GLACIER VALLEY

SHORT-RANGE ENDEMIC INVERTEBRATE FAUNA SURVEY

PREPARED FOR: IRON BRIDGE OPERATIONS PTY LTD

Spectrum
ECOLOGY & SPATIAL

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EXECUTIVE SUMMARY

IB Operations Pty Ltd (IBO) proposes to continue to develop the iron ore mining operations located at North Star (NS) in the Pilbara region of Western Australia (WA). IBO is a majority-owned subsidiary of Fortescue Metals Group Ltd (Fortescue), which owns and operates mining and infrastructure projects in the Pilbara. Glacier Valley (GV) is a proposed extension of NS and will likely involve mine pits, waste rock dumps and supporting infrastructure.

The North Star (Stage 2 – magnetite) project is approved under Ministerial Statement 993 and comprises a mining area, slurry pipeline and infrastructure corridor, and Canning Basin borefield and water supply pipeline. The North Star project is located approximately 100 km south of Port Hedland and approximately 20 km to the east of the Fortescue Main Line Rail (Map 1.1). The host to the magnetite mineralisation at GV is the main banded iron formation (BIF) member of the Pincunah Formation. The Pincunah Formation is one of several prominent BIF units within the greenstone belts of the Pilbara Craton which host primary magnetite mineralisation.

To support the primary environmental approvals process, a comprehensive Short-Range Endemic (SRE) Invertebrate fauna survey and habitat assessment of the GV Survey Area and MDE (Survey Area) was required to assess potential environmental impacts and identify appropriate management strategies. The assessment was designed to build on previous data collected from the GV Survey Area and surrounds and assess previously unsurveyed areas. The first phase of the current survey (wet pitfalls, dry pitfalls, leaf litter, opportunistic) was completed from the 14-25 May 2020. Wet pitfall traps were left in place and collected on 18 July 2020 during the conservation significant vertebrate fauna survey. The second phase of the survey (dry pitfall, foraging) was completed from the 6-15 October 2020.

The database search and literature review identified 11 Mygalomorph (trapdoor) spiders, four Araneomorph (modern) spiders, one Opiliones (harvestman), nine pseudoscorpions, four scorpions, six snails, six isopods (woodlice) and four millipedes that have been recorded from the region surrounding the Survey Area. Of these 45 species, 29 were assessed to have a medium to high likelihood of occurrence in the Survey Area.

During the survey, four broad fauna habitats were recorded from the Glacier Valley Survey Area: Hills, Ranges and Plateaux, Rocky Escarpment, Gorges and Gullies, Minor Drainage Lines. Hills, Ranges and Plateaux, and Minor Drainage Lines habitats were widespread in the greater region and show a high level of connectivity with similar habitat outside the Survey Area. The Rocky Escarpment and Gorges and Gullies habitat types contain microhabitats with characteristics associated with SRE fauna. The two habitat types are primarily associated with the Capricorn Land System within the Survey Area. Glacier Valley represents 2.26% of the land system's total area within the immediate region (50 km) and a large expanse of the land system outside of the Survey Area is well connected with that found within it.

A total of 252 invertebrate specimens belonging to SRE target groups were collected during the SRE invertebrate fauna survey. Invertebrate specimens were collected from four dry pitfall trapping sites over two phases, six wet pitfall trapping sites and were extracted (via Tullgren funnel) from leaf litter collected at six sites. The 252 specimens represent 17 species: two species of pseudoscorpion, six species of scorpion, five species of isopod, one millipede and three species of centipede. Thirteen of the 17 collected species have been assessed as potential SREs (four likely and nine unlikely) and four were confirmed as widespread and as such are not short-range endemics.

The number of SRE species identified by the desktop assessment was higher than the number recorded during the field survey. Potential SRE species are often associated with restricted habitat types and as such

it is unlikely that they will all be present within any one survey area. No trapdoor spiders, snails or millipedes were recorded during the current survey. In comparison, only one trapdoor spider, one snail and one millipede were recorded from the baseline survey at North Star in 2011 which covered a much large area. The majority of regional records of these three groups were returned from the WAM database search which comprises of multiple surveys over multiple seasons. The results from a database should not be compared to one single survey, in particular when a wider variety of habitat types were sampled in the region that are not present within the Survey Area.

Another reason for the elevated species counts of the desktop survey is the lack of detailed information and/or unique phrase names associated with previously collected specimens. Without a unique name or number, it is difficult to consolidate previous and current data to eliminate duplicate species. It also does not allow for the collation of distributional data and, in turn, the update of a species SRE status. In addition, the use of DNA sequencing is not currently a standard method of SRE surveys, so that sequenced specimens are likely conspecific with specimens collected in the past that were not submitted for DNA sequencing. Future collections and submissions for DNA sequencing to a central database will increase this data pool and likely provide information on the distribution of a species which in turn will decrease the number of species known to be widespread.

There were no major constraints on the survey outcomes as a result of survey methods and techniques, and all fauna habitat types were surveyed. The total rainfall for the five months prior to the field survey was 432 mm (January to May) which exceeds the annual average of 392.7 mm recorded from Marble Bar for this period.

1. INTRODUCTION

1.1. Project Background

IB Operations Pty Ltd (IBO) proposes to continue to develop the iron ore mining operations located at North Star (NS) in the Pilbara region of Western Australia (WA). IBO is a majority-owned subsidiary of Fortescue Metals Group Ltd (Fortescue), which owns and operates mining and infrastructure projects in the Pilbara. Glacier Valley (GV) is a proposed extension of NS and will likely involve mine pits, waste rock dumps and supporting infrastructure. The North Star (Stage 2 – magnetite) project is approved under Ministerial Statement 993 and comprises a mining area, slurry pipeline and infrastructure corridor, and Canning Basin borefield and water supply pipeline. The North Star project is located approximately 100 km south of Port Hedland and approximately 20 km to the east of the Fortescue Main Line Rail (Map 1.1). The host to the magnetite mineralisation at GV is the main banded iron formation (BIF) member of the Pincunah Formation. The Pincunah Formation is one of several prominent BIF units within the greenstone belts of the Pilbara Craton which host primary magnetite mineralisation.

1.2. Scope of Work and Justification for Survey Level

To support the primary environmental approvals process, a comprehensive Level 2 Short-Range Endemic (SRE) invertebrate fauna survey and habitat assessment of the GV Survey Area and MDE (Survey Area) was required to assess potential environmental impacts and identify appropriate management strategies. The assessment was designed to build on previous data collected immediately north of the GV Survey Area as part of the NS environmental approval process and assess previously unsurveyed areas.

1.3. Legislation & Guidelines

Nationally threatened species (flora and fauna) and ecological communities are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Western Australian *Biodiversity Conservation Act 2016* (BC Act) provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. Where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to threatened fauna categories, conservation significant species are listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as Priority species.

1.3.1. Assessment Guidance

The SRE fauna assessment was conducted in accordance with the following Commonwealth and State legislation, as well as Environmental Protection Authority (EPA) requirements for environmental surveys as outlined below.

- *Biodiversity and Conservation Act 2016 (BC Act);*
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Technical Guidance: Sampling of Short Range Endemic Invertebrate Fauna (EPA 2016a); and
- Technical Guidance: Terrestrial Fauna Surveys (EPA 2016c);

Survey and other relevant guidelines as provided by IBO were also incorporated into the design of the assessment as below:

- Environmental Datasets – Data Governance 100-GU-EN-0020 (FMG 2012);
- Geographic Information Systems and Raw Data Guidelines 100-GU-EN-0009 (FMG 2011); and
- Environmental Document Standard Terminology 100-GU-EN-0002 (FMG 2010).

600000 650000 700000 750000 800000

7750000 7700000 7650000 7600000

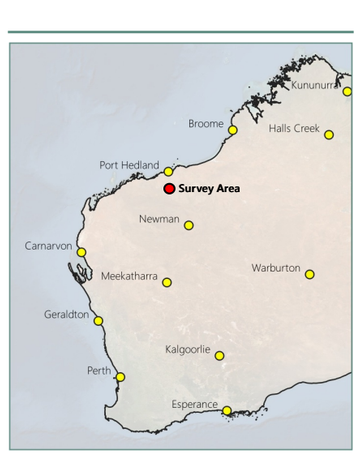
Port Hedland

Marble Bar

Nullagine

Legend

- Survey Area
- North Star Project Boundary
- North Star Stage 2 Area



N

0 5 10 15 20 25 km

Scale 1:720,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY

Author: JV Approved: DC Date: 25-06-2021

Survey Area Location

Glacier Valley Project

Prepared for
IB Operations

MAP
1.1

2. EXISTING ENVIRONMENT

2.1. IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia into regions based on dominant landscape, climate, lithology, geology, landform and vegetation (Thackway and Cresswell, 1995).

The Survey area is in the Pilbara IBRA bioregion (Figure 2.1) located in the central west of Western Australia. The climate is classified arid to tropical with very hot summers and mild or warm winters and a mean average rainfall of between 250-350mm each year (Kendrick, 2001). The bioregion is geologically complex with great mineral wealth and is also biologically special. There are high levels of species endemism and species-rich ecosystems including persisting populations of threatened and endangered species (McKenzie, May and McKenna, 2003).

The Pilbara Craton is made up of four subregions: the Chichester, Fortescue Plains, Hamersley and Roebourne. The Survey Area is in the northern section of the Pilbara bioregion within the Chichester subregion (Figure 2.1). The Chichester subregion is characterised by undulating Archaean granite and basalt plains with significant areas of basaltic ranges (Kendrick, 2001; McKenzie, May and McKenna, 2003). The plains of this subregion support hummock grasslands characterised by shrub steppe of *Acacia pyrifolia* over *Triodia pungens*. The ranges are dominated by *Eucalyptus leucophloia* tree steppes (Kendrick, 2001; McKenzie, May and McKenna, 2003).

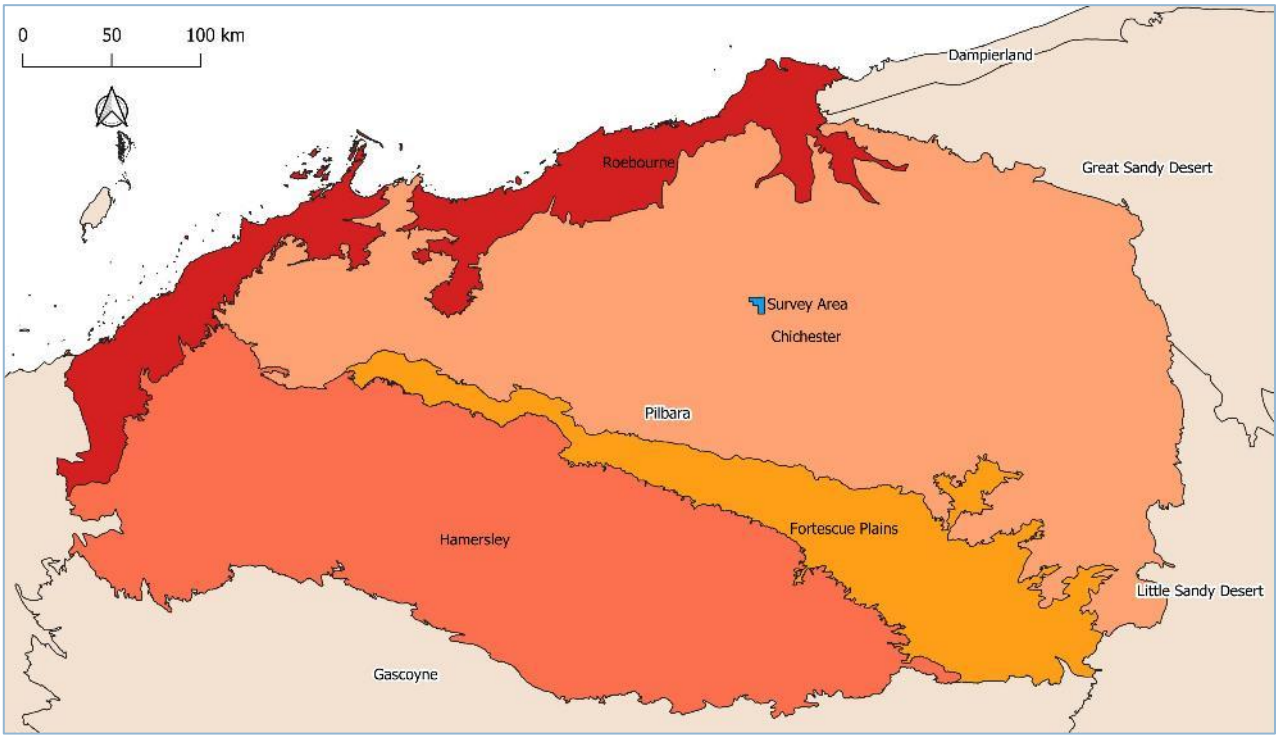


Figure 2.1: IBRA Bioregion

2.2. Climate

Two broad climatic zones occur across the Pilbara region. Semi-desert tropical climatic conditions occur in coastal areas, as well as some higher rainfall inland areas, which experience 9-11 months of dry weather, with hot humid summers and warm winters. Dry desert climatic conditions occur across the remaining inland areas which typically experience higher temperatures and lower rainfall with hot dry summers and mild winters with up to 12 months of dry weather, (Leighton, 2004). The Survey Area is located near the boundary between coastal and dry inland areas.

Annual rainfall is highly variable, but generally follows an inland to coastal and southern to northern increasing trend (Leighton, 2004). The driest months are in spring (September to October) with tropical cyclones and local thunderstorms producing much of the summer and early autumn rainfall (McKenzie, van Leeuwen and Pinder, 2009). Winter rainfall is also highly variable, generally decreasing from the coast through to inland areas (Leighton, 2004). The climate of the Chichester subregion is semi-desert-tropical and receives a on average 300 mm of rain annually.

Monthly maximum temperatures in the Pilbara region range from an average of 25°C in July to 37°C in January, while minimum temperatures range between 12°C in July and 25°C in January (McKenzie, van Leeuwen and Pinder, 2009). December and January are the hottest months in inland areas while coastal areas often experience their highest temperatures later in February or March due to the dampening effect of the ocean. (Leighton, 2004). According to the Köppen-Geiger climate classification, the Survey Area has a hot desert climate (Class BWh) (Peel, Finlayson and McMahon, 2007). This classification includes arid regions where annual evaporation exceeds annual precipitation, and with a mean annual temperate ≥18°C.

Long-term climate data recorded from the nearest Bureau of Meteorology (BOM) station (Marble Bar BOM station #4106) indicates that the Survey Area experiences hot wet summers and dry warm winter temperatures with high rainfall recorded January to March and very little rain consistently across the rest of the year (Figure 2.2). The total rainfall for the five months prior to the field survey was 432 mm (January to May) which exceeds the annual average of 392.7 mm recorded from Marble Bar for this period.

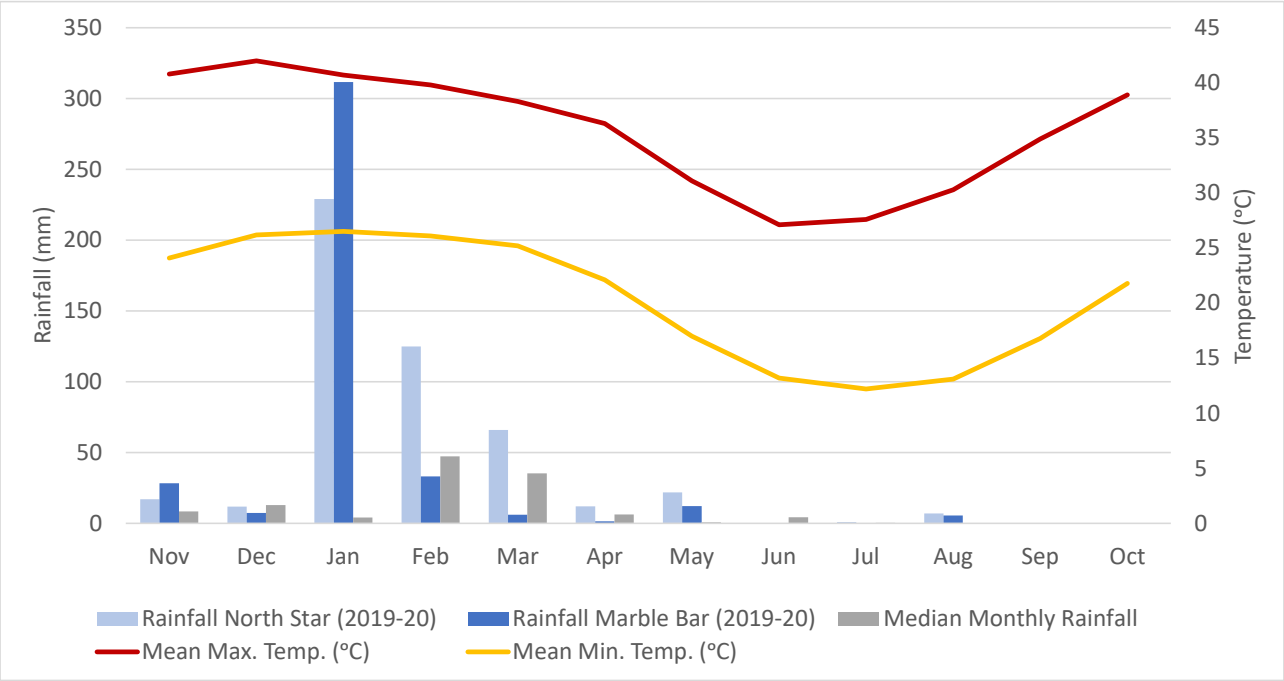


Figure 2.2: Rainfall and Temperature Data for the 12 Months Preceding the Survey (BOM 2020)

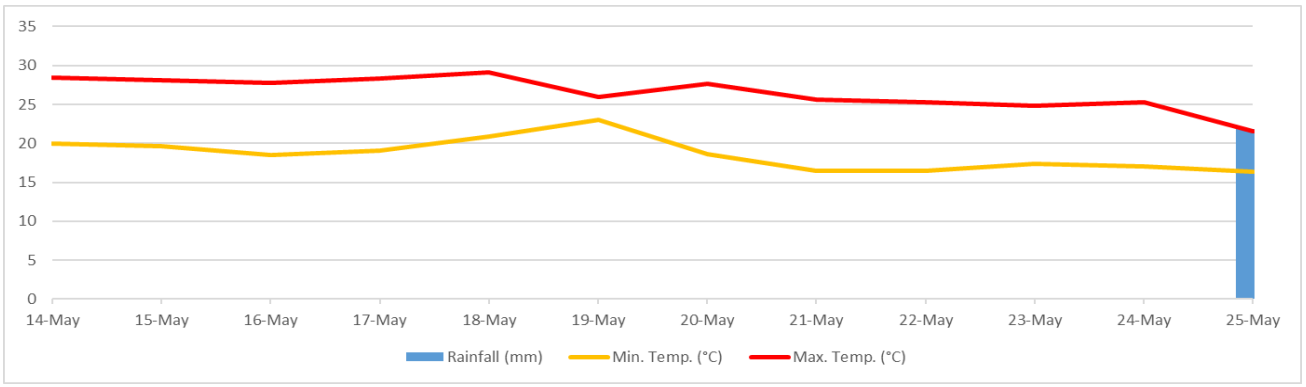


Figure 2.3: Daily Rainfall During the Phase 1 Survey (Fortescue's Weather Station – North Star)

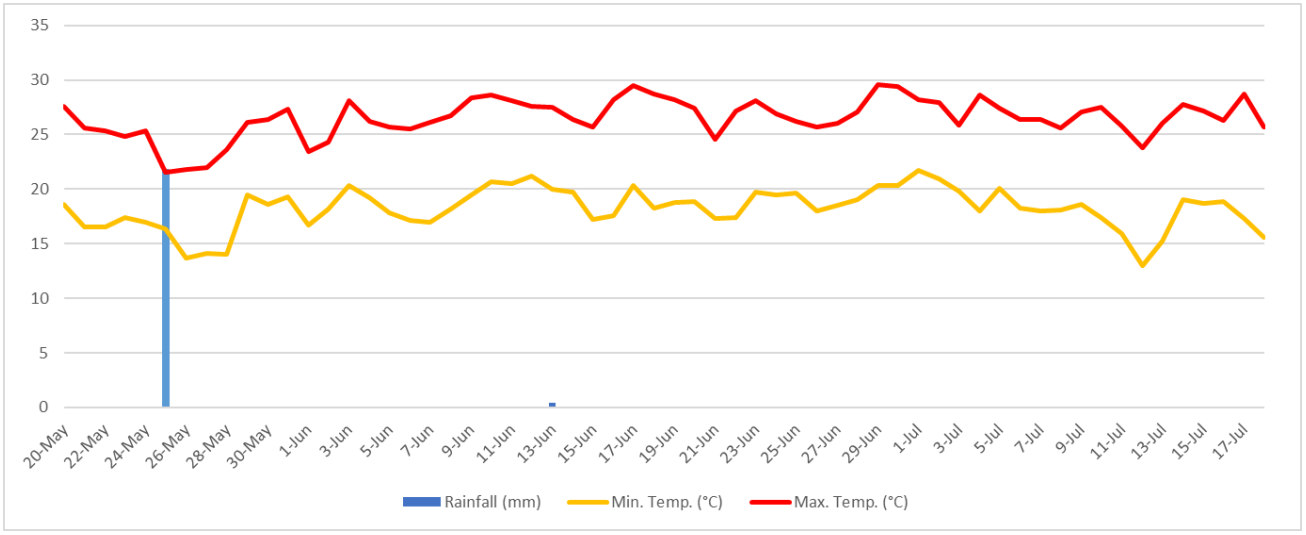


Figure 2.4: Daily Rainfall During the Wet Pitfall Survey (Fortescue's Weather Station – North Star)

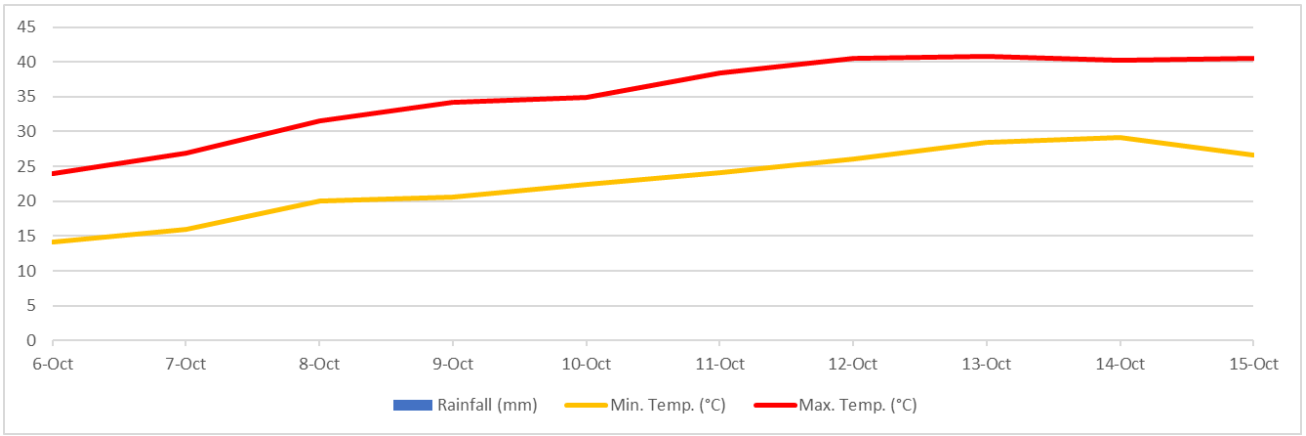


Figure 2.5: Daily Rainfall During the Phase 2 Survey (Fortescue's Weather Station – North Star)

2.3. Land Systems

As part of the rangeland resource surveys the biophysical resources of the Pilbara were comprehensively described and mapped together with an evaluation of the condition of the soils and vegetation (from an agricultural perspective) (Van Vreeswyk *et al.*, 2004). As part of this process an inventory of land types, land systems and land units with particular use capabilities, habitats or conservation values were established to assist in land use planning.

The Capricorn land system is the most common, occurring across 42.2% of the Survey Area. The Rocklea land system is the least well represented, accounting for 26.5% of the total area. The three land systems are widespread within the Pilbara region and their extents within the Survey Area each represent less than 1% of their total respective areas. To further refine this data in a way that is applicable to SRE habitats, land system extents were calculated within a 50 km buffer area to measure potential habitat immediately surrounding the Survey Area. The land systems occurring within the Survey Area and their extents are listed in Table 2.1 and displayed with a 50 km buffer on Map 2.1.

Table 2.1: Land Systems Occurring within the Survey Area

Land System	Description	Area Within Survey Area (ha)	Proportion of Survey Area (%)	Survey Area as Proportion of total LS Area (%)	Area Within 50 km Buffer (ha)	Survey Area as Proportion of 50 km Buffer Area (%)
Capricorn	Hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands.	2,431.7	42.2	0.31	94,857.4	2.56
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	1,526.9	26.5	0.05	127,064.8	1.20
Talga	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands.	1,806	31.3	0.85	78,273.2	2.31

2.4. Pre-European Vegetation

Pre-European vegetation mapping was originally undertaken by Beard at various scales across the state and has since been updated to be consistent with the National Vegetation Information System (NVIS) descriptions at a scale of 1:250,000 (DPIRD 2019).

The Survey Area is located within vegetation sub-association 82.1 that is described as *Eucalyptus leucophloia* over *Triodia* wiseana var. *brevifolia* hummock grassland. The vegetation sub-association extents were extracted from the simplified State-wide Vegetation Statistics Report (DBCA 2019), summarised in Table 2.2 and displayed in Map 2.2.

Table 2.2: Vegetation Association Mapped within the Survey Areas

Sub-association	Area in Survey Area (ha)	% of Survey Area	Pre-European Whole State (ha)	Current Extent State (ha)	% Remaining	% of Current Extent in DBCA Land
82.1	5,765	100	317,182.03	316,855.11	99.90	0

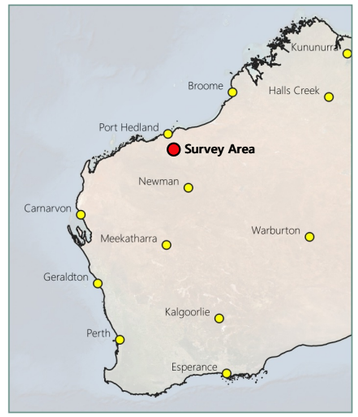
660000
680000
700000
720000
740000
760000
780000
7680000
7660000
7640000
7620000
7600000

Legend

- Survey Area

Land System

- Capricorn
- Rocklea
- Talga



N

0 5 10 15 km

Scale 1:410,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: JV Approved: AH Date: 29-06-2021

Land Systems With a 50 km Buffer

Glacier Valley Project

MAP 2.1

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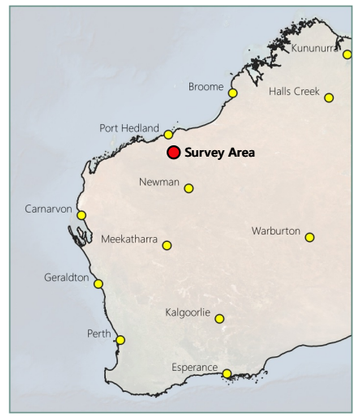
705000
708000
711000
714000
717000
7647000
7644000
7641000
7638000
0
1
2 km

Legend

Survey Area

Vegetation Units

- 82.1
- 93.3
- 93.4



N

0 0.5 1 1.5 km

Scale 1:42,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: JV Approved: AH Date: 29-06-2021

Pre-European Vegetation

Glacier Valley Project

MAP 2.2

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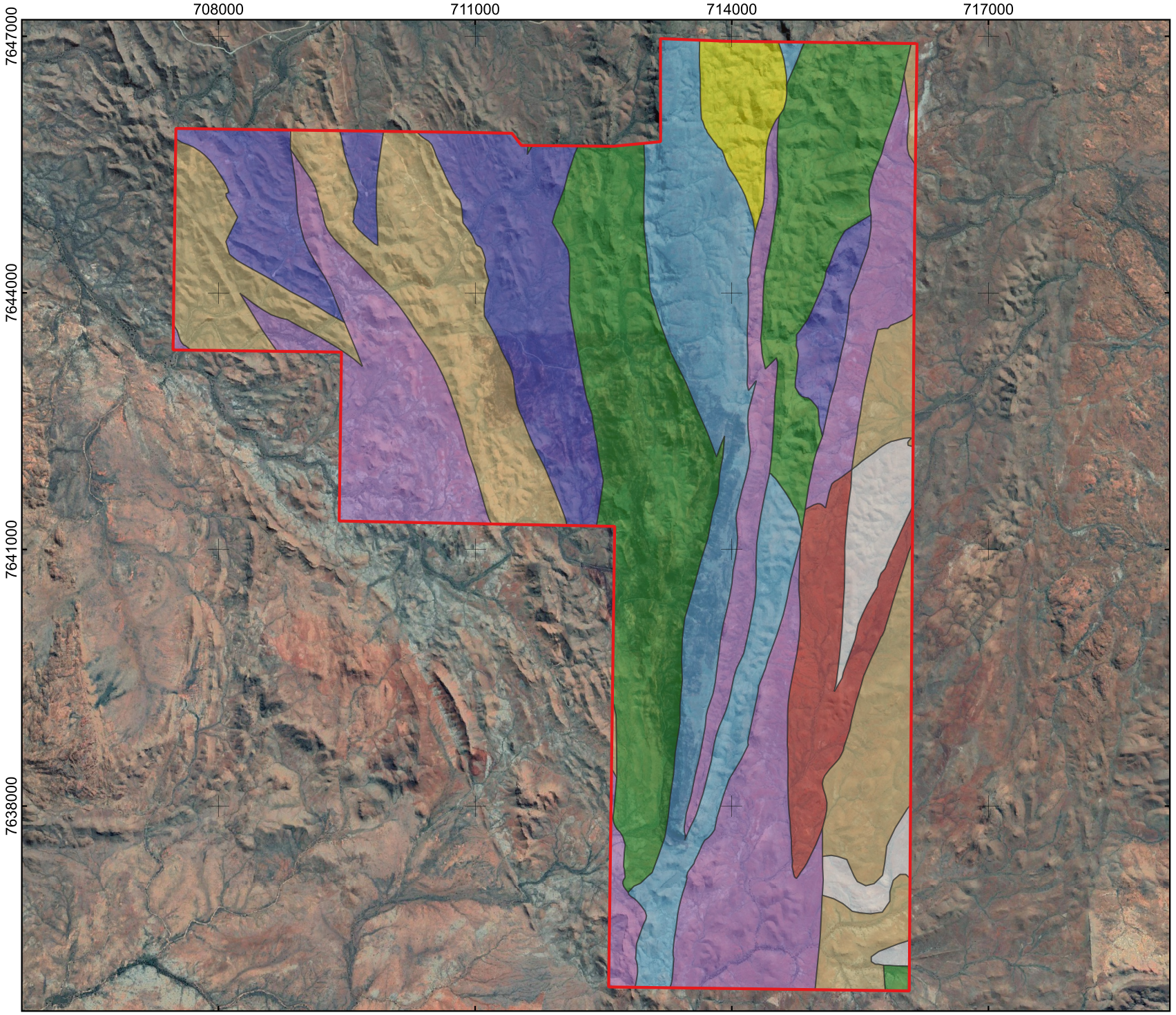
2.5. Geology

The geology of Western Australia has been mapped at a scale of 1:50,000, 1:100,000, 1:250,000 and 1:500,000. The data for this assessment was extracted from the updated 1:500,000 scale dataset released this year by the Department of Mines, Industry Regulation and Safety (DMIRS 2020). The Survey Area consists of eight geological units, the most extensive of which is Dalton Suite, accounting for 22.2% of the Survey Area. The Kangaroo Caves Formation and Leilira Formation each compose 21.6% and 19.4% of the Survey Area respectively. Of particular note is the Leilira Formation, which has 18.5% of its total Pilbara extent within the Survey Area, although this formation (Siliciclastic sedimentary rocks) does not correlate with areas of habitat conducive to providing suitable SRE microhabitats. The geological units and their extents are listed in Table 2.3 and shown on Map 2.3.

Table 2.3: Geological Units of the Survey Area (1:500,000)

Formation	Unit	Description	Area in Survey Area (ha)	% of Survey Area	Total Pilbara Extent (ha)	% of Pilbara Extent within Survey Area
Corboy Formation	A-SOc-s	Siliciclastic sedimentary rocks; metamorphosed	139.4	2.4	27,536.4	0.5
Dalton Suite	A-DA-xo-a	Mafic and ultramafic intrusive rocks; metamorphosed	1,278.9	22.2	36,646.9	3.5
Kangaroo Caves Formation	A-SSc-xf-s	Felsic and mafic volcanic rocks, and siliciclastic sedimentary rocks; metamorphosed	1,245.6	21.6	17,519.5	7.1
Kunagunarrina Formation	A-SSk-b	Basaltic rocks with komatiitic basalt; minor komatiite, siliciclastic rocks and chert; metamorphosed	735.4	12.7	10,065.0	7.3
Leilira Formation	A-SSl-s	Siliciclastic sedimentary rocks, minor felsic volcanic rocks, and chert; metamorphosed	1,116.4	19.4	6,040.9	18.5
Pincunah Banded-Iron Member	A-SOap-ci	Banded iron-formation; jaspilitic; minor layered chert and shale; metamorphosed	788.9	13.7	7,479.6	10.5
Strelley Monzogranite	A-CEst-gm	Hornblende--biotite monzogranite and granophyric monzogranite; local diorite, dolerite, and gabbro; metamorphosed	277.0	4.8	18,043.0	1.5
Strelley Monzogranite	A-CEst-od	Dolerite and gabbro; metamorphosed	183.0	3.2	2,469.9	7.4

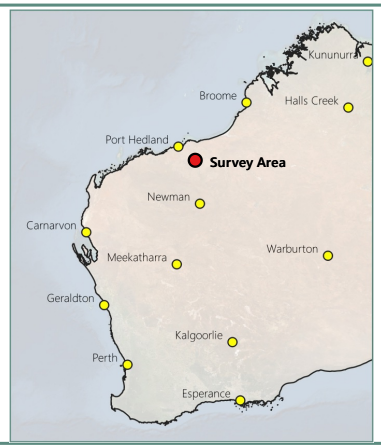


Legend

- Survey Area

Surface Geology (500k)

- A-EM-g
- A-EMjo-gg
- A-MBge-mgtn
- A-MR-g
- A-MRwa-gm
- A-STdi-xo-a
- A-TAbo-mgt



N

0 0.5 1 1.5 2 km

Scale 1:61,000 @ A4

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY • SPATIAL

Author: MH Approved: DC Date: 29-06-2021

Geological Mapping

Glacier Valley

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MAP
2.3

2.6. Environmentally Significant Areas

2.6.1. Threatened and Priority Ecological Communities

Ecological communities are defined as a naturally occurring group of plants, animals and other organisms interacting in a unique habitat with the complex range of interactions between the component species providing an important level of biological diversity in addition to genetics and species diversity (DBCA 2020). Ecological communities that are at risk are listed as Threatened (TECs) under the EPBC and/or BC Act or Priority (PEC) by the DBCA.

No TECs or PECs intersect the Survey Area or occur in the immediate region.

2.6.2. Conservation Estates and Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESA) are areas that are defined by the Department of Water and Environmental Regulation (2019) as:

- a declared World Heritage property as defined in s 13 of the EPBC Act 1999;
- an area that is included on the Register of the National Estate, because of its natural heritage value under the Australian Heritage Council Act 2003;
- A defined wetland and the area within 50 m of the wetland;
- The area covered by vegetation within 50 m of Threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened flora is located;
- The area covered by a TEC;
- A Bush Forever site;
- Areas covered by the Gnangara Mound Crown Land Policy and Western Swamp Tortoise Policy;
- Areas covered by lakes, wetlands and fringing vegetation of the Swan Coastal Plain Lakes Policy, including South West Agricultural Zone Wetlands Policy and Swan and Canning Rivers Policy; and
- protected wetlands as defined in the Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998.

No Conservation Estates or Environmentally Sensitive Areas intersect the Survey Area or occur in the immediate region. The closest Conservation Estate, which is also an ESA, is the Mungaroona Range Nature Reserve located 63 km south-west of the Survey Area.

2.6.3. Australian Wetlands Database

The Australian Wetlands Database includes nationally significant wetlands (as listed in the directory of important wetlands), wetlands listed under the Ramsar convention, wetlands that are representative, rare or unique, or wetlands that are considered of international importance (DoEE, 2019).

No significant wetlands intersect the Survey Area or occur in the immediate region. The Fortescue Marsh south of the Survey Area and Leslie Saltfields System north of the Survey Area are listed wetlands though both are located over 100 km away.

3. METHODS

3.1. Desktop Assessment

Three public databases and two previous survey reports were accessed to provide information to support the current assessment. Details of each database search are listed in Table 3.1, Previous surveys conducted surrounding the Survey Area are listed in Table 3.2. Survey sites established during previous surveys are displayed on Map 3.1. Two foraging sites established as part of the North Star SRE survey in 2012 were located within the current Glacier Valley Survey Area.

Table 3.1: Database Search Details

Custodian	Database	Species Group	Search Details
Western Australian Museum	Arachnida & Myriapoda Database	SRE Invertebrate Fauna Species	Rectangular polygon search area: NW corner -21.024501, 118.73339 SE corner -21.643812, 119.342758
	Crustacea Database		
	Mollusca Database		

Table 3.2: Previous SRE Survey Reports

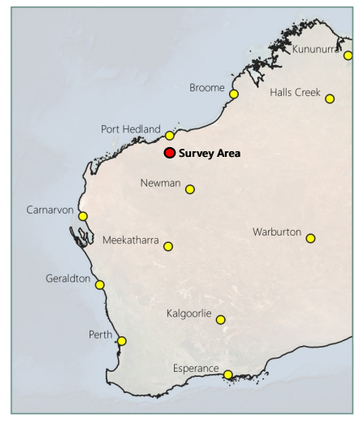
Report Title	Project	Type of Survey	Distance to Survey Area (km)
North Star Short-Range Endemic Invertebrate Survey (ecologia 2012b)	North Star Mine	SRE Wet Pitfall Trapping	0-30
Canning Basin Pipeline and Drawdown Area. Vertebrate and Short-Range Endemic Invertebrate Survey (ecologia 2012a)	Canning Basin and Pipeline Corridor	Foraging	25-100

680000 690000 700000 710000 720000 730000 740000

7670000 7660000 7650000 7640000 7630000

Legend

- Survey Area
- Previous Survey Sites
  - SRE wet pitfall site (ecologia 2012d)
  - Foraging site (ecologia 2012a)
  - Foraging site (ecologia 2012d)



N

0 2.5 5 7.5 km

Scale 1:200,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY

Author: JV Approved: AH Date: 28-06-2021

Previous Survey Site Locations

Glacier Valley Project

Prepared for
IB Operations

MAP
3.1

3.2. Short-Range Endemic Target Groups

Short-range endemic invertebrate species are defined as species with naturally small distributions (<10,000 km^2) that possess ecological, morphological and life history characteristics that affect their range. Poor powers of dispersal, confinement to discontinuous habitats, slow growth rates and low levels of fecundity often result in fragmented or severely restricted distributions. Many species appear to be Gondwanan relicts now isolated in pockets of mesic habitat that was once more widespread and contiguous prior to the aridification of the Australian landscape. A low level of taxonomic resolution, lack of detailed ecological information and difficulties identifying many taxa via morphological means further complicates the assessment of potential SRE species. In many taxa, such as *Antichiropus* sp. millipedes, male only characters (e.g. gonopod morphology) are the primary diagnostic features used when identifying species (Wojcieszek, Harvey and Rix, 2010). If female or juvenile specimens are collected, identification to species level or alignment with known undescribed morphospecies using morphological characters is not possible. The use of DNA barcoding is gradually addressing this issue though the database of known sequences is still limited for many taxa (WAM 2014).

The combination of these factors make SRE species particularly vulnerable to threatening processes such as habitat loss, degradation and climate change (Harvey *et al.*, 2011). The taxa detailed in Table 3.3 have been identified as displaying one or more of the characteristics known to cause short-range endemism (Harvey 2002) and as such are targeted during field assessment.

Table 3.3: SRE Target Groups

Phylum or Subphylum	Class	Order	Details
Annelida	Oligochaeta	Haplotaxida	Earthworms.
Chelicerata	Arachnida	Araneae	Spiders, particularly those belonging to the infraorder Mygalomorphae (trapdoor spider).
		Opiliones	Harvestmen.
		Pseudoscorpiones	False scorpion or book scorpion.
		Schizomida	Micro whip scorpions, mostly known from troglobitic species.
		Scorpiones	Scorpions.
Crustacea	Malacostraca	Isopoda	Terrestrial Isopods, also known as slaters or woodlice.
Mollusca	Gastropoda	Stylommatophora	Land snails.
Myriapoda	Chilopoda	Geophilomorpha	Elongate soil centipedes.
		Scolopendromorpha	Centipedes from the family Cryptopidae.
	Diplopoda	Not specified	Millipedes
Onychophora	Udeonychophora	Euonychophora	Velvet worms, family Peripatopsidae.

3.2.1. SRE Habitat

Sheltered, isolated, and often relictual mesic habitats have an increased likelihood of hosting SRE taxa. The gradual aridification of the Australian continent that began in the early Miocene has resulted in the contraction and isolation of mesic habitats and by association those relictual faunal groups that utilise them (Harvey 2002). The following are examples or habitat types that have been recognised as potentially harbouring SRE species (Harvey 2002; Durrant, 2011; EPA 2016a):

- Deep gorges
- Isolated ranges, mesas, and rock outcrops
- Rainforest patches
- Islands
- Drainage systems
- Vine thickets
- Hillslopes with south-west facing aspects
- Fire refuge areas such as cliffs and rock piles.

Many SRE species are associated with permanently moist, shaded, and sheltered microhabitats. In arid landscapes such as the ranges of the Pilbara region, these habitat types are typically limited and isolated by barriers of exposed, dry habitat not conducive to the dispersal SRE species. This isolation restricts or eliminates gene flow between populations and may result in speciation via selective pressures, genetic drift, and mutation. Even where speciation has not yet occurred, the geographical distribution of these species has severely contracted and fragmented. Isolated gorges and gullies that host complex microhabitats (heavy vegetation, deep leaf litter beds and varied rock cover) and protect relictual mesic habitat characteristics are more likely to host SRE taxa than simple widespread habitats exposed to climatic extremes. Isolated freshwater habitats associated with springs are also likely to provide conditions suitable for SRE taxa. Regionally extensive and exposed habitat types with high connectivity such as spinifex grassland are unlikely to host SRE taxa (Durrant, 2011).

Vegetation, geological, land system, and topographic mapping as well as aerial imagery may be used as surrogates to estimate habitat connectivity and distributional boundaries of potential SRE species. This is to be considered in circumstances where further survey is deemed unlikely to yield more specimens and further taxonomic or distributional information is not available via the museum and subject matter specialists (EPA 2016a).

3.2.2. Determination of SRE Status

The SRE status of invertebrates is based on categories which were developed by the Western Australian Museum (WAM). In an effort to further clarify the status of specimens collected during field assessments, the system employed by the WAM has been expanded to include likely and unlikely SRE sub-categories that fall within the larger potential SRE category (Table 3.4). To assign a species to one of these sub-categories, the habitat associated with the record is assessed to determine its likelihood of hosting SRE species. Further to this, related species at a generic or family level are examined to identify any confirmed SRE species within the group. The combination of habitat preference and prevalence of short-range endemism in closely related species can be indicators as to a species likelihood of being an SRE. Following the Precautionary Principle, all data deficient species from known SRE target groups are regarded as potential short-range endemics.

Several factors are considered when assessing a specimen for potential SRE status (based on the Precautionary Principle) including:

- The collected specimen belongs to an SRE target group (section 3.2).
- The specimen is a juvenile or female. The majority of SRE taxa require an adult male for identification.
- The taxon has previously not been collected and is not present within the reference collection. There can be more than one reference collection which limits the likelihood that certain taxon are present.
- Taxonomic status is unresolved. The taxon is new and has not been previously collected.
- Lack of taxonomic resolution. Taxonomic resolution alone does not necessarily provide the required information to assess a species' SRE status. Species groups are preferably worked on by a taxonomist, or a reference collection is publicly available.
- Taxon exhibits morphological peculiarities that limit the species ability to disperse and distribute widely.

In addition, the SRE status of taxa can also change over time if additional data (specimens) are collected and the distribution indicates that the species is widespread.

Table 3.4: SRE Categories

<table>
<tr><th>Categories</th><th colspan="2">Defining Characteristics</th></tr>
<tr><td>Confirmed SRE</td><td colspan="2">• Known distribution of <10,000 km$^{2.}$
• Taxonomy is well understood.
• Species is well represented in collections.
• Region of occurrence has been comprehensively sampled.</td></tr>
<tr><td rowspan="2">Potential SRE</td><td rowspan="2">• Limited sampling has resulted in incomplete knowledge of the species distribution.
• Poor or limited taxonomic resolution.
• Species not well represented in collections.</td><td>Likely SRE
• Belongs to a group (infraorder, family, or genera) containing a high proportion of confirmed SRE species.
• Occurs within isolated, sheltered and/ or non-contiguous habitat types associated with SRE taxa.</td></tr>
<tr><td>Unlikely SRE
• Belongs to a group (infraorder, family, or genera) containing a low proportion of confirmed SRE species.
• Recorded from a single or multiple exposed, regionally extensive, and contiguous habitat type/s or from a habitat type not typically associated with SRE taxa.</td></tr>
<tr><td>Not SRE</td><td colspan="2">• Known distribution of >10,000 km$^{2.}$
• Taxonomy is well understood.
• Species is well represented in collections.
• Region of occurrence has been comprehensively sampled.</td></tr>
</table>

In order to align with sub-categories used by the WAM, the following sub-categories will also be included to further clarify a species ranking as a Potential SRE (Table 3.5).

Table 3.5: WAM Sub-Categories Used to Justify Potential SRE Status

Sub-Category	Description

A: Data Deficient	• 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; and
	  • The individuals sampled (e.g., juveniles) may prevent identification to species level.

B: Habitat Indicators	• It is becoming increasingly clear that habitat data can elucidate SRE status; and • Where habitat is known to be associated with SRE taxa and vice versa, it will be noted here.
C: Morphology Indicators	• A suite of morphological characters are characteristic of SRE taxa; and • Where morphological characters are known to be associated with SRE taxa and vice-versa, it will be noted here.
D: Molecular Evidence	• If molecular work has been done on this taxon (or a close relative), it may reveal patterns congruent or incongruent with SRE status.
E: Research & Expertise	• Previous research and/ or WAM expertise elucidates taxon SRE status; and • This category takes into account the expert knowledge held within the WAM.

3.3. Determination of Survey Design

3.3.1. Previous Survey Effort and Timing

The previous SRE survey at North Star was completed during the wet season (February to March 2011) which is consistent with the recommended survey timing for SREs as per the Technical Guidelines (EPA 2016a). The Canning Basin and Pipeline survey was conducted in October 2011 (ecologia 2012a).

The locations of previous survey sites relevant to the current survey (where available) are shown on Map 3.1.

3.3.2. Factors Likely to Influence Survey Design

Prior to the development of the survey methods, a review was undertaken of factors likely to influence the design and intensity of the field survey (Table 3.6).

Table 3.6: Factors Likely to Influence Survey Design

Factor	Relevance
Bioregion – level of existing survey/knowledge of the region and associated ability to predict accurately.	The Pilbara region has been extensively surveyed over the past decade with a general expansion in the detailed knowledge of the vertebrate faunal assemblages that occur in the region. The range associated with Glacier Valley and the Abydos Plain have been extensively sampled as part of mining and associated infrastructure environmental impact assessments. Much of the data is accessible online or via database search requests. The data is adequate to predict SRE fauna target groups and the likelihood of occurrence of conservation significant species.
Landform special characteristics/specific fauna/specific context of the landforms and their distribution and rarity in the region.	The landforms of the Survey Area are typical of the wider region and mainly consist of ranges and stony hills. Several minor drainage lines run through the Survey Area. All landforms are considered common throughout the surrounding region.
Lifeforms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The Pilbara region is considered arid and most SRE fauna life cycles are significantly influenced by rainfall. Population increases, species dispersal and the onset of breeding activity is directly affected by rainfall in many taxa. Temperature also influences activity levels with invertebrates being most active during warm wet periods.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	The results of two SRE fauna surveys which were conducted within 25 km of the Survey Area were available to provide regional context to the current assessment. Some overlap of sites occurs with the current Survey Area. Regional and local knowledge for the area is detailed, highly comparable and available for inclusion.
Number of different habitats or degree of similarity between habitats within a study area.	Four broad SRE fauna habitat types were initially identified based on staff experience with the region, previous habitat mapping, land systems and vegetation units. Each of these habitat types include their own specific SRE microhabitats.
Climatic constraints (e.g. temperature or rainfall that preclude certain sampling methods).	The Pilbara region experiences hot summers with occasional cyclonic rain events, followed by warm winters with little rain although rainfall is considered to be highly unpredictable. Field surveys are generally conducted in Autumn and Spring to avoid climatic events that may preclude sampling. No climatic constraints were expected to influence the field surveys and data from previous surveys provides information to cover any survey gaps experienced.
Sensitivity of the environment to the proposed activities.	The Survey Area contains habitat types which are well represented in the surrounding region. Highest impacts are associated with the areas of mining and associated infrastructure. Prior assessments completed as part of the North Star project provided broad baseline knowledge of the area.
Size, shape and location of the proposed activities.	The Survey Area, located approximately 100 km south of Port Hedland, is part of a proposed extension of the North Star Mine currently in construction. The Survey Area is located south of North Star and occupies both the same ridge as the existing mine and areas of lower hills to the east, west and south.
Scale and impact of the proposal.	The Survey Area is part of a proposed extension of the approved North Star Mine located to the north. The impact of the extension will be associated with open pits, access roads, infrastructure, and waste dumps.

3.4. Field Survey Methods

Spectrum Ecology completed a simultaneous two-phase Level 2 terrestrial vertebrate and SRE invertebrate fauna survey as part of the current assessment. All methods followed the state and federal legislation and guidelines listed in section 1.3. Systematic sampling methods include standardised repeatable survey techniques that provide data that can be statistically analysed to measure survey adequacy. Opportunistic surveys include a selection of supplementary sampling techniques that can detect species that that may not be detected during systematic sampling. The combination of sampling methods allows for the accurate identification of local SRE fauna present at the time of sampling. Detailed descriptions for each sampling method are described below.

3.4.1. Systematic Sampling

SRE invertebrate fauna species were sampled systematically using the following methods. Since they were deployed as part of the vertebrate fauna survey, it should be noted that the dry pitfall and funnel traps were not necessarily set up in suitable SRE microhabitat (such as narrow gorges); although sites were generally installed in sheltered positions such as underneath trees (for shading):

- Dry Pitfall trapping (20 L bucket and 50 cm PVC pipe): A trapping grid comprised of 10 alternating buckets and PVC pipes, dug into the ground to act as pitfall traps. A 10 m long, 30 cm high fence was also installed, passing across the top of each pit to direct fauna into it. The pitfalls were opened for seven nights and checked each morning.
- Fraser-type funnel traps: Similar to yabbie traps, these were placed at the ends of each fence to capture fauna that are not readily caught in pitfall traps (20 per trapping grid). All funnel traps were covered with shades to reduce the likelihood of animals suffering from overheating.
- Wet pitfall trapping: Wet pitfall traps consisted of a 1 L plastic jar containing 500-700 ml of preserving solution (a propylene-glycol/ 100% ethanol mix). All wet pitfall traps were covered with a bucket lid, situated approximately 2-3 cm above the surface of the ground to prohibit vertebrate species from being trapped (Figure 3.1). Each wet pitfall site comprised four wet pitfalls which were established in suitable SRE microhabitat and left in-situ for 6-8 weeks.
- Leaf litter collection: Three 1 m^2 quadrats of suitable leaf litter and topsoil were collected from each of the selected sites, in suitable SRE microhabitat. The samples were initially processed using a leaf litter reducer, with the smaller leaf litter components placed into plastic zip-lock bags and transported back to Perth where they were placed under Tullgren funnels for 2-3 days in order to extract the invertebrates (Figure 3.2). Each leaf litter sample was also searched manually for specimens not likely to be extracted via Tullgren funnels (such as snail shells).

Figure 3.1: Wet Pitfall Traps

Figure 3.2: Tullgren Funnels for Extraction of Invertebrate Specimens

3.4.2. Foraging Sites

One limitation of systematic sampling sites is that some species are difficult to detect due to cryptic behaviours or other ecological considerations, such as fossorial or arboreal species. Systematic survey techniques were therefore supplemented with opportunistic sampling techniques that target specific species and habitats not normally covered by systematic trapping sites. Suitable SRE microhabitats were foraged for

invertebrate target groups that potentially include SRE species, as listed in Table 3.3. Search techniques included foraging or raking through rock piles, leaf litter, soil and debris, and checking the underside of rocks, bark and logs. If encountered, live snails were also collected from vegetation and leaf litter, and trapdoor spider burrows were excavated.

3.4.3. Site Selection

Prior to the current survey, information was considered from the previous SRE fauna survey completed as part of the North Star Mine approvals process (ecologia 2012b) as well as habitat and species data collected during previous surveys and ongoing conservation significant fauna monitoring for vertebrate fauna (ecologia 2014; Ecoscape 2016, 2017, 2018; Spectrum 2019, 2020b, 2020a). Likely broad fauna habitat types and areas of interest for SRE invertebrate fauna species were then selected based on the results of the above assessments to ensure adequate sampling of habitats.

Survey sites were established across all broad fauna habitat types. Dry pitfall trapping sites (as part of the vertebrate fauna trap sites) were restricted to two of the four broad habitat types identified due to a combination of recent fire and an inability to install pit traps in areas with significant exposed bedrock and outcropping. Details and locations of all survey sites are listed in Appendix B and displayed on Map 3.2.

3.4.4. Survey Effort and Timing

The EPA's Technical Guidance (EPA 2016a) states that conditions for short-range endemic surveys are suitable between November and April, but recognises the issues around unpredictable rainfall in some regions of WA and that survey work can therefore take place outside the recommended months.

A summary of the survey effort undertaken is detailed in Table 3.7. During both phases of Level 2 survey and the targeted survey the following survey effort was completed:

- A total of four dry pitfall trapping grids were surveyed over two phases (as part of the vertebrate fauna survey) totaling 1,468 trap nights (pitfalls and funnels);
- 20 hours of opportunistic searches (foraging);
- 1,392 nights of SRE wet pitfall trapping were completed at six sites; and
- 18 leaf litter samples from six sites were collected and processed for SRE invertebrate fauna.

Table 3.7: Survey Effort Completed Within the Survey Area

Survey	Survey Timing	Person Days	Trap Nights			No. Sample Locations		Opportunistic Searches (hrs)
			Dry Pitfalls	Funnels	SRE Wet Pitfalls	SRE Wet Pitfalls	Leaf Litter	
Phase 1	14-25 May 2020	34	224	560	1,392	24	18	10
Phase 2	6-15 Oct 2020	20	224	560	-	-	-	10
Ecologia (2012b) – Overlapping area only	February 2011	2	-	-	-	-	-	2
Total		56	448	1,020	1,392	24	18	22

710000

715000

7645000

7640000

GV SRE4

GV S1

GV S2

GV SRE6

GV S3

GV SRE5

GV SRE3

GV SRE2

GV S4

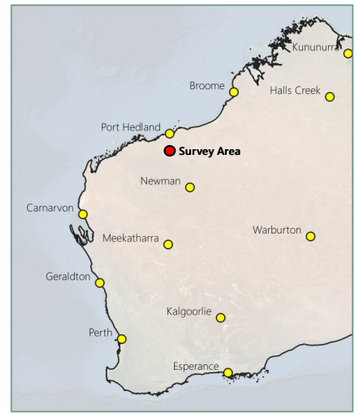
GV SRE1

Legend

- Survey Area

Survey Sites

- SRE Wet Pitfall Site
- Dry Pitfall Trapping Site
- Opportunistic Site
- Leaf Litter Collection



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Scale 1:41,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY

Author: JV Approved: AH Date: 28-06-2021

Survey Site Locations

Glacier Valley Project

Prepared for
IB Operations

MAP
3.2

3.4.5. Survey Timing

The first phase of survey (dry pitfall, leaf litter, foraging) was completed from the 14-25 May 2020. Wet pitfall traps were installed during the first phase on 20 May 2020 and collected on 18 July 2020 during the conservation significant vertebrate fauna survey. The second phase of the survey (dry pitfall, foraging) was completed from the 6-15 October 2020.

Optimal timing for SRE surveys typically coincides with seasonally wet conditions which vary in their timing throughout the state (EPA 2016a). In the Pilbara region, the optimal period is stated as cyclone season (November-April). However, the EPA also recognises that rainfall events can be difficult to predict and as such, survey work for Environmental Impact Assessment (EIA) may take place outside of these months. The timing of the wet pitfall survey fell outside of the peak period of activity described as optimal in the Technical Guidance though significant rainfall was experienced in the area during the survey (Figure 2.4). The risk of extreme weather and the associated animal welfare and logistical issues it creates must also be considered when undertaking field work. To mitigate these risks, many fauna surveys are completed in autumn in the Pilbara region when the chance of extreme rainfall and temperatures have lessened though conditions are still suitable for fauna activity.

3.4.6. Animal Ethics

Any disturbance of animals by the various capture or sampling methods involved followed the state and federal legislation and guidelines listed in section 1.3.

Any potential SRE invertebrates collected during the field survey were humanely euthanized by chilling them in a refrigerator before inserting into a vial of chilled 100% ethanol. Wet pitfall trapping techniques followed the most recent available guidelines to limit the number of by-catch species collected as much as possible (DBCA, 2017).

3.4.7. Survey Team and License

The project team members and their associated roles are detailed in Table 3.8. The field surveys were completed under Regulation 27 license BA27000255.

Table 3.8: Project team

Staff	Role	Years of Experience
Damien Cancilla	Reporting	14
Astrid Heidrich	Field assessment, reporting, data analysis	12
Jordan Vos	Field assessment, reporting, data analysis	10
Jesse Harper	Reporting, data analysis	7
Marcus Cosentino	Field assessment	10
Melinda Henderson	Field assessment	2

3.4.8. Survey Limitations

Survey limitations are unforeseen events that can limit the effectiveness of the field survey to achieve the required objectives. Overall, no significant limitations were experienced during the field survey. Specific potential limitations are addressed below in Table 3.9.

Table 3.9: Survey Limitations

Limitation	Constraint	Comment
Competency/experience of the consultant carrying out the survey.	No	Zoologists that completed the field survey were highly experienced at conducting terrestrial fauna surveys in the Pilbara region, more specifically the Chichester sub-region.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	Sampling techniques were designed for a terrestrial SRE invertebrate fauna assessment. All fauna groups were sampled, and no survey constraints were experienced that limited sampling of specific groups
Proportion of fauna identified, recorded and/or collected.	No	SRE invertebrates were returned to Perth to be identified to the highest level possible by experienced taxonomists.
Sources of information.	No	Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.
The proportion of the task achieved and further work which might be needed.	No	All aspects of the SRE survey were completed, in particular when considering previous survey effort within the Survey Area.
Timing/weather/season/cycle.	No	The SRE survey was conducted during suitable seasonal conditions for SRE species (as per the guidelines). The total rainfall for the five months prior to the field survey was 432 mm (January to May) which slightly exceeds the long-term annual average of 392.7 mm (Marble Bar) for this period. All major fauna groups and fauna habitat types were sampled. Survey methods were supplemented with the use of dry pitfall traps over two phases (as part of the vertebrate fauna trapping survey).
Disturbances (e.g. fire, flood, accidental human intervention) which affected results of survey.	No	No disturbances were recorded during the survey.
Intensity (in retrospect, was the intensity adequate).	No	The completed SRE assessment was adequate to identify the SRE fauna assemblages and habitat present within the Survey Area. Sufficient targeted searches for SRE fauna species were completed within areas of suitable habitat.
Completeness (was the relevant area fully surveyed.	No	All major fauna habitat types were sampled and defined. Habitat types that may host SRE invertebrate fauna species were adequately surveyed.
Resources (degree of expertise available in animal identification to taxon level).	No	The experience level of the zoologists present was sufficient to identify SRE target groups. Resources available were adequate and did not compromise the outcome of the survey. Identification of SRE taxa was completed to the highest possible level based on current taxonomic information.
Remoteness and/or access problems.	No	Access to the eastern and south-eastern part of the Survey Area was limited. However, Spectrum staff have accessed this area previously and are familiar with the fauna habitats present. This in combination with aerial imagery, vegetation mapping, land system data and geological data allowed for the prediction of habitat types by extrapolation.

Limitation	Constraint	Comment
Availability of contextual (e.g. biogeographic) information on the region.	No	Background information about the region was available and sufficient.

3.5. Fauna Habitat Mapping

Fauna habitat mapping identifies areas of vegetation and land features that are distinguishable from other areas. Typically, each fauna habitat supports a characteristic fauna assemblage that is adapted to the features of the fauna habitat. Fauna habitat types are identified and mapped based on the following information:

- General vegetation type (Shepherd, Beeston and Hopkins, 2001)
- Vegetation types mapped within the Survey Area
- Vegetation structure
- Landforms
- Geological units
- Soil substrate
- Aerial imagery
- Fauna assemblage
- Field observations.

Fauna habitat assessments were completed at each survey site, opportunistically while traversing the Survey Area on foot, and when travelling between sites.

Fauna habitat mapping was completed to identify broad habitat type and their general suitability for SRE species. SRE-specific microhabitats consist of small, sheltered pockets, such as deep leaf litter beds on the southern side of a large tree, or leaf litter pockets within a narrow rocky gorge; hence these areas are too small and defined to be mapped across the entire Survey Area.

3.6. SRE Fauna Identification

All invertebrate fauna specimens collected during the current survey were provided to a subcontractor, Bennelongia Environmental Consultants (Bennelongia), where they were identified to the highest possible taxonomic level. Leaf litter samples were handed over immediately following the field survey to ensure maximum survivorship before the samples were placed under Tullgren funnels (Figure 3.2). Invertebrate specimens from the wet and dry pitfall traps were initially sorted by Spectrum Ecology staff before being submitted to Bennelongia for taxa identification.

3.6.1. DNA analysis

DNA analysis was completed for five species for scorpion: *Lychas* `BSCO052`, *Lychas* `BSCO053`, *Lychas* `BSCO059`, *Lychas* `pilbara1` and *Lychas jonesae* to clarify taxonomic status and investigate regional records and distribution of the species to determine the SRE status. DNA extractions were made using tissue samples of legs or whole specimens.

Detailed methodology is provided in Appendix C.

4. RESULTS

4.1. Desktop Assessment

To provide regional context for the assessment of the SRE invertebrate fauna values within the Survey Area, a review was conducted of Western Australian Museum invertebrate database records and two previous SRE survey reports (Table 4.1).

The database search and literature review identified 11 Mygalomorph (trapdoor) spiders, four Araneomorph (modern) spiders, one Opiliones (harvestman), nine pseudoscorpions, four scorpions, six snails, six isopods (slaters) and four millipedes that have been recorded from the region surrounding the Survey Area (Table 4.1). Of these 45 species, nine were assessed to have a medium likelihood to occur. Twenty species have a high likelihood of occurrence in the Survey Area, based on both the record's proximity to the Survey Area and the associated habitat types. The full species list and further details are presented in Appendix A.

Table 4.1: Summary of SRE Invertebrate Fauna Species Previously Recorded in the Region

Data Source	Type	Mygalomorphs	Araneomorphs	Opiliones	Pseudoscorpions	Scorpions	Snails	Isopods	Millipedes	Total Species
Survey Reports										
North Star Project Short-range Endemic Invertebrate Survey (ecologia 2012b)	Wet Pitfall & Opportunistic	1	1		2	1	1	2	1	**9**
Canning Basin and Pipeline and Drawdown Area (ecologia 2012a) (southern sites only)	Foraging Only							1		**1**
Public Databases										
WAM Arachnida and Myriapoda Database Search	-	10	3	1	7	3			3	**27**
WAM Mollusca Database Search	-						5			**5**
WAM Crustacea and Annelida Database Search	-							3		**3**
Total		**11**	**4**	**1**	**9**	**4**	**6**	**6**	**4**	**45**

680000
700000
720000
740000
760000
7660000
7640000
7620000

Legend

Survey Area

Arachnid Database

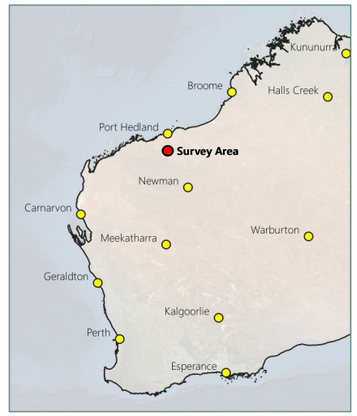
- Olpiidae `Genus 7/4` `sp. 7/4A`
- Buthidae `Hope Downs gen. 2` `Hope Downs sp. 1`
- Aname `MYG371`
- Aname `MYG372`
- Aname `MYG660`
- Aname `MYG662`
- Aname `MYG663`
- Aname `sp. (female; armigera group)`
- Aname `sp. 1`
- Antichiropus `DIP005`
- Antichiropus apricus
- Antichiropus forcipatus
- Aurecocrypta `MYG318`
- Dampetrus `aurizon`
- Feaella tealei
- Indohya `sp. MW`
- Karaops `aurizon`
- Karaops kariyarra
- Karaops nyamal
- Kwonkan `MYG200`
- Lychas `macleod`
- Oratemnus `PSE018`
- Oratemnus `PSE060`
- Synothele `MYG334`
- Synsphyronus `PSE008`
- Synsphyronus `PSE012`
- Tyrannochthonius `sp. nov. near aridus`
- Urodacus `pilbara 2`

Crustacean Database

- Buddelundiinae abydos
- Buddelundiinae mw
- Spherillo wodgina

Mollusc Database

- Gen. nov. cf. `Z` n.sp.
- Quistrachia cf. turneri
- Quistrachia turneri
- Rhagada aff. richardsonii
- Stenopylis cf. coarctata



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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY

Author: JH Approved: AH Date: 28-06-2021

SRE Fauna Database Search Results (WAM)

Glacier Valley Project

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4.1

4.2. SRE Fauna Habitats

Four broad fauna habitat types were recorded from the Glacier Valley Survey Area. The extent of each habitat type is detailed in Table 4.2 and shown on Map 4.2. The defining characteristics of these habitat types and the microhabitats within them that may host SRE taxa are described in the following section.

Table 4.2: Broad Fauna Habitat Types and Extents

Habitat Type	Fortescue Naming Convention	SRE Microhabitat Traits	Extent (ha)	% of Survey Area
Hills, Ranges and Plateaux	Hills/Ranges/Plateaux	South-facing hillslopes, boulder piles and cracks and crevices associated with rock outcrops provide shelter from climatic extremes (in particular heat and flash floods).	5,509.6	95.6
Rocky Escarpment	Rocky Escarpments (Ridges/Mesa/Cliffs/Outcrops/Breakaways)	South-facing hillslopes, rocky outcrops/ ridges/ cliffs and deep leaf litter beds provide shelter from climatic extremes and maintain moisture.	99.1	1.7
Gorges and Gullies	Gorges/Gullys	Deeply incised gorges/ gullies maintain cool, moist microclimates. Rocky cliffs and associated cracks and crevices provide sheltered refugia. Accumulated wood and leaf litter plus variably sized rocks create complex, moist microhabitats. Freshwater springs (when present) provide permanently moist conditions.	41.5	0.7
Minor Drainage Line	Drainage Line/River/Creek (Minor)	Water pooled during rainfall events provides moist conditions for an extended period. Root systems of large trees provide moist, cool refugia. Accumulated sand/ sediment along drainage edges deposited by water movement provides burrowing opportunities.	117.6	2.0

4.2.1. Hills, Ranges and Plateaux

The Hills, Ranges and Plateaux habitat type within Glacier Valley covered 5,509.6 ha (95.6 %) of the Survey Area (Map 4.2). The habitat was characterised by exposed rocky hills, often with areas of rock outcropping. Tree cover on the hills, hillslopes and valley floors was typically limited to scattered *Corymbia hamersleyana*, *Eucalyptus leucophloia* and *Hakea chordophylla* over *Acacia inaequilatera*, *Acacia ptychophylla* and *Acacia adoxa* shrubs. The drainage depressions that dissected the hills and valleys were vegetated with thickets of *Grevillea wickhamii*, *Acacia acradenia* and *Acacia tumida*. In areas not recently burned, a dense layer of spinifex (*Triodia wiseana*) was present growing on skeletal soils (Plate 4.1). Wood and leaf litter was limited to small, shallow, pockets beneath areas of denser vegetation.

Within the Hills, Ranges, and Plateaux broad fauna habitat type, hillslopes with south facing aspects, boulder piles, and rock outcrops hosting deep cracks and caves may represent microhabitats suitable for SRE target groups. Further details pertaining to specimens from SRE target groups captured within this habitat are presented in Table 4.3.

Plate 4.1: Hills, Ranges, and Plateaux Fauna Habitat Type

4.2.2. Rocky Escarpment

The Rocky Escarpment habitat type accounted for 99.1 ha or 1.7 % of the Survey Area (Map 4.2). The defining features of this ridge habitat in the Glacier Valley area were its high elevation, steep gradient, and significant rock outcropping. The BIF and quartzite ridge lines and cliff faces offer abundant cracks, voids, and crevices that act as refugia for fauna. Due to its exposed nature, vegetation was limited to low trees, shrubs, herbs, and grasses. Widely spaced *Ficus brachypoda* were present along the ridge amongst scattered *Acacia pruinocarpa*, *Grevillea wickhamii* and *Gossypium robinsonii* growing over spinifex (*Triodia wiseana*) and tussock grasses (predominantly *Cymbopogon* and *Eriachne* sp.) (Plate 4.2). Wood litter was very scarce though shallow pockets of leaf litter were present beneath *A. pruinocarpa* as well as deeper beds beneath *F. brachypoda*.

The Rocky Escarpment habitat type is associated with the edges of hills and ridges and typically consists of linear strips of rocky cliff habitat. Within the Glacier Valley Survey Area, the deep cracks and crevices within this habitat may offer microhabitats suitable for SRE target groups. Deep litter beds found under scattered *Ficus brachypoda*, often also in association with deep cracks and crevices, may also be regarded as suitable habitat. These microhabitats have the potential to provide a cooler and more mesic microclimate than those found in more exposed positions. Further details pertaining to specimens from SRE target groups captured within this habitat are presented in Table 4.3.

Plate 4.2: Rocky Escarpment Fauna Habitat Type

4.2.3. Gorges and Gullies

The Gorges and Gullies habitat type represented 41.5 ha (0.7 %) of the Survey Area (Map 4.2). It was characterised by steep (often vertical) edges and significant exposed bedrock and rock outcropping. The gorge or gully walls often hosted caves, cracks, crevices, and voids that act as shelter for fauna. The plant assemblage varied greatly, dependent on the depth of the landform and the shelter from the elements this depth provided. The upper and therefore more exposed areas were typically vegetated with scattered *Corymbia hamersleyana* and *Eucalyptus leucophloia* over thickets of *Acacia tumida* and *A. acradenia*. Spinifex (*Triodia* sp.) was abundant with tussock grasses (*Cymbopogon* sp.) often populating the gully floor. Deeper areas that experience a shorter photoperiod were vegetated with *Ficus brachypoda*, *Terminalia circumalata* and in areas with surface or shallow subsurface water, *Melaleuca* sp. and *Stemodia grossa*. Thickets of *A. tumida* were also present with irregularly scattered tussock grasses (*Cymbopogon* and *Eriachne* sp.). Leaf litter was abundant in areas, particularly in deeper sections beneath mature *Ficus* and *Terminalia* (Plate 4.3).

Of the found broad fauna habitat types found within the Glacier Valley Survey Area, the Gorges and Gullies habitat type is the most suitable for use my SRE target groups. Deeply incised gorges provide protection from temperature extremes and trap moisture while also acting as a catchment for extensive litter beds associated with *Ficus*, *Terminalia* and *Acacia* species. The steep, often vertical and bare cliff walls also offer a degree of protection from fire resulting in the buildup of wood and leaf litter. This and the loose rock of varying sizes that is also found on gorge and gully floors combine to create complex microhabitats favoured by SRE target groups. On occasion, freshwater springs occur within this habitat and provide permanent moist conditions. Further details pertaining to specimens from SRE target groups captured within this habitat are presented in Table 4.3.

Plate 4.3: Gorges and Gullies Fauna Habitat Type

4.2.4. Minor Drainage Lines

Minor Drainage Lines habitat accounted for 117.6 ha, or 2.0 % of the Glacier Valley Survey Area. This habitat type was not observed to hold permanent surface water, which is likely to only be present after significant rainfall events. The vegetation lining the drainage edges consisted of widely spaced *Eucalyptus* sp. and *Corymbia hamersleyana* over moderately dense *Petalostylis labicheoides*, *Gossypium robinsonii* and *Grevillea wickhamii* shrubland. Herbs such as *Corchorus* and *Senna* sp. were abundant, particularly in recently burned areas. *Triodia wiseana* populated the upper banks and small patches of *Triodia longiceps* was present within the drainage itself. Wood and leaf litter was scarce though some small pockets existed beneath trees and shrubs. The substrate was a combination of smooth stones and coarse, loose sand (Plate 4.4).

Minor Drainage Lines habitat provides several microhabitats that may host SRE target groups. Though no permanent surface water was recorded within the Glacier Valley Survey Area, evidence of depressions where water had pooled previously was present, particularly at the bases of large *Eucalyptus* sp. trees. Water in these areas persists longer than in the surrounding habitat and when combined with the structure provided by the trees root system it creates a cool, moist, microhabitat suitable for some SRE target groups (e.g., snails). Water flow also deposits sand and sediments along the edges of drainage lines providing a soft substrate that may be utilised by burrowing species such as trapdoor spiders and Urodacid scorpions. Further details pertaining to specimens from SRE target groups captured within this habitat are presented in Table 4.3.

Plate 4.4: Minor Drainage Lines Fauna Habitat Type

4.3. SRE Fauna Assemblage

A total of 252 invertebrate specimens belonging to SRE target groups were collected during the current survey. Invertebrate specimens were collected from four dry pitfall trapping sites over two phases, six wet pitfall trapping sites, and were also extracted (via Tullgren funnel) from six leaf litter sites. The 252 specimens represent 17 species: two species of pseudoscorpion, six species of scorpion, five species of isopod, one millipede and three species of centipede (Map 4.2). Thirteen of the 17 collected species have been assessed as potential SREs (four likely and nine unlikely) and four were confirmed as widespread and as such are not short-range endemics (Table 4.3). All 17 species are discussed in detail in sections 4.3.1.1 - 4.3.1.6.

Table 4.3: SRE Target Group Species Recorded During the Survey

Class/Order & Family	Species/Taxa	No individuals	Site	Trap Type	Details	Habitat Type	SRE status
Arachnida							
Pseudoscorpiones							
Chthoniidae	*Austrochthonius* `BPS291`	4	GV SRE LL2	Tullgren Funnel	Male and juveniles	Gorges and Gullies	Likely SRE
Olpiidae	*Indolpium* `BPS290`	27	GV SRE LL1, GV SRE LL3, GV SRE LL4, GV SRE LL6	Tullgren Funnel	-	Hills, Ranges and Plateaux Rocky Escarpment Gorges and Gullies	Unlikely SRE
Scorpiones							
Buthidae	*Lychas* `BSCO052`	1	GV S1	Dry Pitfall	New species. DNA analysis shows 10.6 % divergence with referenced sequences. Not aligned with anything else.	Hills, Ranges and Plateaux	Unlikely SRE
Buthidae	*Lychas* `BSCO053`	2	GV S2	Dry Pitfall	New species. DNA analysis shows 11.3 % divergence with referenced sequences. Not aligned with anything else.	Minor Drainage Line	Unlikely SRE

Class/Order & Family	Species/Taxa	No individuals	Site	Trap Type	Details	Habitat Type	SRE status
Buthidae	*Lychas* `BSCO059`	2	GV S3, GV SRE4	Dry Pitfall, Wet Pitfall	Tiny eyes, likely new species. Two specimens are conspecific (0.9 % divergence), but 11.9 % divergent to all other species (including specimen BSCO054 from Raven Project in the Hamersley Range which is morphologically similar).	Hills, Ranges and Plateaux Minor Drainage Line	Unlikely SRE
Buthidae	*Lychas* `pilbara1`	3	GV S2, GV S3, GV S4	Dry Pitfall	Hairy-tail group: 11.7% COI divergence to *Lychas* `BSCO051`, Morphologically consistent with other specimens collected from Raven Project in the Hamersley Range.	Hills, Ranges and Plateaux Minor Drainage Line	Unlikely SRE
Buthidae	*Lychas jonesae*	11	GV S1, GV S2, GV SRE6	Dry Pitfall, Wet Pitfall	Aligned with the WAM's SCO024 (2.1% COI distance). That species has been collected at Mulga Downs Station, 129 km SSW from Glacier Valley.	Hills, Ranges and Plateaux Gorges and Gullies Minor Drainage Line	Unlikely SRE
Urodacidae	*Urodacus* `BSCO050`	2	GV S1	Dry Pitfall	-	Hills, Ranges and Plateaux	Unlikely SRE

Class/Order & Family	Species/Taxa	No individuals	Site	Trap Type	Details	Habitat Type	SRE status
Isopoda							
Armadillidae	*Buddelundia* `BIS390`	73	GV S1, GV S2, GV S4, GV SRE1, GV SRE2, GV SRE5, GV SRE6	Dry Pitfall, Wet Pitfall	Males, females and juveniles collected	Hills, Ranges and Plateaux Rocky Escarpment Gorges and Gullies Minor Drainage Line	Unlikely SRE
Armadillidae	*Buddelundia* `BIS416`	102	GV SRE1, GV SRE2, GV SRE5, GV SRE6	Wet Pitfall	Males, females and juveniles collected	Rocky Escarpment Gorges and Gullies	Likely SRE
Armadillidae	*Buddelundia* `BIS417`	3	GV SRE1, GV SRE6	Wet Pitfall	Male collected	Rocky Escarpment Gorges and Gullies	Likely SRE
Armadillidae	*Buddelundia* `BIS418`	5	GV SRE1, GV SRE2, GV SRE5	Wet Pitfall	Species previously recorded from a troglofauna trap at Glacier Valley 713743m E, 7639979m S.	Rocky Escarpment Gorges and Gullies	Likely SRE
Armadillidae	*Buddelundia* `BIS419`	6	GV S1, GV S3, GV S4	Dry Pitfall	Orange skirt, female	Hills, Ranges, and Plateaux	Unlikely SRE
Myriapoda							
Polyxenida							
Synxenidae	*Phryssonotus novaehollandiae*	3	GV SRE3, GV SRE LL1	Wet Pitfall, Tullgren Funnel	Widespread species	Gorges and Gullies Minor Drainage Lines	Not SRE
Scolopendromorpha							
Scolopendridae	*Cormocephalus aurantiipes*	2	GV SRE4, GV SRE6	Wet Pitfall	Widespread species	Gorges and Gullies Minor Drainage Lines	Not SRE
Scolopendridae	*Scolopendra morsitans*	2	GV SRE2, GV SRE6	Wet Pitfall	Widespread species	Gorges and Gullies	Not SRE

Class/Order & Family	Species/Taxa	No individuals	Site	Trap Type	Details	Habitat Type	SRE status
Scutigeromorpha							
Scutigeridae	Scutigeridae sp.	4	GV SRE2, GV SRE5	Wet Pitfall	-	Gorges and Gullies	Not SRE

4.3.1. SRE Species Recorded

4.3.1.1. Pseudoscorpiones (Pseudoscorpions)

Austrochthonius `BPS291`

Category: Potential SRE

Sub-category: Likely SRE

WAM Sub-category: A, B

Four specimens of *Austrochthonius* `BPS291` were collected from one leaf litter site (Tullgren Funnels) from the Gorges and Gullies habitat type within the Survey Area. Based on the limited number of records, the habitat type where the individuals were found and the lack of further information it has been assessed as likely to be an SRE.

Indolpium `BPS290`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A

A total of 27 specimens of *Indolpium* `BPS290` were recorded from four leaf litter sites (Tullgren Funnels). The sites were spread across three different habitat types: Hills, Ranges and Plateaux, Rocky Escarpment, and Gorges and Gullies which indicates that the species is not limited to particular microhabitats and is unlikely to be an SRE.

4.3.1.2. Scorpiones (Scorpions)

Lychas `BSCO052`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A

One specimen was recorded from a dry pitfall site from Hills, Ranges and Plateaux habitat within the Survey Area. DNA analysis shows a 10.6 % divergence with the referenced sequences which indicates that it represents a new species and retains the new name. Despite this, the species was recorded from a widespread habitat type and most species of *Lychas* appear to have wide distributions (ecologia 2012b), therefore the species is unlikely to be an SRE.

Lychas `BSCO053`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A, D

Two specimens were recorded from one dry pitfall site within Minor Drainage Line habitat. DNA analysis shows an 11.3 % divergence with referenced sequences which indicates that it is a new species. It was recorded from a relatively widespread habitat type that shows a high level of connectivity with similar habitat in the region and is therefore unlikely to be an SRE.

Lychas `BSCO059`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A,D

Two specimens were recorded from one dry pitfall site within Minor Drainage Line habitat. DNA analysis shows an 11.9 % divergence with referenced sequences which indicates that it is a new species. Morphologically it shows similarities to specimens collected from the Raven Project in the Hamersley Ranges (*Lychas* `BSCO054`) (Appendix C). It was recorded from a relatively widespread habitat type that shows a high level of connectivity with similar habitat in the region. The majority of *Lychas* species are widespread and the new species is therefore unlikely to be an SRE.

Lychas `pilbara1`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A, D

Three specimens were collected from three dry pitfall sites across two widespread fauna habitat types (Hills, Ranges and Plateaux, and Minor Drainage Line). The specimens belong to the 'hairy-tail group' and DNA analysis indicates that the species is not conspecific (11.7 % divergent) with specimens of *Lychas* `pilbara 1, (now *Lychas* 'BSCO051`) collected from the Sheila Valley Project in the Hamersley Ranges but is morphologically similar to a specimen from another Hamersley Range specimen of the hairy-tail group which failed to return a sequence (Appendix C). The majority of *Lychas* species are widespread and based on the distance between the record locations (Survey Area and Hamersley Range), the new species is therefore unlikely to be an SRE.

Lychas jonesae

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A, D

Eleven specimens were collected from the two dry pitfall sites and one wet pitfall site across three habitat types, two of which are common (Hills, Ranges and Plateaux, and Minor Drainage Line) and one more restricted habitat (Gorges and Gullies). DNA sequencing indicates that the species is aligned with the WAM's SCO024 (2.1% COI distance) which has been collected at Mulga Downs Station, 129 km SSW from Glacier Valley. Based on the widespread habitat types of the records and the large distance between record locations, the species is unlikely to be an SRE.

Urodacus `BSCO050`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A

Two specimens of *Urodacus* `BSCO050` were collected from one dry pitfall site from a widespread habitat type (Hills, Ranges and Plateaux). The genus *Urodacus* contains some SREs; however, the habitat the specimens were collected was common in the area (mesatop with sparse vegetation) and it is therefore unlikely to be an SRE.

4.3.1.3. Isopoda (Slaters)

Buddelundia `BIS390`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A

A total of 73 specimens of *Buddelundia* `BIS390` were collected from four dry pitfall sites and four wet pitfall sites across all four habitat types present within the Survey Area. It is unlikely to be an SRE.

Buddelundia `BIS416`

Category: Potential SRE

Sub-category: Likely SRE

WAM Sub-category: A, B

A total of 73 specimens of *Buddelundia* `BIS416` were collected from four wet pitfall sites from two restricted habitat types (Rocky Escarpment, and Gorges and Gullies). Despite the species being collected in relatively high density, the limited distribution across the habitat types indicates that the species is likely to be an SRE.

Buddelundia `BIS417`

Category: Potential SRE

Sub-category: Likely SRE

WAM Sub-category: A, B

Three specimens of *Buddelundia* `BIS417` were collected from two wet pitfall sites from two restricted habitat types (Rocky Escarpment, and Gorges and Gullies). The species was previously recorded from a troglofaunal trap (by-catch) at Glacier Valley. The lack of records from widespread and/or exposed habitat types indicates that the species is likely to be an SRE.

Buddelundia `BIS418`

Category: Potential SRE

Sub-category: Likely SRE

WAM Sub-category: A, B

Five specimens of *Buddelundia* `BIS418` were collected from three wet pitfall sites from two restricted habitat types (Rocky Escarpment, and Gorges and Gullies) that provide suitable conditions for SRE species. The lack of records from widespread and/or exposed habitat types indicates that the species is likely to be an SRE.

Buddelundia `BIS419`

Category: Potential SRE

Sub-category: Unlikely SRE

WAM Sub-category: A

Six specimens of *Buddelundia* `BIS419` were collected from three dry pitfall sites from one habitat type (Hills, Ranges and Plateaux). The Hills, Ranges and Plateaux habitat type is widespread, highly connected within the region and supports limited microhabitats suitable for SRE taxa and as such this species is unlikely to be an SRE.

4.3.1.4. Polyxenida

Phryssonotus novaehollandiae

Category: Not SRE

Three specimens of *Phryssonotus novaehollandiae* were recorded from one wet pitfall site and one leaf litter collection (Tullgren Funnel). It is a known widespread species and is not an SRE.

4.3.1.5. Scolopendromorpha

Cormocephalus aurantiipes and *Scolopendra morsitans*

Category: Not SRE

Two specimens of *Cormocephalus aurantiipes* and two specimens of *Scolopendra morsitans* were collected from across three wet pitfall sites. Both species are known to be widespread and are not SREs.

4.3.1.6. Scutigeromorpha

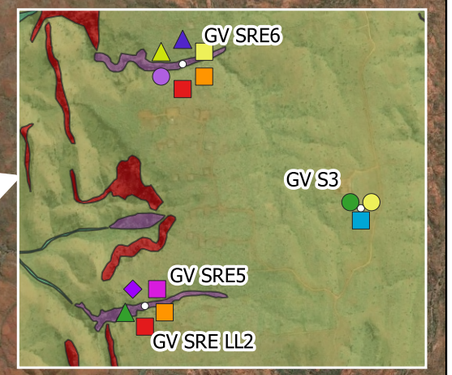
Scutigeridae sp.

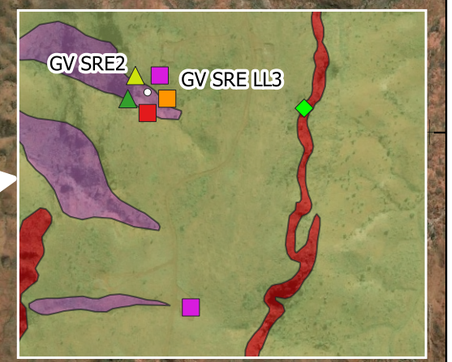
Category: Not SRE

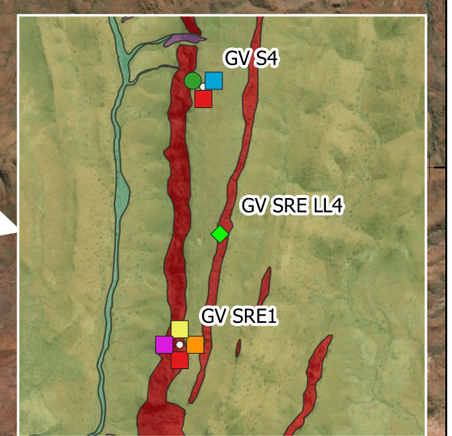
Four specimens were collected from two wet pitfall sites that belong to the family Scutigeridae. The specimens could not be identified to species level; however, this family is not typically limited to certain habitat types and species within it are not regarded as SREs.

708000
711000
714000
717000
720000
7647000
7644000
7641000
7638000

GV SRE4
GV S1
GV S2
GV SRE3
GV SRE LL6
GV SRE LL1
GV SRE6
GV S3
GV SRE5
GV SRE LL2
GV SRE LL3
GV SRE2
GV S4
GV SRE LL4
GV SRE1







Legend

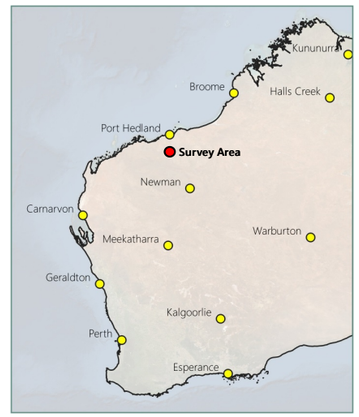
- Survey Area

SRE Species

- Austrochthonius `BPS291`
- Indolpium `BPS290`
- Lychas `BSCO052`
- Lychas `BSCO053`
- Lychas `BSCO059`
- Lychas `pilbara1`
- Lychas jonesae
- Urodacus `BSCO050`
- Buddelundia `BIS390`
- Buddelundia `BIS416`
- Buddelundia `BIS417`
- Buddelundia `BIS418`
- Buddelundia `BIS419`
- Phryssonotus novaehollandiae (Not SRE)
- Cormocephalus aurantiipes (Not SRE)
- Scolopendra morsitans (Not SRE)
- Scutigeridae sp. (Not SRE)

Fauna Habitat Types

- Gorges and Gullies
- Hills, Ranges and Plateaux
- Minor Drainage Line
- Rocky Escarpment



N

0 0.5 1 1.5 km

Scale 1:41,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY

Author: JH Approved: AH Date: 28-06-2021

SRE Fauna Habitats & Species Records

Glacier Valley Project

Prepared for
IB Operations

MAP
4.2

5. DISCUSSION

5.1. Desktop Assessment

The combined data provided by NatureMap, the Western Australian Museum and previous survey reports provide a useful indication of regional SRE invertebrate fauna assemblage. Whilst many species recorded during the desktop assessment have the potential to occur in the Survey Area, the fauna assemblage that typically utilises the habitats found within the Survey Area form a much smaller subset of species. Variations in population distributions and the availability of microhabitats within each area also limit the species that may occur. However, the accumulated data provided by the desktop assessment is invaluable during survey planning to ensure all major fauna assemblages are sampled and any known SRE species that may occur are targeted appropriately.

A total of 45 potential SRE species were identified during the desktop assessment. The number of SRE species identified by the desktop assessment is typically higher than the number recorded during the field survey. Potential SRE species are often associated with restricted habitat types and as such it is unlikely that they will all be present within any one survey area. Another reason for these elevated species counts is the lack of detailed information and/or unique phrase names associated with previously collected specimens. Without a unique name or number, it is difficult to consolidate previous and current data to eliminate duplicate species. It also does not allow for the collation of distributional data and, in turn, the update of a species SRE status. In addition, the use of DNA sequencing is not currently a standard method of SRE surveys, so that sequenced specimens are likely conspecific with specimens collected in the past that were not submitted for DNA sequencing (most likely due to the increased cost, and the fact that it is not a requirement as per the survey guidelines). Future collections and submissions for DNA sequencing to a central database will increase this data pool and likely provide information on the distribution of a species which in turn will decrease the number of species known to be widespread.

5.2. SRE Fauna Habitats

Four broad fauna habitat types were identified within the Glacier Valley Survey Area, all of which contain microhabitats that host species from SRE target groups: Hills, Ranges and Plateaux, Rocky Escarpment, Gorges and Gullies and Minor Drainage Lines. However, habitat connectivity, regional extent, and the presence of relictual mesic habitat characteristics are also major factors influencing the likelihood of geographic speciation, isolation and/or significant contraction of a species' historic range. Land systems, pre-European vegetation and geological mapping can give an indication of how extensive a broad habitat type may be within the region though are of limited use when attempting to determine the presence of microhabitats. In the absence of finer scale datasets and/ or intensive regional habitat mapping, these datasets are the best available option to assess the likelihood of suitable microhabitats occurring in the greater region.

Analysis of the above-mentioned datasets and aerial imagery indicates that both the Hills, Ranges and Plateaux and Minor Drainage Lines habitats are widespread in the greater region and show a high level of connectivity with similar habitat outside the Survey Area (Map 2.1 - Map 2.3). Not only do these two habitat types combined represent 97.6% of the Survey Area, but they are typically exposed to climatic extremes (e.g. extreme heat) and mesic microhabitats are uncommon. The combination of these factors suggests that these habitats, while hosting species from target groups, are unlikely to be suitable for SRE invertebrate fauna. The following eight species found within either or both of these habitats have been determined to fall within the Unlikely SRE sub-category, though in accordance with the Precautionary Principle, still fit within

the greater Potential SRE category due to a lack of distributional data: *Indolpium* `BPS290`, *Lychas* `BSCO052`, *Lychas* `BSCO053`, *Lychas* `BSCO059`, *Lychas jonesae*, *Urodacus* `BSCO050`, *Buddelundia* `BIS390`, *Buddelundia* `BIS419`. Other potential SRE species found in these habitats and identified by the desktop assessment as having a high likelihood of occurrence are the pseudoscorpion *Oratemnus* `PSE018` and the millipede *Antichiropus apricus* (Appendix A).

The Rocky Escarpment and Gorges and Gullies habitat types contain microhabitats with characteristics associated with SRE fauna. Rocky escarpment habitat features deep cracks and crevices, south facing aspects, and scattered deep leaf litter beds that act to trap moisture and create a cool, moist microclimate suited to SRE fauna (Harvey, 2002). Gorges and Gullies can contain all the aforementioned characteristics with the addition of superior protection from extreme temperatures, acting as a sheltered catchment that traps moisture and a barrier to fire that allows the development of complex habitats comprised of collected boulders, rocks, wood and leaf litter. Freshwater springs are also more commonly encountered in this habitat type and, when present, maintain permanently moist conditions. Both the Rocky Escarpment and Gorges and Gullies habitat types are also discontinuous, often separated by expanses of exposed habitat that may not be traversed by SRE taxa with limited dispersal capabilities. Isolation within pockets of discontinuous habitat is a known driver for geographic speciation and may result in SRE species.

Within the Rocky Escarpment and Gorges and Gullies habitat types, four Potential SRE species have been sub-categorised as Likely SRE: *Austrochthonius* 'BPS291`, *Buddelundia* 'BIS416', *Buddelundia* 'BIS417', *Buddelundia* 'BIS418`. Other potential SRE species found in these habitats and identified by the desktop assessment as having a high likelihood of occurrence include the spiders *Aname* sp. indet., *Aurecocrypta* 'MYG318', *Synothele* 'MYG334' and *Karaops* sp. indet.; the pseudoscorpions *Tyrannochthonius* 'sp. nov. near *aridus*', *Feaella tealei*, *Beierolpium* `sp. 8/4 lge` and *Beierolpium* `sp. 8/2`; the scorpion *Lychas* `macleod`; the snails "Gen. nov. cf. `Z` n.sp.", *Rhagada* aff. *richardsonii* and *Stenopylis* cf. *coarctata*; the isopods *Buddelundia* sp. 11, *Buddelundia* sp. 18 and Buddelundiinae Abydos; and the millipedes *Antichiropus forcipatus*, *Antichiropus* `DIP005` and *Antichiropus* sp. (Appendix A).

The Rocky Escarpment and Gorges and Gullies habitat types are primarily associated with the Capricorn Land System within the Survey Area. Glacier Valley represents 2.56% of the land system's total area within the immediate region (50 km) and a large expanse of the land system outside of the Survey Area is well connected with that found within it (Table 2.1, Map 2.1). Though it is unknown if SRE taxa are capable of dispersing between pockets of sheltered habitat during favourable weather conditions, the regional extent of the Capricorn Land System and its connectivity with suitable habitat within the Survey Area suggests that similar habitat is likely to be present outside the Survey Area.

5.3. SRE Fauna Summary

A total of 13 potential SRE species were collected during the survey; six scorpions, two pseudoscorpions, and five isopods (Table 4.3). This assessment recorded a higher number of potential SRE species (13 vs 9) than the nearest previous survey completed adjacent to the Survey Area (ecologia 2012b). This number also represents slightly more than one quarter (13 vs 45) of the potential SRE species identified during the desktop assessment. This discrepancy highlights the typically cryptic nature of SREs and the subsequent difficulty and very low numbers by which they are recorded. Twenty of the 45 potential SRE species identified during the desktop assessment have been determined to have a high likelihood of occurrence within the Survey Area based on the proximity of the records and the associated habitat types (Appendix A).

Following the discussion of the desktop assessment results above, the possibility must also be considered that some of these taxa with different phrase names in fact represent the same species. It is possible that if the collection of specimens at Bennelongia was compared to the WAM collection (or the collections of other private consultants), some individual morphospecies may be found to have multiple phrase names, as comparison between collections and consolidation of data is not often undertaken. Many records also lack unique phrase names and this further limits a consultant's ability to consolidate data without further inspection and comparison of the original specimens. As previously mentioned, this lack of taxonomic resolution is exacerbated by the fact that the WAM collection is not easily accessed, leading to greater inconsistency between reference collections and the few taxonomists able to identify SRE species.

During the current survey, no trapdoor spiders, snails or millipedes were recorded from the Survey Area. This is to be expected when comparing the results with the previous survey at North Star in 2012 (ecologia 2012b) where only one species of each of these groups was recorded. The previous survey was mostly completed in the middle of the wet season of 2011 (February-March) when the rainfall over three months prior to surveying was recorded as 251 mm above long-term average rainfall for the region (ecologia 2012b). The wet season is the ideal survey timing for SRE surveys (as per the EPA guidelines); however, the wet season is often associated with unpredictable heavy rainfall events and cyclones which can result in insignificant access restrictions so that surveys are often undertaken post wet season to reduce access and safety limitations. This can in some cases reduce the number of species or target groups recorded because these species groups are aestivating as soon as conditions dry up (in particular snails and millipedes). The total rainfall for the five months prior to the current field survey was 432 mm (January to May) which exceeds the annual long-term average of 392.7 mm recorded from Marble Bar for this period, therefore survey adequacy has not been compromised as such.

So far as can be ascertained from the available information, none of the species recorded during the current survey have been recorded during previous surveys in the region.

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Appendix A: Regional SRE Invertebrate Fauna List

SRE Invertebrate Fauna Recorded from the Region

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
ARACHNIDA								
Mygalomorphae								
Anamidae	*Aname* `MYG371`	26 km SE	Medium Similar minor drainage line habitat occurs within the Survey Area.	Minor Drainage Lines	X			
Anamidae	*Aname* `MYG372`	28 km NW	Medium Similar minor drainage line habitat occurs within the Survey Area.	Minor Drainage Lines	X			
Anamidae	*Aname* `MYG660`	28 km S	Low Saline flats habitat does not occur within the Survey Area.	-	X			
Anamidae	*Aname* `MYG662`	28 km S	Low Saline flats habitat does not occur within the Survey Area.	-	X			
Anamidae	*Aname* `MYG663`	28 km S	Low Saline flats habitat does not occur within the Survey Area.	-	X			
Anamidae	*Aname* sp. indet	5 km N	High Rocky hills habitat present within the Survey Area and is contiguous with that at record location.	Hills, Ranges, and Plateaux; Rocky Escarpments		X		
Anamidae	*Aname* `sp. (female; *armigera* group)`	28 km S	Low Saline flats habitat does not occur within the Survey Area.	-	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Anamidae	*Aname* `sp. 1`	28 km S 918 km E	**Low** Saline flats habitat does not occur within the Survey Area. The single record from dune swale habitat 918 km east is likely a duplication of the phrase name *Aname* 'sp. 1' and not the same morphospecies.	-	X			
Anamidae	*Kwonkan* `MYG200`	31 km SE	**Medium** Similar rocky hills habitat occurs in the Survey Area though does not appear contiguous between Survey Area and record location.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			
Barychelidae	*Aurecocrypta* `MYG318`	14 km N	**High** Rocky gully habitat is contiguous with that found within the Survey Area.	Gorges and Gullies	X			
Barychelidae	*Synothele* `MYG334`	16 km N	**High** Rocky gully habitat is contiguous with that found within the Survey Area.	Gorges and Gullies	X			
Araneomorphae								
Selenopidae	*Karaops kariyarra*	14 km W	**Low** Granite outcrop habitat does not occur within the Survey Area.	-	X			
Selenopidae	*Karaops nyamal*	28 km SE	**Medium** Record from rocky ridge and gully habitat though not contiguous with similar habitat found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies	X			
Selenopidae	*Karaops* `aurizon`	27 km W	**Medium** Similar rocky slope habitat occurs in the Survey Area though does not appear contiguous between Survey Area and record location.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Selenopidae	*Karaops* sp. indet	2 km N	**High** Rocky gully habitat present within the Survey Area and is contiguous with that at record location.	Gorges and Gullies		X		
Opiliones								
Assamiidae	*Dampetrus* `aurizon`	27 km W	**Low** Granite outcrop habitat not present within the Survey Area.	-	X			
Pseudoscorpiones								
Atemnidae	*Oratemnus* `PSE018`	<1 km S	**High** Minor drainage line habitat similar to that at record location occurs within the Survey Area.	Minor Drainage Lines	X			
Atemnidae	*Oratemnus* `PSE060`	28 km NW	**Low** Granite outcrop habitat not present within Survey Area.	-	X			
Chthoniidae	*Austrochthonius* `BPS291`	-	**Recorded**	-				X
Chthoniidae	*Tyrannochthonius* `sp. nov. near *aridus*`	10 km N	**High** Gorge and gully habitat at record location contiguous with habitat within the Survey Area.	Gorges and Gullies	X			
Feaellidae	*Feaella tealei*	9 km S	**High** Minor drainage line and rocky gully habitat at record location contiguous with habitat within the Survey Area.	Gorges and Gullies; Minor Drainage Lines	X			
Garypidae	*Synsphyronus* `PSE008`	23 km W	**Low** Granite outcrop habitat not present within the Survey Area.	-	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Garypidae	*Synsphyronus* `PSE012`	17 km SW	**Medium** Similar rocky hills habitat present within the Survey Area though not contiguous with that at record location.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			
Olpiidae	`Genus 7/4` `sp. 7/4A`	28 km SE	**Medium** Similar rocky ridge, gorge and gully habitat at record locations present though not contiguous with that found in the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies	X			
Olpiidae	*Beierolpium* `sp. 8/4 lge`	<1 km N	**High** Rocky slope and drainage line habitat at record location contiguous with that within Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies		X		
Olpiidae	*Beierolpium* `sp. 8/2`	2 km N	**High** Rocky gully habitat on ridge contiguous with that within the Survey Area.	Gorges and Gullies		X		
Olpiidae	*Indolpium* `BPS290`	-	**Recorded**	-				X
Scorpiones								
Buthidae	*Lychas* `BSCO052`	-	**Recorded**	-				X
Buthidae	*Lychas* `BSCO053`	-	**Recorded**	-				X
Buthidae	*Lychas* `BSCO059`	-	**Recorded**	-				X
Buthidae	*Lychas jonesae*	-	**Recorded**	-				X
Buthidae	*Lychas* `macleod`	14 km N	**High** Rocky ridge habitat at record location contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			
Buthidae	`Hope Downs gen. 2` `Hope Downs sp. 1`	16 km W	**Low** Granite outcrop habitat not found within the Survey Area.	-	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Buthidae	*Lychas* sp. indet	19 km W	**Low** Granite outcrop habitat not found within the Survey Area.	-		X		
Urodacidae	*Urodacus* `BSCO050`	-	**Recorded**	-				X
Urodacidae	*Urodacus* `pilbara 2`	28 km NW	**Low** Minor drainage line on sandy flats habitat not found within the Survey Area.	-	X			
GASTROPODA								
Camaenidae	Gen. nov. cf. `Z` n.sp.	16 km N	**High** Rocky ridge and minor drainage line habitat at record locations contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies; Minor Drainage Lines	X			
Camaenidae	*Quistrachia* cf. *turneri*	15 km SW	**Low** Granite outcrop habitat not found within the Survey Area.	-	X			
Camaenidae	*Quistrachia turneri*	15 km SW	**Medium** Rocky ridge habitat at record location similar to that found within the Survey Area though not contiguous.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Camaenidae	*Rhagada* aff. *richardsonii*	17 km N	High Rocky ridge and minor drainage line habitat at record locations contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Minor Drainage Lines	X			
Helicodiscidae	*Stenopylis* cf. *coarctata*	16 km N	High Rocky ridge and minor drainage line habitat at record locations contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Minor Drainage Lines	X			
Succineidae	*Succinea* sp.	19 km W	Low Granite outcrop and major drainage line habitat not found within the Survey Area.	-		X		
ISOPODA								
Armadillidae	*Buddelundia* `BIS390`	-	Recorded	-				X
Armadillidae	*Buddelundia* `BIS416`	-	Recorded	-				X
Armadillidae	*Buddelundia* `BIS417`	-	Recorded	-				X
Armadillidae	*Buddelundia* `BIS418`	-	Recorded	-				X
Armadillidae	*Buddelundia* `BIS419`	-	Recorded	-				X
Armadillidae	*Buddelundia* sp. 11	<1 km N	High Rocky gully habitat at record location contiguous with that found within the Survey Area.	Gorges and Gullies		X		
Armadillidae	*Buddelundia* sp. 18	<1 km N	High Rocky gully habitat at record location contiguous with that found within the Survey Area.	Gorges and Gullies		X		

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Armadillidae	*Buddelundia* sp. nov	45 km NE	**Low** Plain, open mature Woodland similar to that found within the Survey area though not contiguous and 45 km NE of Survey Area. Species potentially the same as one of the above species.	-			X	
Armadillidae	Buddelundiinae abydos	12 km N	**High** Ridge, minor drainage, gully, and gorge habitat at record locations contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies; Minor Drainage Lines	X			
Armadillidae	Buddelundiinae mw	29 km SE	**Medium** Rocky ridge habitat at record location similar to that found within the Survey area though not contiguous.	Hills, Ranges, and Plateaux; Rocky Escarpments	X			
Armadillidae	*Spherillo* wodgina	25 km NW	**Low** Sandy drainage line and granite outcrop habitat not found within the Survey Area.	-	X			
MYRIAPODA								
Polydesmida								
Paradoxosomatidae	*Antichiropus apricus*	22 km NE	**High** Minor drainage line habitat at record location contiguous with that found within the Survey Area.	Minor Drainage Lines	X			
Paradoxosomatidae	*Antichiropus forcipatus*	10 km N	**High** Minor drainage line, gully and gorge habitat at record locations contiguous with that found within the Survey Area.	Gorges and Gullies; Minor Drainage Lines	X			

Class/ Order/ Family	Species	Distance and Direction from Survey Area	Likelihood of Occurrence	GV Habitat Types Potentially Suitable for Species	WAM	North Star SRE (ecologia 2012b)	Canning Basin (ecologia 2012a)*	Current Survey
Paradoxosomatidae	*Antichiropus* `DIP005`	14 km N	High Minor drainage line, gully and ridge habitat at record locations contiguous with that found within the Survey Area.	Hills, Ranges, and Plateaux; Rocky Escarpments; Gorges and Gullies; Minor Drainage Lines	X			
Paradoxosomatidae	*Antichiropus* sp.	2 km N	High Rocky gully habitat at record location contiguous with that found within the Survey Area.	Gorges and Gullies		X		

*only the three most southern sites were considered due to distance of remaining sites (>50 km) from the Survey Area.

Appendix B: Survey Site Locations

All SRE Invertebrate Survey Site Locations at GV

Site Name	Survey	Survey Site Type	Coordinates (GDA94 Z50)	
			Easting	Northing
GV PH1 OP1	Ph 1	Opportunistic Site	713904.2602	7640274.444
GV PH1 OP2	Ph 1	Opportunistic Site	713760.3884	7639601.203
GV PH1 OP3	Ph 1	Opportunistic Site	710437.7256	7644037.246
GV PH1 OP4	Ph 1	Opportunistic Site	708640.125	7644132.434
GV PH1 OP5	Ph 1	Opportunistic Site	713515.6478	7638867.401
GV SRE LL1	Ph 1	Leaf Litter Collection	713308.815	7645197.558
GV SRE LL2	Ph 1	Leaf Litter Collection	713255.4309	7643860.681
GV SRE LL3	Ph 1	Leaf Litter Collection	713913.963	7640306.035
GV SRE LL4	Ph 1	Leaf Litter Collection	713530.5708	7638417.977
GV SRE LL5	Ph 1	Leaf Litter Collection	710800.4196	7644436.35
GV SRE LL6	Ph 1	Leaf Litter Collection	709524.5082	7643669.664
GV SRE1	Ph 1	SRE Wet Pitfall Site	713399.3317	7638057.18
GV SRE2	Ph 1	SRE Wet Pitfall Site	713672.2574	7640329.052
GV SRE3	Ph 1	SRE Wet Pitfall Site	709426.29	7643765.919
GV SRE4	Ph 1	SRE Wet Pitfall Site	708305.6131	7645907.218
GV SRE5	Ph 1	SRE Wet Pitfall Site	713311.5525	7643889.391
GV SRE6	Ph 1	SRE Wet Pitfall Site	713423.2241	7644671.35
GV S1	Ph 1/ 2	Fauna Trapping Site	708753.8606	7644962.96
GV S2	Ph 1/ 2	Fauna Trapping Site	710896.9645	7644661.405
GV S3	Ph 1/ 2	Fauna Trapping Site	714004.2002	7644201.783
GV S4	Ph 1/ 2	Fauna Trapping Site	713476.1874	7638898.491
GV PH2 OP1	Ph 2	Opportunistic Site	711893.1016	7645152.804
GV PH2 OP2	Ph 2	Opportunistic Site	712164.3886	7645731.213
GV PH2 OP3	Ph 2	Opportunistic Site	711694.7793	7645366.041
GV PH2 OP4	Ph 2	Opportunistic Site	709597.4872	7645659.368
GV PH2 OP5	Ph 2	Opportunistic Site	709471.4115	7644895.911
GV PH2 OP6	Ph 2	Opportunistic Site	709620.3739	7645076.749
GV PH2 OP7	Ph 2	Opportunistic Site	711088.5356	7643671.386
GV PH2 OP8	Ph 2	Opportunistic Site	711472.3106	7644333.025
GV PH2 OP9	Ph 2	Opportunistic Site	713411.8552	7644890.165
GV PH2 OP10	Ph 2	Opportunistic Site	713334.4103	7643795.614

Appendix C: Bennelongia's DNA Analysis Report

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Review: Huon Clark
11th December 2020

Glacier Valley Short-range Endemic Genetics Results

This memo presents data from genetics work carried out on SRE species collected from the Glacier Valley Project, in the Pilbara region of WA. Bennelongia Environmental Consultants (BEC) were commissioned to identify SRE specimens collected during surveys. Morphological identifications were conducted, and molecular barcoding analyses were performed to support and confirm the morphological identifications in 47 specimens belonging to SRE Groups.

Depending on the size of the specimens, legs or whole animals were used for DNA extractions using a Qiagen DNeasy Blood & Tissue kit (Qiagen 2006). Elute volumes varied from 40 µL to 200 µL depending on the quantity of material.

Primers combinations used for PCR amplifications were: (1) LCO1490:HCO2198 and LCO1490:HCOoutout for the MT-CO1 gene (Folmer *et al.* 1994; Schwendinger and Giribet 2005); (2) 12Sai:12RJ and 12Sai:12Sbi for the 12S gene (Kambhampati and Smith 1995; Simon *et al.* 1994); and (3) Cybj10612:Cybj_id_rl for the MT-CYB gene (Rix *et al.* 2017). Next, dual-direction, sanger sequencing was undertaken for PCR products by the Australian Genome Research Facility (AGRF). Sequences returned were aligned in Geneious (Kearse *et al.* 2012) and neighbour-joining phylogenetic trees were estimated using 1000 bootstraps. Genetic distances (using the Tamura-Nei method) between sequences were measured as uncorrected p-distances (total percentage of nucleotide differences between sequences). Sequences on GenBank and in the grey literature were included in phylogenetic analysis to provide a framework for assessing intra- and interspecific variation, as well as to document the levels of intra-specific differentiation in described species across their geographic ranges.

The results of the genetical analysis are presented below.

Scorpions

Buthidae: Lychas (4 species)

The genus *Lychas* is one of the five genera of Buthidae that occur in Australia, and currently contains five valid species in Australia (*L. buchari, L. jonesae, L. marmoreus, L. mjobergi, L. variatus*). Unfortunately, however, the majority of *Lychas* species in Western Australia are yet to be described (Volschenk *et al.* 2010), and some recognised groups, such as "hairy tail group" and "pilbara 1" probably represent species complexes. We sequenced twelve specimens of *Lychas* from the groups recognized morphologically, choosing one representative of each morphospecies from each project. The Raven specimen from site RV S6 failed to return a sequence, probably because the specimen was poorly preserved (the sample contained water and had a strong smell). The results for the other 11 specimens are described below:

- The Glacier Valley specimens originally identified as the new species *Lychas* '**BSCO052'** and *Lychas* '**BSCO053'** were not aligned with anything else, and retained the new names.
- The two Glacier Valley specimens identified as *Lychas* '**BSCO059**' (one of them being a tiny juvenile) were confirmed to be conspecifics (at 0.9% divergence; Figure 4), and divergent at least 11.9% to all other species (Table 3).
- The two specimens originally identified as *Lychas* **'pilbara 1'** (one from Glacier Valley, one from Sheila Valley) were 11.7% divergent in COI (Table 3), and therefore not conspecifics. The specimens from Sheila Valley were hence renamed *Lychas* **'BSCO051'**. The Raven specimen of *Lychas* **'pilbara 1'** failed to return a sequence, but a reassessment of its morphology suggests that it is consistent with the Glacier Valley specimens under the same name.
- The three specimens identified to *Lychas jonesae* were at least not conspecifics (Figure 4), and each of them belongs to a different genetic clade. The individual from Sheila Valley ('Scorp2', site SVS08, dry pitfall, 30/03/30; 46_C25 in Figure 4) aligned genetically (2.5% to 3.4% COI divergence; Table 3) with the species *Lychas* **BSCO040**, previously collected at Western Ridge, 238 km SE from Sheila Valley. The individual from Raven (site RVJVOP8, hand foraging, 17/03/20; 46_C17 in Figure 4) aligned genetically (0.3% to 5.3% COI divergence; Table 3) with the species *Lychas* **BSCO058**, previously collected at Coombanbunna and West Angelas, 264 km and 180 km SE and from Raven, respectively. Finally, the individual from Glacier Valley (site GV S1, dry pitfall, 21/05/20; 46_C49 in Figure 4) aligned genetically (2.1% COI divergence; Table 3) with *Lychas* '**SCO024**', previously collected at Mulga Downs Station, 129 Km SSW from Glacier Valley.

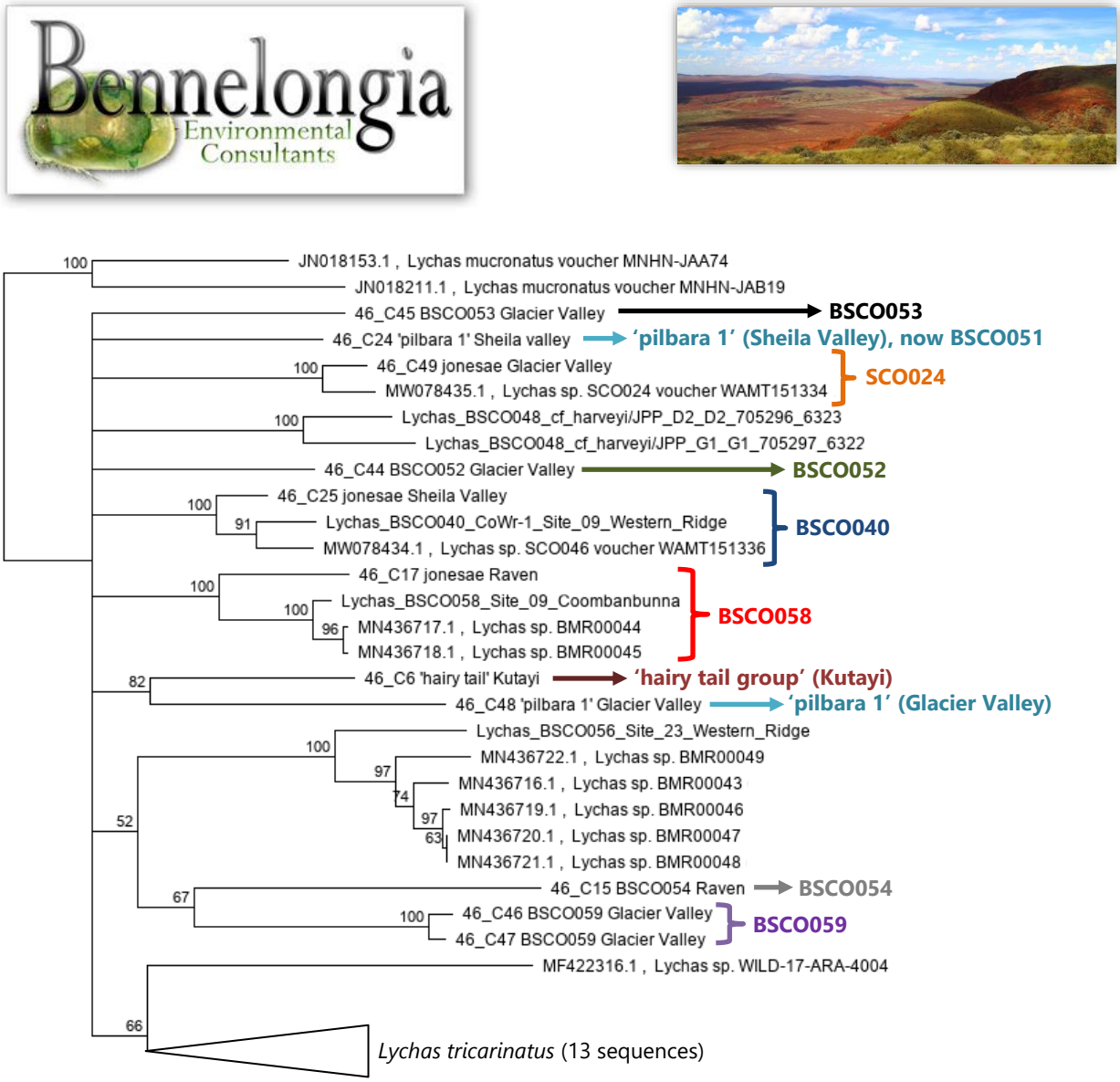

Figure 4: Neighbour-joining tree of species of *Lychas* included in the analysis.

Table 3: Intra (bold) and interspecific genetic divergences (% different base pairs) in sequences of mt-CO1 from species of *Lychas* included in the analysis presented here.

	mucronatus	tricarinatus	MF422316	C6 HTG	BSCO056	C48 PB1	BSCO054	BSCO053	BSCO048	C49 jonesae	BSCO058	C24 PB1	BSCO059	BSCO052	BSCO040
L. mucronatus	**9**														
L. tricarinatus	15.4 - 17.9	**0 - 8.7**													
MF422316.1 (WILD-17-ARA-4004)	15.2 - 16.7	14.4 - 15.8	-												
C6 'hairy tail group' Kutayi	13.5 - 14.4	14.2 - 15.8	14.9	-											
L. BSCO056 and MN436716,19,20,21,22	14.9 - 16.8	14.2 - 16.3	16 - 16.8	13.3 - 13.8	**0 - 6.2**										
C48 'pilbara 1 Glacier Valley	14.5 - 16	16.3 - 17.4	17.4	9.9	14.9 - 16.8	-									
C45 BSCO053 Glacier Valley	12.6 - 14.7	13.8 - 14.5	16.8	11.3	12.6 - 12.9	13.1	15.1	-							
Lychas 'BSCO048'	14.7 - 16.3	14.5 - 16.7	14.2 - 16	12.1	13.7 - 15.8	13.7 - 14	14.7 - 15.1	13.8 - 14.4	**4.3**						
C49 jonesae Glacier Valley; SCO024	13.8 - 17.4	13.5 - 14.9	14.2 - 14.9	11.3 - 11.7	12.8 - 14.9	13.3 - 13.3	15.4 - 15.6	11.2 - 11.7	12.2 - 13.1	**2.1**					
C17 jonesae Raven, BSCO058, MN436717,18	14.7 - 16	14.5 - 15.9	14 - 15.4	11.2 - 11.9	12 - 13.8	12.1 - 12.4	13.1 - 14.3	10.6 - 11.5	11.2 - 12.6	10.6 - 11.7	**0.3 - 5.3**				
C24 'pilbara 1' Sheila Valley (now BSCO051)	13.1 - 15.8	13.8 - 15.4	15.8	10.3	11.7 - 12.9	11.7	14.2	10.1	11.9 - 12.8	12.2 - 12.2	11.3 - 11.7	-			
C46 and C47 BSCO059 Glacier Valley	14.9 - 16.3	14.2 - 16.1	17.6	12.1 - 12.2	11.7 - 12.6	13.7 - 13.8	11.9 - 12.1	12.8 - 13.3	12.8 - 13.5	12.6 - 13.1	11.5 - 12.4	13.8 - 14	**0.9**		
C44 BSCO052 Glacier Valley	14 - 15.6	13.5 - 15.1	13.7	11	11.9 - 13.3	12.8	13.3	11.3	10.8 - 12.1	12.4 - 13.1	10.6 - 11	11.2	12.4 - 12.6	-	
C25 jonesae Sheila Valley, BSCO040, MW078434	13.3 - 14.5	11.7 - 13.7	13.7 - 14.2	11.2 - 11.9	11.3 - 13.3	12.4 - 14.2	12.8 - 14.7	11 - 11.7	11.2 - 12.8	10.5 - 12.8	9.8 - 12.1	8.5 - 10.3	9.8 - 11.3	8.5 - 9.6	**2.5 - 3.4**

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