



Roy Hill Development Project
Short-Range Endemic Invertebrate Fauna
Desktop Assessment

Roy Hill Iron Ore
January 2020



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Final	Morgan Lythe	Brad Durrant	Tegan Stone	03/03/2020

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EXECUTIVE SUMMARY

Roy Hill Iron Ore (RHIO) is proposing to revise and expand the current development envelope for the Roy Hill Mine, located 115 km north of Newman in the Pilbara Region (see Figure 1.1). Since the original proposal, RHIO has further explored the extent and quality of the orebody which has resulted in changes to the Life of Mine (LOM) Plan. These changes are to be reflected in a Revised Proposal as required under s38 of the EP Act.

Several short-range endemic (SRE) invertebrate fauna surveys were conducted within and surrounding the current Development Envelope between 2006 and 2013. This document provides an overview of these previous SRE surveys and provides recommendations for determining the potential for SRE species to occur throughout the Revised Development Envelope (RDE), hereafter known as the Study Area.

Nine SRE invertebrate surveys were conducted within and surrounding the Study Area from 2006 to 2013. Surveys have been undertaken predominantly in the wet season, though some dry season sampling has been conducted. Surveys have been conducted over much of the Study Area, though most thoroughly in the northern section.

Two online databases and three Western Australian Museum (WAM) databases were searched for invertebrate fauna records in the vicinity of the Study Area. A review of all publicly available literature relevant to the Study Area and surrounding areas (within a 40 km radius) was also undertaken in December 2019. A comprehensive list of all SRE invertebrate records within the vicinity of the Study Area was compiled. Every specimen record was assigned an SRE classification; these were Confirmed SRE, Potential SRE or Widespread. Widespread taxa records were removed. Each record was also assessed as to its occurrence inside and outside the Study Area.

The review of databases and previous SRE survey reports for the Study Area yielded an SRE invertebrate fauna list comprising 602 records of Confirmed and Potential SRE invertebrates representing 85 species, morphospecies and higher taxonomic records occurring within 10 km of the Study Area. Of these 85 taxa, 27 were found to occur within the Study Area. Of the 27 taxa, four were considered Confirmed SRE and 23 were considered Potential SRE. The taxonomy and SRE status for many of the species recorded in the previous surveys appear to have changed little since 2012. However, there may be molecular information available for some of these groups as the WAM is increasingly resolving taxonomic uncertainty with molecular phylogenetic studies.

Whilst there is limited sampling undertaken within the southern extent of the Study Area, the dominance of Low suitability, highly connected habitats make it unlikely that

this would be regarded as inadequately sampled. The northern section of the Study Area can also be regarded as adequately sampled.

The habitat mapping shows that the Study Area is dominated by Low suitability, highly connected habitats (Sandy/Stony Plains, Drainage Area/Floodplain and Drainage Lines) with a small area of Moderate suitability Hillcrest/Hillslope habitat in the north-east. The habitat mapping shows that all habitats recorded extend well beyond the Study Area and therefore the likelihood that any SRE invertebrate fauna will be restricted to the Study Area is considered very low.

Based on a preliminary assessment of cumulative impacts to SRE invertebrates, we have determined that impacts will be considered Low for all species except *Antichiropus sloanae*. *Antichiropus sloanae* is known only from the local area and was collected from the Drainage Areas in the northern RDE. However, it is likely to be restricted to the Hillcrest/Hillslope habitat where individuals are protected amongst deep pockets of soil and leaf litter within rocky habitats or on the hillcrest at the base of trees such as *Corymbia hamersleyana*.

This local extent of Hillcrest/Hillslope habitat totals approximately 15,982 ha. Previously approved clearing within the RDE has removed approximately 664 ha (~4%) of this habitat type. Proposed additional clearing will clear another 1,185 ha, for a total of 1,849 ha of this habitat cleared (11.5%). The removal of the Hillcrest/Hillslope habitat within the RDE would likely fragment the remaining areas of suitable habitat into two areas: a northern section of approximately 10,739 ha and a southern section of approximately 3,193 ha. The resulting gap of six kilometres can be regarded as a potentially significant barrier for individuals to disperse across.

Based on a complete development scenario within the RDE, a Low/Moderate cumulative impact level has been identified for this species. This is based on the direct removal of habitat and other indirect impacts, such as habitat fragmentation. If this species is found to occur beyond the extent we have extrapolated, the impacts to this species can be revised and will be lower than the local impacts.

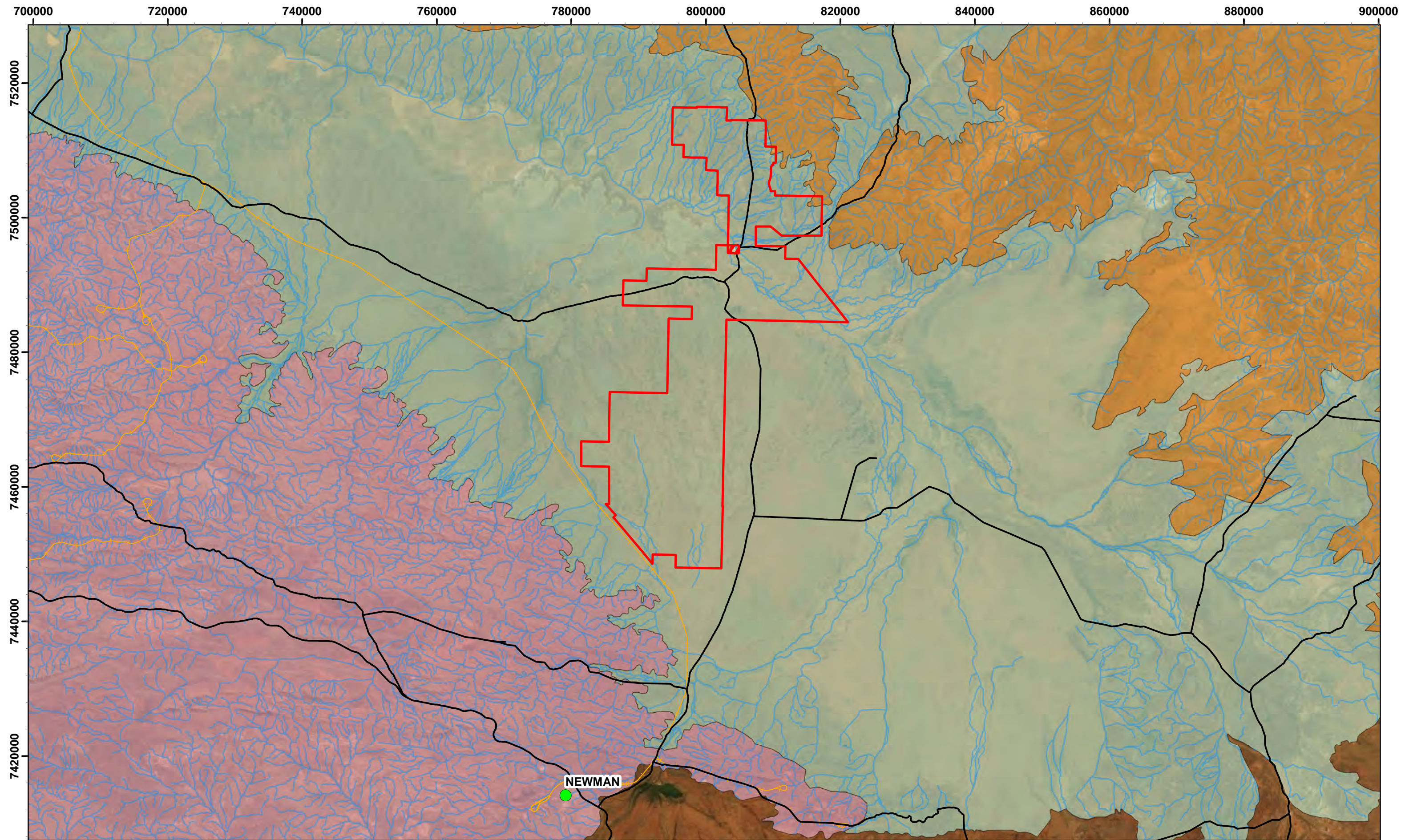
1 INTRODUCTION

Roy Hill Iron Ore (RHIO) is proposing to revise and expand the current development envelope for the Roy Hill Mine, located 115 km north of Newman in the Pilbara Region (see Figure 1.1). Since the original proposal, RHIO has further explored the extent and quality of the orebody which has resulted in changes to the Life of Mine (LOM) Plan. These changes are to be reflected in a Revised Proposal as required under Section 38 of the Environmental Protection Act 1986 (EP Act).





Several short-range endemic (SRE) invertebrate fauna surveys were conducted within and surrounding the current Development Envelope between 2006 and 2013. This document provides an overview of these previous SRE surveys and provides recommendations for determining the potential for SRE species to occur throughout the Revised Development Envelope (RDE), hereafter known as the Study Area as outlined in Figure 1.1.

Biologic Environmental Survey (Biologic) focuses on two main issues associated with the assessment of SRE invertebrate fauna with respect to the Environmental Impact Assessment (EIA) and approvals process. The first issue is survey adequacy; baseline fauna surveys in the Pilbara typically include two seasons (wet and dry) in order to capture seasonal variation in the occurrence/activity of species. This is particularly important for SRE invertebrate fauna which have two main periods of activity during the year; one is the movement of adults for breeding (often associated with rainfall events) and the other is the movement of juveniles for dispersing (often associated with cooler periods). The second issue is the need to bring the previous survey work and habitat assessments up to date with the current knowledge of SRE invertebrate taxonomy, and if possible, investigate further opportunities for reassessing the perceived risks to the fauna.



The aim of this SRE invertebrate desktop assessment was to identify and map any Confirmed and/or Potential SRE taxa known from the Study Area and immediate surrounds, and to develop a better understanding of the likely distributions (through habitat assessment) and potential habitats for these species both within and outside the Study Area. We also provide a preliminary analysis of potential impacts to the distribution of any Confirmed and/or Potential SRE taxa known from the Study Area

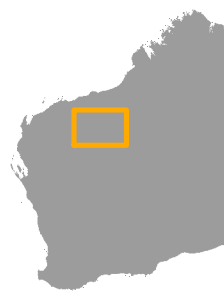
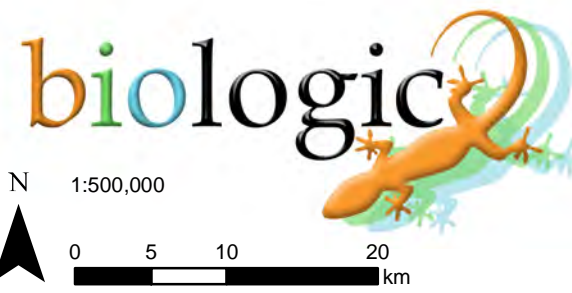


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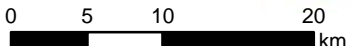
-  Road
-  Rail
-  Creeklines
-  Revised Development Envelope

IBRA Subregions

-  Chichester
-  Fortescue
-  Hamersley

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Roy Hill
SRE Desktop Review
Fig 1.1: Study area and regional location

Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

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1.1 Short-range endemic fauna

Endemism refers to the restriction of a species to a particular area, whether it is at the continental, national or local scale, the latter being commonly referred to as short-range endemism (Allen *et al.*, 2002). Short-range endemism is influenced by several factors including life history, physiology, habitat requirements and availability, dispersal capabilities and opportunities, biotic and abiotic interactions and historical conditions, which not only influence the distribution of a species, but also the tendency for differentiation and speciation (Ponder & Colgan, 2002).

In recent years, a number of invertebrate taxonomic groups have been highlighted as comprising a high proportion of species likely to be regarded as short-range endemics (*i.e.* Harvey (2002); freshwater snails: Ponder and Colgan (2002); land snails: Johnson *et al.* (2004); mygalomorph spiders: (Main *et al.*, 2000). This identification of restricted taxonomic groups has led to the inclusion of SRE invertebrate fauna as an important component of the environmental impact assessment process, as it has provided a focal point for survey work aimed at protecting species of high conservation value.

SRE classification

The SRE categories used in this report broadly follow the WAM’s revised classification system for SRE invertebrates. This system is based upon the 10,000 km² range criterion proposed by (Harvey, 2002) and uses three broad categories to deal with varying levels of taxonomic certainty that may apply to any given taxon (Table 1.1).

Table 1.1: SRE categorization used by Harvey (2002) and WAM

Distribution	Taxonomic Certainty	Taxonomic Uncertainty
< 10 000 km ²	<p>Confirmed SRE</p> <ul style="list-style-type: none"> • A known distribution of < 10,000 km². • The taxonomy is well known. • The group is well represented in collections and/or via comprehensive sampling. 	<p>Potential SRE</p> <ul style="list-style-type: none"> • Patchy sampling has resulted in incomplete knowledge of geographic distribution. • Incomplete taxonomic knowledge. • The group is not well represented in collections. • Category applies where there are significant knowledge gaps.
> 10 000 km ²	<p>Widespread (not an SRE)</p> <ul style="list-style-type: none"> • A known distribution of > 10,000 km². • The taxonomy is well known. • The group is well represented in collections and/or via comprehensive sampling. 	<p>SRE Sub-categories may apply:</p> <ul style="list-style-type: none"> A) Data Deficient B) Habitat Indicators C) Morphology Indicators D) Molecular Evidence E) Research & Expertise

Under this system, “Potential SRE” status is the default category for species within the typical SRE taxonomic groups, including mygalomorph spiders, selenopid spiders, land snails, pseudoscorpions, scorpions, and isopods, unless sufficient evidence exists to confirm Widespread or Confirmed SRE status.

Potential SRE status is further categorized based on current knowledge of the species in question; *i.e.* whether there are B) habitat indicators, C) morphology indicators, D) molecular evidence, or E) a weight of general knowledge and experience with the group that suggests a reasonable likelihood that the species is an SRE. In terms of SRE likelihood, the more evidence that exists under sub-categories 'B', 'C', 'D', and 'E', the greater the likelihood that further investigation would confirm the species is an SRE.

Potential SRE category 'A' - data deficient, indicates that current information is insufficient to adequately assess the SRE status of the taxa in question. In such cases, where the SRE status cannot be confirmed, a conservative approach would be unable to assess the species as high potential to be SRE where:

- A. the taxonomy of the genus (or family) requires significant review in order to make any statement on SRE status, and/or
- B. the genus is not known to include any confirmed SRE species within the region (subject to the extent of prior sampling / taxonomic effort).

To avoid confusion with other Potential SRE species for which there is some certainty and/or some precedent for their SRE status, this report represents the WAM's "Potential SRE - category 'A' - data deficient" only as "data deficient". Species categorizations are presented within the broader context of habitat assessment, desktop review, habitat connectivity, and other relevant ecological information. This approach aims to provide a more holistic assessment of SRE likelihood at scales relevant to the project, as well as the standard SRE range criterion of <10,000 km² (Harvey, 2002).

2 METHODS

2.1 Compliance

This desktop assessment was carried out in a manner consistent with the Western Australian (WA) Environmental Protection Authority (EPA) for the environmental surveying and reporting of fauna, including the following documents:

- EPA Guidance Statement No. 20, Guidance for the Assessment of Environmental Factors (EPA, 2016a);
- EPA Guidance No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA, 2016b);
- EPA Environmental Factor Guideline: Terrestrial Fauna (EPA 2016c); and
- EPA Technical Guidance: Sampling of Short-Range Endemic Invertebrate Fauna (EPA, 2016c).

2.2 Review of databases

Two online databases and three Western Australian Museum (WAM) databases were searched for invertebrate fauna records in the vicinity of the Study Area (Table 2.1). The results of these database searches were examined, and all records of known SRE invertebrate groups were extracted.

Table 2.1: Databases searched for the review of previous records

Provider	Database	Reference	Search parameters
DBCA	NatureMap	(DBCA, 2019)	Circle of radius 40 km centred on the coordinates: -22.68839°, 119.981995°
Atlas of Living Australia	Species Occurrence	(ALA, 2019)	Circle of radius 10 km centred on the coordinates: -22.68839°, 119.981995°
Western Australian Museum	Arachnids and Myriapods	(WAM, 2019a)	40,000 km ² search area surrounding the Study Area with corner points: NW: -22.264369°, 119.669124° SE: -23.166669°, 120.190115°
Western Australian Museum	Crustaceans	(WAM, 2019b)	40,000 km ² search area surrounding the Study Area with corner points: NW: -22.264369°, 119.669124° SE: -23.166669°, 120.190115°
Western Australian Museum	Molluscs	(WAM, 2019c)	40,000 km ² search area surrounding the Study Area with corner points: NW: -22.264369°, 119.669124° SE: -23.166669°, 120.190115°

2.3 Review of previous surveys

A review of all publicly available literature relevant to the Study Area and surrounding areas (within a 40 km radius) was undertaken in December 2019.

SRE invertebrate reports and associated literature pertaining to the Study Area includes:

- Roy Hill Iron Ore Project Short Range Endemic Survey (ecologia, 2006);
- Roy Hill Additional SRE Survey Report (ecologia, 2008);
- Roy Hill Iron Ore Interim Short-Range Endemic Invertebrate Report (ecologia, 2009a);
- Roy Hill Remote Borefield and Pipeline Short Range Endemic Survey (ecologia, 2009b);
- Roy Hill Short-Range Endemic Desktop Survey (ecologia, 2009c);
- The Short-Range Endemic Invertebrate Fauna of Roy Hill (Ecologia Project 1106) (Western Australia)
- Roy Hill Additional Short-Range Endemic Invertebrate Survey (ecologia, 2010);
- Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine (Bennelongia, 2011);
- Level 1 Fauna Survey and Desktop Review for the Roy Hill Infrastructure Railway - Bonney Downs Alignment (Phoenix, 2011);
- Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine Feb 2012 (Bennelongia, 2012);
- Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine April to July 2013 (Bennelongia, 2013).

All SRE invertebrate records from these reports were extracted and records were compared to the WAM database search records. This was to ensure that any taxonomic updates, which would be reflected in the WAM databases, were properly captured.

Once a comprehensive list of all SRE invertebrate records within the vicinity of the Study Area was compiled, the list was paired down to include only those records occurring inside the area within 10km of the border of the Study Area. Every specimen record was assigned an SRE classification: Confirmed SRE, Potential SRE or Widespread, based on the guidelines detailed above. Widespread taxa were not assessed further. Each record was also assessed as to its occurrence inside and outside the Study Area.

2.4 Previous habitat assessment

SRE habitat mapping had not been previously undertaken for the entirety of the Study Area; however, several studies have conducted SRE habitat assessments at sites in the northern part of the Study Area (Bennelongia, 2011, 2012; ecologia, 2010). During these surveys, habitat assessments were undertaken at each of the sites sampled for

SRE fauna and included information on landform (or habitat type), type of vegetation, litter cover and disturbance. ecologia (2010) identified biophysical characteristics of the sites that made them suitable for supporting potential SRE species. Bennelongia (2012) noted that there was no statistical relationship between the measured physical attributes of the sites and the numbers of mygalomorph spider burrows. Habitats are considered of Low, Moderate or High suitability for SRE based on the habitat characteristics of the site. These characteristics are typical of a particular landform type and are verified during field surveys.

Recent flora and vertebrate fauna surveys conducted by Biologic assessed the vegetation and landforms of the entire Study Area (Biologic, 2018a, 2018b) and these maps, along with the habitat assessment by Bennelongia and ecologia, were used to extrapolate SRE habitat mapping for the entire Study Area.

2.5 Preliminary assessment of potential impacts to SRE invertebrate fauna

The preliminary assessment of potential impacts takes into account the following direct and indirect impacts at a local scale. Examples of direct impact are:

- Direct loss of fauna individuals through impacts resulting from ground disturbance machinery or vehicle movement;
- Direct impact on habitat resulting from clearing activities; or
- Direct loss or injury of individual fauna due to presence of water storage facilities and trenching for burial of pipelines.

Indirect impacts can include a decline in health and/or change in habitat composition, arising from:

- dust deposition;
- saline water disposal for dust suppression;
- groundwater abstraction or re-injection;
- alteration of surface water flows;
- introduction and spread of weeds; and
- altered fire regimes.

Both direct and indirect impacts cumulatively affect SRE invertebrate fauna distribution and persistence in the environment. These impacts can also cause the loss of small isolated populations which can have a flow-on effect of reducing the genetic variability of particular species. Cumulative impacts can be considered Low, Moderate or High (Table 2.2). We assess each SRE invertebrate taxon herewith and provide a preliminary assessment of impact if the cumulative impacts both locally and regionally are considered greater than Low.

Table 2.2. Cumulative impact categories for SRE invertebrate fauna

Category	Description
Low	Current cumulative anthropogenic impacts will not permanently affect the long-term persistence of the species as a whole and their genetic variability will be marginally impacted.
Moderate	Current cumulative anthropogenic impacts will temporarily affect the persistence of the species in the local area. Some local populations may be permanently removed but long-term persistence of species in the region will not be affected. Genetic variability within the species may be somewhat impacted.
High	Current cumulative anthropogenic impacts will affect the persistence of the species in the local area. Important source populations may be permanently removed and the long-term persistence of species in the region will be affected. Genetic variability of the species is completely impacted.

3 RESULTS

3.1 Survey effort

Nine SRE invertebrate surveys were conducted within and surrounding the Study Area from 2006 to 2013 (Table 3.1). Surveys have been undertaken predominantly in the wet season, though some dry season sampling has also been conducted. Surveys have been conducted over much of the Study Area, though most thoroughly in the northern half (Figure 3.1).

Table 3.1: Previous SRE invertebrate surveys and sampling effort within and nearby the Study Area

Survey Title	Reference	Survey Type	Sampling Sites	Habitat Assessments
Roy Hill Iron Ore Project Short Range Endemic Survey	ecologia (2006)	Wet season	6 pitfall trap sites, 46 opportunistic foraging sites	0
Roy Hill Additional SRE Survey Report	ecologia (2008)	Dry season	10	10
Roy Hill Iron Ore Interim Short-Range Endemic Invertebrate Report	ecologia (2009a)	Wet season	17	17
Roy Hill Remote Borefield and Pipeline Short Range Endemic Survey	ecologia (2009b)	Dry season	22	22
Roy Hill Additional Short-Range Endemic Invertebrate Survey	ecologia (2010)	Wet season	19	19
Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine	Bennelongia (2011)	Targeted Wet season	18	18
Level 1 Fauna Survey and Desktop Review for the Roy Hill Infrastructure Railway - Bonney Downs Alignment	Phoenix (2011)	Desktop Habitat assessment	0	11
Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine Feb 2012	Bennelongia (2012)	Targeted Wet season	14	14
Monitoring Short Range Endemic Invertebrates at the Roy Hill 1 Mine April to July 2013	Bennelongia (2013)	Targeted Habitat monitoring Wet season	16	16

740000

760000

780000

800000

820000




840000

7500000

7480000

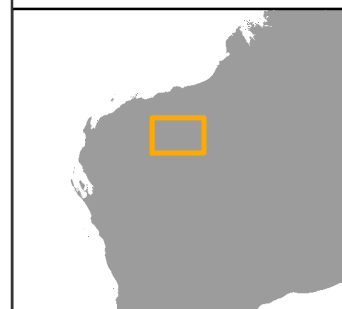
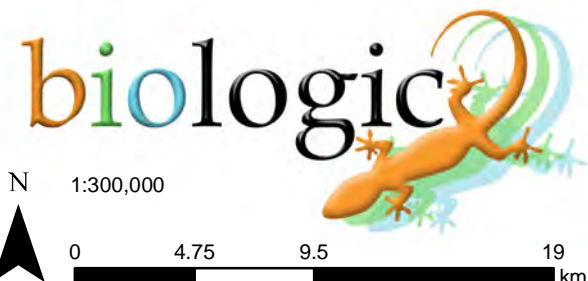
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-  Road
-  Rail
-  Revised Development Envelope

Survey

- | | |
|--|--|
|  Ecologia (2006) |  Phoenix (2011) |
|  Ecologia (2009a) |  Bennelongia (2011) |
|  Ecologia (2009b) |  Bennelongia (2012) |
|  Ecologia (2010) |  Bennelongia (2013) |

N 1:300,000

0 4.75 9.5 19 km

Roy Hill
SRE Desktop Review
Figure 3.1: Location of previous SRE invertebrate fauna sampling sites

Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

Size A3. Created 20/01/2020

3.2 Fauna records

The review of databases and previous SRE survey reports for the Study Area yielded an SRE invertebrate fauna list comprising 602 records of Confirmed and Potential SRE invertebrates representing 85 species, morphospecies and higher taxonomic records occurring within 10 km of the Study Area (Appendix A). Of these 85 taxa, 27 were found to occur within the Study Area (Figure 3.2, Table 3.2). Of the 27 taxa, four were considered Confirmed SRE and 23 were considered Potential SRE. Ten taxa occurring within the Study Area were not resolved to the species or morphospecies level due to specimens being either juvenile or female and so are considered Potential SRE (Data Deficient) and are not considered further.

Table 3.2: Confirmed and Potential SRE invertebrate taxa found to occur within the Study Area

Higher Taxon	Species	Records	Known Habitat
Confirmed SRE			
Mygalomorphae			
Idiopidae	<i>Idiosoma</i> `MYG085`	5	Sandy/Stony Plain, Drainage Line
	<i>Idiosoma</i> `MYG086`	1	Sandy/Stony Plain
Diplopoda			
Paradoxosomatidae	<i>Antichiropus sloanae</i>	5	Drainage Line
Paradoxosomatidae	<i>Antichiropus</i> sp. indet	8	Sandy/ Stony Plain, Drainage Line, (Cleared Area)
Potential SRE			
Mygalomorphae			
Actinopidae	<i>Missulena</i> `MYG252`	10	Sandy/Stony Plain, Drainage Line
	<i>Missulena</i> sp. indet.	18	Sandy/Stony Plain, Drainage Line
Barychelidae	Barychelidae sp. indet.	1	(Cleared Area)
	<i>Idiommata</i> `MYG128`	1	Drainage Line
Halonoproctidae	<i>Conothele</i> `MYG537`	3	Drainage Line
	<i>Conothele</i> `MYG538`	3	Sandy/Stony Plain
Idiopidae	<i>Idiosoma</i> sp. indet.	2	Drainage Line
Nemesiidae	<i>Aname</i> sp. indet	2	Sandy/Stony Plain, Drainage Area/ Floodplain, Drainage Line
	<i>Kwonkan</i> `MYG033`	1	Sandy/Stony Plain
Pseudoscorpiones			
Chthoniidae	<i>Austrochthonius</i> sp. indet.	3	Drainage Line
Olpiidae	<i>Beierolpium</i> `8/2`	25	Sandy/Stony Plain, Drainage Line
	<i>Indolpium</i> `sp. 1`	53	Sandy/Stony Plain, Drainage Area/ Floodplain, Drainage Line
	<i>Indolpium</i> `sp. 2`	4	Sandy/Stony Plain, Drainage Line
	Olpiidae sp. indet.	33	Hillcrest/Hillslope, Sandy/ Stony Plain, Drainage Line

Higher Taxon	Species	Records	Known Habitat
Scorpiones			
Buthidae	<i>Lychas</i> `multipunctatus complex`	8	Sandy/Stony Plain
	<i>Lychas</i> sp. indet.	4	Drainage Line, (Cleared Area)
Urodacidae	<i>Urodacus</i> `Roy Hill keeled`	3	Sandy/Stony Plain, Drainage Line
	<i>Urodacus</i> `Roy Hill smooth`	2	Drainage Line
	<i>Urodacus</i> `sp. 9`	1	Sandy/Stony Plain
	<i>Urodacus</i> `sp. nov.`	1	(Cleared Area)
	<i>Urodacus</i> sp. indet.	16	Sandy/Stony Plain, Drainage Line
	<i>Urodacus</i> `sp. Pilbara 4`	1	Sandy/Stony Plain
Gastropoda			
Bothriembryontidae	<i>Bothriembryon</i> sp. indet.	29	Sandy/Stony Plain

Mygalomorphae

Actinopidae: *Missulena* `MYG252` - Potential SRE (WAM Categories: A, D, E)

This mouse spider has been found at three sites inside, and two sites outside, the Study Area, in Sandy/Stony Plain and Medium Drainage Line habitat. It is not currently known from elsewhere in the Pilbara but due to the extent and connectivity of the habitat in which it was found, it is highly likely to occur well beyond the Study Area.

Idiopidae: *Idiosoma* `MYG085` - Confirmed SRE

Previously identified as *Aganippe* `MYG085`, records show that this armoured trapdoor spider has been found at three sites within, and one site outside, the Study Area, in Sandy/Stony Plain and Medium Drainage Line habitat. This species is currently known outside of the Study Area, from Marillana 60 km to the west of the Study Area, and from Jimblebar, 40 km to the south east.

Idiopidae: *Idiosoma* `MYG086` - Confirmed SRE

This armoured trapdoor spider was previously recorded as *Aganippe* `MYG086`. While this review found only a single record from Sandy/Stony Plain habitat within the Study Area, it has previously been recorded from Marillana, 65 km to the west.

Barychelidae: *Idiommata* `MYG128` - Potential SRE (WAM Categories: A, D, E)

While this review found only a single record of this brushed trapdoor spider morphospecies from within the Study Area, it has been previously recorded at Nammuldi-Silvergrass, 250 km to the west, and at Jimblebar, 40km to the south-east.

Halonoproctidae: *Conothele* `MYG537` - Potential SRE (WAM Categories: A, D, E)

This trapdoor spider was found at one Drainage Line site within, and two sites outside, the Study Area. No records from elsewhere in the Pilbara could be found at this time, however, due to the extent and connectivity of the habitat in which it was found, it is highly likely to occur well beyond the Study Area.

Halonoproctidae: *Conothele* `MYG538` - Potential SRE (WAM Categories: A, D, E)

This trapdoor spider has been found at one site within, and one site outside, the Study Area, in Sandy/Stony Plain habitat. It is unknown if it has been found elsewhere in the Pilbara, but due to the extent and connectivity of the habitat in which it was found, it is highly likely to occur well beyond the Study Area.

Nemesiidae: *Kwonkan* `MYG033` - Potential SRE (WAM Categories: A, D, E)

This species, originally recorded as *Yilgarnia* `MYG033`, was collected from one Sandy/ Stony Plain site within the Study Area. There are several records of this morphospecies from Jinayri, 50 km west of the Study Area.

Pseudoscorpiones

Olpiidae: *Beierolpium* `8/2` - Potential SRE (WAM Categories: A, E)

Twenty-five specimens of this morphospecies were recorded from nine sites, only one of which was located within the Study Area. *Beierolpium* `8/2` has been widely collected throughout the Pilbara; however, it is listed as Potential SRE as it likely represents a species complex (E. Volschenk, pers. comm.). The Olpiidae of the region need further morphological and molecular study in order to discern individual species and their distributions.

Olpiidae: *Indolpium* `sp. 1` - Potential SRE (WAM Categories: A)

This morphospecies was widely collected from many sites both within and outside the Study Area, in Sandy/Stony Plain, Drainage Area/ Floodplain and Drainage Line habitat. As it was not identified to any other known morphospecies, the extent of its distribution outside the Study Area is unknown; however, due to the extent and connectivity of the habitat in which it was found, it is highly likely to occur well beyond the Study Area.

Olpiidae: *Indolpium* `sp. 2` - Potential SRE (WAM Categories: A)

This morphospecies was collected from three sites within, and one outside, the Study Area, in Sandy/ Stony Plain and Drainage Area/Floodplain habitat. While it was not identified to any other known morphospecies, due to the extent and connectivity of its habitat, it is highly likely to occur well beyond the Study Area.

Scorpiones

Buthidae: *Lychas`multipunctatus` complex` - Potential SRE (WAM Categories: A, E)*

This scorpion was recorded from two sites within the Study Area, in Sandy/ Stony Plain habitat. While not recorded outside the Study Area, these records are of a well-known species complex recorded from throughout the Pilbara and due to the extent and connectivity of its habitat, it is highly likely to occur well beyond the Study Area.

Urodacidae: *Urodacus`Roy Hill keeled` - Potential SRE (WAM Categories: A)*

This morphospecies was recorded from two sites on the edge of the Study Area, one just inside and one just outside the boundary, in Sandy/ Stony Plain and Drainage Line habitat. Little is known of this morphospecies, but it is highly likely to occur well beyond the Study Area due to the extent and connectedness of its habitat.

Urodacidae: *Urodacus`Roy Hill smooth` - Potential SRE (WAM Categories: A)*

This morphospecies was recorded from one site, just inside the boundary of the Study Area, in Drainage Line habitat. Little is known of this morphospecies, but it is highly likely to occur well beyond the Study Area due to the extent and connectedness of its habitat.

Urodacidae: *Urodacus`sp. 9` - Potential SRE (WAM Categories: A, E)*

A single record of this scorpion was recorded from Sandy/ Stony Plain habitat within the Study Area. This morphospecies is well-known and distributed throughout the Pilbara.

Urodacidae: *Urodacus`sp. nov.` - Potential SRE (WAM Categories: A)*

A single specimen of this scorpion is recorded from an area that is now cleared. Prior to clearing, this area was likely Sandy/ Stony Plain and as such, this morphospecies is highly likely to occur well beyond the Study Area due to the extent and connectedness of its habitat.

Urodacidae: *Urodacus`sp. Pilbara 4` - Potential SRE (WAM Categories: A, E)*

There is a single record of this scorpion from Sandy/ Stony Plain habitat within the Study Area. This is a well-known morphospecies collected from throughout the Pilbara.

Diplopoda

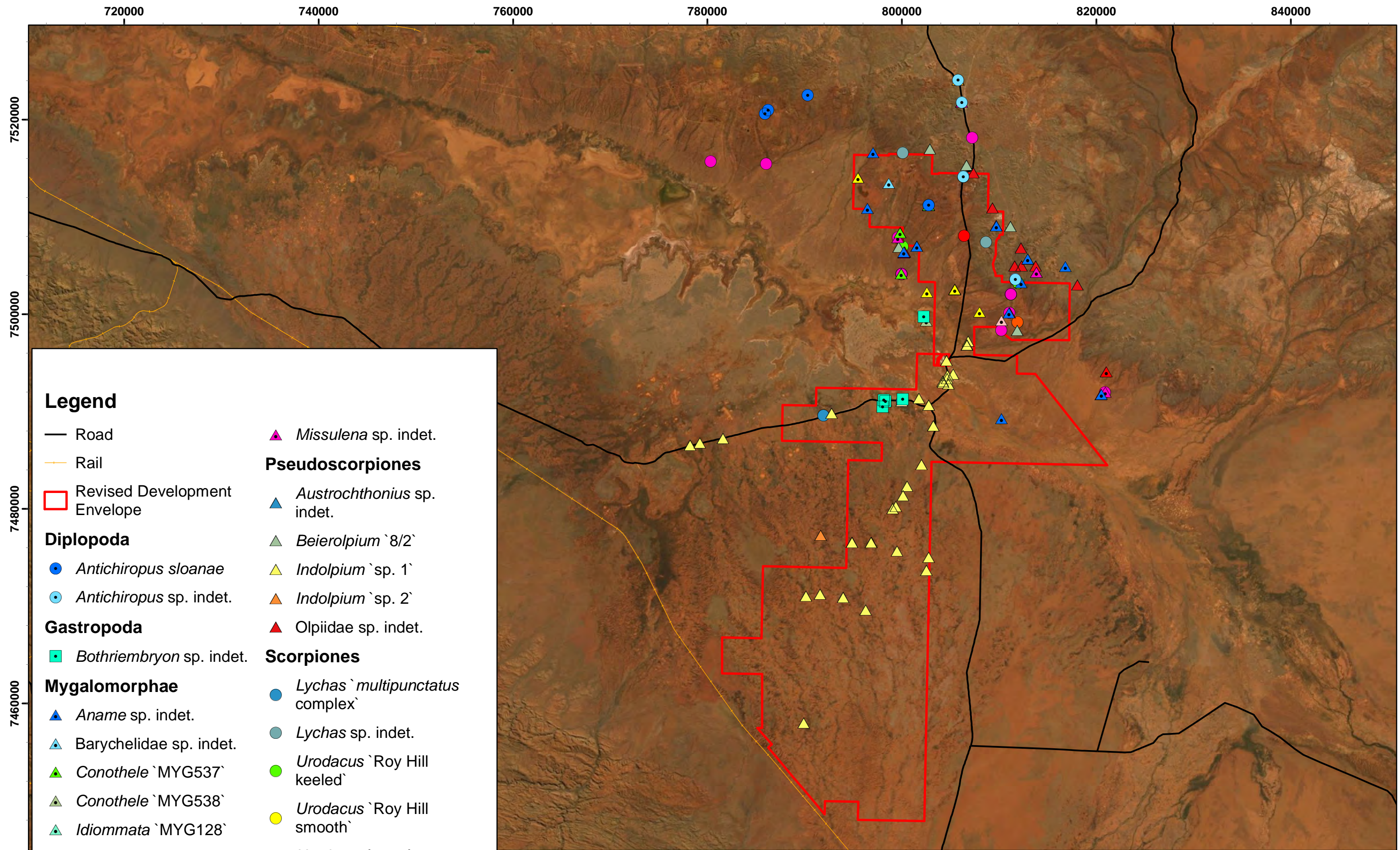
Paradoxosomatidae: *Antichiropus sloanae` - Confirmed SRE*

This recently described species of millipede (Car *et al.*, 2019), is known from one Drainage Line habitat site within the Study Area and three sites approximately 9km outside the Study Area. It has not been found anywhere else in the Pilbara. Due to the

instability of Drainage Lines as a habitat and that these millipedes tend to prefer deeper and more stable crevices to inhabit (Cathy Car, pers. comm.), it is likely that this species most likely inhabits the hilly terrain to the north of the Study Area and is occasionally found in drainage lines due to dispersal during flooding events.

Paradoxosomatidae: *Antichiropus* sp. indet. – Confirmed SRE

These millipedes were recorded from two sites within the Study Area and three sites outside. Identification to species was not possible as the specimens collected were juveniles and females, however due to the proximity of their records to other specimens identified as *A. sloanae*, including being collected at the same site, it is highly likely that these records also represent *A. sloanae* specimens. This would be supported by the fact that many *Antichiropus* species in the Pilbara appear to inhabit rocky, hilly habitats but use drainage lines to disperse throughout the landscape. Molecular analysis would be required to confirm the identity of these specimens, but it is likely that some, if not all, represent the species *A. sloanae*.



Legend

- Road
- Rail
- Revised Development Envelope

Diplopoda

- *Antichiropus sloanae*
- *Antichiropus* sp. indet.

Gastropoda

- *Bothriembryon* sp. indet.

Mygalomorphae

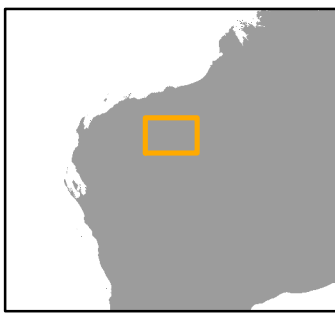
- ▲ *Aname* sp. indet.
- ▲ Barychelidae sp. indet.
- ▲ *Conothele* `MYG537`
- ▲ *Conothele* `MYG538`
- ▲ *Idiommata* `MYG128`
- ▲ *Idiosoma* `MYG085`
- ▲ *Idiosoma* `MYG086`
- ▲ *Idiosoma* sp. indet.
- ▲ *Kwonkan* `MYG033`
- ▲ *Missulena* `MYG252`

Pseudoscorpiones

- ▲ *Missulena* sp. indet.
- ▲ *Austrochthonius* sp. indet.
- ▲ *Beierolpium* `8/2`
- ▲ *Indolpium* `sp. 1`
- ▲ *Indolpium* `sp. 2`
- ▲ *Olpiidae* sp. indet.

Scorpiones

- *Lychas* `multipunctatus complex`
- *Lychas* sp. indet.
- *Urodacus* `Roy Hill keeled`
- *Urodacus* `Roy Hill smooth`
- *Urodacus* `sp. 9`
- *Urodacus* `sp. Pilbara 4`
- *Urodacus* `sp. nov.`
- *Urodacus* sp. indet.



biologic

N 1:350,000

0 5 10 20 km

Roy Hill

SRE Desktop Review

Figure 3.2: SRE invertebrate fauna records within the study area and surrounds

Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

Size A3. Created 23/01/2020

3.3 Habitat mapping

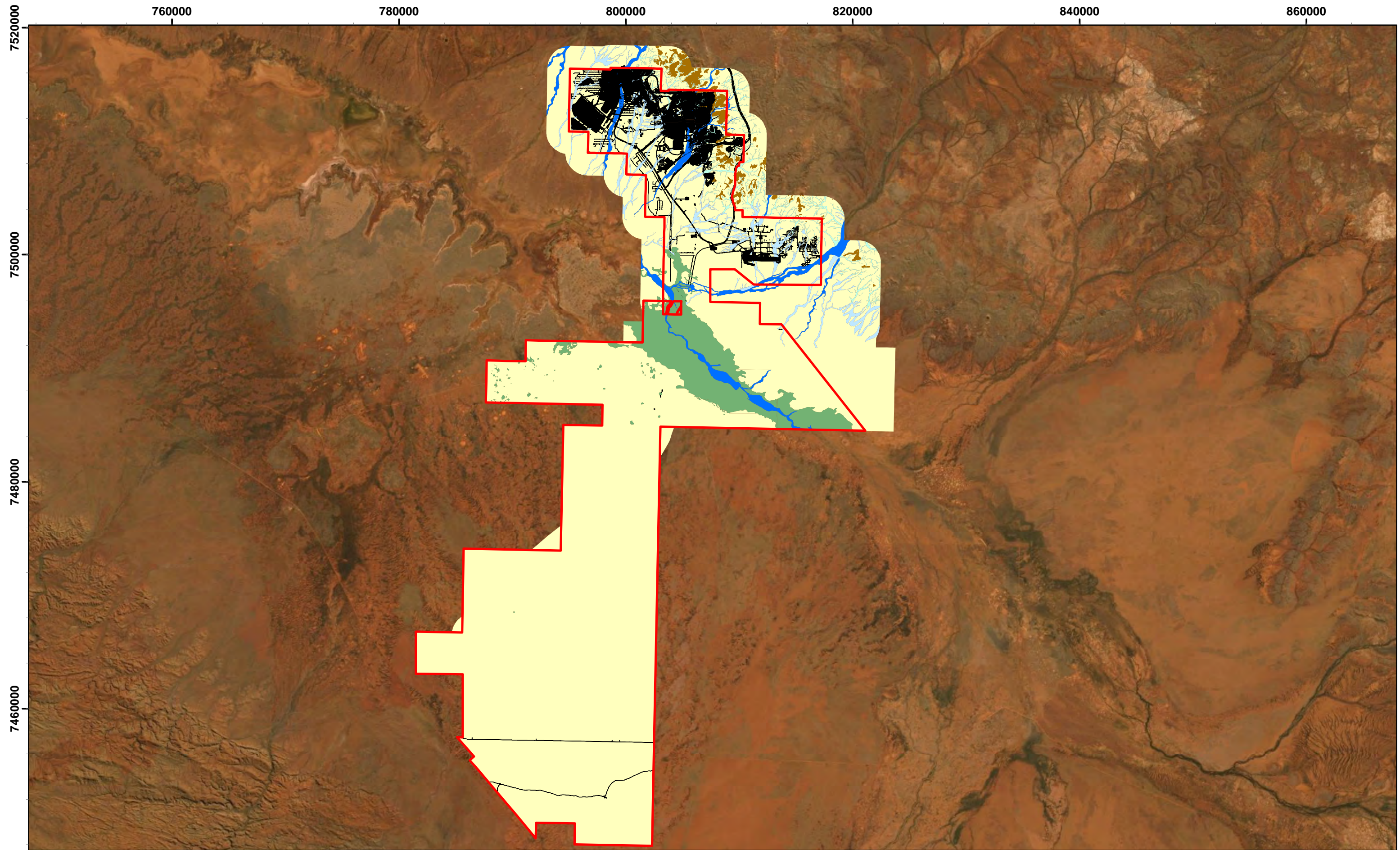
Extrapolated habitat mapping of the Study Area was created based on previous vertebrate fauna habitat and vegetation mapping by Biologic (2018a, 2018b), and previous SRE invertebrate habitat assessment by ecologia (2009b) and Bennelongia (2011, 2012, 2013) (Figure 3.3).

ecologia (2010) mapped eighteen vegetation communities within the original Roy Hill Study Area and identified that SRE species were associated with six of these. Vegetation Community 3A – *Acacia aneura* and *A. rhodophoia* open forest woodlands supported the greatest range of SRE species.

Bennelongia undertook habitat assessments at all sites visited in 2011 and 2012, and related mygalomorph burrow location to habitat-based characteristics and aerial imagery. The Roy Hill sites were found to have low floristic diversity, with *Acacia aneura* the dominant species at 26 sites and absent at only two sites (Bennelongia, 2012).

The current mapping highlights that the Study Area is dominated by Sandy/ Stony Plains which are generally regarded as Low suitability for SRE invertebrate fauna. This is due to the lack of protective microhabitats but also because they usually extend over large areas and are rarely isolated within the landscape. Likewise, habitats such as the Drainage Area/ Floodplain and Drainage Lines are regarded as being lower suitability as they are rarely isolated in the landscape and/or contain habitat qualities that are connected throughout adjacent habitat types. As such, it can be regarded as highly likely that any SRE invertebrate fauna that are recorded primarily within these habitat types will have a distribution extending well beyond the Study Area.

The most suitable habitat recorded within the Study Area is the Hillcrest/ Hillslope in the northern most section, which can be regarded as Moderate suitability for this assessment. The suitability of this habitat is based on the availability of areas protected from exposure during the hottest time of the year, particularly within rocky habitats such as gullies and ridges, and for hillcrests to be isolated within the landscape. While there is the potential for some SRE invertebrate fauna to be restricted to these habitats, the current mapping shows the Hillcrest/Hillslope habitat extending beyond the Study Area to the north and therefore it can be regarded as unlikely that any SRE invertebrate fauna recorded primarily within this habitat will be restricted to the Study Area and will occur throughout the extent of the habitat to the north.



Legend

Revised Development Envelope

Habitat

Cleared Area

Drainage Area / Floodplain

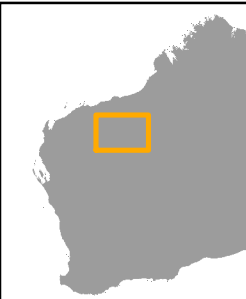
Hillcrest / Hillslope

Sandy / Stony Plains

Minor Drainage Line

Medium Drainage Line

Major Drainage Line



N 1:300,000

0 4.75 9.5 19 km

Roy Hill

SRE Desktop Review

Figure 3.3 Extrapolated habitat mapping for the Study Area and immediate surrounds

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Size A3. Created 20/01/2020

4 PRELIMINARY IMPACT ASSESSMENT

4.1 Sampling adequacy

Whilst there is limited sampling undertaken within the southern extent of the Study Area, the dominance of Low suitability, highly connected habitats (Sandy/Stony Plains, Drainage Area/Floodplain and Drainage Lines) in this part of the Study Area makes it unlikely that this would be regarded as inadequately sampled. The northern section of the Study Area can also be regarded as adequately sampled, particularly within the more suitable habitats, e.g. Hillcrest / Hillslope which are regarded as Moderate suitability within this assessment.

4.2 SRE habitat and fauna

The habitat mapping undertaken for vertebrate fauna that was used for this assessment provides adequate context for the SRE invertebrate fauna. The habitat mapping shows that the Study Area is dominated by Low suitability, highly connected habitats (Sandy/ Stony Plains, Drainage Area/Floodplain and Drainage Lines) with a small area of Moderate suitability Hillcrest/Hillslope habitat in the north-east. The habitat mapping shows that all habitats recorded extend well beyond the Study Area and therefore the likelihood that any SRE invertebrate fauna will be restricted to the Study Area is considered very low. Any Potential or Confirmed SRE fauna recorded within this area can be regarded as highly likely to occur throughout the local area, well beyond the Study Area.

An example of this is displayed using the Confirmed SRE millipede, *A. sloanae*. The millipede most likely inhabits the Moderate suitability Hillcrest/ Hillslope habitat to the north of the Study Area. These millipedes are usually collected in Hillcrest/Hillslope habitat where individuals are protected amongst deep pockets of soil and leaf litter within rocky habitats or on the hillcrest at the base of trees such as *Corymbia hamersleyana*. They are often washed down into Drainage Areas during rain events but will not necessarily persist in these exposed, unstable habitats. The extent of the Hillcrest/Hillslope habitat type has been extrapolated from aerial photography (and hence is not verified by surveying) and shows the extent of habitat this millipede is likely to inhabit (Figure 4.1).

4.3 Likely cumulative impacts

The most significant direct impact to SRE fauna is the removal of habitat. This is due to SRE fauna having very specific habitat requirements and a limited ability to disperse long distances, which results in restricted distributions. This assessment has taken into

consideration all direct and indirect impacts relevant to SRE fauna, as outlined in Section 2.5.

Based on the available information, outlined in the desktop review, cumulative impacts to SRE fauna within the RDE are considered Low for all species except *Antichiropus sloanae*. As outlined in Section 4.2, the majority of the habitats recorded within the RDE are of Low suitability for SRE invertebrate fauna and are widespread and connected throughout the local area. As such, any SRE fauna recorded within these habitats are likely to have distributions that extend throughout these habitats and be widespread within the local area and potentially beyond.

Antichiropus sloanae is only known from the local area and, based on our understanding of *Antichiropus* in the Pilbara, is likely to be restricted to the Hillcrest/Hillslope habitat where individuals are protected amongst deep pockets of soil and leaf litter within rocky habitats or on the hillcrest at the base of trees such as *Corymbia hamersleyana*. Based on a complete development scenario within the RDE, a Low/Moderate cumulative impact level has been identified for this species. This is based on the direct removal of habitat and other indirect impact pathways, such as habitat fragmentation.

Figure 4.1 illustrates the likely extent of distribution of this species in the local area based on extrapolating the connected extent of Hillcrest/Hillslope habitat from aerial photography and our understanding of the dispersal capabilities of *Antichiropus*. This local extent of Hillcrest/Hillslope habitat totals approximately 15,982 ha. Previously approved clearing within the RDE has removed approximately 664 ha (~4%) of this habitat type. Proposed additional clearing will clear another 1,185 ha, for a total of 1,849 ha of this habitat cleared (11.5%). The removal of the Hillcrest/Hillslope habitat within the RDE would fragment the remaining areas of suitable habitat into two areas: a northern section of approximately 10,739 ha and a southern section of approximately 3,193 ha. The resulting gap of six kilometres can be regarded as a likely significant barrier for individuals to disperse across and as such, this species will be fragmented into two separate populations, one in the north and one in the south. However, based on a recent approval at South Flank involving another *Antichiropus* species (*A.* 'DIP007') where 53% of suitable habitat was removed, leaving 3,341 ha, the impact to *A. sloanae* from this project can be regarded as far less significant, with 10,739 ha remaining to the north and 3,193 ha remaining in the south.

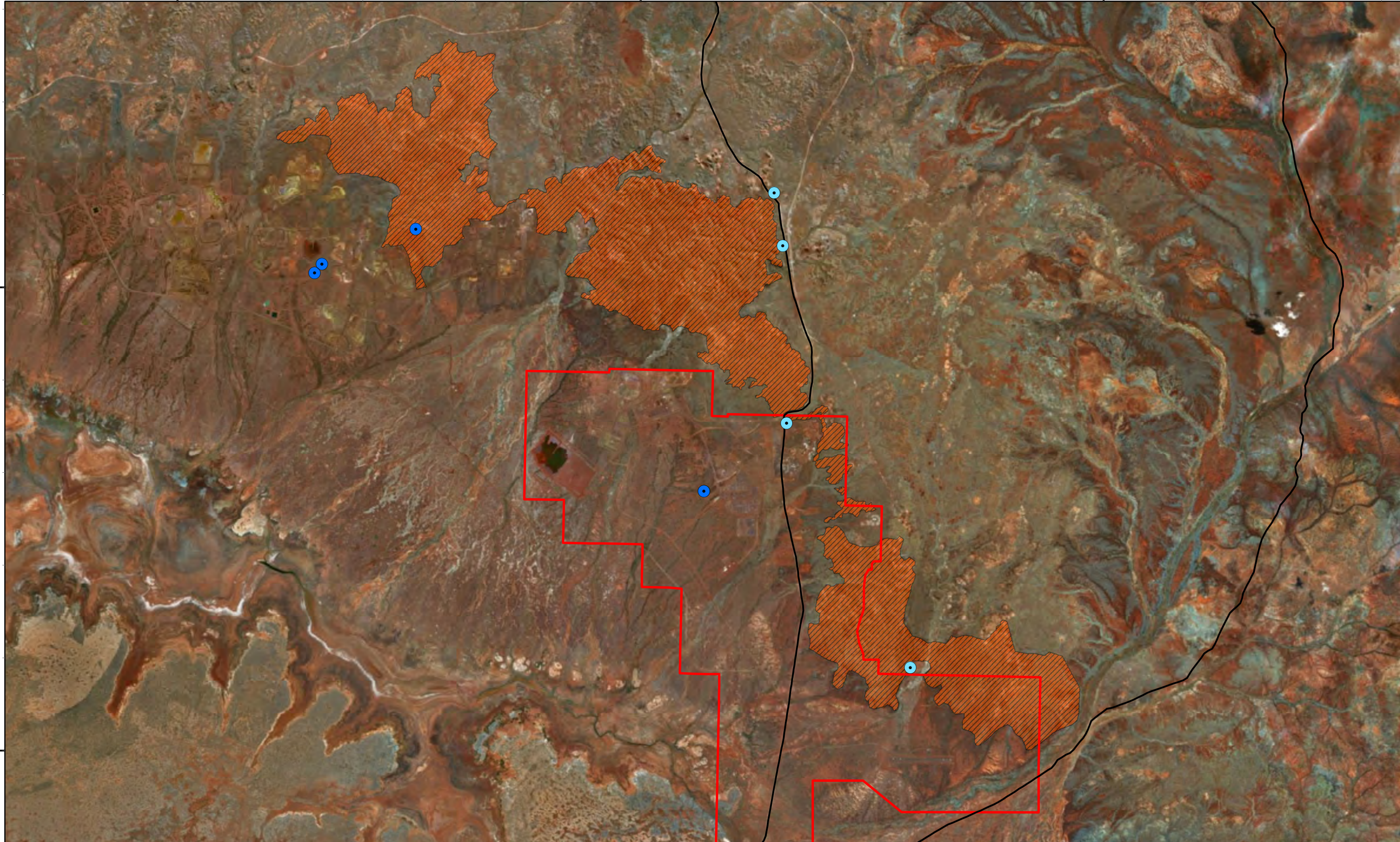
780000

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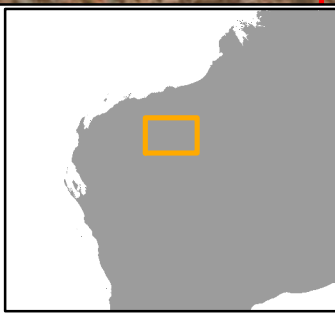
Legend

- Road
- Rail
- Revised Development Envelope

▨ Potential Range/Extent of Habitat

Diplopoda

- *Antichiropus sloanae*
- *Antichiropus* sp. indet.



biologic

N 1:150,000

0 2.25 4.5 9 km

Roy Hill

SRE Desktop Review

Figure 4.1: Extrapolated potential local range of *Antichiropus* spp.

Coordinate System: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

Size A3. Created 23/01/2020

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Appendix A: SRE invertebrate taxa recorded from within 10km of the Study Area

Higher ID	Lowest ID	# Records
Mygalomorphae		
Actinopodidae	Actinopodidae sp. indet.	1
	<i>Missulena</i> `MYG252`	10
	<i>Missulena</i> sp. B3	1
	<i>Missulena</i> sp. indet.	18
Barychelidae	<i>Aurecocypta</i> sp. indet.	1
	Barychelidae sp. indet.	1
	<i>Idiommata</i> `MYG128`	1
	<i>Synothele</i> sp. indet.	24
Ctenizidae	Ctenizidae sp. indet.	1
Halonoproctidae	<i>Conothele</i> `MYG537`	3
	<i>Conothele</i> `MYG538`	3
	<i>Conothele</i> sp. B01	6
	<i>Conothele</i> sp. B03	1
	<i>Conothele</i> sp. indet.	8
Idiopidae	<i>Aganippe</i> sp. `B1`	11
	<i>Aganippe</i> sp. indet.	11
	<i>Eucyrtops</i> `sp. B04`	1
	<i>Gaius</i> sp. indet.	1
	<i>Idiosoma</i> `MYG085`	5
	<i>Idiosoma</i> `MYG086`	1
	<i>Idiosoma</i> `MYG126`	18
	<i>Idiosoma</i> sp. indet.	2
Nemesiidae	<i>Aname</i> sp. `B1`	1
	<i>Aname</i> sp. indet.	11
	<i>Kwonkan</i> `MYG033`	1
	<i>Kwonkan</i> `MYG101`	2
	Nemesiidae sp. indet.	2
Araneomorphae		
Selenopidae	<i>Karaops</i> sp. indet.	1
Pseudoscorpiones		
Atemnidae	<i>Nesidiochernes</i> sp. indet.	2
	<i>Oratemnus</i> sp. `B1`	2
	<i>Oratemnus</i> sp. indet.	13
Cheiridiidae	Cheiridiidae sp. indet.	3
Chernetidae	Chernetidae sp. indet.	1
Chthoniidae	<i>Austrochthonius</i> sp. indet.	3
	<i>Tyrannochthonius</i> sp. indet.	1
Olpiidae	<i>Austrohorus</i> sp. indet.	16
	<i>Beierolpium</i> `8/2`	25
	<i>Beierolpium</i> sp. indet.	3
	<i>Euryolpium</i> sp. `B1`	24
	<i>Indolpium</i> `PSE099`	1

Higher ID	Lowest ID	# Records
Olpiidae	<i>Indolpium</i> `sp. 1`	53
	<i>Indolpium</i> `sp. 2`	4
	<i>Indolpium</i> sp. `B1`	4
	<i>Indolpium</i> sp. `B4`	1
	<i>Indolpium</i> sp. indet.	51
	<i>Linnaeolpium</i> `sp. B01`	1
	Olpiidae sp. indet.	33
	<i>Xenolpium</i> sp. indet.	3
Scorpiones		
Buthidae	Buthidae sp. indet.	2
	<i>Isometroides</i> sp. indet.	1
	<i>Lychas</i> `bituberculatus` group`	3
	<i>Lychas</i> `hairy tail` group`	2
	<i>Lychas</i> `multipunctatus` complex`	8
	<i>Lychas</i> sp. indet.	4
Urodacidae	Urodacidae sp. indet.	8
	<i>Urodacus</i> `Roy Hill keeled`	3
	<i>Urodacus</i> `Roy Hill smooth`	2
	<i>Urodacus</i> `sp. 9`	1
	<i>Urodacus</i> `sp. nov.`	1
	<i>Urodacus</i> `sp. Pilbara 4`	1
	<i>Urodacus</i> `sp. Pilbara 8`	21
	<i>Urodacus pearcei</i>	7
	<i>Urodacus</i> sp. `B1`	4
	<i>Urodacus</i> sp. indet.	16
Diplopoda		
Paradoxosomatidae	<i>Antichiropus</i> `DIP031`	1
	<i>Antichiropus</i> `DIP032`	1
	<i>Antichiropus sloanae</i>	5
	<i>Antichiropus</i> sp. indet.	8
	Paradoxosomatidae sp. indet.	3
Polyxenidae	Polyxenidae sp. indet.	5
Synxenidae	Synxenidae sp. indet.	10
Chilopoda		
Chilenophilidae	<i>Geomerinus</i> sp. indet.	1
Isopoda		
Armadillidae	Armadillidae sp. indet.	13
	<i>Buddelundia</i> sp. `A`	17
	<i>Buddelundia</i> sp. `B`	5
	<i>Buddelundia</i> sp. `B2`	3
	<i>Buddelundia</i> sp. `B5`	1
Armadillidae	<i>Buddelundia</i> sp. `B6`	2
	<i>Buddelundia</i> sp. `B7`	10
	<i>Buddelundia</i> sp. `B8`	2

Higher ID	Lowest ID	# Records
	<i>Buddelundia</i> sp. indet.	3
Philosciidae	Philosciidae sp. indet.	7
Gastropoda		
Bothriembryontidae	<i>Bothriembryon</i> sp. indet.	29
Camaenidae	<i>Rhagada</i> sp. indet.	1
Total		602