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Orebody 31 Targeted Survey and Environmental Impact Assessment of Short-Range Endemic Fauna

BHP Billiton Iron Ore Pty Ltd

September 2014

Orebody 31 Targeted Survey and Environmental Impact Assessment of Short-Range Endemic Fauna

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) is preparing referrals to the Environmental Protection Authority (EPA) to develop new mining areas at Orebody (OB) 31, approximately 40 kilometres (km) east of Newman in the Pilbara region of Western Australia. Totalling 4054.64 hectares (ha), the 'Indicative Mine Disturbance Area' and the 'Indicative Infrastructure Corridor Area' for the proposed development are hereafter referred to as the 'Project area'.

BHP Billiton Iron Ore commissioned Biologic Environmental Survey Pty Ltd (Biologic) to conduct an environmental impact assessment (EIA) of short-range endemic (SRE) invertebrate fauna values within the Project area. In 2013, Biologic conducted a baseline survey of SRE invertebrate fauna within the Project area and surrounds (hereafter referred to as the OB19-31 SRE Survey), and has also recently conducted an additional targeted SRE survey, which is reported herein. This report provides:

- a review of relevant published literature, previous survey reports, and SRE database records within the local area surrounding the Project area;
- a description of the methods and results of the targeted SRE survey;
- identification of important SRE values (comprising SRE species, conservation significant species, and important SRE habitats) within the Project area and surrounds; and
- an assessment of potential impacts to important SRE values (including discussion of potential impact receptors, pathways and magnitude) from the proposed development.

A total of 35 sites were sampled during the targeted SRE Survey in June 2014, in addition to the 57 sites previously visited within the Project area, and 132 sites sampled in the surrounding local area over two seasons during the OB19-31 SRE Survey. The methods and sampling designs for both surveys were conducted according to EPA Guidance Statement 20 and BHP Billiton Iron Ore's Guidance for SRE Surveys in the Pilbara Region (SPR-IEN-EMS-013).

The database searches and previous surveys reported a total of one confirmed SRE and 31 potential SRE species within the local and sub-regional area surrounding the Project area, including mygalomorph spiders, selenopid spiders, pseudoscorpions, scorpions, polydesmid millipedes, and isopods. The OB19-31 SRE Survey had recorded 10 potential SRE species, of which six were found within the Project area, and were therefore considered directly relevant to the assessment:

- two selenopid spiders, *Karaops* 'ARA003-DNA' and *K.* 'ARA004-DNA';
- the pseudoscorpion, *Xenolpium* 'PSE079'; and
- three isopods, *Buddelundia* '10NM', *B.* '49', and Buddelundiinae 'WN'.

The combined faunal data and habitat information collected during the SRE surveys found that none of the six potential SRE species or their habitats were restricted to the Project area, and as such the potential impacts on important SRE values are not considered high.

The selenopid spider *Karaops* 'ARA003-DNA' and the pseudoscorpion *Xenolpium* 'PSE079', may be moderately impacted due to a reduction in available habitat from mining, construction and vegetation clearing within the Project area. Any indirect impacts of habitat fragmentation may potentially be managed in the long term via rehabilitation of suitable habitats following mine closure.

The potential impacts to the selenopid spider *Karaops* 'ARA004-DNA' and the isopod Buddelundiinae 'WN' are likely to be low, as the majority of their potential habitat occurs outside of the Project area. The potential impacts on the more widely occurring species of potential SRE isopods, *Buddelundia* '10NM' and *B*. '49', are expected to be negligible.

1. INTRODUCTION

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) is preparing referrals to the Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (EP Act) to develop new mining areas at Orebody (OB) 31. OB31 is located approximately 40 kilometres (km) east of Newman Township in the Pilbara region of Western Australia (Figure 1.1). The area to be developed has been divided into the 'Indicative Mine Disturbance Area' and the 'Indicative Infrastructure Corridor Area'. These two areas are hereafter referred to in combination as the 'Project area'.

BHP Billiton Iron Ore has commissioned Biologic Environmental Survey Pty Ltd (Biologic) to conduct an environmental impact assessment (EIA) of short-range endemic (SRE) invertebrate fauna values within the Project area. In support of the EIA, Biologic (2014a) has previously conducted a baseline survey of SRE invertebrate fauna within the Project area and surrounds (hereafter referred to as the OB19-31 SRE Survey), and also has recently conducted an additional targeted SRE survey, which is reported herein. This report provides:

- a review of relevant published literature, previous survey reports, and SRE database records within the local area surrounding the Project area;
- a description of the methods and results of the targeted SRE survey;
- identification of SRE values (comprising SRE species, conservation significant species, and important SRE habitats) within the Project area and surrounds; and
- an assessment of potential impacts to SRE values (including discussion of potential impact receptors, pathways and magnitude) from the proposed development.

1.1 Project Description

OB31 is situated to the east of the existing OB17/18 Mine within Mineral Lease ML244SA, which is subject to the *Iron Ore (Mount Newman) Agreement Act 1964*. OB31 has not previously been developed and as such is considered a greenfield development.

BHP Billiton Iron Ore Pty Ltd (BHP Billiton Iron Ore) currently operates a number of iron ore mines and associated rail and port infrastructure within the Pilbara region of Western Australia. Current mining operations in proximity to OB31 include:

- Newman Joint Venture hub, located approximately 2 km west of Newman Township, which consists of Mount Whaleback and OB 29, 30 and 35;
- OB17/18 Mine, located approximately 30 km east of Newman Township (located immediately west of OB31);
- Wheelarra Hill (Jimblebar) Mine, located approximately 40 km east of Newman Township and five to 10 km south of OB31; and
- OB 23, 24 and 25, located approximately 8 km northeast of Newman Township.

750000

800000

7450000

7400000

Jinidi

Hope Downs

Port Operations

Nimingarra

Yarrie

Hope Downs 4

Christmas Creek

Roy Hill

Yandi (Marillana Creek)

Nyidinghu

Area C

Hope Downs

Mudlark

Jinidi

Hope Downs 4

OB23/25

OB19

Mt Whaleback

OB17/18

OB29/30/35

OB23/25

OB19

OB17/18

Mt Whaleback

NEWMAN

OB29/30/35

Jimblebar (Wheelarra Hill)

Legend

- Pilbara Towns
- Pilbara Hwy
- Pilbara Rail
- Iron ore mining/ exploration locations
- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area

IBRA sub-regions

- Augustus
- Fortescue
- Hamersley

1:370,000

0 3.5 7 14 21 km

N

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 1.1: Regional location and IBRA sub-regions

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

The ore resource at OB31 has been estimated at approximately 500 million tonnes (Mt). BHP Billiton Iron Ore is currently considering two development options for this resource. The first is a base option of 15 Mtpa as a long-term replacement for OB18 and the second is a growth option of 30 Mtpa.

Open pits will be developed using conventional drill and blast techniques with ore sent through a proposed new primary crusher at OB31. For the base option (15 Mtpa), crushed ore will be transported via an overland conveyor to stockpiles at the OB17/18 Mine, then railed to the Mount Whaleback Mine, where it will be blended with the ore produced by the Newman Joint Venture. However, the OB31 ore body is estimated to be up to 80% below water table, thus significant dewatering of the ore body will be required to provide dry mining conditions.

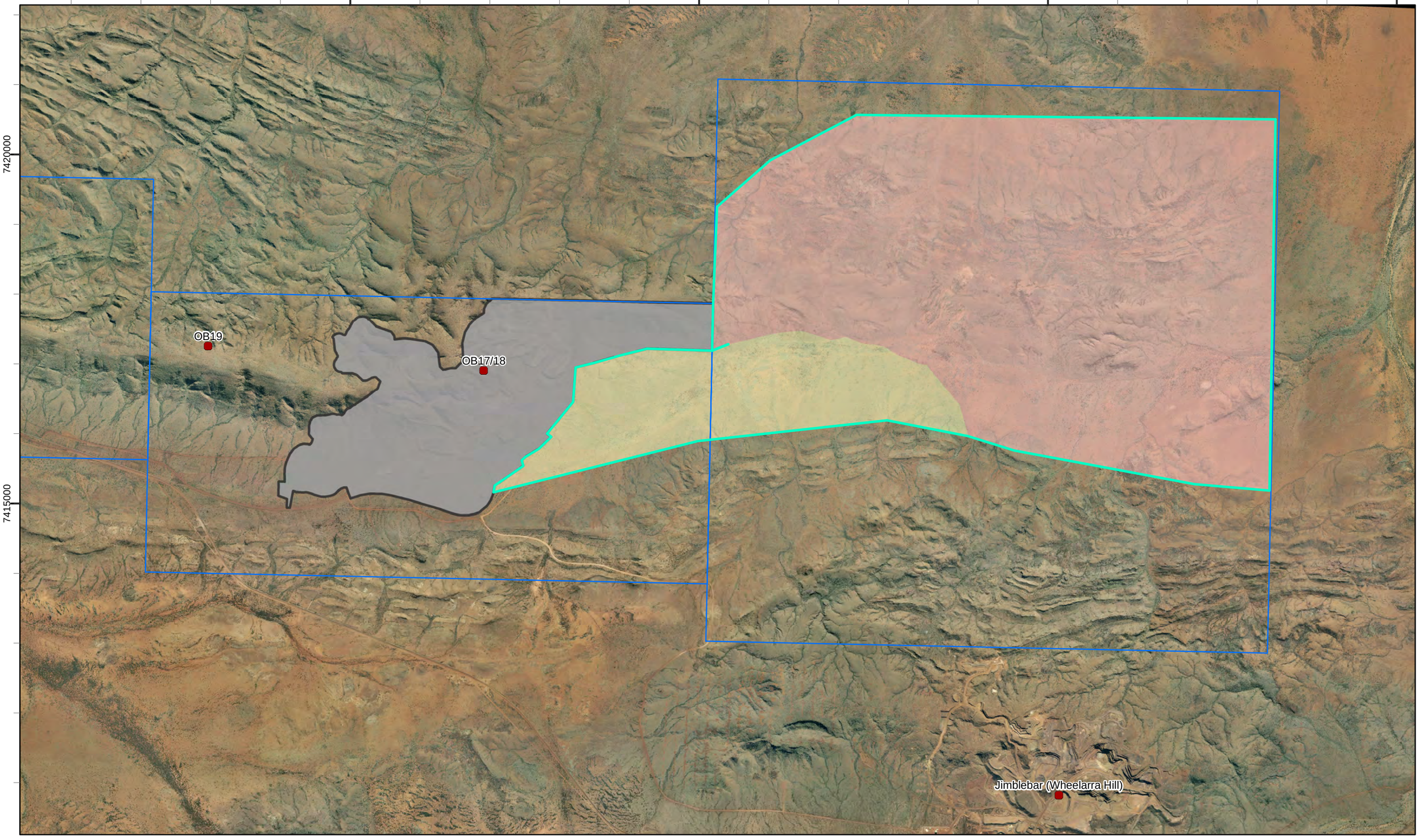
Under the growth option (30 Mtpa), 15 Mtpa will be sent via an overland conveyor to ore stockpiles at the OB17/18 Mine with the remaining 15 Mtpa sent via conveyor to ore stockpiles at the Wheelarra Hill (Jimblebar) Mine. Ore from both the OB17/18 Mine and Wheelarra Hill (Jimblebar) Mine will be railed to the Mount Whaleback Mine and blended with ore produced by the Newman Joint Venture.

Non-mineralised waste rock will be hauled to new OSAs at OB31 or used to backfill the OB31 or OB18 pits.

The proposed OB31 project consists of the following:

- one single open pit;
- three new OSAs;
- a primary crushing facility;
- haulage (heavy vehicles (HV)) and light vehicles (LV) access roads linking OB31 to existing OB17/18 Mine infrastructure;
- an overland conveyor to existing infrastructure at the OB17/18 Mine and/or Wheelarra Hill (Jimblebar) Mine;
- power, water, fibre optic cable and other associated services which may be required along road and/or conveyor alignments;
- topsoil and vegetation stockpiles;
- offices, ablutions, LV and HV parking areas, laydown areas, hydrocarbon storage facilities, Ammonium Nitrate (ANFO) storage facilities and magazine areas and other ancillary facilities; and
- water infrastructure including dewatering/potable/monitoring water bores, diesel generator sets, pipelines, turkeys nests and/or other storage facilities as required.

The area to be developed has been divided into the ‘Indicative Mine Disturbance Area’ and the ‘Indicative Infrastructure Corridor Area’. In combination these areas cover 4054.64 ha, and have been referred to as the ‘Project area’ within this report (Figure 1.2).



Legend

- Iron ore mining/ exploration locations
- Mining Lease AML244SA
- Existing OB18 Part IV area
- Project area
- Indicative OB31 Mine Disturbance Area
- Indicative Infrastructure Corridor Area

1:50,000

0 0.45 0.9 1.8 2.7 km

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 1.2: Project area and indicative disturbance areas

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

1.2 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, Harvey 2002). Short-range endemism is influenced by several factors including life history, physiology, habitat requirements, dispersal capabilities, 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 and Colgan 2002).

In recent years a number of taxonomic groups of invertebrates have been highlighted as comprising a high proportion of species likely to be regarded as short-range endemics (SREs) (*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 SRE invertebrate fauna becoming 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.

2. EXISTING ENVIRONMENT

2.1 Biogeography

Broadly, the Project area lies on the southern fringe of the Pilbara bioregion as defined by the Interim Biogeographic Regionalisation of Australia (Thackway and Cresswell 1995). The Pilbara bioregion is further divided into four subregions, and the Project area lies in the Hamersley subregion (Figure 1.1), which forms the southern section of the Pilbara Craton (Kendrick 2001). This subregion is characterised by mountainous areas of Proterozoic sedimentary ranges and plateaux, dissected by gorges. The vegetation of the subregion is dominated by *Eucalyptus leucophloia* over *Triodia* hummock grassland on skeletal soils atop mountains and slopes, while swathes of Mulga woodland occur over hard and soft grasses on fine-textured soils of the plains and valleys (Kendrick 2001). The Project area is in the immediate vicinity of the Fortescue subregion to the north and Augustus subregion of the Gascoyne bioregion to the south. The Gascoyne bioregion comprises low rugged ranges and broad flat valleys with vegetation dominated by Mulga woodlands (McKenzie *et al.* 2009).

2.2 Climate

The Pilbara region has a semi-desert to tropical climate with highly variable, mostly summer rainfall. Two distinct seasons, a hot summer from October to April and a mild winter from May to September, occurs in the region (Australian Natural Resource Atlas 2008). Rainfall events within the Pilbara are often sporadic and can occur within both summer and winter months. The summer rainfall patterns are heavily influenced by tropical cyclones that develop over the Indian Ocean and occasionally cross the north-west coastline, bringing heavy rainfall to inland regions of the Pilbara. The nearest Bureau of Meteorology (BoM) weather station at Newman Airport reports an average annual rainfall of 310 mm (Figure 2.1), although rainfall can be very patchy in the local area. The area experiences a wide range of temperatures throughout the year with an average temperature of 31.3°C. During summer maximum temperatures may reach a high of 46.0°C, while in winter minimum temperatures may be as low as -2.0°C (BoM 2013). Figure 2.1 shows the monthly long-term average rainfall and maximum temperatures from Newman Airport (BoM 2013).

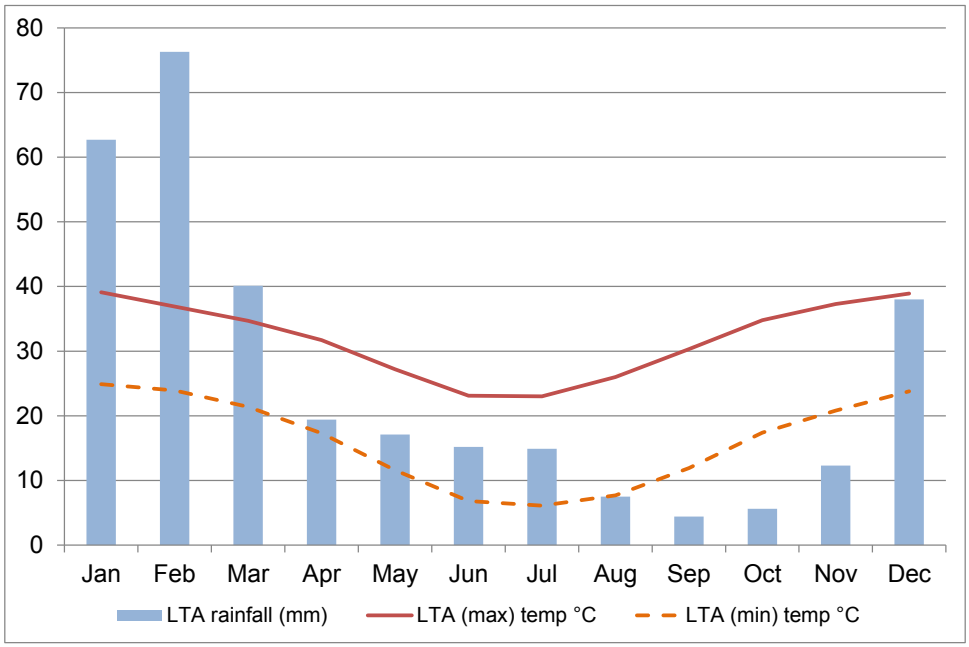

Figure 2.1: Long-Term Averages (LTA) of monthly rainfall (mm) and maximum/ minimum temperatures (°C) at Newman Airport (BoM 2013).

2.3 Geology

The Project area is underlain by Late Archaean to Early Proterozoic bedrock of the Hamersley and Fortescue Groups. In this area, the younger Hamersley Group consists mainly of Banded Iron Formations (BIF), volcanics and minor shale, intruded by dolerite sills. The Fortescue Group consists mainly of mafic volcanics, mudstone, chert and shale, with minor dolerite sills (Thorne and Tyler 1997). The bedrock strata strike mainly east-west, although major faulting has occurred, particularly within south eastern parts. Following Tyler *et al.* (1991) (refer Figure 2.2), the major geological formations within the Project area include:

1. Boolgeeda Iron Formation: fine-grained, finely laminated banded iron-formation, mudstone, siltstone and chert.
2. Woongarra rhyolite: rhyolite/ rhyodacite as sills or flows; commonly porphyritic, phenocrysts of quartz, feldspar, minor tuff and jaspilitic BIF.
3. Weeli Wolli Formation: interlayered jaspilitic BIF, mudstone, siltstone and metadoleritic sills.
4. Brockman Iron Formation: BIF, chert, mudstone and siltstone with minor shale.
5. Mount McRae Shale and Mount Sylvia Formation: interbedded shale, chert, BIF and dolomite.
6. Wittenoom Formation: metamorphosed dolomite, dolomitic mudstone, chert, and felsic to mafic volcanic sandstone.
7. Marra Mamba Iron Formation: metamorphosed chert, BIF, mudstone, and siltstone.

2.4 Soils

On the strike ridges, areas of exposed bedrock are flanked by Cainozoic-Quaternary colluvial/ alluvial deposits (*i.e.* scree, gravel, sand, and silt). On the ridges and hilltops, soils are a thin mixture of silt and gravel, or virtually absent. The slopes and valley floors are generally characterised by gravelly sandy loam to loam-clay with the proportions of rocks and gravel declining as slope decreases (although remaining high in patches). The central palaeochannel running through the valley floor from south-central to central eastern parts is characterised by deep clay-loam to clay soils, with surface gravels only. To the north and east of the Project area, extensive sand plains associated with the Fortescue valley occur, with coarse to fine, silty red sands. The CSIRO Atlas of Australian Soils (McKenzie and Hook 1992, Northcote *et al.* 1960-1968) identifies three major soil units within the local area (Figure 2.3):

1. Mz25 - Plains associated with the Fortescue valley. Surface cover of stony gravels close to the ranges and hills: chief soils are acid red earths with some neutral red earths; red-brown hardpan is absent.
2. Fa13 - Ranges of banded jaspilite (BIF) and chert along with shales. Soils with predominantly physical limitations (shallow-skeletal soils).
3. BE6 - Extensive flat and gently sloping plains. Soils with predominantly physical limitations (shallow soils).

805000 810000 815000 820000 825000

7420000

7415000

7410000

OB19

OB17/18

Jimblebar (Wheelarra Hill)

Legend

- Iron ore mining/ exploration locations
- Project area
- Mining Lease AML244SA
- Existing OB18 Part IV area

GEOLOGY 500k

- Jeerinah Frm. basaltic flows & breccia
- Jeerinah Frm. mudstone-sandstone
- Wittenoom Frm. dolomite-sandstone
- Marra Mamba Iron Frm. chert & BIF
- Mt McRae_Mt Sylvia Frm. mudstone-BIF shale
- Granite to granodiorite
- Brockman Iron Frm. BIF, chert, siltstone
- Weeli Wolli Frm. jaspilite BIF
- Boolgeeda Iron Frm. BIF, chert
- Woongarra rhyolite, rhyodacite, breccia
- Manganese Grp. sandstone-mudstone, cong.
- Turee Creek Grp. mudstone-sandstone, cong.

1:65,000

0 0.5 1 2 3 km

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 2.2: Geology of the Project area and surrounds

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

805000 810000 815000 820000 825000

7420000

7415000

7410000

Mz25

Fa13

Mz25

OB19

OB17/18

BE6

Jimblebar (Wheelarra Hill)

Oc64

Legend

- Iron ore mining/ exploration locations
- Project area
- Mining Lease AML244SA
- Existing OB18 Part IV area

CSIRO Atlas of Australian Soils

- BE6 Extensive flat and gently sloping plains
- Fa13 Ranges of banded jaspilite, chert, shales
- Mz25 Fortescue plains, acid-neutral red earths, surface gravels, calcrete
- Oc64 Low stony hills, dissected pediments on granite

1:65,000

0 0.5 1 2 3 km

N

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 2.3: Soils of the Project area and surrounds

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

2.5 Topography and Landforms

The Project area is located on the far eastern extent of the Hamersley Ranges. The major topographical features in the immediate vicinity of the Project area are a series of deeply dissected strike ridges running north-west to south-east (Figure 2.4). The tallest single range in the local area is the peak at Ninga (OB19) (793 m AHD) which occurs immediately west of the existing mining operations at OB18. To the south of the Project area is a series of undulating hills and low, folded/ faulted ridgelines (approx. 510 m - 570m AHD) that occur on the northern flanks of Wheelarra Hill (715 m AHD) (herein referred to as Wheelarra North). This mountainous area extends further to the south (Figure 2.4) around the existing mining operations at Wheelarra Hill (Jimblebar).

These two major mountainous areas are separated from each other by a flat palaeochannel stretching through the southern part of the Project area. North of the palaeochannel, the Project area is dominated by a series of low hills and weathered BIF outcrops, which feature many small gullies descending to stony washplains (Figure 2.4). This topography continues beyond the Project area to the west, while the areas to the north and east of the central Project area are dominated by extensive flat sandplains associated with the Fortescue IBRA sub-region (Figure 2.4, 1.1).

2.6 Surface Hydrology (Drainage)

The Project area is located in the upper portion of the Fortescue River catchment, which drains to the Fortescue Marsh (RPS Aquaterra 2012). Jimblebar Creek, which runs north to Fortescue Marsh, is the major drainage line receiving runoff from a series of minor, unnamed creeks in the east of the Project area (Figure 2.5). Other minor creeks in the western part of the Project area drain northwards, towards the Fortescue River. Due to climatic conditions, all of the creeks are ephemeral with typically one to three flow events per year (RPS Aquaterra 2012). The average annual rainfall at Newman is approximately 310 mm, but rainfall occurs mainly as tropical summer storms, and annual totals vary widely. Drainage lines flow only after prolonged heavy rain, as short-duration flooding with rapid peaks and slightly less rapid decline. Along major watercourses, including the Fortescue River and Jimblebar Creek, water tends to pond and may persist as pools for several weeks to months.

805000 810000 815000 820000 825000

7420000

7415000

7410000

OB19

OB17/18

Jimblebar (Wheelarra Hill)

Legend

- Iron ore mining/ exploration locations
- Project area
- Mining Lease AML244SA
- Existing OB18 Part IV area

ELEVATION (mAHD)

500 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 700 720 740 750 760 780 800

1:65,000

0 0.5 1 2 3 km

N

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 2.4: Topography of the Project area and surrounds

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

805000 810000 815000 820000 825000

7420000 7415000 7410000

Jimblebar Creek

OB19

OB17/18

Palaeochannel area

Jimblebar (Wheelarra Hill)

637 m 600 m 600 m 700 m 802 m 557 m 550 m 500 m 500 m 696 m 711 m 600 m 670 m 500 m 586 m

Legend

- Iron ore mining/ exploration locations
- Project area
- Mining Lease AML244SA
- Existing OB18 Part IV area
- Major watercourses
- Minor watercourses

1:65,000

0 0.5 1 2 3 km

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BHP Billiton Iron Ore Orebody 31 Project

Fig. 2.5: Drainage of the Project area and surrounds

Created 17/07/2014
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

2.7 Land Systems

Van Vreeswyk *et al.* (2004) classified and mapped the Land Systems of the Pilbara. Land Systems are classified according to similarities in landform, soil, vegetation, geology and geomorphology. The Project area lies across three Land Systems as described below in Table 2.1 (following van Vreeswyk *et al.* 2004), and as shown in Figure 2.6.

Table 2.1: Landforms, soils and vegetation types of the Land Systems within the Project area.

Landform	Soil	Vegetation
Boolgeeda Land System		
Low hills and rises	Stony soils and red shallow loams	Hummock grasslands of *Triodia wiseana* and other *Triodia* spp. with very scattered *Acacia* shrubs.
Groves	Red loamy earths	Moderately close woodlands or tall shrublands of *A. aneura* with sparse low shrubs and tussock or hummock grasses.
Narrow drainage floors and channels	Red loamy earths and minor self-mulching cracking clays. Channels with river bed soils	Scattered to close tall shrublands or woodlands of *A. aneura*, *A. atkinsiana*, *Corymbia hamersleyana* with sparse low shrubs and hummock and tussock grasses. Occasionally hummock grasslands of *T. pungens*.
Stony lower plains	Red loamy earths	Hummock grasslands *T. wiseana, T. lanigera* or *T. pungens*. Also scattered to moderately close tall shrublands of *A. aneura* and other *Acacia*s with hard and soft spinifex ground layer.
Stony slopes and upper plains	Red shallow loams or red loamy earths	Hummock grasslands of *T. lanigera, T. wiseana* or scattered tall shrublands of *Acacia aneura*, *A. ancistrocarpa*, *A. atkinsiana* and other *Acacia*s, occasional *Eucalyptus* trees and prominent hard spinifex ground layer.
Newman Land System		
Lower slopes	Stony soils on upper margins with red loams on lower margins	Hummock grasslands *Triodia wiseana, T. brizoides* with very scattered to scattered shrubs and trees including *Acacia* and *Senna* spp., *Grevillea wickhamii*, *Eucalyptus leucophloia* and other eucalypts.
Narrow drainage floors with channels	Red shallow loams, red loamy earths. Channels with river bed soils.	Smaller floors support hummock grassland of *Triodia pungens* with very scattered shrubs. Larger floors and channels support tall shrublands/ woodlands of *Acacia* spp. and *Eucalyptus victrix* with tussock grass or hummock grass understories.
Plateaux, ridges, mountains and hills	Stony soils, red shallow loams and some red shallow sands.	Hummock grasslands of *Triodia wiseana, T. brizoides, T. plurinervata* with very scattered to scattered shrubs and trees including *Acacia* and *Senna* spp., *Grevillea wickhamii*, *Eucalyptus leucophloia* and other eucalypts.
Stony plains	Stony soils, red shallow loams with red loamy earths.	Hummock grasslands of *Triodia wiseana, T.* spp. with isolated to very scattered shrubs of *Acacia* and *Senna* spp. and occasional eucalypt trees. Occasionally hummock grasslands of *Triodia pungens*.
Washplain Land System		
Alluvial hardpan plains	Red deep sandy duplex and red deep loamy duplex soils.	Herbfields with isolated shrubs or very scattered to scattered shrublands of *Acacia aneura, Eremophila cuneifolia* other eremophilas, *Senna* spp. and small *Maireana* spp.
Groves	Red loamy earths, deep red/ brown non-cracking clays	Moderately close to closed *Acacia aneura* woodlands or tall shrublands with numerous undershrubs and scattered grasses such as *Chrysopogon fallax* and *Digitaria coenicola*.
Sandplains	Red deep sands.	Hummock grasslands of *Triodia* spp. with very scattered or scattered shrubs.
Stony plains	Red loamy earths, deep red/brown non-cracking clays and minor self-mulching cracking clays.	Very scattered shrublands of *Acacia aneura, Senna* and *Eremophila* spp. and occasional tussock grasses.
Tracts receiving through flow	Red deep loamy duplex soils and red loamy earths	Moderately close to closed woodlands or tall shrublands of *Acacia aneura* with scattered low shrubs and occasional perennial grasses.

805000 810000 815000 820000 825000

7420000 7415000 7410000

Rocklea Divide Newman Divide Newman Divide Newman River Boolgeeda Divide Newman Washplain OB19 OB17/18 Newman McKay Divide McKay Divide Washplain Sylvania Divide Cadgie Newman Newman Jamindie Boolgeeda Jimblebar (Wheelarra Hill) Disturbed Land Boolgeeda Divide Sylvania Washplain Newman McKay Laterite McKay Sylvania Talga

Legend

- Iron ore mining/ exploration locations
- Project area
- Mining Lease AML244SA
- Existing OB18 Part IV area

Land System

- Boolgeeda
- Cadgie
- Disturbed Land
- Divide
- Jamindie
- Laterite
- McKay
- Newman
- River
- Rocklea
- Sylvania
- Talga
- Washplain

1:65,000

0 0.5 1 2 3 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 2.6: Land Systems of the Project area and surrounds

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

2.8 Vegetation

Vegetation mapping of the Pilbara region was completed on a broad scale (1:1,000,000) by Beard (1975). The Project area is situated in the Hamersley Plateau in the Eremaean Botanical Province of Western Australia as per Beard (1975) who broadly mapped the area as 'ranges and valley plains'. The ranges are described as a tree steppe of the *Eucalyptus-Triodia* association with a change to *Eucalyptus* mallee at the summits. The valley plains mainly carry Mulga low woodlands to shrubland (*Acacia aneura*) with some areas of open *Triodia* grassland. Shepherd *et al.* (2002) re-assessed the mapping of Beard (1975), updated the vegetation boundaries to account for clearing in the intensive land use zone, and divided some larger vegetation units into small units. Vegetation type 82, described by Shepherd *et al.* (2002) corresponds with 'ranges and valley plains' of Beard (1975) as described above. Onshore (2014) recently surveyed the vegetation and flora of the Project area.

3. METHODOLOGY

3.1 Database Review

Four SRE fauna databases were searched (in February 2013) for terrestrial SRE records within a search area surrounding the Project area as described below in Table 3.1. These databases comprised:

- Department of Parks and Wildlife (DPaW) NatureMap database;
- Atlas of Living Australia (ALA 2013);
- WA Museum (WAM) Arachnida/ Myriapoda database; and
- WAM Mollusca database.

Table 3.1: Databases used for the review

Database	Parameters
NatureMap	40 km radius around 23°19'56"S and 120°04'34"E
ALA	50 km radius around 23°19'56"S and 120°04'34"E
WAM SRE fauna databases	Bounding box (approx.150 km x 100 km) Northwest 22°45'S and 119°20'E Southeast 23°35'S and 120°47'E

BHP Billiton Iron Ore's SRE fauna database was also searched for records resulting from the surveys listed below in Section 3.2.

3.2 Review of Previous Studies

In addition to the WAM database results, reports from SRE invertebrate surveys carried out within 50 km of the Project area were reviewed. Reports from nearby surveys are listed below:

- Orebody 19-31 SRE Invertebrate Survey (Biologic 2014a);
- Orebody 24-25 SRE Invertebrate Survey (Biologic 2014b);
- OB24-OB25 Short-Range Endemic Study, Case Study Pseudoscorpions (ENV 2008);
- Orebody 24-25 Upgrade SRE Survey (Outback Ecology 2008);
- Assessment of Terrestrial Short-range Endemic Invertebrates in the OB35-Western Ridge Area near Newman, Western Australia (AMBS 2011);
- OB35 Short-range Endemic Invertebrate Survey Report (Biologic 2012a);
- South-West Jimblebar Invertebrate SRE Survey (Biologic 2013);
- Wheelarra Hill North SRE Survey (Rapallo 2011); and
- Jimblebar Iron Ore Project Terrestrial Invertebrate Short-range Endemic Assessment (Outback Ecology 2009).

3.3 Survey Chronology within the Project Area

The OB19-31 SRE Survey (Biologic 2014a) detected a new species of potential SRE pseudoscorpion, *Xenolpium* 'PSE079', within the Project area. Based on specialist advice from the WAM and the known distributions of other similar species (Biologic 2014a), *X.* 'PSE079' was thought to be potentially restricted to the Project area. Only one adult was collected during the OB19-31 SRE Survey, but a number of other immature specimens were considered to potentially belong to the same species.

In May 2014, a DNA study (WAMTS300, Appendix 3) was commissioned to determine whether the immature specimens were genetically similar to the adult *Xenolpium* 'PSE079', and to conduct regional comparisons with pre-existing material at the WAM. The WAMTS 300 DNA study confirmed that some of the immature specimens were genetically the same as *Xenolpium* 'PSE079', but failed to find any genetically similar *Xenolpium* species in any of the regional sequences from the WAM. Based on these findings, an additional targeted SRE survey was undertaken from 16 - 20 June 2014, to investigate the wider local distribution of *Xenolpium* 'PSE079' outside of the Project area. The identification of pseudoscorpion material for the targeted SRE survey required a second round of DNA studies (WAMTS317, Appendix 4). The results of the second round of DNA studies are detailed further below in this report.

The current report details the methods and combined results of all SRE surveys within the Project area (and surrounding areas relevant to the assessment). The results of both WAMTS300 and WAMTS317 DNA studies are incorporated into this report and presented in Appendices 3 and 4. Table 3.2 shows the chronology of all SRE surveys and DNA studies relevant to the current assessment.

Table 3.2: Chronology and timing of SRE surveys relevant to the Project area

Date	Survey	Important findings
March 2013	Biologic 2014a: OB19-31 SRE Survey Trip 1	Habitat data and wet season sampling of SRE invertebrates.
September 2013	Biologic 2014a: OB19-31 SRE Survey Trip 2	Additional habitat data and dry season sampling of SRE invertebrates. Adult *Xenolpium* 'PSE079' detected, also several unidentified juveniles.
May 2014	WAMTS300: DNA study of *Xenolpium* 'PSE079'	*Xenolpium* 'PSE079' detected from juvenile specimens within the Project area. Regional comparisons showed *Xenolpium* 'PSE079' to be distinct from other *Xenolpium* species.
16-20 June 2014	Targeted Survey for *Xenolpium* 'PSE079' in wider local area beyond the Project area	Methods and results reported herein.
July 2014	WAMTS317: Second DNA study for *Xenolpium* 'PSE079'	DNA results reported herein.

3.4 Targeted SRE Survey Methods

3.4.1 Site selection

Sites for the targeted SRE survey were chosen according to Guidance Statement 20 (EPA 2009) and BHP Billiton Iron Ore's (2009) Guidance for SRE Surveys in the Pilbara Region (SPR-IEN-EMS-013).

Habitats considered suitable for SRE terrestrial invertebrates in the Pilbara region were targeted, specifically focussing on the same or similar types of habitat where the target species (*Xenolpium* PSE079) had been detected from previous survey work (Biologic 2014a). These habitat types included: low Ridges/ breakaways, Shallow/ open gullies, Hillslopes/ footslopes, Vegetation groves, Drainage foci and Stony plains (Table 3.3).

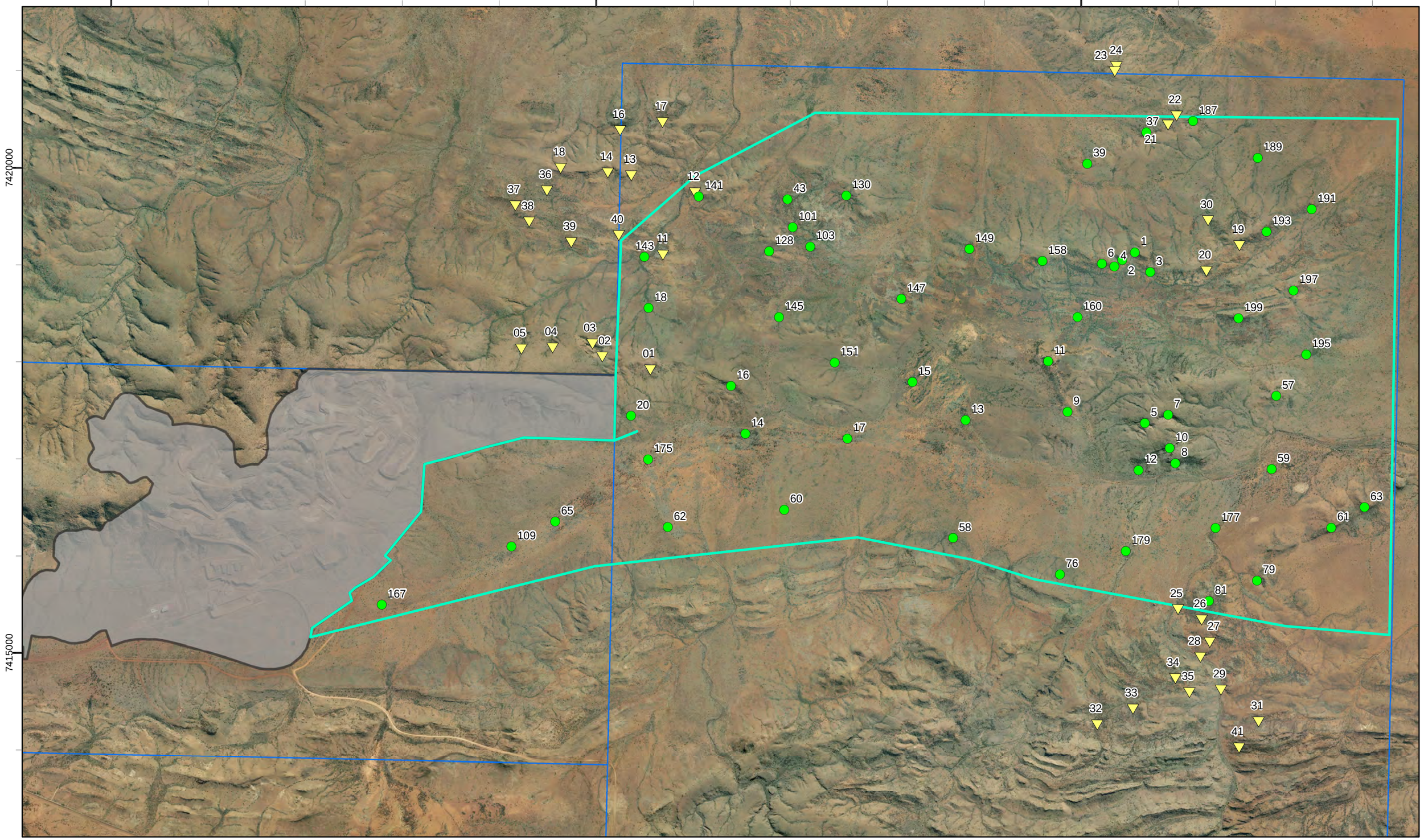
Three main sampling areas were chosen within SRE habitat zones (as identified during the OB19-31 SRE study [Biologic 2014a]) where the target species had previously been found, and/ or where these types of habitat were common). The three main sampling areas were at Wheelarra North, to the north of OB31, and to the west of OB31 (Figure 3.1). The majority of the sampling was conducted outside of the indicative disturbance area in order to determine whether the target species occurred beyond the boundaries of the indicative disturbance area. A total of 35 sites were chosen for targeted sampling, as shown in Table 3.3 below.

Figure 3.1 shows the location of targeted SRE survey sites in relation to the 57 sites previously sampled within the Project area during the OB19-31 SRE survey (Biologic 2014a).

Table 3.3: Site co-ordinates and habitat types sampled during targeted SRE survey.

Site number	Date	Latitude (GDA94)	Longitude (GDA94)	Habitat Type
1	2014-06-20	-23.3177031	120.0852561	Shallow Gully
2	2014-06-17	-23.3165948	120.0803746	Shallow Gully
3	2014-06-17	-23.3154079	120.0793707	Gorge/ Deep Gully
4	2014-06-17	-23.3158528	120.0753561	Shallow Gully
5	2014-06-17	-23.3160329	120.072214	Gorge/ Deep Gully
11	2014-06-19	-23.3070086	120.0862935	Shallow Gully
12	2014-06-19	-23.3011518	120.0893609	Hillslope/ Footslope
13	2014-06-19	-23.2997007	120.0829175	Hillslope/ Footslope
14	2014-06-19	-23.2994786	120.0805578	Ridge/ Breakaway
16	2014-06-19	-23.2955196	120.0816896	Shallow Gully
17	2014-06-19	-23.2946857	120.0859392	Drainage Foci
18	2014-06-19	-23.2991461	120.0757998	Shallow Gully
19	2014-06-20	-23.3049858	120.1443108	Shallow Gully
20	2014-06-20	-23.3074281	120.141031	Shallow Gully
21	2014-06-16	-23.2939102	120.1368184	Drainage Foci
22	2014-06-16	-23.29305	120.1376653	Shallow Gully
23	2014-06-16	-23.2890520	120.1313557	Shallow Gully
24	2014-06-16	-23.2885785	120.1314978	Shallow Gully

Site number	Date	Latitude (GDA94)	Longitude (GDA94)	Habitat Type
25	2014-06-18	-23.3389348	120.1389084	Ridge/ Breakaway
26	2014-06-18	-23.3398617	120.1413048	Drainage Foci
27	2014-06-18	-23.3419213	120.1421678	Shallow Gully
28	2014-06-18	-23.3433215	120.1412534	Ridge/ Breakaway
29	2014-06-18	-23.3463329	120.1434004	Drainage Line
30	2014-06-20	-23.3516703	120.1453654	Shallow Gully
31	2014-06-20	-23.3492024	120.1472728	Hillslope/ Footslope
32	2014-06-18	-23.3498112	120.1310264	Drainage Line
33	2014-06-18	-23.34828	120.1345836	Drainage Foci
34	2014-06-18	-23.3453474	120.1387758	Shallow Gully
35	2014-06-18	-23.3466289	120.1402287	Ridge/ Breakaway
36	2014-06-19	-23.3012608	120.0744617	Stony Plain
37	2014-06-19	-23.3027084	120.0713129	Hillslope/ Footslope
38	2014-06-19	-23.3041958	120.0727408	Vegetation Grove
39	2014-06-19	-23.3060127	120.0770184	Shallow Gully
40	2014-06-19	-23.3052677	120.0817969	Hillslope/ Footslope
41	2014-06-20	-23.3027188	120.1410948	Shallow Gully



Legend

- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area
- OB19-31 sites within Project area
- OB31 Targeted Survey sites

1:36,000

0 0.325 0.65 1.3 1.95 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 3.1: Survey effort for Targeted SRE survey and sites within the Project area (OB19-31 Survey)

Created 01/08/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

3.4.2 Methods

The targeted survey utilised a variety of active foraging techniques such as rock foraging, searching beneath vegetation bark and woody debris, and leaf litter/ soil sifting. Active foraging was undertaken at each site for 1.5 person hours, comprising:

- Searching under rocks, within cracks and crevices;
- Searching within and under large decaying logs/ woody debris;
- Foraging underneath sheets of peeling bark from Mulga trees and shrubs; and
- Leaf litter/ soil sieving - agitating leaf litter and the first 5 cm of topsoil within a geological sieve to divide the sample into four grades (>7 mm, >3 mm, <3 mm). Each grade was then thoroughly searched for pseudoscorpions. The maximum volume of litter in the sieve was approximately 4808 cm^3, and up to two sifts were conducted at each site, providing sufficient leaf litter was available.

These methods were chosen based on the collection of previous *Xenolpium* specimens from rocks and leaf litter (Biologic 2014a). All pseudoscorpions were collected and individually preserved in chilled, 100% ethanol for DNA sequencing as per WAM preservation guidelines (WAM 2013).

Biologic field personnel included S. Callan (leader), and C. Brooks. The sampling methodologies were carried out in accordance with EPA (2009) Guidance Statement No. 20 for SRE Fauna and BHP Billiton Iron Ore (2009) SRE Guidance (SPR-IEN-EMS-013).

3.4.3 Taxonomy and DNA Analysis

All pseudoscorpion specimens were lodged with the WAM, where preliminary identifications to family level were carried out by Dr Amber Beavis, and Dr Kym Abrams. All Olpiidae specimens (20) were selected for genetic analysis at the WAM's DNA laboratories by Dr Gaynor Dolman (Appendix 4).

DNA barcoding analyses used the mitochondrial gene cytochrome-oxidase sub-unit 1 (COI) to indicate genetic similarity or dissimilarity to the target species, *Xenolpium* PSE079. The hypotheses were to:

1. test whether any of the Olpiidae specimens were genetically the same or similar to *Xenolpium* 'PSE079'; and
2. provide comments on the SRE status of the queried specimens.

Olpiidae COI DNA sequences were successfully extracted and amplified from 12 of the 20 specimens by Polymerase Chain Reaction (PCR) at the WAM, and sequenced at the Australian Genomic Research Facility's Perth node (Appendices 3 and 4). The 12 DNA sequences were compared against previously sequenced *Xenolpium* material using the Basic Local Alignment Search Tool (BLAST).

Simple distance-based trees (Neighbour-joining) were developed to investigate species-level differences/ similarities, and the relationships of genetic lineages (Appendices 3 and 4).

Thresholds for defining genetic similarity/ dissimilarity of the target material were derived from these analyses in the context of published literature, available taxonomic and ecological information, and specialist experience with each taxon within the WAM.

3.4.4 SRE Status Categorisation

The SRE status categories used in this report follow the WAM (2013) categorisation for SRE invertebrates (Table 3.4, Appendices 3 and 4). This system is based upon the 10,000 km^2 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 3.4).

Under this system, "Potential SRE" status is the default categorisation 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 sub-categorised by what is currently known about 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 could be 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 will confirm that the species is a SRE.

Table 3.4: SRE categorisation used by WAM taxonomists (Appendices 3 and 4).

<table>
<tr><th></th><th>Taxonomic Certainty</th><th>Taxonomic Uncertainty</th></tr>
<tr><td>Distribution < 10,000 km^2</td><td>Confirmed SRE
A known distribution of < 10,000 km^2.
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td><td rowspan="2">Potential SRE
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.
SRE Sub-categories may apply:
A) Data Deficient
B) Habitat Indicators
C) Morphology Indicators
D) Molecular Evidence
E) Research & Expertise</td></tr>
<tr><td>Distribution > 10,000 km^2</td><td>Widespread (not an SRE)
A known distribution of > 10,000 km^2.
The taxonomy is well known.
The group is well represented in collections and/ or via comprehensive sampling.</td></tr>
</table>

However, the WAM category A) 'data deficient' is different; this category indicates that the current taxonomic data or specimen collection records are insufficient to adequately assess the SRE status of the species in question. The current assessment considers 'data deficient'

taxa to be unable to be assessed as potential SRE species at the current time, owing to a lack of taxonomic information or geographical context.

Within this report, the categorisation of SRE fauna is presented within the context of the results of on-site habitat assessment, habitat connectivity, and ecological information collected during the field survey. This aims to provide a more holistic approach toward the assessment of SRE likelihood incorporating taxonomy, ecological information, species distributions, and habitat information. The potential risks/ impacts to confirmed or putative SRE species are then discussed at scales relevant to the development project, the wider local area (including areas not proposed for development) and the wider region/ sub-regional area.

3.4.5 Habitat Assessment and SRE Likelihood Assessment

Habitats and microhabitats in the Study Area were assessed in accordance with BHP Billiton Iron Ore's Guidance for Short-Range Endemic Invertebrate Surveys in the Pilbara Region (SPR-IEN-EMS-013) (BHP Billiton Iron Ore 2009). These assessments were based on various aspects of the habitat related largely to its protective qualities, *e.g.* landform, aspect, and vegetation, and the presence of suitable microhabitats within rocks, leaf litter, soil and woody debris. The habitat assessments were aimed at determining the significance of each site as potential SRE habitat, and hence the likelihood that each site may contain SRE fauna. The habitat assessment was based on three major factors influencing the significance of habitats for SRE species; isolation, protection and habitat complexity, as briefly outlined below and illustrated in Figure 3.2.

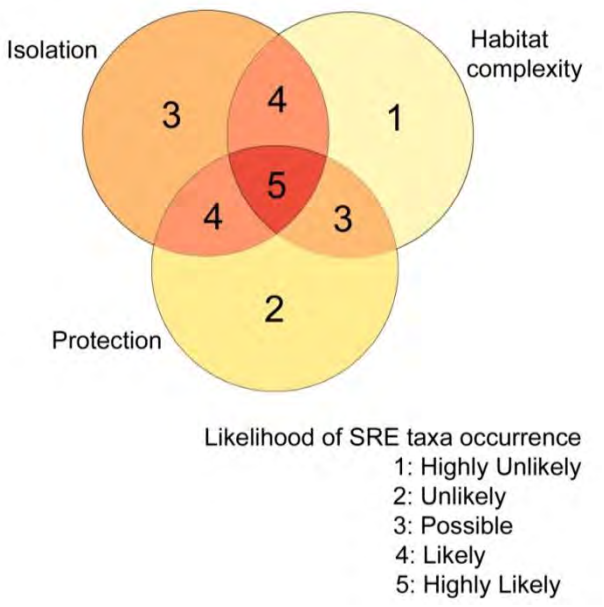


Figure 3.2: Habitat assessment diagram.

Isolation: based on the level of connectivity between sites, which share similar habitat characteristics. Isolation is the most important factor when it comes to the level of risk, as any fauna with limited dispersal characteristics, regardless of the habitat preference, will likely be, at least, an isolated population. Examples include islands and mountaintops; in the Pilbara, peaks like Mount Meharry have been shown to harbour significant SRE species (Durrant 2011).

Protection: this primarily covers protection from exposure. With respect to the Pilbara region however, protection from disturbance is also very important for the long term viability of SRE habitats and communities, *i.e.* protection from fire, flood and invasive species.

Protection is provided at two levels; the site level where the structural composition of the site (aspect, slope *etc.*) can provide protection from exposure and disturbance by providing physical barriers (*e.g.* gorges and gullies); and the habitat level where certain microhabitat characteristics, associated with habitat complexity, provide more direct protection, particularly from exposure (*i.e.* leaf litter, rocky substrates, canopy cover and soil depth).

Habitat complexity**:** this factor drives species richness and often abundance at a site, *i.e.* the more complex a site is, the more species and individuals it is likely to contain. This is particularly important, as a number of SRE groups are predators; therefore the richness and abundance of prey species are critical to their survival.

Complexity, with respect to SREs, is based around a number of microhabitat types:

- Leaf litter: both depth, coverage, and structural variation;
- Rocky substrates: loose rocks, cracks and crevices;
- Woody debris: size, abundance and decomposition rate of dead wood;
- Vegetation variation: flora richness and structural variation; and
- Soil: depth, texture, and structural variation.

Likewise, the complexity of the habitat is important to detritivore SRE taxa, such as isopods, millipedes and some snails, which rely upon decaying leaf litter, woody debris and organic matter for survival. Examples in the Pilbara include deep gullies and gorges, where most of the above microhabitat types occur; these therefore tend to be species-rich areas.

3.4.6 Habitat Mapping

The habitats of the Project area were classified into broad habitat zones that reflect major changes in the important landform features, drainage features and vegetation features which influence SRE likelihood. The information used to classify and map the habitat zones included vegetation mapping (Onshore 2014), topographical contours, drainage information, and the results of on-site habitat assessments. This information was combined with general knowledge of the Project area gained from the field survey, onsite photography and site observations, and mapped according to recent high resolution aerial photography obtained from BHP Billiton Iron Ore.

The resulting map of the estimated extent of habitat zones is an indicative interpretation, based on a combination of the sources listed above. It is acknowledged that specific habitat and microhabitat characteristics that influence SRE likelihood may vary significantly within each habitat zone. Multiple different (but related) habitat types can occur within each habitat zone, and the level of congruence between the spatial extent of a habitat type and the broader zone that it occurs within zone depends upon the habitat type and habitat zone in question.

For example, the Drainage zone aligns with the extent of Drainage line habitats, as these habitats are clearly defined, distinct from all other habitats, and simple to delineate. Drainage line habitats within the Drainage zone can be assumed to be highly connected/ continuous both because of the high level of congruence with the habitat zone, and because they are inherently continuous habitats. In contrast, the Low hills and outcrops zone contains a number of slightly different rocky/ mountainous habitats such as Rocky outcrops, Ridges/ breakaways, Shallow/ open gullies, Gorges/ deep gullies, and Hillslope/ footslopes. Although all of these habitat types are related to mountainous landforms, they all differ in terms of their spatial extent throughout the zone (*i.e.* congruence with the zone boundaries), and in terms of their connectivity, and suitability for SRE fauna. Owing to the differences in habitat and microhabitat requirements for each SRE taxon, and the limitations of sampling it is not practical, or useful for the assessment, to identify every gully, outcrop, hillslope, ridge *etc.* within its own zone; therefore the extent of these habitats is mapped as a combined zone (Low hills and outcrops), and discussed in terms of the potential occurrence of all rocky/ mountainous habitats within this boundary. However, this does not mean that these habitats will be necessarily continuous or connected throughout this zone, as they each vary in their connectivity and extent.

Where the habitat zones have been used to infer the potential local extent of suitable habitats for key species within the EIA, this inference is indicative only, and is subject to the limitations of the data collected on-site, as well as the limitations of current taxonomic and ecological knowledge.

3.5 Limitations

There are several general limitations in regard to the completeness of SRE fauna surveys, particularly with regard to the target fauna living in cryptic habitats, occurring in low numbers, and being generally difficult to detect. Despite this, it is not considered that the surveys or DNA studies suffered from any specific constraints in relation to the number of samples, the coverage of SRE habitat types, the inclusion of seasonal data, the environmental conditions, or the sampling and preservation methods used to detect the target fauna.

The identification of SRE species, the interpretation of species' distributions, and the resulting categorisation of their respective SRE status is dependent on the current state of taxonomic and ecological knowledge of the target groups at the time of survey. Owing to ongoing developments in regional sampling coverage and taxonomic information, the SRE status,

distributions and habitat preferences of the taxa described herein may be subject to change over time.

The estimated extent of habitat zones mapped in Figure 4.5 is a generalised/ indicative interpretation only, based on aerial photography, habitat assessment at sites visited, and general knowledge of the Survey Area. Microhabitat characteristics that influence SRE prospectivity may vary significantly within the estimated extent of each habitat zone. The estimated extent of habitat zones was mapped for descriptive purposes and should not be taken as a precise indication of the extent of habitat characteristics or as a reliable surrogate for the distribution of any SRE species or assemblage (community) of SRE species.

4. RESULTS

4.1 Database Searches

Note: faunal results from the OB19-31 SRE survey (Biologic 2014a) occurring within the Project area are omitted from this section, as these results are presented in more detail in section 4.3, in combination with the results from the current targeted survey.

The DPaW NatureMap and ALA databases contained no records of SRE species or conservation significant invertebrate species within the respective search areas. The WAM databases reported 14 SRE species within the search area, including mygalomorph spiders, polydesmid millipedes and scorpions (Table 4.1). Recent SRE surveys at OB19-31 and OB24-25 (Biologic 2014a, 2014b) revealed a further 18 confirmed and potential SRE species. Figures 4.1 and 4.2 show the locations of these potential SRE species outside of the Project area.

Table 4.1: Potential SRE species known to occur within the database search area. Data from WAM and BHP Billiton Iron Ore databases. * Note: potential SRE records inside Project area at OB31 are not included, as these are presented in section 4.3.

Higher Taxon	Morphospecies	OB 35	OB 24-25	OB 19-31* Wheelarra North	Jimblebar Wheelarra Hill	Davidson Creek	Total
Selenopidae							
	Karaops 'ARA003-DNA'			15			**15**
	Karaops 'ARA004-DNA'			10			**10**
	Karaops 'ARA005-DNA'		32				**32**
Mygalomorphae							
	Aganippe 'MYG085'				1		**1**
	Aganippe 'MYG384-DNA'			1			**1**
	Aname 'MYG098'	2					**2**
	Aname 'MYG205'	3					**3**
	Aname 'MYG206'	3					**3**
	Aname aragog				1		**1**
	Aurecocrypta 'MYG315-DNA'		1				**1**
	Conothele 'MYG385-DNA'		1				**1**
	Cethegus 'MYG299-DNA'		6				**6**
	Kwonkan 'MYG094'				1		**1**
	Missulena occatoria grp.				3		**3**
	Synothele 'MYG116'				1		**1**
Pseudoscorpiones							
	Feaella 'PSE080' (Confirmed SRE)		5				**5**
	Synsphyronus 'sp. indet. (juv.)'			1			**1**
Polydesmida							
	Antichiropus 'DIP014'	7					**5**
	Antichiropus 'DIP015'	2					**2**

Higher Taxon	Morphospecies	OB 35	OB 24-25	OB 19-31* Wheelarra North	Jimblebar Wheelarra Hill	Davidson Creek	Total
	Antichiropus 'DIP042'				1		**1**
	Antichiropus 'sp. indet. (juv.)'			2			**2**
Scorpiones							
	Urodacus 'Davidson creek'					4	**4**
Isopoda							
	Buddelundia sp. nov.				1		**1**
	Buddelundia '10NM'			123			**123**
	Buddelundia '16NM'	1	224				**225**
	Buddelundia '36NM'			4			**4**
	Buddelundia '49'		9	100			**109**
	Buddelundia '78'		115				**115**
	Buddelundia '79'		3				**3**
	Buddelundia '80'		3				**3**
	Buddelundiinae 'OB24'		5				**5**
	Buddelundiinae 'WN'			5			**5**
Total SRE species		**6**	**11**	**9**	**7**	**1**	

760000 765000 770000 775000 780000 785000 790000 795000 800000 805000 810000 815000 820000 825000 830000 835000 840000 845000 850000 855000

7435000 7430000 7425000 7420000 7415000 7410000 7405000 7400000 7395000 7390000 7385000

Hamersley

Fortescue

Augustus

OB23/25

OB17/18

Jimblebar (Wheelarra Hill)

OB29/30/35

Legend

- BHP Billiton Iron Ore Operations
- Mining Lease AML244SA
- Project area

Taxonomic group, species

- Araneomorphae, Karaops 'ARA005-DNA'
- Araneomorphae, Karaops 'ARA003-DNA'
- Araneomorphae, Karaops 'ARA004-DNA'
- Mygalomorphae, Aganippe 'sp. MYG384-DNA'
- Mygalomorphae, Aganippe `MYG085`
- Mygalomorphae, Aname `MYG098`
- Mygalomorphae, Aname `MYG205`
- Mygalomorphae, Aname `MYG206`
- Mygalomorphae, Aname aragog
- Mygalomorphae, Aurecocrypta 'MYG315-DNA'
- Mygalomorphae, Cethegus 'MYG299-DNA'
- Mygalomorphae, Conothele 'MYG385-DNA'
- Mygalomorphae, Kwonkan `MYG094`
- Mygalomorphae, Missulena occatoria-group
- Mygalomorphae, Synothele `MYG116`
- Polydesmida, Antichiropus `DIP014`
- Polydesmida, Antichiropus `DIP015`
- Polydesmida, Antichiropus `DIP042`
- Polydesmida, Antichiropus `sp. indet. (juv.)`
- Pseudoscorpiones, Feaella PSE080 (Confirmed SRE)
- Pseudoscorpiones, Synsphyronus `sp. indet. (juv.)`
- Pseudoscorpiones, Synsphyronus `sp. nov. 8/1 Pilbara`
- Scorpiones, Urodacus `Davidson Creek`

1:250,000

0 2.25 4.5 9 13.5 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.1: Potential SRE species recorded from the wider sub-regional area (part 1)

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

770000 775000 780000 785000 790000 795000 800000 805000 810000 815000 820000 825000

7435000 7430000 7425000 7420000 7415000 7410000 7405000 7400000

Fortescue

Hamersley

Augustus

OB23/25

OB17/18

Mt Whaleback

OB29/30/35

Jimblebar (Wheelarra Hill)

Legend

- BHP Billiton Iron Ore Operations
- Mining Lease AML244SA
- Project area

Taxonomic group, species

- Isopoda, Buddelundia '10NM'
- Isopoda, Buddelundia '16NM'
- Isopoda, Buddelundia '36NM'
- Isopoda, Buddelundia '49'
- Isopoda, Buddelundia '78'
- Isopoda, Buddelundia '79'
- Isopoda, Buddelundia '80'
- Isopoda, Buddelundia sp. nov.
- Isopoda, Buddelundiinae 'OB24'
- Isopoda, Buddelundiinae 'WN'

1:150,000

0 1.25 2.5 5 7.5 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.2: Potential SRE species recorded from the wider sub-regional area (part 2)

Created 17/07/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

4.2 Previous Surveys

A number of previous SRE surveys have been conducted within the wider regional area; where data was available, the study areas and survey effort from these surveys are shown in Figure 4.3.

4.2.1 Orebody 19-31 SRE Survey (Biologic Environmental Survey 2014a)

This survey sampled 163 sites throughout OB17, OB19, OB31, Wheelarra North and Mesa Gap, including the entirety of the Project area and the immediate surrounds. The survey was conducted over two seasons in March and September 2013, collecting mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, snails, millipedes, and isopods. Habitats targeted for sampling included gorges/ deep gullies, ridges/ breakaways, rocky outcrops, shallow/ open gullies, vegetation groves, drainage lines, drainage foci and plains. The survey methods used were active foraging, leaf litter sifting, soil sifting, burrow excavation, and vegetation/ bark searching.

The survey detected 10 species considered to be potential SREs:

- The mygalomorph spider, *Aganippe* 'MYG384-DNA';
- Two selenopid spiders, *Karaops* 'ARA003-DNA' and *K.* 'ARA004-DNA';
- Two pseudoscorpions, *Synsphyronus* 'sp. indet. (juv.)' and *Xenolpium* 'PSE079';
- The millipede, *Antichiropus* 'sp. indet. (juv.)'; and
- Four isopods, *Buddelundia* '36NM', *Buddelundia* '10NM', *Buddelundia* '49', and Buddelundiinae 'WN'.

Within the potential SRE species, the selenopid spiders, *Karaops* ‘ARA003-DNA’ and *K.* ‘ARA004-DNA’, the millipede, *Antichiropus* 'sp. indet. (juv.)', the pseudoscorpion *Xenolpium* 'PSE079', and two of the isopods (*Buddelundia* '36NM' and Buddelundiinae 'WN') were considered to be of high conservation value because they belong to groups with a high likelihood of being SRE, and they were only recorded from restricted mountainous habitats.

Habitat assessment results from this survey from sites within the Project area are presented in Appendix 2.

4.2.2 Orebody 24-25 SRE Survey (Biologic Environmental Survey 2014b)

This survey sampled 124 sites throughout OB24, OB25, and Homestead, approximately 30 km west of the Project area. The survey was conducted over two seasons in April/ May and August 2013, collecting mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, snails, millipedes, and isopods. Habitats targeted for sampling included gorges/ deep gullies, ridges/ breakaways, rocky outcrops, shallow/ open gullies, vegetation groves, drainage lines, drainage foci and plains. The survey methods used were active foraging, leaf litter sifting, soil sifting, burrow excavation, and vegetation/ bark searching.

760000 765000 770000 775000 780000 785000 790000 795000 800000 805000 810000 815000 820000 825000 830000 835000

7430000 7425000 7420000 7415000 7410000 7405000 7400000 7395000 7390000

Hamersley

Fortescue

Augustus

OB23/25

OB17/18

Mt Whaleback

OB29/30/35

Jimblebar (Wheelarra Hill)

Legend

- BHP Billiton Iron Ore Locations
- Mining Lease AML244SA
- Project area
- \+ SRE sites (habitat, opportunistic, and sampling)

Previous survey (reference)

- Orebody 35/ Western Ridge (AMBS 2011)
- Orebody 35 Additional Area (Biologic 2012)
- Jimblebar SRE Survey (Outback Ecology 2009)
- South West Jimblebar (Biologic 2013)
- Orebody 19-31 SRE Survey (Biologic 2014a)
- Orebody 24-25 SRE Survey (Biologic 2014b)
- Orebody 24-25 Upgrade SRE Survey (Outback Ecology 2008)
- Orebody 24-25 SRE Study, Case Study Pseudoscorpions (ENV 2008)
- Wheelarra North SRE Survey (Rapallo 2011)

1:190,000

0 1.75 3.5 7 10.5 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.3: Previous SRE survey areas and sites within the sub-regional area (habitat, opportunistic and sampling sites)

Created 17/09/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

The sampling detected one confirmed SRE species; the pseudoscorpion, *Feaella* 'PSE080', and the following 10 species considered to be potential SREs:

- a selenopid spider - *Karaops* 'ARA005-DNA';
- three mygalomorph spiders - *Aurecocrypta* 'MYG315-DNA', *Cethegus* 'MYG299-DNA', and *Conothele* 'MYG385-DNA'; and
- six species of isopods - *Buddelundia* '16NM'; *Buddelundia* '49'; *Buddelundia* '78'; *Buddelundia* '79'; *Buddelundia* '80'; and Buddelundiinae 'OB24'.

Within these species, the confirmed SRE pseudoscorpion *Feaella* 'PSE080', the mygalomorph spider *Conothele* 'MYG385-DNA' and the isopod *Buddelundia* '80' were considered to be of high conservation value because they were only recorded from restricted mountainous habitats.

4.2.3 OB24-OB25 Short-Range Endemic Study, Case Study Pseudoscorpions (ENV 2008)

A targeted survey and DNA analysis of pseudoscorpions was undertaken at OB24-25 from 7-12 March 2006. The survey sampled 12 sites by targeted searching in habitats such as range crests, range slopes, breakaways, gullies and gorges, targeting pseudoscorpions only. The specimens were frozen in liquid nitrogen to preserve DNA, and a pedipalp was dissected and placed in 80 % ethanol to allow for morphological identifications (ENV 2008). The survey detected three lineages of pseudoscorpions from three different genera (*Indolpium*, *Euryolpium* and *Austrohorus*) in the family Olpiidae. The three lineages clearly corresponded to at least three different species, but the study was inconclusive about whether or not the species' distributions and the level of genetic divergence within these species indicated a potential dispersal barrier between OB24 and OB25 (ENV 2008).

4.2.4 Orebody 24-25 Upgrade SRE Survey (Outback Ecology 2008)

This survey sampled eight sites at OB24-25 in April and June 2008. Habitats such as south facing slopes, ridges, gullies, and vegetation groves were sampled by dry pitfall trapping, targeted searches, leaf litter extraction, soil sifting, and nocturnal searching with UV lights. The target groups included mygalomorph spiders, scorpions, snails, millipedes and pseudoscorpions. Two millipede species identified as possible SRE taxa, Paradoxosomatidae sp. (juveniles) and *Austrostrophus stictopygus* were collected from south to south-east facing ridgelines and rocky slopes. *A. stictopygus* is now known to be widespread throughout many other locations in the Pilbara and is not considered SRE (C. Car, WAM pers. comm. 2013). To the best of our knowledge, the identification and SRE status of Paradoxosomatidae sp. (juveniles) have not been further resolved since the time of the survey. This family is known to include a number of SRE species in the genus *Antichiropus*, although additional adult specimens or DNA analyses would be required to further resolve the identification and SRE status of the specimens collected from this survey.

4.2.5 OB35-Western Ridge SRE Survey (AMBS 2011)

This survey sampled 30 sites at OB35/ Western Ridge approximately 45 km southwest of the current Project area in March/ May and August 2010. SRE habitats such as gorges and gullies and south/ southeast facing slopes were targeted, as well as more open habitats such as minor outwashes, valley floors, and low rolling hills. Sampling was conducted by wet and dry pitfall trapping, targeted searches, and soil sampling. The target groups comprised mygalomorph spiders, scorpions, snails, millipedes and pseudoscorpions. Seven species were originally identified as possible SRE taxa: three mygalomorph spiders (*Aname* 'MYG205', *A.* 'MYG206' and *A.* 'MYG098'), two paradoxosomatid millipedes (*Antichiropus* 'OB_1' and *A.* 'OB_2'), one pseudoscorpion (*Austrochthonius* sp.) and one scorpion (*Urodacus* 'pilbara 12'). All of the species, other than the *Aname* spiders, were recorded primarily or exclusively in habitats that had high SRE potential (AMBS 2011). The *Aname* species were all recorded in open floodplains, which was unlikely to be restricted due to its widespread occurrence and high connectivity (AMBS 2011). Subsequent information from the WAM has indicated that the *Austrochthonius* pseudoscorpions and the scorpion *Urodacus* 'pilbara 12' are no longer considered to be potential SRE species. The two species of *Antichiropus* ('OB_1' and 'OB_2') have been re-named *A.* 'DIP014' and *A.* 'DIP015' respectively, and are still considered to be potential SRE taxa (A. Beavis, pers. comm. 2013).

4.2.6 OB35 Additional SRE Survey (Biologic 2012a)

This survey sampled 30 sites in an additional area at OB35, approximately 45 km southwest of the current Project area, in September 2011. SRE habitats such as gorges and deep gullies, steep south/ southeast facing slopes, and ridges were targeted. Sampling was conducted by active foraging, leaf litter searching, and soil sifting. The target groups comprised mygalomorph spiders, scorpions, snails, isopods, millipedes and pseudoscorpions. The survey collected seven species from groups such as pseudoscorpions, land snails, scorpions and spirobolid millipedes, although none of the species were found to be SRE.

4.2.7 South-West Jimblebar SRE Survey (Biologic 2013)

This survey sampled 30 sites in an area southwest of the Wheelarra Hill (Jimblebar) Mine, approximately 10 km southwest of the current Project area, in February 2013. The habitats available for sampling comprised Mulga woodland, low ridges/ outcrops, and tall open shrubland. Sampling was conducted by active foraging, leaf litter sifting, soil sifting, and burrow excavations. The target groups comprised mygalomorph spiders, scorpions, snails, isopods, millipedes and pseudoscorpions. A new species of isopod, *Buddelundia* sp. nov., collected from a single specimen on an isolated low ridge/ outcrop, was considered to be a potential SRE. This was the first survey in the local area to target isopod fauna, and the lack of regional context information available limited the ability to clarify this species' SRE status. The species has not been collected in any subsequent surveys to date (S. Judd pers. comm. 2014).

4.2.8 Wheelarra Hill North SRE Survey (Rapallo 2011)

This survey sampled 47 sites within the Wheelarra Hill North and Mesa Gap areas, approximately 5 km south of the current Project area, in May 2011. Habitats such as south facing slopes, minor creek lines, gorge/ gullies, and plains were sampled by targeted searches and leaf litter extraction, and two sites in gorge/ gullies and creek lines were sampled by dry pitfall trapping. The survey targeted mygalomorph spiders, selenopid spiders, pseudoscorpions, scorpions, millipedes, and land snails. None of the taxa detected were found to be SRE species.

4.2.9 Jimblebar SRE Survey (Outback Ecology 2009)

This survey sampled 14 sites (including eight pit trapping sites and six opportunistic sites) within the Wheelarra Hill (Jimblebar) Mine lease, approximately 5 km southeast of the current Project area, in August 2008 and February 2009. Habitats such as south facing slopes, ridges, breakaways, gullies, minor drainage lines, and Mulga groves were sampled by dry pitfall trapping, targeted searches, leaf litter extraction, soil sifting, and nocturnal searching with UV lights. The target groups included mygalomorph spiders, scorpions, snails, millipedes and pseudoscorpions. None of the species detected were found to be SRE at the time of the survey but subsequent taxonomic revisions of some of the material collected have found that the potential SRE species *Aganippe* 'MYG085', *Aname aragog*, and *Missulena occatoria* grp. occur in the area.

4.3 SRE Invertebrate Fauna Results

The OB19-31 SRE survey (Biologic 2014a) collected a total of 1464 invertebrate specimens from 163 sites in the Project area and surrounding areas. The targeted SRE survey at OB31 in June 2014 collected a further 40 specimens of pseudoscorpions from 35 sites within the Project area and immediate surrounds (for full results, refer Appendix 1). The combined sampling effort within the Project area comprises 57 sites sampled during the OB19-31 SRE survey (Biologic 2014a) and seven sites sampled during the targeted SRE survey.

Table 4.2 shows that a combined total of 20 taxa (species and morphospecies) are known to occur within the Project area, excluding indeterminate juvenile or damaged specimens. Eighteen out of these 20 taxa were also detected from the wider local area surrounding the Project area boundaries (*i.e.* from the OB19-31 SRE survey and targeted SRE survey sites), while the remaining two taxa (*Aname mellosa* and *Urodacus megamastigus*) are known to be regionally widespread (Biologic 2014a).

Based on the combined results from both SRE surveys, none of the species detected from the Project area are considered to be restricted to the Project area.

Six taxa occurring within the Project area were considered to be potential SREs, including;

- The selenopid spiders *Karaops* 'ARA003-DNA' and *K.* 'ARA004-DNA' (WAM category 'D' molecular evidence);

- The pseudoscorpion *Xenolpium* 'PSE079' (WAM category 'D' molecular evidence); and
- The isopods *Buddelundia* '10NM', *Buddelundia* '49', and Buddelundiinae 'WN'.

Table 4.2: Numbers of target taxa detected within the Project area and their wider local/ regional occurrence. Potential SRE taxa within the Project area are highlighted orange.

Higher taxon	Species/ morphospecies	SRE status	Within Project area	Wider local area	Wider regional occurrence	Total individuals
Mygalomorphae						
	Aname mellosa	Not SRE	2		Yes	**2**
	Aname ' MYG004'	Not SRE	4	3	Yes	**7**
Selenopidae						
	Karaops 'ARA003-DNA'	Potential	5	10	No	**15**
	Karaops 'ARA004-DNA'	Potential	1	9	No	**10**
Pseudoscorpiones						
	Oratemnus 'sp.'	Data deficient	24	38	Unknown	**62**
	Austrohorus 'sp.'	Data deficient	17	54	Unknown	**54**
	Beierolpium '8/2'	Data deficient	2	4	Yes	**4**
	Beierolpium '8/3'	Data deficient	11	45	Yes	**32**
	Beierolpium '8/4'	Data deficient	1	68	Yes	**26**
	Indolpium 'sp.'	Data deficient	2	5	Unknown	**6**
	Xenolpium 'PSE079'	Potential	5	5	No	**10**
Scorpiones						
	Lychas 'hairy tail group'	Not SRE	1	17	Yes	**18**
	Urodacus megamastigus	Not SRE	1		Yes	**1**
Isopoda						
	Buddelundia '10NM'	Potential	12	123	OB35	**49**
	Buddelundia '14CR'	Not SRE	9	242	Yes	**98**
	Buddelundia '49'	Potential	9	100	OB24-25	**60**
	Buddelundiinae 'WN'	Potential	1	5	Unknown	**2**
Pulmonata						
	Gastrocopta mussoni	Not SRE	24	314	Yes	**77**
	Pupoides cf. *beltianus*	Not SRE	16	73	Yes	**37**
	Eremopeas interioris	Not SRE	2	4	Yes	**2**
Totals			**20 spp.**	**18 spp.**		**574**

In addition, the following potential SRE taxa were collected from the area immediately surrounding the Project area, but not within the Project area:

- *Aganippe* 'sp. MYG384-DNA' (mygalomorph spider) - collected immediately north of the Project area during the OB19-31 SRE survey. DNA studies confirmed that this species also occurs regionally at Mudlark and South Flank (Biologic 2014a).
- *Synsphyronus* 'sp. indet. (juv.)' (pseudoscorpion), and *Buddelundia* '36NM' (isopod) - collected only from Wheelarra North, south of the Project area (Biologic 2014a).

Suitable habitats for both of these taxa are likely to occur inside and outside of the Project area; however, as no records of these taxa have been detected within the Project area, they are not considered further within this assessment.

4.3.1 Potential SRE taxa within the Project area

Details regarding the six potential SRE taxa that occur within the Project area are presented below. The known locations of these species relative to the Project area boundaries are shown in Figure 4.4.

Karaops species (Araneae: Selenopidae)

All selenopid spiders collected during the OB19-31 survey were immature, therefore DNA analyses were used to determine species identifications and make regional comparisons with previously collected material in the WAM. The analyses revealed the presence of two new potential SRE species, *Karaops* 'ARA003-DNA' and *K.* 'ARA004-DNA' (approximately 3% divergence COI) (Biologic 2014a). Following the known habitat preferences within this genus, the two species of *Karaops* were found only in rocky/ mountainous habitats such as Gorges/ deep gullies, Ridges/ breakaways, Rocky outcrops and Shallow/ open gullies.

These two sister species were not found within the same areas, with *K*. 'ARA003-DNA' occurring only in rocky/ mountainous habitats at OB31 and OB19, while *K*. 'ARA004-DNA' was found only to the south east in mountainous habitats at Wheelarra North. This sympatric distribution pattern was attributed to a habitat discontinuity between the two major mountainous habitat zones (*i.e.* the flat palaeochannel that lies between OB19/ OB31 and Wheelarra North was thought to form a dispersal barrier). Owing to the fact that these mountainous habitat zones are surrounded by broad plains to the north, east, and south, and a third sister species (*K*. 'ARA005-DNA') is known to occur west of the Fortescue River at OB24-25 (Biologic 2014b), it appears that *Karaops* 'ARA003-DNA' and *K.* 'ARA004-DNA' may be locally restricted to their respective mountainous zones at OB19-31 and Wheelarra North. However, neither species is restricted to the Project area for the current assessment.

Xenolpium 'PSE079' (Pseudoscorpiones: Olpiidae)

Based on morphological identifications and DNA results (Appendices 3 and 4), *Xenolpium* 'PSE079' was detected from four sites within the Project area and a further five sites beyond the Project area boundaries (Figure 4.4). The regional DNA comparisons showed a very high level of divergence (minimally 18.67% COI) from all other regional *Xenolpium* sequences, while the variability within the lineage was very low (1.23% COI), supporting the identification of *X*. 'PSE079' as a distinct species.

Two adult specimens have been found, one from the southwest of the Project area, and one immediately north of the Project area boundaries. An additional eight juvenile specimens have been detected at three sites throughout the Project area and five sites immediately south, north and west of the Project area boundaries. Based on its current distribution inside and outside of the Project area, and the limited ranges of most other species within this genus (Appendix 4), *X*. 'PSE079' is considered to be a potential SRE species.

805000 810000 815000 820000

7420000

7415000

Legend

- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area

Potential SRE species

- Buddelundia '10NM'
- Buddelundia '49'
- Buddelundiinae 'WN'
- Xenolpium 'PSE079'
- Karaops 'ARA003-DNA'
- Karaops 'ARA004-DNA'

1:50,000

0 0.45 0.9 1.8 2.7 km

N

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Fig. 4.4: Potential SRE species within the Project area and surrounding surveyed areas

Created 01/08/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

Buddelundia species (Isopoda: Armadillidae)

Three species of potential SRE isopods are known to occur within the Project area; *Buddelundia* '10NM', *Buddelundia* '49' and Buddelundiinae 'WN'. The former two species were commonly collected throughout the wider local area (Figure 4.2) and are known to occur from other regional locations near Newman (Table 4.2) (Biologic 2012, 2014b). Buddelundiinae 'WN' was only detected from one specimen within the Project area and five specimens outside the Project area at Wheelarra North. The taxonomy of this species was not well-resolved, due to the lack of adult specimens, and it was considered a potential SRE as a precautionary measure (Biologic 2014a). None of the isopod species were restricted to the Project area.

4.4 SRE Habitats

4.4.1 SRE Habitat Zones

The Project area and surrounding areas were classified into five broad habitat zones reflecting the major changes in landform features, drainage features and vegetation features that influence SRE occurrence. Each zone contained a number of specific habitat types as assessed on-site and as discussed further below. The methods and constraints of this categorisation system have been discussed in section 3.4.6. The classification of the zones integrated vegetation mapping (Figure 2.7), topography (Figure 2.4), drainage (Figure 2.5), aerial photography (Figure 1.2), and on-site habitat assessment information (Appendix 2). Figure 4.5 shows the location and habitat type of sites assessed within the Project area, in the context of the broader habitat zones discussed below.

The five SRE habitat zones within the Project area comprised:

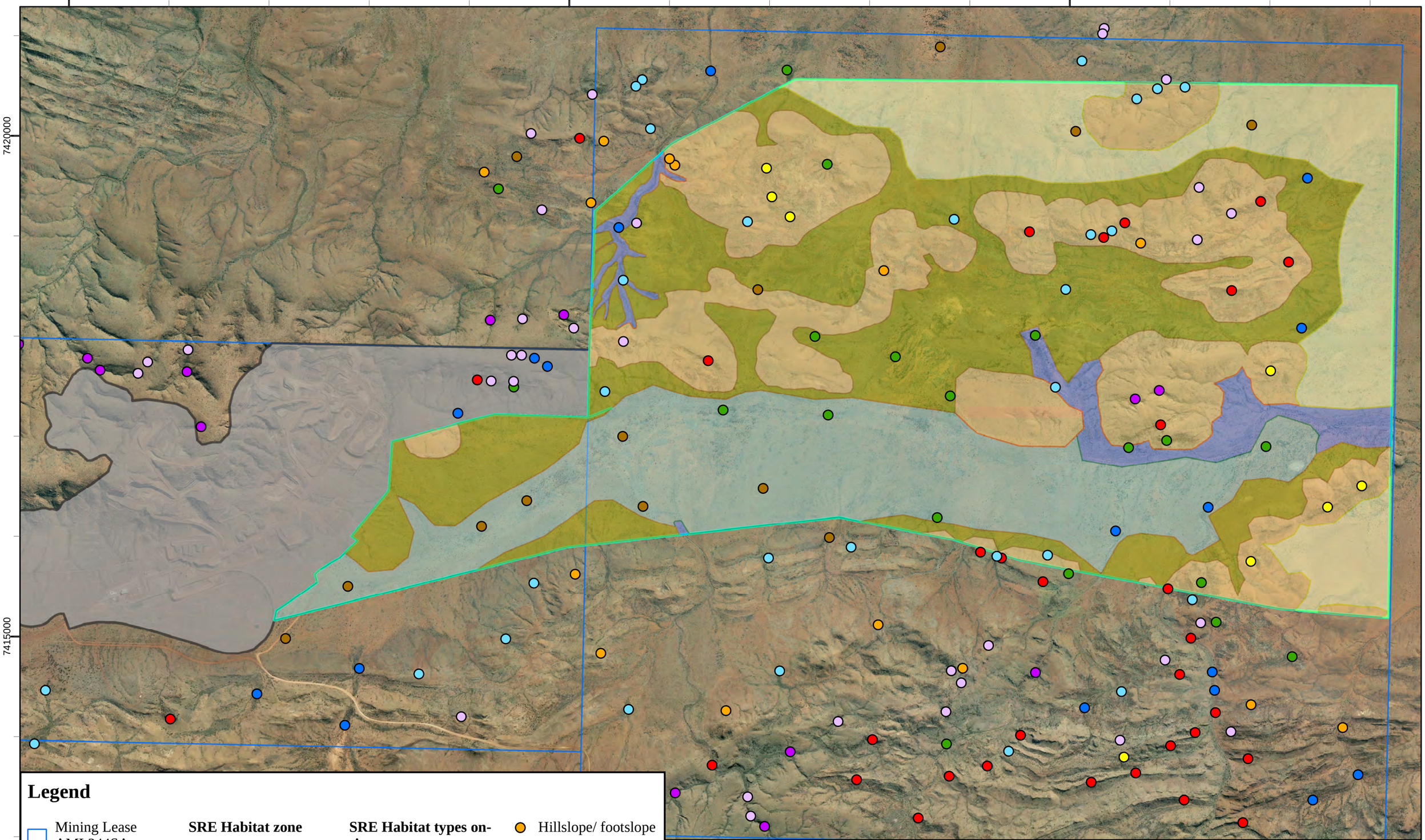
1. Low hills and outcrops zone - a series of undulating hills and moderately steep, isolated outcrops occurs throughout the central part of the Project area, featuring low Ridges/ breakaways, small Gorges/ deep gullies and many Shallow gullies that are considered moderately to highly suitable for SRE fauna. The major mountainous habitats are flanked by extensive areas of undulating Hillslope/ footslopes, and Drainage foci with Vegetation groves in the valleys between the low hills.

   In a landscape sense, this zone is a remnant of an easterly projection of the Hamersley Ranges, which has undergone extensive erosion and weathering to leave behind only a few small patches of low rocky hills, surrounded by colluvial/ alluvial plains. The larger patches of the Low hills and outcrops zone within the central part of the Project area form a somewhat continuous network of rocky habitats, while smaller, more isolated patches of similar habitat occur in the northeast and southeast. Further beyond the Project area to the south and west, more extensive and taller mountainous areas occur at Wheelarra Hill and OB19. The OB19-31 SRE Survey (Biologic 2014a) found that there was habitat connectivity between the Low hills and outcrops zone of the central Project area (OB31)

and the mountains of OB19 to the west, but the mountainous habitats to the south at Wheelarra North were isolated for rocky habitat specialist fauna (*i.e. Karaops* species).

For the purposes of the current assessment, the Low hills and outcrops zone encompasses all rocky habitats at OB31, as well as a small, northern part of Wheelarra North that is within the Project area (Figure 4.5). The extent of potential habitats for key species within the assessment is described further below in Section 4.5.

2. Stony plain zone - low sloping washplains on the flanks of the hills and ridges, descending into stony valleys with vegetated drainage tracts receiving local runoff. This zone surrounds and occurs between patches of Low hills and outcrops, and forms a buffer between these steeper areas and the relatively flat Sandplain and Palaeochannel zones. Habitats sampled within this zone included Stony plains, Vegetation groves and Drainage foci (Figure 4.5, Appendix 2), and were generally considered to have a low suitability for SRE fauna, owing to the relatively high exposure and the lack of highly complex microhabitats (except within dense Vegetation groves).
3. Drainage zone - vegetation-based, riparian habitats on the banks and floodplains of the drainage lines in the northwest and southeast of the Project area. Habitats sampled within this zone included Vegetation groves and Drainage lines (Figure 4.5, Appendix 2). This zone features relatively continuous habitats that are considered moderately suitable for some SRE fauna (and may be dispersal habitats for these species), and that are known to extend far beyond the Project area.
4. Sandplain zone - broad, flat sandy plains associated with Jimblebar Creek to the north and east of the Project area. The habitat types sampled within this zone were Plains, Vegetation groves and Drainage lines that were generally considered to have a low suitability for SRE fauna, owing to generally high exposure and the lack of complex microhabitats (except within dense Vegetation groves).
5. Palaeochannel zone - broad, flat alluvial plains with clay pans and groves occurring along the palaeochannel in the south of the Project area. Rock-based microhabitats are almost completely absent within this zone, which is dominated by deep accumulations of fine sediments. The absence of rocky microhabitats within this zone may form a dispersal barrier for rocky habitat specialised species such as *Karaops*. Habitats sampled within this zone included Vegetation groves, Plains and Drainage lines that were generally considered to have a low suitability for SRE fauna, owing to generally high exposure, low isolation, and a lack of complex microhabitats (except within denser Vegetation groves).



Legend

Mining Lease AML244SA

Project area

Existing OB18 Part IV area

SRE Habitat zone

- Drainage zone
- Low hills and outcrops zone
- Palaeochannel zone
- Sandplain zone
- Stony plain zone

SRE Habitat types on-site

- Plain (Stony plain/ Sandplain)
- Vegetation grove
- Drainage foci
- Drainage line
- Hillslope/ footslope
- Shallow gully
- Outcrop/ dome
- Ridge/ breakaway
- Gorge/ deep gully

1:35,000

0 0.325 0.65 1.3 1.95 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.5: Estimated extent of habitat zones within the Project area and SRE habitat types assessed on-site

Created 01/08/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

4.4.2 SRE Habitat Types Assessed

Nine specific habitat types were identified at sites throughout the Project area and immediate surrounds, comprising:

- Gorges/ deep gullies (only within the Low hills and outcrops zone) - moderately to highly suitable, refugial habitats for SRE fauna. The suitability for SRE fauna depends on high protection (shelter), complex rocky microhabitats, and high isolation due to discontinuous mountainous landforms. Gorges/ deep gullies differ from Shallow/ open gullies by having steeper faces that provide greater protection from exposure.
- Shallow/ open gullies (Low hills and outcrops zone, and Stony plain zone) - low to moderate/ high suitability for SRE fauna due to variable shelter, microhabitat complexity, and potential connectivity with other habitats such as Drainage foci. Micro habitats within Shallow/ open gullies tend to be rock based where the gradient is steep, and more vegetation based where the gradient is gentle.
- Ridges/ breakaways (only within the Low hills and outcrops zone) - moderately to highly suitable habitats offering to sheltered landforms (depending upon aspect and slope), complex rocky microhabitats, and moderate isolation due to discontinuous landforms. Ridges/ breakaways differ from Rocky outcrops and Hillslopes/ footslopes by being generally taller and larger, and by having steeper faces at the crest that provides greater shelter and complexity.
- Rocky outcrops (only within the Low hills and outcrops zone) - moderately to highly suitable habitats offering moderate to high shelter (dependent on aspect and slope), complex rocky microhabitats, and high isolation due to discontinuous outcrop. Rocky outcrop sites such as granite domes, boulder piles, and mesas are generally smaller, more isolated and less sheltered than Ridges/ breakaways.
- Hillslopes/ footslopes (Low hills and outcrops zone, and Stony plain zone) - low to moderate SRE suitability due to open (exposed) habitats that are not highly complex and can occur widely between mountains and plains. Patches of suitable habitat can such as leaf litter under large trees and shrubs can be common. Hillslope/ footslopes may form habitats for some SRE species during the cooler months of the year, when protection from exposure is not so crucial.
- Drainage foci (Low hills and outcrops zone, Stony plain zone, Drainage zone) - minor drainage features with low to moderate/ high suitability for SRE fauna due to vegetation-based shelter and leaf litter microhabitats. As they only receive minor runoff, these habitats can be more isolated than Drainage lines.
- Drainage lines (Stony plain zone, Drainage zone, Palaeochannel zone) - major drainage features that provide low to moderate/ high suitability for SRE fauna, due to vegetation-based shelter and leaf litter microhabitats. Considered to be dispersal habitats only as the habitat is inherently continuous and not restricted.
- Vegetation groves (Stony plain zone, Low hills and outcrops zone, Drainage zone, Palaeochannel zone) - vegetation based habitats occurring in a variety of landform

settings that can range from low to moderate/ high suitability for SRE fauna. The vegetation within groves/ thickets is dense and structurally distinct from the surrounding landscape.

- Plains including Sandplains and Stony plains (Stony plain zone, Sandplain zone, Palaeochannel zone) - flat/ open, extensive landforms that may have small pockets of vegetation-based or rocky microhabitats, but are unlikely to support SRE species due to high exposure, low complexity, and high connectivity throughout the landscape.

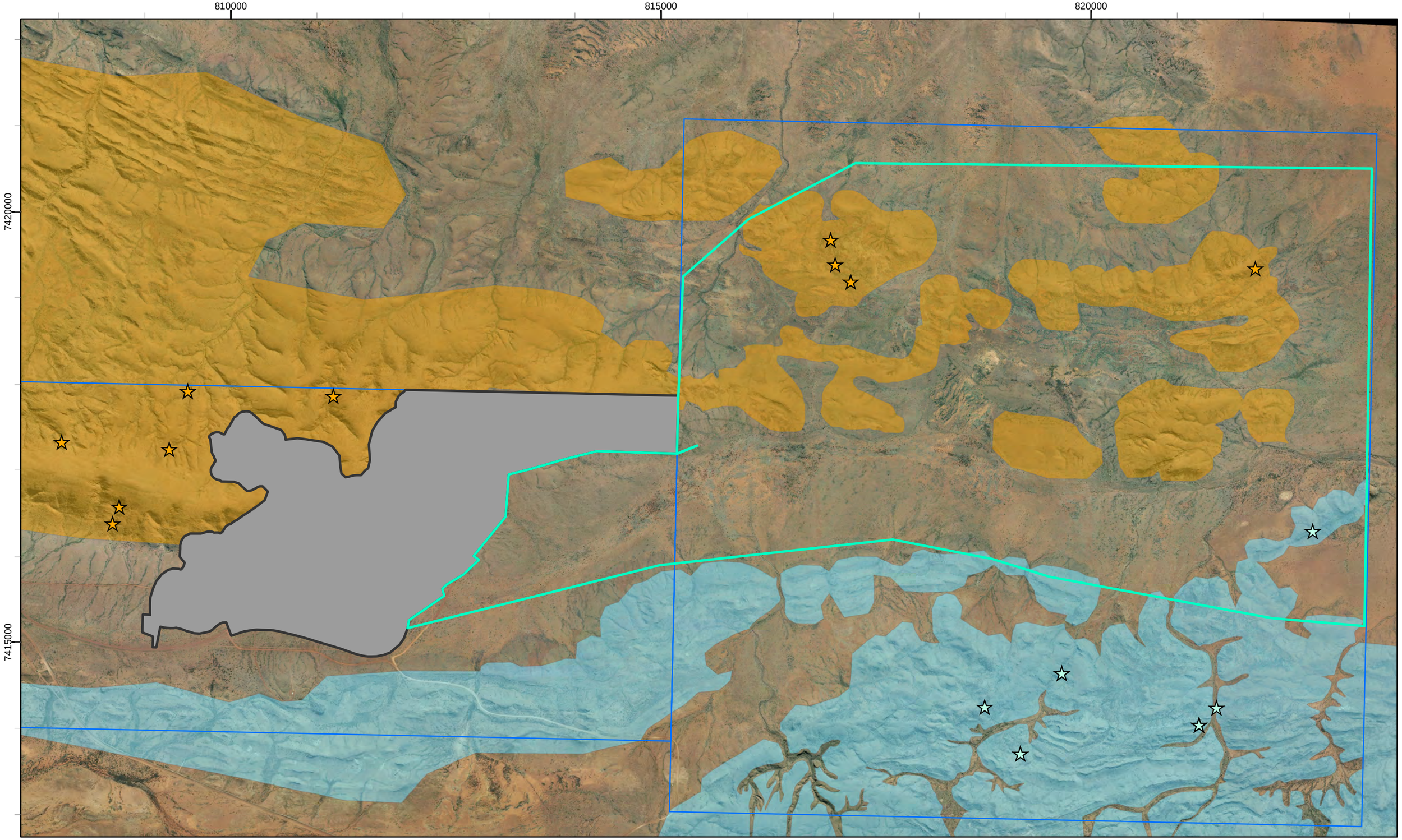
Appendix 2 provides further details regarding the habitat and microhabitat characteristics of each site sampled within the targeted SRE survey, and each site assessed within the Project area during the OB19-31 SRE survey (Biologic 2014a).

4.5 Estimated Extent of Potential Habitats for Potential SRE Species

The estimated extent of potential habitats for each of the species discussed below, and shown in Figures 4.6 to 4.8, is based on the assessed extent of habitat zones where each fauna species was detected, and the extrapolation of these habitat zones based on aerial photography and relevant environmental data. The habitat mapping was not a parsimonious interpretation of potential extent for each species, but rather an indication of the likely extent of suitable habitats (*i.e.* the species in question was not required to be recorded within all of the patches of habitat that were mapped as suitable). The potential extent of habitats for these species were indicative estimates only and were not intended to represent the actual distribution of the species.

4.5.1 *Karaops* species

The selenopid spiders *Karaops* 'ARA003-DNA' and *K*. 'ARA004-DNA' were found only within rocky habitats/ microhabitats, which fits the pattern for most species within this genus in the Pilbara region (Crews 2013). Within the Project area, the occurrence of rocky/ mountainous habitats is patchy but semi-continuous from east to west, following the extent of the Low hills and outcrops habitat zone (Figures 4.4, 4.6). *Karaops* 'ARA003-DNA' is known to occur at OB19 as well as OB31 (Biologic 2014a). As such, it can be inferred that there is some habitat continuity between the Low hills and outcrops zone within the Project area and the mountainous habitats at OB19, via similar habitats to the north of OB18 beyond Mining lease AML244SA (as mapped in Figure 4.6). This is further indicated by the similar topography (Figure 2.4) and the extent of the Newman Land System (Figure 2.6) across these areas.



Legend

- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area

Potential SRE species records

- Karaops 'ARA003-DNA'
- Karaops 'ARA004-DNA'

- Potential extent of habitat for Karaops 'ARA003-DNA'
- Potential extent of habitat for Karaops 'ARA004-DNA'

1:40,000

0 0.375 0.75 1.5 2.25 km

N

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Fig. 4.5: Estimated extent of potential habitat for potential SRE selenopid species in the wider local area

Created 01/08/2014

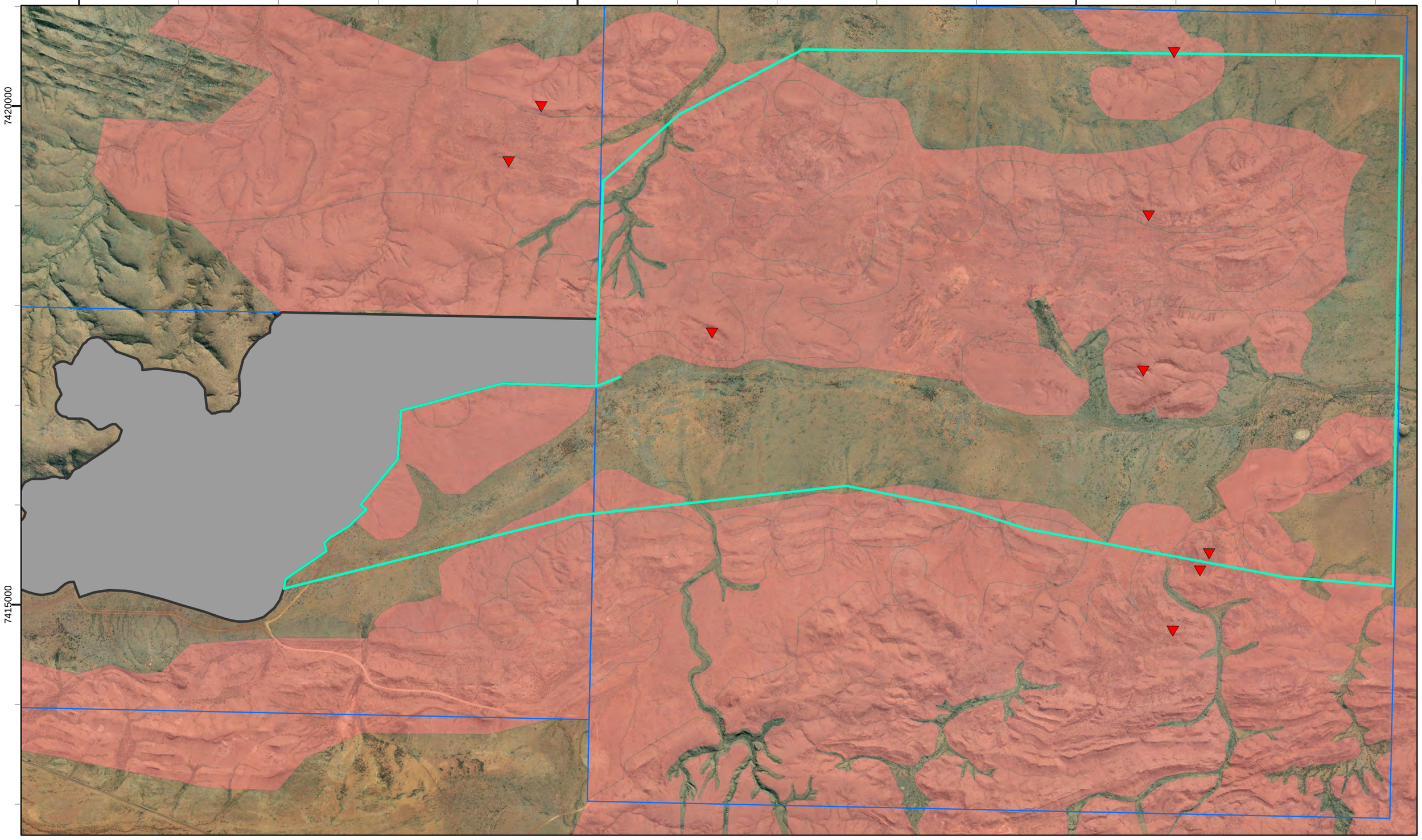
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

The mountainous habitats at Wheelarra North (to the immediate south of the Project area) are separated from those at OB31 by the flat plains of the Palaeochannel habitat zone (Figure 4.5); where there are almost no rocky microhabitats (*i.e.* the surface comprises fine sediments and clay). The plains are not extensive between the two mountainous areas (700-800 m at the narrowest point), but this area appears to act as a significant barrier to the dispersal of *Karaops* species, as the species occurring at Wheelarra North (*Karaops* 'ARA004-DNA') was consistently genetically dissimilar (approx. 3% COI) to *Karaops* 'ARA003-DNA'. Only a very small proportion of the Low hills and outcrops zone associated with *Karaops* 'ARA004-DNA' was within the Project area (Figure 4.6). The potential habitat for *K.* 'ARA004-DNA' extends to the south beyond the Project area throughout Wheelarra North, and possibly even further south around the Wheelarra (Jimblebar) Mine.

4.5.2 *Xenolpium* PSE079

During the OB19-31 SRE survey (Biologic 2014a), *Xenolpium* 'PSE079' was mainly found in sparse leaf litter (although one specimen was collected directly under rocks) on moderate to low stony slopes (*e.g.* low Ridges/ breakaways, Hillslope/ footslopes and Shallow gullies). The targeted SRE survey focused on similar habitat types (particularly Shallow/ open gullies, low Ridges/ breakaways, and Hillslope/ footslopes), that featured stony substrates and leaf litter. Due to the targeted nature of the current survey, it was not possible to remove a level of sampling bias in the interpretation of suitable habitat. However, the overall results indicate that the species favours moderately open, low sloping habitats, where there is a combination of rocky substrates (*e.g.* from surface gravels to low outcrops) and sparse to moderate leaf litter from *Eucalyptus* or Mulga trees. These kinds of habitats are not typically considered to be highly suitable for SRE species, and it was noteworthy that the species was not detected in any of the more 'typical' SRE habitats such as Gorges/ deep gullies, large Ridges/ breakaways, and isolated Rocky outcrops. It is likely that this species of pseudoscorpion is more highly dependent on the microhabitat characteristics of leaf litter than rocky microhabitats, but even within this distinction, it ranged from sites with very sparse to very dense leaf litter. Seasonality may have been a factor in its occurrence, as the species was only detected during the cooler months of June to September (in both surveys), and it may have been dispersing through the more open habitats (such as Shallow/ open gullies, low Ridges/ breakaways, and Hillslope/ footslopes) during this time.

Xenolpium 'PSE079' has a relatively wide potential extent of habitat throughout the Project area and surrounds (Figure 4.7), based on the current collection records, and its apparent preference for leaf litter within open, moderately sloping habitats. The estimated extent of habitat for the species roughly follows the extent of the Low hills and outcrops and Stony plain zones in combination, as well as similar areas outside of the Mining lease. The species was not detected within the Sandplain or Palaeochannel zones that feature flat, open, sandy/ silty substrates, nor was it detected within the steeper mountainous habitats at OB19 (Biologic 2014a).



Legend

- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area

Potential SRE species

- Xenolpium 'PSE079'

- Potential extent of habitat for Xenolpium 'PSE079'

1:35,000

0 0.325 0.65 1.3 1.95 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.7: Estimated extent of potential habitat for potential SRE Xenolpium species in the wider local area

Created 01/08/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

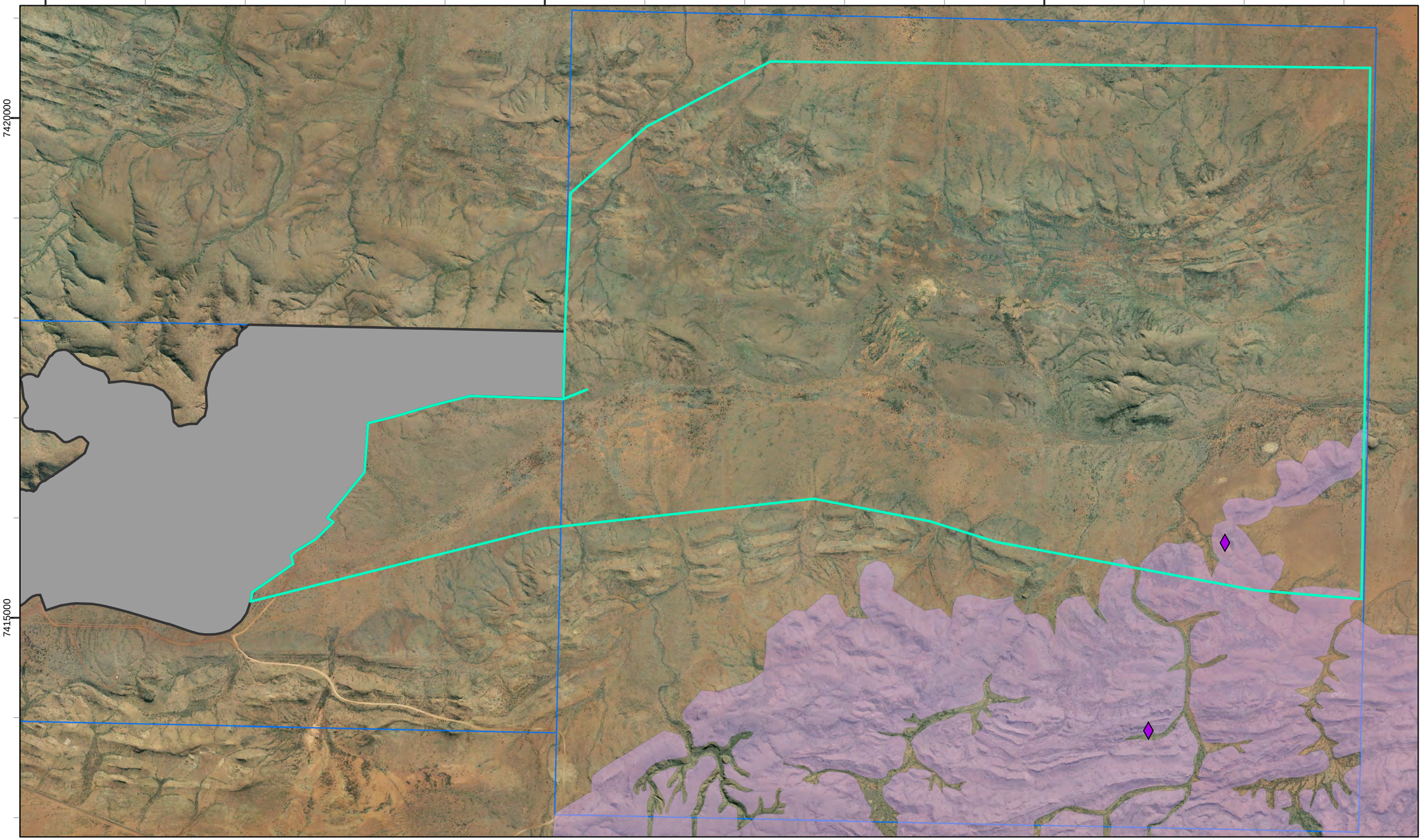
Despite the lack of *Xenolpium* 'PSE079' specimens from the Palaeochannel zone, this area does not appear to form a dispersal barrier for this species; in contrast to the selenopid spider genus *Karaops*, which showed two distinct species on either side of the Palaeochannel zone. The DNA studies for *Xenolpium* (Appendices 3 and 4) found a low level of genetic divergence (1.34 % COI) between all specimens, including those within the Project area, to the west beyond the Mining lease boundary, and at Wheelarra North. This suggests that the species can disperse between these areas, or at least, that a degree of gene flow exists throughout the Project area and immediate surrounds.

The estimated extent of habitat (Figure 4.7) is not intended to be an accurate representation of the distribution of the species, which could be considerably patchier within the estimated boundary. However, owing to the broad changes in landforms further to the north, east, south and west of the immediate local area, estimated extent of habitat is not considered to be widespread throughout the sub-region. As the Low hills and outcrops zone and the Stony plain zone transition towards flat, open sandplains in the north and east, and towards taller, more deeply incised mountainous areas to the west (OB19) and to the south (Wheelarra Hill), the potential habitats for *Xenolpium* 'PSE079' are less likely to occur. As a result, it is not considered likely that the species would range far beyond the immediate surrounds of the Project area, based on current habitat information.

4.5.3 Isopod species

Buddelundia '10NM' and *B.* '49' were found in all habitat zones (except for the Sandplains zone) and within all habitat types throughout the Project area, including vegetation-based and rock-based habitat types. Although these taxa are regarded as potential SRE species (due to their distribution being < 10,000 km^2, following Harvey 2002), they are not considered to be specialised to any particular habitat type. For this reason, the potential extent of their habitat is considered unrestricted throughout the wider local area and has not been specifically mapped. Nevertheless, Figure 4.4 shows the locations of records of these species throughout the wider local area, and Figure 4.2 shows the regional records of *B.* '49' occurring at OB24-25 (collected from Biologic 2014b).

In contrast, Buddelundiinae 'WN' was only found within rocky/ mountainous habitats at Wheelarra North (*e.g.* at Ridge/ breakaway and Rocky outcrop habitats, in leaf litter and under rocks). Although very little is known about this taxon (including its species level taxonomy and ecology), the available habitat information suggests that it could be expected to occur throughout similar rocky habitats within the Low hills and outcrops zone at Wheelarra North (Figure 4.8). Only a very small proportion of this patch of the Low hills and outcrops zone occurs inside of the Project area, and based on aerial photography and topography information, it is likely that the habitat zone extends further to the south around the flanks of Wheelarra Hill (Figure 4.8).



Legend

- Mining Lease AML244SA
- Project area
- Existing OB18 Part IV area

Potential SRE Species

- Buddelundiinae 'WN'
- Potential extent of habitat B. 'WN'

1:35,000

0 0.325 0.65 1.3 1.95 km

N

biologic

BHP Billiton Iron Ore Orebody 31 Project

Fig. 4.7: Estimated extent of potential habitat for potential SRE isopod species in the wider local area

Created 01/08/2014

Coordinate System: GDA 1994 MGA Zone 50

Projection: Transverse Mercator

Datum: GDA 1994

5. IMPACT ASSESSMENT

5.1 Potential Impacts

Potential impacts on SRE fauna and habitats from the proposed development may include:

- Direct impacts including the removal of SRE habitat or complete loss of SRE values from;
    - Mining and earthworks;
    - Construction of infrastructure, OSAs/ stockpiles/ waste dumps; and
    - Vegetation clearing.
- Indirect impacts *i.e.* more subtle or gradual degradation of SRE habitat values via changes to the physical condition of habitats and microhabitats associated with vegetation, landforms, and drainage features. Indirect impacts may include:
    - Habitat fragmentation (creation of barriers to species movement, increased edge effects);
    - Alteration to surface drainage patterns or groundwater hydrology (via effects on drainage and vegetation-based habitats);
    - Spread of introduced flora or fauna species that may degrade the quality of terrestrial habitats;
    - Alteration of fire regimes (effects on vegetation-based habitats);
    - Spills and contamination (localised effects); and
    - Vibration, noise and dust (localised effects near active mining areas).

5.2 Direct Impacts to Species and Habitats

Database searches revealed no previously existing SRE records or records of conservation significant SRE invertebrate species within the Project area.

Assessment of direct impacts on potential SRE species is limited to species and their habitats occurring within the Project area. Table 5.1 summarises the types of potential impacts, pathways, and the magnitude of impacts to potential SRE species and their habitats within the Project area.

The proposed development is likely to have a moderate impact on the potential SRE selenopid spider *Karaops* 'ARA003-DNA' and the pseudoscorpion *Xenolpium* 'PSE079' via the removal of part of their habitat within the Project area. The removal of habitat will occur via mining, construction of waste dumps, stockpiles and infrastructure, and via the clearing of vegetation. For both species, the habitats within the Project area represent only a portion of their wider extent throughout the local area beyond the Project area. *Karaops* 'ARA003-DNA' occurs extensively at OB19 and the potential extent of its habitat ranges to the north beyond Mining lease AML244SA (Figures 4.6).

Table 5.1: Impacts to potential SRE species and habitats.

Potential SRE taxa	Records inside/ outside Project area	Estimated potential extent of habitat	Potential impacting processes	Magnitude of impact
Selenopid Spiders				
Karaops 'ARA003-DNA'	5 inside 10 outside - west (OB19)	Extends beyond Project area Low hills and outcrops OB31/ OB19	Removal of habitat via mining, construction, vegetation clearing	**Moderate impact** Decreased extent of habitat, but suitable habitat occurs beyond Project area. Negligible impacts from changes to hydrology, vibration, noise, dust, environmental incidents
Karaops 'ARA004-DNA'	1 inside 9 outside - south (Wheelarra North)	Extends beyond Project area Low hills and outcrops, Wheelarra North	Removal of habitat via mining, construction, vegetation clearing	**Low impact** Minor decrease in habitat, suitable habitat occurs beyond Project area. Negligible impacts from changes to hydrology, vibration, noise, dust, environmental incidents.
Pseudoscorpions				
Xenolpium 'PSE079'	5 inside 5 outside - north, south (Wheelarra North), and west beyond mining lease	Wide within local area Low hills and outcrops OB31/ Wheelarra North, Stony plain	Removal of habitat via mining, construction, vegetation clearing Potential fragmentation of populations.	**Moderate impact** Decreased extent of habitat, but suitable habitat occurs beyond Project area. Northern and southern populations may be fragmented over the duration of mining. Negligible impacts from changes to hydrology, vibration, noise, dust, environmental incidents
Isopods				
Buddelundia '10NM'	12 inside 123 outside - north, south, and west	Wide within local area All habitat zones except Sandplains	Removal of habitat via mining, construction, vegetation clearing	**Negligible impact** Occurs widely throughout the local area (OB19- Wheelarra North).
Buddelundia '49'	9 inside 100 outside - north, south, west, and regionally OB24-25	Wide within local area All habitat zones except Sandplains, and regionally OB24-25	Removal of habitat via mining, construction, vegetation clearing	**Negligible impact** Occurs widely elsewhere regionally (OB24-25).
Buddelundiinae 'WN'	1 inside 1 outside - south (Wheelarra North)	Extends beyond Project area Low hills and outcrops, Wheelarra North	Removal of habitat via mining, construction, vegetation clearing	**Low impact** Minor decrease in extent of habitat (northern portion of Low hills and outcrops, Wheelarra North) suitable habitat occurs beyond Project area. Negligible impacts from changes to hydrology, vibration, noise, dust, environmental incidents

Xenolpium 'PSE079' occurs beyond the Project area to the north (within Mining lease AML244SA), to the south (at Wheelarra North), and to the west beyond the Mining lease. The potential extent of its habitat ranges beyond the Project area throughout Wheelarra North and further to the west of the Project area, beyond the Mining lease, broadly following the extent of the Low hills and outcrops and Stony plain zones (Figure 4.7).

The proposed development is likely to have a low impact on the selenopid spider *Karaops* 'ARA004-DNA' and the isopod Buddelundiinae 'WN', via the removal of a very minor part of their habitat (*i.e.* the Low hills and outcrops habitat zone at Wheelarra North), which occurs within the Project area. Owing to the much larger extent of this habitat outside of the Project area (Figures 4.5, 4.6 and 4.8), the impact on these species is considered low (Table 5.1).

The direct impacts on the more widely-occurring potential SRE species of isopods, *Buddelundia* '10NM' and *B*. '49' (Figures 4.8 and 4.2), are considered negligible (Table 5.1).

5.3 Indirect Impacts

The proposed development will potentially remove part of the known habitat of the pseudoscorpion *Xenolpium* 'PSE079' (*i.e.* that part which occurs within the Project area). This may have an indirect impact of fragmenting the remaining populations of this species over the duration of mining. The existing mining operations at OB18, as well as the tall mountainous habitats at OB19, and the extensive sandplains to the north and east of the Project area, would all currently be regarded as potential barriers to dispersal for *Xenolpium* 'PSE079' (based on current habitat information, and existing disturbance at OB18). Therefore, it is likely that the Project area forms the only potential dispersal corridor between the populations to the south (at Wheelarra North) and to the northwest of the Project area (Figure 4.7).

During the proposed mining development at OB31, these two populations could be isolated from one another. Permanent isolation of the populations would be regarded as detrimental to their long term viability; however, the duration of mining (between 16 to 33 years, depending upon the development option) is insignificant in an evolutionary sense, and there may be opportunities for reconnecting the two populations via rehabilitation of habitats following mine closure. Suitable rehabilitation within the Project area or surrounding areas (such as the OB18 Mine) could re-establish habitats for this species (such as stony plains with Mulga shrubland and low rocky slopes and gullies with Mulga or *Eucalyptus* trees), thereby minimising the impacts of habitat fragmentation.

Many of the other potential indirect impacts are expected to be effectively managed by BHP Billiton Iron Ore's standard management procedures, as per Environmental Management Plans (EMPs) for nearby operations at OB18 Mine and Jimblebar (Wheelarra Hill) Mine. Such EMPs regularly provide management procedures for limiting the effects of noise and vibration, dust, changes to hydrology, and particularly environmental incidents such as fires, spills, contamination and the spread of invasive species. Provided that the vegetation communities surrounding the Project area remain intact as a result of suitable management procedures, the risk of these indirect impacts to potential SRE fauna is considered negligible.

6. SIGNIFICANT OUTCOMES

Six potential SRE species are known to occur within the Project area, which comprises the indicative disturbance areas for the proposed mine and infrastructure corridor at OB31. The combined faunal data and habitat information collected during the SRE surveys found that none of these species or their habitats are restricted to the Project area, therefore the potential impacts on important SRE values will not be high.

The selenopid spider *Karaops* 'ARA003-DNA' and the pseudoscorpion *Xenolpium* 'PSE079', may be moderately impacted due to a reduction in available habitat from mining, construction and vegetation clearing within the Project area. Any indirect impacts of habitat fragmentation on the pseudoscorpion *Xenolpium* 'PSE079' may potentially be managed in the longer term by rehabilitation of suitable habitats within the Project area following mine closure.

The potential impacts to the selenopid spider *Karaops* 'ARA004-DNA' and the isopod Buddelundiinae 'WN' are likely to be low, as the majority of their potential habitat occurs outside of the Project area. The potential impacts on the more widely occurring species of potential SRE isopods, *Buddelundia* '10NM' and *B*. '49, are expected to be negligible.

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Appendix 1: Faunal Results (Targeted SRE Survey)

Appendix 1: Pseudoscorpions sampled during the Targeted SRE survey at OB31

SITE	SRE HABITAT	LOCATION DESC	LAT_GDA94	LONG_GDA94	FAMILY	SPECIES	COUNT	MICRO HABITAT	COMMENTS	FIELD NUMBER	WAMTS
1	Shallow Gully	Project area	-23.317703	120.085256	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
2	Shallow Gully	W of OB31	-23.316595	120.080375	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
3	Gorge/ Deep Gully	W of OB31	-23.315408	120.079371	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X03-T1-L-BES1570	133199
4	Shallow Gully	W of OB31	-23.315853	120.075356	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
5	Gorge/ Deep Gully	W of OB31	-23.316033	120.072214	Olpiidae	Beierolpium '8/3'	1	Leaf litter	Successful DNA Sequence	X05-T1-L-BES1568	133200
11	Shallow Gully	Project area	-23.307009	120.086294	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
12	Hillslope/ Footslope	Project area	-23.301152	120.089361	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
13	Hillslope/ Footslope	OB31	-23.299701	120.082918	Olpiidae	Beierolpium '8/3'	1	Under rocks	Successful DNA Sequence	X13-T1-R-BES1590	133201
13	Hillslope/ Footslope	OB31	-23.299701	120.082918	Not Olpiidae	Indet.	1	Under rocks	Morphological ID	X13-T1-R-BES1591	133202
14	Ridge/ Breakaway	W of OB31	-23.299479	120.080558	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
16	Shallow Gully	W of OB31	-23.295520	120.081690	Olpiidae	Beierolpium '8/3'	1	Leaf litter	Successful DNA Sequence	X16-T1-L-BES1588	133203
16	Shallow Gully	W of OB31	-23.295520	120.081690	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X16-T1-L-BES1589	133204
17	Drainage Foci	OB31	-23.294686	120.085939	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X17-T1-L-BES1587	133205
18	Shallow Gully	W of OB31	-23.299146	120.075800	Olpiidae	Xenolpium 'PSE079'	1	Leaf litter	Successful DNA Sequence	X18-T1-L-BES1592	133206
19	Shallow Gully	Project area	-23.304986	120.144311	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
20	Shallow Gully	Project area	-23.307428	120.141031	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X20-T1-L-BES1598	133207
20	Shallow Gully	Project area	-23.307428	120.141031	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X20-T1-L-BES1599	133208
21	Drainage Foci	Project area	-23.293910	120.136818	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
22	Shallow Gully	OB31	-23.293050	120.137665	Olpiidae	Beierolpium '8/3'	1	Leaf litter	Successful DNA Sequence	X22-T1-L-BES1562	133210
22	Shallow Gully	OB31	-23.293050	120.137665	Olpiidae	Austrohorus sp.	1	Leaf litter	Morphological and DNA Sequence	X22-T1-L-BES1563	133211
22	Shallow Gully	OB31	-23.293050	120.137665	Olpiidae	Xenolpium 'PSE079'	1	Leaf litter	Morphological (adult) and DNA	X22-T1-L-BES1561	133209
23	Shallow Gully	N of OB31	-23.289052	120.131356	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X23-T1-L-BES1564	133212
23	Shallow Gully	N of OB31	-23.289052	120.131356	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X23-T1-L-BES1565	133213

SITE	SRE HABITAT	LOCATION DESC	LAT_GDA94	LONG_GDA94	FAMILY	SPECIES	COUNT	MICRO HABITAT	COMMENTS	FIELD NUMBER	WAMTS
23	Shallow Gully	N of OB31	-23.289052	120.131356	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X23-T1-L-BES1566	133214
23	Shallow Gully	N of OB31	-23.289052	120.131356	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X23-T1-L-BES1567	133215
24	Shallow Gully	N of OB31	-23.288579	120.131498	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
25	Ridge/ Breakaway	Wheelarra North	-23.338935	120.138908	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X25-T1-L-BES1583	133216
26	Drainage Foci	Wheelarra North	-23.339862	120.141305	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X26-T1-L-BES1581	133218
26	Drainage Foci	Wheelarra North	-23.339862	120.141305	Olpiidae	Xenolpium 'PSE079'	1	Leaf litter	Successful DNA Sequence	X26-T1-L-BES1580	133217
27	Shallow Gully	Wheelarra North	-23.341921	120.142168	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X27-T1-L-BES1582	133219
28	Ridge/ Breakaway	Wheelarra North	-23.343322	120.141253	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
29	Drainage Line	Wheelarra North	-23.346333	120.143400	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
30	Shallow Gully	Project area	-23.351670	120.145365	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X30-T1-L-BES1600	133220
30	Shallow Gully	Project area	-23.351670	120.145365	Olpiidae	Indolpium sp.	1	Leaf litter	Successful DNA Sequence	X30-T1-L-BES1601	133221
31	Hillslope/ Footslope	Wheelarra North	-23.349202	120.147273	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
32	Drainage Line	Wheelarra North	-23.349811	120.131026	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
33	Drainage Foci	Wheelarra North	-23.348280	120.134584	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X33-T1-L-BES1584	133222
33	Drainage Foci	Wheelarra North	-23.348280	120.134584	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X33-T1-L-BES1585	133223
33	Drainage Foci	Wheelarra North	-23.348280	120.134584	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X33-T1-L-BES1586	133224
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X34-T1-L-BES1572	133225
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X34-T1-L-BES1578	133231
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Indet. (juv.)	1	Leaf litter	DNA failed	X34-T1-L-BES1573	133226
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Indet. (juv.)	1	Leaf litter	DNA failed	X34-T1-L-BES1574	133227
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Indet. (juv.)	1	Leaf litter	DNA failed	X34-T1-L-BES1575	133228

SITE	SRE HABITAT	LOCATION DESC	LAT_GDA94	LONG_GDA94	FAMILY	SPECIES	COUNT	MICRO HABITAT	COMMENTS	FIELD NUMBER	WAMTS
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Indet. (juv.)	1	Leaf litter	DNA failed	X34-T1-L-BES1577	133230
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Indet. (juv.)	1	Leaf litter	DNA failed	X34-T1-L-BES1579	133232
34	Shallow Gully	Wheelarra North	-23.345347	120.138776	Olpiidae	Xenolpium 'PSE079'	1	Leaf litter	Successful DNA Sequence	X34-T1-L-BES1576	133229
35	Ridge/ Breakaway	Wheelarra North	-23.346629	120.140229	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
36	Stony Plain	W of OB31	-23.301261	120.074462	Olpiidae	Austrohorus sp.	1	Leaf litter	Morphological and DNA Sequence	X36-T1-L-BES1341	133248
37	Hillslope/ Footslope	W of OB31	-23.302708	120.071313	N/A	N/A	0	N/A	Nothing sampled	N/A	N/A
38	Vegetation Grove	W of OB31	-23.304196	120.072741	Olpiidae	Xenolpium 'PSE079'	1	Leaf litter	Successful DNA Sequence	X38-T1-L-BES1593	133233
39	Shallow Gully	W of OB31	-23.306013	120.077018	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X39-T1-L-BES1594	133234
40	Hillslope/ Footslope	W of OB31	-23.305268	120.081797	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X40-T1-L-BES1595	133235
40	Hillslope/ Footslope	W of OB31	-23.305268	120.081797	Not Olpiidae	Indet.	1	Leaf litter	Morphological ID	X40-T1-L-BES1596	133236
41	Shallow Gully	Wheelarra North	-23.302719	120.141095	Olpiidae	Beierolpium '8/3'	1	Leaf litter	Successful DNA Sequence	X41-T1-L-BES1597	133237

Appendix 2: Habitat Data (Targeted SRE Survey and OB19-31 SRE Survey sites within the Project area)

Appendix 2: SRE Habitats - Targeted SRE Survey of OB31 and Surrounds

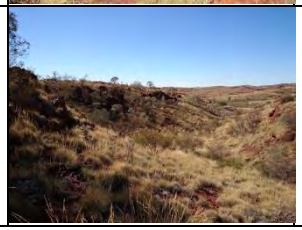
Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
1		Shallow Gully; Mod/Low	Project area. -23.3177031; 120.0852561	Shallow gully with *Eucalyptus* and sparse burnt Mulga	Mod; S/W	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	Mod (3-5 yrs)	C: 2-10; M: <2	2-10%; <1cm	Litter thin/ patchy under *Eucalyptus* and Mulga; mod. woody debris	Cobble (60-250mm)	Shallow (0-10cm) gravelly silty loam and scree
2		Shallow Gully; Mod	W of OB31. -23.3165948; 120.0803746	Gully running into gorge with Mulga and mixed geology	Mod; N/E	Mulga Grove; *Eucalyptus* trees; Spinifex	N/A	C: 31-70; M: 11-30	11-30%; 1-5cm	Litter patchy under *Eucalyptus* and rock cracks; neg. woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree
3		Gorge/ Deep Gully; High	W of OB31. -23.3154079; 120.0793707	Steep gully gorge with Mulga and *Eucalyptus* at geological contact	Steep; S/W	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	N/A	C: 11-30; M: 2-10	2-10%; <1cm	Litter sparse in rock cracks; scarce woody debris	Boulder (>250mm)	Shallow (0-10cm) Sandy clay loam
4		Shallow Gully; Mod/ High	W of OB31. -23.3158528; 120.0753561	Dense old regrowth thicket in gully	Mod; E	*Acacia* Thicket; mixed shrubland	Old (6+ yrs)	C: 31-70; M: 31-70	11-30%; 1-5cm	Litter scattered throughout but not deep; common woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree
5		Gorge/ Deep Gully; Mod/ High	W of OB31. -23.3160329; 120.072214	Dense mixed thicket in gully	Steep; E	Mulga Grove; *Acacia* Thicket; *Eucalyptus* trees	N/A	C: 31-70; M: 11-30	31-70%; 5-10cm	Litter very dense and common among rocks; common woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
11		Shallow Gully; Mod	Project area. -23.3070086; 120.0862935	Very shallow drainage gully. *Acacia* and dead Mulga trunks.	Low; S	Open Mulga Shrubland; Spinifex	Mod (3-5 yrs)	C: 2-10; M: 2-10	11-30%; 5-10cm	Litter moderate, mainly dead spinifex; scarce woody debris	Pebble (2-60mm)	Moderate (10-20cm) Sandy loam
12		Hillslope/ Footslope; Low	Project area. -23.3011518; 120.0893609	Dense leaf litter under sparse low Mulga on footslope of low ridge	Low; S	Open Mulga Shrubland; Spinifex	Old (6+ yrs)	C: <2; M: 2-10	2-10%; 1-5cm	Litter patchy under shrubs; neg. woody debris	Cobble (60-250mm)	Moderate (10-20cm) gravelly silty loam
13		Hillslope/ Footslope; Mod/Low	OB31. -23.2997007; 120.0829175	Sparse low shrubs on hill crest with minor outcrop	Mod; S/E	*Acacia* Open Shrubland; Spinifex	Mod (3-5 yrs)	C: <2; M: 2-10	2-10%; 1-5cm	Litter patchy under shrubs; neg. woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly silty loam and scree
14		Ridge/ Breakaway; High	W of OB31. -23.2994786; 120.0805578	South face of large breakaway ridge with *Ficus* and cave overhang	Cliff; S	Ficus Tree/ Shrub; Spinifex	Mod (3-5 yrs)	C: <2; M: <2	11-30%; 5-10cm	Litter only under fig; neg. woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly Sand and scree

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
16		Shallow Gully; Mod/Low	W of OB31. -23.2955196; 120.0816896	Open gully with Mulga and mixed shrubs sparse leaf litter	Mod; S/E	Open Mulga Shrubland; mixed shrubland; Spinifex	Old (6+ yrs)	C: 2-10; M: 31-70	2-10%; <1cm	Litter very sparse and thin; scarce woody debris	Pebble (2-60mm)	Moderate (10-20cm) gravelly silty loam and scree
17		Drainage Foci; Mod/Low	OB31. -23.2946857; 120.0859392	Drainage focus in valley with *Eucalyptus* trees and Mulga shrubs	Low; S/E	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	Old (6+ yrs)	C: 11-30; M: 11-30	11-30%; 1-5cm	Litter dense under *Eucalyptus*; patchy under Mulga; scarce woody debris	Pebble (2-60mm)	Deep (>20cm) silty gravelly Sandy loam alluvium
18		Shallow Gully; Mod	W of OB31. -23.2991461; 120.0757998	Sheltered leaf litter under *Eucalyptus* in gully	Steep; S/W	*Eucalyptus* trees; Spinifex	Mod (3-5 yrs)	C: 31-70; M: <2	11-30%; 1-5cm	Litter dense under *Eucalyptus*; mod. woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly silty loam and scree
19		Shallow Gully; High	Project area. -23.3049858; 120.1443108	Open gully on very steep ridge slope with tall dense mixed Mulga	V. Steep; S	Mulga Grove; mixed shrubland; Spinifex		C: 31-70; M: 31-70	31-70%; 1-5cm	Litter thin regular beds among rocks; mod. woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly Sandy loam and sand
20		Shallow Gully; Mod/ High	Project area. -23.3074281; 120.141031	Open gully on steep hillside with mixed tall Mulga *Eucalyptus* and spinifex	Steep; S/E	Mulga/ *Acacia* Thicket; *Eucalyptus* trees; Spinifex	Old (6+ yrs)	C: 11-30; M: 31-70	11-30%; 5-10cm	Litter dense under *Eucalyptus* and large Mulga; scarce woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly Sandy loam and sand

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
21		Drainage Foci; Mod/Low	Project area. -23.2939102; 120.1368184	Drainage focus Mulga shrubs	Low; N/W	Open Mulga Shrubland	Old (6+ yrs)	C: 2-10; M: 11-30	11-30%; 1-5cm	Litter patchy under *Eucalyptus*; mod. woody debris	Pebble (2-60mm)	Deep (>20cm) Sandy loam
22		Shallow Gully; Mod/Low	OB31. -23.29305; 120.1376653	Small rocky gully low leaf litter	Low; E	Open Mulga Shrubland	Old (6+ yrs)	C: 11-30; M: 11-30	2-10%; <1cm	Litter scarce and thin; neg. woody debris	Cobble (60-250mm)	Shallow (0-10cm) gravelly silty loam gravelly
23		Shallow Gully; Mod	N of OB31. -23.28905201; 120.1313557	Good leaf litter under tall *Eucalyptus* in small gully	Low; S/W	*Eucalyptus* trees; Spinifex	Old (6+ yrs)	C: 31-70; M: 2-10	31-70%; 1-5cm	Litter dense under *Eucalyptus*; neg. woody debris	Pebble (2-60mm)	Shallow (0-10cm) gravelly silty loam gravelly
24		Shallow Gully; Mod	N of OB31. -23.2885785; 120.1314978	Open gully system with low shrubs and outcrop	Mod; S/E	Open Mulga Shrubland; mixed shrubland; Spinifex	Old (6+ yrs)	C: <2; M: 11-30	2-10%; 1-5cm	Litter dense under shrubs; neg. woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly silty loam and scree
25		Ridge/ Breakaway; High	Wheelarra North. -23.3389348; 120.1389084	Dense shrubs on slope in front of large cave overhang	V. Steep; W	*Acacia* Thicket; mixed shrubland; Spinifex	N/A	C: 11-30; M: 31-70	31-70%; <1cm	Litter scarce except under Coolibah; scarce woody debris	Boulder (>250mm)	Moderate (10-20cm) gravelly Sand and scree

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
26		Drainage Foci; Mod	Wheelarra North. -23.3398617; 120.1413048	Mixed shrub thicket and *Eucalyptus* with litter in drainage focus	Low; N/W	Mulga Grove; *Eucalyptus* trees; mixed shrubland	Old (6+ yrs)	C: 11-30; M: 31-70	11-30%; 1-5cm	Litter dense under *Eucalyptus* otherwise scarce; scarce woody debris	Pebble (2-60mm)	Deep (>20cm) gravelly silty clay loam alluvium
27		Shallow Gully; Mod/Low	Wheelarra North. -23.3419213; 120.1421678	Small gully with minor outcrop and *Eucalyptus* Mulga	Mod; S	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	Mod (3-5 yrs)	C: 11-30; M: 2-10	11-30%; <1cm	Litter thin under *Eucalyptus* and Mulga; scarce woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree
28		Ridge/ Breakaway; Mod	Wheelarra North. -23.3433215; 120.1412534	Small ridge with outcrop and few *Eucalyptus*	V. Steep; S	*Eucalyptus* trees; Spinifex	N/A	C: 2-10; M: <2	2-10%; 1-5cm	Litter sparse in rock cracks; neg. woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree
29		Drainage Line; Mod/Low	Wheelarra North. -23.3463329; 120.1434004	Floodplain of drainage line dense litter under *Eucalyptus*	Flat	*Eucalyptus* trees; mixed shrubland; Spinifex; Tussock grass	N/A	C: 11-30; M: 31-70	31-70%; 5-10cm	Litter moderate under Coolibah and shrubs; scarce woody debris	Pebble (2-60mm)	Deep (>20cm) gravelly clayey Sand alluvium
30		Shallow Gully; Mod/ High	Project area. -23.3516703; 120.1453654	Mulga grove on steep open gully tall outcrop	Steep; S/W	Mulga Grove; Spinifex	N/A	C: 31-70; M: 2-10	11-30%; <1cm	Litter fairly sparse patches among rocks; mod. woody debris	Boulder (>250mm)	Moderate (10-20cm) gravelly silty loam and scree

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
31		Hillslope/ Footslope; Mod/Low	Wheelarra North. -23.3492024; 120.1472728	Low rocky hillside with Mulga and mixed shrubs	Mod; S/E	Open Mulga Shrubland; *Acacia* Open Shrubland; mixed shrubland	Old (6+ yrs)	C: 11-30; M: 31-70	11-30%; <1cm	Litter moderate patches under Mulga; scarce woody debris	Cobble (60-250mm)	Shallow (0-10cm) gravelly silty loam and sand
32		Drainage Line; High	Wheelarra North. -23.3498112; 120.1310264	Dense Mulga and *Eucalyptus* grove on stony minor drainage down from gully excellent litter	Low; S/E	Mulga/ *Eucalyptus* Grove; mixed shrubland; Spinifex	N/A	C: 71-100; M: 31-70	31-70%; 1-5cm	Litter regular dense beds undisturbed; common woody debris	Cobble (60-250mm)	Moderate (10-20cm) gravelly Sandy clay loam alluvium
33		Drainage Foci; Mod/Low	Wheelarra North. -23.34828; 120.1345836	Mulga grove on drainage focus	Flat	Mulga Grove; Spinifex	N/A	C: 31-70; M: 11-30	11-30%; <1cm	Litter regular but thin under Mulga; mod. woody debris	Pebble (2-60mm)	Deep (>20cm) Sandy clay loam surface pebbles
34		Shallow Gully; Mod	Wheelarra North. -23.3453474; 120.1387758	Open gully drainage focus with Mulga snakewood and *Eucalyptus*	Mod; N/E	Mulga Grove; *Eucalyptus* trees; mixed shrubland; Spinifex	Old (6+ yrs)	C: 31-70; M: 31-70	11-30%; 1-5cm	Litter patches under *Eucalyptus* and Mulga; scarce woody debris	Boulder (>250mm)	Shallow (0-10cm) gravelly Sandy loam and scree
35		Ridge/ Breakaway; Mod/ High	Wheelarra North. -23.3466289; 120.1402287	Mulga and *Eucalyptus* on south face of wide gully	Steep; S	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	Old (6+ yrs)	C: 11-30; M: 11-30	31-70%; 1-5cm	Litter mainly sparse, dense under *Eucalyptus*; scarce woody debris	Boulder (>250mm)	Skeletal gravelly silt and scree

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
36		Stony Plain; Low	W of OB31. -23.3012608; 120.0744617	Mixed *Eucalyptus* Mulga woodland on stony plain	Flat	Open Mulga Shrubland; *Eucalyptus* trees; Spinifex	Old (6+ yrs)	C: 31-70; M: 11-30	11-30%; 1-5cm	Litter dense under *Eucalyptus*; mod. woody debris	Pebble (2-60mm)	Deep (>20cm) silty clay loam
37		Hillslope/ Footslope; Low	W of OB31. -23.3027084; 120.0713129	Low stony hill slope with Mulga and low shrubs	Low; S/W	Open Mulga Shrubland; mixed shrubland	Old (6+ yrs)	C: 2-10; M: 11-30	2-10%; <1cm	Litter moderate under Mulga; scarce woody debris	Pebble (2-60mm)	Moderate (10-20cm) gravelly silty clay loam
38		Vegetation Grove; Mod	W of OB31. -23.3041958; 120.0727408	Dense mixed Mulga in patchy grove on gently sloping plain	Flat	Mulga Grove; *Acacia* Thicket	N/A	C: 31-70; M: 31-70	31-70%; 1-5cm	Litter very dense undisturbed; mod. woody debris	Pebble (2-60mm)	Deep (>20cm) gravelly silty clay loam
39		Shallow Gully; Mod/ High	W of OB31. -23.3060127; 120.0770184	Mulga grove on gently sloping gully with minor outcrop	Low; W	Mulga Grove; *Acacia* Thicket; Spinifex	Old (6+ yrs)	C: 31-70; M: 31-70	31-70%; 1-5cm	Litter regular under shrubs, moss/ fungi; scarce woody debris	Boulder (>250mm)	Moderate (10-20cm) silty clay loam
40		Hillslope/ Footslope; Mod	W of OB31. -23.3052677; 120.0817969	Hillslope /footslope. Mulga patch on stony ground	Low; E	Mulga Woodland; Spinifex	Mod (3-5 yrs)	C: 11-30; M: 11-30	2-10%; 1-5cm	Litter patchy under Mulga; scarce woody debris	Pebble (2-60mm)	Shallow (0-10cm) Sandy clay loam

Site	Photo	SRE Habitat type; SRE Suitability	Location Lat; Long (GDA94)	Habitat comment	Slope/ aspect	Vegetation	Fire age	Veg shade canopy: midstorey	Leaf litter (% cover; depth)	Leaf litter micro-habitat	Rock micro-habitat	Soil micro-habitat
41		Shallow Gully; Mod	Wheelarra North. -23.3027188; 120.1410948	Shallow gully with tall Mulga and mixed shrubs over spinifex	Mod; N/E	Mulga Grove; *Acacia* Thicket; Spinifex	N/A	C: 31-70; M: 31-70	31-70%; 1-5cm	Litter dense under Mulga; scarce woody debris	Cobble (60-250mm)	Moderate (10-20cm) gravelly Sandy loam alluvium

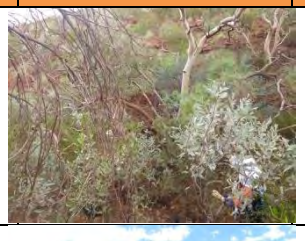
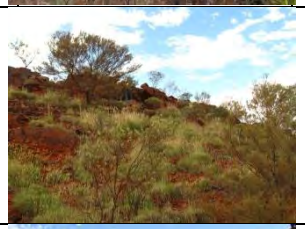
SRE Habitats - OB19-31 SRE Survey Sites within the Project area.

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
1		Ridge/ breakaway; Mod	-23.30604; 120.13392	Mod; SW	*Acacia* shrubs	Neg.	N/A	Mod; Mixed *Acacia* shrubs	Mod	Boulders; High	Gravelly Sand; Low	Scorpion
2		Drainage foci; Mod/Low	-23.30680; 120.13267	Low; S	*Eucalyptus*	Low	Mod weeds	Mod/High; *Eucalyptus*	Mod/Low	Cobbles; Mod/Low	Loam ; Mod/High	N/A
3		Hillslope/ footslope; Mod/Low	-23.30784; 120.13552	Mod; S	*Acacia* shrubs & *Eucalyptus*	Neg.	N/A	Low; Mixed *Acacia* shrubs	Mod/Low	Boulders; Mod/High	Skeletal sand/gravel; Neg.	N/A
4		Ridge/ breakaway; Mod	-23.30739; 120.13189	Mod/High; S	Mulga	Neg.	Minor weeds	Mod/Low; Mulga	Low	Boulders; High	Loam & gravel; Mod/Low	N/A
5		Gorge/ deep gully; Mod/High	-23.32189; 120.13531	Mod/High; S	*Acacia* shrubs	Mod	N/A	Mod; *Eucalyptus*, mixed	Mod	Cobbles; Mod/Low	Gravelly Sandy Loam; Low	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
6		Drainage foci; Mod/Low	-23.30717; 120.13062	N/A	Mulga	Mod	N/A	Low; Mulga	Mod/Low	Boulders; Mod/High	Gravelly Loam; Mod/High	N/A
7		Gorge/ deep gully; Mod/High	-23.32107; 120.13764	High; S	*Acacia* shrubs & *Eucalyptus*	Neg.	N/A	Neg.	Low	Boulders; High	Mostly gravel/ scree; Neg.	N/A
8		Vegetation grove; Mod/Low	-23.32556; 120.13846	Mod; S	*Eucalyptus*	Mod	N/A	Mod/High; *Eucalyptus*, *Acacia*	Mod	Boulders; Mod/High	Gravelly Sandy Loam; Low	N/A
9		Drainage foci; Mod/Low	-23.32099; 120.12750	N/A	Mulga	Low	Minor weeds	Mod; *Eucalyptus*	Low	N/A	Clay-Loam; High	Mygal.
10		Ridge/ breakaway; Mod/High	-23.32417; 120.13785	Mod; SE	*Eucalyptus*	Low	N/A	Mod; *Eucalyptus*, *Acacia*	Mod/Low	Boulders; High	Gravelly Loam-Sand; Mod	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
11		Vegetation grove; Mod/Low	-23.31636; 120.12542	N/A	Mulga	Low	Mod/High grazing	Neg.	Mod	N/A	Clay-Loam; High	N/A
12		Vegetation grove; Mod/Low	-23.32628; 120.13477	N/A	Mulga	Mod	N/A	High; Mulga	Low	Boulders; Mod/High	Loam; Mod/High	N/A
13		Vegetation grove; Mod/Low	-23.32197; 120.11725	N/A	Mulga	Mod/High	High grazing	Low; Mulga	Low	N/A	Clay-Loam; High	N/A
14		Vegetation grove; Mod/Low	-23.32368; 120.09511	N/A	Mulga	Low	Mod weeds	High; Mulga	Mod/Low	N/A	Loam; Mod/High	N/A
15		Vegetation grove; Mod/Low	-23.31855; 120.11182	N/A	*Acacia* shrubs	Low	N/A	High; Mixed *Acacia*, fungus	Low	Pebbles/ gravel; Low	Loam; Mod/High	N/A

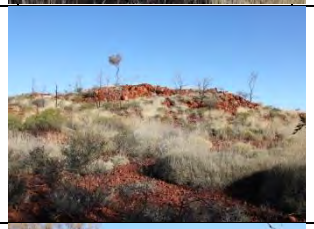
Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
16		Ridge/ breakaway; Mod	-23.31927; 120.09355	Mod; SW	*Eucalyptus*	Neg.	N/A	Low; *Eucalyptus*	Mod/Low	Boulders; High	Mostly gravel/ scree; Neg.	N/A
17		Vegetation grove; Mod/Low	-23.32393; 120.10538	N/A	Mulga & *Eucalyptus*	Mod	Minor weeds	High; Corymbia, fungus	Low	N/A	Loam-Sand; Mod	N/A
18		Drainage foci; Low	-23.31218; 120.08509	N/A	*Eucalyptus*	Low	N/A	Mod/High; *Eucalyptus*	Mod/Low	N/A	Gravelly Sandy Loam; Low	N/A
20		Drainage foci; Low	-23.32225; 120.08355	N/A	*Eucalyptus*	Low	High weeds	Mod/High; *Eucalyptus*	Low	N/A	Gravelly Sandy Loam; Mod	N/A
37		Drainage foci; Mod/Low	-23.29486; 120.13483	N/A	Mulga & *Eucalyptus*	Mod	Mod surface flow	Mod/High; *Eucalyptus*, mixed	Mod/Low	Cobbles; Mod/Low	Clay-Loam; High	Mygal

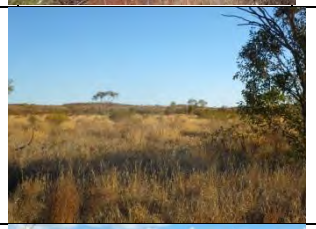
Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
38		Shallow gully; Mod	-23.29790; 120.12895	Mod; SW	*Eucalyptus*	Mod/High	Mod fire	Mod; *Eucalyptus*, *Acacia*	Mod/Low	Boulders; High	Loam; Mod/High	N/A
43		Outcrop/ dome; Mod	-23.30181; 120.09885	Mod/High; S	Mulga	Neg.	N/A	Neg.	Neg.	Boulders; High	Gravelly Sand; Low	Mygal.
57		Outcrop/ dome; Mod/Low	-23.31910; 120.14847	Mod/High; SW	Triodia	Neg.	N/A	Neg.	Low	Boulders; Mod/High	Skeletal silt/gravel; Neg.	N/A
58		Vegetation grove; Mod/Low	-23.33296; 120.11624	N/A	*Acacia* shrubs	Low	M/H weeds	Mod/Low; Mixed *Acacia*	Mod/Low	N/A	Clay-Loam; High	N/A
59		Vegetation grove; Mod/Low	-23.32592; 120.14817	N/A	Mulga	Low	Minor weeds	Mod/High; Mulga, fungus	Mod/Low	N/A	Loam-Sand; Mod	Mygal.

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
60		Sandplain; Low	-23.33066; 120.09919	N/A	*Acacia* shrubs	Neg.	Old fire	Neg.	Low	N/A	Sandy Loam; Mod	N/A
61		Outcrop/ dome; Mod	-23.33125; 120.15430	Mod/High; SW	Mulga	Neg.	N/A	Mod/High; Mulga	Mod/Low	Boulders; High	Loam & gravel; Mod/Low	N/A
62		Sandplain; Low	-23.33252; 120.08750	N/A	*Eucalyptus*	Low	Mod weeds	Mod/Low; *Eucalyptus*	Low	Cobbles; Mod/Low	Sand; Mod/Low	N/A
63		Outcrop/ dome; Mod	-23.32927; 120.15760	Mod/High; S	Mulga	Neg.	Minor weeds	Neg.	Mod/Low	Boulders; High	Skeletal loam/gravel; Neg.	N/A
65		Sandplain; Low	-23.33223; 120.07615	N/A	Mulga	Neg.	High grazing	Low; Mixed *Acacia* shrubs	Low	N/A	Loam-Sand; Mod	Mygal

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
76		Drainage foci; Mod/Low	-23.33612; 120.12709	N/A	*Eucalyptus*	Neg.	Minor weeds	Mod; *Eucalyptus*	Low	Boulders; Mod/High	Loam & gravel; Mod/Low	N/A
79		Outcrop/ dome; Mod/Low	-23.33630; 120.14693	Mod; S	Mulga	Neg.	Mod fire	Mod; Mulga, mixed	Low	Boulders; Mod/High	Skeletal sand/gravel; Neg.	N/A
81		Vegetation grove; Mod/Low	-23.33829; 120.14215	Mod; W	Mulga & *Eucalyptus*	Low	N/A	Neg.	Low	Boulders; Mod/High	Skeletal sand/gravel; Neg.	N/A
101		Outcrop/ dome; Mod/Low	-23.30439; 120.09942	Mod; NW	Mulga	Neg.	N/A	Neg.	Neg.	Boulders; Mod/High	Skeletal sand/gravel; Neg.	N/A
103		Outcrop/ dome; Mod	-23.30614; 120.10124	High; S	Mulga	Neg.	N/A	Neg.	Low	Cobbles; Mod/Low	Mostly gravel/ scree; Neg.	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
109		Sandplain; Low	-23.33462; 120.07179	N/A	*Eucalyptus* over Triodia	Neg.	Mod weeds	Mod; *Eucalyptus*	Low	N/A	Clay-sand; Mod/High	N/A
128		Drainage foci; Mod/Low	-23.30667; 120.09710	N/A	Mulga	Mod	Old fire	Low; Mulga	Low	N/A	Loam; Mod/High	N/A
130		Vegetation grove; Mod/High	-23.30134; 120.10476	N/A	Mulga	Low	N/A	Mod; Mulga	Mod/Low	N/A	Clay-Loam; High	N/A
141		Hillslope/ footslope; Mod/Low	-23.30172; 120.08991	Mod/Low; S	Mulga	Neg.	N/A	Neg.	Low	Boulders; Mod/High	Gravelly Sand; Low	N/A
143		Drainage line; Mod/Low	-23.30744; 120.08456	Low; S	*Acacia* shrubs	Low	Minor weeds	Low; Mixed *Acacia*	Mod	Cobbles; Mod/Low	Skeletal sand/gravel; Neg.	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
145		Sandplain; Low	-23.31277; 120.09824	N/A	*Acacia* shrubs	Low	Old fire	Neg.	Low	Cobbles; Mod/Low	Loam-Sand; Mod	N/A
147		Hillslope/ footslope; Mod/Low	-23.31082; 120.11051	Mod/Low; SW	Mulga	Neg.	N/A	Neg.	Low	Boulders; Mod/High	Skeletal silt/gravel; Neg.	N/A
149		Drainage foci; Mod/Low	-23.30605; 120.11727	N/A	Mulga & mixed shrub	Low	N/A	Low; Mulga & mixed shrub	Mod/Low	N/A	Clay-Loam & gravel; Mod	Indet.
151		Vegetation grove; Mod/Low	-23.31689; 120.10393	N/A	*Acacia* shrubs & *Eucalyptus*	Mod	Minor weeds	Mod/High; Mixed *Acacia*, *Eucalyptus*	Mod	N/A	Loam; Mod/High	Indet.
158		Ridge/ breakaway; Mod	-23.30703; 120.12463	Mod/Low; S	*Eucalyptus*	Neg.	Old fire	Mod; *Eucalyptus*	Low	Cobbles; Mod/Low	Gravelly Sandy Loam; Mod	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
160		Drainage foci; Mod	-23.31217; 120.12830	N/A	Mulga & *Eucalyptus*	Neg.	Old fire	Mod/High; Mulga & *Eucalyptus*	Low	Boulders; Mod/High	Loam-Sand; Mod	N/A
167		Sandplain; Low	-23.34028; 120.05885	N/A	Triodia	Neg.	M/H weeds	Mod/High; *Eucalyptus*	Low	N/A	Clay-Loam; High	N/A
175		Sandplain; Low	-23.32625; 120.08537	N/A	Mulga	Neg.	M/H grazing	Neg.	Low	N/A	Sandy Clay-Loam; High	Mygal.
177		Drainage line; Mod/Low	-23.33150; 120.14265	Low; S	*Eucalyptus* & mixed *Acacia*	Mod	Mod weeds	Mod/High; *Eucalyptus*, *Acacia*	Mod/Low	N/A	Gravelly Sandy Loam; Mod	N/A
179		Drainage line; Mod/Low	-23.33382; 120.13367	N/A	*Eucalyptus* & mixed *Acacia*	Mod	Mod weeds	Mod/High; *Eucalyptus*, *Acacia*	Mod	N/A	Loam-Sand; Mod	N/A

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
187		Drainage foci; Mod/Low	-23.29371; 120.13950	N/A	Mulga	Mod	N/A	Mod/High; Mulga	Mod/Low	N/A	Gravelly Sandy Loam; Mod	N/A
189		Sandplain; Low	-23.29699; 120.14610	N/A	Mixed shrubs	Mod	N/A	Mod/Low; Mixed *Acacia* shrubs	Low	N/A	Loam-Sand; Mod	N/A
191		Drainage line; Mod/Low	-23.30166; 120.15164	N/A	Mulga	Mod	N/A	Mod/High; Mulga	High	Boulders; Mod/High	Loam-Sand; Mod	N/A
193		Ridge/ breakaway; Mod	-23.30385; 120.14713	Mod/High; SE	*Acacia* shrubs	Low	N/A	Neg.;	Low	Boulders; High	Skeletal sand/gravel; Neg.	N/A
195		Drainage line; Mod/Low	-23.31518; 120.15140	N/A	*Eucalyptus*	Mod	Minor grazing	High; *Eucalyptus*	Mod/Low	N/A	Loam-Sand; Mod	Mygal.

Site	Photo	SRE Habitat; SRE Suitability	Lat; Long (GDA94)	Slope; Aspect	Dominant Vegetation	Vegetation Shelter	Disturbance	Leaf Litter Suitability	Woody debris Suitability	Rocky micro-habitat suitability	Soil Micro-habitat	Burrows
197		Ridge/ breakaway; Mod	-23.30925; 120.14998	High; S	*Acacia* shrubs	Mod	N/A	Neg.	Mod/Low	Boulders; High	Skeletal loam/gravel; Neg.	N/A
199		Ridge/ breakaway; Mod	-23.31194; 120.14449	Mod/High; S	*Acacia* shrubs	Low	N/A	Neg.	Low	Boulders; High	Skeletal loam/gravel; Neg.	N/A

Appendix 3: WAMTS300 DNA Analysis Report

Molecular Identification of Olpiidae from ca. 38 and 41 km ENE of Newman, WA

Brief report to *Biologic Environmental*

08 May 2014

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Summary

Seven specimens of the family Olpiidae were among those collected from Orebody 31, ca. 41 km ENE of Newman and Wheelarra North, ca. 38km ENE of Newman, and were lodged into the Western Australian Museum collection by *Biologic Environmental* (see Appendix 1 for specimen details). These specimens were originally part of a morphology project (WAMTS247). As six of the queried specimens were juvenile and unidentifiable through morphology, DNA-based identifications were sought. The main objectives of the WA Museum's Molecular Systematics Unit (MSU) were to use COI DNA barcoding to: 1) test whether the six juvenile Olpiidae specimens from WAMTS247 are the same as *Xenolpium* PSE079 identified in that project; 2) test whether any of the fifteen regional specimens are the same as any of the seven queried specimens; 3) add comments on SRE status of the queried specimens.

DNA was extracted and DNA barcoding sequences (CO1) were amplified by PCR in the MSU and sequenced at the Australian Genomic Research Facility (AGRF) Perth node. To provide additional reference sequence data for molecular identification of the six queried specimens, DNA barcoding sequences (CO1) were sought for fifteen museum specimens from the collection (see Appendix 2 for specimen details). DNA sequences were BLASTED against the Western Australian Museum DNA database.

A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 3.

Table 1. Summary of WAMTS194 specimen identifications and SRE status.

FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE SUB-CATEGORY
Olpiidae	*Xenolpium*	`PSE079`	5 (including T131402)	Potential SRE- (D) Molecular Evidence
Olpiidae	*Indolpium*	'sp.'	1	Potential SRE- (D) Molecular Evidence
Olpiidae	*Indolpium*	'sp.'	1	Potential SRE- (D) Molecular Evidence

Results

COI DNA barcodes were amplified and successfully sequenced from all seven specimens submitted by *Biologic Environmental* and from 10 of 15 museum specimens selected for analyses by *Biologic Environmental*. The seven queried Olpiidae COI sequences were compared to the Western Australian Museums' DNA barcode database and the ten additional reference DNA sequences generated as part of this project. A summary of the comparison (BLAST results) is provided in Table 2. Details of museum specimens that were identified in BLAST searches and contextualise the status of the queried species are provided in Table 3. A simple Neighbour-Joining (distance based) tree is provided in Appendix 4 for visualisation of genetic relationships. DNA sequences of queried specimens are provided in Appendix 5.

Table 2. Summary of BLAST analysis

REGNO	SPECIES	SUMMARY OF BLAST RESULTS
T131402 T131392 T131395 T131443 T131444	*Xenolpium* `PSE079`	These specimens represent a distinct lineage, not previously recognised molecularly. Within this lineage there is an average of 1.34% sequence diversity. This lineage forms a sister (18.82% divergence) to a second lineage consisting of six of the specimens sequenced from the collection for regional context (T93556; T93561; T94812; T127760; T127763; T127766) Together these two lineages are sister (20.96% divergence) to four other specimens sequenced from the collection for regional context, these themselves representing two distinct lineages (1) 'PSE033':T122340; T122341; T122342; 2) 'sp.' T131577).
T131451	*Indolpium* 'sp.'	T131451 is divergent from T132700 (7.64%) These two lineages are sister to T113494 (*Indolpium* 'sp." from 60 km North of Tom Price.
T132700*	*Indolpium* 'sp.'	T132700 is divergent from T131451 (7.64%) These two lineages are sister to T113494 (*Indolpium* 'sp." from 60 km North of Tom Price.

* Second specimen in vial with T131444.

Table 3. Details of registered WAM specimens in related, yet distinct, lineages to the queried Olpiidae specimens.

REG NO	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Latitude	Longitude	Habitat
T93556	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	Jinary, ca. 60 km NW. of Newman	timed search	0	1	0	-22.974	119.3	
T93561	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	Jinayri, ca. 60 km NW. of Newman	timed search	1	0	0	-22.974	119.3	
T94812	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	West Angelas; c. 22 km SSE. Mt Meharry	diurnal, timed	1	0	0	-22.9843	119.268	
T127760	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	West Angelas; c. 22 km SSE. Mt Meharry		1	0	0	-23.1557	118.691	Leaf litter
T127763	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	West Angelas; c. 32 km ESE. Mt Meharry		0	1	0	-23.1723	118.624	Leaf litter
T127766	Pseudoscorpiones	Olpiidae	*Xenolpium*	'sp.'	Jinary, ca. 60 km NW. of Newman		1	0	0	-23.1229	118.862	Leaf litter
T113414	Pseudoscorpiones	Olpiidae	*Indolpium*	`sp. indet. (juv.)`	Rio Tinto Nammuldi Silvergrass, 60 km N. of Tom Price	tullgren funnel	0	0	1	22°25` 40"S	117°35` 02"E	Leaf litter

Conclusions

The main objectives were to use DNA barcoding to: 1) test whether the 6 juvenile Olpiidae specimens from WAMTS247 are the same as *Xenolpium* 'PSE079'; 2) test whether any of the regional specimens are the same as any of the seven specimens from WAMTS247; 3) add comments on SRE status of the queried specimens. According to DNA barcoding (COI) data, four of the six juvenile Olpiidae are *Xenolpium* 'PSE079'. The other two specimens represent two distinct lineages of *Indolpium*. Currently available DNA (COI) sequence data suggest that *Xenolpium* 'PSE079' has not been recognized molecularly prior to this study and is distinct from specimens that were barcoded from the region (18.82% divergence). Based on morphological data, *Xenolpium* 'PSE079' was a potential SRE, subcategory A, lacking taxonomic and geographic information. These molecular data are congruent with SRE status (sub-category D) and provide additional geographic distributional data.

Appendix 1. Specimen data for seven queried Olpiidae specimens

Reg. No.	Field No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Habitat
T131402	16-OB31-L-T2-BES0955	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41 km ENE. of Newman	Leaf sifting	0	1	0	Leaf litter
T131392	03-OB31-L-T2-BES0929	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41km ENE of Newman	Leaf sifting	0	0	1	Leaf litter
T131395	05-OB31-R-T2-BES0927	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41km ENE of Newman	Foraging	0	0	1	Under rocks
T131443	81-WN-L-T2-BES1200	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Wheelarra North, ca. 38km ENE of Newman	Leaf sifting	0	0	1	Leaf litter
T131444	81-WN-R-T2-BES1178	Pseudoscorpiones	Olpiidae	*Indolpium*	`sp. indet. (juvenile)`	Wheelarra North, ca. 38km ENE of Newman	Foraging	0	0	2^	Under rocks
T131451	94-WN-R-T2-BES1204	Pseudoscorpiones	Olpiidae	*Indolpium*	`sp. indet. (juvenile)`	Wheelarra North, ca. 38km ENE of Newman	Foraging	0	0	1	Under rocks
T132700*	81-WN-R-T2-BES1178	Pseudoscorpiones	Olpiidae	*Indolpium*	`sp. indet. (juvenile)`	Wheelarra North, ca. 38km ENE of Newman	Foraging	0	0	1	Under rocks

* Second specimen in vial with T131444.

^ Originally 2 juvenile samples for T13444, second now registered as T132700

Appendix 2. Specimen data for fifteen Western Australian Museum reference Olpiidae specimens

REG NO	DNA Barcoding	Field No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Habitat
T62908	unsuccessful	RTYE12	Pseudoscorpiones	Olpiidae	Xenolpium	`sp. 2`	Marillana Station, 26.5 km SW. of Marillana Homestead, Yandi Extension site YEX75		1	0	0	
T62937 re-registered as T132687	unsuccessful	RTYE19	Pseudoscorpiones	Olpiidae	Xenolpium	`sp. 1`	Marillana Station, 23 km SW. of Marillana Homestead, Yandi Extension site YEX81		0	0	0	
T93556	complete	AMBS site Jin012/126	Pseudoscorpiones	Olpiidae	Xenolpium		Jinary, ca. 60 km NW. of Newman	timed search	0	1	0	
T93561	complete	AMBS site Jin012/132	Pseudoscorpiones	Olpiidae	Xenolpium		Jinary, ca. 60 km NW. of Newman	timed search	1	0	0	
T94809	no specimen	Jin003/107	Pseudoscorpiones	Olpiidae	Xenolpium		Jinayri, ca. 60 km NW. of Newman	nocturnal, timed	0	1	0	
T94812	complete	Jin025/104	Pseudoscorpiones	Olpiidae	Xenolpium		Jinayri, ca. 60 km NW. of Newman	diurnal, timed	1	0	0	
T122340	complete	PS20120208. MAR05-01	Pseudoscorpiones	Olpiidae	Xenolpium	`PSE033`	Marillana, 173.6 km NW. of Newman	leaf litter sieving	1	0	0	

T122342	complete	PS20120208.MAR02-01	Pseudoscorpiones	Olpiidae	Xenolpium	`PSE033`	Marillana, 173.9 km NW. of Newman	leaf litter sieving	1	0	0	
T123227	unsuccessful	MCPH 1-9	Pseudoscorpiones	Olpiidae	Xenolpium	`PSE063`	McPhee Creek, c. 33 km N. Nullagine	hand collected	1	0	0	gully
T123230	very dry,clear specimen: unsuccessful	MCPH 9-20	Pseudoscorpiones	Olpiidae	Xenolpium	`PSE063`	McPhee Creek, c. 33 km N. Nullagine	hand collected	1	0	0	gully
T127506 re-registered as 132686	dry specimens: unsuccessful	TSFN.S10.11	Pseudoscorpiones	Olpiidae	Xenolpium	`sp.`	BlueSpec, 19 km NE. Nullagine	Hand foraging	3	0	0	Under bark of Melaleuca argentea and Corymbia sp.
T127760	complete	1458; EE12:0265	Pseudoscorpiones	Olpiidae	Xenolpium		West Angelas; c. 22 km SSE. Mt Meharry		1	0	0	Leaf litter
T127763	complete	1458; EE12:0267	Pseudoscorpiones	Olpiidae	Xenolpium		West Angelas; c. 22 km SSE. Mt Meharry		0	1	0	Leaf litter
T127766	complete	1458; EE12:0424	Pseudoscorpiones	Olpiidae	Xenolpium		West Angelas; c. 32 km ESE. Mt Meharry		1	0	0	Leaf litter
T131577	complete	1515;13:1391	Pseudoscorpiones	Olpiidae	Xenolpium	`sp.`	c.a. 40 km N. of Tom Price	leaf litter	1	0	0	Plain

Appendix 3. WAM Short-Range Endemic Categories

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • *A known distribution of < 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	**Potential SRE** • *Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.* • *We have incomplete taxonomic knowledge.* • *The group is not well represented in collections.* • *This category is most applicable to situations where there are gaps in our knowledge of the taxon.* **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** • *A known distribution of > 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. <u>*Data Deficient:*</u>
- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - Lack of geographic information.
  - Lack of taxonomic information.
  - The group may be poorly represented in collections.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

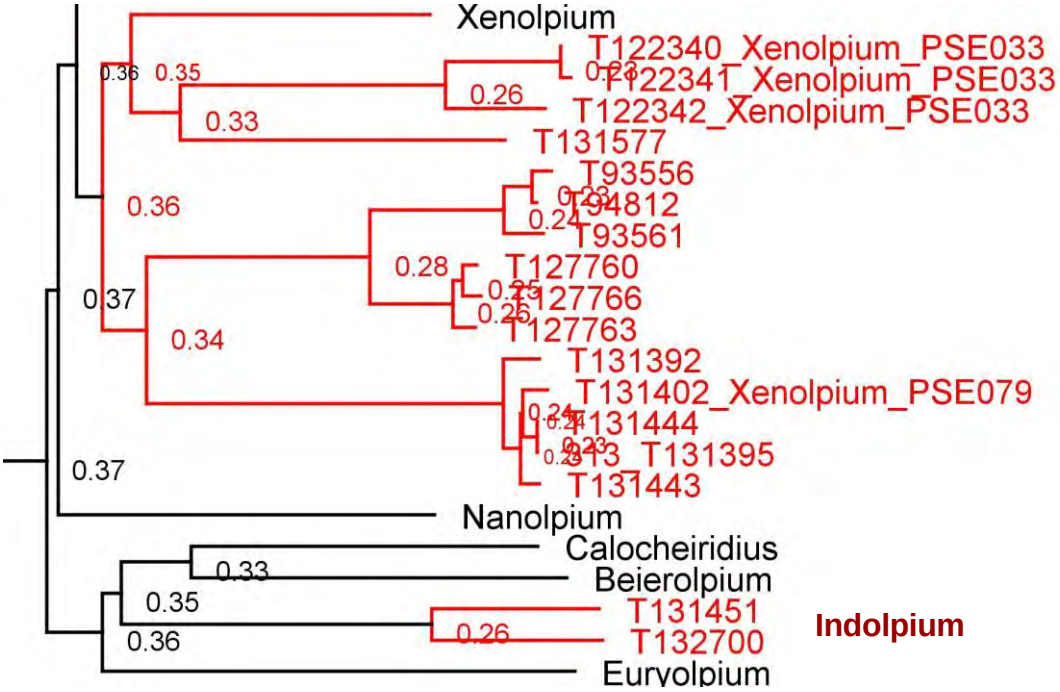
B. <u>*Habitat Indicators:*</u>
- It is becoming increasingly clear that habitat data can elucidate SRE status.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. <u>*Morphology Indicators:*</u>
- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

D. <u>*Molecular Evidence:*</u>
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. <u>*Research & Expertise:*</u>
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

Appendix 4. Simple Neighbour-Joining (distance based) tree to be used *ONLY* for visualisation of genetic distance relationships (not a comprehensive analysis using appropriate molecular models and search algorithms).



Appendix 5. COI DNA sequence data for queried Olpiidae specimens

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Appendix 4: WAMTS317 DNA Analysis Report

Molecular Identification of Olpiidae from ca. 38 and 41 km ENE of Newman, WA

Report to *Biologic Environmental*

24 July 2014

Gaynor Dolman

Department of Terrestrial Zoology, Western Australian Museum,
Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Summary

Forty specimens of pseudoscorpians were collected from Orebody 31, ca. 41 km ENE of Newman, west of Orebody 31 and Wheelarra North, ca. 41km ENE of Newman, and were lodged into the Western Australian Museum collection by *Biologic Environmental*. Amber Beavis and Kym Abrams identified potential Olpiidae (N=20) from these specimens and these were conveyed to the Molecular Systematics Unit (MSU) for molecular identification (see Appendix 1 for specimen details). The main objectives of the WA Museum's MSU were to use COI DNA barcoding to: 1) test whether any of the Olpiidae specimens are identified as *Xenolpium* 'PSE079' recognized previously in WAMTS247 and WAMTS300; 2) add comments on SRE status of the queried specimens.

DNA was extracted and DNA barcoding sequences (CO1) were amplified by PCR in the MSU and sequenced at the Australian Genomic Research Facility (AGRF) Perth node. DNA sequences were BLASTED against the Western Australian Museum DNA database.

A summary of specimen identifications together with their SRE status may be found in Table 1. A full explanation of the SRE categories used by the Western Australian Museum may be found in Appendix 2.

Table 1. Summary of WAMTS194 specimen identifications and SRE status.

FAMILY	GENUS	SPECIES	# OF SPECIMENS	SRE SUB-CATEGORY
Olpiidae	*Xenolpium*	`PSE079`	5	Potential SRE- (D) Molecular Evidence
Olpiidae	Genus nov.	'sp.'	2	Potential SRE- (A, D) Data Deficient, Molecular Evidence
Olpiidae	*Beierolpium*	'8/3'	5	Widespread
Olpiidae	*Indolpium*	'sp'	1	Potential SRE- (A, D) Data Deficient, Molecular Evidence

Results

COI DNA barcodes were amplified initially from 17 of 20 specimens. Successful Olpiidae COI coding DNA sequences were obtained from twelve specimens and one specimen returned a pseudogene (stop codons present in coding gene). The twelve queried Olpiidae COI sequences were compared to the Western Australian Museums' DNA barcode database. A summary of the comparison (BLAST results) is provided in Table 2. Details of museum specimens that were identified in BLAST searches and contextualise the taxonomic and distributional status of the queried species are provided in Table 3. A simple Neighbour-Joining (distance based) tree is provided in Appendix 3 for visualisation of genetic relationships. DNA sequences of queried specimens are provided in Appendix 4.

Table 2. Summary of BLAST analysis

REGNO	SPECIES	SUMMARY OF BLAST RESULTS
T133206 T133209 T133217 T133229 T133233	*Xenolpium* `PSE079`	There is 1.23% average sequence divergence within this lineage. The nearest lineage to *Xenolpium* 'PSE079' is 18.67% divergent (T93556, T93561, T94812, T127760, T127763, T127766).
T133211 T133248	Genus nov.	There is 1.99% average sequence divergence between these two specimens. Together they form a lineage which represents a new genus of Olpiidae. This lineage is 20.27% divergent to the genus *Xenolpium*.
T133200 T133201 T133203 T133210 T133237	*Beierolpium* '8/3'	There is 5.67% average sequence divergence among these five specimens. T133210 is most divergent, but there is still high genetic diversity (4.28% average divergence) among the other 4 specimens. These are the only molecular sequences available for the morphologically identified species, *Beierolpium* '8/3'. This lineage is 17.26% divergent to *Beierolpium bornemisszai* (GenBank number EU559545; Murienne et al. (2008).
T133221	*Indolpium 'sp.'*	This specimen represents a new and unique lineage that is 14.65% divergent from specimens T131451 and T132700, both distinct in their own right and sequenced as part of WAMTS300 for regional context.

Table 3. Details of registered WAM specimens in related, yet distinct, lineages to the queried Olpiidae specimens.

Reg. No.	Field No.	Order	Family	Genus	Species	Locality	Collection method	Male	Female	Juvenile	Habitat
T131392	03-OB31-L-T2-BES0929	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41km ENE of Newman	Leaf sifting	0	0	1	Leaf litter
T131395	05-OB31-R-T2-BES0927	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41km ENE of Newman	Foraging	0	0	1	Under rocks
T131402	16-OB31-L-T2-BES0955	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Orebody 31, ca. 41 km ENE. of Newman	Leaf sifting	0	1	0	Leaf litter
T131443	81-WN-L-T2-BES1200	Pseudoscorpiones	Olpiidae	*Xenolpium*	`PSE079`	Wheelarra North, ca. 38km ENE of Newman	Leaf sifting	0	0	1	Leaf litter
T131444	81-WN-R-T2-BES1178	Pseudoscorpiones	Olpiidae	*Indolpium*	`PSE079`	Wheelarra North, ca. 38km ENE of Newman	Foraging	0	0	1	Under rocks

Conclusions

The main objectives were to use DNA barcoding to: 1) test whether any of the Olpiidae specimens are identified as *Xenolpium* 'PSE079' recognized previously in WAMTS247 and WAMTS300; 2) add comments on SRE status of the queried specimens. According to the DNA barcoding (COI) data obtained for this study and the data currently available for context, the thirteen specimens represent four distinct lineages. First, there were five specimens of *Xenolpium* 'PSE079'. Originally based on morphological data, *Xenolpium* 'PSE079' is a potential SRE, subcategory A, lacking taxonomic and geographic information. These molecular data are congruent with SRE status (sub-category D) and provide additional geographic distributional context data. Second, two species represent a lineage within a previously unrecognised genus. As it represents a new and distinct genus, molecular data are congruent with the specimen representing SRE status (sub-category D). However, it is currently lacking taxonomic and geographic information (SRE, subcategory A). Third, five specimens are the first DNA sequence representatives of the morphologically defined, *Beierolpium* '8/3'. Currently the morphological data suggests that this species is widespread. Finally, one specimen represents a third new distinct species within the genus *Indolpium*. As it represents a new and distinct species molecular data are congruent with the specimen representing SRE status (sub-category D). However, it is currently lacking taxonomic and geographic information (SRE, subcategory A).

Reference

Murienne, J., Harvey, M.S. and Giribet, G. (2008). First molecular phylogeny of the major clades of Pseudoscorpiones (Arthropoda: Chelicerata). *Molecular Phylogenetics and Evolution* **49**(1): 170-184.

Appendix 1. Specimen data for twenty queried Olpiidae specimens

REG NO	DNA Barcoding	Field No.	Order	Family	Genus	Species	Locality	Collection method	Habitat
T133200	complete	X05-T1-L-BES1568	Pseudoscorpiones	Olpiidae	*Beierolpium*	'8/3'	OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Gorge/Deep Gully. Mulga Grove. Open Eucalyptus
T133201	complete	X13-T1-R-BES1590	Pseudoscorpiones	Olpiidae	*Beierolpium*	'8/3'	OB31. ca 41 km ENE of Newman	Rock Forage	Hillslope/Footslope. Acacia Shrubland.Triodia
T133203	complete	X16-T1-L-BES1588	Pseudoscorpiones	Olpiidae	*Beierolpium*	'8/3'	W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga.Triodia
T133204	Amplified pseudogene	X16-T1-L-BES1589	Pseudoscorpiones	Olpiidae			W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga Shrubland.Triodia
T133206	complete	X18-T1-L-BES1592	Pseudoscorpiones	Olpiidae	*Xenolpium*	'PSE079'	W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Eucalyptus.Triodia
T133208	Human contamination	X20-T1-L-BES1599	Pseudoscorpiones	Olpiidae			OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga. Eucalyptus. Triodia
T133209	Complete (PCR failed initially)	X22-T1-L-BES1561	Pseudoscorpiones	Olpiidae	*Xenolpium*	'PSE079'	OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga Shrubland
T133210	complete	X22-T1-L-BES1562	Pseudoscorpiones	Olpiidae	*Beierolpium*	'8/3'	OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga Shrubland

REG NO	DNA Barcoding	Field No.	Order	Family	Genus	Species	Locality	Collection method	Habitat
T133211	complete	X22-T1-L-BES1563	Pseudoscorpiones	Olpiidae	Genus nov.	sp.	OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Open Mulga Shrubland
T133217	complete	X26-T1-L-BES1580	Pseudoscorpiones	Olpiidae	*Xenolpium*	'PSE079'	Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Drainage Foci. Mulga Grove.Open Eucalyptus
T133221	complete	X30-T1-L-BES1601	Pseudoscorpiones	Olpiidae	*Indolpium*	sp.	Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Triodia
T133226	PCR failed	X34-T1-L-BES1573	Pseudoscorpiones	Olpiidae			Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia
T133227	Human contamination	X34-T1-L-BES1574	Pseudoscorpiones	Olpiidae			Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia
T133228	PCR failed	X34-T1-L-BES1575	Pseudoscorpiones	Olpiidae			Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia
T133229	complete	X34-T1-L-BES1576	Pseudoscorpiones	Olpiidae	*Xenolpium*	'PSE079'	Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia
T133230	Sequencing failed	X34-T1-L-BES1577	Pseudoscorpiones	Olpiidae			Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia
T133232	Human contamination	X34-T1-L-BES1579	Pseudoscorpiones	Olpiidae			Wheelara North. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Open Eucalyptus.Triodia

REG NO	DNA Barcoding	Field No.	Order	Family	Genus	Species	Locality	Collection method	Habitat
T133233	complete	X38-T1-L-BES1593	Pseudoscorpiones	Olpiidae	*Xenolpium*	'PSE079'	W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Vegetation Grove. Mulga Grove. Acacia Thicket
T133237	complete	X41-T1-L-BES1597	Pseudoscorpiones	Olpiidae	*Beierolpium*	'8/3'	W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Shallow Gully. Mulga Grove.Other Acacia.Triodia
T133248	complete	X36-T1-L-BES1341	Pseudoscorpiones	Olpiidae	Genus nov.	sp.	W of OB31. ca 41 km ENE of Newman	Leaf Litter Sieve	Stony Plain. Mixed Eucalyptus

Appendix 2. WAM Short-Range Endemic Categories

	Taxonomic Certainty	Taxonomic Uncertainty
Distribution < 10 000km^2	**Confirmed SRE** • *A known distribution of < 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	**Potential SRE** • *Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group.* • *We have incomplete taxonomic knowledge.* • *The group is not well represented in collections.* • *This category is most applicable to situations where there are gaps in our knowledge of the taxon.* **Sub-categories for this SRE designation are outlined below**
Distribution > 10 000km^2	**Widespread (not an SRE)** • *A known distribution of > 10 000km².* • *The taxonomy is well known.* • *The group is well represented in collections and/ or via comprehensive sampling.*	

SRE SUB-CATEGORIES

If a taxon is determined to be a "Potential SRE", the following sub-categories will further elucidate this status.

A. <u>*Data Deficient:*</u>
- There is insufficient data available to determine SRE status.
- Factors that fall under this category include:
  - Lack of geographic information.
  - Lack of taxonomic information.
  - The group may be poorly represented in collections.
  - The individuals sampled (e.g. juveniles) may prevent identification to species level.

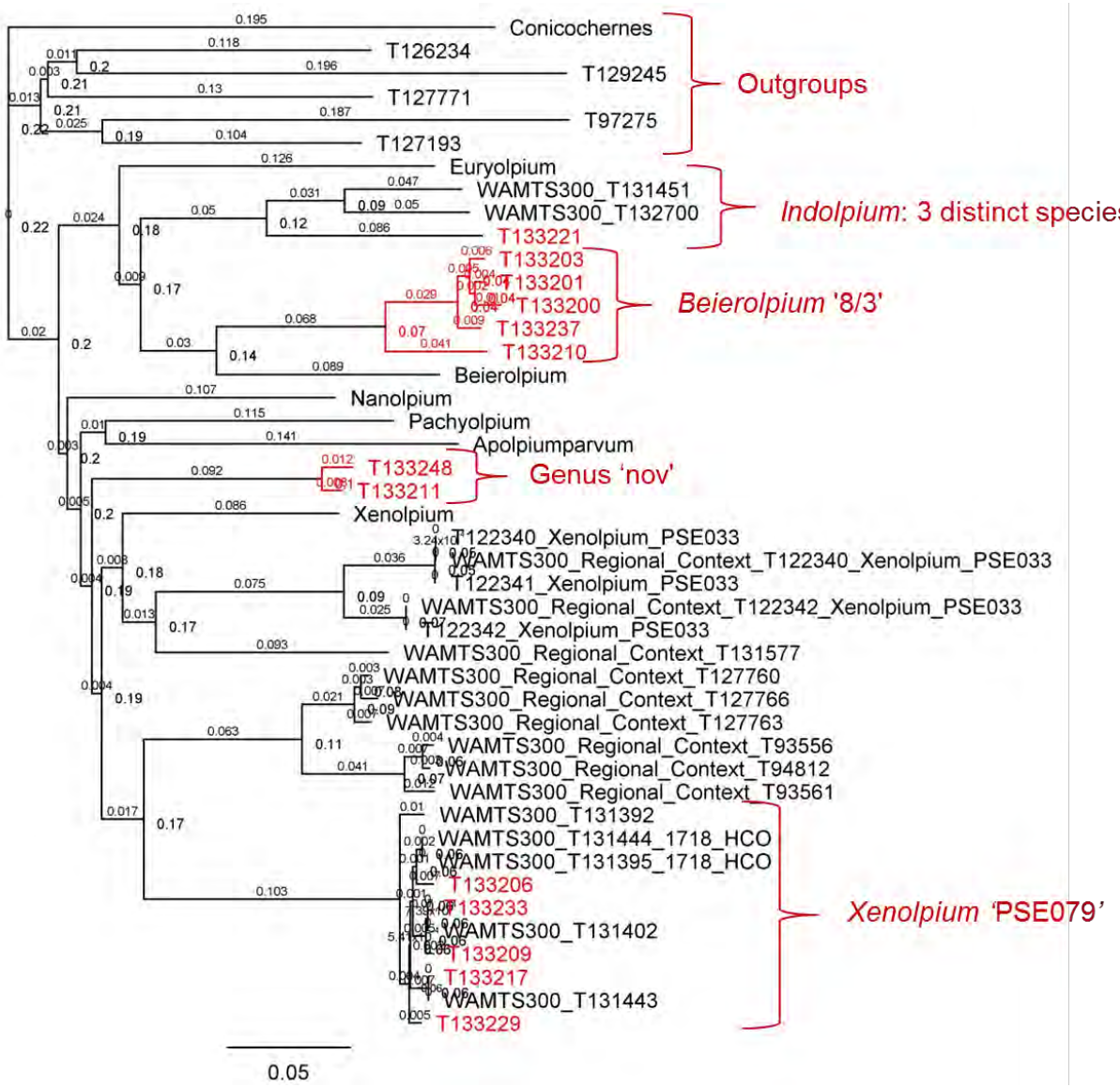
B. <u>*Habitat Indicators:*</u>
- It is becoming increasingly clear that habitat data can elucidate SRE status.
  - Below are some examples of habitats that are currently known to be associated with SRE taxa and vice versa.

C. <u>*Morphology Indicators:*</u>
- A suite of morphological characters are characteristic of SRE taxa.
- Below are some examples of morphological characters associated with SRE taxa and vice-versa.

D. <u>*Molecular Evidence:*</u>
- If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
- Below are some examples of phylogenetic patterns associated with SRE taxa and vice-versa.

E. <u>*Research & Expertise:*</u>
- Previous research and/ or WAM expertise elucidates taxon SRE status.
- This category takes into account the expert knowledge held within the WAM.

Appendix 3. Simple Neighbour-Joining (distance based) tree to be used *ONLY* for visualisation of genetic distance relationships (not a comprehensive analysis using appropriate molecular models and search algorithms).



Appendix 4. COI DNA sequence data for queried Olpiidae specimens

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