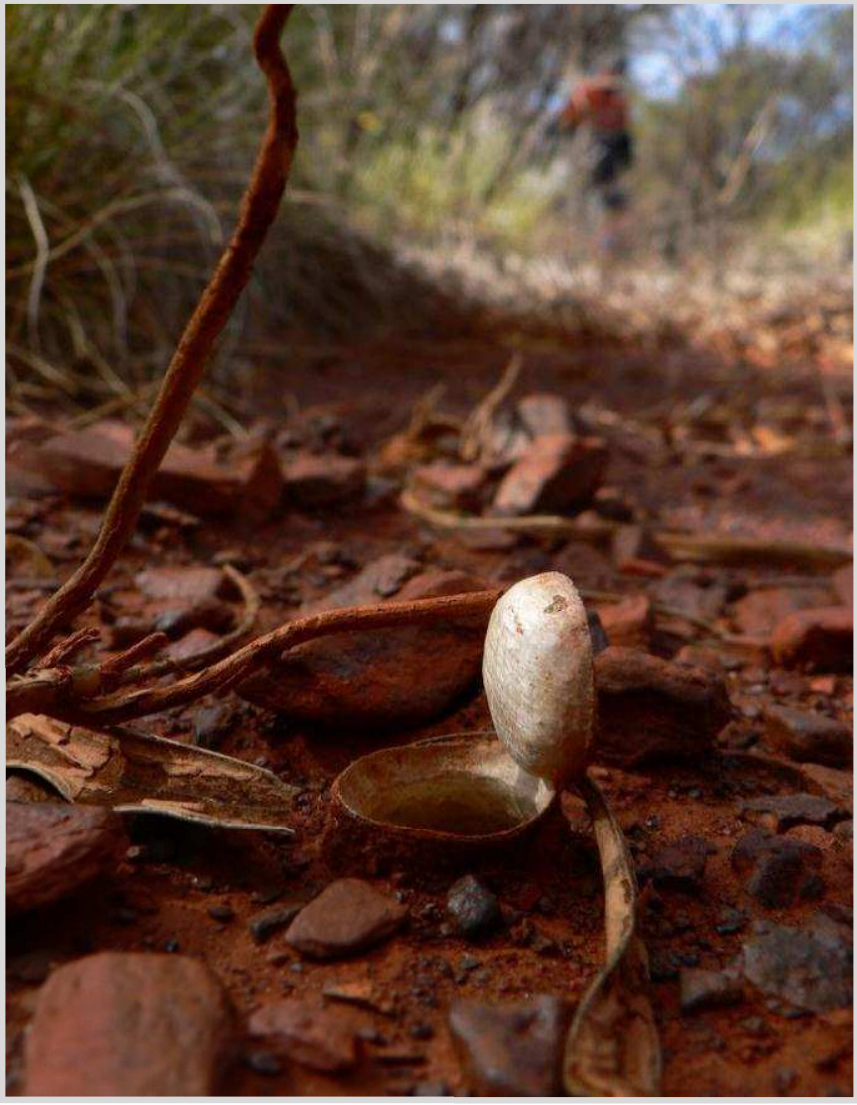
Rio Tinto

Turee Syncline Iron Ore Project, Short Range Endemic Invertebrates Survey



Final Report

Prepared for
Rio Tinto
by Bennelongia Pty Ltd

February 2012

Turee Syncline Iron Ore Project, Short Range Endemic Invertebrates Survey

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Cover picture: Burrow and lid of mygalomorph spider *Eucyrtops* sp. B02

Client – Rio Tinto

Report	Version	Prepared by	Checked by	Submitted to Client	
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EXECUTIVE SUMMARY

The proposed Turee Syncline Iron Ore Project (the Project) is located approximately 10 km east of Paraburdoo airport in the Pilbara region of Western Australia. The Project is located along a 30 km stretch of the northern and north-western ridges of the Turee Syncline.

This report has been prepared by Bennelongia for Rio Tinto to support its environmental impact assessment of the Project. The report collates the results of survey conducted by Bennelongia and previous baseline survey by Phoenix Environmental Sciences in 2009. The objectives of this report are:

- To document the known and possible SRE species occurring within the Potential Impact Area of the Project;
- To determine which, if any, of the known or possible SRE species are apparently restricted to, or have most of their population within, the Potential Impact Area;
- To characterise the habitats in which any apparently restricted SREs occur and identify other occurrences of these habitats in the Potential Impact Area and the larger Study Area that includes the surrounding 5 km; and
- To assess the threat to persistence of any potential SRE species as a result of mine construction and operation.

The survey approach and methods used in the SRE survey for the Project were based on the Environmental Protection Authority's (EPA) Position Statement 3 and Guidance Statement 20. In accordance with best practice in arid areas of Western Australia, the survey was designed to target seven invertebrate groups: land snails, scorpions, trapdoor and wall crab spiders, false scorpions, slaters, centipedes and millipedes. A total of 2276 specimens, representing 51 species belonging to the seven target SRE invertebrate groups, were collected.

The results of an assessment of the SRE status of each species were as follows:

- None of the species was considered to be definitely an SRE nor highly likely to be an SRE; and
- Twelve species were considered to be potential SREs. These comprised one species of scorpion, four pseudoscorpions, four mygalomorph spiders, two isopods and one centipede that were represented in sampling by one or two animals.

In terms of assessing the likely threat posed by mining to the conservation of the species known only from the Potential Impact Area, no information on the real extent of a species can be deduced from the collection of a single animal and little can be concluded from the collection of two specimens. Low animal abundance and sparse collections are to be expected in SRE surveys because of the biological characteristics of SREs and EPA Guidance Statement 20 proposes that habitat mapping is a method of determining whether species are likely to be found more widely. Habitat mapping at Turee Syncline indicates there are large connected areas of suitable undisturbed habitat of the two habitat types (FT and GG) in which possible SRE species occur. These areas of FT and GG habitats extend beyond the Potential Impact Area. Therefore, it is unlikely that any possible SRE species in these habitats would actually be restricted to the 157 km^2 of the Potential Impact Area. It is most likely that they are currently known only from the Potential Impact Area because there has been little invertebrate sampling across the Pilbara.

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1. INTRODUCTION

The proposed Turee Syncline Iron Ore Project (the Project) is located approximately 10 km east Paraburdoo airport in the Pilbara region of Western Australia (Figure 1.1). The Project is located along a 30 km stretch of the northern and north-western ridges of the Turee Syncline.

Major mine components/processes that represent potential impacts to short-range endemic (SRE) invertebrates include the following:

- Iron ore will be mined by open pit methods from a series of pits along Turee Syncline, with approximately 350 ha cleared to mine the orebodies;
- the overburden removed from the pits prior to mining ore will be disposed of as in-fill within mined-out sections of the open pits and in adjacent overburden storage areas (OSAs) of approximately 250 ha;
- clearing of land of approximately 600 ha for mining infrastructure, including, primary crushers administration facilities, workshops, roads, laydown and wash down areas, waste management facilities, power and water infrastructure, and depending on the processing option pursued stockyard and train load-out (TLO) facility and rail spur.

Collectively an area of 157 km^2 ha has been identified by Rio Tinto that will include all of the above mining components/processes and this area has been designated the Potential Impact Area (Figure 1.1).

Short range endemic (SRE) species are defined in the Environmental Protection Authority's (EPA) 2009 Guidance Statement No. 20 as *'terrestrial and freshwater invertebrates that have naturally small distributions of less than 10,000 km^2'.* In practice, assessment of risk to SRE species is focussed on eight groups of terrestrial invertebrates that are characterised by having high proportions of SRE species in arid areas Western Australia. These groups include some families of land snails (Gastropoda), scorpions (Scorpionida), trapdoor and wall crab spiders (Araneae), false scorpions (Pseudoscorpionida), slaters (Isopoda), centipedes (Chilopoda), millipedes (Diplopoda) and worms (Oligochaeta) (EPA 2009). Their restricted ranges are often the result of events that fragmented historically broader distributions such as the extensive flooding of inland Australia during the Cretaceous and progressive climatic aridification since the Miocene (Harvey 2002). As a result of drying, faunal groups originally associated with historically damp conditions tend to be restricted to relictual islands of cooler more humid habitats such as caves, rock piles, springs, southern slopes, vegetated gorges and drainage channels (Harvey 2002; EPA 2009). Over time, habitat fragmentation has led to speciation and an array of distinct taxa where previously there was one species. In addition to restricted ranges, SREs are characterised by limited capacity for dispersal, confinement to discontinuous habitats, slow growth rates, and low fecundity; all of which make them vulnerable to disturbance (Harvey 2002; Ponder and Colgan 2002).

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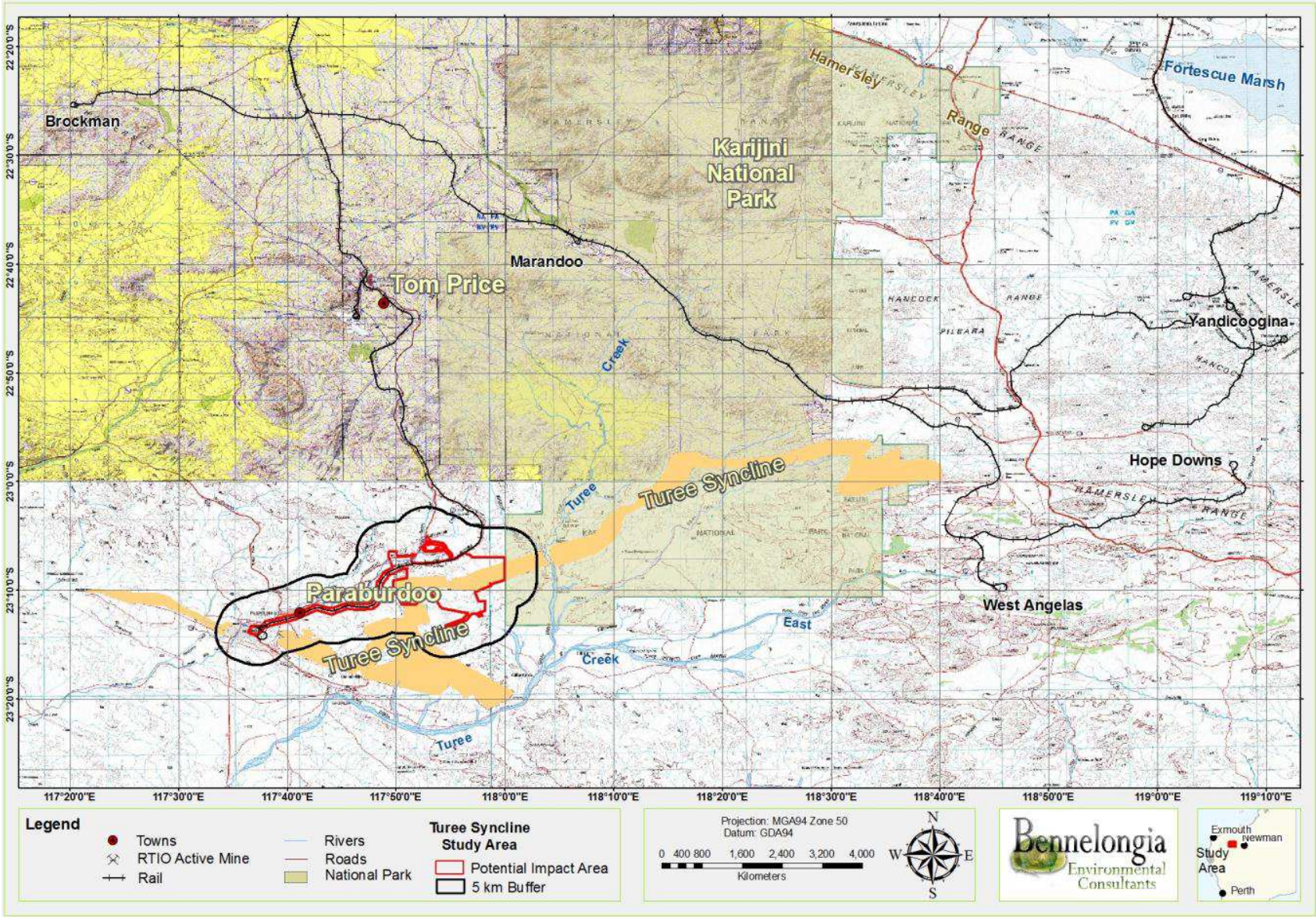

Figure 1.1. Location of Turee Syncline Study Area in relation to Turee Syncline itself.

- To characterise the habitats in which any apparently restricted SREs occur and identify other occurrences of these habitats in the Potential Impact Area and the larger Study Area that includes the surrounding 5 km; and
- To assess the threat to persistence of any potential SRE species as a result of mine construction and operation.

2. SHORT-RANGE ENDEMICS IN THE VICINITY OF TUREE SYNCLINE

Habitats with the potential to support SREs occur within all bioregions of Western Australia. The common theme of these habitats is that they have greater moisture holding capacity than surrounding areas (Harvey 2002). In the context of the Pilbara, these habitats are likely to be found associated with south-facing rock faces and steep slopes, deep gorges and springs, deep litter beds, rocky outcrops, and undisturbed watercourses (where there is little grazing and buffel grass) or various combinations of these features (Main 1999; EPA 2009). Such habitats support only small, localised populations and the mostly low dispersal powers of SREs lead to the populations usually being isolated from each other.

Surveys of SREs for environmental impact assessment in the Pilbara have typically identified few species that are actually considered to be SREs. For example, at Kings mining area in the central Pilbara, 50 species were identified from targeted SRE groups, but only 12 were considered to be potential SREs (Phoenix 2010); while at the adjacent Firetail mining area, five potential and one confirmed SRE species were identified during a survey that collected about 27 species from targeted groups (Ecologia 2010). At Area C only three potential SRE species were recorded among approximately 21 species from target groups (Outback Ecology 2008).

3. STUDY AREA

The Turee Syncline Iron Ore Project lies on a 30 km stretch of the northern and north-western ridges of the Turee Syncline (Figure 1.1). The Turee Syncline features landforms typically observed in the Hamersley Subregion of the Pilbara Bioregion, including prominent ironstone ridges and hills of outcropping that separate deep to moderately deep valleys. Vegetation includes shrublands of mulga and snakewood scrub, shrub steppe and spinifex grasslands (Beard 1978).

Geologically, the Project focuses on the iron-rich Brockman Formation on the northern limb of the Turee Syncline. The large concave fold of the Turee syncline trends east-west and plunges to the east, raising the Brockman Formation, together with the underlying and older Marra Mamba Formation, at its western end. The rock layers are tilted south and form prominent outcrops along both the northern and north-eastern ridges of the syncline.

3.1. Climate

Paraburdoo airport, which is approximately 10 km east of the Project, is the nearest Bureau of Meteorology (BOM) weather station. Rainfall and temperature data for the airport are provided in Table 3.1 and are used to infer climatic conditions. The Paraburdoo area experiences a hot, dry summer and a mild winter. Most rainfall occurs in summer, with occasional cyclonic activity, but there is substantial year-to-year variation in the amount and pattern of rainfall. Average annual rainfall is 310 mm, ranging from a monthly average of 3.6 mm in September and October to 78.5 mm in February (Table 3.1).

Table 3.1. Climatic data for Paraburdoo Airport.

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean maximum temperature (^{O}C)	41.1	38.5	36.6	33.4	29.1	25.2	24.8	27.3	31.1	35.6	38.2	40.2	33.4	16
Mean minimum temperature (^{O}C)	26	25	23.2	19.7	14.6	11	9.8	10.8	13.4	18.1	21.3	24.3	18.1	16
Mean rainfall (mm)	47.7	78.5	45.6	27.1	16.9	22.5	15	11.9	3.6	3.6	8.3	29.2	310.4	37
Mean no. of days of rain >= 1 mm	5.1	6.3	4.3	3.1	2	2.5	1.9	1.2	0.5	0.7	1.3	3.3	32.2	37
Mean no. of days of rain >= 25 mm	0.4	0.9	0.4	0.3	0.1	0.2	0.1	0.1	0	0	0	0.2		37

Data courtesy of the online records of the Australian Bureau of Meteorology, 2012.

4. METHODS

4.1. EPA Guidance

The survey approach and methods used in the SRE survey for the Project were based on the Environmental Protection Authority (EPA) Position Statement 3 and Guidance Statement 20 (EPA 2002; EPA 2009). In accordance with best practice in arid areas of WA, the survey was designed to target seven invertebrate groups: land snails, scorpions, trapdoor and wall crab spiders, false scorpions, slaters, centipedes and millipedes. The only recognised SRE group not targeted was earthworms because the Study Area was in excess of 200 km inland and native earthworms have coastal distributions (Abbott 1994).

Guidance Statement 20 indicates that the SRE habitats which should be surveyed include islands, the Devonian Reef system in the Kimberley, isolated sandstone/limestone outcrops, isolated mesas, volcanic vents, granite outcrops, banded ironstones of the Mid-west and Goldfields, exposed dolomites or calcretes, boulder piles, isolated birridas, and lakes (EPA 2009; see also Section 2). In practice, most surveys of SREs in the Pilbara sample a slightly different array of habitats and the current survey followed suit (see Section 4.2.2).

4.2. Survey Rationale, Habitat Characterisation and Site Selection

4.2.1. Study Area

The Turee Syncline Study Area includes:

1. Potential Impact Area (157 km^2), which contains all of the proposed mining infrastructure and potential impacts to SREs and; and
2. A 5 km wide area around the Potential Impact Area that was assessed for SRE habitat using ortho-photographs. The Potential Impact Area and 5 km 'buffer' covered 799 km^2, Figure 4.1).

Part of the Potential Impact Area was previously surveyed by Phoenix during the winter of 2008. The data from the Phoenix report have been assimilated with the data collected by Bennelongia and are presented as a single dataset.

4.2.2. Survey Design

Habitat types were selected based on EPA (2009) guidelines and the information produced by previous SRE surveys in the Pilbara (e.g. Outback Ecology 2008; Phoenix 2010; Ecologia 2010; Bennelongia 2011b). Likely SRE habitat types within the Potential Impact Area were initially mapped during a desktop study (Bennelongia 2011a).

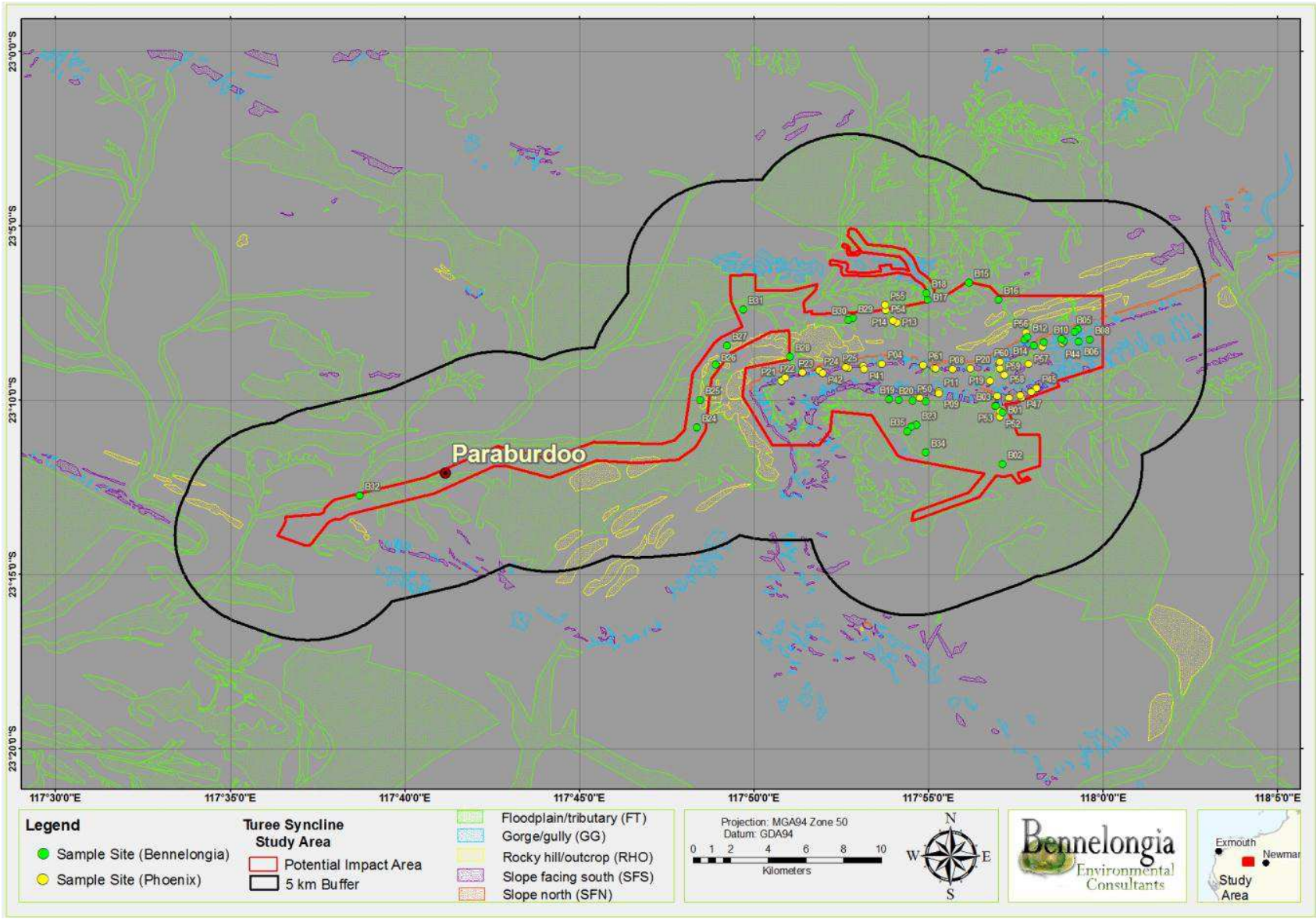

Figure 4.1. Study Area, Potential Impact Area, habitat characterisation and sampling sites at the Turee Syncline Project.

Habitat mapping in the desktop study formed the basis for the selection of sampling sites by Bennelongia, including determination of the number of sites sampled within each habitat in the Potential Impact Area (Table 4.1). Bennelongia selected sites so that the combined number of sites sampled by Phoenix and Bennelongia in each likely SRE habitat type was proportional to the area of each habitat in the Potential Impact Area (see Phoenix 2009), except that Gully/gorge (GG) habitat was sampled at about 10 times the intensity of other habitats because it was considered to be more prospective (e.g. Outback Ecology 2008; Phoenix 2010; Ecologia 2010; Bennelongia 2011b). Floodplain and tributary (FT), Slope - facing south (SFS), Slope - facing north (SFN) and Rocky hill or outcrop (RHO) were sampled at intensities ranging from 0.5 to 1.2 samples per km^2, whereas GG habitat was sampled at 6.2 samples per km^2.

Photographs of the sites surveyed, and their co-ordinates, are presented in Appendix 1.

4.3. Sampling Dates and Rainfall

Phoenix installed wet pitfall traps, foraged and collected litter from 23 to 27 June 2008. Traps were retrieved four weeks later between 28 July and 6 August (Phoenix 2009). Bennelongia foraged and collected litter between 8 and 12 August 2011 but do not use traps. There was 1.6 mm of rainfall during the Phoenix survey and no rainfall during the Bennelongia survey (online records of the Australian Bureau of Meteorology 2012).

Table 4.2. Habitat types, their extent within the Study Area.

Habitat Type	Survey site	Area (km^2) within Potential Impact Area	Area (km^2) within Study Area
Habitat 1 (*n*=30) Floodplain and tributary (FT)	B01, B02, B12, B15, B16, B17, B18, B19, B20, B21, B22, B23, B24, B28, B30, B31, B32, B33, B34, B35, P13, P14, P41, P50, P51, P52, P54, P55, P56, P59	54.3	307.1
Habitat 2 (*n*=34) Gully/gorge (GG)	B04, B05, B06, B07, B08, B09, B10, B11, B14, P03, P04, P06, P07, P08, P09, P10, P11, P18, P19, P20, P21, P22, P23, P24, P42, P43, P44, P45, P46, P48, P49, P58, P60, P61	5.5	12.7
Habitat 3 (*n*=6) Slope - facing south (SFS)	B03, P01, P25, P47, P53, P57	5.1	8.4
Habitat 4 (*n*=4) Rocky hill or outcrop (RHO)	B25, B26, B27, B29	7.8	26.1
Habitat 4 (*n*=1) Slope - facing north (SFN)	B13	0.9	1.3
Non-prospective Sparsely vegetated hilltops, plains and man-made structures		83.4	443.5
	Total Areas	**157.0**	**799.2**

4.4. Sample Effort

4.4.1. Phoenix

The Phoenix survey consisted of wet pitfall trapping, active searches (foraging) and the collection of litter samples at 40 sites (Figure 4.1). Ten wet pitfall traps were set at each of the 40 sites. Foraging at each site in an area 50 x 50 m was undertaken by two people for 45 minutes (i.e. 1.5 person hours of

foraging). Litter was collected from sites considered to be particularly prospective but which did not yield target taxa during foraging.

4.4.2. Bennelongia

The Bennelongia survey consisted of foraging and litter collecting at 35 sites (Figure 4.1). At the request of the Rio Tinto, wet pit trapping was not undertaken because the company was concerned there might be significant vertebrate by-catch. Sampling at each site was undertaken by four people for 45 minutes (i.e. 3.0 person hours of foraging). The extent of the area searched at each site was not pre-defined; rather the spatial extent of searching varied according to the nature of the specific habitat at each site.

4.5. Survey Methods

4.5.1. Phoenix

The habitat of each site was characterised during survey (descriptions were re-worked later by Bennelongia, see Section 4.8 and Appendix 2). Photographs were taken of all sites, but at least 23 photos of sites P01, P06, P08, P11, P13, P14, P18, P19, P20, P21, P22, P25, P41, P44, P45, P46, P47, P48, P49, P54, P57, P59 and P60 were lost as a result of camera malfunction (Phoenix 2009).

Pit traps comprised a 1-L plastic vessel of 70 mm diameter, filled with a mixture of ethylene glycol and formaldehyde (2.5% by volume). Traps were set for minimum of four weeks in suitable microhabitats within each site (Phoenix 2009).

Hand foraging included searching under bark, logs and rocks; and searching amongst leaf litter under tall shrubs and trees. Trapdoor spider burrows, where located and considered inhabited, were excavated (Phoenix 2009). Invertebrates were preserved in 100% ethanol.

When litter was collected, the number of samples was variable (Phoenix 2009).

4.5.2. Bennelongia

Prior to sample collection at each site, a site description was compiled and, where possible, quantitative information was collected about the habitat at each site, particularly in relation to landform, dominant substrate, amount of litter, vegetation types and indicative plant species present, and the extent of existing disturbance. Photographs were taken of all sites.

Hand foraging included raking and searching in crevices and under boulders, logs and bark in a range of microhabitats, especially where litter had accumulated. Numbers of trapdoor spider burrows were counted (these data are not presented) and representative burrows were excavated. Invertebrates caught while foraging were preserved in 100% ethanol.

At each site, 10 mixed soil and litter samples were collected from a representative range of microhabitats. Samples were placed in calico bags and transported live to the laboratory.

4.6. Sample Sorting and Species Identification

Soil and litter samples were sorted using two sieves (16 mm and 2 mm). Litter retained by the sieves was checked for fauna, and then discarded. The component of the sample passing through the 2 mm sieve was sorted under a MagiLamp™ and all fauna present were picked out.

All animals picked from samples were identified to Order level and all specimens belonging to target SRE groups were identified to species or morphospecies level using published and unpublished keys, unless damaged or otherwise unsuitable for identification. Specimens were dissected as required and viewed under dissecting and compound microscopes.

The alignment of identifications in the SRE groups that both Phoenix and Bennelongia collected (pseudoscorpions, millipedes, scorpions, trapdoor spiders, snails and slaters) was done by the following people: pseudoscorpions by Michael Curran (Bennelongia) and Mieke Burger (Western Australian Museum); millipedes by Michael Curran and Jane McRae (Bennelongia); scorpions Michael Curran and Erich Volschenk (Phoenix and ScorpionID); and snails by Vince Kessner (private consultant, Adelaide River, NT). Trapdoor spiders where not compared because only one mature male was collected (taxonomy is based on mature males) and slaters were not compared because the specimens collected by Phoenix could not be located.

4.7. Determining SRE Status

Decisions about whether a particular species belonging to an SRE group is actually an SRE (i.e. has a range <10,000 km^2) are often difficult and inconclusive. In this report, a two-stage approach was adopted to determining whether species were SREs. If possible, the likelihood of a species being an SRE was determined using available literature or expert advice (Appendix 3). In the absence of expert opinion, the decision about SRE status was based on the maximum recorded range of the species, the number of habitats in which it was recorded, and whether these habitats were expansive or well connected with other patches of the same habitats. The SRE status of related species (e.g. the proportion of species in the family/genus known to be SREs) was also taken into account in determining SRE status. The framework against which this information was used to assess likely SRE status is outlined in Appendix 3.

Species identified as possible SREs using the Appendix 3 framework were coded as R1, R2 or R3 according to the reliability of the evidence supporting SRE status. R1 species have least reliable evidence and R3 species the most reliable evidence.

4.8. Habitat mapping for analysis

The initial habitat mapping for site selection purposes in the Potential Impact Area was refined for use in this report. In addition, the mapping was extended across the broader Study Area using four sources of information. These were:

1) Ortho-photographs (provided by Rio Tinto);
2) Field descriptions obtained both at survey sites and while traversing the Study Area;
3) 1:250,000 scale vegetation mapping (Beard 1972); and
4) Land systems mapping (Van Vreeswyk *et al*. 2004) (Figure 4.1; Appendix 1 and Appendix 2).

The extent of connectivity between habitat patches was also assessed when mapping.

4.9. Personnel

4.9.1. Phoenix

Fieldwork was undertaken by Jarrad Clark, Belinda Barnett, Morgan O'Connell, Olivia Davies and Gaynor Owen. Trapdoor spiders and scorpions were identified by Phoenix staff to the lowest level possible; however in some cases Robert Raven of the Queensland Museum and Barbara Main of the University of

Western Australia undertook final species identifications on trapdoor spiders. Pseudoscorpions, scorpions, millipede and snails were identified by staff at the Western Australian Museum.

4.9.2. Bennelongia

Fieldwork was undertaken by Michael Curran, Jim Cocking, Dean Main, and Jeremy Quartermaine. Samples were sorted by Michael Curran, Grant Pearson, Jim Cocking, Lucy Gibson, Jeremy Quartermaine, Sean Bennett and Sabrina Cocking. Identifications to species level were made by Michael Curran, Jane McRae and Lucy Gibson in consultation with Mark Harvey, Mark Castalanelli and Mieke Burger of the Western Australian Museum (mygalomorphs, selenopids and pseudoscorpions), Simon Judd, private consultant (slaters), Erich Volschenk of ScorpionID (scorpions) and Vince Kessner, private consultant (snails).

5. RESULTS

5.1. Habitat Characterisation

Five types of habitat were considered to be potential SRE habitats within the Turee Syncline Study Area (Figure 4.1, Table 4.1). The five habitat types were classified and characterised as follows:

Floodplain and tributary. This habitat includes large (3+) to first order streams[1] and the flat floodplains that surround them. FT occurs on plains and flat country. FT occurs within eight different Land systems types (Van Vreeswyk *et al*. 2004) (see Appendix 2). Wet season rains and/or floods are likely to further enhance connectivity along the FT water courses. This habitat is considered to be well connected throughout the Study Area. Many sections of this habitat have relatively high tree cover and, in the case of large tributaries, support phreatophytic *Melaleuca* trees. No true claypans are present in the Study Area at Turee Syncline, the 'claypans' present are akin to washouts and are considered here to be FT habitat. Hence, the Phoenix 'claypan' site P52 (see Habitat 1a, Table 5.1) within the floodplain on the southern side of the syncline, is considered to be part of the wider floodplain, as indicated in text by Phoenix (2009).

Gully/*gorge*. This habitat type includes steep tributaries in hilly or high elevation landscapes. With steep elevation and shading, there is likely to be greater moisture retention in GG than most other habitats; even species that are not SRE are likely to retreat to such habitats during the dry season. GG habitat usually has a moderate cover of trees and shrubs. All of the GG sites were located in the much larger system "*Rugged ironstone ridges, plateaux and mountains; hard spinifex pastures in good to excellent condition; no erosion*" under Land systems mapping (Van Vreeswyk *et al*. 2004, see Appendix 2).

In the Potential Impact Area, and much of the Pilbara, GG habitats are always associated with watercourses and are therefore intrinsically linked to FT habitat through water flow. Connectivity for SREs among parallel GG habitats is assumed to be negligible during the dry season but some connection via FT habitat may occur during the wet season, depending on site and species characteristics. Consequently, this habitat is considered to be relatively to be well connected.

Slope - facing south. Mountain and hill slopes with a south facing aspects and, usually, with rock ledges or small cliffs that provide shelter from the sun year-round (gradient dependent). SFS habitats are similar in many ways to GG habitat and are often spatially associated, hence some connectivity is likely.

[1] Strahler Stream Order system. A headwater stream is first order, a lowland river is usually fifth order.

The orientation of this habitat allows reasonable moisture retention in the very dry, elevated hill country, although probably less than occurs in SFS and FT habitat types.

Slope - facing north. North facing slopes along mountain/hillsides, often with breakaways/cliffs and gullies associated with elevation and runoff. Orientation means sites are exposed to full sun and retain little moisture or vegetation cover.

Rocky hill or outcrop. Broken and often heavily weathered ironstone, typically with numerous small holes and fissures and some 'micro-shading'. This habitat retains less moisture and, therefore, supports less vegetation cover than other SRE habitats except SFN, but more moisture and vegetation cover than most non-prospective SRE habitats (hummock grasslands, hilltops). RHO often supports a patch of trees or shrubs. This habitat type is considered to have good habitat connectivity between sites on the syncline and beyond the Potential Impact Area (see Figure 4.1).

No obvious potential SRE habitat, other than those described above, was identified in the Potential Impact Area by examination of orthophotographs or during ground survey. There were no isolated mesas, large boulder piles (as often found in the Chichester Range), no permanent waterbodies and no significant fig (*Ficus* spp.) groves, although fig trees were observed at Sites B6 (one tree) and P47 (about four trees). No potential SRE species was collected at either Site B6 orP47 (see Section 5.2).

5.2. SRE Invertebrates

A total of 2276 animals belonging to 51 species occurred in the seven groups considered likely to support SREs (representative images in Figure 5.1). Of the 51 species, 39 species were considered not to be SREs, based on available knowledge (Table 5.2). The other 12 species were considered to be possible SRE species and were treated as SREs for the purpose of impact assessment. However, under the framework for determining whether species are SREs, all 12 were in the R1 category meaning there was relatively weak evidence for concluding the species were SREs and the assignment was precautionary. The 12 possible SRE species comprised one species of scorpion, four pseudoscorpions, four mygalomorph spiders, two isopods and one centipede (Table 5.2, Figure 5.2). All of these species were represented by only one or two specimens.

Survey results by SRE group are presented below.

5.2.1. Land Snails

All five gastropod species collected are known to occur widely beyond the Turee Syncline Study Area (Appendix 4). Notably, no species of the family Camaenidae, which most commonly contains SREs land snails in the Pilbara (Harvey 2002), were collected.

5.2.2. Scorpions

Four scorpion species were identified as members of the genus *Lychas*, which is abundant across all of mainland Australia (Koch 1977), as well as adjacent parts of south-eastern Asia. Expert advice determined that the four *Lychas* species are likely to be widespread and not SREs (E. Volschenk pers. comm. 2011).

Table 5.1. Numbers of species collected from target taxonomic groups and SRE status. All potential SRE species in R1 category (see Appendix 3)

SRE group	No. of species	Potential SRE Species
Gastropoda	5	-
Scorpionida	5	*Urodacus* sp.
Pseudoscorpionida	11	*Beierolpium* sp. 1 *Indolpium* sp. B09 *Afrosternophorus* sp. B01 *Austrohorus* sp. B02
Araneae	9	*Eucyrtops* sp. B02 *Synothele* sp. B04 *Idiommata* n. sp. 1 *Kwonkan/Yilgarnia* sp. 1
Isopoda	9	*Buddelundia* sp. B26 Philosciidae sp. B18
Chilopoda	9	Chilenophilidae sp. B05
Diplopoda	3	-
Species	**51**	**12**

Urodacus sp. is considered to be a potential SRE species (Tables 5.1 and 5.2). The genus *Urodacus* is endemic to Australia with 20 named species (Koch 1977; Volschenk and Prendini 2008) and many undescribed species known in Western Australia. The genus contains a mixture of SREs and relatively widespread species (Phoenix 2010), so that SRE determination of new species is unaccompanied by uncertainty.

Two juvenile specimens of *Urodacus* sp. were recorded in the Potential Impact Area at Site B23 in FT habitat. Mature males or DNA analysis are required to identify *Urodacus* specimens to species level and, therefore, the specific identities of the juveniles remain unknown. However, *Urodacus* are burrowing species and soil is thought to be an important determinant of species distribution (pers. comm. E. Volschenk 2011). At Site B23, the soil was sandy loam, which is widespread on the southern side of the syncline in the FT habitat surveyed and beyond the Study Area. Other specimens of *Urodacus* have been collected 16 km SSE (*Urodacus* sp. 9) and 25 km ESE (*Urodacus* sp.) of the specimens collected at Turee Syncline (E. Volschenk unpublished data). While it is possible that the Turee Syncline *Urodacus* sp. is conspecific to these animals, the species is regarded as a potential SRE (R1 category).

5.2.3. Pseudoscorpions

Pseudoscorpions are most commonly found under bark of trees, from the under rocks, or in leaf litter and occur in a variety of biotopes (Harvey 2010). Pseudoscorpions of Western Australia are diverse with 17 families and, except for subterranean species, few are SREs (Harvey 2002). Nevertheless, four species of pseudoscorpion are considered to be possible SREs (R1 category), namely *Beierolpium* sp. 1, *Indolpium* sp. B09, *Afrosternophorus* sp. B01 and *Austrohorus* sp. B02 (see Tables 5.1 and 5.3). Apart from *Austrohorus* sp. B02, which occurred in GG habitat, the pseudoscorpion species were recorded in the FT habitat. One of the reasons the pseudoscorpions were considered to be possible SREs was that single animals of each species were collected.

Figure 5.1. Photographs of Species from SRE Target Groups. (A) *Buddelundia* sp. B20 (Isopoda); (B) Karaops sp. (Araneae); (C) *Eucyrtops* sp. B02 (Araneae); (D) *Mecistocephalus* sp. B05 (Geophilomorpha); (E) Urodacus sp. (Scorpionida); (F) *Afrosternophorus* sp. B01 (Pseudoscorpionida).

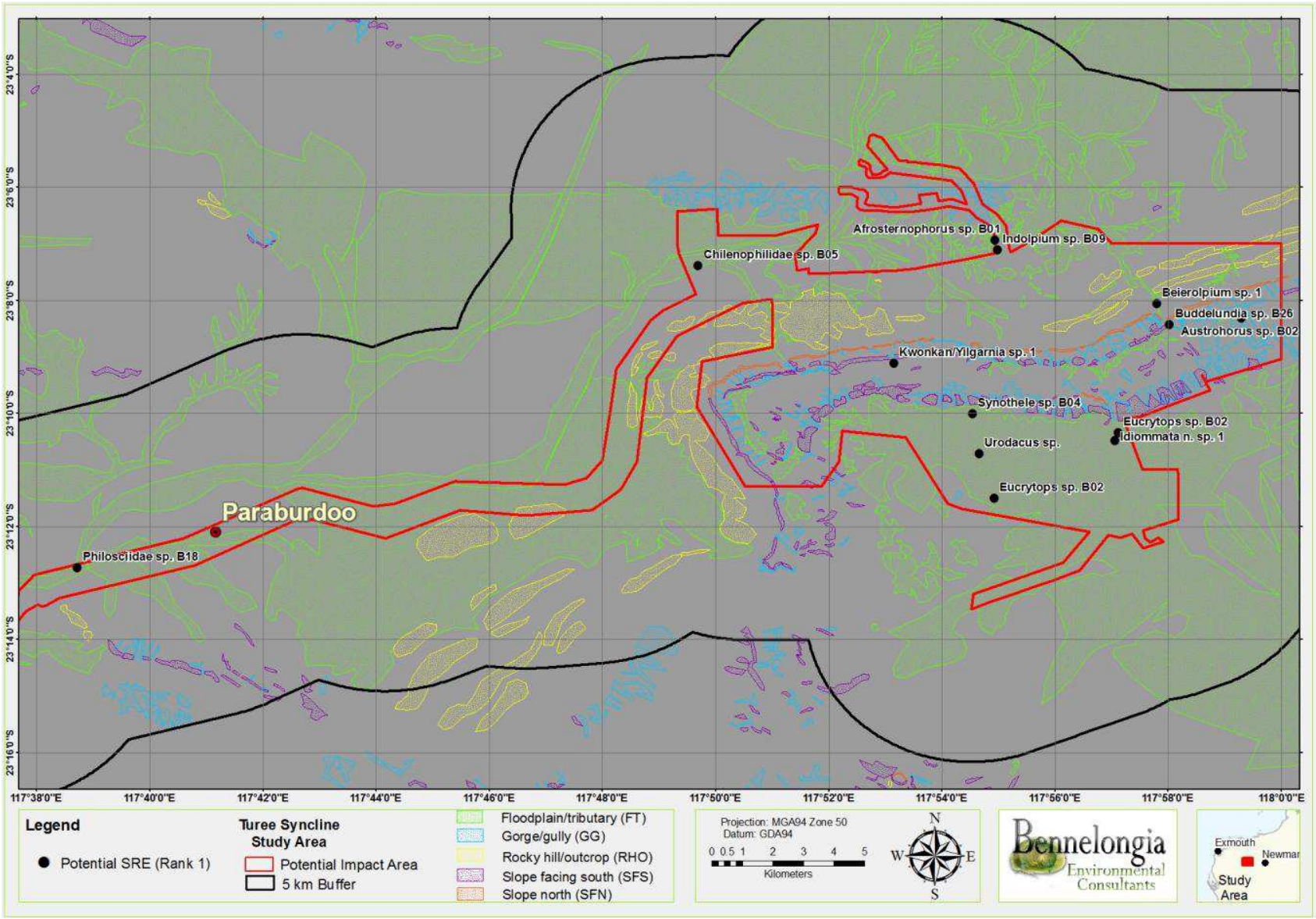

Figure 5.2. Location of Potential SRE species in Relation to Habitat and the Potential Impact Area.

Table 5.2. Scorpions collected in the Turee Syncline study area with SRE status indicated.
Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	B01	B04	B10	B12	B18	B23	B25	B32	P01	P10	P11	P25	P44	P45	P55	P60	*No. specimens*	*No. Habitats*	SRE Status	Authority
Arachnida	Scorpionida	Buthidae	*Lychas* sp.			1				1					1					3	3	NA	NA
			Lychas 'bituberculatus' ms	1	2						1	1	1	2		1		1		10	3	No	1
			Lychas 'hairy tail group'		1		1	1			3									6	2	No	1
			Lychas 'harveyi' ms				1													1	1	No	1
			Lychas 'spiny hairy tail group'														1		1	2	1	No	2
		Urodacidae	*Urodacus* sp.						2											2	1	R1	3

Note: NA indicates these data are not considered to represent a species and the specimens are considered to belong to species listed in the table.
[1]Pers. comm. Erich Volschenk (2011); [2]Phoenix (2009); [3]Appendix 3.

5.2.4. *Spiders (Trapdoor and Wall Crab)*

The Western Australian mygalomorph fauna is considered to be vast and mygalomorph or trapdoor spiders are well known as SRE species (Harvey 2002; Durrant *et al*. 2010). Hence, it is not surprising that three families of trapdoor spider were recorded, representing six genera and eight species (Table 5.4). No formally described species were recorded but the informally named *Synothele* n. sp. 'xkarara' 1 is known from a number of other locations in the central Pilbara and Midwest regions (Phoenix 2009).

There is no strong indication that any of the recorded spider species is highly restricted in habitat preference. However, four species are considered to be potential SREs (R1 category), namely *Eucyrtops* sp. B02, *Synothele* sp. B04, *Idiommata* n. sp. 1, and *Kwonkan*/*Yilgarnia* sp.1 (Tables 5.1 and 5.4). All of these species were recorded from FT habitat only.

Wall crab spiders (selenopids) have recently been added to mygalomorphs as spiders with the potential to be SREs (Crews and Harvey 2011). One species of selenopid was recorded at Turee Syncline, but it is considered unlikely to be SRE because survey data indicate a relatively widespread occurrence (Table 5.4).

Table 5.3. Pseudoscorpions collected in the Turee Syncline Survey Area with SRE status indicated.

Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	B01	B02	B03	B06	B08	B09	B10	B14	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B27	B28	B29	B30	B32	B33	P03	P10	P11	P47	P48	P50	P56	P60	P61	*No. specimens*	*No. Habitats*	SRE Status	Authority
Arachnida	Pseudoscorpionida	Chernetidae	*Sundochernes* 'PSE021'											2																							2	1	No	1
		Garypidae	*Synsphryonus* nr. 'PSE014'																		1																1	1	No	1
		Olpiidae	*Euryolpium* sp. B02 (=*Euryolpium* sp.1)					1																					1	1	1	1		1	1	7	3	Unlikely	2
			Austrohorus sp. B01									1					1																				2	1	Unlikely	2
			Austrohorus sp. B02				2																														2	1	R1	2
			Beierolpium 8/4 sp. B04																1		1																2	2	Unlikely	2
			Beierolpium sp. 1																															1			1	1	R1	2
			Indolpium sp. B07								1	1	1																								3	2	Unlikely	2
			Indolpium sp. B08 (=*Indolpium* sp. 1)	2	2	1	1		1	1	3	1	5	2	7	7	3	5	1	2		1	1	2	2	2	1	1									54	4	No	2
			Indolpium sp. B09										1																								1	1	R1	2
			Indolpium sp.																										1								1	1	NA	NA
		Sternophoridae	*Afrosternophorus* sp. B01											1																							1	1	R1	2

Note: NA indicates these data are not considered to represent a species and the specimens are considered to belong to species listed in the table.

[1]pers. comm. Mieke Burger and Mark Harvey (2011); [2]Appendix 3.

Table 5.4. Spiders, trapdoor and wall crab (Selenopidae) collected in the Turee Syncline Survey Area with SRE status indicated.
Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	B01	B02	B03	B04	B05	B06	B07	B08	B09	B12	B14	B15	B16	B17	B19	B21	B24	B28	B31	B33	B34	B35	P07	P14	P18	P25	P41	P49	P51	P52	P53	*No. specimens*	*No. habitats*	SRE Status	Authority
Arachnida	Araneae	Barychelidae	Mygalomorphae sp.											3																					3	1	NA	NA
			?Aurecocrypta sp.																	1			1	1						1					4	1	Unlikely*	1
			Eucyrtops sp. B02	1																				1											2	1	R1	1
			Synothele sp. B04																1																1	1	R1	1
			Synothele 'MYG127A'												1																				1	1	No	2
			Synothele n. sp. ('xkarara') 1																							1	1		1		2				5	3	No	3
		Nemesiidae	*Aname* sp. 'MYG001'/'MYG125'[#]		1		1									1	1					1	1	1	1		1	1		1		1		1	13	2	No	2
			Idiommata n. sp. 1																														1		1	1	R1	1
			Kwonkan/Yilgarnia sp.1																											1					1	1	R1	1
		Selenopidae	*Karaops* sp.			1	10	2	1	2	2	1	1					1			2														23	3	Unlikely	1

Note: NA indicates these data are not considered to represent a species and the specimens are considered to belong to species listed within the table.
*All *?Aurecocrypta* sp. collected by Bennelongia were female. The specimen recorded by Phoenix (Phoenix 2009) was female and reported as *Aurecocrypta* n. sp.1. Males or DNA analysis is required to delineate species. However, it is consider likely that all these specimens are conspecific.
[#]*Aname* 'MYG001'/'MYG125' indicate female specimens that are either *Aname* 'MYG001' or *Aname* 'MYG125', both of which are widespread in the area and Pilbara (M. Castalanelli pers. comm. 2011). The specimen recorded as *Aname* n. sp. by Phoenix (Phoenix 2009) is considered in the same manner and is named as such.
[‡]*Karaops* sp. specimens were all juvenile and definitive identification requires mature animals or DNA analysis. However, secondary characteristics indicate that the specimens are all conspecific.
[1]Appendix 3; [2]WAM data; [3]Phoenix (2009).

5.2.1. Isopods

Of the nine species of isopod accessible specimens, only two species (*Buddelundia* sp. B26 and Philosciidae sp. B18), were considered to be a potential SREs (R1 category) (Table 5.5). The other six species of *Buddelundia* were found across multiple sites and most habitat types and were not considered to be SREs, based on the criteria outlined in Appendix 3 as well as expert advice (S. Judd pers. comm. 2011). *Barrowdillo pseudopyrgoniscus* was described from Barrow Island (Dalens 1993) and, presumably, has a wide distribution in the Pilbara. The three species of *Buddelundia* collected by Phoenix, for which specimens could not be located, probably represent species also collected by Bennelongia and were omitted from analysis. All were represented by multiple specimens from multiple habitats.

Both potential SRE species (*Buddelundia* sp. B26 and Philosciidae sp. B18) were collected as singletons, the former in GG habitat and the latter in FT habitat (Table 5.5).

5.2.2. Centipedes

One of the nine species of centipedes was considered to be a potential SRE (R1 category), based on the criteria in Appendix 3 (Table 5.6). Chilenophilidae sp. B05, which belongs to the order Geophilomorpha, was represented by a singleton in FT habitat. Harvey (2002) states that Geophilomorpha are known to contain some SREs but the extent of short range endemism in the group is unclear because of taxonomic constraints. All of the other centipedes, other than two species of Scolopendromorpha, were represented by multiple specimens in multiple habitats (Table 5.6). Listing Chilenophilidae sp. B05 as an SRE is precautionary; more extensive sampling will probably show the species to be moderately widespread.

5.2.3. Millipedes

Only three millipede species were collected and none is considered to be an SRE (Appendix 5). Two species belong to the family Polyxenidae, which is not recognised as a family that contains SREs (Harvey 2002; Bennelongia unpublished data). The third species, *Austrostrophus stictopygus*, was originally described from Barrow Island but is now known to extend across the Pilbara (Harvey et al. 2011).

5.2.4. Survey Limitations

Very little or no rain fell during the surveys, which may have reduced the number of species collected in the SRE target groups. Nonetheless, sampling is considered to have been adequate because a substantial list of species from the target SRE groups was compiled, with similar composition at genus and family levels to lists of previous surveys in the Pilbara (e.g. Outback Ecology 2008; Ecologia 2010; Phoenix 2010).

6. THREAT TO SRE SPECIES FROM MINING AT TUREE SYNCLINE

Four characteristics of SREs and the availability of information about them shape the process of assessing the likely impacts of development. These are:

- Information on the distribution and biology of SRE species in the Pilbara is limited, so that statements about likely distributions are accompanied by uncertainty;
- The ranges of SRE species are usually orders of magnitude greater than the scale of impact of mining developments, so that SRE species are not at risk from mining developments because of their ranges alone;

Table 6.1. Isopods collected in the Turee Syncline Survey Area with SRE status indicated.
Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	B03	B04	B05	B06	B07	B08	B10	B11	B12	B17	B18	B19	B20	B21	B22	B24	B25	B26	B27	B28	B29	B30	B31	B32	B33	B35	P01	P03	P04	P06	P07	P08
Malacostraca	Isopoda	Armadillidae	*Barrowdillo pseudopyrgoniscus*																																
			Buddelundia n. sp.1																												4	6	3		
			Buddelundia n. sp.2																											8	3		1	2	20
			Buddelundia n. sp.3																														1		
			Buddelundia sp.																							8									
			Buddelundia sp. B20		29	4	25					6															85								
			Buddelundia sp. B21	1	4		1				2	3	12		2												15								
			Buddelundia sp. B22	1	8	1	2	3	2	3	4	7	1		6	5	16	4				1	14					3	3						
			Buddelundia sp. B24	1											2											42									
			Buddelundia sp. B25												1											29									
			Buddelundia sp. B26		1																														
			Buddelundia sp. B27										1	3	4				46	1	2	17		1	1										
		Philosciidae	Philosciidae sp. B18																								1								

Table 5.5 (cont.) Isopods collected in the Turee Syncline Survey Area with SRE status indicated.

Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	P09	P10	P11	P14	P18	P19	P20	P21	P22	P23	P24	P25	P41	P42	P43	P44	P45	P47	P48	P49	P50	P52	P53	P54	P56	P58	P59	P60	P61	*No. specimens*	*No. habitats*	SRE Status	Authority
Malacostraca	Isopoda	Armadillidae	*Barrowdillo pseudopyrgoniscus*													5																	5	1	No	3
			Buddelundia n. sp.1	4	30		1	2	1	50	4	8	4	3	2					8		5	5	10		5	1		5		5		166	NA	NA	NA
			Buddelundia n. sp.2				1		50	50			3	4		1	4	8	12		10	5	7	20	2	2	1	10	3	3		1	231	NA	NA	NA
			Buddelundia n. sp.3			1																											2	NA	NA	NA
			Buddelundia sp.																														8	1	NA	NA
			Buddelundia sp. B20																														149	2	No	2
			Buddelundia sp. B21																														40	3	Unlikely	2
			Buddelundia sp. B22																														84	4	No	2
			Buddelundia sp. B24																														45	2	No	1
			Buddelundia sp. B25																														30	1	No	1
			Buddelundia sp. B26																														1	1	R1	1
			Buddelundia sp. B27																														76	2	No	1
		Philosciidae	Philosciidae sp. B18																														1	1	R1	2

Note: NA indicates specimens of three the species of *Buddelundia* collected by Phoenix could not be located for comparison to species collected by Bennelongia and these species are possibly conspecific. These species are not considered further in this assessment as taxonomy cannot be advanced at this point in time.

[1]Simon Judd pers. comm. (2011); [2]Appendix 3; [3]Dalens (1993).

Table 6.2. Centipedes collected in the Turee Syncline Survey Area with SRE status indicated.
Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - north facing.

Class	Order	Family	Taxa	B01	B02	B03	B04	B05	B06	B07	B08	B09	B10	B11	B14	B15	B16	B18	B19	B20	B21	B22	B23	B25	B26	B27	B28	B29	B31	B32	B35	No. specimens	*No. habitats*	SRE Status	Authority
Chilopoda	Geophilomorpha	Chilenophilidae	Chilenophilidae sp. B05																										1			1	1	R1	1
		Mecistocephalidae	*Mecistocephalus* sp. B05	2		1	1	3	3	1	1	2	1	2			1		4		2							1			1	26	4	No	1
		Oryidae	*Orphnaeus* sp. B02 (nr *brevilabiatus*)	1		1		3		2	1		2		1	2			1	1	1	2	1	1		1	1			2	24	4	No	1
	Scolopendromorpha	Cryptopidae	*Cryptops* sp. B24 (nr *spinipes*)		1								1							1		1			1	1					6	3	No	2
			Cryptops sp. B25					1		1					1	2				1										1		7	2	No	2
		Scolopendridae	*Scolopendra* sp. B02						1																						1	1	No	2
			Scolopendra sp. B03																		1										1	1	No	2
			Scolopendra sp. B04									3						1	1	1											6	2	No	2
	Scutigeromorpha		Scutigeromorpha sp.				2			1			2																	5	2	No	2

[1]Appendix 3; [2]Harvey (2002).

- SRE species commonly occur in only a few isolated patches of habitat within their broader geographic range; and
- SRE species have poor dispersal ability. If the habitat of a population with poor dispersal ability is removed or altered significantly, the animals in the population will usually die rather than migrate to other suitable areas (Tilman *et al*. 1997). Thus, loss of a small number of restricted habitats and their populations can threaten species persistence.

The threat to persistence of SRE species found only inside the impact area of a development is likely to be inversely proportional to the amount of nearby habitat of the type in which the species was found and the connectivity of this habitat. There are strong indications from habitat mapping that substantial areas of similar habitats to those used by SRE species in the Potential Impact Area occur in the outer parts of the Study Area and beyond, including within Karijini National Park.

The 12 species identified as possible SREs are not, as far as we are aware, known to occur outside the Potential Impact Area (Table 5.1). While it is possible that one or more of these species may be restricted to the Potential Impact Area, such restricted occurrence is considered to be highly unlikely for the following reasons:

1. The ranges of SRE species may be as much as 10,000 km^2, covering an area about 60 times larger than Potential Impact Area. SRE status in itself should not be equated likelihood of a species being restricted to the Potential Impact Area.
2. Ten of the 12 possible SRE species were collected from FT habitat, which is well connected with surrounding areas because of the linear nature of rivers and their floodplains. The other two possible SRE species occurred in GG habitat, which is also relatively well connected.
3. All of the possible SRE species were collected as single animals other than the scorpion and one pseudoscorpion, which were each represented by two animals (Tables 5.2 and 5.3). The main factor suggesting that these species may be restricted is their collection from only one or two sites. However, it is likely that further sampling would show the species have a wider range. The collection of two species (millipede *Austrostrophus stictopygus* and isopod *Barrowdillo pseudopyrgoniscus*) at Turee Syncline that were first described as being from Barrow Island illustrates this point (see Harvey *et al*. 2011).

No sampling was undertaken outside the Potential Impact Area during this study. As a result, species were known to occur outside the Potential Impact Area only when recorded in other studies (including those where species were formally named). For most species, a wider range must be inferred on the basis of occurrence in widespread habitats.

7. CONCLUDING SUMMARY

A total of 2276 specimens, representing 51 species belonging to seven target SRE invertebrate groups were collected. The groups collected were land snails (Gastropoda), scorpions (Scorpionida), trapdoor spiders, wall crab spiders (Araneae), false scorpions (Pseudoscorpionida), slaters (Isopoda), centipedes (Chilopoda), and millipedes (Diplopoda).

The results of an assessment of the SRE status of each species were as follows:

- Twelve species were considered to be potential SREs. They comprised one species of scorpion, four pseudoscorpions, four mygalomorph spiders, two isopods and one centipede that were represented in sampling by one or two animals.

In terms of assessing the likely threat posed by mining to the conservation of the species known only from the Potential Impact Area, no information on the real extent of a species can be deduced from the collection of a single animal and little can be concluded from the collection of two specimens. Low animal abundance and sparse collections are to be expected in SRE surveys because of the biological characteristics of SREs and EPA Guidance Statement 20 proposes that habitat mapping is a method of determining whether species are likely to be found more widely. Habitat mapping at Turee Syncline indicates there are large connected areas of suitable undisturbed habitat of the two habitat types (FT and GG) in which possible SRE species occur. These areas of FT and GG habitats extend beyond the Potential Impact Area. Therefore, it is unlikely that any possible SRE species in these habitats would actually be restricted to the 157 km^2 of the Potential Impact Area. It is most likely that they are currently known only from the Potential Impact Area because there has been little invertebrate sampling across the Pilbara.

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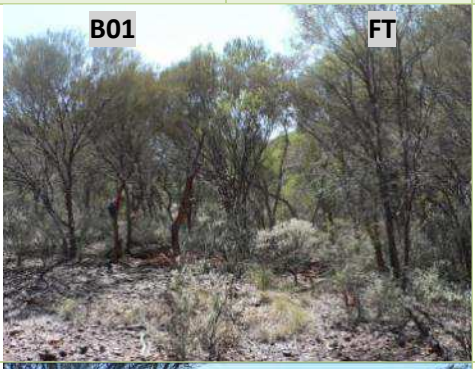
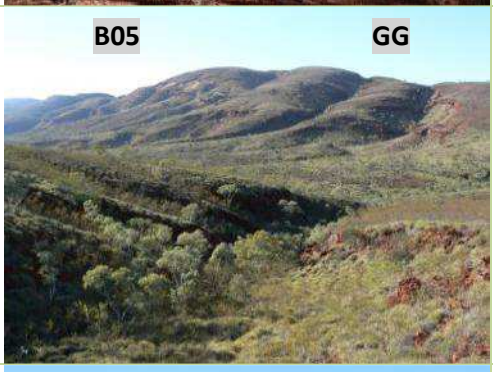
9. APPENDICIES

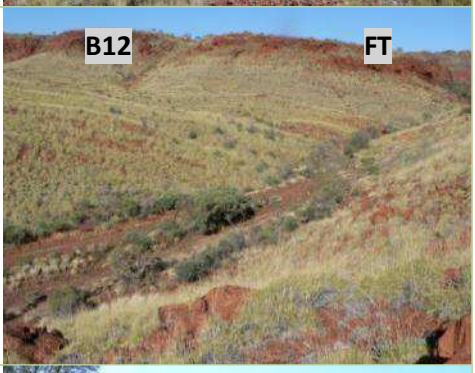
Appendix 1. Survey Site Photographs and Co-ordinates (starting next page)

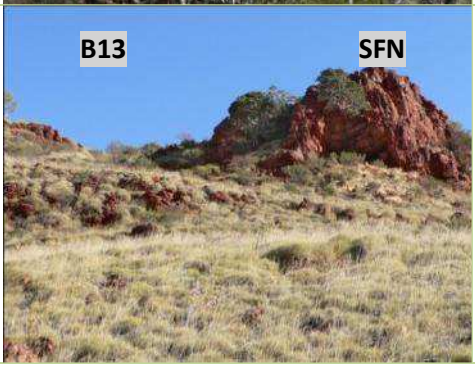
Note: Photos of Phoenix sites are representative of site floristically and structurally, but may not be actual site. Several photos taken during the survey were lost because of a camera malfunction (Phoenix 2009). Sites from Phoenix 2009 were reclassified to align them to that of the Bennelongia classification, based on ground-truthing, ortho-photographs or description provide in Phoenix (2009). All UTM coordinates are projection MGA94, datum GDA94 and zone 50.

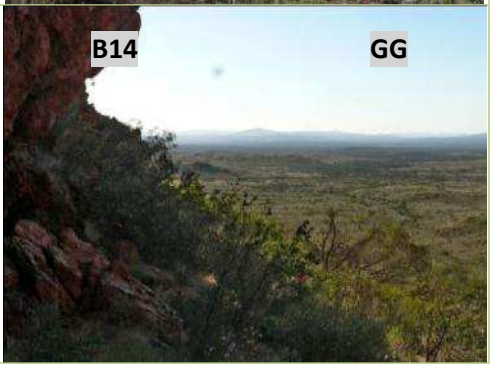
Site	Habitat	Site	Habitat	Site	Habitat
B01	FT	B02	FT	B03	SFS
B04	GG	B05	GG	B06	GG
B07	GG	B08	GG	B09	GG
B10	GG	B11	GG	B12	FT
B13	SFN	B14	GG	B15	FT



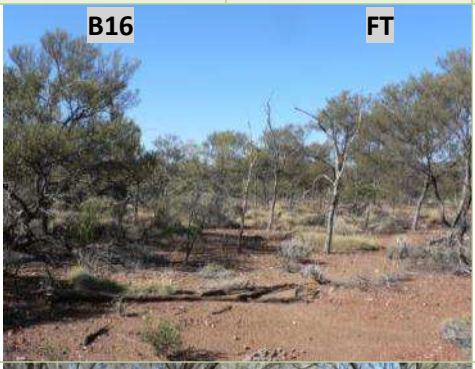


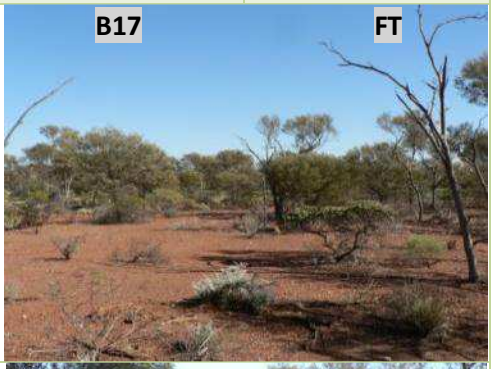


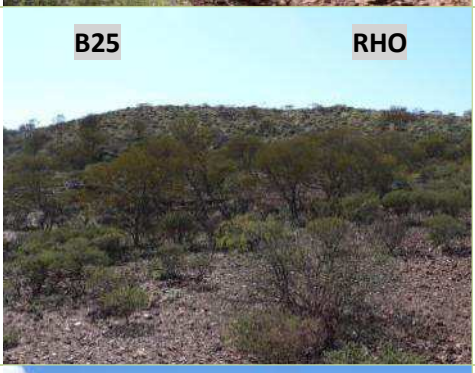


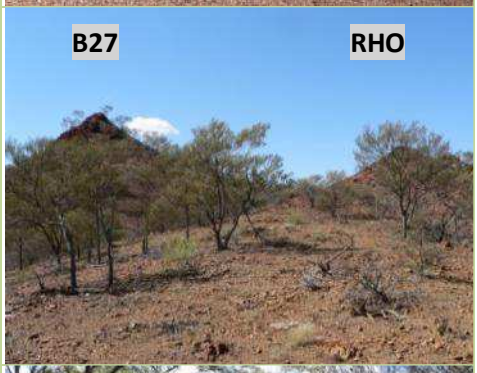


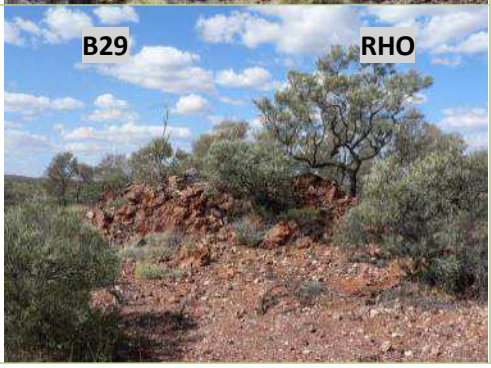
Site	Habitat	Site	Habitat	Site	Habitat
B16	FT	B17	FT	B18	FT
B19	FT	B20	FT	B21	FT
B22	FT	B23	FT	B24	FT
B25	RHO	B26	RHO	B27	RHO
B28	FT	B29	RHO	B30	FT

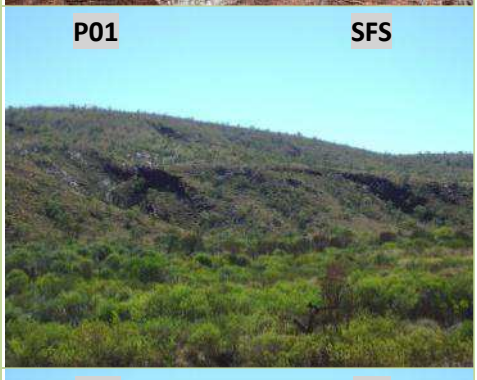
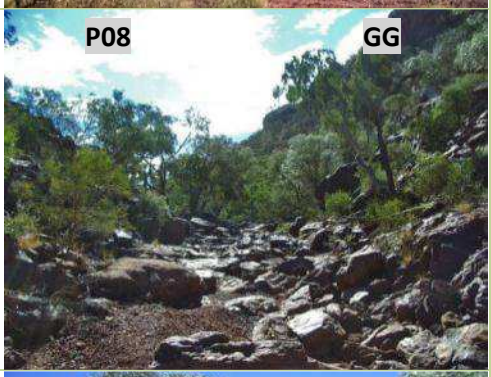
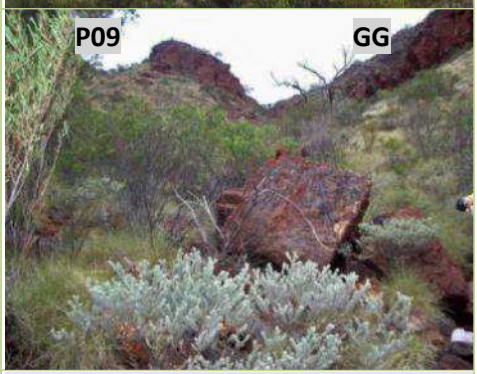
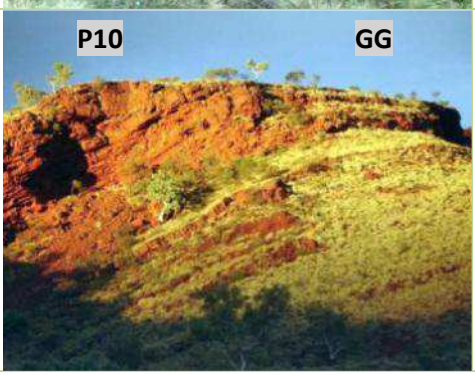
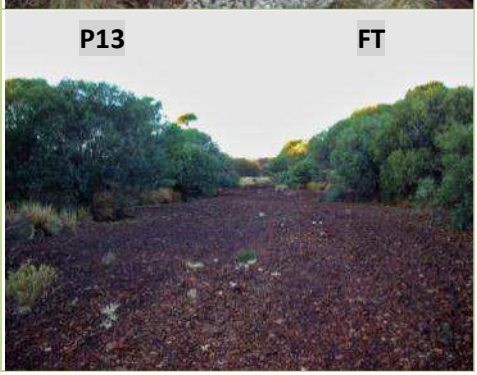


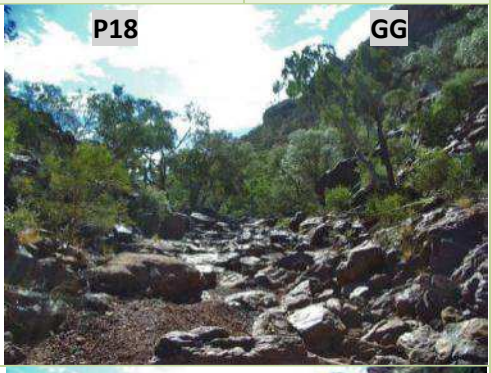
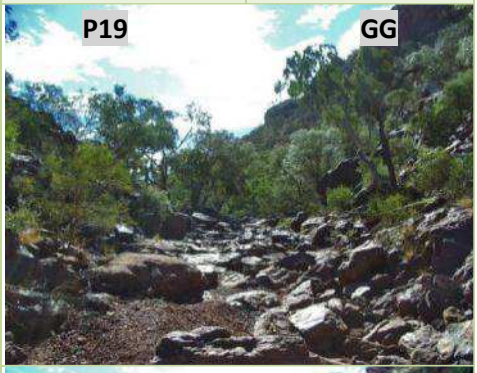
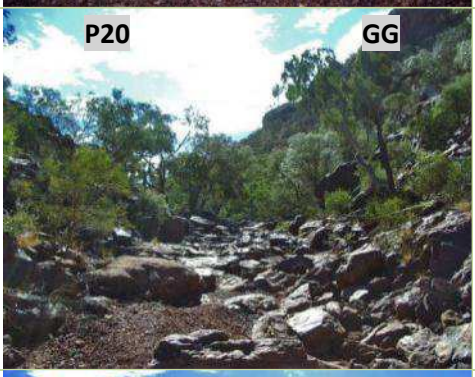
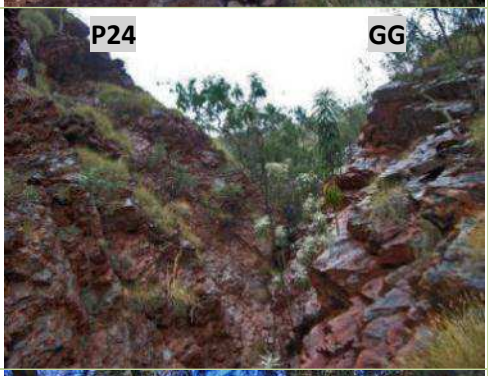
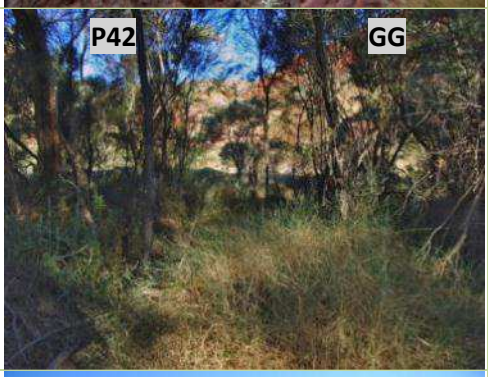
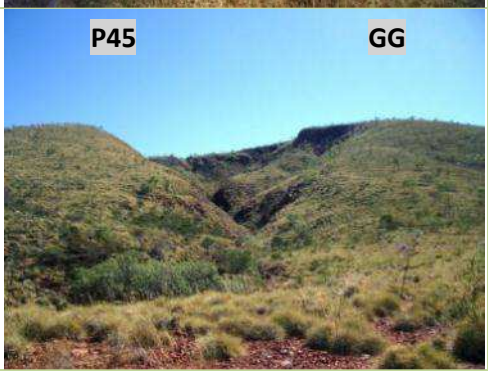
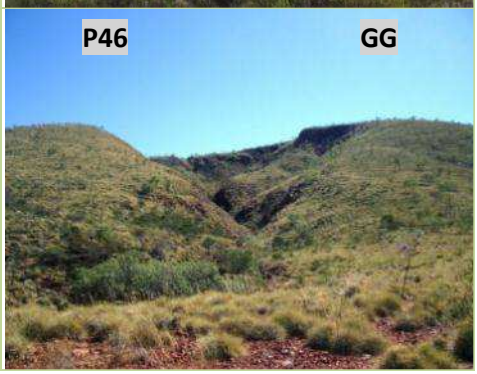








Site	Habitat	Site	Habitat	Site	Habitat
B31	FT	B32	FT	B33	FT
					
B34	FT	B35	FT	P01	SFS
					
P03	GG	P04	GG	P06	GG
					
P07	FT	P08	GG	P09	GG
					
P10	GG	P11	GG	P13	FT
					

Site	Habitat	Site	Habitat	Site	Habitat
P14	FT	P18	GG	P19	GG
					
P20	GG	P21	GG	P22	GG
					
P23	GG	P24	GG	P25	SFS
					
P41	FT	P42	GG	P43	GG
					
P44	GG	P45	GG	P46	GG
					

Site	Habitat	Site	Habitat	Site	Habitat
P47	SFS	P48	GG	P49	GG
P50	FT	P51	FT	P52	FT
P53	SFS	P54	FT	P55	FT
P56	FT	P57	SFS	P58	GG
P59	FT	P60	GG	P61	GG

Name	Latitude	Longitude	Easting	Northing	Potential SRE Habitat Type
B01	-23.172444	117.952000	597441	7437072	Floodplain/tributary
B02	-23.197278	117.952083	597432	7434322	Floodplain/tributary
B03	-23.169417	117.949056	597142	7437409	Slope facing south
B04	-23.140639	117.967028	599003	7440583	Gorge/gully
B05	-23.132806	117.988000	601156	7441436	Gorge/gully
B06	-23.138722	117.988278	601180	7440781	Gorge/gully
B07	-23.134028	117.986639	601016	7441302	Gorge/gully
B08	-23.137917	117.993667	601732	7440866	Gorge/gully
B09	-23.138306	117.981472	600483	7440831	Gorge/gully
B10	-23.137361	117.980278	600362	7440937	Gorge/gully
B11	-23.139028	117.971667	599479	7440758	Gorge/gully
B12	-23.136528	117.963778	598673	7441040	Floodplain/tributary
B13	-23.137528	117.962972	598590	7440930	Slope facing north
B14	-23.137667	117.962639	598556	7440915	Gorge/gully
B15	-23.110694	117.936111	595859	7443919	Floodplain/tributary
B16	-23.118833	117.950139	597289	7443009	Floodplain/tributary
B17	-23.118639	117.916333	593828	7443052	Floodplain/tributary
B18	-23.115639	117.915639	593759	7443385	Floodplain/tributary
B19	-23.166361	117.898000	591918	7437781	Floodplain/tributary
B20	-23.166667	117.902444	592373	7437744	Floodplain/tributary
B21	-23.166889	117.909028	593046	7437715	Floodplain/tributary
B22	-23.167306	117.915500	593709	7437665	Floodplain/tributary
B23	-23.178583	117.910944	593234	7436419	Floodplain/tributary
B24	-23.179722	117.806000	582492	7436356	Floodplain/tributary
B25	-23.166694	117.807556	582660	7437798	Rocky hill/outcrop
B26	-23.149750	117.815111	583443	7439669	Rocky hill/outcrop
B27	-23.140722	117.820333	583984	7440666	Rocky hill/outcrop
B28	-23.145917	117.850444	587063	7440073	Floodplain/tributary
B29	-23.127583	117.880583	590161	7442085	Rocky hill/outcrop
B30	-23.128500	117.878583	589956	7441984	Floodplain/tributary
B31	-23.123306	117.828167	584797	7442590	Floodplain/tributary
B32	-23.212306	117.645167	566015	7432831	Floodplain/tributary
B33	-23.179500	117.908556	592989	7436319	Floodplain/tributary
B34	-23.191806	117.915472	593689	7434952	Floodplain/tributary
B35	-23.181639	117.906750	592803	7436084	Floodplain/tributary
P01	-23.151329	117.878414	589923	7439457	Slope facing south
P03	-23.150276	117.885772	590677	7439569	Gorge/gully
P04	-23.149305	117.894508	591572	7439671	Gorge/gully
P06	-23.151231	117.919341	594113	7439442	Gorge/gully
P07	-23.151514	117.920222	594203	7439410	Gorge/gully
P08	-23.151909	117.928342	595034	7439361	Gorge/gully
P09	-23.163620	117.921544	594330	7438069	Gorge/gully
P10	-23.162859	117.921775	594354	7438153	Gorge/gully
P11	-23.162487	117.921716	594348	7438194	Gorge/gully
P13	-23.129700	117.901537	592305	7441837	Floodplain/tributary
P14	-23.128744	117.899763	592124	7441944	Floodplain/tributary
P18	-23.164885	117.949584	597199	7437910	Gorge/gully
P19	-23.157386	117.946080	596846	7438743	Gorge/gully
P20	-23.151706	117.936731	595893	7439378	Gorge/gully
P21	-23.157681	117.846581	586660	7438773	Gorge/gully
P22	-23.155991	117.848485	586856	7438959	Gorge/gully
P23	-23.153310	117.856468	587675	7439251	Gorge/gully
P24	-23.152560	117.864727	588521	7439329	Gorge/gully
P25	-23.151065	117.877103	589789	7439487	Slope facing south
P41	-23.151982	117.885813	590680	7439380	Floodplain/tributary
P42	-23.153681	117.866161	588667	7439204	Gorge/gully
P43	-23.141220	117.970999	599409	7440516	Gorge/gully
P44	-23.139262	117.980733	600407	7440726	Gorge/gully

Name	Latitude	Longitude	Easting	Northing	Potential SRE Habitat Type
P45	-23.160927	117.968191	599107	7438336	Gorge/gully
P46	-23.162957	117.965754	598856	7438113	Gorge/gully
P47	-23.165749	117.961046	598372	7437807	Slope facing south
P48	-23.164280	117.960586	598326	7437970	Gorge/gully
P49	-23.165757	117.955243	597778	7437810	Gorge/gully
P50	-23.165776	117.912573	593410	7437836	Floodplain/tributary
P51	-23.172072	117.950687	597307	7437114	Floodplain/tributary
P52	-23.174816	117.950921	597329	7436810	Floodplain/tributary
P53	-23.169554	117.948705	597106	7437394	Slope facing south
P54	-23.123714	117.896301	591773	7442503	Floodplain/tributary
P55	-23.121269	117.895924	591736	7442774	Floodplain/tributary
P56	-23.134502	117.963284	598624	7441265	Floodplain/tributary
P57	-23.149452	117.964505	598738	7439609	Slope facing south
P58	-23.154734	117.952918	597548	7439032	Gorge/gully
P59	-23.151540	117.950903	597344	7439387	Floodplain/tributary
P60	-23.148424	117.950764	597332	7439732	Gorge/gully
P61	-23.149870	117.914135	593581	7439596	Gorge/gully

Appendix 2. Distribution of SRE Survey Sites at Turee Syncline According to SRE Habitats Recognized in this Study and Vegetation Categories and Land Systems

Explanation of vegetation and land system codes is given below

		Floodplain/tributary	Gullies/gorges	Rocky hill/outcrop	Slope - facing north	Slope - facing south	Total
Vegetation and land system	**82**						
	RGENEW	2	34		1	4	**41**
	RGEPLA	8				2	**10**
	RGEROC	1					**1**
	169						
	RGEJAM	1					**1**
	RGEPLA	4					**4**
	181						
	RGEPAR						**2**
	567						
	RGEMDO	9		2			**11**
	RGERIV	2					**2**
	RGEROB			1			**1**
	RGEROC	1		1			**2**
	Grand Total	**30**	**34**	**4**	**1**	**6**	**75**

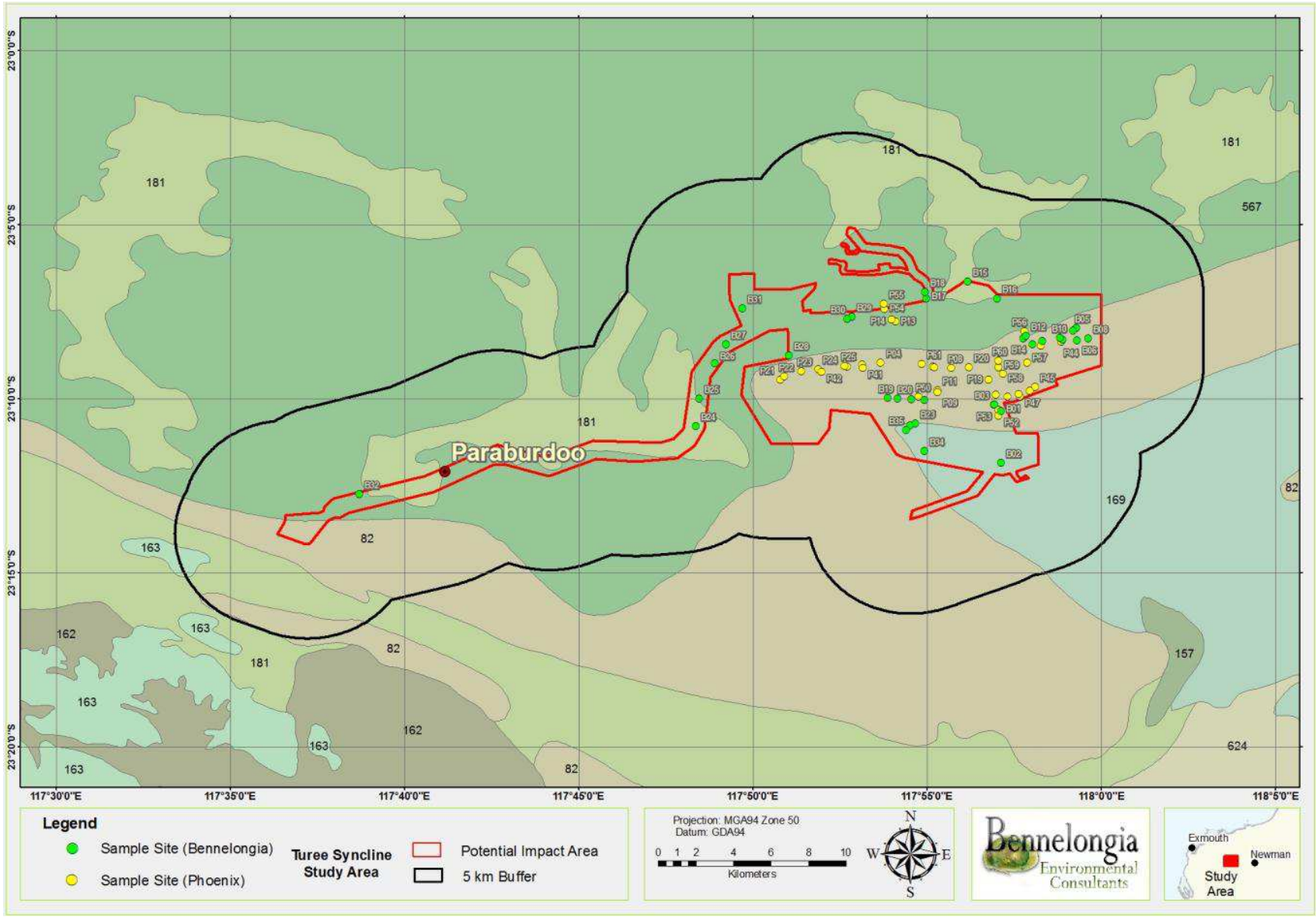
Vegetation categories (Beard 1972)

82: Hummock grasslands, low tree steppe; snappy gum over Triodia wiseana
169: Shrublands; mulga and minnieritchie scrub
181: Shrublands; mulga and snakewood scrub
567: Hummock grasslands, shrub steppe; mulga and kanji over soft spinifex and Triodia basedowii

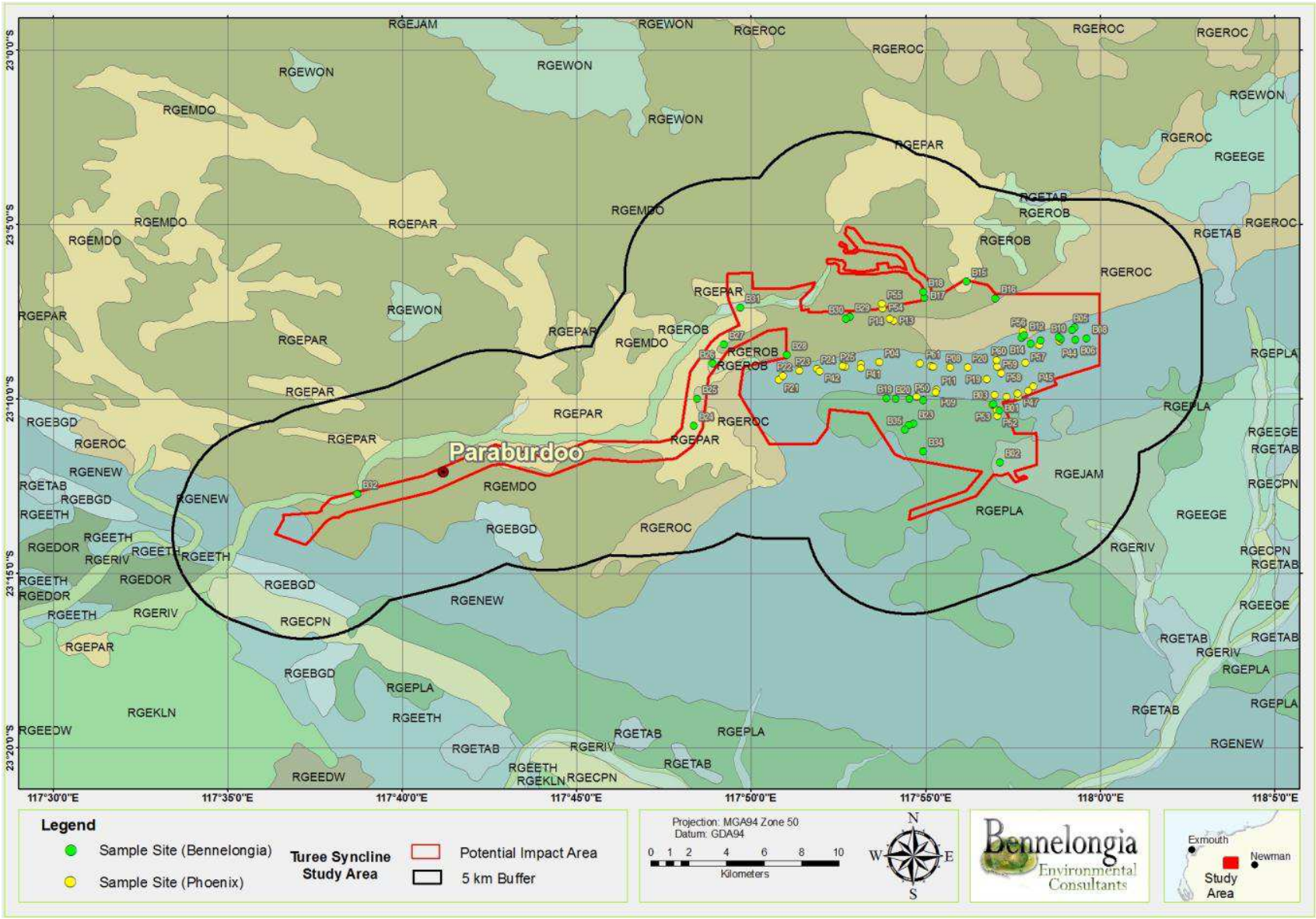
Land systems (Van Vreeswyk *et al*. 2004)

RGEJAM: Stony hardpan plains and rises supporting groved mulga shrublands, occasionally with spinifex understorey
RGEMDO: Basalt hills and restricted stony plains supporting grassy mulga shrublands
RGENEW: Rugged ironstone ridges, plateaux and mountains; hard spinifex pastures in good to excellent condition; no erosion
RGEPAR: Stony drainage floors and gilgai plains developed from basalt; snakewood with stony chenopod pastures in poor to fair condition; moderate erosion on drainage floors.
RGEPLA: Dissected slopes and raised plains supporting hard spinifex grasslands
RGERIV: Flood plains and terraces flanking major rivers and creeks; little pasture degradation or erosion
RGEROB: Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands
RGEROC: Rugged basalt hills and dissected plateaux; poorly accessible, not degraded or eroded

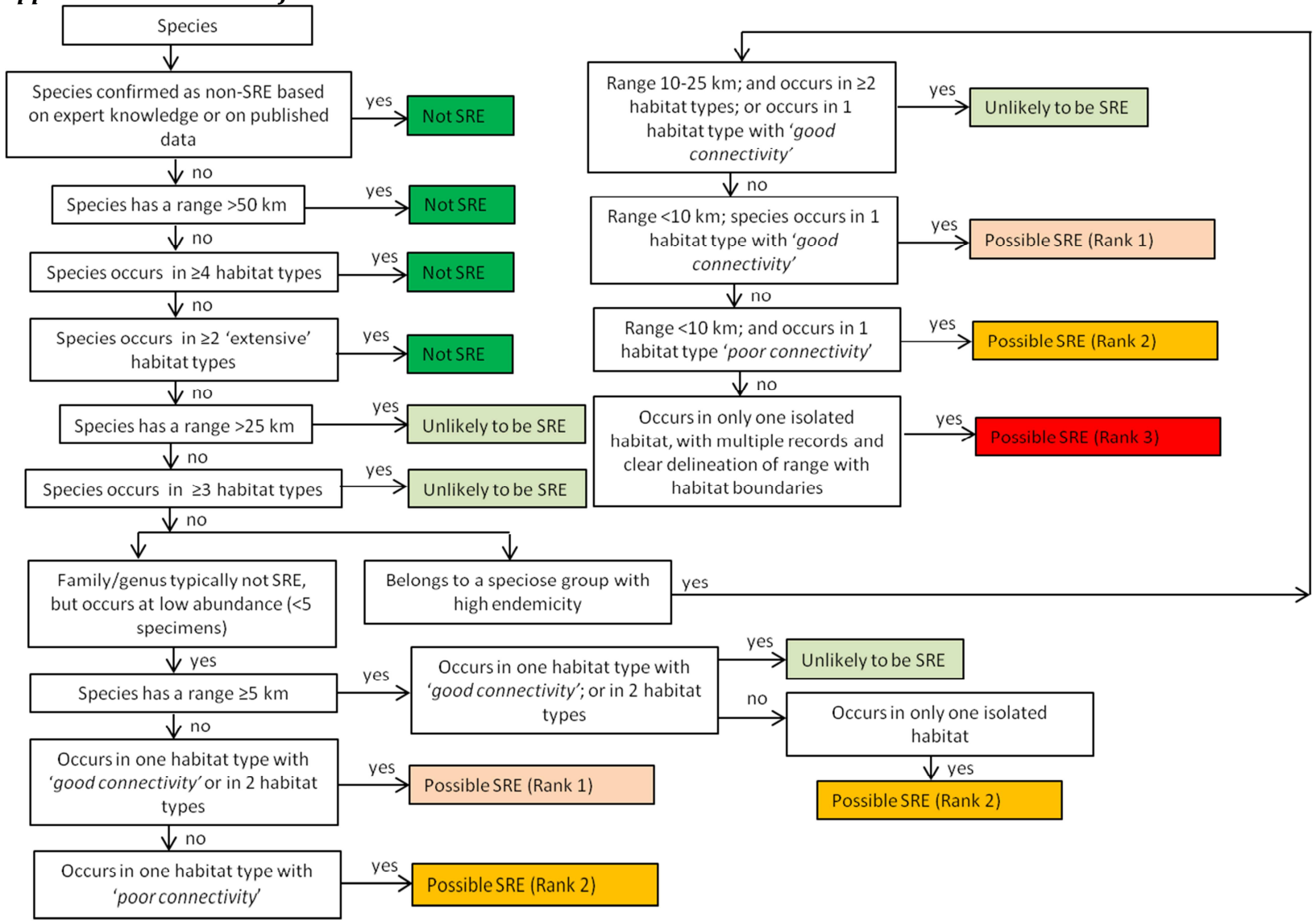
Vegetation Categorgies at Turee Syncline Accoding to Beard (1972)



Land systems at Turee Syncline Accoding to Van Vreeswyk *et al*. (2004)



Appendix 3. Flow Chart of Criteria Used to Assess SRE Status



Appendix 4. Land snails collected in the Turee Syncline Survey Area with SRE status indicated

Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Species	B02	B03	B04	B10	B13	B14	B15	B16	B17	B18	B20	B21	B22	B23	B24	B25	B26	B27	B29	B30	B31	B32	B33	B34	B35	P14	P18	P47	P56	*No. specimens*	*No. Habitats*	SRE Status	Authority
Gastropoda	Orthurethra	Pupillidae	*Gastrocopta deserti*	4								32		2		1	16	19			4			2	25	2	2						109	3	No	1
			Gastrocopta hedleyi	3	7			1		19	5	6	6			2	5	7			1	3	24		3				1	2	8	1	104	1	No	1
			Pupoides contrarius							3	18	6						1	2				4	6									40	1	No	1
			Pupoides pacificus	1		1	1	2	1	15	53	35	3	6	1		3	91	45	37	11	56	12	7	104								485	5	No	1
	Sigmurethra	Orthalicidae	*Bothriembryon* n. sp.	52																						1	22	16					91	1	No	2

[1]Solem (1986); [2]Pers. comm. Vince Kessner (2011).

Appendix 5. Millipedes collected in the Turee Syncline Survey Area with SRE status indicated

Millipedes collected in the Turee Syncline Survey Area with SRE status indicated.

Habitat types: Floodplain/tributary; Rocky hill or outcrop; Gully-gorge; Slope - south facing; Slope - north facing.

Class	Order	Family	Taxa	B02	B03	B04	B05	B06	B10	B12	B13	B20	B21	B22	B25	B28	B29	B32	B33	P06	P20	P46	P51	P60	No. specimens	No. habitats	SRE Status	Authority
Diplopoda	Polyxenida	Polyxenidae	Polyxenidae sp. B05	8	1	2	6			1		1	1	1		6		1	51						79	3	No	1
			Polyxenidae sp. B06												1		1								2	2	No	1
	Spirobolida	Trigoniulidae	*Austrostrophus stictopygus*					1	1		1									1	1	3	1	1	10	4	No	2

[1]Appendix 3; [2]Harvey (2002).