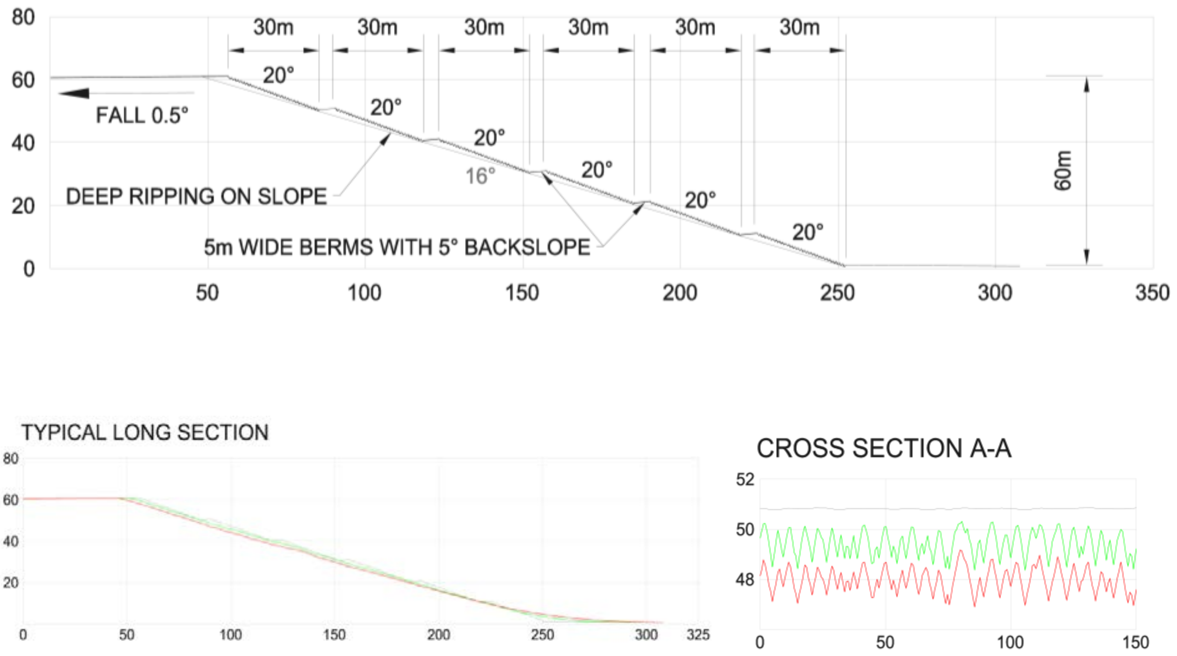


Figure 8-16 Cross section and performance of "Guideline" profile- 500 years (green) and 1000 years (red)

In contrast, the wide berms on a concave slope performed best. Trajectory (2017) stated "*Overall slope lengths are constrained between benches with enough capacity to permanently interrupt flow* (Figure 8-17). *Although the fact that this design is superior has long been acknowledged, it has the effect of significantly extending overall slope length and landform footprint and hence reduces the total overall volume stored per unit of area.*"

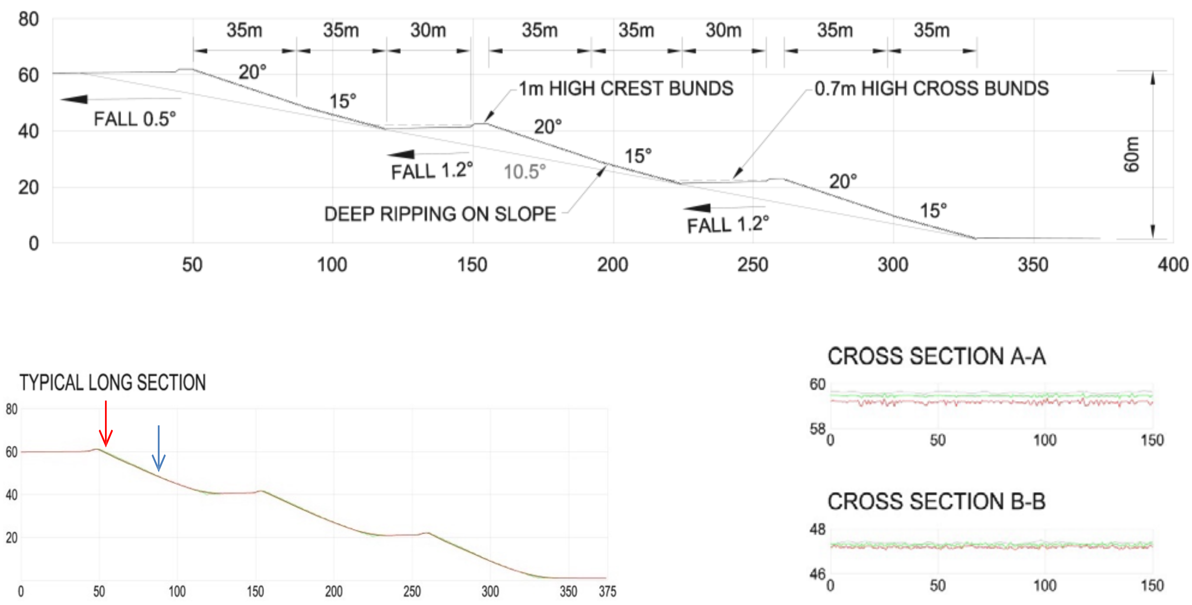


Figure 8-17 Wide berms and concave slopes profile- 500 years (green) and 1000 years (red)

Once an ideal slope profile was determined, Trajectory then used the DRAINS model (Watercom Pty Ltd 2017) to determine the maximum slope height. The design criteria required landform berms to contain the critical duration 2000-year average recurrence interval (ARI) rainfall event with a minimum 300 mm freeboard and the ability to contain the critical duration probable maximum precipitation (PMP) ARI without overtopping. Average rainfall intensity for design were sourced for the 2000-year and PMP ARI 24 hour, 48 hour and 72 hour rainfall events. Based on the modelling, a preliminary maximum slope height of 30 m was recommended.

Taking account of each of the relevant factors, Trajectory (2017) prescribed a set of design specifications and performance measures (Table 8-8), using information from waste characterisation studies conducted to-date, erosion modelling and long term monitoring studies of revegetation establishment in mining.

Table 8-8 Landform design specifications and performance measures (Trajectory 2017)

Specification	Performance Measure
Maximum 40m lift height (provides conservatism against model)	A). Erosion features average <0.5m depth B). Erosion < 5 tonnes/ha/year after 3-year establishment period
Average slope angle 17.5 degrees	A and B above and post construction angle QA/QC survey
20 degrees in upper 50% of Slope and 15 degrees in lower 50% of slope	A and B and post construction angle QA/QC survey
Hydrology measures to PMP estimate to limit run-on from top surface or berms to batters below. Nominal 1m crest bund.	C) Top and bench tolerances <.5m variability. Post construction angle QA/QC survey Zero run-on from up gradient surfaces demonstrated via foot traverse inspection after three years
Cell bunding of .7m and perimeter bunding of 1m. Infiltration + Evapotranspiration > 100% of incident rainfall on flat surfaces	C and Permeameter testing demonstrates infiltration in as constructed and 3 years post revegetation
Berms for 20m high batters (Bald Hill) are 20m wide after reprofiling	Post construction angle and berm width QA/QC survey
0.5m high bunds at 10m offset from final toe position. Cross bunds installed where natural ground at gradient greater than 2 degrees	Post construction QA/QC survey
Rip lines *on contour* and minimum 0.5m deep and 1m wide at base of windrow	Post construction QA/QC survey
40% of exposed surface comprised of durable fraction equal to or greater than gravel	Post re-profiling stability mapping QA/QC survey
Armouring subsoils spread at 150 – 200mm over re-profiled waste rock. 20% of final exposed surface after 3-year stabilisation period will be gravels/cobbles form the soil	Post re-profiling stability mapping QA/QC survey
Minimum 2m of in situ or imported durable armouring granite waste rock after final re-profiling	Post Construction validation survey
Provenance seed mix of grasses, shrubs and woody plants	25% plant cover after three-year establishment period
Provenance seed mix of grasses, shrubs and woody plants	50% of pre-mining diversity after three-year establishment period

Specification	Performance Measure
Include introduction of biological matter and soil inoculants in revegetation process	Presence/absence of cryptograms in survey after three-year establishment period
Provenance seed mix of grasses, shrubs and woody plants	5% surface cover by humus layer after three-year establishment period

Deviation from the Trajectory (2017) prescribed design specifications for closure and ATC Williams (2017) design criteria may result in the integrity of the landforms being compromised over the long term. During the operational phase of the proposal, signs of any failure of landform integrity would be addressed and rectified quickly due to the presence of people and equipment on-site. During the closure phase, rehabilitation monitoring would also detect signs of failure of landform integrity, although the time taken to address the issue would not be as prompt as that of the operations phase. In perpetuity, signs of failure of landform integrity would be monitored by those using the land, i.e. pastoralist. If those signs went undetected and the landform integrity failed, the failure would be expected to be minor i.e. break in the HDPE liner as well as a break in the clay liner, and erosion of the TSF wall. The impacts would be expected to be localised due to the location of the landforms i.e. located at high elevation in the water catchment. If the design specifications of Trajectory (2017; Appendix 6-1) are implemented, it is unlikely this scenario will occur within 1000 years post-closure.

Seepage from sewage treatment plants

Significant discharge or leakage of contaminated water from the waste water treatment plant is unlikely. The construction and operations of prescribed facilities has strict regulatory controls under part V of the *Environmental Protection Act 1987* (administered by the Department of Water and Environment Regulation (DWER)). This also applies to other prescribed facilities such as the landfill.

Drainage and associated erosion of waste rock landform surfaces

Surface and subsurface waste rock characterisation identified materials that were highly erosive. The fresh waste rock and transitional rock components of the pits' lithology have a higher proportion of gravels, cobbles and larger clasts, and will therefore provide more suitable armouring and growth media layers. If waste rock material is not characterised during mining and if the subsurface soils are used on the WRL surfaces then the integrity of the surface structure will be compromised and likely to erode.

8.5.3 Contaminated sites assessment

Contaminated sites are administered by the Department of Water and Environmental Regulation under the *Contaminated Sites Act 2003* (WA; CS Act) and associated regulations. The CS Act defines a contaminated site as follows:

> 'Site' is defined as an area of land and includes underground water under that land and surface water over that land.
>
> 'Contaminated' in relation to land, water or a site is defined as having a substance present in or on that land, water or site at above background concentrations that presents or has potential to present, a risk of harm to human health, the environment or any environmental value.

A number of mining related activities have been identified as potentially contaminating activities: Mining and extractive industries, sewage treatment plant, storage facilities – chemical, hydrocarbon storage, explosives storage (Department of Environment 2004), many of which are prescribed activities under Part V of the *Environmental Protection Act 1986* (WA; and thus have another level of regulatory Approval requirements administered by DWER). Most of these activities are common to all mining operations in Western Australia. All of these potentially contaminating activities will occur as components of the Proposal. At closure, each site will be decommissioned and removed, and the footprint on which they were located will be rehabilitated. However, tailings storage facilities will remain in perpetuity as a component of the landscape.

Specifically, TSF 2 and 3 will contain elevated radionuclides at above background concentrations and thus represent a potential contamination source. However, in order to present a risk of harm, and according to the Guidelines (DWER 2017), a site must have a credible pathway of exposure and the presence of a receptor that is, or is likely to, experience harm from the presence of the contaminating substance(s).

Receptors that are present in the proposal development envelope include:

- Groundwater dependent ecosystems (GDEs or potential GDEs) associated with the Lyons River.
- Pastoral bores.
- The Gifford Creek Priority Ecological Community.

However, there is not a credible pathway of exposure present for the following reasons:

- Radionuclides in TSF 1, 2 or 3 tailings are not water soluble.
- TSF 3 design will encapsulate tailings using a double liner system.
- During operations, the TSFs will be maintained as ‘wet’ facilities and thus there will be no exposure from radioactive dust.
- Cover systems and rehabilitation ensure there will be no exposure from radon or gamma radiation at closure (JRHC 2017; Appendix 6-2).
- TSF integrity will be maintained for at least 1000 years (Trajectory 2017; Appendix 6-1).

The TSFs will not be a contaminated site under the CS Act as long as there is no credible pathway of exposure.

8.6 MITIGATION HIERARCHY

Hastings commits to the following controls for the mitigation of potential impacts:

Best Practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- Design, construction and operation of TSFs in accordance with policy and guidelines (listed in section 8.2).

Avoidance

Hastings has avoided potential impacts by:

- On-going characterisation and management of waste rock to ensure erosive materials are not used on surface slopes of waste rock landforms.
- Avoid using Plains topsoils as a growth medium for rehabilitation of disturbed areas.
- Location of processing plant, evaporation pond and TSFs outside of the flood plain.

Minimisation

Hastings will minimise potential impacts as follows:

- Minimise dust generation during operations using water sprays, where possible.
- Store concentrate in enclosed facilities during maintenance and repairs to the processing plant.
- Minimise potential for spills through personnel training and awareness.

Management

The following management plans and associated documentation will be implemented to mitigate potential risks of impact to the terrestrial environmental quality.

Contractor management

OBJECTIVE(S)

Ensure contractors and subcontractors conform to Hastings Environmental policy, legal requirements, and other environmental requirements and commitments.

MANAGEMENT ACTIONS

The following management actions will be implemented:

- Environmental compliance requirements will be incorporated in contractual documentation.
- An Environmental Specification for Contractors (to be developed) will include:
    - a requirement for site-specific and activity-specific EMP;
    - roles and responsibilities;
    - provision of Hastings relevant management plans, procedures, licence conditions;
    - provision of Hastings environmental policy;
    - ensuring each contractor has adequate resourcing for environmental management of their activities relative to the level of risk;
    - requirement for activity-based and task-specific environmental risk assessment; and
    - environmental performance reporting requirements.
- Site-wide coordination of waste segregation, recycling and management.
- Training and awareness.

MONITORING

Hastings will conduct regular audits and inspections to ensure contractor conformance with Hastings requirements.

CONTINGENCY

Where on-going non-conformances are identified and a lack of cooperation is evident, the relevant issue will be escalated to Hastings senior management team to resolve.

Radiation Waste Management Plan (Appendix 5-7)

OBJECTIVE(S)

Ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations.

MANAGEMENT ACTIONS

The management of radioactive waste applies to the management of TSFs. Key considerations follow a risk based approach and include:

Detailed engineering phase

- Design of the TSFs will conform to relevant international standards.
- Key design features when considering elevated radionuclides include:
  - embankment stability taking account of site stability;
  - freeboard to accommodate severe weather events;
  - landform evolution modelling, specifications for long-term performance;
  - encapsulation and liners; and
  - leak detection.

Construction phase

- Preparation of a *TSF construction management plan* with quality assurance procedures will be developed and implemented to ensure that the TSF construction meets design specifications and tolerances.

Operations phase

- Preparation of a *TSF operating manual* with all pertinent information with respect to operation, rehabilitation and closure of the TSFs including:
  - deposition methodology;
  - water management;
  - seepage control (including drain details and requirements)
  - pipeline management;
  - all measures that should be followed during the operating phase to reduce the amount of work required at decommissioning;
  - planned measures to reduce impact(s) to the surrounding environment; and
  - planned measures for progressive rehabilitation during operations.

MONITORING

Construction phase

Monitoring of the construction process will occur to ensure the TSFs are built in accordance with design specifications. A competent person will be engaged to certify that the construction of the respective TSF meets design specifications and tolerances.

Operations phase

An *Environmental Radiation Monitoring Work Instruction*, a component of the Hastings EMS, will be developed to provide specific protocols for environmental radiation monitoring from the following sources:

- Direct gamma radiation: A survey of the perimeter of the Development Envelope to measure gamma radiation levels will be conducted on an annual basis.
- Radon decay products: Track etch monitors will rotate between off-site locations.
- Seepage into groundwater: A network of 5 monitoring bores will surround the TSFs (as per ATC Williams 2017) and downstream pastoral bores will be sampled and analysed for heavy metals including radionuclides, on a quarterly basis.
- Contamination of surface water run-off: Surface water sampling will be conducted opportunistically following significant rainfall events or on a quarterly basis.
- Contamination of potable water supply: Sampling and radiometric analysis will be conducted as detailed in the Drinking Water Quality Management Plan (to be developed and as required by the Department of Health).
- Dust containing long-lived alpha-emitting radionuclides: Dust deposition gauges and high volume samplers will collect dust samples at pre-determined locations for composite analysis on an annual basis and rotate between approved off-site locations, respectively.

Monitoring of controls for containment of radioactive waste will include:

- Weekly visual inspection of surface water management structures including bunds, drainage channels, tailings and water pipelines, and evaporation ponds.
- Weekly inspection of the walls of TSF 2 and 3 for erosion or other signs of potential compromise to the integrity of their structure, including signs of seepage of tailings or water from tailings into the environment immediately surrounding the TSFs.
- Inspections of management controls following major rainfall or extreme weather events.
- Annual inspection/audit by closure specialist to identify potential hazards, risks and opportunities for continual improvement, including aspects that require further investigation or research.
- Internal audits (in accordance with the Audits and Inspections Standard Operating Procedure) of the implementation of this RWMP.

Trigger values are based on authorised limits and/or baseline values of *NORM Guideline 6 Reporting Requirements* (DMP 2010). Exceedances of a trigger value will be considered an incident unless significant seasonal environmental variation of background levels are expected. In such instances, a trend of exceedances in trigger values will then be treated as an incident.

Contingency

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. Contingency plans will form a component of the *Emergency Response Plan* (ERP). Where containment of radioactive waste fails, the ERP will include:

- Human health and safety first: response to exposure, evacuation, decontamination of the persons exposed to radiation.
- Stabilisation of the containment and prevention of impact to surrounding environmental receptors.
- Consideration of secondary containment and drainage.
- Clean-up procedures.
- Training of personnel on the Emergency Response Team to address radioactive waste containment failures.
- Identification of radiation specialists and TSF experts to review contingency plans.
- Suspension of operations (also considered in the Care and Maintenance section of the MCP).

Land Management Plan (to be developed)

OBJECTIVE(S)

To maintain the quantity of water so that existing and potential environmental values, including ecosystem maintenance, are protected.

To maintain the quality of water so that environment values or the health, welfare and amenity of people and land uses are protected, by meeting statutory requirements and acceptable standards.

To ensure that emissions do not adversely affect environment values or the health, welfare and amenity of people and land uses, by meeting statutory requirements and acceptable standards.

To ensure that changes to the biophysical environment do not adversely affect historical and cultural associations and comply with relevant heritage legislation.

To ensure that rehabilitation achieves an acceptable standard compatible with the intended land use, and consistent with appropriate criteria.

MANAGEMENT ACTIONS

The following management actions will be implemented for each key aspect within the Land Management Plan:

<u>Water management</u>

- Surface water management structures will be designed and constructed to minimise erosion.
- Diversion drains will be constructed to ensure water re-enters natural drainage lines at a velocity and depth that can be accommodated by the natural flow rate without increased scouring.
- Containment bunding, silt and oil traps will be established where necessary to remove sediments or pollutants from runoff before water enters local drainage.
- Road design will ensure surface water drainage patterns are maintained through the use of culverts at a size and density along the road to accommodate natural water flow rates.
- Measures to reduce water usage or re-use water will be implemented, where possible.
- Shallow relief drains will also be constructed to direct water off the roads (during heavy rainfall events) and away from spoon drains on either side of the road.
- WRL and TSFs will be designed to accommodate long-term weather events, as per specifications and performance measures recommended in Trajectory (2017; Appendix 6-1).
- Surface drainage around crushing and processing activities will be captured to ensure overflows, spillages or leaks are contained.
- Surface water will be managed in the vicinity of the landfill to minimise runoff entering the landfill.
- Reference to management and monitoring actions in the following related documentation: Water Management Plan, Water Operating Strategy (as required by the Department of Water and

Environmental Regulation for a 5C water abstraction licence), Drinking Water Quality Management Plan (as required by the Department of Health).

Waste management

- Application of waste management hierarchy (i.e. avoidance of unnecessary resource consumption, resource recovery: reuse and recycle, and disposal)
- Spill clean-up procedures, training and resources.
- Waste management for general domestic and office waste, industrial waste, landfill, hydrocarbons, tyres, and sewage (as per requirements of prescribed premises works approvals and operating licenses administered by the Department of Water and Environmental Regulation).

Chemical storage

- All hazardous substances stored on site shall be documented in the *Hazardous Substances Register*.
- *Material Safety Data Sheets* (MSDS) shall be available at all times where hazardous substances are stored.
- A *Hydrocarbon and Hazardous Substance Management Work Instruction* will be developed to provide instructions for transport and storage of hydrocarbons and hazardous substances, spill management and incident reporting.
- An explosives magazine will be constructed and operated in accordance with the *Dangerous Goods Safety Act 2004* (WA) and the Dangerous Goods Safety (Explosives) Regulations 2007.

Emissions

Generation of, and exposure to, dust will be controlled through standard dust management procedures including:

- All mining vehicles would be fitted with air conditioners and air filters.
- Ensuring wet processes are used and where this is not possible, ensuring that adequate watering occurs to significantly reduce dust generation on roads and in the processing plant.
- Covering and/or misting on conveyor belts, where used.
- Spillage management and control.
- Watering of roads and ore stockpiles.
- Maintaining 'wet' tailings in TSF 2 and 3.
- Progressive covering of drying tailings during decommissioning, where possible.

Social aspects

Potential risks to stock and pastoral activities, and cultural heritage, arising from the project's implementation will be managed through the following measures:

- Hastings will liaise with pastoralists of Gifford Creek and Wanna stations throughout the life of the project.
- The Site Induction will instruct all personnel of pastoral lease activities and cultural heritage values in the vicinity of the proposal.
- The landfill will be regularly covered to prevent stock entering and litter escaping.
- Water levels and water quality parameters will be measured regularly in regional pastoral bores and ephemeral ponds (i.e. Fraser Creek pond and Lyons River pond) to ensure no impact to land use activities occur as a result of the implementation of the proposal.
- Implementation of the Cultural Heritage Management Plan (draft).

MONITORING

Monitoring considerations to be included in the Land Management Plan are:

- Groundwater and surface water monitoring will be undertaken in accordance with *the Groundwater Operating Strategy, Water Management Plan* and *Drinking Water Quality Management Plan*.
- Inspections of all landforms and infrastructure will occur immediately after heavy rainfall for evidence of erosion. Visual monitoring will be undertaken of diversion channels and downstream drainage lines, and the condition of vegetation in the diversion channels.
- Regular maintenance inspections of all water infrastructure will be undertaken to identify potential leaks.
- Visual monitoring of dust generation.
- Audits and inspections to ensure implementation of management measures in accordance with relevant laws, licence conditions, commitments and Hastings Environmental policy and management actions as per the Land Management Plan.

CONTINGENCY

Contingency measures for water quality monitoring are described in the respective management plans.

Should substantial erosion occur, the cause of the erosion will be identified, erosion/deposition areas rehabilitated as appropriate, and measures implemented to prevent further erosion.

Contingency measures (e.g. additional water application, vehicle speed limits) will be implemented immediately upon observation of excessive dust generation. Where contingency measures have no effect, the activity generating the dust will be stopped until a solution is found.

Waste Rock Management Plan (WRMP; Appendix 5-11)

OBJECTIVES

The WRMP identifies the legal provisions that Hastings proposes to implement to meet the EPA objective for terrestrial environmental quality:

To maintain the quality of land and soils so that environmental values are protected.

Specific objectives of the WRMP are to ensure the effective characterisation, placement and configuration of waste rock, which meet closure objectives of being:

Safe: The waste rock landforms will, on average, have radionuclide levels below the proposed threshold of <1Bq/g. Landforms are geotechnically stable and safe to access on foot.

Stable: The waste rock landforms will have a durable, mixed fraction of waste rock exposed on the final surfaces such that erosion is minimised and the landforms are stable over the long-term.

Non-polluting: The waste rock landforms will not discharge unacceptable Acid and Metalliferous Drainage (AMD), neutral metalliferous or saline drainage to surface or groundwater.

Ecologically sustainable: The landforms, to the extent that the stabilising substrate allows, will be revegetated with local provenance species and ecological communities, which generally reflect the surrounding landscape.

MANAGEMENT ACTIONS

The following management actions will be implemented for each key aspect:

<u>Dilution of waste rock with elevated radionuclide levels</u>

- *Mining Schedule* to take into account waste rock movement and placement from source locations adjacent to ore body (i.e. waste rock most likely to have elevated levels of radionuclides).
- Areas of the WRLs with elevated radionuclide levels that exceed thresholds of 1Bq/g will be covered with benign rock materials.

<u>Segregation and management of waste rock lithologies</u>

- *Mining Schedule* to take into account waste rock movement and placement i.e. walls and surfaces of WRL to be comprised of fresh granite.
- WRL to be constructed in accordance with the respective WRL design specifications as detailed in the *WRL Design Report*.

<u>Management of soils</u>

- Plains soils will not be harvested in accordance with the *Land Clearing and Topsoil Stockpiling Work Instruction*.
- Topsoil delineation, harvesting and storage to be conducted in accordance with the *Land Clearing and Topsoil Stockpiling Work Instruction* includes instructions for:
    - mapping of soil types;
    - delineation of Plains versus Hills soils prior to clearing activities;
    - collection and disposal of Plains soils; and

- collection and storage of Hill soils.

MONITORING

The following monitoring activities detailed in the WRMP include:

- Re-profiled waste rock landform will be monitored for exceedances in radionuclide thresholds.
- Audit of construction of each WRL against the respective WRL design specifications.
- Annual audit of mining schedule to ensure segregation of waste types and placement of competent waste to ensure landform stability and prevention of surface erosion.
- Routine inspections of waste rock landforms to ensure that slope angle, berm width and cover material are according to design.
- Inspections of WRL surfaces following heavy rainfall events to establish competent materials are performing as determined by the geotechnical assessment.
- Audit of implementation of *Land Clearing and Topsoil Stockpiling Work Instruction*.

CONTINGENCY

Where the management target/s is not met or exceeded, Hastings will review and revise the risk assessment, review and revise management actions and identify additional management actions where necessary.

Hastings will implement adaptive management to learn from the implementation of mitigation measures, monitoring and evaluation against management target/s, to more effectively meet the environmental objective. The following approach will be followed:

- Monitoring data will be evaluated and compared to baseline and reference site data on an annual basis (or more frequently in some instances) in a process of adaptive management to verify whether or not responses to the impact are the same or similar to predictions.
- Address evaluation of assumptions and uncertainties listed.
- Annual review of the risk assessment and revision of risk-based priorities on the basis of monitoring program information, incidences, verification of modelling outcomes and new information.
- Increased understanding of the ecological regime, best practice, new technologies.
- Revision through consideration of incidents and associated investigations, or when management actions are not as effective as predicted or as result of change management (e.g. construction versus operations phases).
- External changes during the life of the proposal (e.g. changes to the sensitivity of the key environmental factor, implementation of other activities in the area, etc.).
- Annual review of the WRMP as a component of the continual improvement process within the mining management system.

Rehabilitation

The closure objectives relevant to terrestrial environmental quality are:

Construct safe, stable, non-polluting post mining landforms which support vegetation growth and are erosion resistant.

TSF1 will have a fit for purpose cover, which will encourage evapotranspiration.

TSF2 and TSF3 will have a fit for purpose liner and cover systems, which will limit infiltration and seepage.

Land contamination will be remediated as part of the decommissioning process.

Control radiation levels at the surface of rehabilitated landforms, consistent with background levels.

The completion criteria relevant to terrestrial environmental quality are:

Landforms are placed outside the pit void zone of instability.

Surface water management and drainage is incorporated into the landform design.

Final surfaces do not significantly erode following heavy rainfall events.

Characterisation of waste and rehabilitation materials to determine appropriate placement / segregation in the final landform.

TSF cover measures meet design criteria.

Drain-down of TSF 1 does not result in impacts to Groundwater Dependent Ecosystems (GDEs).

No alteration of groundwater system beyond the immediate vicinity of TSF2 and TSF3.

Soil remediation, to agreed levels, shall occur where contamination is assessed and reported.

Landforms do not emit radiation at surface exceeding background levels determined through baseline monitoring.

A Preliminary Mine Closure Plan (Appendix 6) and Radiation Waste Management Plan (Appendix 5-7) include closure strategies and 'next steps' identified (where possible), specific to terrestrial environmental quality:

Collection of baseline data

- Baseline studies and investigations:
  - verification of waste characterisation assessments during operations phase;
  - verification of landform stability parameters post construction.
- Closure research, investigations and trials:
  - progressive rehabilitation (as per Trajectory 2017 recommendations).
- On-going monitoring during operations
  - verification that landforms were/are constructed in accordance with design specifications; and
  - water availability, recycling and storage as per water balance.

Materials handling and utilisation

- Harvesting and stockpiling of Hills soils for use during rehabilitation:
  - implementation of topsoil harvest and stockpiling procedure;

    - preparation of communication materials of procedure during construction phases (e.g. induction, contractor specification documentation); and
    - environmental personnel presence during clearing activities.
- Temporary stockpiling of competent benign waste rock for use during rehabilitation:
    - determine how much and where the waste rock is sourced; and
    - incorporate requirements into pre-strip/mining schedule.

Design and construction of landforms

- TSF covers and / or encapsulation specific to each of the facilities:
    - TSF design reports to incorporate closure considerations (Figure 8-18); and
    - detailed design to incorporate closure considerations.
- Landforms are constructed as per design specifications:
    - waste rock landform design reports to incorporate closure considerations; and
    - detailed design to incorporate closure considerations

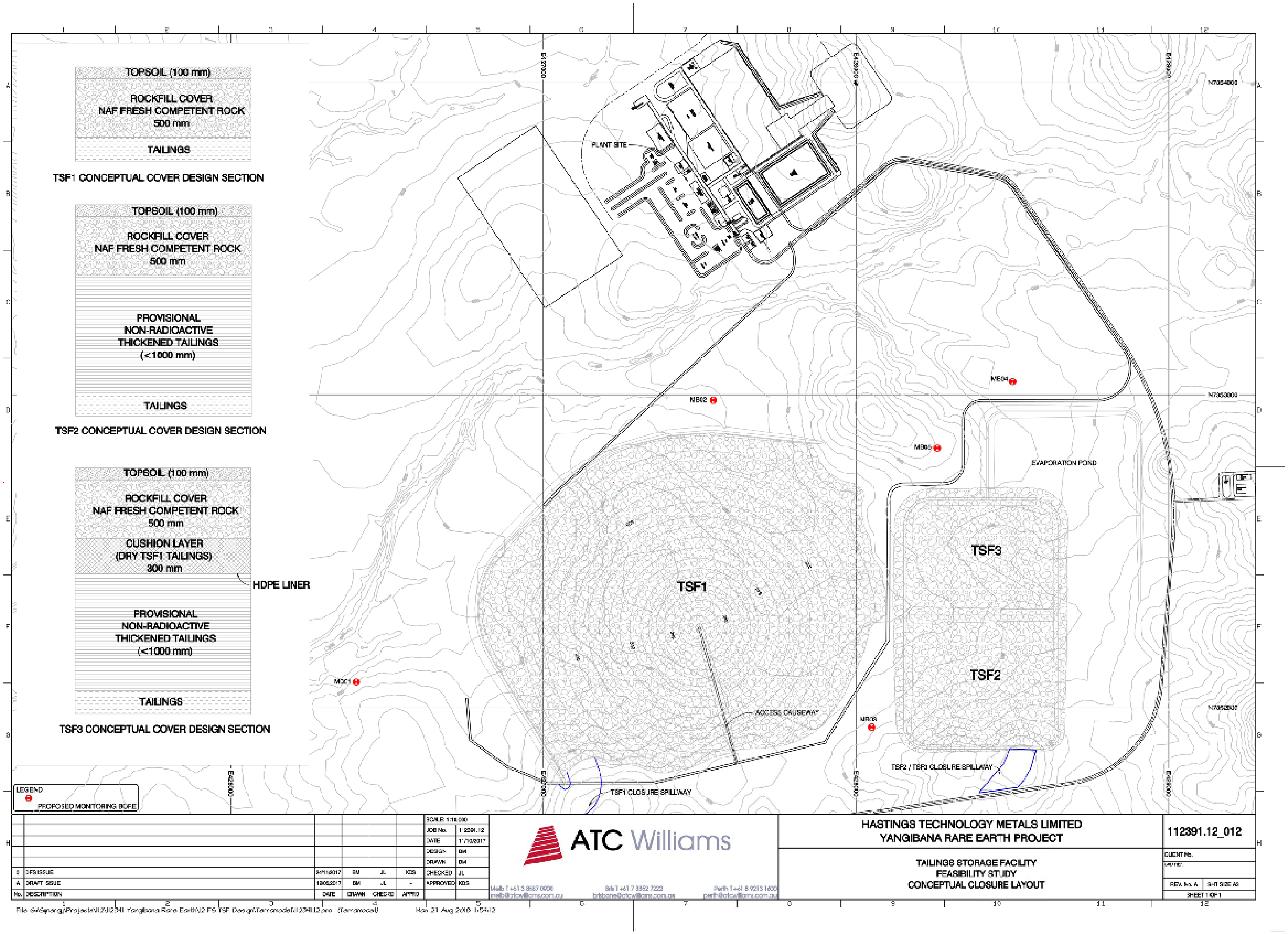


Figure 8-18 Conceptual layout of the Tailing Storage Facilities at closure

Identification and management of site contamination:

- Areas of site (e.g. TSFs, hydrocarbon storage areas, workshops, chemical storage areas, process plant) with the potential for contamination will be assessed by an accredited contaminated site auditor at closure, in accordance with DWER requirements under the *Contaminated Sites Act 2003* (WA) and associated regulations.
- Develop and implement *Land Management Plan* and associated procedures for management of hydrocarbons, chemical use and storage, and spill response procedures, identification of areas at risk of contamination.
- Implement *Radiation Waste Management Plan.*
- Develop and implement *TSF operating manual.*

Decommissioning and removal of infrastructure:

- Progressive removal of support infrastructure where possible.
- Potentially radioactive materials and/or equipment will be surveyed, and disposed of as per DMIRS and Radiological Council requirements.
- Placement of soils and shallow ripping.
- Dispersal of seed mixes containing local provenance species:
    - development and implementation of seed collection work instruction;
    - develop and implement seed storage and data management work instruction; and
    - *Rehabilitation Management Plan* to consider methods for breaking seed dormancy, site preparation, seasonal considerations, measures to maximise seed germination and establishment success, and a monitoring regime.

Rehabilitation of landforms:

- Rehabilitation of TSFs will meet requirements specific to each facility, particularly relating to placement of covers and / or encapsulation layers, prior to cover with growth medium:
    - progressive rehabilitation as per Trajectory (2017); and
    - development and implementation of *Rehabilitation Management Plan.*
- WRLs will be reshaped prior to cover with growth medium:
    - closure considerations to be incorporated during construction and operations phase to reduce closure cost liability.
- Construction of pit abandonment bunds and surface water diversion bunds.
- Dispersal of seed mixes containing local provenance species:
    - consideration and assessment of analogue sites; and
    - development and implementation of seed collection procedure.

Post closure monitoring and maintenance:

- Monitoring of rehabilitation performance.
- Maintenance of rehabilitation works.

8.7 PREDICTED OUTCOME

8.7.1 Residual impacts

The mining operations, process plant and TSFs occur at the higher elevation locations in the local water catchment. In addition, much of the disturbance footprint occurs over the benign Hill's soils.

There are evident risks where infrastructure intersects Plains soils, the presence of waste rock lithologies that are not competent for landform surfaces, and where radionuclides become elevated and concentrated in the tailings materials, particularly TSF 3. The implementation of the mitigation hierarchy and management plans, described in Section 8.6, ensures risks will be as low as reasonably possible and the surrounding environment will not be significantly impacted.

Due to the storage and containment of tailings with elevated radionuclides above background levels, TSF 2 and 3 are considered potentially contaminating activities. In addition, sensitive environmental receptors occur within the Development Envelope. However, any credible pathway of exposure has been eliminated via the TSF design. Construction and operation in accordance with the design criteria and mitigation measures ensures that the TSFs are not contaminated sites as defined under the *Contaminated Sites Act 2003* (WA) and associated regulations (2007).

8.7.2 EPA objective

Potential impacts will be mitigated as described in section 8.6 so that the Proposal meets the EPA objective:

To maintain the quality of land and soils so that environmental values are protected.

HUMAN HEALTH

Chapter 9

9 KEY ENVIRONMENTAL FACTOR: HUMAN HEALTH

9.1 OBJECTIVE

Hastings is committed to ensuring that workers and the public are protected from the harmful effects of radiation. In doing so, Hastings has undertaken an assessment of the potential radiological impacts; and will be implementing control and management measures to ensure that potential exposures remain low and well controlled.

The overall approach of Hastings is consistent with the EPA objective, which is:

To protect human health from significant harm.

9.2 POLICY AND GUIDANCE

Approach

Hastings aim to ensure that its approach to radiation protection is consistent with international best practice, taking into account the national and state regulatory requirements.

The overall basis for radiation protection is based on the philosophies provided by the International Commission on Radiological Protection (ICRP). In Publication 26 (ICRP 1977), the ICRP first recommended the 'system of dose limitation', which is made up of three key elements as follows:

- Justification – this means that a practice involving exposure should only be adopted if the benefits of the practice outweigh the risks associated with the exposure.
- Optimisation – this means that the doses and potential costs should be balanced so that doses are As Low As Reasonably Achievable (ALARA), taking into account economic and social factors. This is also known as the ALARA principle.
- Limitation – this means that individuals should not receive doses greater than the prescribed dose limits.

Within the 'system of dose limitation', the ALARA principle is generally regarded as the most important and the most effective of these elements for the control and management of radiation.

While the ALARA principle is the foundation for radiation protection, prescribed dose limits have been established to provide an absolute level of protection. The limits apply only to the dose received as a result of a 'practice', and excludes natural background emissions levels. The limits are:

- 20 mSv/y for a worker (averaged over 5 years, with a maximum of 50mSv/y in any one year).
- 1 mSv/y for a member of the public (averaged over 5 years).

Regulation and Guidance

The primary laws for radiation protection in Western Australia are:

Mines Safety and Inspection Act 1994 (WA)

Occupational Safety and Health Act 1984 (WA)

Radiation Safety Act 1975 (WA)

The primary radiation protection related guideline documents are:

Western Australian Department of Mining and Petroleum guidelines on managing naturally occurring radioactive material (NORM) in mining and mineral processing - guideline (2nd edition) (also known as the NORM Guidelines) (DMP 2010)

National Code of Practice & Safety Guide: Radiation protection and radioactive waste management in mining and mineral processing; known as "the Mining Code" (ARPANSA 2005)

National Safety guide: Management of naturally occurring radioactive material (ARPANSA 2008)

National Fundamentals: Protection against ionising radiation (ARPANSA 2014a)

National Code of Practice: Safe transport of radioactive material (ARPANSA 2014b)

Western Australian EPA Environmental Factor Guideline: Human health (EPA 2016f)

9.3 RECEIVING ENVIRONMENT

The radiological characteristics of the receiving environment have been determined through a program of baseline monitoring and have been summarised in this section. The following key studies have been undertaken:

- Baseline Radiation Report (RadPro 2016a; Appendix 5-4)
- Radiation Waste Characterisation Report (RadPro 2016b; Appendix 5-5)
- Radiation Impact Assessment (JRHC Enterprises 2016; Appendix 5-6)
- Air Quality Assessment and Memo (Pacific Environment 2016a and b; Appendix 7-1 and 7-2)

9.3.1 Baseline radiological assessment

The baseline monitoring occurred at a number of locations across the proposed operations area and various parameters were sampled. As the project progresses, it is planned to make some of these locations permanent environmental radiation monitoring locations for continued monitoring into operations.

The assessment of radionuclides within the Proposal area required the measurement of alpha, beta, and gamma radiations. In addition to assessing the Proposal area in its entirety, areas of elevated activity and their extent and activities were identified. No single instrument is capable of measuring all of the parameters required for assessing radiation with different half-lives and decay modes. In the following sections, reference is made to the instrument and measurement method used to detect the type of radiation of interest.

Note that a summary of the results is provided in this section. For more detail refer to the appendices listed above. The radiological parameters summarised include:

- Gamma radiation.
- Radionuclides in dust.
- Radon and thoron concentrations.
- Radionuclides in soil.
- Radionuclides in water (surface and groundwater).

9.3.1.1 Gamma radiation

Gamma radiation levels across the project area have been determined via three methods: Hand-held instrument gamma surveys, integrating monitors and interpretation of an aerial radiometric survey.

The most comprehensive survey was the hand-held survey with most of the project area being surveyed across a grid pattern with 100 m spacings. This survey provided a total of 416 readings. **Table 9-1** provides a summary of the survey results.

Table 9-1 Gamma radiation

Location	Average ($uGy.h^{-1}$)	Maximum ($uGy.h^{-1}$)	Minimum ($uGy.h^{-1}$)	Number of locations
On Deposit (combined)	0.37	1.26	0.19	194
Off Deposit (combined)	0.23	0.42	0.16	198
Other (Background)	0.20	0.24	0.15	24
Other (Exploration)	0.29	0.42	0.22	47

The monitoring shows that gamma radiation levels are elevated above mineralisation as expected, which is associated with the outcropping ironstone.

The aerial radiometric and the integrating monitors support the gamma survey data, indicating a higher dose rate over the near surface and outcropping mineralisation.

9.3.1.2 Radionuclides in airborne dust

Radionuclides are solids by nature and tend to remain fixed in the rock as they decay (break down). However, these radionuclides can reach the atmosphere if they occur at the soil-air interface and subject to weathering, erosion type forces. At this interface, they become attached to particulate matter (dust). Dust becomes easily suspended in the air by wind.

Dust sampling was conducted across the project area from 2015 onwards using low volume pumps to collect samples over a sampling period of at least four hours. Activity concentrations in air are measured by drawing a known volume of air through a filter. The filter is then assayed for the radionuclide content of the dust deposit on it. Readings were taken at locations on the deposit and off the deposit (**Table 9-2**).

Table 9-2 Alpha activity in dust

Location	Average (αdps.m^{-3})	Maximum (αdps.m^{-3})	Minimum (αdps.m^{-3})	Number of Samples
On Deposit	0.010	0.019	0.005	15
Off deposit	0.009	0.013	0.005	9

Results are given in αdps.m^{-3}, where "αdps" is alpha[1] decays per second from airborne material captured by sampling. The alpha emissions from radionuclide decay products, which with exposure for sufficient periods and concentration, can increase the risk of lung cancer. Airborne alpha activity concentrations are similar for the whole of the project area. This shows that despite the mineralisation being exposed at surface over the deposit, the radionuclide decay products remain fixed in the rock as they decay.

9.3.1.3 Radon and Thoron Concentrations

Radon and thoron isotopes are natural decay products of both uranium and thorium, respectively, as they decay into lead. Radon (referring collectively to the radon and thoron isotopes) is a colourless, odourless and tasteless gas. Radon occurs naturally and has a short half-life of 3.8 days but is constantly being regenerated by the presence of thorium and uranium. Radon gas is a health hazard and can often be the greatest contributor to an individual's dose exposure. Due to differences in the geology of the site, levels of radon gas can differ from one location to the next.

Radon levels fluctuate naturally, due to weather conditions, wind conditions or time of day, so one sample may not accurately measure radon levels at a particular location. Therefore, both passive and real time monitoring was undertaken.

Passive radon monitoring commenced in 2015 using Landauer Radtrak devices, which were placed at four locations around the Project. One pair were located at Gifford Creek Station Homestead, approximately 20 km south of the Project area, to measure background levels. Monitors were placed in pairs, one measuring radon only and the other measuring radon and thoron. Subtraction of the radon only concentration value from the combined exposure allows measurement of both radon (Rn_{222}) and thoron (Rn_{220}) at each location. These single use devices provide a measure of the average concentration for the exposure period. A summary of the results are shown in **Table 9-3**.

1 Naturally occurring radionuclide materials and their decay chains emit alpha and beta particles, and gamma rays of varied energy.

Table 9-3 Passive radon monitoring (rounded)

Location	Average Concentration in Air (Bq.m^{-3})	
	Radon	Thoron
Bald Hill	10	25
Fraser's	10	29
Yangibana North	10	17
Gifford Creek H.S	9	16

Real time radon monitoring was conducted with a Durridge Rad7. This instrument actively samples air every 30 minutes and logs radon concentrations. For this survey, the instrument was run for approximately two days at each location (approximately 100 samples). A summary of the results are shown in **Table 9-4**.

Table 9-4 Real time radon monitoring (results rounded)

Location	Start Date	Avg. Radon Concentration (Bq.m^{-3}) (two sigma variation in brackets)
Bald Hill South	13 Aug 2016	15 (2)
Gifford Creek Homestead	17 Aug 2016	5 (1)
Bald Hill Central	20 Aug 2016	7 (1)
Exploration Camp	24 Aug 2016	33 (3)
Accommodation Facilities Area	3 Sept 2016	44 (3)

During the monitoring period, high winds resulted in a high degree of mixing in the surface layer of air. As a result, variation in measurements from the passive and active monitoring were identified.

The existing radon and thoron concentration levels are consistent with levels form other regions of Australia. Typically, concentrations are between 20 and 40 Bq/m^3 for radon.

9.3.1.4 Water

Groundwater

Groundwater sampling and analysis was conducted in 2015 at a number of existing bores in the region. Samples were obtained from footprint of the Project (YGBW1 and RC082), within approximately 5 km of the Project (Yangibana Bore and Fraser Well) and the surrounding region (Figure 10-1; **Table 9-5**). Additional groundwater sampling was undertaken by Hastings in 2016. Results for elemental uranium and thorium are summarised in **Table 9-5**.

Table 9-5 Regional Groundwater Analysis (ATC Williams, 2015)

Sampling Area	Concentration Range ($Bq.L^{-1}$)	
	Uranium	Thorium
Project Footprint	0.17 – 0.20	<0.004
Within 5km of Project	0.31 – 0.36	<0.004 – 0.008
Regional	0.11 – 0.98	<0.004 – 0.004

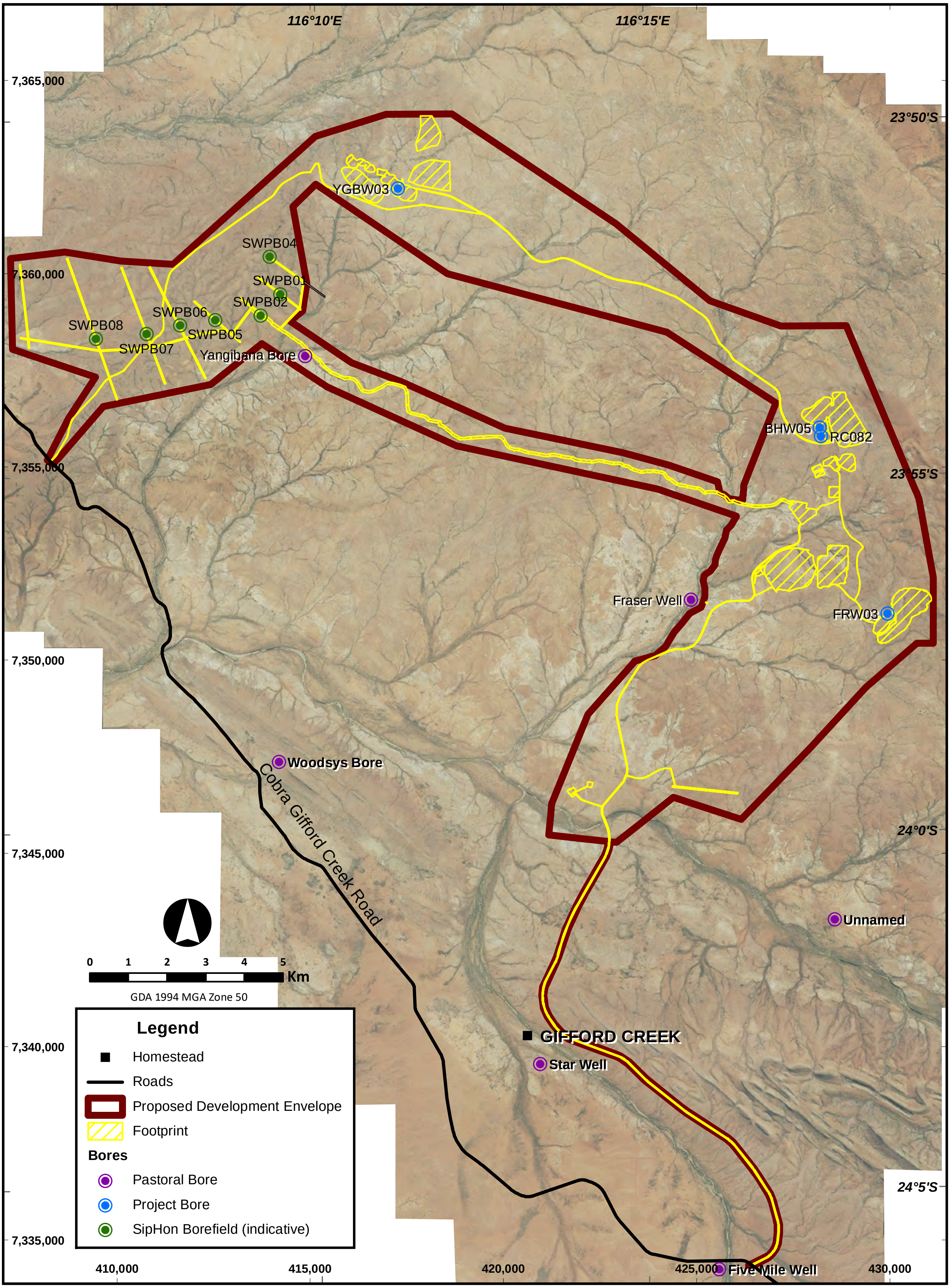
These results show a high level of regional and local variation in uranium content. As a result, future water sampling will measure radium as a more water-soluble decay product of uranium and thorium.

Surface Water

In October 2016, Hastings collected water samples (**Table 9-6**) from two ephemeral (seasonal) pools on the Lyons River, which only flows after heavy rainfall events. The pools are located approximately 5-10 km from the proposed processing plant area.

Table 9-6 Uranium and thorium concentration in Lyons River ephemeral pool samples

Location	Total uranium ($Bq.L^{-1}$)	Total thorium ($Bq.L^{-1}$)
LC-Pool 800US	0.05	<0.004
FR - Pool	0.01	<0.004



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Pastoral and Project Bores within the Yangibana Project

Figure 9-1

9.3.1.5 Summary of radiological baseline results

The radiation monitoring to date has shown the following:

- Gamma radiation levels in the region are generally elevated in the vicinity of the ore.
- Radon concentrations are spatially and temporally variable.
- The levels observed are consistent with levels reported at other similar projects.

9.3.2 Materials characterisation

9.3.2.1 Mineralised materials

Subsurface samples were collected from eight drill holes, within or immediately adjacent to mineralisation and are approximately representative of the Project target resource material. Analysis (**Table 9-7**) shows that concentrations of uranium and thorium in mineral samples vary widely, with higher concentrations of radionuclides are found with the target rare earths oxides (i.e. the ironstone) in mineralised areas compared to surrounding granites and metamorphics (e.g. psammite, quartzite).

Table 9-7 Sample origin and lithology: Uranium and thorium content (rounded)

Hole ID	Metre from	Metre to	Lithology Description (from field logs)	U (ppm)	Th (ppm)
BHRC007	21	22	Fenitic Granite (interburden between two ironstone lenses).	32	2521
BHDD027	14.5	14.9	Strongly weathered granite, immediate FW[2] to ironstone	11	1177
FRRC009	104	105	Ironstone	144	1309
KGRC005	71	72	Ironstone	50	1511
HKRC005	11	12	Fenetic Granite with 40% ironstone	5	1382
LERC007	9	10	Fenitic Granite, immediate HW[3] to ironstone	16	1871
YGRC024	37	38	Ironstone	21	1246
YGRC028	39	40	Ironstone and quartz (10%).	62	2455

[2] Footwall (FW) is the rock below the mineralisation
[3] Hanging wall (HW) is the rock above the mineralisation

Radionuclide analysis (**Table 9-8** and **Table 9-9**) indicates that decay progeny of the uranium and thorium series' are in approximate secular equilibrium[4] with their parent radionuclides.

Table 9-8 Uranium series radionuclide equilibrium in sub-surface material

Hole ID	U^{238} (Bq.g^{-1})	Ra^{226} (Bq.g^{-1})	Pb^{210} (Bq.g^{-1})
BHRC007	0.40	0.43 ± 0.03	0.41 ± 0.11
BHDD027	0.14	0.15 ± 0.01	0.13 ± 0.03
FRRC009	1.78	1.79 ± 0.11	1.65 ± 0.40
KGRC005	0.62	0.68 ± 0.04	0.66 ± 0.17
HKRC005	0.06	0.07 ± 0.01	0.05 ± 0.03
LERC007	0.19	0.16 ± 0.01	0.15 ± 0.06
YGRC024	0.26	0.41 ± 0.03	0.33 ± 0.08
YGRC028	0.77	0.84 ± 0.06	0.86 ± 0.22

Table 9-9 Thorium series radionuclide equilibrium in sub-surface material

Hole ID	Th^{232}(Bq.g^{-1})	Ra^{228} (Bq.g^{-1})	Th^{228} (Bq.g^{-1})
BHRC007	10.25	10.41 ± 0.74	11.10 ± 1.70
BHDD027	4.79	4.76 ± 0.34	4.87 ± 0.76
FRRC009	5.32	4.96 ± 0.34	5.16 ± 0.80
KGRC005	6.14	6.20 ± 0.44	5.79 ± 0.90
HKRC005	5.62	5.13 ± 0.36	4.71 ± 0.73
LERC007	7.61	7.18 ± 0.51	6.35 ± 0.98
YGRC024	5.06	5.38 ± 0.38	5.60 ± 0.88
YGRC028	9.98	9.39 ± 0.66	9.50 ± 1.50

[4] Secular equilibrium means the quantity of a radioactive isotope remains constant because its production rate is equal to its decay rate. The production rate remains constant due to the decay of the parent isotope.

Results generally indicate that the uranium and thorium decay chains are in approximate secular equilibrium.

9.3.2.2 Process materials

As shown in the baseline assessment above, elevated concentrations of naturally occurring radionuclides are present in the ore. A goal of the metallurgical processing is to remove the radionuclides and other impurities to produce a high quality final product for export.

While the process flowsheet has been determined, Hastings is conducting testwork on the main process streams to determine the radionuclide concentrations in the various materials. Preliminary work has been conducted and the results can be seen in **Table 9-10**.

Table 9-10 Uranium (U) and thorium (Th) content of materials

Material	Unit	U	Th	Comment
Ore	ppm	27	450	Est. to be in secular equilibrium
Waste Rock	ppm	10	71	Est. to be in secular equilibrium
Beneficiation Tailings (TSF1)	ppm	23	147	Est. to be in secular equilibrium
Re-flotation Tailings (TSF2)	ppm	45	1,922	Est. to be in secular equilibrium
TREO Concentrate	ppm	171	9,298	Est. to be in secular equilibrium
Hydromet Residue (TSF3)	ppm	94	5,092	Considered to be out of equilibrium
Liquid Residue from Hydromet	mg/L	0.19	0.003	Considered to be out of equilibrium
Rare Earth Product	ppm	<80	6	Considered to non-radioactive with any remnant radionuclides out of equilibrium

9.3.3 Emissions from materials

9.3.3.1 Radon and thoron emissions

A summary of the radon emission rates is shown in **Table 9-11**. The estimates are based on a combination of measured emission rates from a similar project and the approximate surface areas of the various sources. Further detail is provided in Appendix 5-6.

Table 9-11 Estimated radon and thoron releases

Source	Radon (MBq/s)	Thoron[5] (MBq/s)
Mine	0.8	40
Beneficiation Plant	0.1	0.1
Beneficiation Tailing	0.1	25
Processing Plant	0.1	175
Process Residues	Minor	Minor
Stockpiles	0.9	60
Total	2	300

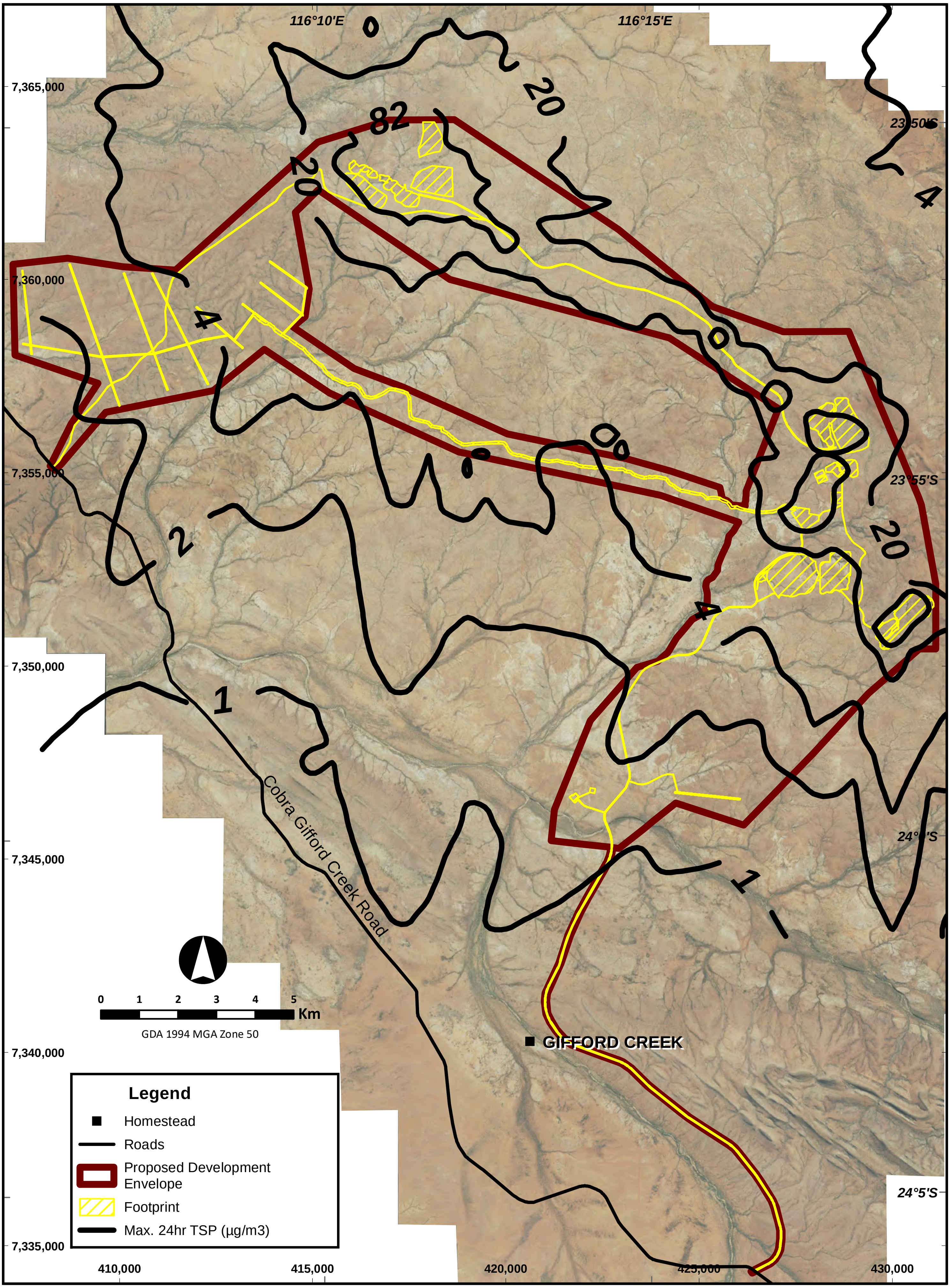
9.3.3.2 Radionuclides in dust emissions

Dust dispersion modelling (Pacific Environment 2016; Appendix 7-1 and 7-2) was conducted as a component of a broader air quality assessment and was used to determine radionuclide in dust dispersion from the operation. This is achieved by converting the modelled dust mass concentrations or dust mass deposition rate to activity concentrations or activity deposition rates using a knowledge of the specific activity of the dust.

The air quality modelling used AERMOD (AERMIC Dispersion Model) and produced contours of average dust concentrations for different types of dusts and dust deposition rates. For human radiological impact assessment it is usual to consider the total suspended particulates (TSP) for air concentrations because it is conservative and takes into account all dust size ranges. **Figure 9-2** shows the maximum 24-hour TSP concentration contours.

To convert the model outputs to radiological quantities, a specific activity for the dust is used. For this assessment, it was conservatively assumed that all dust is ore dust, that is, the dust has an average uranium concentration of 27ppm (0.3 Bq/g) and average thorium concentration of 450 ppm (2 Bq/g). This is a conservative estimate given that a proportion of the emitted dust will be non-mineralised.

[5] Note that the relatively higher figure for thoron is due to its very short half-life. Once thoron is produced, it almost immediately decays, therefore, its activity is high. Whereas, for radon, the longer half-life means that there is a lower activity for a similar number of atoms of radon (JRHC 2016; Appendix 5-6).



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PER_F10-2_Max24hr_TSP.mxd
12 June 2018

Max. 24hr TSP (µg/m3)

Figure 9-2

9.3.3.3 Gamma dose rates

To estimate the potential exposure rates from the various material, references to standard conversion factors have been used. The factors convert a concentration level into a dose rate. For uranium in a material, a gamma dose rate factor of 65µSv/h per %U is used for a 2π exposure situation i.e. equivalent to standing on an infinite plane source (exposure from all sides) or exposure from one side only. For thorium in ore, a factor of 16µSv/h per %Th for 2π exposure is used (Thompson and Wilson, IAEA 2006). Based on these conversion factors, dose rates for the various materials are shown in **Table 9-12**.

Table 9-12 Gamma dose rate for various materials

Material	Concentrations (ppm)		Calculated Total Dose Rate (µSv/h)
	Uranium	Thorium	
Ore	27	450	0.9
Waste Rock	10	71	0.2
Beneficiation Tailings (TSF1)	23	147	0.4
Refloat Tailings (TSF2)	45	1,922	3.4
TREO Concentrate	171	9,298	16
Hydromet Residue (TSF3)	94	5,092	8.8
Final Product	<80	6	0.5

9.4 Potential Impacts

Mining of ore will disturb areas that contain elevated concentrations of uranium and thorium or other elevated radionuclides. The potential impact of radiation exposure to humans occurs via four main exposure pathways:

- Gamma irradiation and absorption, from a person being in close proximity to material with elevated radioactive levels.
- Inhalation of radon decay products (RnDP) and thoron decay products (TnDP).
- Inhalation of radionuclides in dust.
- Ingestion of animals or plants that have come in contact with emissions.
- Radiation exposure to members of the public on the rehabilitated landform.

9.5 Assessment of Impacts

9.5.1 Overview

This section provides an assessment of the potential impacts to humans as a result of operations. This will include estimates of workers doses and members of the public doses at the sensitive receptors locations.

Occupational doses have been estimated to the following work groups:

- Mine workers.
- Processing plant workers.
- Other workers.

Doses to members of the public occur when emissions from inside the operation impact upon people outside the operation. This is quantified by identifying a representative person at sensitive receptor locations and then determining the potential dose to that person from the project emissions. In this assessment, the sensitive receptors are:

- Accommodation village (approximately 5 km from the main project area).
- Gifford Creek Station homestead (approximately 10 km to the south of the main project area).
- Edmund Station homestead (approximately 20 km north of the main project area).

The assessment assumes that a member of the public resides at the sensitive receptor for a full year at the Edmund and Gifford Creek Station homestead locations, and 4,000 hours per year for the accommodation village location.

The potential exposure pathways to humans includes:

- Gamma irradiation.
- Inhalation of radon decay products (RnDP) and thoron decay products (TnDP).
- Inhalation of radionuclides in dust.
- Ingestion of animals or plants that have come in contact with emissions (sensitive receptor locations only).

9.5.2 Assumptions

The key assumptions in occupational dose assessment are as follows:

- Worker exposure hours (working year) – 2,000h/y.
- Worker breathing rate – 1.2m^3/h.
- Radon decay product conversion factor 1.2mSv /mJ (workers) (ARPANSA 2005).
- Thoron decay product conversion factor 0.39mSv /mJ (workers) (ARPANSA 2005).
- Radon/RnDP equilibrium factor is 0.4 (UNSCEAR 2000).
- Thoron/TnDP equilibrium factor is 0.01 (Arafura 2016).
- Mine dust mass concentration of 3mg/m^3.
- Radionuclide in dust inhalation for uranium in ore 7.2µSv/αdps (ARPANSA 2005).
- Radionuclide in dust inhalation for thorium in ore 11µSv/αdps (ARPANSA 2005).

Note that for radon and thoron decay product conversion factors, the IRCP has suggested a higher dose factor (ICRP 2015). While this new higher factor is not yet included in government guidelines, it was determined that an additional assessment would be conducted using the new factor (and thus has been considered in the following assessment).

9.5.3 Mine workers

Doses to mine workers were calculated for each of the main exposure pathways. A summary of the method of assessment and doses are shown in the **Table 9-13**.

Table 9-13 Dose assessment for miners

Pathway	Method of Assessment	Dose (mSv/y)
Gamma	Assumes 50% attenuation due to operators on heavy mining equipment. Multiply attenuated gamma dose rate by exposure hours.	0.9
Inhalation of decay products of radon	Model radon concentrations in the pit using a modified box model and convert to a radon decay product concentration. Multiply concentration by hours worked to give exposure and apply dose factor to give a dose.	0.013
Inhalation of decay products of thoron	Model radon concentrations in the pit using a modified box model and convert to a radon decay product concentration. Multiply concentration by hours worked to give exposure and apply dose factor to give a dose.	0.033
Inhalation of uranium radionuclides in dust	Estimate average dust mass concentrations in the mine and convert to an activity concentration for the uranium radionuclides. Apply breathing rate and exposure hours to calculate an exposure, then apply the appropriate dose factors to determine the inhalation dose.	0.081
Inhalation of thorium radionuclides in dust	Estimate average dust mass concentrations in the mine and convert to an activity concentration for the thorium radionuclides. Apply breathing rate and exposure hours to calculate an exposure, then apply appropriate dose factor to determine the inhalation dose.	0.119
Total	Add together doses for each exposure pathway.	~1.2

9.5.4 Processing plant workers

The key workgroups in the processing plant are the beneficiation plant workers and the hydrometallurgical plant workers. An assessment of doses via the exposure pathways is difficult due to non-continuous and uncertain exposure geometries[6]. Therefore, for this assessment, it is assumed that the doses received by workers will be similar to doses received at an existing operation that is processing radioactive materials.

Key radiation aspects of the beneficiation and hydrometallurgical plants include:

- Once crushed and ground, the ore will be in a slurry form, therefore opportunities for dust generation will be absent.

[6] Exposure geometry is a term used to describe the complexities in time, angles, concentrations, radioactivity medium and type as seen by the individual being exposed to a dose of radiation.

- The slurries will be in process vessels and tanks in a diluted form (due to the slurry nature) and therefore instantaneous radionuclide concentrations will be relatively low.
- Defacto shielding for gamma radiation will be provided by the processing vessels and tanks.
- Processing facilities do not have permanent work locations, apart from control rooms. It is usual for plant operators to move all around the plant to undertake their duties.

For this assessment, published doses from an operating processing plant will be used. The assumptions used for the assessment are based on the average Olympic Dam processing plant doses from 2001 to 2007 (**Table 9-14**).

Table 9-14 Method of assessment used in processing plant for workers dose estimates

Processing Plant Area	Method of Assessment
Beneficiation Plant	Use doses received by Olympic Dam concentrator plant workers and scaled
Hydrometallurgical Plant	Use doses received by Olympic Dam hydrometallurgical plant workers

The dose estimates for the processing plant work areas are therefore outlined as shown in the following table (**Table 9-15**).

Table 9-15 Processing plant work area dose estimates

Processing Plant Work Area	Doses (mSv/y)			
	Gamma	Dust Inhalation	RnDP	Total
Beneficiation Plant	0.3	0.3	0.1	**0.7**
Hydrometallurgical Plant	0.8	0.7	0.3	**1.8**

Workers in both plants would be required to manage the respective tailings storage facilities (TSFs). The beneficiation plant operators would look after TSF1 and TSF2, while the hydrometallurgical plant operators would look after TSF3.

The expected doses to workers while working at the TSF's have been separately considered. TSF1 is not classified as radioactive, therefore any exposure when working in the vicinity would be negligible.

The activity of radionuclides in TSF2 is approximately 9 Bq/g, with a calculated gamma dose rate of 3.4 µSv/h at 1m. Therefore, working full time (2,000 hours per year) on the TSF would give an annual gamma dose of approximately 6.8 mSv. Dust dose would be negligible because the tailings are expected to be maintained in a damp state to eliminate dust generation. For TSF3, the estimated gamma dose rate is 8.8 uSv/h at 1m, giving a full year dose of approximately 17 mSv/y. In a similar manner to TSF2, dust doses are expected to be negligible due to the wet and damp nature of the tailings.

However, it should be noted that it is highly improbable that doses of these levels would be received. In the first instance, the TSFs are not full-time workplaces, therefore exposure hours would be limited. Secondly, ongoing monitoring would highlight any higher exposures and therefore remedial action would be implemented.

9.5.5 Other workers

Administration workers would mainly work in offices located adjacent to the processing plant. The work area would be outside of the main processing plant area and workers would not be required to undertake any special requirements for exposure control.

Exposures for administration workers would be as follows:

- Gamma – no close sources of gamma ore, therefore gamma dose expected to be negligible.
- Dust exposure – assume that a dust concentration of 0.5 mg/m^3 of ore dust is present in the workplace (note that this would be considered a relatively high concentration and require mitigation), the inhalation dose would be approximately dose 0.033 mSv/y.
- RnDP exposure – assumed to be negligible (based on miner doses).

Transport workers, such as logistics personnel, truck drivers and workers at the port would receive negligible doses because the processing has removed radionuclides and the final product is not considered radioactive.

9.5.6 Members of the public

A summary of the method of assessment and doses are shown in **Table 9-16**.

Table 9-16 Exposure pathway and method of assessment used to assess impacts to members of the public

Pathway	Method of Assessment
Gamma	Gamma exposure from sources within the project area is considered to be negligible due to the distance between the sources and the public.
Inhalation of decay products of radon and thoron	The annual average ground level radon and thoron concentrations during operations at each of the sensitive receptor locations was obtained from air quality modelling. The gas concentrations were converted to decay product concentrations using recognised equilibrium factors. Exposure were determined based on exposure time and inhalation rate. The exposures were converted to dose using standard dose factors.
Inhalation of uranium and thorium radionuclides in dust	The annual average ground level dust concentrations during operations at each of the sensitive receptor locations was obtained from air quality modelling. The dust concentration is multiplied by the specific activity of the dust to give an activity concentration. Exposure to the dust was determined based on exposure time and inhalation rate. The exposures were converted to dose using standard dose factors.
Ingestions of uranium and thorium radionuclides in flora and fauna uptake	Using the dust deposition rates from the air quality modelling, the change in soil radionuclide concentrations was calculated using the specific activity of the modelled dust. Using standard uptake factors, the project related radionuclide uptake into plants and animals was calculated. Using assumed consumption rates and standard ingestion dose factors, the dose to people was determined.
Total	Add together doses for each exposure pathway.

The total dose estimates at the sensitive receptors are based on 100% occupancy (i.e. 8,760 hours per year) for the station homestead locations and 4,000 hours per year for the accommodation village (**Table 9-17**).

Table 9-17 Public total dose estimates

Location	Exposure Pathway Dose (mSv/y)					
	Gamma	Dust	ThDP	RnDP*	Ingestion	Total Dose
Accommodation Village	0.000	0.000	0.000	0.001 (0.002)	0.005	0.006 (0.007)
Gifford Station	0.000	0.000	0.000	<0.001 (0.001)	0.001	0.002 (0.002)
Edmund Station	0.000	0.000	0.000	0.001 (0.002)	0.003	0.004 (0.006)

* The figures in parenthesis represent the calculated dose based on the new ICRP dose factor for radon decay products.

The following radiation exposure scenario's to members of the public from the rehabilitated landforms are considered:

- Gamma radiation at 1m above the TSFs, and
- radon exhalation rates from the TSFs.

The gamma radiation levels from tailings mainly depends upon the radionuclide content of the tailings. The density of the tailings and other constituents in the tailings may also affect the gamma radiation levels to a lesser level. Placing inert cover material above the tailings acts as a shield and attenuates the gamma radiation coming from the tailings **(Table 9-18**).

Table 9-18 Gamma dose rate from each TSF with and without an inert cover material

	Gamma Dose Rate (µSv/h)	
Facility	Uncovered	Covered (1m inert compact soil or rock)
TSF1	0.3	0.01
TSF2	3.0	0.01
TSF3	10.6	0.01

A conservative approach was used to estimate the emission rate of radon from the different tailings streams (**Table 9-19**). The US EPA assumes a radon emission rate of 1Bq (Rn222)/m^2/s per Bq (Ra226)/g of tailings.

Table 9-19 Concentration of Ra226 and the calculated radon emission rates in each tailings storage facility (TSF)

Sources	Ra226 Content (Bq/g) (Based on analysis)	Calculated Radon Emission Rate ($Bq/m^2/s$)
TSF1	0.25	0.25
TSF2	0.59	0.59
TSF3	1.45	1.45

For radon emission, the aim of a cover material above the tailings is to sufficiently constrain the rate of migration of radon so that the radon decays within the cover material and is therefore unable to be released into the atmosphere. The rate of constraint is dictated by the permeability of the cover material to inert gases. Therefore, taking into account the calculated radon emission rates, permeability of different cover materials to inert gases (from Chambers 2009) and a post closure radon emission target of the order of $0.1Bq/m^2/s$ (from Sonter 2002), the following cover is recommended for each TSF:

- TSF 1: 0.5 m of soil reduces the emissions to 0.125 Bq/m2/s and another 0.5 m of soil reduces the emission to 0.06 Bq/m2/s.
- TSF 2: 0.5 m of soil reduces the emissions to 0.3 Bq/m2/s and 0.24 m of clay reduces the emission to 0.08 Bq/m2/s.
- TSF 3: 0.5 m of clay reduces the emissions to 0.1 Bq/m2/s.

9.5.7 Health risk assessment

The radiation impact assessment presented previously indicated that anticipated doses to workers and members of the public would be low and well below the annual dose limits (for further detail, see Appendix 5-6).

In this section, potential exposure situations are described where doses may be higher than expected.

Activities associated with the potential exposure situations have been identified and an assessment of the likelihood and consequence has been made. Where necessary, mitigation measures are also identified. It should be noted that one of the purposes of routine radiation monitoring is to identify potential unexpected exposure situations to ensure that doses remain well controlled (Table 9-20).

Table 9-20 Key exposure situations, impact assessment and mitigation measures

Exposure Situation	Impact assessment*	Mitigation Measures
Excessive dust generation from mining activities In the event of elevated dust levels, the absolute quantities of dust would require control for the purposes of	Elevated dust levels are likely to occur on occasions when ore is very dry or when it is windy. The impact assessment assumed dust concentrations of 3 mg/m^3 and resulted in dust doses of approximately 0.2 mSv/y. If dust	Dust is routinely controlled in mining. When required, water sprays would be used during mining and an increase in watering of haul roads may be implemented.

Exposure Situation	Impact assessment*	Mitigation Measures
general health before the levels become a radiological risk.	levels reached 10 mg/m^3 (the level at which the dust would be intolerable from a nuisance perspective) for a full year, the dose from inhalation would be less than 1 mSv/y. Therefore the potential impact is low.	
Significant spillage of ore A build-up of ore or fines can lead to the creation of a radiation source. Where radionuclide concentrations are elevated, the spillage can constitute both a dust and a gamma source.	The gamma dose rate from ore is presented in Appendix 5-5. A build-up of spillage can lead to gamma dose rates of 0.9 µSv/h. Full time exposure to ore gives 1.8 mSv/y from gamma radiation. Full time dust exposure would result in low doses (see previous exposure situation).	Standing requirement for clean-up of all spillages. Regular workplace inspections by line management would identify areas requiring additional clean up. Routine monitoring would identify areas of elevated radiation levels. Emphasis of clean-up is a major management control.
Significant spillage of tailings The tailings to TSF1 is not radioactive and not considered further. The tailings to TSF2 and TSF3 contain elevated concentrations of radionuclides. The exposure situation is based on direct exposure to a major tailings spill.	The gamma dose rate from tailings has been calculated and presented in Appendix 5-5. A build-up of spilled tailings could result in a dose rates at 1m of; - 3.4 µSv/h (TSF2) - 8.8 µSv/h (TSF3) Full time (2,000 hours per year) gamma exposure to TREO could result in doses of 7.8 and 18 mSv/y respectively from gamma radiation.	The tailings pipelines would be bunded to contain any spillages. Standard requirement for clean-up of spillages would be in place. Full time exposure is highly unlikely to occur due to the variety of tasks that would be undertaken by operators (i.e. TSF operations would be one of a number of tasks).
Direct contact with beneficiation concentrate in the processing plant (TREO) The TREO is an intermediate process material and will be recognised as radioactive. At any one time, the quantities in one location will be limited. This potential exposure situation is based on excessive build-up of spillage.	The gamma dose rate from TREO has been calculated and presented in Appendix 5-5. A build-up of spilled TREO could result in a dose rate of 16 µSv/h (at 1m). Full time (2,000 hours per year) gamma exposure to TREO could result in doses of 32 mSv/y. This is highly unlikely to occur due to monitoring and also design controls. Any spilled product would be returned to the process. Exposure to TREO dust for 2,000 hours in a year at dust concentrations of 1 mg/m^3 would result in an inhaled dose of approximately 2 mSv/y.	TREO concentrate is recognised as a radioactive material and would be controlled as such. Standing requirement for clean-up of all spillages would be in place. Regular workplace inspections by line management would identify areas requiring additional clean up. Routine monitoring would identify areas of elevated radiation levels. Plant design would aim to contain spillages. Clean-up would occur with wet methods (hosed up) and with minimal dust.

Exposure Situation	Impact assessment*	Mitigation Measures
Maintenance in areas containing TREO It is likely that maintenance would be required in areas where TREO is present. This could result in elevated doses to workers. Maintenance occurs across the plant and an estimate is that a worker may spend 10% of their time close to TREO concentrate.	Based on the previous assessment, potential doses to maintenance workers working near a build-up of TREO materials could be: - 3.2mSv/y (gamma) - 0.2mSv/y (dust)	The area of the plant where TREO is present would be defined as a controlled area and maintenance would require approved work procedures. Work would be performed under a work permit requirement, which requires a "radiation clearance". Therefore the calculated doses are unlikely to occur.

* Note that "impact" here is a qualitative assessment based on a combination of likelihood and consequence. The impact is expressed as a potential dose.

9.6 MITIGATION HIERARCHY

Hastings commits to the following principles for the mitigation of potential impacts:

Best Practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- Thorough understanding of baseline radionuclide levels.
- The development and implementation of a HSEQ Management System based on international standards.
- The establishment of a safety culture and a culture of responsible environmental management.

Avoidance

Hastings has avoided potential impacts by:

- Locating TSF 2 and 3, and evaporation pond to avoid potential risk of contamination of water courses:
  - distance from rivers and creeks;
  - geotechnical considerations i.e. situated on impermeable granites; and
  - elevations where surface water from flood events is minimal.
- Designing a wet process and TSF 2 and 3 will be maintained as 'wet' to prevent dust emissions during operations.

Minimisation

Hastings will minimise potential impacts as follows:

- Establishment of detailed design requirements for the processing plant in order to minimise dust emissions and exposure to gamma radiation. Mandatory controls include:
  - covering and/or misting on conveyor belts, where used;

    - ensuring wet processes are used, where possible; and
    - barriers between ore and humans.
- Spill management procedures and bunding to ensure spilt ore or concentrate is contained quickly.
- Removal of radionuclides in product to as low as reasonably achievable thus minimising risk along the transport route.

Management

Objective

The overall objective for the management of radiation for the project is to:

> "…*ensure that there is no unacceptable health risk to people, both now and in the future, and no long-term unacceptable detriment to the environment from the waste so managed, and without imposing undue burdens on future generations*." (ARPANSA 2005)

Management plans

The Radiation Management Plan (Appendix 5-8) is the primary document for the management and monitoring of potential impacts to human health and safety and will form a component of the Safety Management System and will include (but not limited to):

- Training and induction requirements.
- Competent personnel requirements.
- Workplaces classification.
- Radiation monitoring program.
- Record keeping and reporting.
- Investigation and action thresholds.

Dust management

Dust generation and exposure will be managed as follows:

- All mining vehicles would be fitted with air conditioners and air filters, which would be serviced/replaced at regular intervals.
- Restricting access to stockpiles and ROM pad.
- Sprinkler systems on stockpiles used for blending material on ROM pad.
- Ensuring wet processes are used, where possible.
- Covering and/or misting on conveyor belts, where used.
- Spillage management and control.
- Watering of roads and ore stockpiles.
- Maintaining 'wet' tailings in TSF 2 and 3.
- Progressive covering of drying tailings during decommissioning, where possible.

- Sealant, such as Gluon, for stockpiles that are to remain in place for extended periods of time.

Transport management

The metallurgical test work showed that the radionuclides are removed from the ore during processing. The resultant product is not defined as radioactive. The product will be packaged during transport due to the small volumes of radionuclides. The product will be double encapsulated in bulka bags, which will be sealed and put in shipping containers with floor lining.

Monitoring

The occupational radiation monitoring program is detailed in the Radiation Management Plan (Appendix 5-8) is summarised as follows:

- External gamma radiation: Every full time employee spending a significant period of time working within 'supervised' areas will wear a Thermo Luminescence Dosimeter (TSD)/Optically Stimulated Luminescence Dosimeter (OSLD) badge to monitor their exposure to gamma radiation. In addition, surveys will be conducted within or at the boundary of the following facilities: Mining pits, product storage area, processing plant, TSFs boundaries, and temporary concentrate storage areas.
- Dust monitoring: Personal dust sampling will be conducted in mining, processing plant areas and for maintenance staff working within 'supervised' areas. Positional area sampling will also be undertaken.
- Radon and thoron decay products: Investigative monitoring of concentrations will be carried out in the mine and processing plant.
- Surface contamination monitoring: Monitoring of crib rooms and offices will occur on a regular basis. Mobile equipment, light vehicles and all plant and equipment to be checked for surface contamination before leaving site.

Action Levels

Monitoring results will be compared to agreed action levels as listed in the Radiation Management Plan. Where action levels are exceeded, an incident will be recorded, and an investigation will occur commensurate to the level of risk to determine the root cause, effectiveness of controls and further management actions to be instigated. Exceedances of an action value will be considered an incident unless significant seasonal environmental variation of background levels are expected. In such instances, a trend of exceedances in action values will then be treated as an incident.

Contingency

Contingency plans will form a component of the *Emergency Response Plan.*

Where containment of radioactive ore or waste fails (e.g. trucking accident on haul road), the Hastings *Emergency Response Plan* will include:

- Human health and safety first: First aid to individuals involved in the accident.
- Stabilisation of the containment and prevention of impact to surrounding environmental receptors.
- Consideration of secondary containment and drainage.

- Clean-up procedures.
- Training of personnel on the Emergency Response Team to address radioactive waste containment failures.

Rehabilitation

The closure objective relevant to human health in relation to radionuclides is:

> *Control radiation levels at the surface of rehabilitated landforms, consistent with pre operational background levels*.

The completion criteria relevant to human health in relation to radionuclides is:

> *Landforms do not emit radiation at surface exceeding background levels determined through baseline monitoring.*

A Preliminary Mine Closure Plan (Appendix 6) and Radiation Waste Management Plan include decommissioning considerations, specific to human health, including:

- An inventory will be developed, and an assessment of contamination will be conducted for all plant and equipment.
- Where recycling or reuse of plant or equipment is feasible, items will be decontaminated to radiation levels less than 1Bq/g before leaving site.
- An appropriate disposal method will then be determined for each plant and equipment, identified as waste, based on level of contamination.
- TSF 2 and 3, as well as the evaporation pond will be drying during the decommissioning phase. Cover materials will need to allow drying to take place without generating excessive dust.

Following rehabilitation, no alpha-emitting dust, gamma radiation or radon gas emanations will occur above that of background levels (JRHC and Associates 2017) if the TSFs are covered up to 1 m with an inert cover material to manage gamma radiation and alpha-emitting dust. To manage radon gas emanations, the following cover recommendations to manage radon gas emanations for each TSF include:

- TSF 1: 1 m of soil.
- TSF 2: 0.5 m of soil and 0.24 m of clay.
- TSF 3: 0.5 m of clay.

Closure considerations, specific to human health, will include:

- Identify sources of suitable materials for final encapsulation of TSF2 and TSF3.
- Storage of suitable rock cover materials during operations.
- Specifications of encapsulation layer(s) to limit infiltration into tailings.
- Prescribed thickness of rock cover / batters to protect tailings against long-term erosion.
- The TSFs will then be capped, covered with overburden and rehabilitated.

9.7 PREDICTED OUTCOME

9.7.1 Residual Impacts

Taking into account the 'system of dose limitation', the predicted outcomes are discussed in context of the three key elements as follows:

- Justification – naturally occurring radionuclides are associated with the target rare earths ore body. During processing they become concentrated in two of the three tailings streams. It is not possible to avoid mining and concentrating the radionuclides. However, an impact assessment to determine dose demonstrated that occupational and public doses are well below the dose limit.
- Optimisation – exposure to doses are reduced to As Low As Reasonably Achievable (ALARA), by maintaining a 'wet' processing plant and 'wet' tailings in TSF 2 and 3 to reduce potential dust generation. Considerations during design, operations and closure also consider reducing doses to ALARA as described in the RMP and RWMP. Encapsulation of the tailings waste and capping of TSF 2 and 3 at closure will also ensure doses are reduced to ALARA and are representative of the background gamma levels. A TSF operating manual will also ensure the TSFs are constructed in accordance with design specifications and will describe monitoring of the integrity of each TSF structure to be conducted during the operations phase.
- Limitation – the impact assessment determined that doses will not exceed the prescribed dose limits for the workforce or members of the public. Development and implementation of a safety management system, establishment of a safety culture, and implementation of the mitigation hierarchy will ensure human health is protected from exposure pathways. A precautionary approach will be maintained commensurate with the level of risk.

Therefore, residual impacts from radiation to workers and the public are low.

9.7.2 EPA Objective

As a result of the application of the 'system of dose limitation' as demonstrated by the workforce dose assessment and public dose assessment and the on-going commitment to ALARA (for example, implementation of the RMP and the RWMP), the EPA's objective will be achieved:

To protect human health from significant harm.

TERRESTRIAL FAUNA

Chapter 10

10 OTHER ENVIRONMENTAL FACTOR: TERRESTRIAL FAUNA

10.1 EPA OBJECTIVE

The EPA objective for terrestrial fauna is:

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

10.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of terrestrial fauna include:

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act)

Environmental Protection Act 1978 (WA) (EP Act)

Wildlife Conservation Act 1950 (WA) (WC Act)

Relevant guidelines include:

DoE (2013) Matters of National Environmental Significance. Significant impact guidelines 1.1 - *Environment Protection and Biodiversity Conservation Act 1999*

EPA (2016m) Environmental Factor Guideline: Terrestrial fauna

EPA & DEC (2010) Technical Guide – Terrestrial vertebrate fauna surveys for environmental impact assessment

EPA (2016p) Technical Guidance – Terrestrial fauna surveys

EPA (2016q) Technical Guidance – Sampling of short range endemic invertebrate fauna

10.3 RECEIVING ENVIRONMENT

A Level 2 terrestrial fauna survey was conducted by Ecoscape in 2015 and a follow up Level 1 fauna survey of the access road was conducted by Ecological in 2017. The purpose of the surveys was to identify the values and significance of the fauna and habitats present within the Development Envelope. The two surveys covered an area of approximately 55,560 ha (fauna study area) (Figure 11-1). The survey outcomes are described in the following reports and inform this section:

- Terrestrial Fauna Assessment (Ecoscape 2018; Appendix 2-1)
- Flora and Fauna Survey (Ecological 2017; Appendix 1-4)

10.3.1 Fauna habitat

A total of seven fauna habitat types were recorded within the fauna study area (**Figure 10-1**):

1 claypans;

2 granite outcrop;

3 major river;

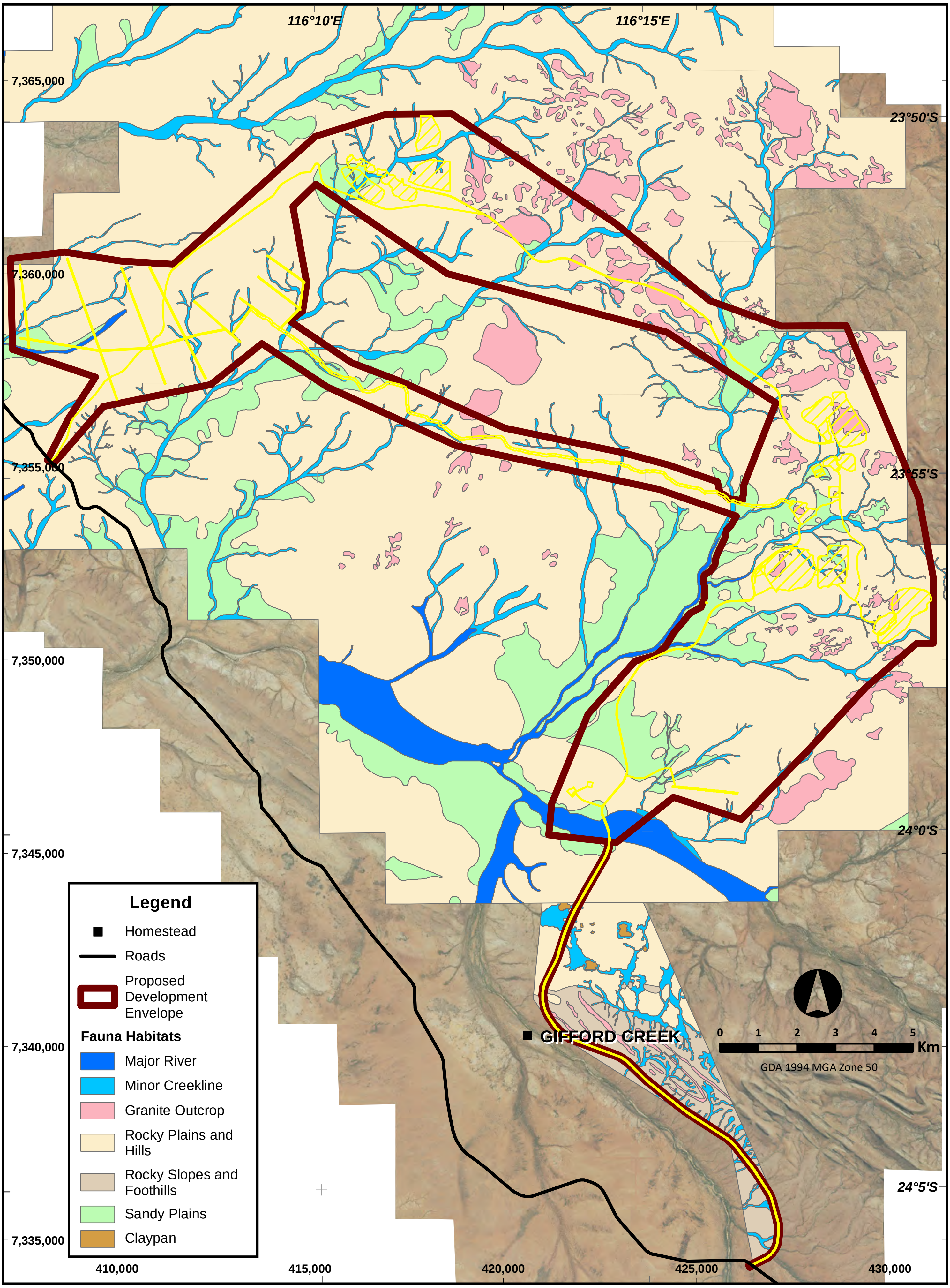
4 minor creeklines;

5 rocky plain (includes undulating hills and lower hillslopes);

6 rocky slope and foothills; and

7 sandy plain.

Table 10-1 describes the fauna habitat in the fauna study area and development envelope. Of these, the rocky plain is the most widespread habitat type with 40,963 ha in the study area, of which 24.7% occurs in the development envelope, followed by sandy plain (5,814 ha in the study area, and 23.8% within the development envelope) (**Table 10-1**). The remaining other habitats, granite outcrops, major river, minor creek line and clay pans were recorded from isolated areas of smaller extent. All habitat types were recorded from the wider region and are not unique to the Development Envelope (Ecoscape 2018). The major river habitat and minor creek lines habitat types are the most vulnerable to impacts from vegetation clearing, mining activities and fire (Ecoscape 2018).



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YANGIBANA RARE EARTHS PROJECT

PER_F11-1_Fauna_Habitat.mxd
12 June 2018

Fauna Habitat Mapping

Figure 10-1

Table 10-1 Fauna habitat in the regional Study Area (SA) and local Development Envelope (DE)

Fauna Habitat	Description	Extent of habitat within the SA (ha)	Extent of habitat within the Development Envelope (Ha)	Direct impact (ha)	Indirect impact	Total impact	% Total Impact
Claypans	This habitat is the least represented within the fauna study area and is characterised by cracking clay basin and flats. The vegetation consists of *Vachellia* sparse shrubland over mixed grassland over mixed sparse forbland (EcoLogical 2017).	20.3	0	0	0	0	0
Granite Outcrop	This habitat is the most elevated habitat type within the fauna study area. The vegetation consists of *Acacia cyperophylla* tall woodland over mixed shrubland, over mixed tussock grass and herbland (Ecoscape 2016).	2,681.5	837.56	73.8	129.8	203.6	7.59
Major River	The vegetation is typified by *Eucalyptus camaldulennsis* trees, over mid shrubland of *Acacia citrinovirdis* and *A. coriacea* over lower shrubs and closed tussock grassland (Ecoscape 2016).	1,891.8	182.84	2.6	4	6.6	0.35
Minor Creekline	The vegetation of this habitat type is characterised by *Acacia cyperophlla* shrubs, over mid sparse shrubland over sparse Sedgeland and sparse herbland (Ecoscape 2016).	3,314.8	693.92	41.1	167.6	208.7	6.30

Fauna Habitat	Description	Extent of habitat within the SA (ha)	Extent of habitat within the Development Envelope (Ha)	Direct impact (ha)	Indirect impact	Total impact	% Total Impact
Rocky Plains and Hills	This habitat was the most represented within the fauna study area and is characterised by gravelly ironstone and quartz stone. The vegetation consists of scattered *Acacia xiphopylla* and *Exocarpos latifolius* sparse shrubs over low shrubland and open herbland (Ecoscape 2016).	40,962.7	10,112.27	760.0	2,536.5	3,296.5	8.05
Rocky Slope and Foothills	The vegetation of this habitat type consists of Acacia and Grevillea tall sparse shrubland over low sparse shrubland (EcoLogical 2017).	875.6	52.54	24.8	35.2	60.0	6.85
Sandy Plains	The vegetation of this habitat type is dominated by open *Acacia xiphophylla* tall shrubs over scattered shrubs over occasional low isolated shrubs (Ecoscape 2016).	5,813.8	1,382.47	89.2	215.2	304.4	5.24
Total		**55,560.5**	**13,261.6**	**991.5**	**3,088.3**	**4,079.9**	

10.3.2 Fauna assemblage

A total of 134 vertebrate fauna species were recorded in the fauna study area over the two phases of assessment, which consisted of 20 species of mammal (12 species of non-volant mammals, eight species of bat), 85 species of bird, 25 species of reptile and four species of amphibian (Ecoscape 2018).

Five species of conservation significance were recorded in the fauna study area (Figure 11-2):

- Long-tailed Dunnart *(Sminthopsis longicaudata;* listed as a Priority 4 species by DBCA).
- Western Pebble-Mound Mouse (*Pseudomys chapmani;* listed as a Priority 4 species by DBCA).
- Eastern Great Egret (*Ardea modesta*; listed as a Schedule 5 species under the WC Act; Marine protected species[1] under the EPBC Act).
- Grey Falcon (*Falco hypoleuca;* listed as a Schedule 3 species under the WC Act).
- Rainbow Bee-eater (*Merops ornatus;* listed as a Schedule 5 species under the WC Act; Marine protected species under the EPBC Act).

No fauna species recorded in the fauna study area are listed as Threatened under the EPBC Act. The list does contain species listed as Schedule 3 and 5 under the WC Act and listed as Priority species by the Department of Biodiversity, Conservation and Attractions (DBCA; previously known as the Department of Parks and Wildlife).

The Grey Falcon was recorded 3.5 km south of the Level 2 study area and close to the area of the proposed southern access road (Ecoscape 2018). This species was not subsequently recorded during the access road fauna survey itself (Ecological 2017).

In addition to the species recorded, a likelihood assessment for species of conservation significant fauna to occur within the fauna study area identified an additional four conservation significant species with a moderate to high likelihood of occurring within the fauna study area (Ecoscape 2018):

- Yinnietharra Rock Dragon (*Ctenophorus yinnietharra*, listed as Vulnerable under the EPBC Act).
- Peregrine Falcon (*Falco peregrinus*, listed as a Schedule 7 species under the WC Act).
- Golden Gudgeon (*Hypseleotris aurea*, listed as a Priority 2 species by DBCA).
- Fork-tailed Swift (*Apus pacificus*, listed as a Schedule 5 species under the WC Act; listed as Migratory and Marine protected species under the EPBC Act).

10.3.3 Short range endemic fauna

Overall, 935 specimens belonging to 24 species in seven Short Range Endemic (SRE) groups were collected. Pseudoscorpions and terrestrial slaters were most diverse with six and five species, respectively. Spiders, scorpions and centipedes were represented by three species each, and centipedes and snails were present with two species (Ecoscape 2018). In total, 27 taxa were recorded from groups that support SRE species. No SRE species of conservation significance were recorded within the fauna study area (**Figure 10-2**).

[1] Marine species are listed under 'Other Matters' under the EPBC Act, which is only relevant when the proposal is being undertaken by a Commonwealth agency or is on Commonwealth land or within Commonwealth waters.

Thirteen potential SRE species were recorded within the fauna study area (potential SRE's belong to a group where there is knowledge gaps).

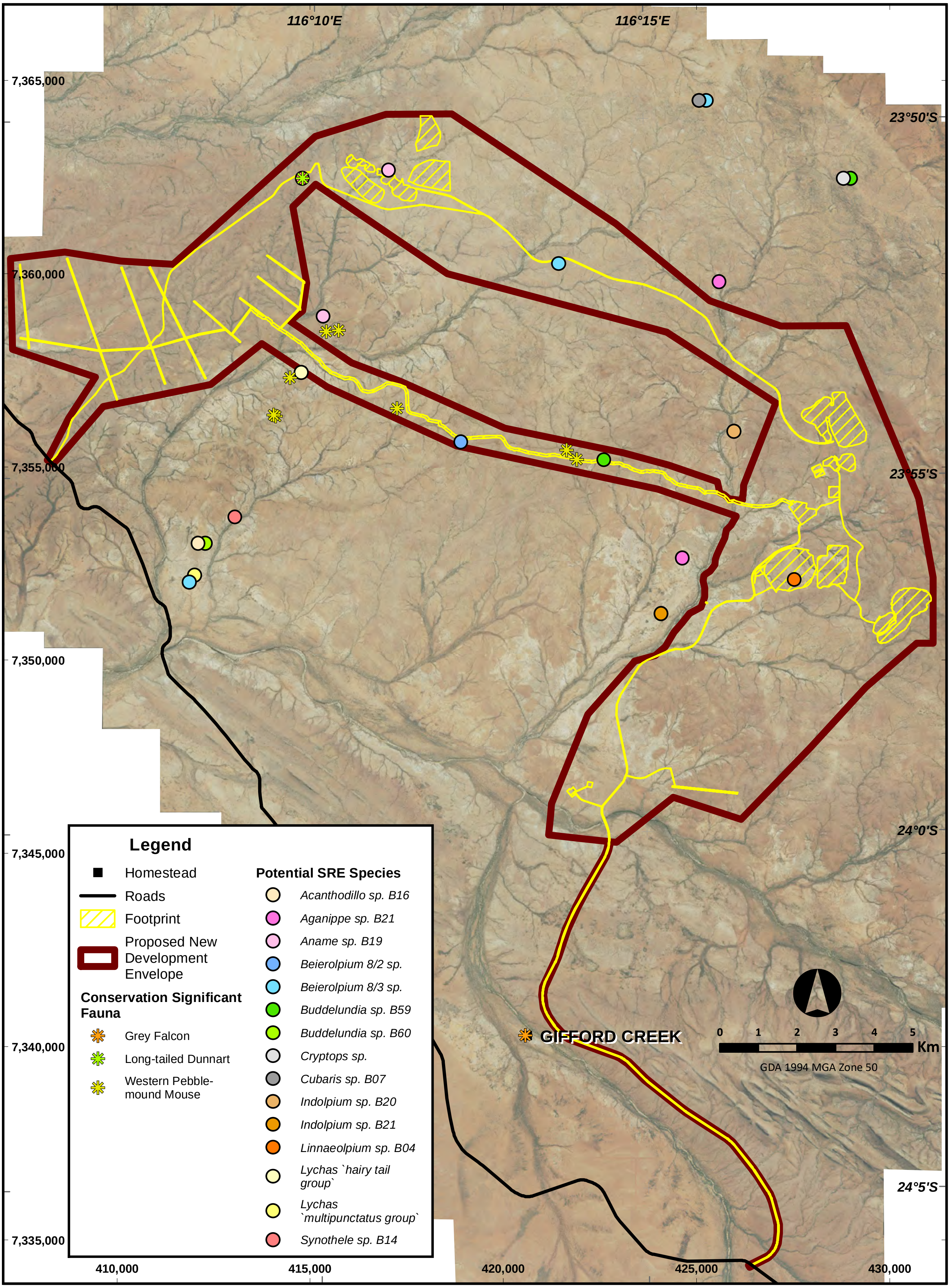
The following species are considered to be potential SREs:

- Spiders:
  - *Aname* sp. B19
  - *Synothele* sp. B14
  - *Aganippe* sp. B21
- Scorpions:
  - *Lychas* 'hairy tail group'
  - *Lychas* 'multipunctatus group'
- Pseudoscorpions:
  - *Beierolpium* 8/2 sp.
  - *Beierolpium* 8/3 sp.
  - *Linnaeolpium* sp. B04
- Slaters:
  - *Acanthodillo sp. B16*
  - *Buddelundia sp. B59*
  - *Buddelundia sp. B60*
  - *Cubaris* sp. B07
- Centipedes:
  - *Cryptops sp.*

Of these, three species occur within the development envelope:

- *Linnaeolpium* sp. B04
- *Beierolpium* 8/3 sp
- *Aname* sp. B19

The most suitable habitat for these species is major rivers and minor creek lines, associated with the dendritic pattern of surface hydrology and groundwater dependent ecosystems, which provide shade, leaf litter and moisture. This is in comparison to the surrounding flat, sparsely vegetated plains and slightly elevated hills, which the majority of the Activity Area overlies (Ecoscape 2018).



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YANGIBANA RARE EARTHS PROJECT

Conservation significant fauna and potential SRE

PER_F11-2_Signif_Fauna_SRE.mxd
24 June 2018

Figure 10-2

10.4 Potential impacts

Potential impacts include:

- Habitat loss and fragmentation from vegetation clearing.
- Displacement of fauna species.
- Attraction of feral vertebrates resulting in impacts to native fauna and/or their habitat.
- Attraction of migratory birds to anthropogenic water sources with adverse chemical characteristics.
- Potential radiation impacts on fauna.

10.5 Assessment of impacts

10.5.1 Habitat loss and fragmentation

The loss of fauna habitat and fragmentation associated with vegetation clearing and infrastructure will occur. The Proposal will remove a maximum of 1,000 ha of potential fauna habitat.

There are seven fauna habitat types within the fauna study area (**Table 10-1**). All habitat types are well represented and are not restricted to the Development Envelope. As the habitat types are represented outside of the Development Envelope and represent only a small portion available locally (i.e. as identified within the broader fauna study area), the Proposal will have minimal impact to habitat types as a result of vegetation clearing.

Table 10-3 details the preferred habitat and potential impacts to conservation significant fauna species likely to occur within the Development Envelope.

Table 10-3 Preferred fauna habitat and potential impact to conservation significant fauna species

Fauna	Preferred habitat	Potential impact	Likelihood to occur
Long-tailed Dunnart	Rocky areas of central western Australia, including rocky scree and plateau areas, generally with little vegetation or spinifex hummock grassland (Burbidge et al. 2008)	Local impact is expected, however it is not expected to affect the species at a regional level. Populations are expected to occur outside the fauna study area due to the continuity of habitat within the region (Ecoscape 2018).	Recorded within the fauna study area.
Western Pebble mound mouse	Rocky, hummock grassland areas with little or no soil, with pebbles present (Ecological 2017).	Impact to the species is not considered to be significant, as the on recorded record was not within the development envelope.	Recorded within fauna study area.
Eastern Great Egret	Wooded and shrubby swamps (Johnstone and Storr, 1998)	Minor impact may occur through the reduction of wet-season foraging habitat. However this is unlikely to be significant due to the	Recorded within fauna study area.

Fauna	Preferred habitat	Potential impact	Likelihood to occur
		large area of similar habitat available nearby (Ecoscape 2018).	
Grey Falcon	Arid habitats, open woodlands and open Acacia shrubland, hummock and tussock grasslands, low shrublands and swamps and waterholes (Ehmann & Watson, 2008).	Minor impact expected for this species. However clearing of large trees should be avoided as these could be potential breeding habitats (Ecoscape 2018).	Likely to occur. Recorded outside of the fauna study area.
Rainbow Bee-eater	Does not depend on any particular habitat or vegetation, except for the arid interior where they prefer lightly wooded sandy areas near a water source (DoEE, prev. DSEWPaC, 2012).	Impacts to the species is low because of its ability to utilise a variety of habitats and move to other areas (Ecoscape 2018).	Recorded within the fauna study area.
Yinnietharra Rock Dragon	Tall open shrubland inhabiting granite outcrops, separated by stony flats with sparse Acacia shrubs (Ecoscape 2018).	Impact to the species is not expected to be significant at a regional level, as granite outcrops were recorded outside the Development Envelope (Ecoscape 2018).	Likely to occur
Peregrine Falcon	Rocky ledges, cliffs, watercourses, open woodland or margins with cleared land (Debus 2012).	Impacts to foraging habitat is not likely to be significant. However clearing of trees with hollows or nests could affect the value of the habitat for breeding. Impact likely to be minor due to low density of population and the ability to relocate (Ecoscape 2018).	Likely to occur
Golden Gudgeon	Small, quiet pools with turbid water and a boulder substratum, often with dead branches (Hoese & Allen 1983)	Impacts are minimal, unless dewatering is anticipated which may influence on groundwater fed river pools (Ecoscape 2018).	Potential to occur in permanent pools of the Lyons River.
Fork-tailed Swift	Dry and open plains.	No impacts expected, due to its nomadic and aerial lifestyle (Ecoscape 2018).	Likely to occur intermittently.

Impacts to conservation significant species from loss of habitat and fragmentation are restricted to the local area and are not expected to be significant due to the widespread occurrence of suitable habitat outside the Development Envelope.

The one potential location of an active Western Pebble-Mound Mouse mound did not occur within the activity area, and therefore will not be impacted.

Major rivers and minor creek lines are the most suitable habitat types for potential SRE species and direct impacts of 2.6 ha and 41.1 ha respectively, and potential indirect impacts (calculated as a 20m buffer around disturbance footprint and water drawdown) of 4 ha and 41.1 ha, respectively. This represents a total potential impact of 0.35 % (major rivers) and 6.3% (minor creek lines) of the available habitat in the study area.

On a regional scale (within the study area), none of the SRE invertebrate species are anticipated to be significantly impacted. On a local scale there will be individuals that will be impacted by the proposal (Ecoscape 2018) however, this is not expected to result in the loss of any species locally due to the retention of habitat outside of the Activity Area.

The proposal will not have a significant impact on conservation significant fauna species or potential SRE species due to habitat loss.

10.5.2 Displacement of fauna species

Fauna species are likely to be displaced by the implementation of the project i.e. impacts from noise, movement of equipment and infrastructure placement. These effects are expected to be highly localised. As no species is restricted to the Development Envelope, and suitable habitat exists immediately outside the Development Envelope, noise and other displacement impacts are not expected to be significant.

10.5.3 Attraction of feral vertebrates

Feral fauna may be attracted to the proposal areas due to:

- Increased water availability from dripping taps and leaking pipes.
- Provision of food from humans at the accommodation facilities.
- Availability of food waste in the landfill facility.

The presence of increased numbers of feral fauna could result in impacts to native fauna and native fauna habitat. Management measures will be implemented to ensure the Proposal does not introduce or facilitate increased numbers of feral animals.

10.5.4 Attraction of migratory birds to water sources

An ecotoxicity assessment (Appendix 2-2) has determined that migratory birds may be attracted to standing water sources, such as the evaporation pond. The evaporation pond is predicted to have concentrations of salt and metals that would exceed ANZECC ecological guidelines values for freshwater aquatic ecosystems. Detailed design and ongoing management of the evaporation pond will include controls to deter migratory birds. Active engineering and operational control to limit access, and to establish the most effective controls such as fencing and netting, is required. There is the potential for harm to migratory birds from ingesting the high concentrations of metals in the water. Alternate natural water sources (i.e. the river and associated pools) occur approximately 10 km from the evaporation pond, and man-made water sources will occur approximately 1 km from the evaporation pond.

10.5.5 Potential radiation impacts on fauna

The ERICA assessment is based on the potential airborne emissions that could lead to deposition of radioactive dust on the surrounding soil. The assessment indicates that there is no radiological risk to fauna from project emissions (Section 11.3.4; JRHC 2016; Appendix 5-6).

10.6 Mitigation

The mitigation hierarchy has been applied to the potential impacts. Avoid and minimise are the main mitigation methods. The following mitigation of potential impacts will be implemented:

Best practice

The following actions are considered 'industry best practice' and will be implemented by Hastings:

- A thorough understanding of the fauna values within the Proposal area (as described in Section 11.3).
- Consideration of fauna habitat values during each phase of the Project:
  - design and engineering: location of infrastructure;
  - construction: consideration of trenches, ground disturbance;
  - operations: management and monitoring; and
  - closure: rehabilitation activities take account of fauna habitat values.

Avoidance

- Exclusion of disturbance within 150 metres of Lyons River, Gifford Creek, and Yangibana and Fraser Creeks, with the exception of linear infrastructure crossings.

Minimisation

- All vegetation clearing and direct disturbance will be kept to a minimum, where practicable, and will be clearly demarcated.

Management

- The Preliminary Terrestrial Fauna Management Plan (Appendix 2-3), includes consideration of the following mitigation measures:
  - feral fauna: Training and awareness of workforce (i.e. will not feed feral animals), feral animal control program, reference to waste management program in Land Management Plan (see below); and
  - native fauna: training and awareness, snake handling, speed limits, incident reporting, egress from trenches and inspection of trenches and lined ponds during construction.

  A monitoring program will be implemented to determine the effectiveness of mitigation measures and includes:
  - feral fauna: inspections of landfill, feral fauna trapping program, and audits and inspections of mitigation measures, and
  - native fauna: visual inspections of trenches and implementation of egress for fauna, fauna deaths at the Proposal area, presence of fauna at evaporation pond and effectiveness of mitigation measures to deter fauna at the evaporation pond.
- Land Management Plan (to be developed) will include:
  - the management of putrescible waste to deter feral fauna; and
  - consideration of pastoral activities, training and awareness, speed limits in the vicinity of cattle grazing and mustering activities, and land access requirements during mustering activities (in consultation with the station manager).

- Water Management Plan (to be developed) will include consideration of:
    - an inspection and monitoring program of pipelines and facilities where water is used (e.g. waste water treatment plant); and
    - the design of the evaporation pond to include features that deter birds and other fauna including fencing around the evaporation pond, ensure banks do not provide good landing sites and bird deterrents, such as netting.
- Compliance with all relevant state regulations on radiation protection. The radiological impacts of the project will be managed and controlled through design and operational management systems, including the Radioactive Waste Management Plan and associated documentation.

Rehabilitation

The closure objective relevant to fauna is:

> *Rehabilitated areas support self-sustaining and resilient vegetation, with biodiversity trending towards analogue sites.*

The completion criteria relevant to terrestrial fauna are:

> *Rehabilitated areas show trends that indicate long-term return to a functioning and sustainable ecosystem.*
>
> *Rehabilitated areas (excluding final pit voids and remaining infrastructure corridors i.e. roads, bores) support revegetation with local provenance vegetation in the short-medium term.*

A Preliminary Mine Closure Plan includes the following considerations, specific to fauna:

- Storage of vegetation and logs during clearing activities for use in rehabilitation.
- Progressive rehabilitation using local provenance flora species.
- Encapsulation of TSF 2 and 3 tailings material at closure.
- Further consideration of pit void lakes for post-closure fauna habitat include:
    - water quality monitoring;
    - subject to verification of water quality assessments and salinity modelling[2] (on-going monitoring program), rehabilitation measures will include the following considerations:
        - riparian habitat
        - landing/perching sites
        - fauna access to pit void/lake.
- Post-closure rehabilitation will use local provenance flora species and consider actions to promote fauna colonisation including: logs and branches, perching and nesting boxes, and covers for small reptiles and insects.

[2] In the long-term, the pit void lakes may become hypersaline and not suitable as fauna habitat and thus these considerations may not come to fruition.

10.7 Predicted outcomes

10.7.1 Residual impacts

The proposal will displace fauna and result in clearing of a maximum of 1,000 ha of fauna habitat. The majority of this impact is to the rocky plain habitat type. This habitat type is represented outside of the Development Envelope and is of no particular importance to conservation significant fauna. There are no known populations of conservation significant fauna considered susceptible to significant impact from this Proposal. Impacts to major rivers and minor creek line habitat types, which may support SREs, are small in comparison to that available locally. Mitigation measures (Section 10.6) will be put in place to ensure these habitat types are not impacted indirectly by mining activities.

10.7.2 EPA objective

The environmental effect of the proposal is not expected to result in a significant impact on fauna, fauna habitat and potential SRE fauna. The potential impacts can be minimised and controlled through the implementation of management actions. Therefore the Proposal will meet the EPAs objective for the environmental factor, terrestrial fauna:

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

SOCIAL SURROUNDINGS

Chapter 11

11 OTHER ENVIRONMENTAL FACTOR: SOCIAL SURROUNDINGS

11.1 EPA OBJECTIVE

The EPA objective for social surroundings is:

To protect social surroundings from significant harm.

11.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of social surroundings include:

Aboriginal Heritage Act 1972 (WA)

Environmental Protection Act 1986 (WA)

Heritage of Western Australia Act 1990 (WA)

Protection of Moveable Cultural Heritage Act 1986 (Commonwealth)

Relevant guidelines include:

DAA/DPC (2013) Aboriginal heritage due diligence guidelines

EPA (2016j) Environmental Factor Guideline: Social surroundings

11.3 RECEIVING ENVIRONMENT

Aboriginal cultural heritage surveys reported by Brad Goode and Associates (2016, 2017a and 2017b) and publicly available data on listed heritage places have informed this section.

11.3.1 Heritage

There are eight Western Australian listed Commonwealth Heritage Places in the Upper Gascoyne LGA:

1. Cobra Station Homestead, Cobra - Mount Augustus Rd, Bangemall via Gascoyne Junction, WA, Australia: Indicative Place on the Register of the National Estate.
2. Fossil Hill, Bidgemia Station, WA, Australia: Registered Place on the Register of the National Estate.
3. Indigenous Place, Mount Augustus National Park, WA, Australia: Registered Place on the Register of the National Estate.
4. Indigenous Place, Waldburg Station via Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.
5. Kennedy Range Area, Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.

6. Mount Augustus Area, Mount Augustus via Gascoyne Junction, WA, Australia: Registered Place on the Register of the National Estate.
7. Nundigo Well and Stockyard, Landor Station via Meekatharra, WA, Australia: Indicative Place on the Register of the National Estate.
8. Top Camp Unconformity, Ashburton Downs Station, via Paraburdoo, WA, Australia: Indicative Place on the Register of the National Estate.

There are no Commonwealth Heritage Places within or immediately surrounding the proposal. The Mt Augustus Area is the nearest listed Commonwealth Heritage Place, which is located approximately 80 km from the proposal.

There are no State listed Heritage Places within or immediately surrounding the proposal. The nearest sites listed on *inHerit* (Government of Western Australia Heritage Council, State Heritage Office), approximately 60 km from the proposal, are:

- Bangemall Wayside Hotel (fmr), Cobra Station (Cobra Station Homestead (fmr), Euranna Hotel; Heritage Place No. 4129).
- Cobra Station Homestead – Original, Cobra-Mt Augustus Rd Bangemall via Gascoyne Junction (Heritage Place No. 15419).

11.3.2 Native title

Most of Hastings tenure (under the *Mining Act 1978*) was obtained prior to the lodgement of a native title (NT) claim over the proposal area. All mining leases for the proposal were granted prior to the lodgement of a claim. In August 2016, the combined *Thin-Mah Warianga, Tharrikari, Jiwarli* (TMWTJ) People lodged a NT claim (WC2016/003 and WAD464/2016) under the *Native Title Act 1993* (WA), which was formally registered in October 2016. For remaining infrastructure tenure, Hastings was required to consult with the TMWTJ group. However, Hastings voluntarily entered into negotiations for a project wide Native Title Agreement, which includes (but not limited to) provisions for:

- Consultation with the TMWTJ People, through the Implementation Committee[1], on environmental matters associated with the Proposal operations, including environmental management planning and mine closure planning.
- Any environmental concerns raised by the Implementation Committee to be recorded in environmental approval documents submitted to the government.
- Maximising the TMWTJ People involvement in environmental monitoring activities.

The agreement was ratified at a community meeting in November 2017.

11.3.3 Aboriginal heritage

Hastings works closely with the TMWTJ People to identify cultural heritage values and has entered into a number of heritage agreements with the group. Hastings acknowledges the significance of the environment

[1]The Implementation Committee, consisting of representatives from Hastings and the TMWTJ People, will be the primary channel by which the Parties will consult with each other.

to the TMWTJ People. The majority of areas to be disturbed by the proposal have undergone archaeological and ethnographic cultural heritage surveys with representatives of the TMWTJ group (Figure 11-1).

All surveys conducted to-date have been undertaken in accordance with the *Aboriginal Heritage Act 1972* (WA). There are no registered Aboriginal sites of heritage significance intersecting the project area according to the Department of Planning, Lands and Heritage (DPLH; WA) Aboriginal Heritage Inquiry System (AHIS).

A number of other potential sites, as defined under Section 5[2] of the *Aboriginal Heritage Act 1972* (WA), have been identified during surveys. During heritage surveys, several areas of cultural significance were found within or adjacent to the Proposal areas (Brad Goode and Associates, 2016, 2017) including the Thalaangkaya Corroboree Site, which is located outside of the development envelope approximately 800m from the accommodation facilities on the Lyons River.

In addition, the survey participants recommended that:

- The waterways are culturally significant and should not be subject to water abstraction, recreation use or pollution.
- A 150m exclusion buffer zone be placed on either side of the Lyons River, Fraser Creek and Gifford Creek, acknowledging that some proposal roads will cross the Lyons River and Fraser Creek at approved locations.
- The waste water treatment plant at the accommodation facilities be located at the further most extent from the Lyons River.
- Native vegetation clearing be kept to a minimum.
- A heritage induction, including a presentation on the cultural heritage values of the area, is important.
- The Tailings Storage Facilities (TSFs; and other mine-related activities) be actively managed to ensure that they do not contaminate or pollute any natural waterways (Brad Goode and Associates, 2016, 2017).

Hastings will commission further Aboriginal heritage surveys with the TMWTJ People, where required.

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[2] Section 5 of the act applies to —

- any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the traditional cultural life of the Aboriginal people, past or present;
- any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;
- any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State;
- any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed.

11.3.4 Bush tucker

During the heritage surveys, traditional bush tucker was discussed (Brad Goode and Associates, 2017a). The following species were identified as traditional bush tucker:

- Karara bush (*Eremophila oldfieldii*): Seeds were used to make damper.
- Wild lemon grass (*Cymbopogan procerus*): Medicinal uses.
- Milk bush (*Euphorbia tirucalli*): Sap was used to catch fish.
- Emu (*Dromaius novaehollandiae*): Meat was edible.
- Kangaroo (*Macropus* sp.): Meat was edible.
- Goanna (*Varanus* sp): Meat was edible.
- Fish (possibly mullet).

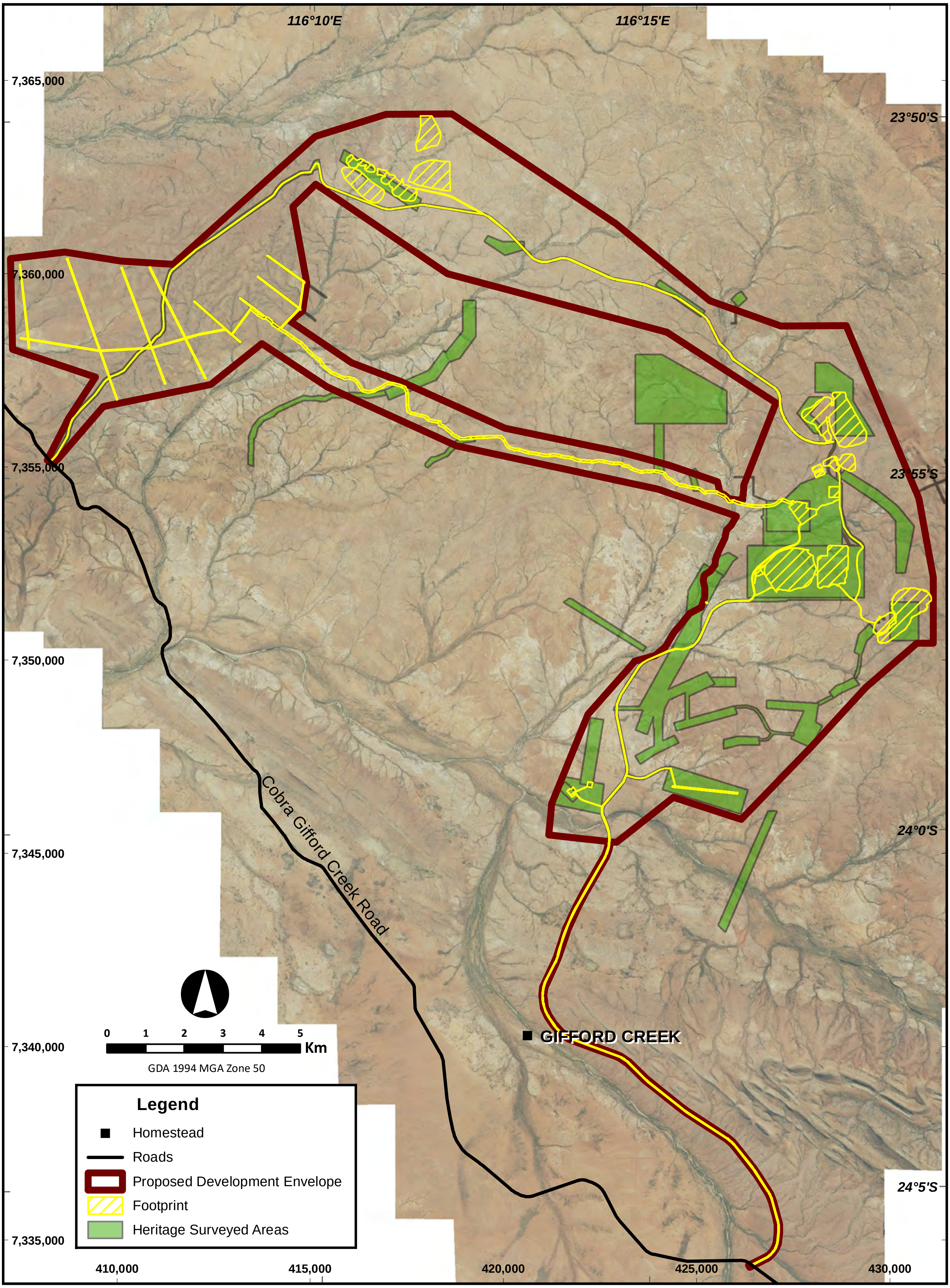
Given that elevated levels of radionuclides pose a potential risk of exposure to the surrounding flora and fauna values (including bush tucker), a Tier 2 ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) was conducted (JRHC 2016; Appendix 5-6). The Australian Government's primary authority on radiation protection and nuclear safety, ARPANSA (2010) recommends the ERICA software tool for assessing risk to Australian plants and animals. The availability of data, specifically for the Australian kangaroo, enable users to apply the tool for Australian operations at a Tier 2 level. Other flora and fauna utilise the ERICA default value.

The assessment method produces a dose rate, which is then compared to a 'screening level' set at 10 µGy/h (default ARPANSA 2010). If the dose rate is below the screening level then no impacts of radionuclides would be observed in the respective flora or fauna. The dose rates determined in the ERICA assessment are shown in **Table 11-1**. When compared to the screening level, the ERICA assessment indicates that there is no radiological risk to reference plants and animals including kangaroos from emissions from the proposal.

Table 11-1 ERICA Assessment: Output (total dose rate) for each class of flora or fauna

Class of flora or fauna (ERICA default unless noted)	Total Dose Rate (µGy/h)
Amphibian	<0.001
Annelid	<0.001
Arthropod - detritivores	<0.001
Bird	<0.001
Flying insects	<0.001
Grasses & Herbs	0.005
Lichen & Bryophytes	0.014
Mammal - large	<0.001
Mammal - small-burrowing	<0.001

Class of flora or fauna (ERICA default unless noted)	Total Dose Rate (µGy/h)
Mollusc - gastropod	<0.001
Reptile	<0.001
Tree	<0.001
Kangaroo (user defined)	<0.001



YANGIBANA RARE EARTHS PROJECT

PER_F12-1_Heritage.mxd
28 August 2018

HASTINGS Technology Metals Limited

Cultural heritage survey areas

Figure 11-1

11.4 Potential impacts

Potential impacts to cultural heritage values include:

- Direct and indirect impacts to known areas of heritage significance.
- Potential impacts to unidentified areas of heritage significance.
- Excavation of human remains.
- Potential radiation impacts on bush tucker.

11.5 Assessment of impacts

11.5.1 Direct and indirect impacts to known areas of heritage significance

Several areas of Aboriginal cultural significance occur within the development envelope or in the near vicinity. No areas of cultural heritage significance will be impacted by the indicative disturbance footprint. One area within the processing plant area will be avoided through design of the processing plant.

The Lyons River and Fraser Creek crossings were not identified as areas of heritage significance and therefore do not require Ministerial consent under Section 18 of the *Aboriginal Heritage Act 1972* (WA) approval prior to disturbance. However, an area of cultural significance identified as Windarra Pool is located approximately 65m from the location where the access road crosses the Lyons River.

Figure 11-2 shows the locations of each site in relation to the development envelope and the indicative footprint.

Potential indirect impacts to areas of cultural significance may occur without mitigation. In particular, the TMWTJ People stated concerns regarding indirect impacts from:

- Construction of the access road across the Lyons River to the Windarra Pool.
- Contamination from chemicals and the Waste Water Treatment Plant (WWTP) at the accommodation facilities.
- Recreational use of the Lyons River and entry to the Thalaankaya Corrobboree Site by the workforce (due to it being near the accommodation facilities).
- Contaminants, entering waterways, from the processing plant and tailings storage facilities.

11.5.2 Potential impacts to unidentified areas of heritage significance

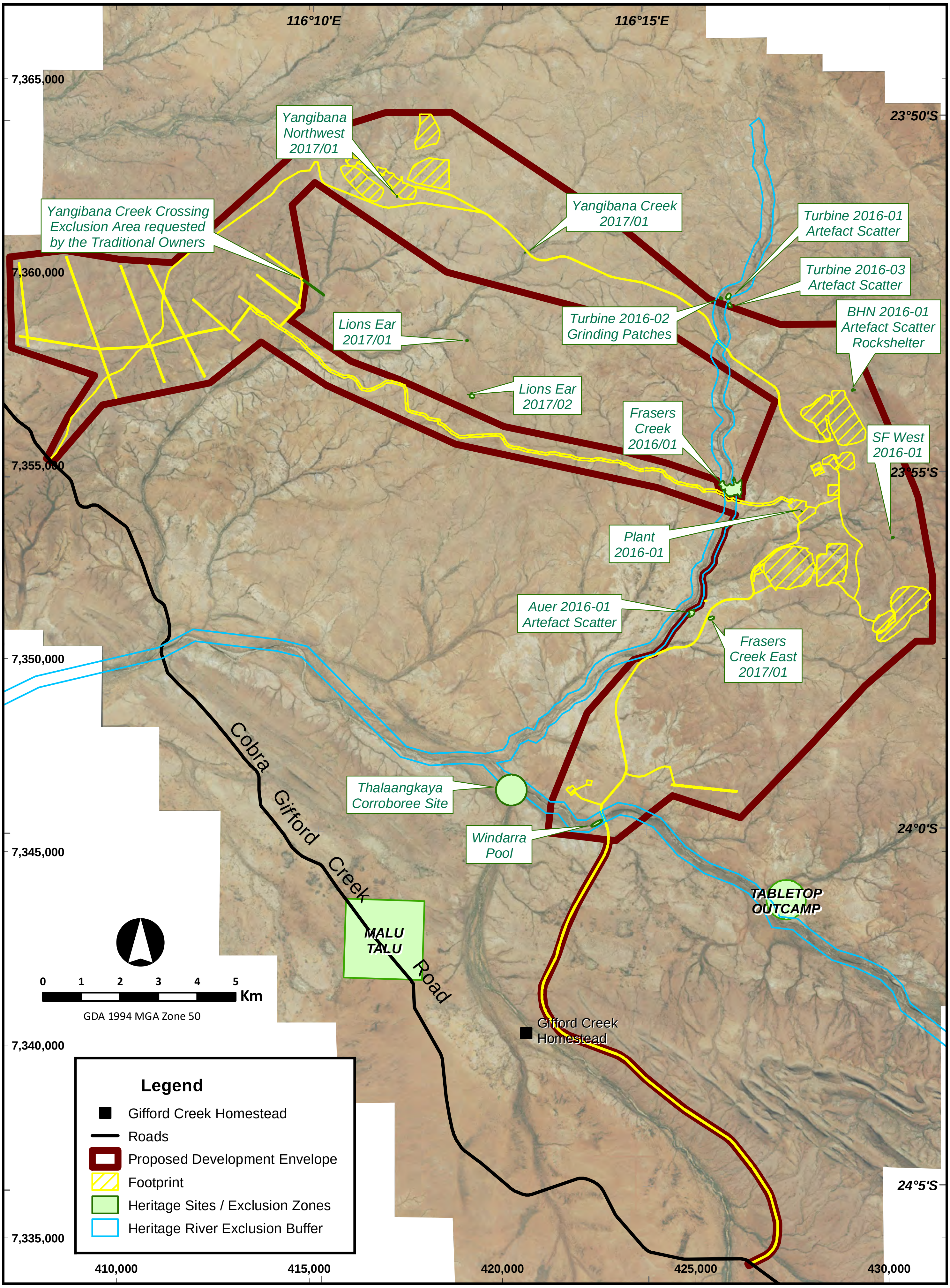
While heritage surveys have been conducted over the majority of known disturbance areas, there will be a variety of additional or miscellaneous disturbance areas required for implementation of the proposal. As a result, there is the potential for impacts to heritage sites of significance, yet to be identified.

11.5.3 Excavation of human remains

Potential burial sites (not distinguished by markers or signage) require consideration from a cultural heritage perspective. Surveys of undisturbed areas cannot distinguish conclusively whether or not an area includes a burial site. As a result, there is the potential to recover human remains during excavation activities.

11.5.4 Potential radiation impacts on bush tucker

There are naturally occurring radioactive materials (NORM) associated with the ore body. Dust containing NORM will be generated during mining activities. The processing of the ore will be wet and the tailings generated from the processing plant will also be maintained in a wet or moist state during operations and covered with benign materials at closure. The ERICA assessment is based on potential airborne emissions that could lead to deposition of radioactive dust on the surrounding soil. The assessment shows that there is no radiological risk to bush tucker (i.e. flora and fauna) from project emissions (JRHC 2016; Appendix 5-6; Section 11.3.3).



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YANGIBANA RARE EARTHS PROJECT

Cutural Heritage Sites

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12 June 2018

Figure 11-2

11.6 MITIGATION

Hastings commits to the following mitigation of potential impacts:

Best Practice

Hastings will comply with the conditions of the Native Title Agreement, and continue to consult with the TMWTJ People with regard to activities at the Yangibana Rare Earths Project.

Avoidance

A number of exclusion areas have been identified, as per Schedule 4 of the Mining Agreement, including but not limited to:

- A 150 m exclusion buffer occurs on both sides of the Lyons River and Fraser Creek (Figure 12-2), (except where linear infrastructure crosses these water courses at approved locations).
- A cave at Bald Hill.
- The Thalaangkaya Corrobboree Site.
- A grinding stone to the west of the processing plant.
- The Kangaroo Thalu[3].

In addition, where areas of heritage significance occur in close proximity to infrastructure, Hastings has avoided impact to these sites by relocating or rearranging the position of infrastructure (i.e. processing plant and where the access road crosses the Lyons River).

Management

A draft Cultural Heritage Management Plan has been developed, which includes:

- Consideration of known areas of heritage significance:
  - areas are identified through ethnographic and archaeological surveys (areas that have been surveyed are shown on the *Heritage Survey Map*), in accordance with the existing agreements and / or the *Aboriginal Heritage Survey Protocol* (Schedule 1 of the Mining Agreement);
  - all areas of heritage significance located within the Project area are documented, including accurate mapping of their boundaries and extents (*Yangibana Heritage Site Register* and *Yangibana Heritage Sites Map)*;
  - prior to any ground disturbance, a *Ground Disturbance Approval Form* shall be submitted to the Environment Department, during the construction and operations phases, for internal approval in accordance with *Ground Disturbance Work Instruction*. Whether or not a heritage survey has been undertaken (*Yangibana Heritage Survey Map*), and if so, whether or not areas of heritage significance are listed on the *Yangibana Heritage Site Register* and their respective management will be considered in order to grant approval in accordance with the *Ground Disturbance Work Instruction*;

[3] Brad Goode and Associates (2017a) provides the following definition:

> "Thalu sites are places set aside as a focus for ceremonies that will ensure the continuation or proliferation of particular species of animals, plants and natural phenomena. The ceremonies to achieve this are aimed at "taming" and then driving or directing the spiritual forces inherent in the landscape. Such ceremonies are not aimed at supplanting the natural processes but enhancing them (Daniel 1990)."

    - the coordinates of identified areas of heritage significance are included within the GIS database of the Proposal area and the *Yangibana Heritage Site Register*;
    - information on areas of cultural heritage significance are provided as part of the *HSEC Induction*; and
    - detailed maps (*Yangibana Heritage Sites Map*) showing all known areas of heritage significance are displayed on site for perusal by ground personnel.
- If a previously unidentified area of heritage significance is found (i.e. artefacts are discovered) then the specific activity will stop immediately and follow the procedure as per the *Aboriginal Heritage Survey Protocol*; Schedule 1 of the Mining Agreement):
    - stop work and cordon off the boundary of the area;
    - immediately report to the TMWTJ People the location of the area; and
    - comply with the requirements of any applicable law.
- If a burial site is identified then the specific activity will stop immediately and a procedure will be followed including informing the Western Australian police and notifying the TMWTJ People.

Mitigation of potential indirect impacts from contamination of waterways is discussed in detail in Section 8 Terrestrial Environmental Quality.

11.7 PREDICTED OUTCOME

11.7.1 Residual impacts

No impacts to known areas of heritage significance will occur as a result of implementation of the Proposal. If cultural heritage sites, identified during future surveys, occur within the disturbance footprint then Hastings will avoid impact where possible. However, if it is not possible to avoid impact then Hastings will submit a Section 18 application seeking permission to disturb the site. Mitigation actions are identified to avoid indirect impacts to cultural heritage values (known and unknown). In addition, Hastings will continue to acknowledge the importance of the environment to the TMWTJ People, and will continue to consult with and involve the TMWTJ People in environmental management and monitoring activities via the Implementation Committee.

11.7.2 EPA objective

With mitigation, the Proposal will meet the EPAs objective for the environmental factor, social surroundings:

> *To protect social surroundings from significant harm.*

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MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Chapter 12

12 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

12.1 EPBC ACT OBJECTIVES

The objectives of the *Environment Protection and Biodiversity Act 1999* (Commonwealth; EPBC Act) are to:

Provide for the protection of the environment, especially matters of national environmental significance.

Conserve Australian biodiversity.

Provide a streamlined national environmental assessment and approvals process.

Enhance the protection and management of important natural and cultural places.

Control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife.

Promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources.

Recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity.

Promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

12.2 POLICY AND GUIDANCE

Laws and regulations relevant to the consideration of Matters of National Environmental Significance (MNES) include:

Environment Protection and Biodiversity Conservation Act 1999 (C'th; EPBC Act)

EPBC Regulations 2000 (C'th)

Relevant guidelines include:

Australian Government Department of the Environment (2013) Matters of National Environmental Significance. Significant Impact Guidelines 1.1 - Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act provides for the protection of nationally and internationally significant flora, fauna, ecological communities and heritage places. Under the EPBC Act, the potential to significantly impact the following Matters of National Environmental Significance (MNES) trigger the requirement for assessment as a 'controlled action':

- World heritage properties.
- National heritage places.

- Wetlands of international importance (listed under the RAMSAR Convention).
- Listed threatened species and ecological communities.
- Migratory species protected under international agreements.
- Commonwealth marine areas.
- The Great Barrier Reef Marine Park.
- A water resource, in relation to coal seam gas or coal mining.
- Nuclear actions (including uranium mines).

The proposal was deemed a 'controlled action' under the EPBC Act. The 'nuclear action' was deemed the controlling provision that required assessment as per section 21 and section 22A of the EPBC Act. As defined in clause 22(1)(e) of the EPBC Act and clauses 2.02(1)(c) and 2.02(2) of the EPBC Regulations 2000 (Cwth), the Proposal may be considered a nuclear action due to two tailings storage facilities (TSFs) being considered "large scale facilities for the disposal of radioactive waste".

Radionuclides concentrate in different process streams, particularly the beneficiation regrind and flotation circuit, and the hydrometallurgical circuit. Tailings will be disposed into three distinct TSFs, each with different uranium and thorium concentration ratios relative to the ore. Tailings in TSF 1 will be <1 Bq/g. TSF 2 and TSF 3 will have average concentrations of 4 Bq/g and 32 Bq/g, respectively. TSF 2 and TSF 3 tailings represent less than 9% of the tailings generated by the ore processing plant. TSF 2 and TSF 3 trigger the "nuclear action" criteria specified in the EPBC Act and EPBC Regulations.

No other MNES triggered the requirement for assessment.

This chapter addresses sections 21 and 22A under the EPBC Act, with a specific focus on TSF 2 and TSF 3.

At a national level, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) provides guidance and codes. The main ARPANSA radiation code that applies to the proposal is the *Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, 2005* (also known as the Mining Code) (ARPANSA 2005).

ARPANSA references international guidance from The International Atomic Energy Agency (IAEA), the Recommendations of the International Commission on Radiological Protection (ICRP) and on the Reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The internationally recognised basis of radiation protection is the ICRP recommended 'System of Dose Limitation'. This requires that planned doses to workers or to members of the public from industrial activities need to be justified, optimised and limited:

- Justification – this means that a practice involving exposure should only be adopted if the benefits of the practice outweigh the risks associated with the exposure.
- Optimisation – this means that the doses and potential costs should be balanced so that doses are As Low As Reasonably Achievable (ALARA), taking into account economic and social factors. This is also known as the ALARA principle.
- Limitation – this means that individuals should not receive doses greater than the prescribed dose limits.

Within the 'system of dose limitation', the ALARA principle is generally regarded as the most important and the most effective of these elements for the control and management of radiation.

While the ALARA principle is the foundation for radiation protection, prescribed dose limits have been established to provide an absolute level of protection. The limits apply only to the dose received as a result of a 'practice', and excludes natural background emissions levels. The limits are:

- 20 mSv/y for a worker (averaged over 5 years, with a maximum of 50mSv/y in any one year.
- 1 mSv/y for a member of the public (averaged over 5 years).

The method of dose assessment for workers and the public is based on the recognised methods of the ICRP as outlined in national standards, including the Mining Code and ARPANSA (2010).

12.3 Receiving environment

The Proposal will process ore that contains naturally occurring uranium (U) and thorium (Th) with average concentrations of 27 parts per million (ppm) and 450 ppm, respectively. The ore is defined as radioactive material i.e. it contains radionuclides above 1 Bq/g.

In describing the receiving environment, the following reports have been undertaken:

- Baseline radiation studies describing background radiation levels in the surrounding environment (RadPro 2016a, Appendix 5-4)
- Waste characterisation studies: Ore and waste rock (RadPro 2016b, Appendix 5-5), and tailings (JRHC 2017, Appendix 5-5)
- Design of the Tailings Storage Facilities (ATC Williams 2017, Appendix 6-3)

12.3.1 Baseline radiation studies

Baseline radiation studies conducted to-date included:

- Gamma radiation.
- Radionuclides in dust particles.
- Radon and thoron gas concentrations.
- Radionuclides in soil.
- Radionuclides in groundwater and surface water.

Detailed descriptions of the studies are provided in Chapter 8 Terrestrial Environmental Quality (section 8.3.6) and Chapter 9 Human Health (section 10.3.1).

The radiation monitoring to-date has shown the following:

- Gamma radiation levels in the region are generally elevated in the vicinity of the ore body.
- Radon concentrations are spatially and temporally variable.
- The radiation levels observed are consistent with levels reported at other similar projects.

12.3.2 Waste characterisation studies

Analysis of ore, waste rock and tailings materials has been conducted during the development of the metallurgical testwork program. The most recent results are from tailings samples generated during a pilot plant test work program.

In summary,

- The ore body contains naturally occurring radionuclides at 2 Bq/g.
- Waste rock contains radionuclides below 1 Bq/g, however due to the scale of the equipment used during mining, there may be small volumes of waste rock that exceed 1 Bq/g.
- Three tailings streams generated from the process plant have radionuclide concentrations from:
    - rougher tailings generated by beneficiation process will be deposited in TSF 1: <1 Bq/g;
    - smoother tailings generated by the beneficiation process will be deposited in TSF 2: 4 Bq/g;
    - tailings generated by the hydrometallurgical plant will be deposited in TSF 3: 32 Bq/g; and
    - radionuclides are below 1 Bq/g in tailings pore water of all tailings streams.

Further detail is provided in Chapter 8 Terrestrial Environmental Quality (section 8.3.5) and Chapter 9 Human Health (section 10.3.2).

12.3.3 Design of the Tailings Storage Facilities

The TSFs have been designed to comply with the *Code of Practice -Tailings Storage Facilities in Western Australia* issued by the Western Australian Department of Mines, Industry Regulation and Safety (DMIRS) (formerly Department of Mines and Petroleum (DMP; 2013)).

The design of the TSFs and the content of the TSF design report (ATC Williams 2017b; Appendix 6-3) also conforms to:

- DMP (2015) *Guideline to the preparation of a design report for tailings storage facilities* (TSFs), which includes a requirement to justify the basis of the design and the parameters adopted for the engineering design, construction, operation, rehabilitation and closure of the TSF.
- Australian National Committee on Large Dams (ANCOLD; 2012) *Guidelines on tailings dams - planning, design, construction, operation and closure.* ANCOLD prepares and issues guidelines, which represent best engineering practice, and are widely used across Australia and internationally. ANCOLD is an active member of the International Commission on Large Dams (ICOLD), which shares international practice and new techniques to advance all aspects of TSF engineering.

The development of a design concept took into consideration tailings storage capacity requirements, and the physical, geochemical and radiological properties of the various tailings streams, and ground (hydrogeology; geotechnical) and climatic conditions. The design of TSF 2 and TSF 3 will be paddock type facilities with spigotted perimeter discharge lines. Provision of a composite geomembrane / compacted clay liner is proposed for TSF 3. At the time of referral of the proposal to the Department of the Environment and Energy (December 2016), Hastings had planned to also line TSF 2, however, ATC Williams (2017b; Appendix 6-3) have since determined this is not required based on recent geochemical analysis of tailings pore water and outcomes of a seepage assessment.

Further considerations in the design of TSF 2 and 3 are summarised in Chapter 8 Terrestrial Environmental Quality, and included:

- Specific design requirements for tailings dams as per DMIRS (formerly DMP 2015) and ANCOLD (2012) depending on the TSF type and category.
- A dam break assessment.
- Stormwater retention.
- Spillway capacity.
- Seismic loading.

Furthermore, ATC Williams (2017b; Appendix 6-3) further refined the design concept for each TSF, taking into consideration the following:

- Construction materials and source.
- Water storage requirements and freeboard.
- Storm water storage events.
- Surface water management and drainage.
- Water balance.
- Embankment stability.
- Liquefaction assessment.
- Seepage assessment.

12.4 POTENTIAL IMPACTS

Mining of ore will disturb areas that contain elevated concentrations of uranium and thorium or other elevated radionuclides. The potential impact of radiation exposure occurs via the following main exposure pathways:

- Gamma irradiation and absorption by workers in close proximity to material with elevated radioactive levels.
- Inhalation of radon decay products (RnDP) and thoron decay products (TnDP).
- Inhalation of radionuclides in dust.
- Ingestion of radionuclides by animals or plants (for consumption by humans).
- Radiation exposure to members of the public on the rehabilitated landform.
- Impacts to flora and fauna.

12.5 ASSESSMENT OF IMPACTS

12.5.1 Workers and members of the public

An assessment of the potential impacts to humans, as a result of operations, was completed by JRHC (2016; Appendix 5-6) is provided in section 9.5 of Chapter 10 Human Health. This included estimates of workers doses, specifically for:

- Mine workers (section 9.5.3).
- Process plant workers (section 9.5.4).
- Other workers (section 9.5.5).

In addition, the assessment included exposure doses to members of the public at sensitive receptor locations (i.e. accommodation village - 5 km from process plant, Gifford Creek Station homestead - approximately 10 km to the south of the process plant, and Edmund Station homestead - approximately 20 km north of the main project area (section 9.5.6). The assessment assumed that a member of the public resides at the sensitive receptor for a full year at the Edmund and Gifford Creek Station homestead locations, and 4,000 hours per year for the accommodation village location.

The potential exposure pathways to humans includes:

- Gamma irradiation.

- Inhalation of radon decay products (RnDP) and thoron decay products (TnDP).
- Inhalation of radionuclides in dust.
- Ingestion of animals or plants that have come into contact with emissions (sensitive receptor locations only).

The key assumptions in occupational dose assessment are as follows:

- Worker exposure hours (working year) – 2,000h/y.
- Worker breathing rate – 1.2m^3/h.
- Radon decay product conversion factor 1.2mSv /mJ (workers) (ARPANSA 2005).
- Thoron decay product conversion factor 0.39mSv /mJ (workers) (ARPANSA 2005).
- Radon/RnDP equilibrium factor is 0.4 (UNSCEAR 2000).
- Thoron/TnDP equilibrium factor is 0.01 (Arafura 2016).
- Mine dust mass concentration of 3mg/m^3.
- Radionuclide in dust inhalation for uranium in ore 7.2µSv/αdps (ARPANSA 2005).
- Radionuclide in dust inhalation for thorium in ore 11µSv/αdps (ARPANSA 2005).

Note that for radon and thoron decay product conversion factors, the IRCP has suggested a higher dose factor (ICRP 2015). While this new higher factor is not yet included in government guidelines, it was determined that an additional assessment would be conducted using the new factor (and thus was considered in the assessment).

In summary, the impact assessment determined that dose exposure was well below the limits of:

- 20 mSv/y for a worker (averaged over 5 years, with a maximum of 50mSv/y in any one year).
- 1 mSv/y for a member of the public (averaged over 5 years).

In addition, the assessment also considered radiation exposure to members of the public on the rehabilitated landform. The following radiation exposure scenarios to members of the public from the rehabilitated landforms were considered:

- Gamma radiation at 1m above the TSFs.
- Radon exhalation rates from the TSFs.

Placing inert cover material above the tailings acts as a shield and attenuates the gamma radiation coming from the tailings. It was determined that gamma dose rates would be reduced to acceptable levels should 1m of inert cover material be placed on TSF 2 and TSF 3 at closure.

For radon emission, the cover material constrains the rate of migration of radon so that the radon decays within the cover material and is therefore unable to be released into the atmosphere. The rate of constraint is dictated by the permeability of the cover material to inert gases. Therefore, taking into radon emission rates and permeability of different cover materials to inert gases, the following prescribed cover for each TSF:

- TSF 2: 0.5 m of soil and 0.24 m of clay;

- TSF 3: 0.5 m of clay,

would reduce post closure radon emissions to approximately 0.1 $Bq/m^2/s$.

While the radiation impact assessment (Chapter 9 Human Health, section 9.5.7) indicated that anticipated doses to workers and members of the public would be low and well below the annual dose limits, a health risk assessment was then undertaken to determine potential exposure situations where doses may be higher than expected. Activities associated with potential exposure situations were identified and an assessment of the likelihood and consequence was made. Where necessary, mitigation measures were also identified.

12.5.2 Flora and fauna

An ERICA assessment has been conducted to assess potential impacts to flora and fauna. This is described in detail in Chapter 11 Social Surroundings, section 11.3.4. The ERICA assessment indicated that there is no radiological risk to reference plants and animals including kangaroos from emissions from the proposal.

12.6 Mitigation

Hastings has applied the following mitigation hierarchy relevant to elevated radionuclides stored in TSF 2 and TSF 3:

- Best Practice.
- Avoidance.
- Minimisation.
- Management.
- Rehabilitation.

Chapter 8 Terrestrial Environmental Quality (section 8.6) and Chapter 9 Human Health (section 9.6) describes the application of the mitigation hierarchy relevant to radiation.

Hastings has considered the potential risks and impacts as a result of the proposal. In doing so, Hastings has:

- Conducted baseline studies.
- Conducted waste characterisation studies.
- Conducted an impact assessment.
- Conducted an environmental risk assessment for the Proposal, including impacts to environmental receptors from the presence of TSF 2 and TSF 3.
- Developed measures to mitigate these risks to as low as reasonably acceptable (ALARA).

Hastings has a high level of confidence that radiological impacts will be low. Management measures to ensure this outcome include the following key documents:

- Radiation Waste Management Plan (Appendix 5-7).
- Radiation Management Plan (Appendix 5-8).
- Preliminary Mine Closure Plan (Appendix 6).

An Environmental Management System (EMS) and Safety Management System (SMS) will be implemented to manage all environmental and safety aspects of the Proposal. The above-listed Management Plans with form a component of the EMS and SMS.

12.7 PREDICTED OUTCOME

Taking into account the 'system of dose limitation', the predicted outcomes are discussed in context of the three key elements as follows:

- Justification – naturally occurring radionuclides are associated with the target rare earths ore body. During processing they become concentrated in two of the three tailings streams. It is not possible to avoid mining and concentrating the radionuclides. However, an impact assessment to determine dose demonstrated that occupational and public doses are well below the dose limit.
- Optimisation – exposure to doses are reduced to As Low As Reasonably Achievable (ALARA), by maintaining a 'wet' processing plant and 'wet' tailings in TSF 2 and 3 to reduce potential dust generation. Considerations during design, operations and closure also consider reducing doses to ALARA as described in the RMP and RWMP. Encapsulation of the tailings waste and capping of TSF 2 and 3 at closure will also ensure doses are reduced to ALARA and are representative of the background gamma levels. A TSF operating manual will also ensure the TSFs are constructed in accordance with design specifications and will describe monitoring of the integrity of each TSF structure to be conducted during the operations phase.
- Limitation – the impact assessment determined that doses will not exceed the prescribed dose limits for the workforce or members of the public. Development and implementation of a safety management system, establishment of a safety culture, and implementation of the mitigation hierarchy will ensure human health is protected from exposure pathways. A precautionary approach will be maintained commensurate with the level of risk.

Therefore, residual impacts from radiation to workers, the public and the surrounding environment are low.

HOLISTIC IMPACT ASSESSMENT

Chapter 13

13 HOLISTIC IMPACT ASSESSMENT

The greatest benefit of this Proposal is its contribution to a more sustainable energy market and progress in medical technologies (amongst other technologies and innovations), which plays a key role in satisfying the principle of intergenerational equity.

The Proposal will bring economic opportunities to an area that has a significant need of job opportunities for its residents and industries. It will do so in a manner that is environmentally sustainable and will produce a product that is a critical component of the worldwide renewable energy transition, such as electric vehicles and wind energy generation.

A thorough understanding of the surrounding environment has been achieved with baseline studies of:

- Flora and vegetation
- Fauna, including vertebrates, short range endemic fauna and subterranean fauna
- Groundwater
- Surface water
- Waste, including AMD and radionuclide assessments
- Soils
- Baseline radiation assessment (air, soil, water)
- Air quality, including dust
- Heritage values

A direct impact to flora and vegetation will occur from ground disturbance (approximately 1000 Ha). This also represents potential fauna habitat. Surveys have shown that all flora and fauna species, vegetation types and habitat are well represented outside of the development envelope and thus the proposal satisfies the EPAs objectives for these environmental factors:

- Flora and vegetation: *To protect flora and vegetation so that biological diversity and ecological integrity are maintained.*
- Fauna: *To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.*

Subterranean fauna species were found within the pit footprint. Further consideration of their interconnections with the broader Gifford Creek Priority Ecological Community (the PEC) instigated a regional survey to determine the representation of species outside of the footprint. A greater diversity and species richness was shown to occur in the PEC outside of the Proposal, thus demonstrating the direct impacts to the subterranean fauna would not compromise the biological diversity of the ecological community. In fact, as a result of these surveys, over 50 species that are new to science were found in the Gifford Creek calcrete PEC and surrounds. Hastings has contributed to our knowledge of biodiversity in the region by commissioning these studies.

Surface water studies and management plans demonstrate that there are no downstream impacts on the local and regional surface water drainage systems and any risks can be managed appropriately.

Groundwater assessments included the characterisation of aquifers associated with the proposed mine pit and their interconnectivity with the shallow calcrete aquifer network of the PEC. The fractured rock aquifers associated with the proposed pit dewatering activities were shown to have no interconnection with the calcrete aquifers of the PEC. Consideration of potential impacts from water drawdown associated with pit dewatering activities was also undertaken. A restricted water drawdown impact, associated with the fractured rock aquifers within the pit footprints, also confirmed the lack of connectivity with the PEC habitat and demonstrated this would have no impact on the ecological integrity of the PEC. However isotopic analysis and additional hydrogeological assessment demonstrated the fractured rock aquifers will not provide a sustainable water supply capable of supporting the full process plant water demand. The design of the Hastings water exploration program proactively avoided the network of shallow calcrete aquifers of the Gifford Creek calcrete PEC. Water abstraction from a deep palaeochannel tributary at the SipHon Well Borefield also took account of the PEC and its relationship with shallow calcrete aquifers in the area. The lithology of the aquifer, water quality and water level drawdown modelling demonstrated a sustainable water source with limited hydraulic connectivity to the shallow calcrete aquifer system in the local area. As such the principle of the conservation of biological diversity and ecological integrity was applied and meets the EPA's objective:

- Subterranean fauna: *To protect subterranean fauna so that biological diversity and ecological integrity are maintained.*

The PEC is also closely associated with the Lyons River and pastoral bores. There are also Aboriginal heritage values of the Lyons River. Concerns of groundwater contamination associated with the geochemical nature of the tailings were raised during consultation with pastoralists and traditional owners.

The ore that is processed contains naturally occurring radioactive material (NORM). Characterisation of tailings waste revealed that two of the tailings streams will contain elevated NORM in the solids component of the tailings stream. Analysis of tailings pore water generated from laboratory and pilot process plant studies, and those generated by kinetic leach testing showed that concentrations of radionuclides were well below 1 Bq/g, confirming that the NORM is not water soluble. Design and management of the tailings storage facilities will ensure risk of groundwater (as well as land and air quality) contamination is mitigated (as described in the Radiation Waste Management Plan). Human health was also considered due to the naturally occurring radionuclides associated with the ore body, and the concentration of these in the processing plant. Risk to our workforce and members of the public were demonstrated to be well below exposure limits, as was also demonstrated for flora and fauna using an ERICA assessment. Mitigation of potential indirect impacts will ensure the EPA's objectives are met:

- Terrestrial Environmental Quality: *To maintain the quality of land and soils so that environmental values are protected.*
- Inland Waters Environmental Quality: *To maintain the quality of groundwater and surface water so that environmental values are protected.*
- Human Health: *To protect human health from significant harm.*

Impacts associated with waste management have been considered more broadly. The polluter pays principle has been applied to ensure Hastings bears the cost of containment and encapsulation of tailings with elevated radionuclides in accordance with relevant policy and guidelines. The principle of waste minimisation has been and will continue to be applied to minimise the generation of waste. Waste management (i.e. waste rock landforms and tailings storage facilities) is also a key consideration in the closure phase of the proposal. Tailings test work has shown that the tailings can settle out efficiently in accordance with the design parameters and closure rehabilitation can be practically achieved. As such, landform evolution modelling (over a 1000-year period) prescribed landform design specifications to be implemented during each phase of the Project and a Preliminary Mine Closure Plan will continue to be developed in consultation with relevant stakeholders (including the EPA, DWER and DMIRS).

The Proposal has been designed to ensure that the NORM material is removed from the ore though processing and is retained on-site. As such the Rare Earths product that is produced by the Proposal can be safely transported as general freight cargo by using existing logistics operators and ports and the risk of environmental contamination outside the Proposal area is minimal.

The consideration of risks associated with implementing the proposal against environmental factors have been assessed (Chapters 5-11). A conservative approach has been taken to determine the management of potential risks to the environment. As such the precautionary principle has been applied and will continue through the implementation of an Environmental Management System (aligned with the international standard ISO 14001) during construction, operations and closure phases of the proposal.

Review of risks, identification of information gaps where there is a lack of full scientific certainty and application of the precautionary principle will be on-going throughout the life of the proposal, including closure. Management plans will therefore remain dynamic and will be reviewed annually to ensure the continual improvement of management performance in meeting environmental objectives (goals) and targets.

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Chapter 14

14 REFERENCES

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APPENDICES

Chapter 15

15. APPENDICES

FLORA AND VEGETATION

Appendix 1-1 Flora and Vegetation Assessment (Ecoscape 2015)

Appendix 1-2 Flora and Fauna Memo: Access Road (Ecoscape 2017)

Appendix 1-3 GDE Memo (Ecoscape 2017)

Appendix 1-4 Flora and Fauna Assessment (EcoLogical 2017)

Appendix 1-5 Flora and Vegetation Environmental Management Plan (Hastings 2018)

TERRESTRIAL FAUNA

Appendix 2-1 Terrestrial Fauna (Ecoscape 2016a)

Appendix 2-2 Ecotoxicity Assessment (Hastings 2017a)

Appendix 2-3 Preliminary Fauna Management Plan (Hastings 2017b)

SUBTERRANEAN FAUNA

Appendix 3-1 Subterranean Fauna Assessment (Ecoscape 2016b)

Appendix 3-2 Subterranean Fauna Assessment (Bennelongia 2018)

WATER

Appendix 4-1 Conceptual Hydrogeological Assessment (Global Groundwater 2016)

Appendix 4-2 Hydrogeological Report Fractured Rock Aquifer II (GRM 2018a)

Appendix 4-3 Surface Water Assessment (JDA 2016)

Appendix 4-4 Water Management Plan (GRM and Hastings 2017)

Appendix 4-5 Hydrogeological Report Palaeochannel Tributary II (GRM 2018b)

MATERIALS CHARACTERISATION

Appendix 5-1 Waste Characterisation Reports (Trajectory and Graeme Campbell & Associates, 2016, 2017)

Appendix 5-2 Soils Assessment Reports (Landloch 2016a, 2017)

Appendix 5-3 Preliminary Landform Surface Erodibility Assessment (Landloch 2016b)

Appendix 5-4 Baseline Radiation Report (RadPro 2016a)

Appendix 5-5 Radiation Waste Characterisation Report (RadPro 2016b and JRHC Enterprises 2017)

Appendix 5-6 Radiation Impact Assessment (JRHC Enterprises 2016)

Appendix 5-7 Radiation Waste Management Plan (Hastings 2017)

Appendix 5-8 Radiation Management Plan (Safety Resources and Hastings 2017)

Appendix 5-9 Tailings Storage Facility Geotechnical Assessment (ATC Williams 2017)

Appendix 5-10 Yangibana Geology Technical Note (Border 2016)

Appendix 5-11 Waste Rock Management Plan (Trajectory and Hastings 2017)

Appendix 5-12 Tailings Leach Study Report (Trajectory and Graeme Campbell and Associates 2018)

CLOSURE

Appendix 6 Preliminary Mine Closure Plan (Ecoscape, Trajectory and Hastings 2017)

Appendix 6-1 Landform Evolution Assessment (Trajectory 2017)

Appendix 6-2 Tailings Storage Facility Closure: Design Considerations Technical Note (JRHC Enterprises 2017)

Appendix 6-3 Tailings Storage Facility Design Report Draft Rev 0 (ATC Williams 2018)

AIR QUALITY

Appendix 7-1 Air Quality Assessment (Pacific Environment 2016)

Appendix 7-2 Memo: Radon and thoron modelling (Pacific Environment 2016)