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**FORTESCUE METALS GROUP LTD
NORTH STAR PROJECT
SHORT-RANGE ENDEMIC INVERTEBRATE SURVEY**

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ACRONYMS

List all acronyms used in the report here. Format alphabetically as follows:

ACE	Abundance-based Coverage Estimator
DEC	Department of Environment and Conservation
ECU	Edith Cowan University
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EP Act	<i>Environmental Protection Act 1986</i>
EPBC	<i>Environment Protection and Biodiversity Conservation Act 1950</i>
IBRA	Interim Biogeographic Regionalisation for Australia
NVIS	National Vegetation Information System
SAC	Species Accumulation Curve
SRE	Short-Range Endemic
WAM	Western Australian Museum
WC Act	<i>Wildlife Conservation Act 1950</i>

EXECUTIVE SUMMARY

Fortescue Metals Group Limited (Fortescue) is developing the Pilbara Iron Ore and Infrastructure Project, which involves a series of iron ore mines in the Pilbara region of Western Australia, and associated rail and port infrastructure.

Fortescue intends to expand its current operations to include the development of the North Star Project Area, approximately 100 km south of Port Headland and 25 km east of Fortescue's PH – CC Rail line.

As part of the environmental approvals processes for Fortescue's North Star Project, baseline Short-Range Endemic invertebrate surveys of the proposed Project Area as well as additional reference/non-impact areas were required to assess potential impacts and identify appropriate management strategies.

Baseline SRE invertebrate fauna surveys were undertaken between February and March 2011 and July and August 2011 for the North Star Project Areas and Lalla Rookh reference/non-impact area. Survey methods consisted of wet-pitfall trapping, foraging and leaf-litter collection within different habitat types present across all the Project Areas.

The main conclusions of the survey were:

- A total of 38 conservation significant species were found during the NatureMap database search of the nearby areas. None were recorded during the survey;
- The survey methods were consistent with the EPA Guidance Statement 20 to sample for SRE fauna;
- Species estimators found the survey was adequate with an estimated 76% of predicted SRE species collected during the survey;
- A total of 45 species were collected, of which 10 species were considered to represent potential or unknown SRE species;
- The isopod *Buddelundia* sp. 11 was recorded from the Lalla Rookh reference/non-impact area where it will not be impacted by the Project;
- All other potential and/or unknown SREs were located inside the Project Area where they may be impacted by the Project;
- None of the SRE habitats from which the potential and/or unknown SRE species were located are unique to the Project Areas;
- All vegetation associations, that SREs were located within, extend beyond the Project boundary; and,
- On the scale of impact ranging from high - moderate - low, the impact from the Project development on the potential and/or unknown SRE species is expected to be moderate to low.

1 INTRODUCTION

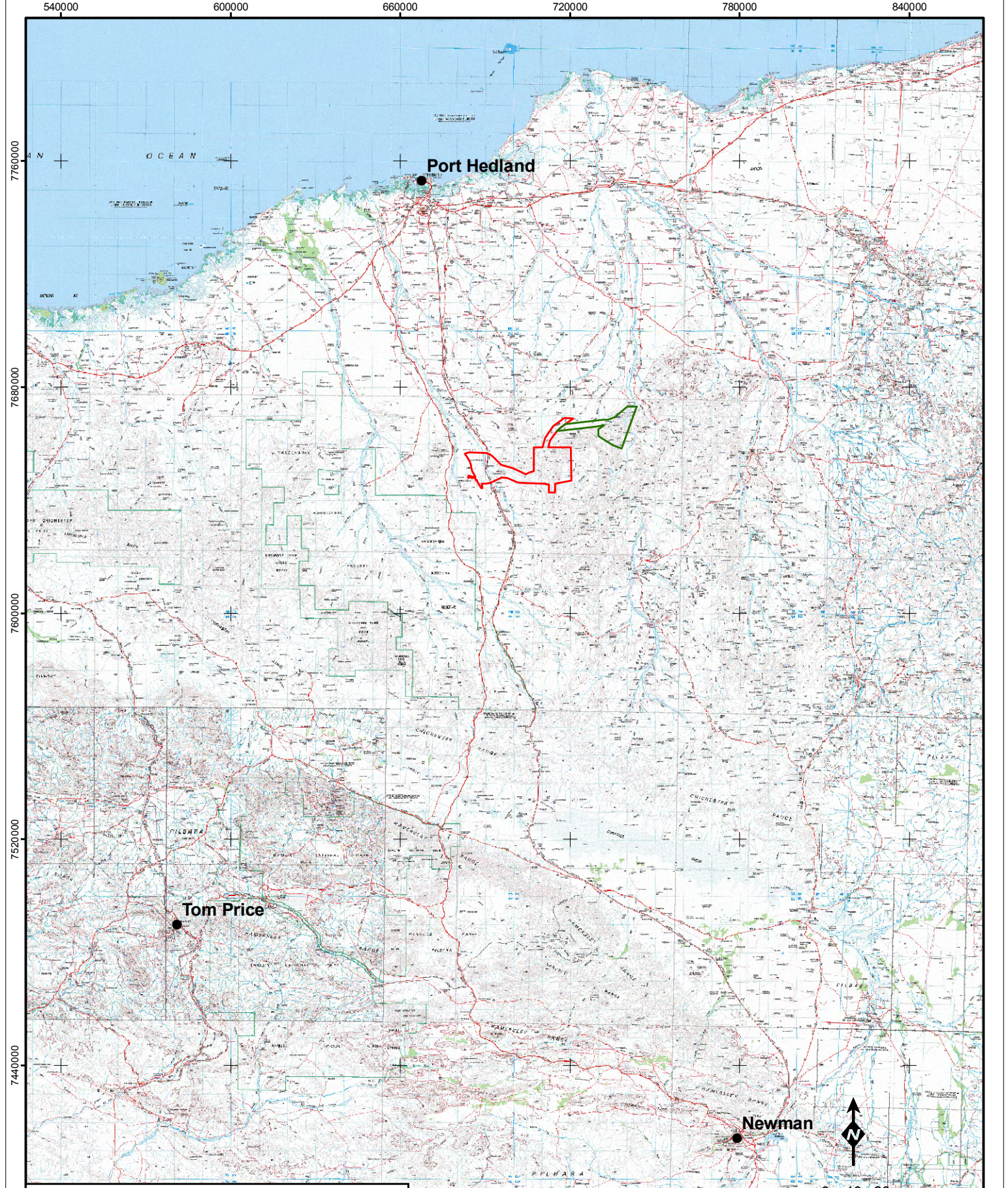
1.1 PROJECT OVERVIEW

Fortescue Metals Group Limited (Fortescue) is developing the Pilbara Iron Ore and Infrastructure Project, which involves a series of iron ore mines in the Pilbara region of Western Australia, and associated rail and port infrastructure.

Fortescue intends to expand its current operations to include the development of a proposed mine site, North Star, approximately 100 km south of Port Headland and 25 km east of the Fortescue Rail Line together with support infrastructure such as access road, accommodation, offices, stockpiles and waste dumps. The Project Area is divided into three areas (Survey Area) (Figure 1.1):

1. North Star Mine Area and Infrastructure Corridor;
2. North Star Additional Mine areas; and
3. Lalla Rookh reference/non impact area.

As part of the environmental approvals process for the North Star Project, baseline Short-Range Endemic (SRE) invertebrate fauna surveys of the proposed Survey Area were required.



Legend

- Lalla Rookh Reference/non-impact area
- North Star Project Area

0 10 20
Kilometres
Absolute Scale - 1:1,745,700



North Star Project Location

Figure: 1.1
Project ID: 1374,
1323

Drawn: NT
Date: 13/10/2011

Unique Map ID: NT036
A4

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

1.2 LEGISLATIVE FRAMEWORK

Federal and State legislation applicable to the conservation of native fauna include, but are not limited to, the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, the *Wildlife Conservation (WC) Act 1950*, and the *Environmental Protection (EP) Act 1986*. Section 4a of the EP Act 1986 requires that developments take into account the following principles applicable to native fauna:

- The Precautionary Principle

Where there are threats of serious or irreversible damage, a lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

- The Principles of Intergenerational Equity

The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations.

- The Principle of the Conservation of Biological Diversity and Ecological Integrity

Conservation of biological diversity and ecological integrity should be a fundamental consideration.

This document includes background information on the project, a literature review of the SRE fauna of Hamersley subregion; particularly in reference to the habitats and environments of the project. The conservation significance of fauna in Western Australia is also outlined.

The document was constructed with a view to satisfy the requirements of:

- The EPA Guidance Statement No. 20: *Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009); and,
- The EPA Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004).

Some better-known SRE species have been listed as threatened or endangered under State or Commonwealth legislation in the WC Act and/or EPBC Act, but the majority have not. Often the lack of knowledge about these species precludes their consideration for listing as threatened or endangered. Listing under legislation should therefore not be the only conservation consideration in environmental impact assessment.

The State is committed to the principles and objectives for the protection of biodiversity as outlined in The National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth Government 1996). The EPA expects that environmental impact assessment will consider impacts on conservation of SRE species (EPA 2004).

1.3 SURVEY OBJECTIVES

The EPA's objectives with regards to the management of SRE invertebrate fauna is to:

- Maintain the abundance, diversity, geographic distribution and productivity of SRE fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge; and
- Protect specially protected (Threatened) fauna, consistent with the provisioning of the WC Act.

Thus, the primary objective of the biological survey is to provide sufficient information to assess the impact of the development on the invertebrate fauna of the Project Area, thereby ensuring that the EPA objectives will be upheld.

Specifically, this survey was carried out to satisfy the requirements of the EPA's Guidance Statement 20 and 56, thus providing:

- A review of background information (including literature and database searches);
- An inventory of invertebrate fauna species occurring in the Project Area, incorporating recent published and unpublished records;
- An inventory of species of biological and conservation significance recorded or likely to occur within the Project Area and surrounds;
- An assessment of likely habitats that may potentially support SREs based on vegetation mapping data as well as bioregion and land system information; and
- An assessment to determine likely impacts of threatening processes on SRE habitats within the Project Area.

1.4 SHORT-RANGE ENDEMIC FAUNA: A REVIEW

The decline in biodiversity of terrestrial communities has already been observed both nationally and state-wide (CALM 2004). There is also an increasing shift in environmental protection from species based conservation to biodiversity based conservation (Chessman 1995; Burbidge *et al.* 2000; McKenzie *et al.* 2000) and one of the important considerations involved in this is the presence of endemic species.

Endemism refers to the restriction of species to a particular area, whether it is at the continental, national or local level (Allen *et al.* 2002). SREs are defined as '*terrestrial and freshwater invertebrates that have naturally small distributions of less than 10, 000 km²*' (EPA 2009). This review focuses on SREs, outlines the major paths to Short-Range Endemism, the current knowledge of Short-Range Endemism in Australia and the conservation significance of such species. It is important to note that the individual taxa and broader groups discussed are not an exhaustive list of all SREs. This is due to the fact that SRE are dominated by invertebrate species, which are historically understudied and in many cases lack formal descriptions. An extensive, reliable taxonomic evaluation of these species has begun only relatively recently and thus the availability of literature relevant to SREs is relatively scarce.

1.4.1 Processes Promoting Short-Range Endemism

Short-Range Endemism is influenced by numerous processes, which generally contribute to the isolation of a species. A number of factors, including the ability and opportunity to disperse, life history, physiology, habitat requirements, habitat availability, biotic and abiotic interactions, and historical conditions, influence not only the distribution of a taxon, but also the tendency for differentiation and speciation (Ponder and Colgan 2002).

Isolated populations of plants and animals tend to differentiate both morphologically and genetically as they are influenced by different selective pressures over time. Additionally, a combination of novel mutations and genetic drift promote the accumulation of genetic differences between isolated populations. Conversely, the maintenance of genetic similarity is promoted by a lack of isolation

through migration between the populations, repeated mutation and balancing selection (Wright 1943). The level of differentiation and speciation between populations is determined by the relative magnitude of these factors, with the extent of migration generally being the strongest determinant. Migration is hindered by the poor dispersal ability of the taxon as well as geographical barriers to impede dispersal. In summary, those taxa that exhibit Short-Range Endemism are generally characterised by poor dispersal, low growth rates, low fecundity and reliance on habitat types that are discontinuous (Harvey 2002).

The historical connections between habitats are also important in determining species distributions and often explain patterns that are otherwise inexplicable by current conditions. Many SREs are considered to be relictual taxa (remnants of species that have become extinct elsewhere) and are confined to certain habitats, and in some cases, single geographic areas (Main 1996). Relictual taxa include extremely old species that can be traced back to the Gondwanan periods (180-65 million years ago) and have a very restrictive biology (Harvey 2002).

In Western Australia, relictual taxa generally occur in fragmented populations, from lineages reaching back to historically wetter periods. For example, during the Miocene period (from 25 million to 13 million years ago), the aridification of Australia resulted in the contraction of many areas of moist habitat and the fragmentation of populations of fauna occurring in these areas (Hill 1994). With the onset of progressively dryer and more seasonal climatic conditions since this time, suitable habitats have become increasingly fragmented. Relictual species now generally persist in habitats characterised by permanent moisture and shade, maintained by high rainfall and/or prevalence of fog. This may be induced by topography or coastal proximity, or areas associated with freshwater courses (e.g. swamps or swampy headwaters of river systems), caves or microhabitats associated with southern slopes of hills and ranges, rocky outcrops, deep litter beds or various combinations of these features (Main 1996; 1999). As a result, these habitats support only small, spatially isolated populations, which are further restricted by their low dispersal powers typical for all SRE species.

1.4.2 Taxonomic Groups Likely to Support Short-Range Endemism

There are currently at least five orders of invertebrate fauna that are known to contain SRE species including the arachnids, myriapods, molluscs, worms and isopods. These are discussed in the following sections.

1.4.2.1 Arachnids (Phylum: Arthropoda, Sub Class: Arachnida)

Four orders of arachnids can exhibit Short-Range Endemism: Pseudoscorpiones (false scorpions), Scorpiones (true scorpions), Schizomida (short-tailed whip spiders) and Araneae (i.e. Infraorder: Mygalomorphae or trap-door spiders). Many mygalomorph trap-door spider species are vulnerable to disturbance and exhibit Short-Range Endemism due to their limited ability to disperse. These spiders also have extreme longevity and the long-term persistence of females in a single burrow (Raven 1982). Mygalomorph spiders are largely considered 'old world' spiders and, as such, are generally adapted to past climatic regimes making them vulnerable to desiccation in arid environments. They use a variety of behavioural techniques to avoid desiccation, the most obvious of which is their burrow, which may reach up to 70 cm in depth (Main 1982). Mygalomorph groups are thus capable of surviving on the periphery of the great central desert region and minor habitats within the general arid regions of the continent. Many mygalomorph spider species are known from the Pilbara region with representatives of the families Nemesiidae, Barychelidae, Actinopidae, Idiopidae, Dipluridae and

Ctenizidae and over 20 potential SRE mygalomorph species known from nearby locations to the Project Area.

Another member of the arachnid class, the Schizomida, is comprised entirely of SREs, with most recorded from single localities (Harvey 2002). Forty-six schizomid species have been described in northern Australia. Most are known to occur in the entrances to and inside caves, while the remainder occur in nearby habitats (Harvey 2002). No epigeal schizomids are known from the Pilbara region (Harvey *et al.* 2008).

Scorpions and pseudoscorpions also exhibit high degrees of endemism (Koch 1981; Harvey 1996). Scorpions are popularly thought of as desert animals although they can be found in most of Australia's climatic zones. Several SRE scorpions and pseudoscorpions are known from the Pilbara region including species from the scorpion genera *Lychas* and *Urodacus* and the pseudoscorpion species *Synsphyronus gracilis*.

1.4.2.2 Myriapods (Phylum Arthropoda, Class Myriapoda)

Despite millipedes being highly abundant in soil and leaf litter and highly diverse at the order level, they are inadequately studied and relatively little is known of their biogeography (Harvey 2002). SRE millipedes known to occur in the Pilbara include species from the genus *Antichiropus*. All species from this genus are known to be Short-Range Endemics with the exception of two species *Antichiropus variabilis* and *Antichiropus 'PM1'*, from the jarrah forests and northern Wheatbelt respectively. This genus extends from the Nullarbor Plain to the Pilbara region and has been collected close to the Project Area.

Centipedes are not listed by Harvey (2002) as SRE species; however they have been shown to be endemic to small areas on the east coast (Edgecombe *et al.* 2002). Examination of the distributions of species featured in the CSIRO centipede webpage also reveals disjunct and isolated occurrences of many species. A number of genera have Pangaeal and Gondwanan affinities (Edgecombe *et al.* 2002). In general, these animals have a relatively cryptic biology, preferring moist habitats in deep litter accumulations, under rocks and in rotting logs, and they have relatively poor dispersal abilities (Lewis 1981). This suggests that they are potential candidates for designation as SREs.

1.4.2.3 Molluscs (Phylum: Mollusca)

Numerous species of freshwater and terrestrial molluscs belonging to many genera have been identified in Australia, with most being SREs (Harvey 2002). Restricted ranges of the terrestrial molluscs of the drier northern and Western Australia were noted for a vast number of species (Solem 1997). Among these were seven endemic species of *Rhagada* from the Dampier Archipelago, five of which were found to occur sympatrically on one island. However, in a recent genetic study conducted on *Rhagada* (Johnson *et al.* 2004), allozyme analysis revealed little variation between taxa. Such a finding could indicate that there is merely high morphological diversity within one or a few species. It is also possible however, that there is a number of highly endemic species and that morphological diversity has taken place rapidly with little genetic change (Johnson *et al.* 2004).

Some species of the terrestrial snail genera *Rhagada* and *Bothriembryon* are known to be SREs. Species of these genera have been recorded within the Pilbara region with some occurring in areas close to the Project Area.

1.4.2.4 Worms (Phylum: Annelida & Onychophora)

The taxonomic status of the earthworm family, Megascolecidae, in Western Australia was revised by Jamieson in 1971. As a result of this study, it was concluded that most of the earthworm genera are made up almost entirely of SREs (Harvey 2002). This is also the case with the velvet worms (Onychophorans). Due to several taxonomic revisions that have been conducted (see references within Harvey, 2002), the number of onychophoran species has expanded from six to over 70 species, and a number of species still remain undescribed (Harvey 2002). Very few of these species exceed ranges of 200 km² and some are restricted to single localities and have high genetic differentiation, indicating very little mobility and dependence on their permanently moist habitats (Harvey 2002). No terrestrial SRE worms are known from the Pilbara region.

1.4.2.5 Isopods (subphylum: Crustacea, Class malacostraca)

There are currently around 10,215 described species of isopod classified into 11 suborders: however, little understanding of the taxonomy of Australian genera exists to date (Brusca and Brusca 2003; Judd *et al.* 2008). Numerous species of terrestrial and subterranean isopods belonging to several different genera have been identified in Western Australia with several genera containing known and potential SREs including *Pseudolaureola*, *Buddelundia*, *Cubaris* and Platyarthridae (Judd 2009, 2010, 2011b). SRE isopods have been collected from the Pilbara and Kimberley regions of Western Australia (Judd *et al.* 2008). Many species have Gondwanan affinities suggesting that relictual habitats originating from much wetter climate periods persist across the State (Main 1987). Due to a lack of taxonomic knowledge and paucity of data, the precise distributions of each species is unknown and more taxonomic work at species level is required before the status of individual populations can be ascertained.

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2 BIOPHYSICAL ENVIRONMENT

2.1 CLIMATE

The Project Area is located in the Pilbara region of Western Australia. The Pilbara experiences an arid-tropical climate with two distinct seasons; a hot summer from October to April and a mild winter from May to September. Temperatures are generally high, with summer temperatures frequently exceeding 40°C. Light frosts occasionally occur inland during July and August. (BOM 2011).

Rainfall is generally localised and unpredictable (some years have recorded zero rainfall), and temperatures are high, resulting in annual evaporation exceeding rainfall by as much as 500 mm per year. The majority of the Pilbara has a bimodal rainfall distribution; from December to March rains result from tropical storms producing sporadic thunderstorms. Tropical cyclones moving south also bring heavy rains. From May to June, extensive cold fronts move eastwards across the state and occasionally reach the Pilbara. These fronts usually produce only light rains. Surface water can be found in some pools and springs in the Pilbara all year round, although watercourses generally flow intermittently due to the short wet season (Beard 1975).

The nearest Bureau of Meteorology (BoM) stations for which both rainfall and temperature data are available are Marble Bar (Site No. 004106), 71 km to the northeast, and Redmont (Site No. 004043), 80.9 km to the southwest of the Project Area. Redmont and Marble Bar stations have an average annual rainfall of 311 mm and 362 mm respectively (BOM 2011). Both locations have a typical Pilbara climate of hot summers with sporadic summer storms and warm dry winters (Figure 2.1).

Rainfall data in the period preceding and during which the surveys occurred is also available for Hillside Station (Site No 004015) and Wallareenya (Site no 004038), located 61 km and 62 km south east and southwest of the Project Area respectively (Table 2.1). These two stations provide a more reliable indication of local conditions. Summer rainfall to the east of the Project Area occurred later in the season and was consistently lower than the long term average. However rainfall at Wallareenya during January and February 2011 was significantly above average, falling to below average for most of the following months, a pattern which is consistent with that observed during both SRE surveys. The higher than average rainfall preceding Phase 1 of the survey was conducive higher activity in SREs and therefore favourable for the survey.

Table 2.1 – Rainfall at Wallareenya and Hillside Meteorological Stations.

Total rainfall (mm)	Hillside		Wallareenya	
	Monthly total	Monthly average (1917-2011)	Monthly total	Monthly average (1908-2011)
December 2010	14	24.2	0	23.2
January 2011	63.4	72.1	114.3	64.9
February 2011	12	80.0	312.0	86.3
March 2011	18.2	52.8	42.2	64.6
April 2011	4.6	21.4	11.6	17.8
May 2011	0	19.1	24	22.2
June 2011	0	19.6	2	25.4
July 2011	13	12.3	2	9.4
August 2011	0	7.1	0	4.5
September 2011	n/a	1.2	0	1.8

(BOM 2011)

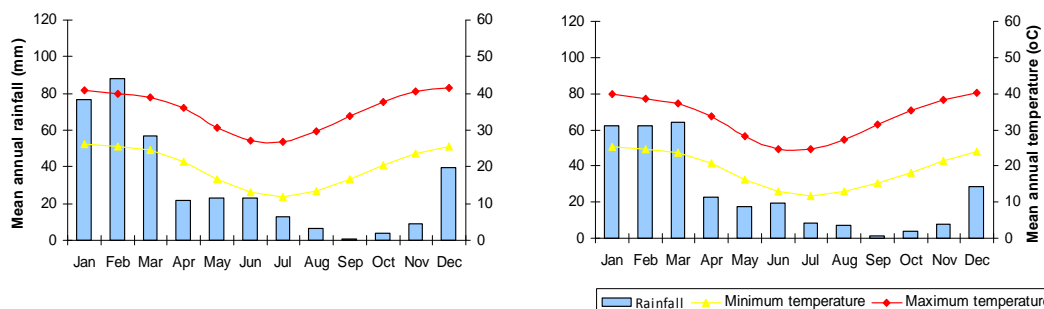


Figure 2.1 – Mean Monthly Climate Data for Marble Bar (left) and Redmont (right) (BOM 2011)

2.2 VEGETATION

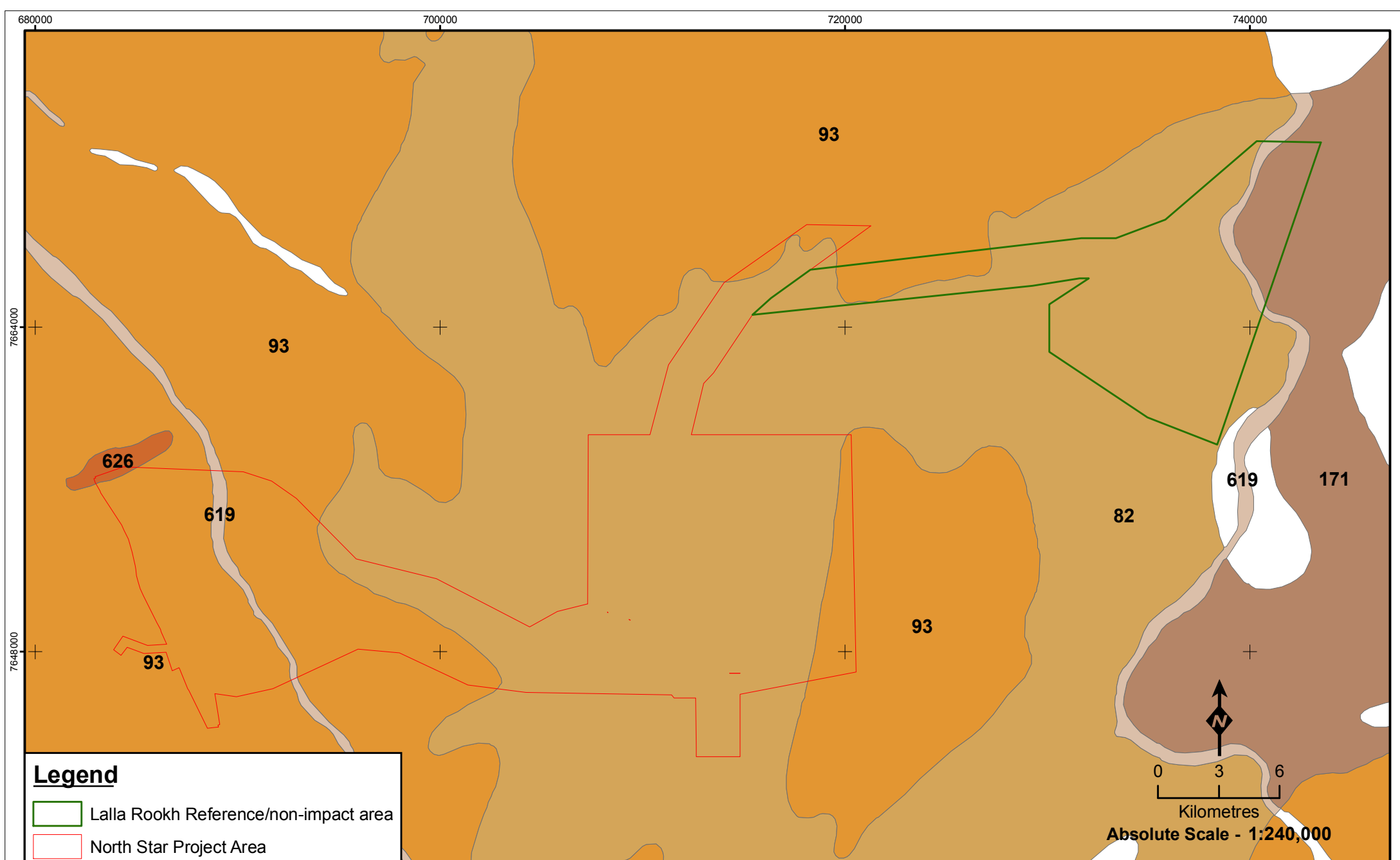
The survey area lies within Beards (1975) Fortescue Botanical District of the Pilbara. The vegetation mapping of Beard and Hopkins throughout Western Australia was subsequently reinterpreted and updated to reflect the National Vegetation Information System (NVIS) standards (Shepherd *et al.* 2002), as described and mapped in Table 2.2 and Figure 2.2.

The Project Area lies predominantly in the George Ranges of the Abydos Plains within the Chichester subregion of the Fortescue Botanical Province. Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* (formerly *Triodia pungens*) hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges (Beard 1975).

Table 2.2 – Beard Vegetation of the Project Area

Vegetation Association	Vegetation Description	Vegetation Unit	Survey Sites	Total Area in Pilbara (Km ²)	Area within Project Areas (Km ²)	Total Vegetation Type Impacted (%)
93	Hummock grasslands, shrub steppe; kanji over soft spinifex	a2Sr t1Hi	1323_S1, 2, 3, 4, 5, 6, 7, F3 1374_F10	30540.99	142.64	0.47
171	Hummock grasslands, low tree steppe; snappy gum over soft spinifex & <i>Triodia brizoides</i>	e16Lr t1,6Hi	none	3325.11	16.56	0.49
619	Medium woodland; river gum (<i>Eucalyptus camaldulensis</i>)	e18Mi	1323_S14	1190.55	9.78	0.82
82	Hummock grasslands, low tree steppe; snappy gum over <i>Triodia wiseana</i>	e16Lr t3Hi	1323_S8, 9, 10, 11, 12, 13, F01, F02 1374_S1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, F1, F2, F3, F4, F5,	25647.77	315.17	1.23

Vegetation Association	Vegetation Description	Vegetation Unit	Survey Sites	Total Area in Pilbara (Km ²)	Area within Project Areas (Km ²)	Total Vegetation Type Impacted (%)
			F6, F7, F8, F9, F11, F12			
626	Hummock grasslands, shrub-steppe; kanji over soft spinifex & <i>Triodia brizoides</i>	a2Sb t1,6Hi	1323_S15	1176.72	0.53	0.05



Legend

- Lalla Rookh Reference/non-impact area
- North Star Project Area

Absolute Scale - 1:240,000



Vegetation Associations of the North Star Project Areas and Lalla Rookh

Figure: 2.2
Project ID: 1374, 1323

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

Drawn: NT
Date: 13/10/2011

Unique Map ID: NT037

A4

2.3 LAND SYSTEMS

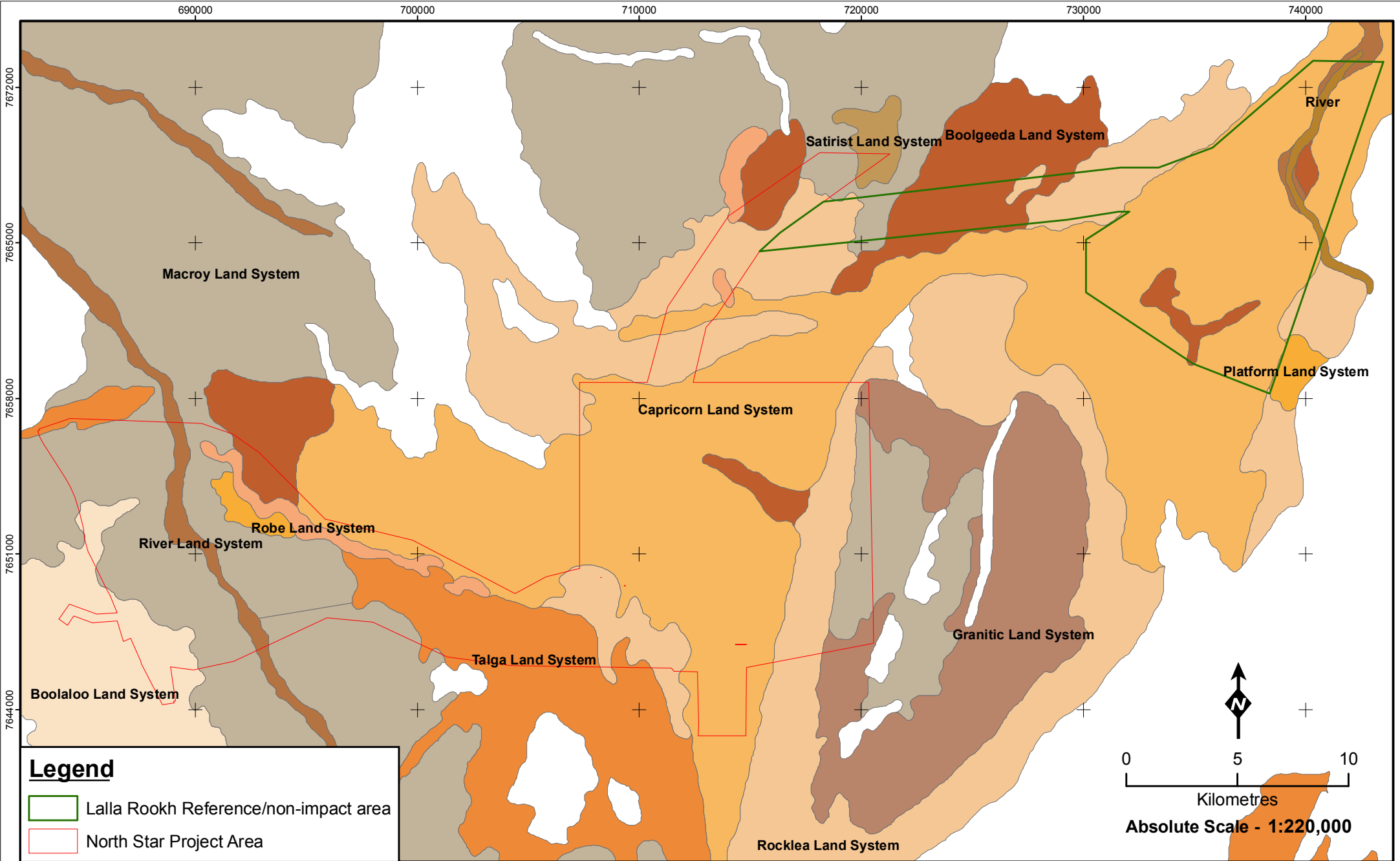
An inventory of the land systems occurring in the Pilbara was completed by van Vreeswyk *et al.* (2004). The survey aimed to provide a comprehensive description and mapping of the biophysical resources of the region, as well as an evaluation of the condition of soils and vegetation throughout. Each land system is classified into a particular land type defined by the landforms and vegetation it contains.

Ten land systems are mapped within the proposed North Star Project Area and Lalla Rookh reference/non-impact area. These include the Satirist, Boolaloo, Boolgeeda, Capricorn, Macroy, Platform, River, Robe, Rocklea and Talga land systems. Each of these land systems are presented in Figure 2.3 and with descriptions summarised in Table 2.3.

Table 2.3 – Land Systems of the North Star Project Area

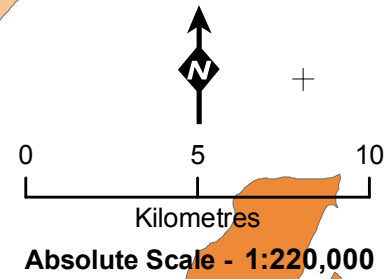
Land System	Description	Survey Sites	Total Area in WA (Km ²)	Area in Survey Area (Km ²)	Total Land System Impacted (%)
<i>Land type 18 – Stony plains with spinifex grasslands</i>					
Boolgeeda	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard Spinifex (and occasionally soft Spinifex) grasslands.	1374_S1, S5, F9, F10	9616.36	31.96	0.33
Macroy	Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands.	1323_S1, 2, 6	13316.10	94.21	0.71
Satirist	Stony plains and low rises supporting hard spinifex grasslands, and gilgai plains supporting tussock grasslands.	None	434.84	0.80	0.18
<i>Land type 2 - Hills and ranges with spinifex grasslands</i>					
Booaloo	Granite hills, domes and tor fields and sandy plains with shrubby spinifex grasslands.	1323_S4, 5	2383.74	12.70	0.53
Capricorn	Hills and ridges of sandstone and dolomite supporting low shrublands or shrubby spinifex grasslands.	1323_S9, 10, 11, 12, 13, F1, F2 1374_S2, 4, 7, 8, 10, 11, 12, F01, F03, F04, F04, F06, F11	6985.26	216.15	3.09
Granitic	Rugged granitic hills supporting shrubby hard and soft spinifex grasslands.	None	4100.01	2.51	0.06
Rocklea	Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands.	1374_S3, 6, F02, F07, F08	28818.97	69.08	0.24
Talga	Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands.	1323_S3, 7, 8, 15, F3	2024.2	31.00	1.53

Land System	Description	Survey Sites	Total Area in WA (Km ²)	Area in Survey Area (Km ²)	Total Land System Impacted (%)
<i>Land type 42 - River plains with grassy woodlands and tussock grasslands</i>					
River	Active flood plains, major rivers and banks supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands	1323_S14	4821.79	9.10	0.19
<i>Land type 6 - Mesas, breakaways and stony plains with spinifex grasslands</i>					
Robe	Low plateaux, mesas and buttes of limonites supporting soft spinifex (and occasionally hard spinifex) grasslands.	None	1286.19	9.78	0.76



Legend

- Lalla Rookh Reference/non-impact area
- North Star Project Area



Land Systems of the North Star Project Areas and Lalla Rookh

Figure: 2.3
Project ID: 1374, 1323

Drawn: NT
Date: 13/10/2011

Unique Map ID: NT038

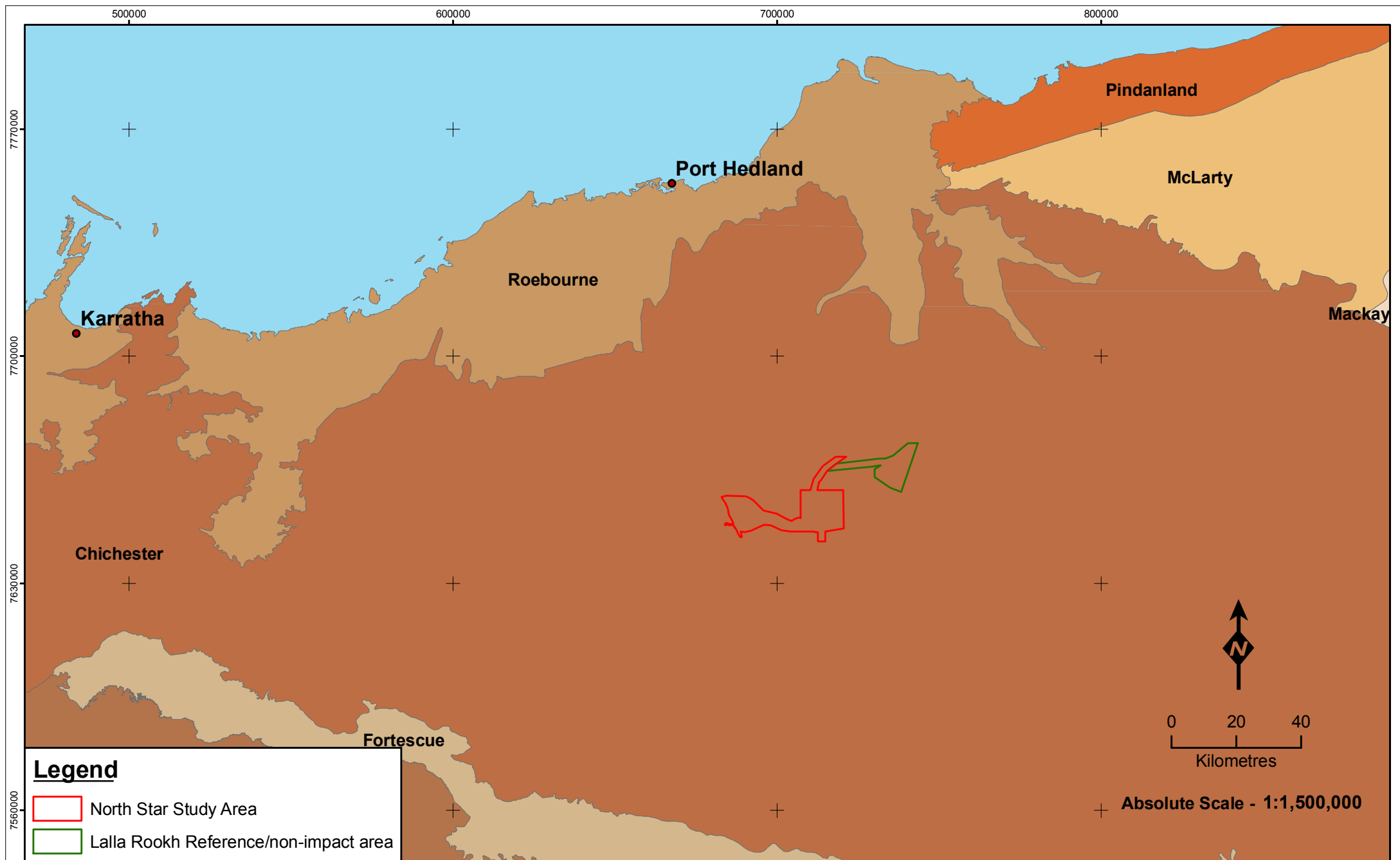
Coordinate System
 Name: GDA 1994 MGA Zone 50
 Projection: Transverse Mercator
 Datum: GDA 1994

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2.4 BIOGEOGRAPHY


The North Star Study Area is situated within the Pilbara Region of the Interim Biogeographic Regionalisation of Australia, IBRA 6.1 (Australian Government 2005). The Pilbara biogeographic region comprises four subregions: Hamersley, Fortescue Plains, Chichester and Roebourne. The North Star Project is situated in the Chichester subregion (Figure 2.4).

The Chichester subregion comprises the northern section of the Pilbara Craton. Undulating Archaean granite and basalt plains include significant areas of basaltic ranges. Plains support a shrub steppe characterised by *Acacia inaequilatera* over *Triodia wiseana* (formerly *Triodia pungens*) hummock grasslands, while *Eucalyptus leucophloia* tree steppes occur on ranges. The climate is semi desert tropical and receives 300 mm of rainfall annually. Drainage occurs to the north via numerous rivers (e.g. De Grey, Oakover, Nullagine, Shaw, Yule, Sherlock and Turner). Subregional area is 9,044,560ha (Kendrick and McKenzie 2001).



Legend

- North Star Study Area
- Lalla Rookh Reference/non-impact area


 0 20 40
 Kilometres
Absolute Scale - 1:1,500,000



**Biogeographic Subregions
of the North Star Project Areas
and Lalla Rookh**

Figure: 2.4
 Project ID: 1374, 1323

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

Drawn: NT
 Date: 13/10/2011

Unique Map ID: NT038

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3 METHODS

The methodology used was based on the principles outlined in EPA Guidance statement 20: *Sampling of Short-Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009). The methodology developed for the survey is compliant with these requirements and in accordance with the guidance received from the DEC before the survey period.

3.1 DETERMINATION OF SURVEY DESIGN AND INTENSITY

Prior to the development of field survey methods, a review was undertaken of factors likely to influence survey design and intensity (Table 3.1). Based on this review, the level of disturbance, data from previous surveys and the results of a desktop study, a SRE field survey, that incorporated a variety of SRE collecting techniques, was adopted.

Table 3.1 – Factors Influencing Survey Design

Factor	Relevance
Bioregion-level of existing survey knowledge of the region and associated ability to predict accurately.	Previous biological surveys have been conducted within 100 km of the Project Area.
Landform special characteristics/specific fauna/specific context of the landform characteristics and their distribution and rarity in the region.	The Project Area covers ten land systems: Satirist, Boolaloo, Boolgeeda, Capricorn, Macroy, Platform, River, Robe, Rocklea and Talga land systems. They are not exclusive to the Project Area.
Life forms, life cycles, types of assemblages and seasonality (e.g. migration) of species likely to be present.	The best time to survey for all invertebrate fauna groups in the Pilbara is the wet season (typically November – March). The survey of the mining tenement and rail alignment was undertaken February to March. The survey for the Lalla Rookh reference/non-impact area was undertaken July to August. Rainfall was above average and prolonged during 2011 which meant surveying outside the EPA's recommended survey period for SREs was considered acceptable.
Level of existing knowledge and results of previous regional sampling (e.g. species accumulation curves, species/area curves).	Regional surveys have been conducted with the closest one approximately 40 km south east of the Project Area. SREs from arachnid and myriapod orders have been recorded from within 100 km of the Project Area.
Number of different habitats or degree of similarity between habitats within a survey area.	The majority of the Project Area had very uniform habitat. Five different habitats were defined based on vegetation types present in the Project Area (Table 2.2).
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. Rainfall is highly unpredictable. Wet-pitfall trapping during heavy rainfall events may lead to traps being flooded and losing data. Some of the traps retrieved during phase one had overflowed, however it was not possible to establish how much, if any, data was lost.
Scale and impact of the Project.	Will determine the number of trapping sites, number of traps per site, type of trapping sites and whether to collect reference data from outside the boundary. The survey area covers approximately 483 km ² . Number of trapping sites was based on size.

3.2 LITERATURE REVIEW AND DATABASE SEARCHES

Fauna species formally recognised as rare, threatened, or as having high conservation value are protected under Commonwealth and State legislation. A DEC NatureMap database search was undertaken in order to determine if any species listed under the EPBC Act or the WC Act have potential to occur in the Project Area.

Ideally, a database search for SRE species would be undertaken of the Project Area and surrounding local area. However, as knowledge of invertebrate diversity throughout the Pilbara region is very limited, a regional approach was taken. Taxa (Orders) known to contain SREs were searched within the Malacology and Terrestrial Invertebrate electronic databases of the Western Australian Museum (WAM) and *ecologia's* internal database. The surrounding area was searched, between 22°S and 23S, and 117°E and 118 °E.

3.3 SURVEY TIMING

The EPA's Guidance Statement 20 recommends surveys in the Pilbara be optimally conducted during the wet season (November to March).

The survey of the mining area and infrastructure corridor was undertaken during February to March 2011 during a period of higher than average rainfall. Wallareenya received 312 mm of rainfall during the month of February which is 226 mm over the monthly average.

The survey for the additional area and Lalla Rookh reference/non-impact area was undertaken during July to August 2011, also after a period of slightly heavier than average rainfall. Hillside received 13 mm of rainfall during August whereas the monthly average was 12.3 mm.

3.4 SITE SELECTION

Survey site locations (Table 3.2, Table 3.3 and Figure 3.1) were selected based on those habitats likely to support SRE invertebrates in areas both inside and outside the proposed impact areas. Aerial photographs (Google Earth™) and vegetation and land system maps of the Project Area were studied to determine the habitat types in which the SREs were likely to occur. Micro-habitats likely to maintain higher moisture levels and 'island' habitats were targeted. Forty potential SRE survey sites were selected within each separate Project Area in this way and a random number generator was then used to pick 12-15 sites to be sampled. These site locations were further refined following on-site examination. The site descriptions can be found in Appendix 1.

Table 3.2 – North Star Mine Area and Infrastructure Corridor SRE Survey Sites

Site ID	Easting	Northing	Location
1323_01	690245	7648817	Infrastructure corridor
1323_02	689534	7651084	Infrastructure corridor
1323_03	700285	7648969	Infrastructure corridor
1323_04	685795	7651868	Infrastructure corridor
1323_05	688116	7647873	Infrastructure corridor
1323_06	689817	7654940	Infrastructure corridor
1323_07	700907	7648076	Infrastructure corridor

1323_08	704214	7646901	Infrastructure corridor
1323_09	711578	7651202	Infrastructure corridor
1323_10	712891	7649980	Infrastructure corridor
1323_11	713457	7647952	Infrastructure corridor
1323_12	713403	7646217	North Star Mine Area
1323_13	694815	7653405	North Star Mine Area
1323_14	691823	7648893	North Star Mine Area
1323_15	683501	7656606	Infrastructure corridor
1323_F1	713900	7643384	Infrastructure corridor
1323_F2	713741	7644802	Infrastructure corridor
1323_F3	697394	7648742	Infrastructure corridor

Datum:GDA94, Zone: 50K

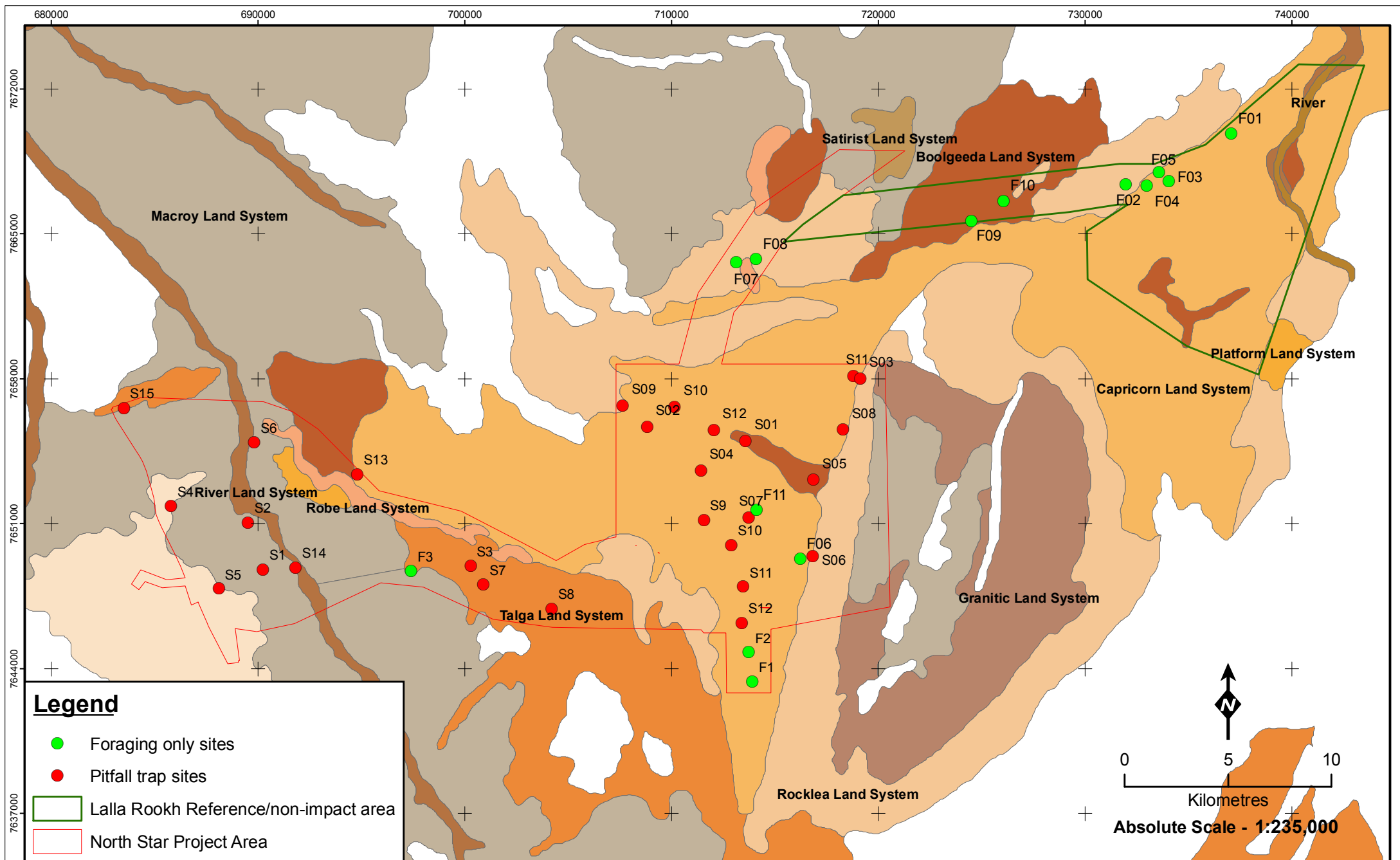
Table 3.3 – North Star Additional Mine Area and Lalla Rookh Reference/Non-impact Area* SRE Survey Sites

Site ID	Easting	Northing	Location
1374_01	713577	7655010	Additional Mine Area
1374_02	708819	7655685	Additional Mine Area
1374_03	719127	7658028	Additional Mine Area
1374_04	711417	7653583	Additional Mine Area
1374_05	716862	7653125	Additional Mine Area
1374_06	716829	7649434	Additional Mine Area
1374_07	713717	7651302	Additional Mine Area
1374_08	718289	7655554	Additional Mine Area
1374_09	707643	7656702	Additional Mine Area
1374_10	710135	7656654	Additional Mine Area
1374_11	718789	7658147	Additional Mine Area
1374_12	712044	7655528	Additional Mine Area
1374_F1	737082	7669853	Lalla Rookh reference/non-impact area
1374_F2	733573	7667996	Lalla Rookh reference/non-impact area
1374_F3	734051	7667547	Lalla Rookh reference/non-impact area
1374_F4	732983	7667338	Lalla Rookh

Site ID	Easting	Northing	Location
			reference/non-impact area
1374_F5	731974	7667400	Lalla Rookh reference/non-impact area
1374_F6	728765	7666745	Lalla Rookh reference/non-impact area
1374_F7	716229	7649299	Additional Mine Area
1374_F8	713132	7663634	Lalla Rookh reference/non-impact area
1374_F9	714086	7663775	Lalla Rookh reference/non-impact area
1374_F10	724492	7665644	Lalla Rookh reference/non-impact area
1374_F11	726053	7666608	Lalla Rookh reference/non-impact area
1374_F12	714968	7652240	Additional Mine Area

Datum:GDA94, Zone: 50K

*Foraging only conducted at Lalla Rookh reference/non-impact area



SRE Survey Sites and Land Systems of the North Star Project Areas and Lalla Rookh

Figure: 3.1
Project ID: 1374, 1323

Drawn: NT
Date: 8/3/2012

Unique Map ID: NT038

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

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3.5 SAMPLING METHODS

Surveys were undertaken using a variety of sampling techniques, both systematic and opportunistic. Systematic sampling refers to data methodically collected over a fixed time period in a discrete habitat type, using an equal or standardised sampling effort. The resulting information can be analysed statistically, facilitating comparisons between habitats. Opportunistic sampling includes data collected non-systematically from both fixed sampling sites and as opportunistic records gathered during foraging sessions.

Wet pitfall trapping sites were deployed in all the North Star Project Areas except for Lalla Rookh reference/non-impact area where foraging only and leaf litter collection was undertaken.

3.5.1 Wet Pitfall Trapping

Wet pitfall traps (Figure 3.2) consisting of a PVC tube (25cm long) and containing 30% Ethylene Glycol and 5% Formaldehyde were dug into the ground so that the surface was flush with the ground level. A receptacle (containing 700 ml of pitfall trapping solution) and funnel (fitting flush to the inside of the pitfall trap) were deployed into each tube and a cover was fitted 2 cm above the tube with steel fittings to exclude medium sized vertebrates and rain, and to deter attention of larger vertebrates. Traps were left open for 40 days, after which period they were cleared.



Figure 3.2 – Wet Pitfall Traps

3.5.2 Foraging

Opportunistic foraging was undertaken at each site and involved physically searching through microhabitats for SRE's. The underside of rocks and logs were closely investigated for SRE invertebrates. Snail shells and trapdoor spiders were collected and documented where found.

3.5.3 Litter/soil Collection

At each site, three quadrats (3m²) of leaf litter were collected and placed into a leaf-litter reducer separately (Figure 3.3). The contents from each collection was placed into a paper bag inside a zip-lock bag and kept separate. A small amount of wet tissue paper was placed into each sample to keep

humid. Samples were then transported back to Perth in a cool, dark container. Samples were then placed on the Tullgren Funnels to extract any specimens.



Figure 3.3 – Examples of the Leaf Litter Redcuer and Tullgren Funnels

3.5.4 Extraction Methods

Tullgren funnels were used to extract any animals from the collected leaf litter samples (Figure 3.3). The general principle of Tullgren funnels is that a sample of leaf litter is suspended above a vessel containing ethanol. Animals inhabiting the sample are forced downwards by the progressive drying of the sample and ultimately fall into the collecting vessel containing ethanol. Drying is enhanced by the incandescent lamp or heat source above the sample.

After the leaf litter samples were processed on the Tullgren funnels, each sample was then examined for dead snail shells, or any other dead animals that were not collected during the Tullgren funnel extraction. Each sample was emptied into a tray and examined using a fluorescent light magnifier. Any dead animals were collected and immediately placed into ethanol.

3.5.5 Laboratory Sorting and Specimen Identification

All samples, whether from foraging or pitfall traps were then sorted under a Stereo microscope into potential SRE groups and sent to the relevant taxonomic expert for further identification. A list of taxonomic specialists used for identification is shown in Table 3.4.

Table 3.4 – Taxonomic Experts used to Identify Potential SRE Taxa Found During the Survey

Taxonomic Expert	Institution	Specialist Group
Mark Harvey Mieke Burger	Western Australian Museum	Arachnids Myriapods
Volker Framenau	Private Consultant	Mygalomorph spiders
Shirley Slack-Smith Corey Whisson	Western Australian Museum	Molluscs
Simon Judd	Private consultant	Isopods
Erich Volschenk	Private consultant	Scorpions

3.5.6 Field Team

Field survey team members are listed in Table 3.5. The survey was conducted under DEC Regulation 17 Licence SF007851.

Table 3.5 – *ecologia* Staff Involved with Survey

Name	Qualification	Relevant Experience
Nicki Thompson	BSc (Hons)	4 years experience with SRE invertebrates
Pia Roberts	BSc	3 years experience with SRE invertebrates
Brett Stewart	BSc (Hons)	1 years experience with invertebrates
Nicholas Dight	BSc	4 years experience with SRE invertebrates
Maria Majer	PhD	15 years experience with invertebrates

3.6 SRE STATUS

The likelihood of the invertebrate species to be considered a SRE or not a SRE was determined by expert taxonomists (Mark Harvey, Department of Terrestrial Invertebrates, WAM; Shirley Slack-Smith and Corey Whisson, Department of Malacology; Erich Volschenk and Volker Framenau, Phoenix Environmental) based on the current knowledge of the distribution and biology of each species, as follows:

- No - Not considered a SRE
- Confirmed - Current knowledge confirms that this species is a SRE
- Potential - Current knowledge of this species or group is very limited however, there is the potential for this species to represent a SRE. Further research is required to confirm status
- Unknown - No comment can be made regarding SRE status, usually due to uncertainty over species level due to life stage/sex, and/or lack of taxonomic knowledge.

All potential and unknown SREs should be treated as confirmed SREs under the precautionary principle (Section 4a of the EP Act).

3.7 DATA ANALYSIS

3.7.1 Survey Adequacy

There are three general methods of estimating species richness from sample data: extrapolating species-accumulation curves (SAC), fitting parametric models of relative abundance, and using non-parametric estimators (Bunge and Fitzpatrick 1993; Colwell and Coddington 1994; Gaston 1996). In this report, the level of survey adequacy was estimated using the rarefaction of SACs as computed by Mao Tao estimator. In addition, the following species richness estimators: ACE, ICE, Chao-1, Jackknife-1, Jackknife-2, Bootstrap and their 95% confidence limits were calculated. Finally, a Michaelis-Menten enzyme kinetic curve was calculated and used as a stopping rule technique. To eliminate features caused by random or periodic temporal variation, the sample order was randomised 50 times. The estimators applied to the data set were performed using EstimateS (version 8, Colwell 2009).

3.7.2 Habitat assessment

Effective invertebrate conservation cannot rely on conventional single species approach adopted for the conservation of vertebrates and plants (Clark and Spier-Ashcroft 2003). The focus of modern invertebrate conservation has changed to a more community and landscape scale approach with a primary emphasis on habitat conservation. Invertebrate conservation should be promoted more effectively by habitat preservation and management rather than single species-initiatives (Lewinsohn *et al.* 2005).

Habitat types play an important role in SRE invertebrate diversity as variability of habitats has been strongly linked with invertebrate species richness and diversity. All survey sites were assessed for their suitability for supporting SREs in terms of moisture, shade, suitable microhabitat and geographical isolation. Ten land systems and five vegetation types occur within the Project Areas (Section 2.2 and 2.3). All were sampled except for land systems Satirist, Granitic and Robe, which were not sampled due to access difficulties and/or restrictions due to heritage areas.

Vegetation type reflects underlying soil, surface hydrology and position in the landscape, and provides a reasonable surrogate of habitat parameters in respect to SREs. The survey sites were located over five vegetation types and all were found to have the potential to support SREs due to moderate levels of shade, moisture and/or suitable microhabitat i.e. moderately deep leaf litters.

Vegetation types were used in this report as surrogates of the SRE habitat type. The five vegetation types occurring on the Project Area are:

- 93; Hummock grasslands, shrub steppe; kanji over soft Spinifex
- 171; Hummock grasslands, low tree steppe; snappy gum over soft spinifex & *Triodia brizoides*
- 619; Medium woodland; river gum (*Eucalyptus camaldulensis*)
- 82; Hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana*
- 626; Hummock grasslands, shrub-steppe; kanji over soft spinifex & *Triodia brizoides*

All of these vegetation types were sampled in, except for 171 due to access issues; however, this vegetation type occurs outside any impact areas and is found in mosaics with other vegetation types sampled during the survey.

Habitats were analysed based on the vegetation type within which the sites were located. Due to the continuous nature of the vegetation classifications within the Project Area (Figure 2.2), statistical methodologies used for habitat correlation were not required. Instead, habitat impacts were calculated from the total area of each vegetation association within the Project Area.

4 RESULTS

4.1 DATABASE RESULTS

The results of the DEC NatureMap search are provided in Table 4.1. A total of 38 species are listed by the *EPBC Act*, *WC Act* or DEC as being formally recognised as rare, threatened, or as having high conservation value in the Pilbara. These species are protected under Commonwealth and State legislation. These species include 11 arachnid, 18 crustacean, one annelid, four millipede, three insect and one mollusc species. None of those listed species were recorded in the Project Areas.

Table 4.1 – DEC Naturemap Database Results of Rare, Threatened, and Conservation significant Invertebrate Species Likely to occur in the Pilbara. * Denotes subterranean fauna.

Taxa	Species	EPBC Act	WC Act	DEC
Arachnids	<i>Indohya damocles</i> (pseudoscorpion) *	CR		
	<i>Bamazomus subsolanus</i> *	EN	S1	
	<i>Bamazomus vespertinus</i> *	EN	S1	
	<i>Draculoides brooksi</i> *	EN	S1	
	<i>Draculoides julianneae</i> *	EN	S1	
	<i>Draculoides bramstokeri</i> *	VU	S1	
	<i>Paradraculoides anachoretus</i> *	VU	S1	
	<i>Paradraculoides bythius</i> *	VU	S1	
	<i>Paradraculoides gnophicola</i> *	VU	S1	
	<i>Paradraculoides kryptus</i> *	VU	S1	
	<i>Draculoides vinei</i> *			P4
Crustaceans	<i>Bunderia misophaga</i>	CR		
	<i>Stygocloppia australis</i>	CR		
	<i>Lasionectes exleyi</i> *	CR		
	<i>Speleophria bundeae</i>	CR		
	<i>Danielopolina kornickeri</i>	CR		
	<i>Liagoceradocus branchialis</i>	EN	S1	
	<i>Stygiocaris lancifera</i>	VU		
	<i>Bogidomma australis</i>	VU	S1	
	<i>Liagoceradocus subthalassicus</i>	VU	S1	
	<i>Nedsia fragilis</i> *	VU	S1	
	<i>Nedsia humphreysi</i> *	VU	S1	
	<i>Nedsia hurlberti</i> *	VU	S1	
	<i>Nedsia macrosculptilis</i> *	VU	S1	
	<i>Nedsia sculptilis</i> *	VU	S1	

Taxa	Species	EPBC Act	WC Act	DEC
	<i>Nedsia straskraba</i> *	VU	S1	
	<i>Nedsia urifimbriata</i> *	VU	S1	
	<i>Nedsia chevronia</i> *			P2
	<i>Stygiocaris stylifera</i> *			P4
Annelids	<i>Prionospio thalanji</i> *	CR		
Millipedes	<i>Stygiochiropus peculiaris</i> *	CR		
	<i>Speleostrophus nesioties</i> *	VU	S1	
	<i>Stygiochiropus isolatus</i> *	VU	S1	
	<i>Stygiochiropus smypatricus</i> *	VU	S1	
Insects	<i>Antipodogomphus hodgkini</i> (dragonfly)			P2
	<i>Nososticta pilbara</i> (dragonfly)			P2
	<i>Nocticola flabella</i> (cockroach)			P2
Molluscs	<i>Dupucharopa millestriata</i>			P2

The results of the WAM database search are presented in Appendix 2. The search identified three confirmed SREs, eight potential SREs and nine species of which the SRE status is unknown that may occur in the area. Of these, there were seven Mygalomorph spiders, four scorpions, seven pseudoscorpions and three millipede species. Spiders from the genus *Aname* and *Karaops* were recorded from the Project Area with the potential for Short-Range Endemism. None of the other species were recorded, and none are listed as species of conservation significance.

The results of the *Ecologia* internal database search are presented in Appendix 3. The search identified five potential SREs and four unknown SREs. Of these, there were four mygalomorph spiders, one isopod, one snail and three pseudoscorpions. The isopod *Buddelundia* sp. 11, the snail *Succinea* sp., and spiders from the genus *Aname* were all recorded from the Project Area; however, none of these species were listed as species of conservation significance.

4.2 SPECIMENS COLLECTED

During phase one of the North Star survey over 300 invertebrate specimens were collected represented by at least five orders, 12 families, and 26 species of invertebrates. Of these, four were potential SREs, including two isopods (*Buddelundia* sp. 11 and *Buddelundia* sp. 18), one mollusc (*Succinea* sp.) and one millipede (*Antichiropus*), and two species were with SRE status unknown, including one scorpion (*Lychas* sp. indet.) and one mollusc (*Rissooidea* sp. 1) (Table 4.2, Figure 4.1). None of the formally listed species were recorded during the survey and no confirmed SRE species were recorded during this survey.

During phase two of the North Star survey over 150 invertebrate were collected specimens represented by eight orders, 13 families and 31 species. Of these, six were potential SREs, including two spiders (*Aname* sp. indet. and *Karaops* sp.), two pseudoscorpions (*Beierolpium* 'sp. 8/2' and *Beierolpium* 'sp. 8/4 lge') and two isopods (*Buddelundia* sp. 11 and *Buddelundia* sp. 18) (Table 4.3,

Figure 4.1). None of the formally listed species were recorded during the survey and no confirmed SRE species were recorded during this survey.

The taxonomy, distribution and SRE status of these genera are discussed in the following sections.

Table 4.2 – Specimen Summary for Phase One North Star Mine Area and Infrastructure Corridor Survey (Site prefix 1323)

Family	Genus	Species	SRE	Wet Pitfall Trapping Sites															Foraging Sites		
				01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	F1	F2	F3
Arachnida (Spiders)																					
Nemesiidae	<i>Aname</i>	MYG001'	No	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	
Arachnida (Scorpions)																					
Buthidae	<i>Lychas</i>	hairy tail' group	No	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	
	<i>Lychas</i>	'harveyi'	No	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Lychas</i>	multipunctatus'	No	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
	<i>Lychas</i>	'pilbara 1'	No	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	
	<i>Lychas</i>	sp. indet	Unknown	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
Urodacidae	<i>Urodacus</i>	pilbara 4'	No	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	
Arachnida (Pseudoscorpions)																					
Atemnidae	<i>Oratemnus</i>	sp.	No	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	
Olpiidae	<i>Indolpium</i>	sp.	No	0	1	0	0	0	0	2	1	0	1	0	0	0	0	0	0	0	
Isopoda (Slaters)																					
Armadiillidae	<i>Acanthodillo</i>	sp. 6	No	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 11	Potential	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 13	No	0	3	0	32	3	0	2	0	26	2	2	31	22	4	2	0	0	
	<i>Buddelundia</i>	sp. 18	Potential	0	0	0	0	0	0	6	0	14	0	0	2	1	0	0	0	0	
	<i>Buddelundia</i>	sp.	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 19	No	3	0	2	0	0	0	1	0	4	6	1	0	1	1	0	0	0	
Gastropoda (Snails)																					
Camaenidae	<i>Pupoides</i>	c.f. <i>beltianus</i>	No	0	3	0	0	0	2	0	0	2	0	0	0	0	0	0	0	1	
	<i>Pupoides</i>	<i>beltianus</i>	No	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
Pupillidae	<i>Pupoides</i>	<i>pacificus</i>	No	0	6	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	
	<i>Pupoides</i>	<i>eremicolus</i>	No	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Gastrocopta</i>	<i>mussoni</i>	No	1	13	0	0	0	3	0	5	0	0	0	0	0	0	0	0	0	
	<i>Gastrocopta</i>	<i>larapinta</i>	No	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	
Helicodiscidae	<i>Stenapylis</i>	<i>coarctata</i>	No	0	7	0	0	0	1	0	0	0	0	0	3	0	0	0	0		
Succineidae	<i>Succinea</i>	sp.	Potential	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0		
Planorbidae	<i>Gyrulus</i>	sp.	No	0	0	0	0	0	16	0	9	0	0	0	0	0	0	0	0		
Rissooidea		sp.1	Unknown	0	0	0	0	0	1	0	2	1	0	0	0	0	0	0	0		
Diplopoda (Millipedes)																					
Paradoxosomatidae	<i>Antichiropus</i>		Potential	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		

Table 4.3 – Specimen Summary for Phase Two North Star Additional Mine Areas and Lalla Rookh Reference/non-impact Areas Survey (Site prefix 1374)

Family	Genus	Species	SRE	Wet Pitfall Trapping Sites												Foraging Sites														
				01	02	03	04	05	06	07	08	09	10	11	12	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12			
Arachnida (Spiders)																														
Barychelidae	<i>Synothele</i>	MYG127'	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Nemesiidae	<i>Aname</i>	sp.indet	Potential	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Selenopidae	<i>Karaops</i>	sp.indet	Potential	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arachnida (Scorpions)																														
Buthidae	<i>Lychas</i>	bituberculatus	No	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Lychas</i>	'hairy tail grp'	No	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Lychas</i>	'harveyi'	No	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Urodacidae	<i>Urodacus</i>	'pilbara 8'	No	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Arachnida (Opiliones)																														
Assamiidae			No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
Arachnida (Pseudoscorpions)																														
Garypidae	<i>Synsphyronus</i>	'sp. Pilbara (8/1)'	No	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Olpiidae	'Genus 7/4'	sp.	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	'Genus indet.'	'sp. juv.'	No	2	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	'PSEAAA'	sp.	No	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Austrohorus</i>	sp.	No	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	
	<i>Beierolpium</i>	'sp. 8/4 lge'	Potential	0	1	0	0	1	0	1	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Beierolpium</i>	'sp. 8/2'	Potential	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Indolpium</i>	sp.	No	1	1	3	1	1	1	0	3	0	0	4	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Chilopoda (Geophilomorpha)																														
Geophilidae			No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	
Chilopoda (Scolopendramorpha)																														
Cryptopidae			No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	
Isopoda (Slaters)																														
Armadillidae	<i>Buddelundia</i>	sp. 11	Potential	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 13	No	0	0	1	0	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 14	No	0	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Buddelundia</i>	sp. 18	Potential	0	0	0	0	0	3	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Buddelundia</i>	sp. 19	No	0	1	0	0	0	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda (Snails)																														
Pupillidae	<i>Pupoides</i>	<i>cf. beltianus</i>	No	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Pupoides</i>	sp.	No	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	<i>Pupoides</i>	<i>pacificus</i>	No	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	
	<i>Pupoides</i>	<i>cf. pacificus</i>	No	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Gastrocopta</i>	<i>mussoni</i>	No	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planorbidae	<i>Isidorella</i>	<i>cf. egregia</i>	No	0	8	0	0	0	4	0	0	0	0	21	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	
	<i>Gyrulus</i>	sp.	No	0	4	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Lymnaeidae	<i>Austropeplea</i>	<i>cf. lessoni</i>	No	0	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	

4.2.1 Arachnids

4.2.1.1 Mygalomorphae

Family Barychelidae

Synothele 'MYG127'

One male specimen was collected from site 1374_07, a gully base within the Additional Mine Area. The genus is widespread throughout Western Australia (21 species) and South Australia (3 species) with most species known from limited ranges. *Synothele* 'MYG127' is the most commonly collected Barychelid spider in the Pilbara and therefore this specimen **does not represent a SRE** (Framenau 2011).

Family Nemesiidae

Aname 'MYG001'

Two male specimens were collected from sites 1323_4 and 1323_12, a rocky outcrop and south facing midslope from within the Mine Area and Infrastructure Corridor. They belong to *Aname* 'MYG001' group of which the nominal species is widespread throughout the Pilbara region, and further South in WA. The genus *Aname* currently includes 33 named species in Australia, with four named and numerous unnamed species from many different regions in WA. These specimens **do not represent SREs** (Framenau 2011).

Aname sp. indet. (female)

One specimen was collected from site 1374_09, a river bed within the Additional Mine Area. This specimen could not be identified to species level, but based on the known distribution of other *Aname* species in WA it could potentially represent a SRE. The collection of males from the area for further morphological assessment may result in the species being classified as 'not SRE' but until this is determined, this species should be **considered a potential SRE** (Framenau 2011).

4.2.1.2 Araneomorphae

Family Selenopidae

Karaops sp. indet

Two juvenile specimens were collected from sites 1374_01 and 1374_11 (creek bed and river bed within the Additional Mine Area), and could not be identified to species level. *Karaops* is currently only known from Australia (Crew and Harvey 2011). Five species are described from the Pilbara region and its vicinity, of which one species is fairly widespread. Since this study, six more undescribed species have been collected from single localities in the Pilbara region, thus supporting a high diversity of the genus in the region. These specimens should be **considered potential SREs** (Framenau 2011).

4.2.1.3 Scorpiones

Twelve scorpion specimens were collected from the survey area. These represent two families and six species, of which one has SRE status unknown.

Family Buthidae

Lychas bituberculatus

Two specimens were collected from sites 1374_02 and 1374_08, both creek beds within the Additional Mine Area. This species is clearly defined and well recognised, and has been recorded widely throughout the Midwest, Pilbara and Kimberley regions of Western Australia. These specimens **do not represent SREs** (Volschenk 2011).

Lychas 'hairy tail grp'

Three specimens were collected from sites 1323_07, 1323_09 and 1323_10 in the Infrastructure Corridor, and two specimens were recorded from site 1374_08 in the Additional Mine Area. *Lychas* 'hairy tail grp' is highly variable and likely to represent a species complex. Both subtle and graded variation makes consolidation of species boundaries only possible after large series have been examined and represents a work in progress (Volschenk unpublished data). Members of this complex are known from the Midwest, Pilbara and Kimberley regions of Western Australia. These specimens **do not represent SREs** (Volschenk 2011).

Lychas 'harveyi'

One specimen was recorded from site 1323_03 located along the Infrastructure Corridor, and three specimens were recorded from site 1374_01, 1374_02 and 1374_F03 in the Additional Mine Area and Lalla Rookh reference/non-impact area. *Lychas* 'harveyi' is a widespread species with records from the Midwest and Pilbara regions of WA where it is one of the most common scorpion species. This specimen **does not represent a SRE** (Volschenk 2011).

Lychas 'multipunctatus'

Two specimens were collected from sites 1323_02 and 1323_14, both river beds within the Infrastructure Corridor. *Lychas* 'multipunctatus' is a well defined and clearly recognised morphospecies, and has been recorded throughout the Pilbara region of Western Australia where it is one of the most common scorpion species. These specimens **do not represent SREs** (Volschenk 2011).

Lychas 'pilbara 1'

Two specimens were collected from sites 1323_09 and 1323_10, a creek line and ridge top within the Mine Area and Infrastructure Corridor. *Lychas* 'pilbara 1' is widespread throughout the Pilbara region of Western Australia: however, it appears to have a very patchy distribution and is never common. These specimens **do not represent SREs** (Volschenk 2011).

Lychas sp. indet.

One juvenile specimen was collected from site 1323_05, a rocky outcrop within the Infrastructure Corridor. As the specimen was a juvenile it could not be identified to species level, and therefore SRE status is difficult to determine. The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic with numerous undescribed species known in Australia. The situation is further complicated with the genus being represented in Africa, India and eastern Asia. All of the Australian species are endemic and are currently under revision by E.S. Volschenk. Most species of *Lychas* appear to have wide distributions: however, a small number of species are known SREs. The **SRE status of this specimen is unknown** (Volschenk 2011).

Family Urodacidae

Urodacus 'pilbara 4'

Three specimens were collected from sites 1323_09 and 1323_10, within the Mine Area and 1323_15, within the Infrastructure Corridor. This species is widespread throughout the Pilbara region of Western Australia; however despite this it appears to have a very patchy distribution. These specimens **do not represent SREs** (Volschenk 2011).

Urodacus 'pilbara 8'

Two specimens were collected from sites 1374_P08 and 1374_10, a creek and river bed within the Additional Mine Area. This species is a well defined and clearly recognised morphospecies, and has been recorded widely throughout the Northern Pilbara where it is one of the most common scorpion species. These specimens **do not represent SREs** (Volschenk 2011).

4.2.1.4 Olpilonines

Family Assamiidae

A single specimen was collected from site 1374_F8, a minor channel within the Lalla Rookh reference/non-impact area. This specimen belongs to the family Assamiidae. While some olpilionid species are known in the Pilbara, this specimen **does not represent a SRE** (M. Burger, Pers. comm. 27/10/2011).

4.2.1.5 Pseudoscorpiones

Family Atemnidae

Oratemnus sp.

Two specimens of *Oratemnus* were collected from site 1323_13, a rocky outcrop within the Infrastructure Corridor. Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus *Oratemnus* is uncertain and the taxonomy of individual species unclear. Based on current evidence, it seems that most species will eventually be found to be widely distributed and these specimens therefore **do not represent SREs** (Burger *et al.* 2011).

Family Garypidae

Synsphyronus 'sp. Pilbara (8/1)'

Two specimens were collected from site 1374_02, a creek bed within the Additional Mine Area. *Synsphyronus* 'sp. Pilbara (8/1)' is an undescribed species which is known from several locations in the Pilbara. As such, these specimens **do not represent SREs** (Burger *et al.* 2011).

Family Olpiidae

Austrohorus sp.

Five specimens were collected from sites 1374_03, a river bed within the Additional Mine Area and 1374_F3 and 1374_F12, creek beds within the Lalla Rookh reference/non-impact area. The specimens belonged to an undescribed species of *Austrohorus* which resembles specimens collected from elsewhere in the Pilbara, as such these specimens **do not represent SREs** (Burger *et al.* 2011).

***Beierolpium* 'sp. 8/4 lge'**

Six specimens were collected from sites 1374_02, 1374_05, 1374_07, 1374_10 and 1374_12, within the Additional Mine Area. These specimens belong to the undescribed species *Beierolpium* 'sp. 8/4 lge'. Due to a lack of taxonomic knowledge, the SRE status cannot be confirmed and as such these specimens represent **potential SREs** (Burger *et al.* 2011).

***Beierolpium* 'sp. 8/2'**

Two specimens were collected from site 1374_11, a river bed within the Additional Mine Area. These specimens belong to the undescribed species *Beierolpium* 'sp. 8/2'. Due to a lack of taxonomic knowledge, the SRE status cannot be confirmed and as such these specimens represent **potential SREs** (Burger *et al.* 2011).

'Genus 7/4' sp.

A single specimen was collected from site 1374_07, a gully base within the Additional Mine Area. This specimen belonged to an undescribed genus currently known as 'Genus 7/4'. Based on current knowledge, this specimen **does not represent a SRE** (Burger *et al.* 2011).

'Genus indet' 'sp. juv.

Six juvenile specimens were collected from sites 1374_01, 1374_02, 1374_03 and 1374_06, within the Additional Mine Area. Due to the juvenile stage, the specimens could not be described, however, these specimens **do not represent SREs** (Burger *et al.* 2011).

'PSEAAA' sp.

Three specimens were collected from sites 1374_05 and 1374_10, river beds within the Additional Mine Area. These belong to the undescribed genus 'PSEAAA'. Based on current levels of knowledge, these specimens **do not represent SREs** (Burger *et al.* 2011).

***Indolpium* sp.**

Twenty-seven specimens were collected from 15 sites across the North Star Project Areas and Lalla Rookh reference/non-impact areas. The specimens look to comprise a single species, and similar species have been collected from other regions of Western Australia suggesting that only a single species is involved. Based on current knowledge, these specimens **do not represent SREs** (Burger *et al.* 2011).

4.2.2 Chilopoda

4.2.2.1 Geophilomorpha

Family Geophilidae

Two specimens were collected from 1374_F8, a minor channel within the Lalla Rookh reference/non-impact area. These specimens belonged to the family Geophilidae. Due to the lack of taxonomic knowledge of the family the species is unknown, however, Geophilidae does not contain any known SRE species and therefore these specimens **do not represent SREs** (M. Burger, Pers. comm. 27/10/2011).

4.2.2.2 Scolopendramorpha

Family Cryptopidae

Two specimens were collected from 1374_F8, a minor channel within the Lalla Rookh reference/non-impact area. These specimens belonged to the family Cryptopidae. Due to the lack of taxonomic knowledge of the family the species is unknown, however, Cryptopidae does not contain any known SRE species and thus these specimens **do not represent SREs** (M. Burger, Pers. comm. 27/10/2011).

4.2.3 Malacostraca

4.2.3.1 Isopoda

Family Armadillidae

Acanthodillo sp. 6

Three specimens were collected from 1323_03, woodland on a plain within the Infrastructure Corridor. These specimens represent a new species of *Acanthodillo*. This genus is often partially subterranean and cryptic and has been found elsewhere in the Pilbara. All specimens are very similar and there is a distinct and consistent pattern of dorsal ornamentation. The three specimens are juveniles and so this is a tentative diagnosis. As yet, it has not been collected outside the Pilbara. There are similar species found the south-west and the Kimberley. This is probably a common and widespread in the Pilbara and therefore these specimens **do not represent SREs** (Judd 2011a).

Buddelundia sp. 11

Two specimens were collected from 1323_12 (a south facing midslope within the Mine Area) and one specimen was collected from site 1374_F03 (creek bed within the Lalla Rookh reference/non-impact area). This is a highly unusual and spectacular new species of *Buddelundia*. It has previously been recorded from nearby locations in the Pilbara, and is a large species morphologically adapted to a dry climate. It is likely to be restricted to a particular habitat type in the Pilbara although more information regarding the species is required. This species should be considered **a potential SRE** (Judd 2011a).

Buddelundia sp. 13

A total of 129 specimens were collected from sites 1323_02, 04, 05, 07, 09, 10, 11, 12, 13, 14 and 15, across the Mine Area and Infrastructure Corridor, and five specimens were collected from sites 1374_03, 06, and 10 within the Additional Mine Area. This is a large species and perhaps the most common arid zone form of *Buddelundia*. It is widespread but there are slight differences among specimens collected across the Pilbara. It has been collected elsewhere and is likely to be relatively common and widespread and therefore these specimens **do not represent SREs** (Judd 2011a).

Buddelundia sp. 14

Four specimens were collected from sites 1374_04 and 1374_F01, a riverbed within the Additional Mine Area and a creek bed within the Lalla Rookh reference/non-impact area. This is one of the most common and widespread species found in the Pilbara and therefore these specimens **do not represent SREs** (Judd 2011a).

***Buddelundia* sp. 18**

A total of 23 specimens were collected from sites 1323_07, 09, 12 and 13 across the Mine Area and Infrastructure Corridor, and five specimens were collected from sites 1374_S06, 04 and 05 within the Additional Mine Area. This is a relatively small and highly convex species, and there are a number of related species. None of these species have wide distributions and, to date, all are found in the Pilbara. These specimens should be considered **potential SREs** (Judd 2011a).

***Buddelundia* sp.**

One specimen was collected from site 1323_07, a creek line within the Infrastructure Corridor, and appeared to be a juvenile of a species of *Buddelundia* different from the three listed above. It is most likely one of the other common species of *Buddelundia* but due to being a juvenile cannot be fully identified. This specimen **does not represent a SRE** (Judd 2011a).

***Buddelundia* sp. 19**

A total of 19 specimens were collected from sites 1323_01, 03, 07, 09, 10, 11, 13 and 14 across the Mine Area and Infrastructure Corridor, and seven specimens collected from sites 1374_02, 06, 07 and 10 within the Additional Mine Area. This was previously thought to be a new genus closely related to *Buddelundia* and *Barrowdillo*: however, this species is actually a more primitive form of *Buddelundia*. There are similar specimens found across the Pilbara and a considerable amount of work is needed to establish the systematics and distribution of this species and to refine the diagnoses of both *Buddelundia* and *Barrowdillo*. These specimens **do not represent SREs** (Judd 2011a).

4.2.4 Mollusca

4.2.4.1 Gastropoda

Family Pupillidae

Pupoides* sp.cf.*P. beltianus

Eight specimens were recorded from sites 1323_02, 1323_06, 1323_09 and 1323_F02 within the Mine Area and Infrastructure Corridor, and a further one specimen recorded from site 1374_S2 in the Additional Mine Area. These specimens most closely resemble *Pupoides beltianus*, which has a known distributional range encompassing an area from the Reynolds and Jervis ranges in the Northern Territory, south to the Musgrave and Mann Ranges in South Australia and then west to the Barrow Ranges in Western Australia. These areas are situated near the junction of the borders of Western Australia, South Australia and the Northern Territory. These specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

***Pupoides pacificus* (incl. *P. cf. pacificus*)**

A total of 10 specimens were collected from sites 1323_02 and 1323_08 within the Infrastructure Corridor, and a further six specimens from sites 1374_S6 and 1374_S10 within the Additional Mine Area. This species is widespread throughout the Pilbara, extending east of Kununurra westward and southward to Quondong Point, north of Broome, and possibly with an even wider distribution. These specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Pupoides eremicolus

One specimen was collected from site 1323_02, a riverbed within the Infrastructure Corridor. The specimen collected mostly resembles the large sinistral species *Pupoides eremicolus* which is a known species from central Australia. This species has a known distributional range in the southern part of the Northern Territory with a few records from western Queensland. More recent records suggest that this species is also widely distributed throughout the inland Pilbara region. This specimen **does not represent a SRE** (Whisson and Slack-Smith 2011).

Sub-family Gastrocoptinae

Gastrocopta mussoni

Twenty-two specimens were collected from sites 1323_01, 1323_02, 1323_06 and 1323_08 within the Infrastructure Corridor, and a further two specimens from 1374_S6 within the Additional Mine Area. There are two forms of this species, a cylindrical form and an ovate form. *G. mussoni* is recorded as having a geographical distribution in Central Australia, with specimens recorded from a few localities in the northern parts of Western Australia, the northern parts of the Northern Territory, the northern and north-eastern parts of Queensland and also from the mid-west coastal region of Western Australia. There are also a few records from South Australia. This species is widespread and therefore these specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Gastrocopta larapinta

Two specimens were collected from sites 1323_02 and 1323_13, a riverbed and rocky outcrop within the Infrastructure Corridor. *G. larapinta* is a minute dextrally-coiled species that has a large but patchy distribution in central Australia, with a few records from north-western and eastern coasts of Queensland. There is a single published record of this species from the Oscar Ranges in the southern Kimberley region of Western Australia. These specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Family Helicodiscidae

Stenophlis coarctata

Eleven specimens were collected from sites 1323_02, 1323_06 and 1323_13 within the Mine Area and Infrastructure Corridor. This species has been found throughout the Kimberley, many parts of the northern territory, Queensland and central Australia. It is also known from other countries such as the Philippines, Indonesia, New Guinea and the Solomon Islands, however more recently collected specimens indicate this species is widely spread throughout the Pilbara region. These specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Family Succineidae

***Succinea* sp.**

Six specimens were collected from sites 1323_02 and 1323_06, a riverbed and river bank within the Infrastructure Corridor. Specimens of this family have been poorly collected in the Pilbara and in many other areas of the state. This is likely due to the fragile nature of the shell and to the apparent inability of succineids to be active when conditions are not wet, highly humid and/or cool in temperatures. Under sub-optimal conditions the snails remain buried – in more southern areas for many months.

Only two species have been described from Western Australia, *Succinea strigillata* and *Succinea interioris*. Due to the paucity of data on this species there has been very little taxonomic research done on the family, and these specimens should therefore be **considered potential SREs** (Whisson and Slack-Smith 2011).

Family Lymnaeidae

Austropeplea cf. lessoni

A total of 18 specimens were collected from sites 1374_02, 1374_06 and 1374_F7 within the Additional Mine Area. These dead-taken shells closely resemble specimens of the Australian freshwater snail species, *Austropeplea lessoni*, widespread particularly in northern areas. Currently regarded as a single native Australian species, *A. lessoni* is common in northern and eastern areas of Australia, and has been recorded in Western Australia at least as far south as the Gascoyne region. These specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Family Planorbidae

Gyraulus sp.

Twenty-one specimens were collected from sites 1323_06 and 1323_08 within the Infrastructure Corridor, and a further eight specimens from site 1374_06 and four specimens from site 1374_02 within the Additional Mine Area. Records of the occurrence of this, or any other freshwater molluscan family in the Hamersley Range area, as in most of the inland Pilbara region, are sparse. Species of the genus are known from coastal and inland areas of all Australian states. This species has wide dispersal capabilities using flooding and/or transport by aquatic birds and as such these specimens **do not represent SREs** (Whisson and Slack-Smith 2011).

Isidorella cf. egregia

Forty-two specimens were collected from sites 1374_02, 1374_06, 1374_11 and 1374_F7 from within the Additional Mine Area. These small, solid shells most closely resemble the species *Isidorella egregia*. This species appears to have a wide distribution across the Pilbara region of Western Australia (Smith 1992). These specimens do not represent SREs (Whisson 2011).

Superfamily Rissoidae

Sp. 1

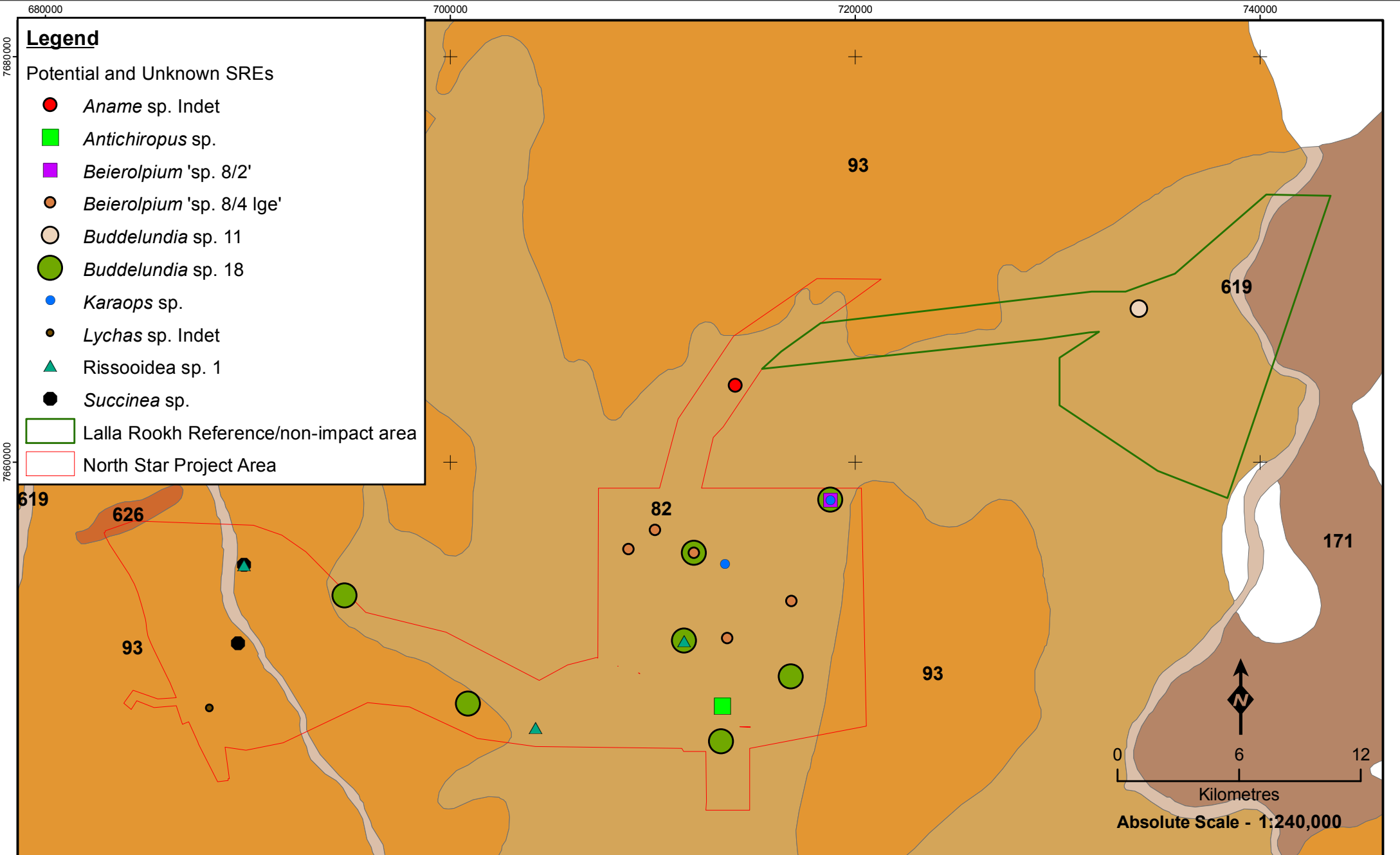
Four specimens were collected from sites 1323_04, 1323_06 and 1323_09 from riverbeds located within the Additional Mine Area. Members of this superfamily occupy all aquatic environments with some being amphibious. The specimens collected were dead, live taken material is generally needed to progress to a higher level of identification. Some members of this superfamily exhibit Short-Range Endemism, especially when associated with groundwater systems (Whisson and Slack-Smith 2011). The **SRE status of these specimens is unknown**.

4.2.5 Diplopoda

4.2.5.1 Polydesmida

Paradoxosomatidae

One specimen was collected from site 1323_11, a gully base within the Mine Area. The specimen could not be identified to species level, but is likely to be in the genus *Antichiropus*. The genus is the most abundant and diverse millipede group in Western Australia, and consists of over 110 species ranging as far north as the Pilbara and extending into the Nullabor Plain in South Australia. With the exception of *Antichiropus variabilis* and *Antichiropus* 'PM1' all species are potential SREs (Burger *et al.* 2011). This specimen should therefore be **considered a potential SRE**.



4.3 HABITAT ASSESSMENT ANALYSIS

Five different vegetation associations occur within the Project and potential and/or unknown SRE species were found in two (Table 4.4) - hummock grasslands, shrub steppe; kanji over soft Spinifex (vegetation association 93); and hummock grasslands, low tree steppe; snappy gum over *Triodia wiseana* (vegetation association 82). These two vegetation associations both have very little representation inside the Project Area (Table 2.2). Due to the overwhelmingly large area outside the Project Area, it is reasonable to assume that the widespread area of continuous vegetation association that remains non-impacted by the Project contains the potential and unknown SRE species collected during this survey.

Table 4.4 – Habitat Descriptions and SREs Present

Vegetation Association	Impact from the Project (%)	SRE Species Collected
93; Hummock grasslands, shrub steppe; kanji over soft Spinifex	0.47	<i>Succinea</i> sp. Rissooidea sp. 1 <i>Lychas</i> sp. ident <i>Buddelundia</i> sp. 18
171; Hummock grasslands, low tree steppe; snappy gum over soft spinifex & <i>Triodia brizoides</i>	0.49	-
619; Medium woodland; river gum (<i>Eucalyptus camaldulensis</i>)	0.82	-
82; Hummock grasslands, low tree steppe; snappy gum over <i>Triodia wiseana</i>	1.23	Rissooidea sp. 1 <i>Antichiropus</i> sp. <i>Buddelundia</i> sp. 11 <i>Buddelundia</i> sp. 18 <i>Karaops</i> sp. <i>Beierolpium</i> 'sp. 8/4 lge' <i>Beierolpium</i> 'sp. 8/2' <i>Aname</i> sp. ident
626; Hummock grasslands, shrub-steppe; kanji over soft spinifex & <i>Triodia brizoides</i>	0.05	-

4.4 SURVEY ADEQUACY

4.4.1 Species Accumulation Curves/ Number of Samples

North Star Mine Area and Infrastructure Corridor Survey

Both the empirically observed SAC and the estimated Mao and Tau rarefaction curve suggest that a fraction of the diversity of SRE groups was sampled (Figure 4.2). The observed SAC is nearly a straight line with a slight plateau near the centre and an indication of asymptotic behaviour at the end. The Chao-1 estimator of total species richness predicts that the SRE assemblage in the area consists of approximately 28 species, with 95% confidence interval between 26 and 39 species. Most of the other richness estimators resulted in estimate values between 28 and 37 species (Table 4.5 –). The Michaelis-Menten (MMS) estimator used as stopping rule predicts that a total of 36.56 species potentially occur in the survey area. This number indicates that approximately 71 % (of the predicted 36.56) of the predicted SRE species were collected during this survey.

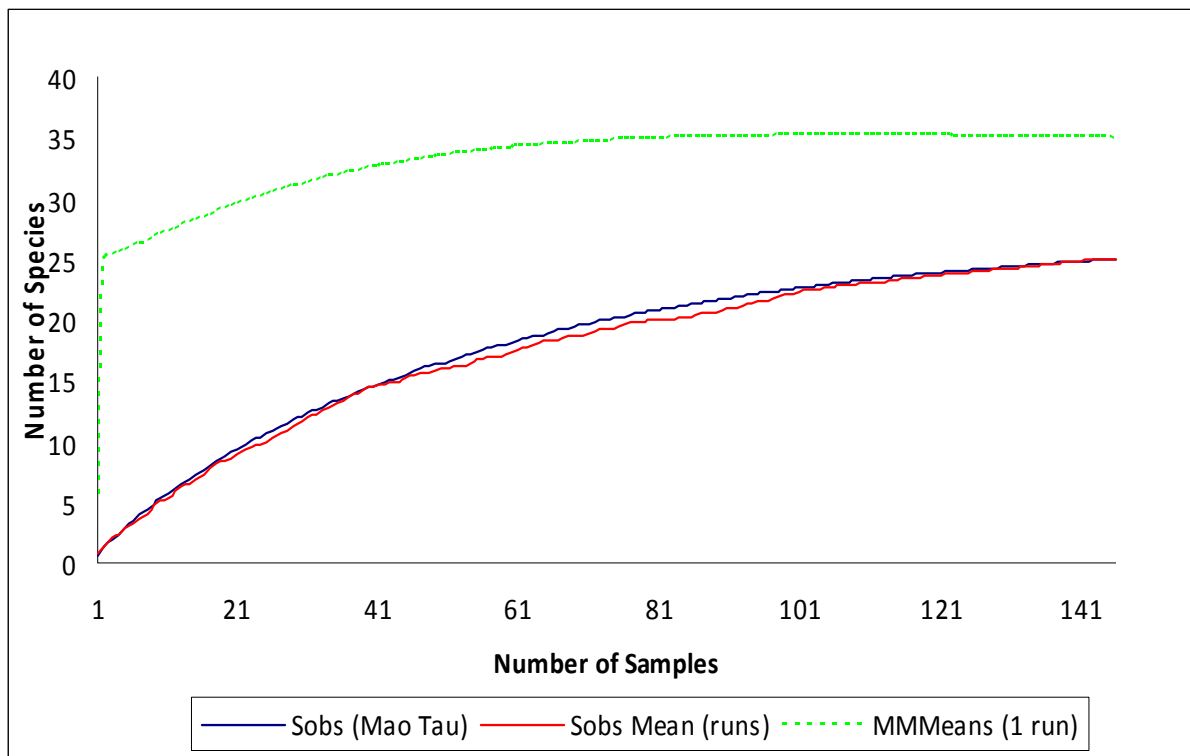


Figure 4.2 – Estimated Species Accumulation Curve for North Star Mine Area and Infrastructure Corridor Area (1323) (showing SRE assemblage in the area consists of approximately 37 species).

Table 4.5 – Mean estimates of total species richness of the SRE assemblage for North Star Mine Area and Infrastructure Corridor based on 50 randomisations.

Richness Estimators	Richness Estimate
ACE	31.37
ICE	29.29
Chao-1	28.14
Jack-1	31.96
Jack-2	31.02
Bootstrap	29.41
Michaelis-Menten	36.56

North Star Additional Mine Area and Lalla Rookh Reference/Non-impact Area Survey

Both the empirically observed SAC and the estimated Mao and Tau rarefaction curve suggest that a portion of the diversity of SRE groups was sampled (Figure 4.3). The observed SAC is a slight curve which begins to level near the end. The Chao-1 estimator of total species richness predicts that the SRE assemblage in the area consists of approximately 34 species, with 95% confidence interval between 31 and 46 species. Most of the other richness estimators resulted in estimates between the same values (Table 4.6). The Michaelis-Menten (MMS) estimator used as stopping rule predicts that a total of 49 species potentially occur in the survey area, the only estimator outside the 95% confidence range. This number indicates that approximately 63 % (31 species collected out of predicted 49) of the predicted SRE species were collected during this survey.

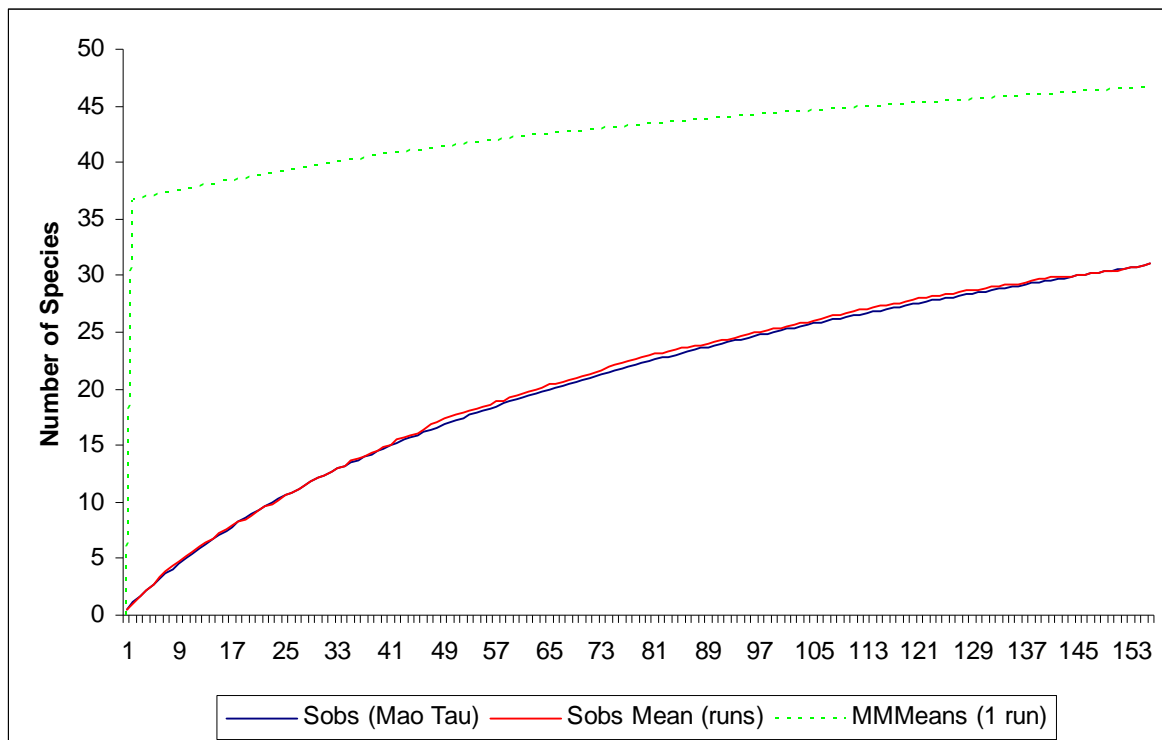


Figure 4.3 – Estimated Species Accumulation Curve for North Star Additional Mine Area and Lalla Rookh Reference/non-impact Area (1374)

Table 4.6 – Mean estimates of total species richness of the SRE assemblage for North Star Additional Mine Area and Lalla Rookh Reference/non-impact Area (1374) based on 50 randomisations

Richness Estimators	Richness Estimate
ACE	36
ICE	45.95
Chao-1	34.11
Jack-1	44.91
Jack-2	54.81
Bootstrap	36.99
Michaelis-Menten	49.06

Combined Survey Data

Both the empirically observed SAC and the estimated Mao and Tau rarefaction curve suggest that a portion of the diversity of SRE groups was sampled (Figure 4.4). The observed SAC is a slight curve which begins to level near the end. The Chao-1 estimator of total species richness predicts that the total SRE assemblage across both surveys consists of approximately 50 species, with 95% confidence interval between 47 and 63 species. Most of the other richness estimators (with the exception of Jack-2) resulted in estimates between the same values (Table 4.7). The Michaelis-Menten (MMS) estimator used as stopping rule predicts that a total of 62 species potentially occur in the survey area. This number indicates that approximately 74% (46 species collected out of predicted 62) of the predicted SRE species were collected during this survey. At this level of collection success, the possibility that some SRE species have not been recorded cannot be discounted.

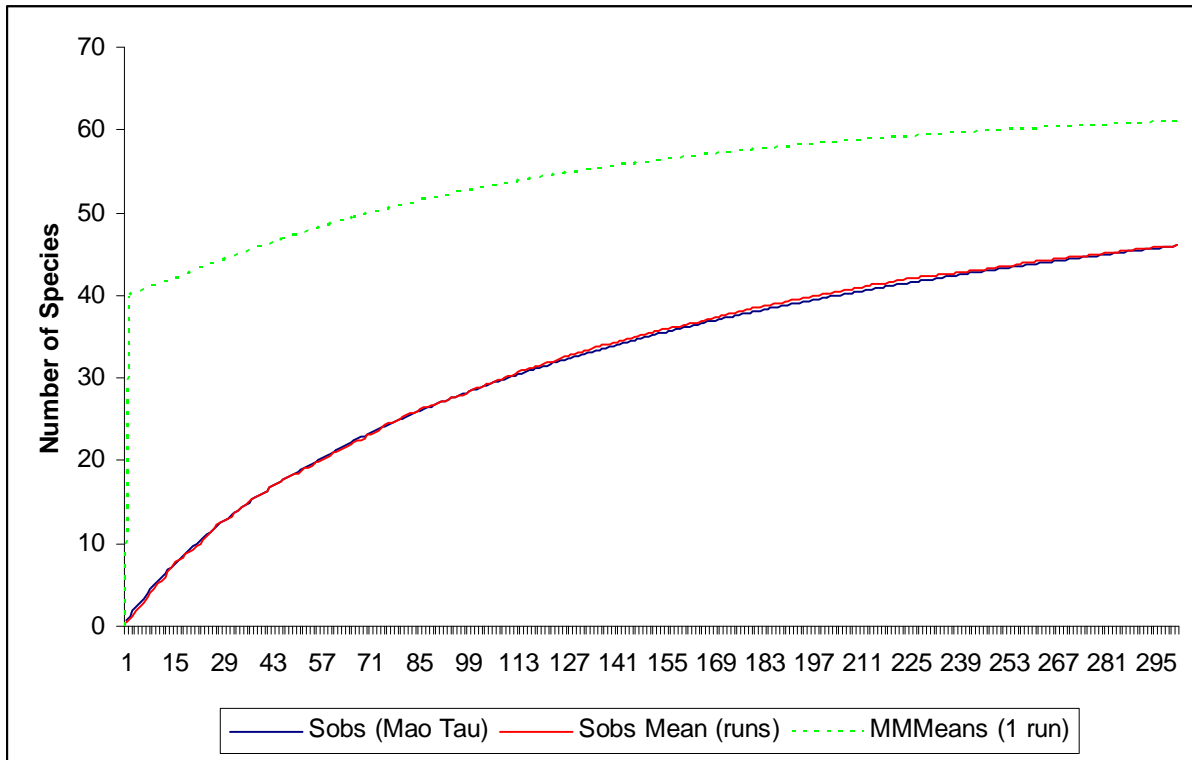


Figure 4.4 – Estimated Species Accumulation Curve for Combined Survey Data (1323 and 1374)

Table 4.7 – Mean estimates of total species richness of the SRE assemblage Combined Survey Data (1323 and 1374) based on 50 randomisations

Richness Estimators	Richness Estimate
ACE	54.44
ICE	58.79
Chao-1	50.23
Jack-1	60.95
Jack-2	67.93
Bootstrap	53.1
Michaelis-Menten	61.96

4.5 SURVEY LIMITATIONS

The limitations of the survey are provided below in Table 4.8. The main limitation of the survey was the species identification resolution of some specimens due to the lack of knowledge of the species collected. This can make it difficult to determine the distribution of the species collected and therefore the level of management they require. The precautionary principle addresses this limitation by treating all unknown and potential SREs as confirmed SREs thus allowing for management recommendations to be put in place despite the lack of knowledge.

Table 4.8 – Limitations for the SRE Surveys at the North Star Project

Aspect	Limitation (Y/N)	Comment
Survey Adequacy	No	Test of survey adequacy estimated survey sufficiency as 71% for North Star Mine Area and Infrastructure Corridor Survey, and 77 % for North Star Additional Mine Area and Lalla Rookh Reference/non-impact areas.
Method Efficiency	No	Survey methods utilised were efficient at collecting a broad range of SRE groups
Seasonality	No	Survey occurred during the wet season which is consistent with the EPA Guidance Statement 20. Significant rainfall did occur before and during the sampling period.
Field Personal Experience	No	All field personnel had a minimum of three years experience working with terrestrial invertebrates.
Species Identification Resolution	Possible	Poor taxonomic knowledge of various taxa (e.g. pseudoscorpions) Specimens could not be identified to species level due to poor taxonomic knowledge of these groups, however are considered potential SREs because of biology or knowledge of closely related species.
		New species but unknown distribution. Considered a SRE because of biology and closely related species.
		Specimens could not be identified to species level due to gender or immaturity. Unknown if they represent new or known species, however, considered a potential SRE as similar species have limited distribution
Adverse Weather Conditions	Yes	Heavy rainfall prevented field team from sampling all 22 survey sites during the North Star Mine Area and Infrastructure Corridor survey. A total of 15 survey sites were sampled instead. A further three 'foraging only' sites were sampled during phase two giving a total of 18 SRE survey sites. Heavy rainfall may result in SRE pitfall traps being washed out and therefore losing specimens or affecting the condition of the specimens for identification. Several traps were found to be full of rainwater; however there is no way of quantifying how much, if any, data was lost.

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5 DISCUSSION

Results from the DEC NatureMap database showed that 38 species are listed by the *EPBC Act*, *WC Act* or DEC as being formally recognised as rare, threatened, or as having high conservation value in the Pilbara. These species include 11 arachnids, 18 crustaceans, one annelid, four millipedes, three insects and one mollusc. None of those listed species were recorded in the North Star Project Areas or Lalla Rookh reference/non-impact area.

Twenty-one species recognized as either confirmed SREs, potential SREs or unknown SREs were identified as the result of WAM database searches. These included seven Mygalomorph spiders, four scorpions, seven pseudoscorpions and three millipede species. Spiders from the genus *Aname* and *Karaops* were recorded from the Project Area with the potential for Short-Range Endemism; however, neither of these species represented species of conservation significance.

The *ecologia* database search identified five potential SREs and four unknown SREs. Of these, there were four mygalomorph spiders, one isopod, one snail and three pseudoscorpions. The isopod *Buddelundia* sp. 11, the snail *Succinea* sp., and spiders from the genus *Aname* were all recorded from the Project Area; however, none of these species were listed as species of conservation significance.

More than 450 invertebrate specimens from SRE groups were collected during the survey, represented by nine orders, 20 families, and 45 species. This suggests that the Project Area is very rich in invertebrate biodiversity when compared to other surveys of similar size conducted in the Pilbara where number of species recorded was between 36 and 41 (*ecologia*, unpublished data). This is also supported by the large number of singletons and doubletons in the data, which suggests, too, that the area is rich in invertebrate species. The survey efficiency estimated at 76% suggests that although the survey sampling was adequate for the purpose of the survey it is possible that some species, from invertebrate groups containing SREs, have not been collected. None of the species collected were listed by the *EPBC Act*, *WC Act* or DEC, and no confirmed SRE species were recorded during the survey; however, under the precautionary principle, all unknown and potential SREs should be treated as confirmed SREs.

The eight potential SREs collected during the survey included two spiders (*Aname* sp. indet. and *Karaops* sp.), two pseudoscorpions (*Beierolpium* 'sp. 8/2' and *Beierolpium* 'sp. 8/4 lge'), two isopods (*Buddelundia* sp. 11 and *Buddelundia* sp. 18), one mollusc (*Succinea* sp.), and one millipede (*Antichiropus* sp.), and the two species with unknown SRE status included one scorpion (*Lychas* sp. Indet) and one mollusc (*Rissooidea* sp. 1).

A summary of the SREs collected and location can be found in Table 5.1.

A single, juvenile specimen from the spider genus *Aname* was collected from site nine within the North Star Additional Mine Area. Due to the life stage of the specimen it could not be identified to species level but based on the distribution of many *Aname* species, all species are considered SRE unless proven otherwise. This specimen should therefore be considered a potential SRE. The specimen was collected in a creek bed which represents typical SRE habitat. It was located within vegetation association 82 which is widespread in regional areas that will not be affected by the Project. Further *Aname* specimens were collected from two sites within the Mine Area and Infrastructure Corridor; however, these specimens did not represent SREs. The juvenile specimen could potentially represent the same species, in which case the species would appear to have a wide distribution across the Project Area; however, unless male specimens are collected there is no way to positively identify this specimen. Under the precautionary principle, this specimen should be treated

as a confirmed SRE and whilst it is likely to exist in regional areas, populations inside the Project Area may still be affected by the Project. These affects may be lowered due to the specimens' proximity to the Lalla Rookh reference/non-impact area, and also by the low percentage of impact (1.23%) to vegetation association 82.

Two specimens from the spider genus *Karaops* were collected within the North Star Additional Mine Area from typical SRE habitat types (a creek bed and a river bed). Spiders from this family tend to inhabit rocky areas where they may be restricted due to adaptations to this habitat type. One specimen was collected from site 11, located in the north-east corner of the Additional Mine Area, from a river bed which extends beyond that of the Project Area. This specimen was located in close proximity to the Project boundary. The other specimen was collected from site 01, located in the rocky hills and gullies of the Mine Area. As the specimens were collected from two different habitats, one of which extends beyond that of the Project Area, it is likely that this species exists outside the impact areas; however, no specimens were collected from the Lalla Rookh reference/non-impact area and as such this species may be impacted by the Project. Both specimens were collected in vegetation association 82, which extends beyond that of the Project Boundary and is expected to be impacted 1.23% by the Project. Any impacts to *Karaops* sp. is therefore expected to be low.

The pseudoscorpions *Beierolpium* 'sp. 8/2' and *Beierolpium* 'sp. 8/4 lge' were both collected from within the North Star Additional Mine Area in vegetation association 82. This vegetation type is widespread in regional areas that will not be affected by the Project. The pseudoscorpion *Beierolpium* 'sp. 8/2' was recorded at one site, close to the north-east boundary of the Additional Mine Area in a river bed that extends beyond the Project boundary. The vegetation association also spreads across the Project boundary and it is likely that *Beierolpium* 'sp. 8/2' exists there. However, this species was collected from only one site and no other specimens were collected from the Lalla Rookh reference/non-impact area. As such, this species may be impacted by the Project. *Beierolpium* 'sp. 8/4 lge' was collected at five different sites across the Additional Mine Area. These specimens were also collected from vegetation association 82 which is widespread in regional areas that will not be affected by the Project. *Beierolpium* 'sp. 8/4 lge' has also been collected in other areas of the Pilbara such as north-west of Tom Price (*ecologia*, unpublished data) and therefore any impacts from the Project are expected to be low.

Two isopods, *Buddelundia* sp. 11 and *Buddelundia* sp. 18 were collected from within the North Star Mine Area, Infrastructure Corridor and Additional Mine Area. All specimens were located in the same vegetation association (82) which is widespread in regional areas outside the Project Area. Both species were also located at more than one site representing typical SRE habitat (i.e. rocky outcrops, creek lines, river beds and south facing slopes) and have been recorded elsewhere in the Pilbara (S. Judd, pers. comms.). *Buddelundia* sp. 11 was also collected from the Lalla Rookh reference/non-impact area where it will not be affected by the Project, and it is likely that both species will exist in regional areas offering the same typical SRE habitat types. Any impacts from the Project on these species are therefore expected to be low.

A single specimen from the millipede genus *Antichiropus* was collected from within the North Star Mine Area within a gully base. While species are known in other areas of Western Australia and, in particular, the Pilbara, all species collected are considered potential SREs with the exception of *Antichiropus variabilis* and *Antichiropus* 'PM1'. The specimen was collected from vegetation association 82 which is widespread in regional areas outside the Project Area, and from a site that does not represent typical SRE habitat. Whilst it is likely that this species exists outside the impact areas, no further specimens were collected from Lalla Rookh reference/non-impact area. As such, this species may be impacted by the Project.

Six specimens of the snail genus *Succinea* were collected from two sites within the Infrastructure Corridor. Both sites were located on a river bank which represents typical SRE habitat. The river extends beyond that of the Project Area and it is likely that these specimens exist there, however no specimens have been collected outside the impact areas to date, although this is due to a lack of sampling. The sites were located within vegetation association 93 of which 0.47% may be impacted by the Project. Given this low impact, and the likelihood that *Succinea* sp. exists in areas outside the Project Area any impacts to this species are expected to be low.

Four specimens from the snail family Rissoidae were collected from three sites, in river beds and creek lines, within the Mine Area and Infrastructure Corridor. The specimens were collected from two different vegetation associations 82 and 93, both of which are widespread outside the Project Area. The river at site six also extends beyond that of the Project Area. It is possible that specimens from the family Rissoidae exist outside the Project Area in areas that will not be affected by the Project, however none were collected outside during this survey. The percentage impacts to the vegetation type the specimens were located in area 1.23% and 0.47% respectively. Any impacts from the Project are therefore expected to be low.

One juvenile scorpion specimen from the genus *Lychas* was collected from within the Infrastructure Corridor. The specimen could not be identified to species level due to life-stage and as such has SRE status unknown. It was collected from a rocky outcrop which represents typical SRE habitat. Despite this, no other SREs were collected from this site. Several other species of *Lychas* which were not SREs were also collected during the survey from both the Mine Area and Infrastructure Area, and Additional Mine Area. There is a possibility that this specimen represents one of these species, however due to it being a juvenile this cannot be determined and under the precautionary principle it should be treated as an SRE. It was located within vegetation association 93 which extends beyond the Project Area and will only be impacted from the Project by 0.47%. Any impacts to this species are therefore expected to be low.

Because effective invertebrate conservation cannot rely on conventional single species approaches adopted for the conservation of vertebrates and plants (Clark and Spier-Ashcroft 2003; Clarke and Spier-Ashcroft 2003), the focus of modern invertebrate conservation has changed to a more community and landscape scale approach with a primary emphasis on habitat conservation. Invertebrate conservation should be promoted more effectively by habitat preservation and management rather than single species-initiatives (Lewinsohn *et al.* 2005). Applying such approach to the outcomes of this survey, the land systems and vegetation types were used to assess the overall impact of the Project on the invertebrate assemblage within the Project Area. This is because the vegetation types along with the land system reflects underlying geology, soil, surface hydrology and position in the landscape, and thus provide a reasonable surrogate of habitat parameters in respect to SREs.

The survey sites were located over 10 land systems, which all had the potential to support SREs due to moderate to high levels of shade, moisture and/or suitable microhabitat i.e. moderately deep leaf litter beds, canyons and gullies. All of the four vegetation associations found within the Project Area extend beyond the limits of the Project Area. Whilst several sites were located in typical SRE habitat (i.e. river beds, creek lines, rocky outcrops, south facing slopes) none were considered unique to the Project Area. Consequently, it is likely that the invertebrate assemblage found within the Project Area extends well beyond the Project Area and thus the impact from the Project development on the potential SRE is expected to be moderate to low.

Table 5.1 – Summary of SRE Specimens Collected for North Star Project

Species	SRE Status	Collected Outside	Comments
<i>Aname</i> sp.	Potential	No	Collected in close proximity to Lalla Rookh reference/non-impact area, in widespread vegetation association. Likely to exist outside impact areas.
<i>Karaops</i> sp.	Potential	No	Collected from two localities, one of which is close to Project Boundary. Also collected in river system which extends beyond Project Boundary. Likely to exist outside impact areas.
<i>Lychas</i> sp.	Unknown	No	Could not be identified to species level due to life stage. Possibly represents non-SRE <i>Lychas</i> species collected elsewhere in Project Area.
<i>Beierolpium</i> 'sp. 8/2'	Potential	No	Collected from riverbed that extends beyond the Project Boundary. Likely to exist in areas outside impact area.
<i>Beierolpium</i> 'sp. 8/4 lge'	Potential	No	Collected from several sites across both Project Areas, and from other parts of the Pilbara. Likely to exist outside the impact areas.
<i>Buddelundia</i> sp. 11	Potential	Yes	Collected from Lalla Rookh reference/non-impact area. Will not be impacted by the Project.
<i>Buddelundia</i> sp. 18	Potential	No	Collected at several sites across both Project Areas, and collected elsewhere in the Pilbara. Likely to exist outside the impact areas.
<i>Antichiropus</i> sp.	Potential	No	Only collected from one site, in non typical SRE habitat.
<i>Succinea</i> sp.	Potential	No	Collected from river bed which extends north and south of Project Area. Expected to exist outside impact area.
Rissooidea sp. 1	Unknown	No	Collected from two vegetation associations, and from a river bed that extends beyond the Project Boundary. Expected to exist outside the impact areas.

6 CONCLUSIONS

The main conclusions of the survey were:

- A total of 38 conservation significant species were found during the NatureMap database search of the nearby areas. None were recorded during the survey;
- The survey methods were consistent with the EPA Guidance Statement 20 to sample for SRE fauna;
- Species estimators found the survey was adequate with an estimated 76% of predicted SRE species collected during the survey;
- A total of 45 species were collected, of which 10 species were considered to represent potential or unknown SRE species;
- The isopod *Buddelundia* sp. 11 was recorded from the Lalla Rookh reference/non-impact area where it will not be impacted by the Project;
- All other potential and/or unknown SREs were located inside the Project Area where they may be impacted by the Project;
- None of the SRE habitats from which the potential and/or unknown SRE species were located are unique to the Project Areas;
- All vegetation associations, that SREs were located within, extend beyond the Project boundary; and,
- On the scale of impact ranging from high - moderate - low, the impact from the Project development on the potential and/or unknown SRE species is expected to be moderate to low.

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7 STUDY TEAM

The Fortescue North Star Short-Range Endemic Invertebrate Surveys described in this document were planned, coordinated, and executed by:



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Special Thanks:

Dr Mark Harvey and Mieke Burger: Department of Terrestrial Invertebrates, Western Australian Museum and Dr Shirley Slack-Smith and Mr Corey Whisson: Department of Malacology, Western Australian Museum for database searches and species identification. Dr Erich Volschenk for Scorpion identification, Dr Volker Framenau for spider identification and Dr Simon Judd for isopod identification.

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APPENDIX 1

SITE DESCRIPTIONS

APPENDIX 2

WAM DATABASE SEARCH RESULTS

APPENDIX 3

ECOLOGIA INTERNAL DATABASE SEARCH RESULTS