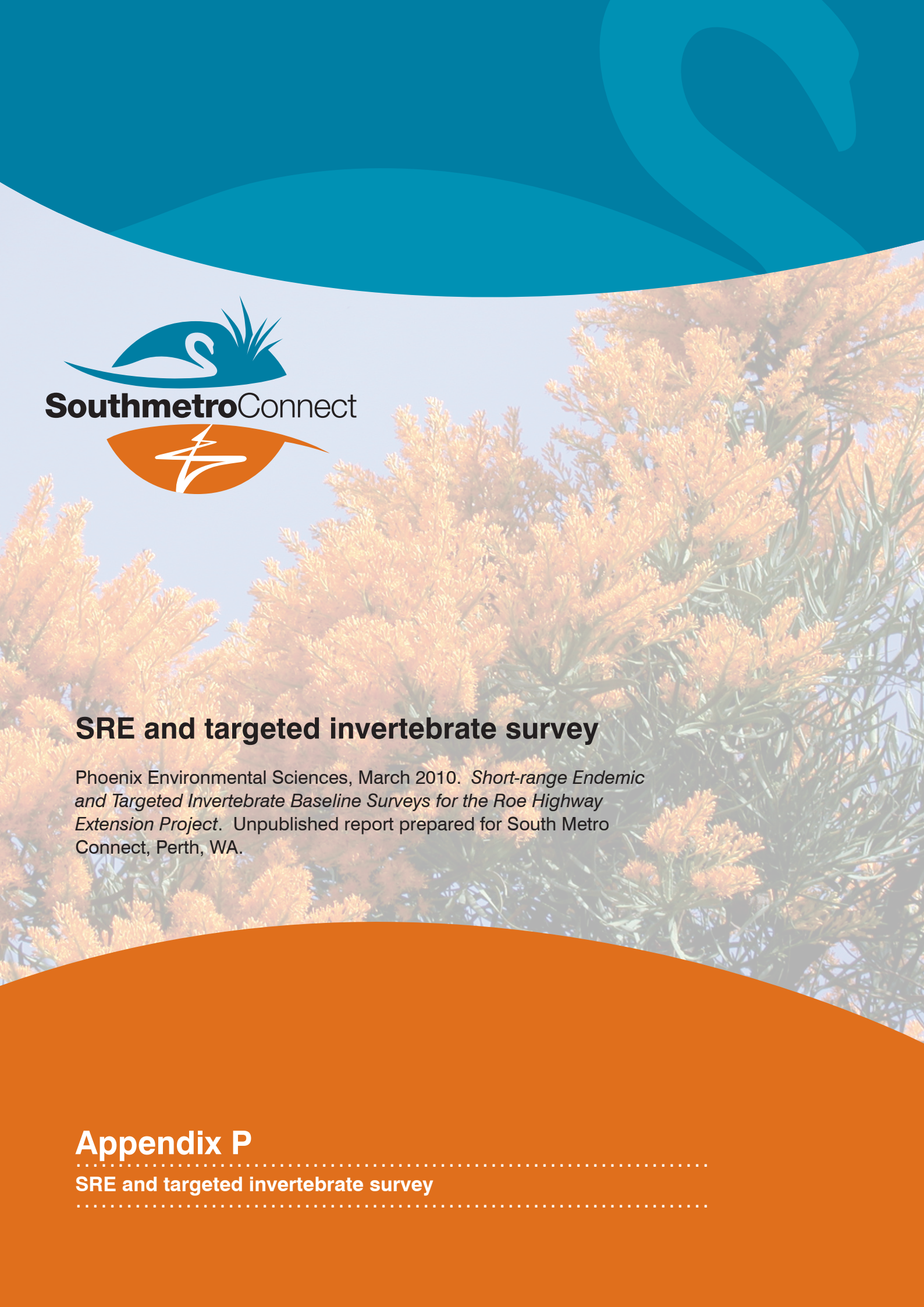

SRE and targeted invertebrate survey

Phoenix Environmental Sciences, March 2010. *Short-range Endemic and Targeted Invertebrate Baseline Surveys for the Roe Highway Extension Project*. Unpublished report prepared for South Metro Connect, Perth, WA.

Appendix P

SRE and targeted invertebrate survey

PHOENIX
ENVIRONMENTAL SCIENCES

Short-range Endemic and Targeted Invertebrate Baseline Surveys for the Roe Highway Extension Project

Prepared for South Metro Connect

Final Report

March 2010

Short-range Endemic and Targeted Invertebrate Baseline Surveys for the Roe Highway Extension Project

Prepared for South Metro Connect

Final Report

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EXECUTIVE SUMMARY

In November 2009, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by South Metro Connect to undertake invertebrate fauna surveys for the Roe Highway Extension project ('the proposed project'). The Government of Western Australia is planning to extend Roe Highway from Kwinana Freeway in Jandakot to Stock Road in Coolbellup in the City of Cockburn, Perth, Western Australia (the 'project area').

This report documents the final results from surveys conducted for the proposed project, specifically:

- A short-range endemic (SRE) invertebrate fauna survey; and
- A targeted invertebrate assessment (TIA) survey, incorporating surveys for the Graceful Sun-moth (*Synemon gratiosa*) and other conservation significant invertebrate species.

SRE fauna are defined as those animals that display restricted geographic distributions, nominally less than approximately 10,000km^2 (Harvey 2002). The Swan Coastal Plain (SCP) is a coastal subregion covering 13,339km^2 from north of Jurien Bay in the north to Cape Naturaliste in the south (Mitchell et al. 2002). The SCP is just 30km wide (roughly) at its widest point; many species that only occur in some stretches of this subregion, although often locally abundant, may meet Harvey's (2002) SRE criterion. Some of these are of conservation significance, but not all. Therefore two levels of short-range endemism have been considered in this report:

- Swan Coastal Plain SRE (SCP SRE)

  Species broadly distributed within the SCP, but still adhering to Harvey's (2002) SRE area criterion. In the context of the proposed development these species are of lesser conservation significance. Many of the SCP SRE's defined in this report occur within conservation estates providing sufficient protection.

- Perth Metropolitan Area SRE (PMA SRE)

  Populations that appear to have a highly localised distribution and have only been recorded around the Perth Metropolitan Area (PMA) (PMA SRE). These species are potentially threatened by further urbanization, particularly if urban bushland remnants that harbor these species are in danger of being developed

Due to pressures faced by PMA SRE's in relation to urban development, discussion of species habitat preferences and distribution has not been limited to the project area but also addresses other known populations in Perth.

The SRE and TIA surveys were undertaken within the project area and bushlands present within a 4km radius of the project area ('the study area'). The complete suite of invertebrate surveys was completed in November 2010.

The SRE survey comprised three sampling techniques in the most distinct variations in vegetation complexes and habitat types of the study area from December 2009 to September 2010 (excluding the winter month of June). The TIA survey design considered timing and collection techniques appropriate to each target species as well as known plant associations. TIA surveys were undertaken in summer 2009, autumn and spring 2010. Transect surveys for the Graceful Sun-moth were conducted in March and April 2010.

The potential for short-range endemism within the study area was initially considered low due to the relatively young geological age of the Swan Coastal Plain (SCP). However, previous surveys by the Western Australian Museum in remnant bushlands in Perth recovered some species with narrow distributions limited to the PMA, including millipedes in the genus *Antichiropus* (Polydesmida: Paradoxosomatidae) and in the family Siphonotidae (Polyzoniida). Some extremely localized mygalomorph spiders are found within Perth such as *Idiosoma hirsutum* (Idiopidae), currently only known from a few specimens collected around South Perth.

Eight SCP SREs were collected from the study area, but are not considered to be of conservation significance:

- *Idiosoma sigillatum* (Mygalomorphae: Idiopidae);
- *Notiasemus glauerti* (Chilopoda: Scolopendridae);
- *Cormocephalus novaehollandiae* (Chilopoda: Scolopendridae);

- *Buddelundia ?nigripes* and *Buddelundia* sp. (SJ #7) (Isopoda: Oniscoidea);
- ?*Spherillo* sp. (SJ #2) (Isopoda: Oniscoidea); and
- *Bothriembryon bulla* and *B. kendricki* (Gastropoda: Bulimidae).

Seven PMA SREs were recorded in the study area. They are considered to be of conservation significance as they currently have distributions confined to the Perth Metropolitan Area. They are:

- *Synothele michaelseni* (Mygalomorphae: Barychelidae): known only from Swan Coastal Plain around Perth and few localities on the Darling Escarpment;
- *Kwonkan* `MYG225` (Mygalomorphae: Nemesiidae): taxonomically a poorly resolved genus; difficult to establish without further taxonomic work if the three males from this survey are conspecific with other specimens recorded around Perth;
- *Tinytrema yarra* (Araneomorphae: Trochanteriidae): extremely rare, previously only known from a single female on the Darling Escarpment approximately 60km E of study area;
- *Antichiropus* `UBS2` (Polydesmida: Paradoxosomatidae): only known from the Swan Coastal Plain from Hepburn Heights in the North to Rockingham in the South;
- *Antichiropus* `UBS3` (Polydesmida: Paradoxosomatidae): rare, previously only known from Bold Park, Mt Claremont and Brookdale;
- Siphonotidae sp. (Polyzoniida): single specimen; on Perth Coastal Plan this family is only known from a population at Woodman Point and unspecified historical localities in “Perth”; species taxonomy cannot be resolved as all polyzoniidan millipedes from the Western Australian Museum are out on loan.
- *Podykipus collinus* (*Spirostreptida: Iulomorphidae*): putative SRE; taxonomically poorly resolved genus and difficult to establish if the specimens recorded from this survey are conspecific with other specimens found around Perth including the five sites where an unidentified spirostreptidan species was obtained during the WAM urban bushland survey (UBS) (Harvey et al. 1996). *Podykipus collinus* was collected from six SRE sites (SRE 1-5 and 8) and appears locally abundant and widespread throughout the vegetation complexes of the study area.

Of targeted invertebrates (TIA surveys), only one conservation significant species, the Graceful Sun-moth (*Synemon gratiosa*) was recorded from six individuals in the north-western quadrant of the Stock Road and Forrest Road intersection. This area contains a fairly high density of *Lomandra hermaphrodita*; however it is a heavily disturbed site and less than five hectares in size. This host plant has also been recorded in several other locations within the study area and while most of these locations were surveyed, no additional Graceful Sun-moth observations were made. Additional *L. hermaphrodita* mapping and Graceful Sun-moth surveys will be undertaken in 2011.

Suitable habitat exists within the study area for the native bee species *Neopasiphae simplicitor* (Colletidae), the native cricket species *Thoscodectes xiphos* (Tettigoniidae) and the scorpion fly *Austromerope poultoni* (Meropeidae), but these were not recorded during the surveys.

1.0 INTRODUCTION

In November 2009, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by South Metro Connect to undertake invertebrate surveys for the Roe Highway Extension project ('the proposed project') (Figure 1-1).

This report documents the results from surveys conducted to December 2010 for the proposed project, specifically:

- Short-range endemic (SRE) invertebrate fauna survey; and
- Targeted invertebrate assessment (TIA) survey, incorporating surveys for the Graceful Sun-moth (GSM).

The Government of Western Australia is planning to extend Roe from Kwinana Freeway in Jandakot to Stock Road in Coolbellup in the City of Cockburn, Perth Western Australia (the 'project area').

The SRE and TIA surveys undertaken encompass the project area (comprising the original 'project area' and an extension, referred to as the 'extended project area') and some bushlands within 2km north and south of the project area (collectively termed 'the study area') (Figure 1-2).

1.1 BACKGROUND

The proposed alignment for the Roe Highway Extension between the Kwinana Freeway and North Lake Road is through the Beeliar Wetlands between Bibra Lake and North Lake (Figure 1-1 and Figure 1-2). The project area is considered to be of high environmental value and therefore extensive biological surveys are required.

1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The scope of works for the invertebrate surveys is to undertake periodic invertebrate sampling over 12 months to record invertebrate variability within all four seasons. The objectives of the surveys were to:

- Undertake a desktop habitat assessment and database searches for SRE and priority invertebrate species;
- Conduct field surveys for priority (targeted) invertebrate species and SRE taxa of the study area;
- Map potential priority/threatened invertebrate and SRE habitats; and
- Provide a technical report that includes:
    - Full results of the survey;
    - Incorporation of available, relevant data and information from previous invertebrate fauna surveys in the area;
    - Identification and discussion of any priority/threatened invertebrate species or SRE species recorded in the current survey and other previous surveys;
    - Assessment of priority/threatened invertebrate species and SRE habitats.

Figure 1-1
Location of the Roe Highway Extension Project

Project Area

0 1 2 3
Kilometres
Datum: GDA94 Projection: MGA z50

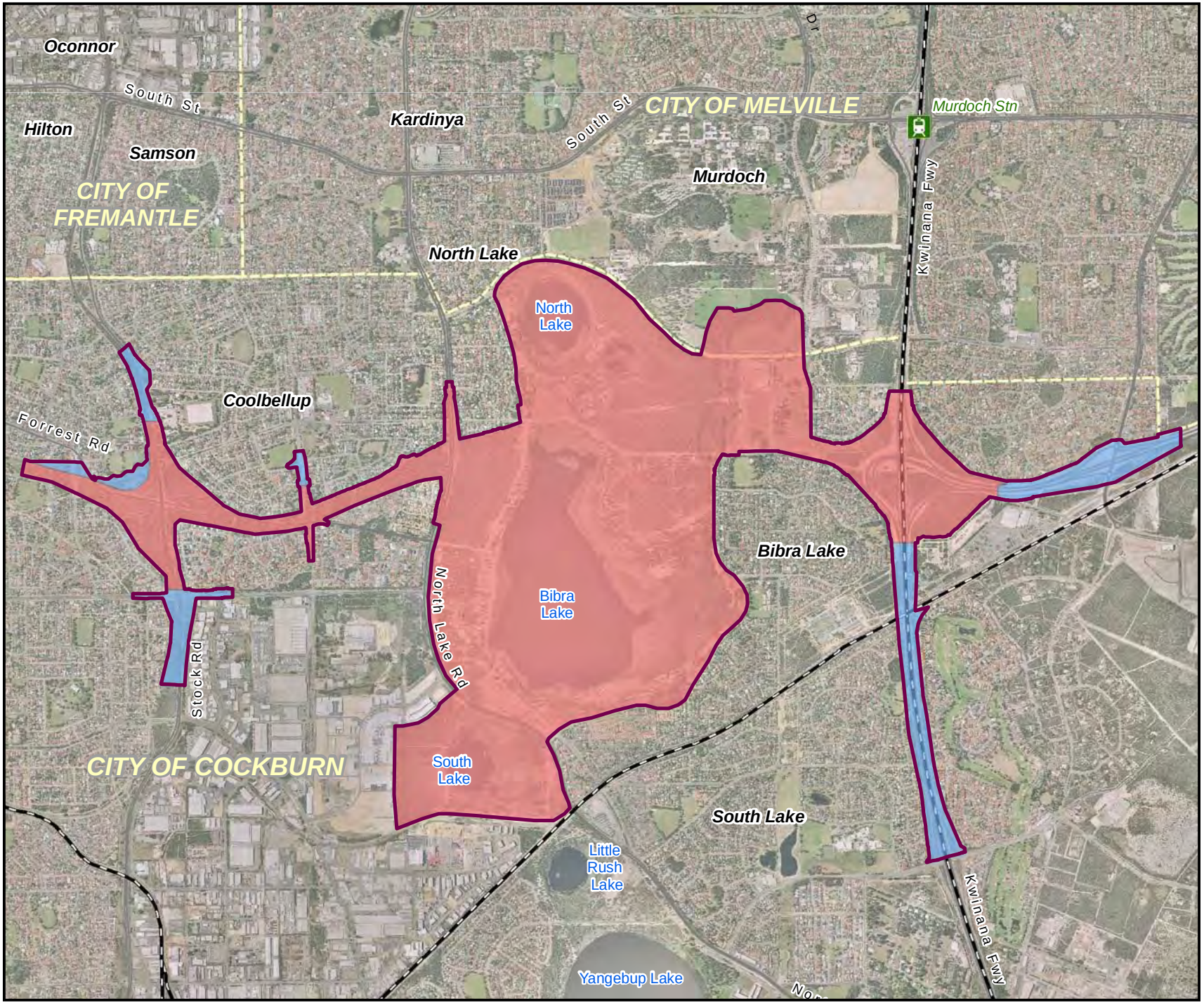


Figure 1-2
Study Area for the Roe Highway Extension Project Invertebrate Surveys

0 0.25 0.5 0.75 1
Kilometres

Datum: GDA94 Projection: MGA z50

- Total Study Area
- Level 1 Study Area
- Level 2 Study Area

Date Modified: 15/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 1-2 - Study Area for the Roe Highway Extension Project Invertebrate Surveys.mxd

1.3 SURVEY SIGNIFICANCE

SRE fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000km^2, that may also be disjunct and highly localised (Harvey 2002). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

The Swan Coastal Plain (SCP) subregion comprises a coastal stretch from north of Jurien Bay in the north to Cape Naturaliste in the south (approximately 520km length) which is approximately 30km wide at its widest point. The total area of the SCP is 13,339km^2 (Mitchell et al. 2002). Much of the bushland in this area is now restricted to remnant areas isolated from each other through urban development. Some species recorded in the study area are endemic to the SCP and may only occur in part of this small subregion or are located in a single habitat type and therefore fall within Harvey's (2002) SRE range criteria; however these can be fairly widespread in the subregion and may be highly abundant on a local scale, including within existing reserves.

Therefore two levels of short-range endemism were considered in this report:

- Swan Coastal Plain SRE (SCP SRE)

  Species endemic to the SCP and adhering to Harvey's SRE area (km^2) criteria but often broadly distributed and locally abundant. In the context of the proposed development these species are of lesser or no conservation significance. Many of the SCP SRE's defined in this report are also found within conservation estates and therefore are considered to receive sufficient protection.

- Perth Metropolitan Area SRE (PMA SRE)

  Populations that appear to have a highly localised distribution and have only been recorded around the Perth Metropolitan Area (PMA) (PMA SRE).

Due to the considerable development pressures faced by PMA SRE's (and to a lesser degree SCP SRE's) an interpretation of species habitat preferences and distribution has not been limited to the study area of the Roe Highway Extension Project. Discussion of the species listed in this report therefore takes into consideration the preferences and distributions of other known populations in particular in the Perth Metropolitan Area.

Initial remote investigations using aerial photographs, topographic maps and other GIS data suggested that the proposed project had few features that might prevent the dispersal of invertebrate fauna, such as disconnection of vegetation and habitat corridors caused by roads and urban infrastructure.

State and federal conservation legislation, published literature and reports and database searches have indicated that a number of priority invertebrate taxa may occur within the study area as they have been reported from other areas on the SCP and/or are known from habitats similar to those in the study area.

Target groups for the SRE survey included, for example, millipedes in the genus *Antichiropus* (Polydesmida: Paradoxosomatidae) and in the family Siphonotidae (Polyzoniida) as these were recovered in very localized populations during surveys by the Western Australia Museum in remnant bushlands of the Perth Metropolitan Area (Harvey, Dell *et al.* 1997; How, Harvey *et al.* 1996). Some extremely restricted mygalomorph spiders are found within Perth such as *Idiosoma hirsutum* (Idiopidae), currently only known from a few specimens collected around South Perth (Main 1952).

The TIA survey design focused on species listed within state and federal conservation legislation, such as the WA *Wildlife Conservation Act 1950* (WC Act) (Table 1-1). The target species included the Graceful Sun-moth, *Synemon gratiosa,* which is listed on Schedule 1 ("Fauna that is rare or likely to become extinct") of the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2) of the Western Australian Government (WA *Wildlife Conservation Act 1950*). This species is also listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Table 1-1 Target invertebrate species of the Roe Highway Extension Project, conservation significance, location and known associations.

Common Name	Scientific Name	Conservation Status	Distribution	Plant or other Association
Hymenoptera (Bees, Wasps and Ants)				
Native Bee	*Leioproctus bilobatus*	DEC P2 CS Level 2	• Kenwick Region • South East of Perth, Brookton Highway • Christmas Tree Well • Stirling Range	Jarrah/Wandoo Forest (Yellow Flowering Pea) *Gompholobium aristatum*
Native Bee	*Leioproctus contrarius*	DEC P3 CS Level 2	• Lake Forrestdale • Armadale Golf Course • Moore River National Park	*Goodenia* sp. *Lechenaultia* sp.
Native Bee	*Leioproctus douglasiellus*	Schedule 1 (WC Act 1950) CS Level 1	• Lake Forrestdale • Armadale Golf Course	*Goodenia* sp.
Native Bee	*Neopasiphae simplicior*	Schedule 1 (WC Act 1950) CS Level 1	• Lake Forrestdale • Armadale Golf Course • Cannington	Banksia Woodland *Goodenia* sp. *Lobelia* sp.
Lepidoptera (Butterflies and Moths)				
Graceful Sun-moth	*Synemon gratiosa*	Endangered (EPBC Act 1999) Schedule 1 (WC Act) CS Level 1	• Koondoola bushland, Bush Forever site 201 (5 records) • Errina Road Bushland, Bush Forever site 493 (1 record) • Gumblossom Reserve • Marangaroo (Decourcey Way) Bushland, Bush Forever site 328 (3 records) • Landsdale Road Bushland • Shenton Bushland, Bush Forever site 218 (1 record) • Whiteman Park • Wanneroo (16 records) • Neerabup National Park (21 records) • Warwick Bushland, Bush Forever site 202 (26 records)	*Lomandra maritima* and *L. hermaphrodita*
Yellow Admiral	*Vanessa itea*	CS Level 3	• Perth, across Swan Coastal Plain	Urban areas, forest Woodland
Mecoptera (Scorpionflies)				
Scorpion fly	*Austromerope poultoni*	DEC P2 CS Level 2	• Midwest, South West and Warren Regions	*Banksia* Woodland
Orthoptera (Grasshoppers and Crickets)				
Cricket	*Austrosaga spinifer*	DEC P3, IUCN Vulnerable CS Level 2	• Northern Sandplains Region •Neerabup National Park •Jurien Bay, Cervantes	Banksia Heaths Low Woodlands
Cricket	*Throscodectes xiphos*	DEC P1 CS Level 2	• South of Perth • Cutler Road, Jandakot • Ken Hurst Park, Banjup	Banksia Woodland Near Grand Spider Orchid, *Caladenia huegelii*

Three levels of conservation significance (CS) are recognised in Table 1-1 (next page):

- CS Level 1: Species listed under State or Commonwealth Acts.

- CS Level 2: Species not listed under State or Commonwealth Acts, but are listed in publications on threatened fauna or as Priority species by DEC.
- CS Level 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. This level may have links to preserving biodiversity at the genetic level (EPA Position Statement No. 3, (EPA 2002)). For example, if a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3. Species listed as having declined around Perth area in Perth Bushplan are considered to be CS3 in the Perth area (Bamford and Bamford 2006).

1.4 ENVIRONMENTAL PROTECTION AUTHORITY GUIDANCE

In May 2009, the Environmental Protection Authority (EPA) released Guidance Statement No. 20: *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009). The guidance outlines preferred methods for undertaking SRE surveys in Western Australia.

The habitat assessment and field survey work herein has considered all aspects outlined and addressed in Guidance Statement 20 and other relevant principles and guidelines, including:

- EPA Position Statement No. 3: *Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002); and
- EPA Guidance Statement No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004).

All survey methods presented below have been developed in consultation with experts within the Department of Environment and Conservation (DEC), prior to undertaking the surveys.

2.0 EXISTING ENVIRONMENT

2.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA (IBRA) REGION

The proposed project lies within the Swan Coastal Plain (SWA2) subregion of the Interim Biogeographic Regionalisation of Australia v. 6.1 (IBRA) (Thackway and Cresswell 1995). Landforms within the region are composed of colluvial and aeolian sands, alluvial river flats and coastal limestone. The vegetation of the region broadly consists of *Banksia* species and Jarrah-*Banksia* woodlands on Quaternary marine dunes of various ages and Marri species on colluvial and alluvial substrates (Mitchell, Williams *et al.* 2002).

The subregion includes a complex series of seasonal wetlands associated with low-lying interdunal areas (Mitchell, Williams *et al.* 2002; WAPC 2000). Rare features of the subregion include Holocene dunes and wetlands and, because it is part of the South West Botanical Province, the subregion is characterised by high species and ecosystem diversity compared to other areas (Mitchell, Williams *et al.* 2002).

2.2 LANDFORMS AND VEGETATION

The region surrounding the study area consists of several interacting landform elements, including Bassendean Sands of the Bassendean Dunes landform, Sands derived from Tamala Limestone (Spearwood Dune System) and Holocene Swamp Deposits (peaty silts within the Spearwood/Bassendean Dune interface). Vegetation complexes such as plant communities or patterns of vegetation are associated with landforms and soil types that exist at a regional scale (Tingay 1998).

Vegetation complexes within the study area comprise of Bassendean, Herdsman, Karrakatta and Cottlesloe complexes (Heddle, Loneragan *et al.* 1980). These complexes and their associated geological soil types (Figure 2-1) comprise:

- Bassendean Complex (central, west and south) – Woodland of *Eucalyptus marginata*, *Corymbia calophylla* with well defined second storey of *Calytrix fraseriana* and *Banksia* species on the deeper soils and a closed scrub on the moister sites. Soil type is S8 (Sand) - very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of aeolian origin.
- Herdsman Complex (North Lake and Bibra Lake) - Sedgelands and fringing woodland of *Eucalyptus rudis* and *Melaleuca preissiana, M. rhaphiophylla* and *Banksia ilicifolia* forest to woodland with *Kunzea glabrescens*, *Acacia saligna* and *Agonis linearifolia*; *Melaleuca teretifolia* tall shrubland; and *Baumea articulata* and *Typha orientalis* sedgelands. Soil type is Mps (Peaty Silt) - black, friable silt with abundant organic material, variable fine quartz sand content, soft, of lacustrine origin.
- Karrakatta Complex (central and south) - Open forest of *Eucalyptus gomphocephala*, *E. marginata*, *Corymbia calophylla* and woodland of *E. marginata* and *Banksia* species. Soil type is S7 (Sand) - pale yellowish brown, medium to coarse-grained sub-angular quartz, trace of feldspar, moderately sorted, of residual origin.
- Cottesloe Complex (central and west) - Open woodland of *Eucalyptus gomphocephala*, *E. marginata* and *Corymbia calophylla*; closed heath on the limestone outcrops. Soil type is LS1 (Limestone) - pale yellowish brown, fine to coarse-grained, sub-angular to well rounded, quartz, trace of feldspar, shell debris, variably lithified, surface kankar of aeolian origin.

In relation to remnant vegetation surrounding the project area, vegetation linkages include adjacent bushland to the north and south (Piney Lakes Reserve, Booragoon Lake, Blue Gum Reserve, Samson Park, Wireless Hill, Little Rush Lake, Yangebup and Thompsons Lakes which also form part of Greenways 82 and 90), west (Manning Lake, Coogee Lake) and east (Ken Hurst Park and Jandakot Airport) (Tingay 1998).

The study area also forms part of three regionally significant ‘ecological linkages’, which connect Bush Forever sites, DEC managed estate and adjacent local natural areas. The first linkage lies in a north-south direction east of the Beeliar Wetlands. The second linkage runs from the south-west and connects the North Lake and Bibra Lake area to the west of the Beeliar Regional Park (Lake Coogee). The third linkage runs from the North-Bibra Lake area to the west.

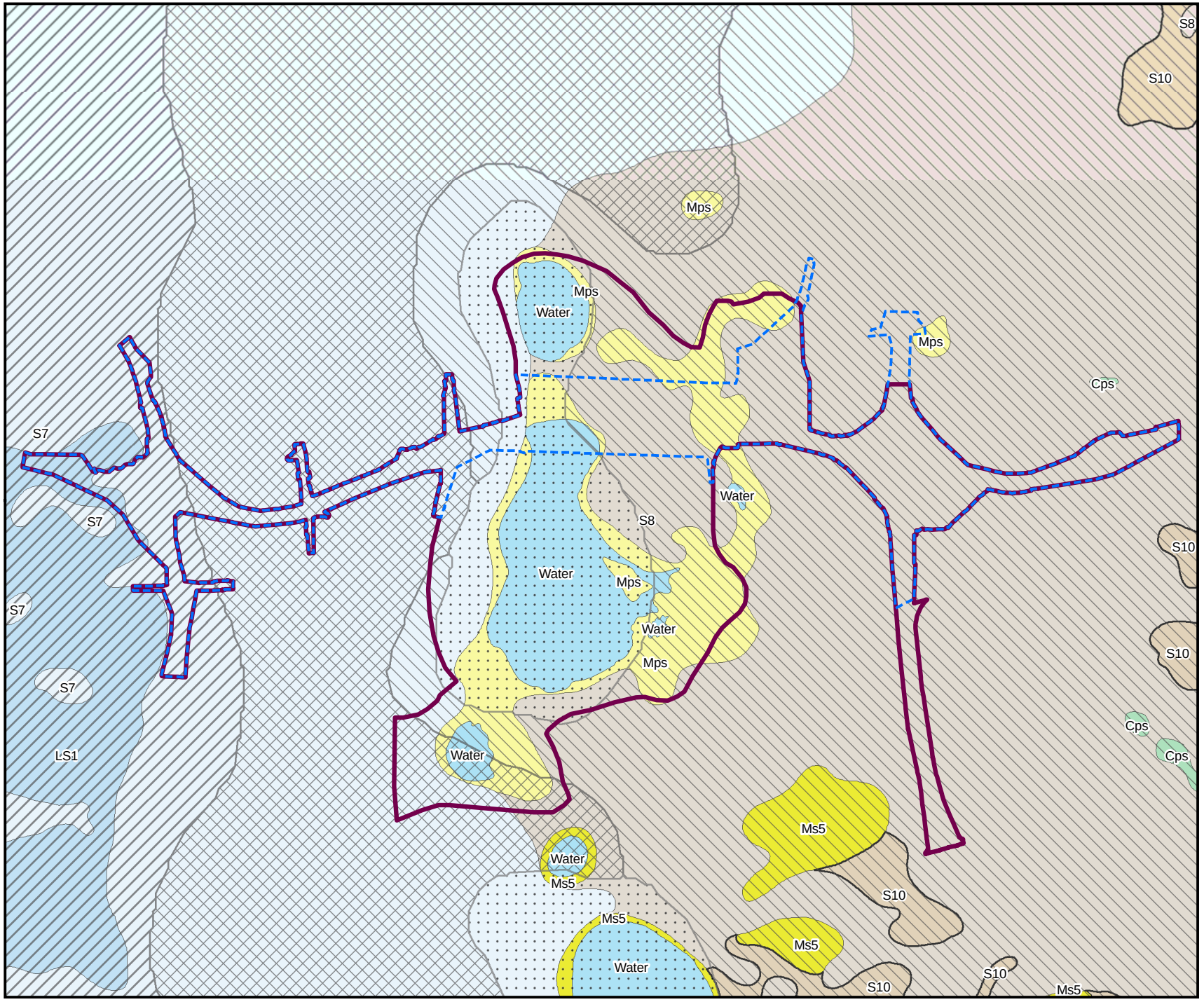


Figure 2-1
Soil Types and Vegetation Complexes of the Roe Highway Extension Project

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- Project Area
- Study Area

Geological Landforms

- Cps - Peaty clay
- Mps - Peaty silt
- Ms5 - Sandy silt
- S7 - Pale yellow-brown sand
- LS1 - Limestone
- S8 - Light grey sand (LGS)
- S10 - LGS over brown silt/clay
- Water

Vegetation Complexes

- Bassendean complex
- Cottesloe complex
- Herdsman complex
- Karrakatta complex

Date Modified: 15/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 2-1 - Soil types and vegetation complexes of the Roe Highway Extension Project.mxd

2.3 CLIMATE

Climate conditions for the study area were surmised from long-term Bureau of Meteorology (BoM) data for Jandakot Airport, approximately 3km to the east of the project area (Table 2-1). Historically, the mean daily maximum temperature of 31.3°C occurs in February, along with the highest minimum of 16.8°C. July is the coldest month on average, reaching a maximum temperature of 17.8°C. The lowest minimum is shared between July and August, both of which average 6.9°C.

Rainfall occurs mainly during the cooler winter months between May and August, peaking in July with an average rainfall (36 year period) of 180.3mm (Table 2-1). Annual rainfall is 837mm (BOM 2010).

Climatic data for the SRE, TIA and GSM surveys has been compiled for each survey period. The lowest temperatures of all surveys were recorded during the June and July SRE survey Round 5 and the TIA Autumn survey, where the lowest temperatures recorded were -2.5°C and -1.9°C respectively. The highest temperatures were recorded during the SRE Round 3 (April 2010) and during the GSM survey in March 2010 (Table 2-2; Figure 2-2 to Figure 2-13).

Although a total of 485mm of rainfall fell over the study area during the survey months of December 2009 to November 2010, only five of the twelve surveys undertaken recorded rainfall greater than 2mm. The survey rounds SRE Round 3 (April); SRE Round 4 (May); TIA Autumn (May-June); GSM (March-April) and SRE Round 6 (August) recorded a total of 145.2mm of rain during the days of survey (Table 2-2; Figure 2-2 to Figure 2-13).

Table 2-1 Climate parameters for the study area from 1972 to 2010.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years	Range
Mean maximum temperature (°C)	31.1	31.3	29.5	25.6	22	18.9	17.8	18.4	19.8	22.4	26	28.8	24.3	20	1989-2010
Mean minimum temperature (°C)	16.5	16.8	15.2	12.2	9.4	7.3	6.9	6.9	8.1	9.4	12.4	14.5	11.3	20	1989-2010
Monthly Rainfall (mm)	14.2	17.3	15.7	43.1	108.3	161.1	178.2	126.4	86.1	47.7	29.5	9.7	833.2	36	1972-2010
Decile 5 (median) rainfall (mm)	1.5	4	9	44.4	101.7	167.6	180	127.2	87.6	42.6	23.3	5.7	869.4	36	1972-2010
Mean number of days of rain ≥ 1 mm	1.4	1.4	2.3	4.7	10	13.6	15.4	12.9	10.5	6.2	4.1	1.7	84.2	36	1972-2010

Table 2-2 Climate parameters for the study area recorded during the survey period.

Parameter	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10
Mean maximum temperature (°C)	31.5	34.4	32.8	30.9	25.3	21.9	19.1	18.1	19.2	22	24.8	29.8
Mean minimum temperature (°C)	14.7	17.8	17.5	16.7	11.8	6.8	5.5	4.3	4.5	6.6	8.9	13.9
Highest Temperature (°C)	39.6	43	42.1	40.8	31.9	28.5	24.3	22.3	23.9	29.3	33.4	39.9
Lowest Temperature (°C)	8.4	9.8	7.8	10.3	4.6	-0.1	-2.5	-1.9	-0.4	0.5	2.6	4.8
Monthly rainfall (mm)	0	0.2	0	36.6	49.8	91	65.6	106.8	74.6	32.4	21.4	6.6

2.3.1 SRE Round 1

In February 2010, the Round 1 SRE survey recorded minimum temperatures of 13.8°C (20 February) to 20.7°C (17 February), with an average of 17.4°C. The lowest maximum was 28.0°C (19 February) and the highest was 34.2°C (18 February), with an average for the duration of the survey of 31.4°C (BOM 2010). No rainfall was recorded during the survey (Figure 2-2).

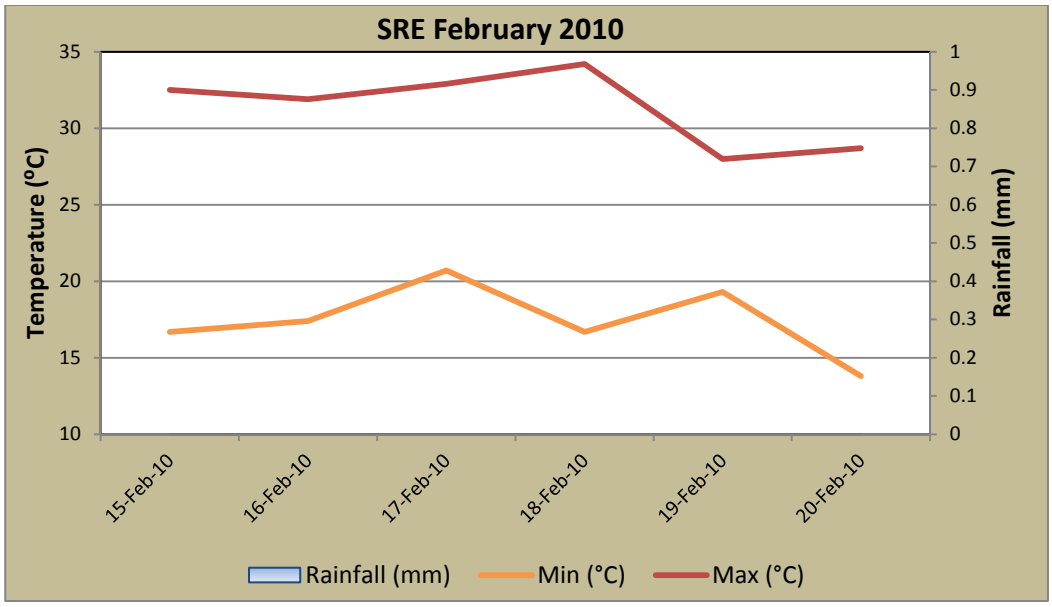


Figure 2-2 Climate information for the SRE Round 1 (February) survey.

2.3.2 SRE Round 2

The March 2010 Round 2 SRE survey recorded minimum temperatures of 10.9°C (29 March) to 18.9°C (25 March), with an average of 15.6°C. The lowest maximum was 24.7°C (27 March) which was also the lowest for the month of March. The highest maximum was 32.4°C (30 March). The average temperature for the duration of the survey was 28.2°C (BOM 2010) (Figure 2-3). No rainfall was recorded during the survey; however a large storm front came through Perth on Monday 22 March 2010 recording 36.6mm in the 24hr period to 23 March 2010 resulting in moist conditions across the study area.

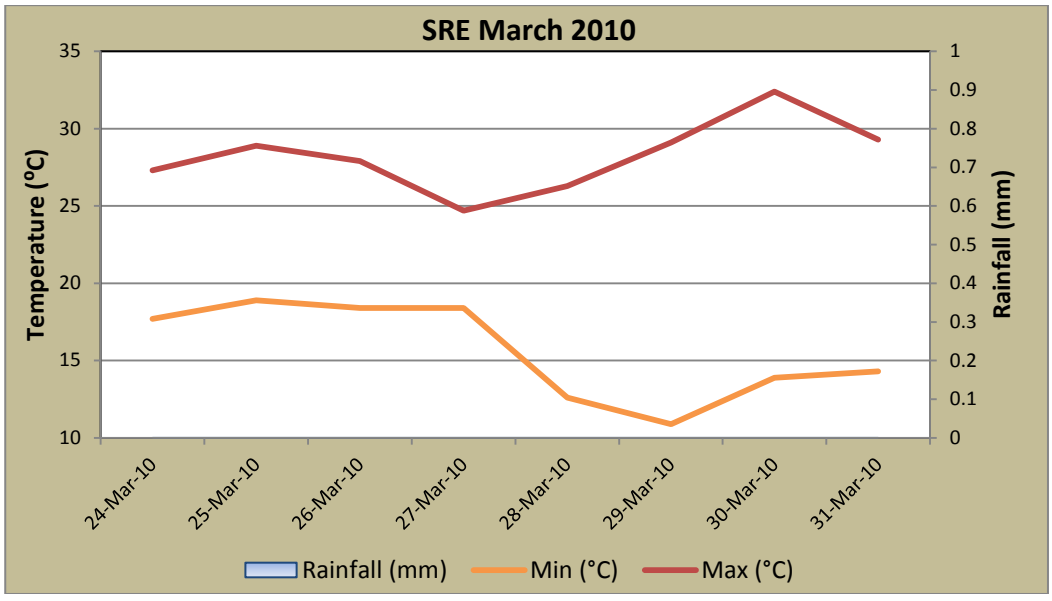


Figure 2-3 Climate information for the SRE Round 2 (March) survey.

2.3.3 SRE Round 3

The Round 3 SRE survey in late April to early May 2010 recorded minimum temperatures of 5.9°C (04 May) to 11.0°C (01 May), with an average of 8.6°C. The lowest maximum was 21.6°C (04 May) and the highest was 36.9°C (29 April), with an average for the duration of the survey of 28.5°C (BOM 2010). Only 1.6mm of rain fell during the survey period on 01 May (Figure 2-4).

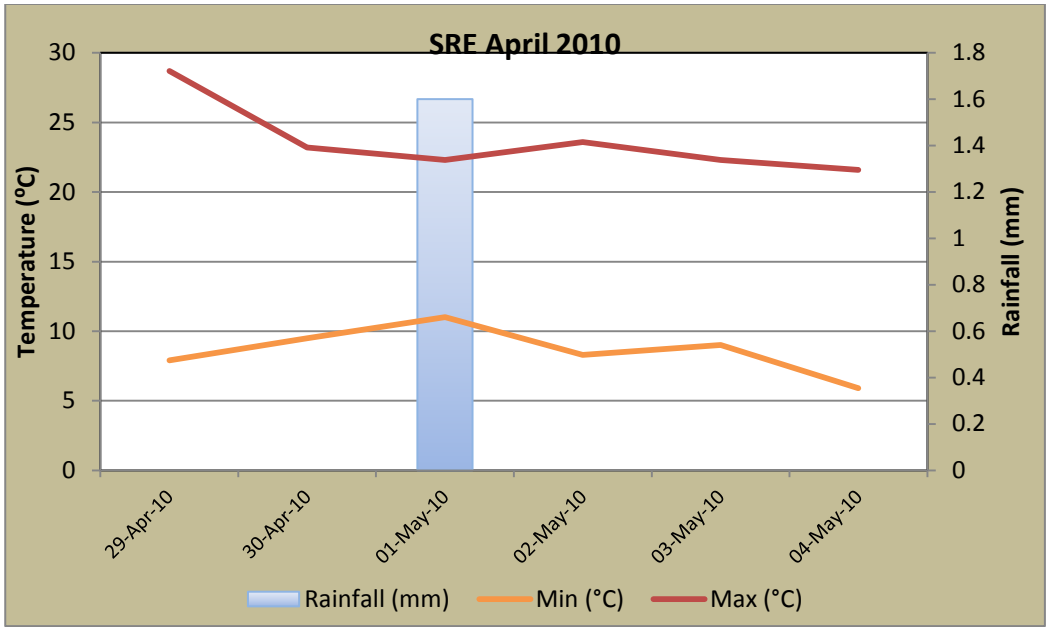


Figure 2-4 Climate information for the SRE Round 3 (April) survey.

2.3.4 SRE Round 4

The Round 4 SRE survey in May 2010 recorded minimum temperatures of 4.6°C (17 May) to 14.7°C (22 May), which was also the highest recorded minimum for the month. The average minimum temperature recorded was 8.4°C. The lowest maximum was 19.1°C (22 May) and the highest was 27.7°C (20 May), with an average for the duration of the survey of 23.1°C (BOM 2010). A total of 29.8mm of rainfall was recorded on the final day of the survey (22 May) (Figure 2-5).

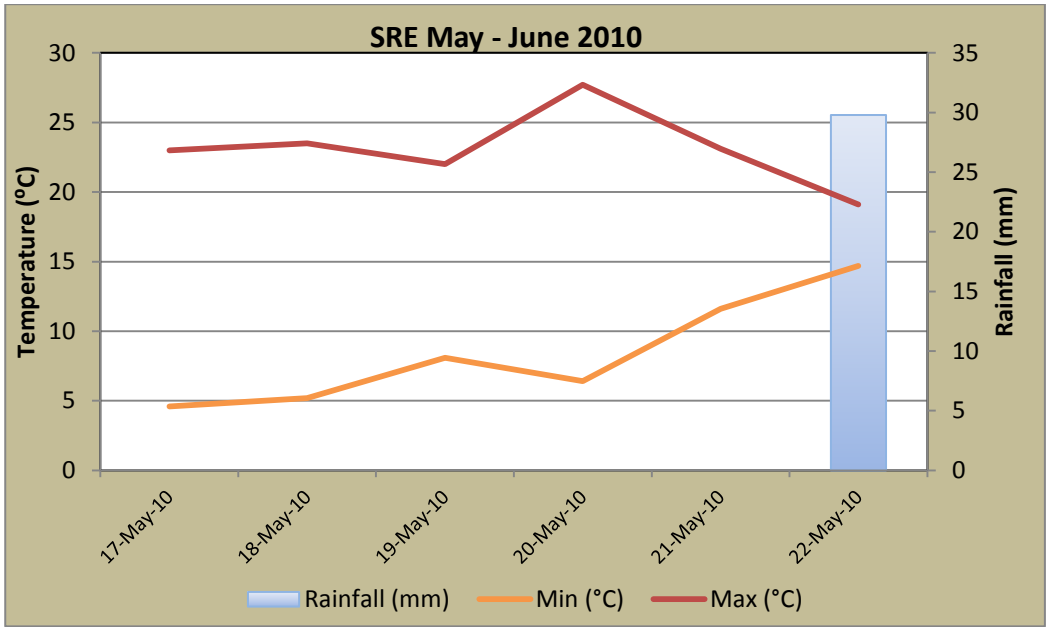


Figure 2-5 Climate information for the SRE Round 4 (May) survey.

2.3.5 SRE Round 5

The Round 5 SRE survey recorded minimum temperatures of 1.1°C (24 July) to 5.7°C (19 July), with an average of 2.6°C. The lowest maximum was 17.4°C (19 July) and the highest was 20.3°C (24 July), with an average for the duration of the survey of 19.1°C (BOM 2010). No rainfall was recorded during the survey (Figure 2-6).

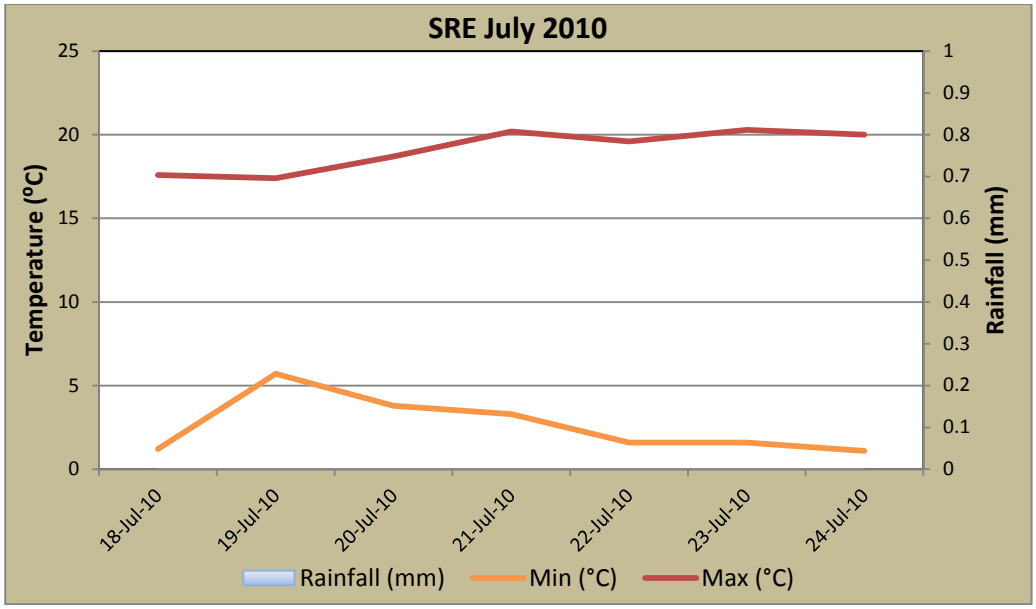


Figure 2-6 Climate information for the SRE Round 5 (July) survey.

2.3.6 SRE Round 6

The Round 6 SRE survey recorded minimum temperatures of 2.0°C (17 August) to 12.5°C (12 August), with an average of 6.5°C. The lowest maximum was 17.2°C (14 August) and the highest was 20.5°C (11 August), with an average for the duration of the survey of 18.74°C (BOM 2010). Rainfall was recorded during the survey on three days (12-14 August) recording rainfall of 25.2mm (12 August), 14.2mm (13 August) and 1.4mm (14 August) totaling 40.8mm during the survey period (Figure 2-7).

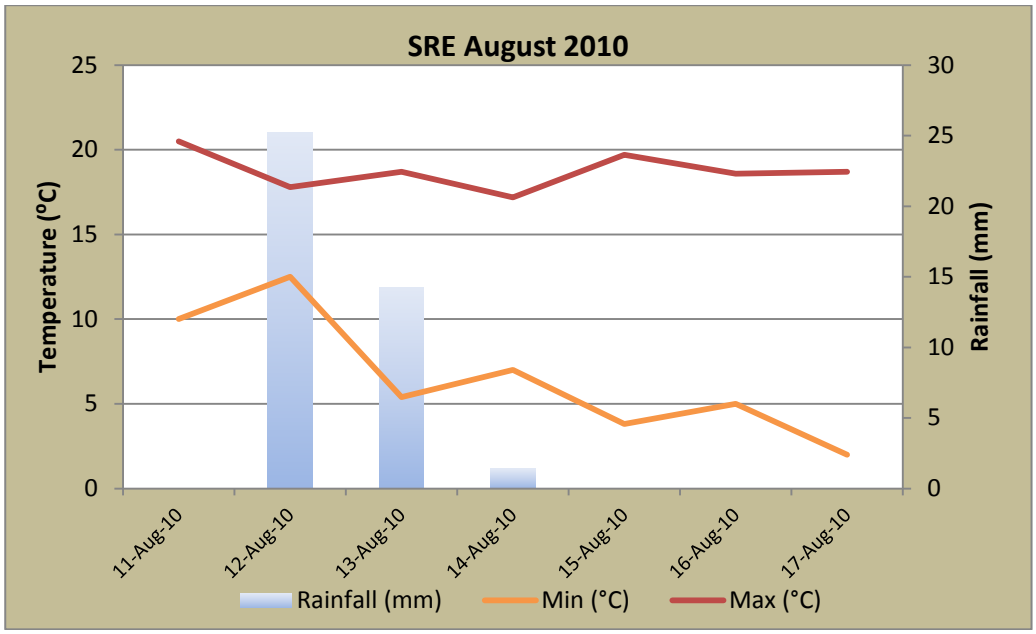


Figure 2-7 Climate information for SRE Round 6 (August) survey

2.3.7 SRE Round 7

The Round 7 SRE survey recorded minimum temperatures of 3.1°C (23 September) to 8.4°C (19 September), with an average of 5.52°C. The lowest maximum was 23.5°C (19 September) and the highest was 28.0°C (23 September), with an average for the duration of the survey of 25.82°C (BOM 2010). No rainfall was recorded during the survey (Figure 2-8).

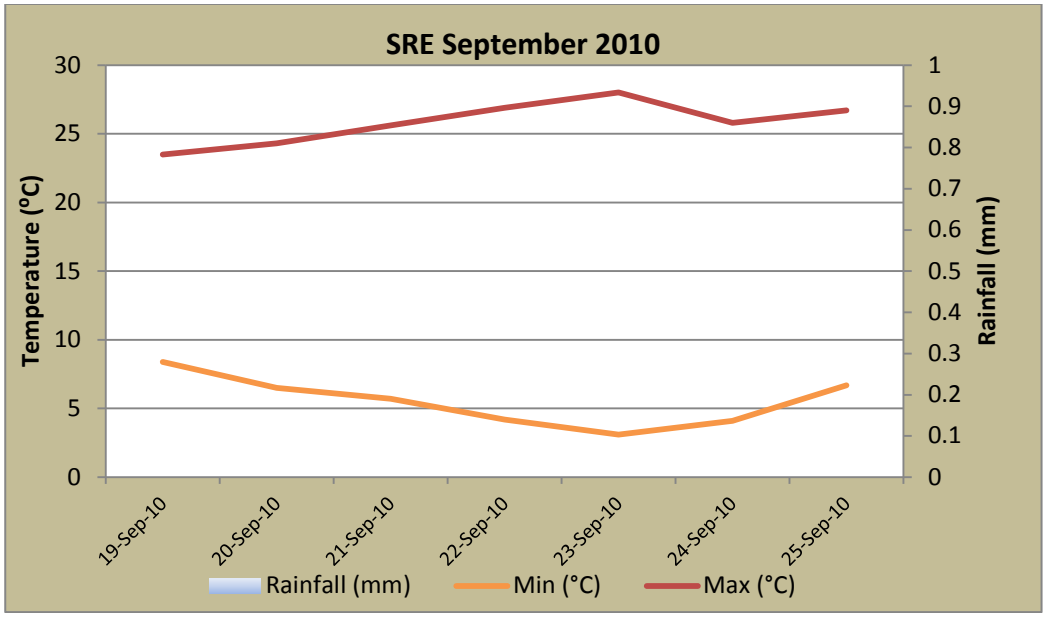


Figure 2-8 Climate information for SRE Round 7 (September) survey

2.3.8 TIA Summer 2009

The minimum temperatures recorded in the TIA survey in summer 2009 ranged from 7.8°C (03 December) to 18.2°C (07 December), with an average of 14.2°C. The lowest maximum was 25.1°C (06 December) and the highest was 34.3°C (08 December), with an average for the duration of the survey of 29.8°C (Figure 2-9). The minimum temperatures recorded during the survey were the lowest for the month of December. No rainfall was recorded during the survey, however a total of 204.4mm fell during the preceding two months, resulting in moist conditions across the study area (BOM 2010).

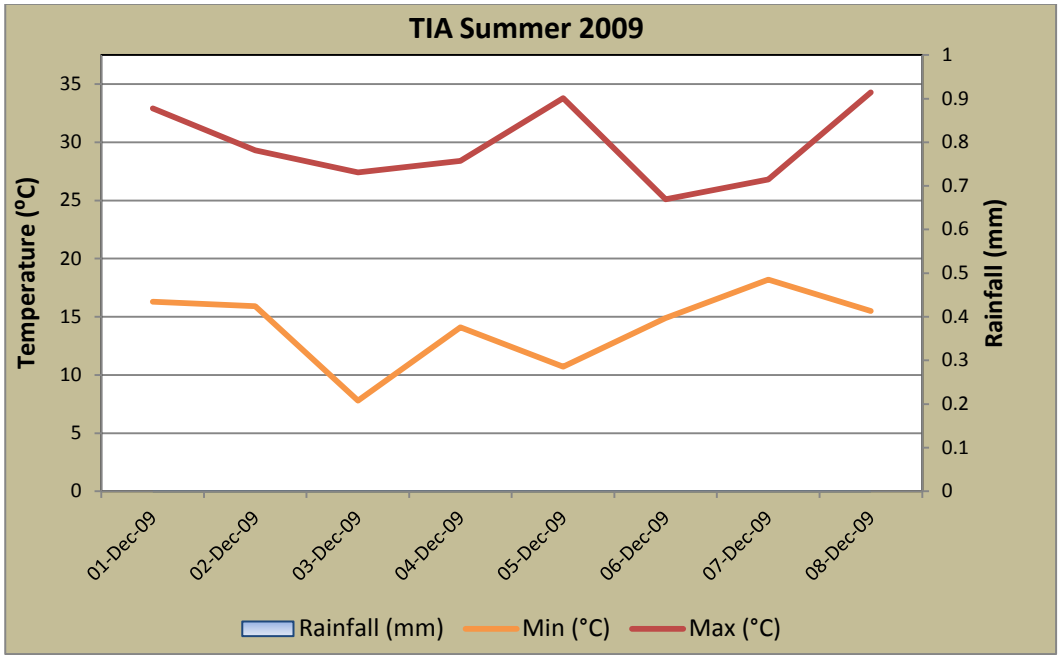


Figure 2-9 Climate information for the TIA Summer 2009 survey.

2.3.9 TIA Autumn 2010

The autumn TIA survey conducted in May and June 2010 recorded minimum temperatures of -1.9°C (03 June), also the coldest day of the month, to 10.8°C (27 May), with an average of 4.4°C. The lowest maximum was 15.0°C (03 June) and the highest was 23.4°C (30 May), with an average for the duration of the survey of 19.3°C (BOM 2010).

Rainfall during the survey period totaled 35.4mm during five rainfall events; however, less than 1mm was recorded on three of the five events (24 May, 02 June and 03 June 2010) (Figure 2-10). The two most significant rainfall days (27 May and 28 May) recorded 23.4mm and 11mm respectively although the survey was postponed temporarily between 26 May and 02 June due to the wet conditions, recommencing on 03 June 2010.

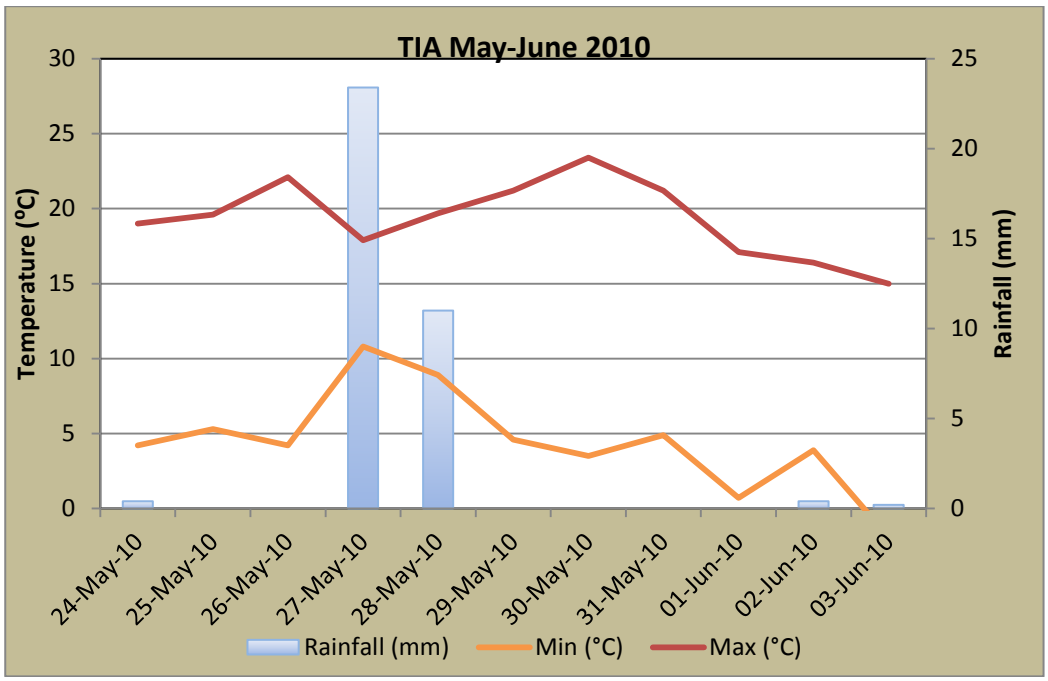


Figure 2-10 Climate information for the TIA Autumn/Winter 2010 survey.

2.3.10 TIA Spring 2010

The spring TIA survey was conducted in two parts in September and November 2010 and recorded minimum temperatures of 3.1°C (23 September) and 7.6°C (6 November), to 6.7°C (25 September) and 17.8°C (9 November) with an average of 5.05°C (September) and 12.6°C (November). The lowest maximums were 24.3°C (20 September) and 22.4°C (5 November) the highest were 28.0°C (23 September) and 30.0°C (8 November), with an average for the duration of the September survey of 26.21°C and the November survey of 24.63°C (BOM 2010). No rainfall was experienced during either part of the spring surveys (Figure 2-11).

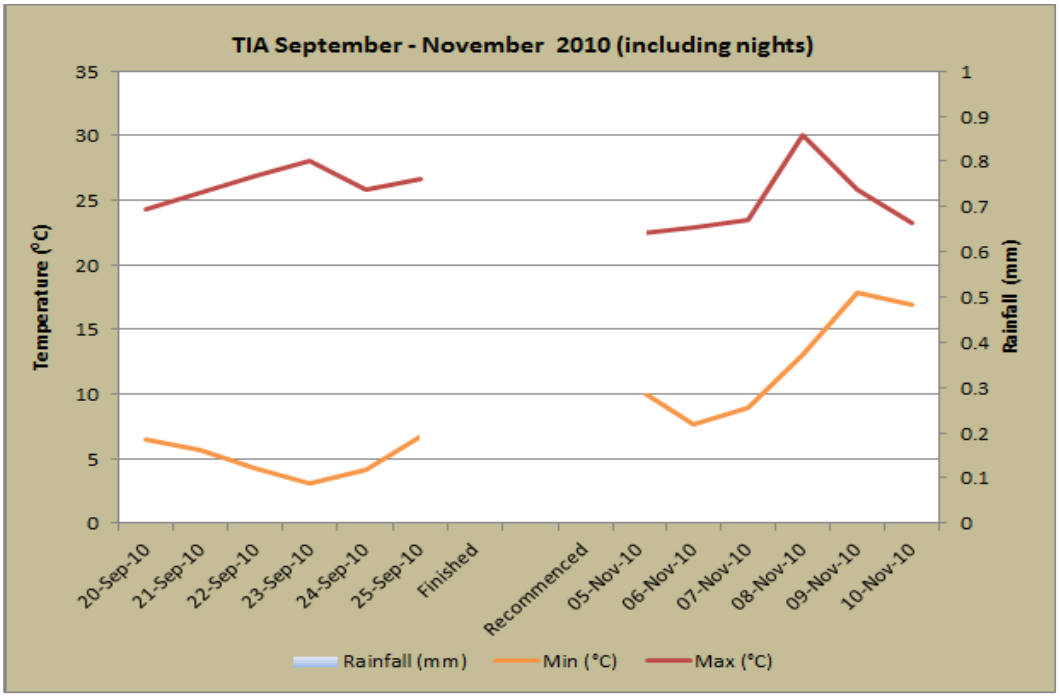


Figure 2-11 Climate information for the TIA Spring 2010 survey

2.3.11 TIA Late Spring 2010

The late spring TIA survey conducted for targeted bees in November 2010 recorded minimum temperatures of 12.7°C (17 November), to 21.1°C (19 November) with an average of 16.76°C (November). The lowest maximum was 34.7°C (17 November) and the highest was 39.9°C (19 November), with an average for the duration of the November survey of 37.53°C (BOM 2010). No rainfall was experienced during the late spring survey (Figure 2-12).

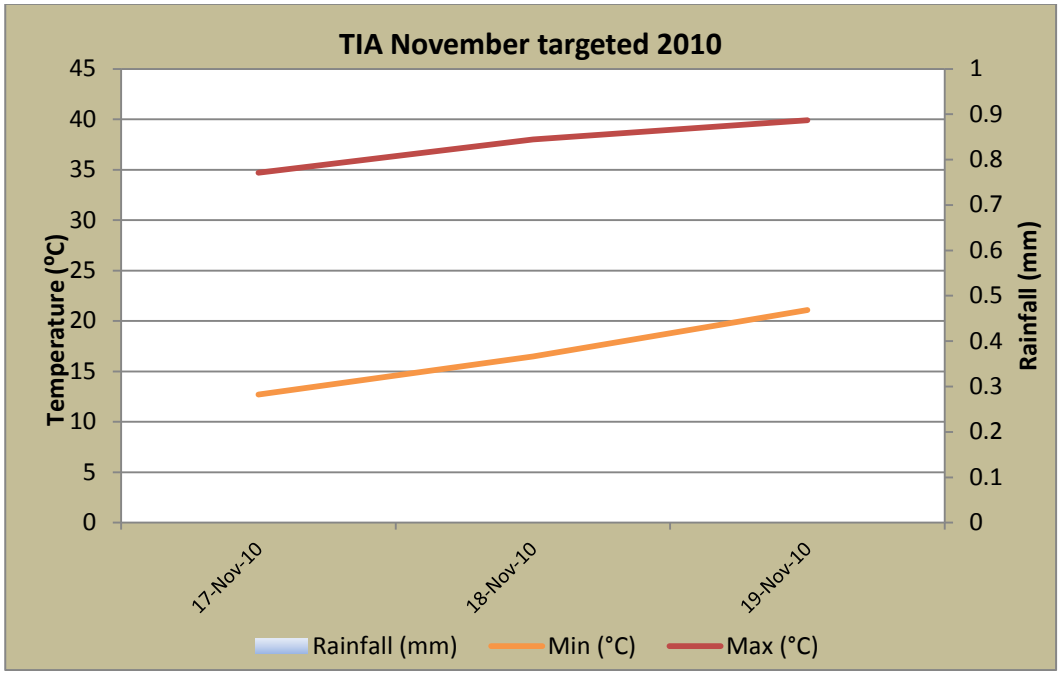


Figure 2-12 Climate information for the TIA Late Spring 2010 survey

2.3.12 GSM Survey Season 2010

The GSM survey conducted over the months of March and April 2010 recorded minimum temperatures of 10.3°C (20 March) (the monthly record) to 8.6°C (05 April). The highest minimum for the survey period in March was 27.9°C (12 March) and in April was 17.8°C (03 April) with an average of 16.1°C. The lowest maximum for the survey period was 23.0°C (03 April) and the highest was the monthly record of 40.8°C (12 March), with an average for the duration of the survey of 37.6°C (BOM 2010).

Rainfall during the survey period fell mainly during the unseasonal hail storm which hit Perth in late March recording 36.6mm by 23 March 2010; however, a total of 37.6mm was recorded for the survey period as there were two other rain days (04 and 05 May) where 0.8mm and 0.2mm were recorded, respectively (Figure 2-13).

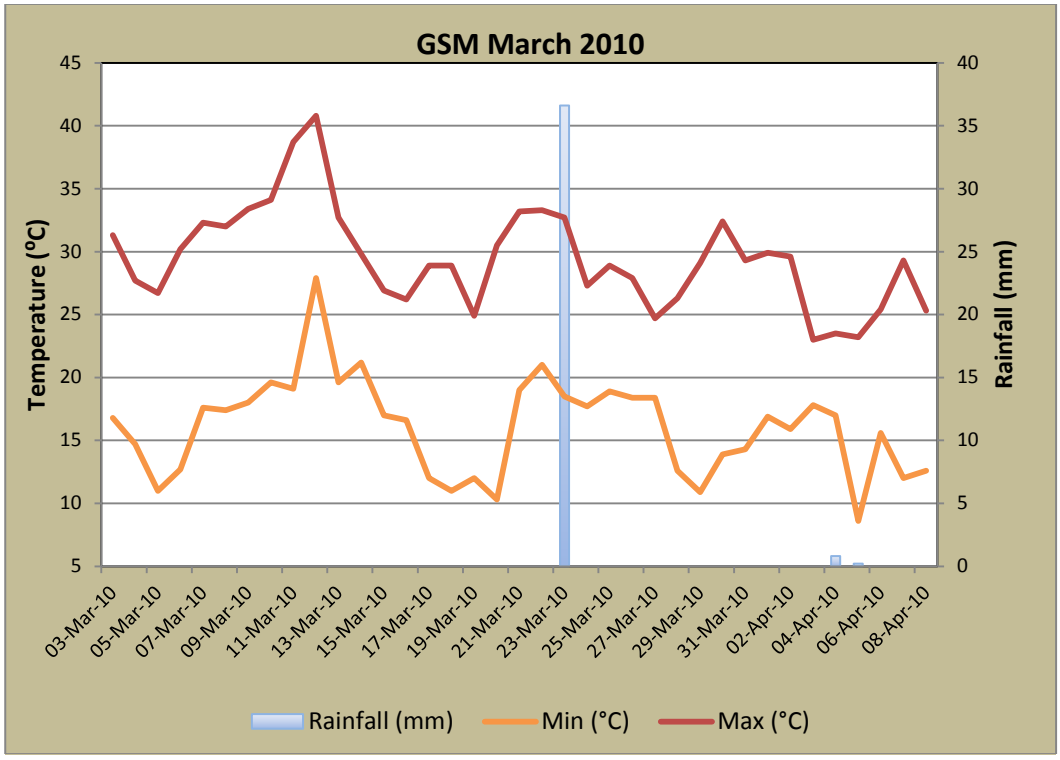


Figure 2-13 Climate information for the GSM survey rounds.

2.4 BIOLOGICAL CONTEXT

No previous SRE surveys or surveys specifically targeting conservation significant invertebrate species are known to have occurred within the study area.

A number of other biological surveys have been conducted within the project area by local interest groups, academic researchers, private consultants, non-government organisations and government agencies. Some of these may be relevant to invertebrates in the project area, including:

- A summary of information for the project area as part of the Bush Forever project (WAPC 2000), under which the project area is listed as Bush Forever Site 244;
- An Environmental Management Plan (EMP) for Bibra Lake (Strategen 2008); and
- The Beeliar Regional Park Management Plan produced by the (then) Department of Conservation and Land Management (CALM 2006a) (now DEC).

The Western Australian Museum has conducted two extensive invertebrate (and vertebrate) surveys within the Perth Metropolitan Area that provided detailed inventories of some of the SRE target groups (e.g., arachnids and myriapods) in urban remnant bushlands. The Urban Bushland Survey 1993-1996 ("WAM UBS") investigated 36 invertebrate sites at 13 locations (comprising 22 discrete bushland remnants) from Hepburn Heights in the North to Woodman Point in the south (How, Harvey *et al.* 1996). A later survey, the Ridge Hill Shelf and Pinjarra Plain Survey 1996-1997 ("WAM RHS") added further invertebrate data for nine bushlands on the Swan Coastal Plain in the Perth Metropolitan Area (Harvey, Dell *et al.* 1997). Although neither of these surveys included bushlands in the project area, these surveys act here as benchmarks to assess the distribution of SREs in the Perth Metropolitan area.

2.5 LAND USE

Land use on the Swan Coastal Plain, specifically the Perth Metropolitan area, includes urban, rural residential, roads, other easements and infrastructure, agriculture and plantations, forestry-plantations, conservation land, unallocated crown land, crown reserves, cultivation – irrigated horticulture and dry land agriculture, and grazing (Mitchell, Williams *et al.* 2002). Smaller areas are also used for mining and defence.

The impacts of these varying land uses, specifically urbanisation and the subsequent creation of road networks, can have a profound impact on native wildlife. Impacts may occur through habitat loss and fragmentation, the loss of native species and decreases in abundance.

3.0 METHODS

3.1 CONSULTATION

In November 2009 Phoenix met with members of the Cockburn Wetland Education Centre and representatives from the DEC to discuss the attributes of the general area, DEC survey expectations and site selection criteria.

Substantive liaison with the DEC was undertaken in regard to the surveys. The timing of the SRE, TIA and GSM surveys were designed to capture the seasonal changes that are integral to the many invertebrate species' life histories (Table 3-1).

Table 3-1 Survey design parameters and timing factors.

Survey Type	Survey Design Parameters	Survey Timing Factors
SRE	Cover the transition from autumn to winter, winter to spring and into summer.	Driven by conditions at the time of survey period in an attempt to capture significant climatic events (like the first rains) that can trigger invertebrate activity in each of the selected sites.
TIA	Biological attributes and habitat preferences of each target species.	Surveys were undertaken in the summer 2009, autumn 2010 and spring 2010 seasons.
GSM	Must be undertaken in locations with known or suspected *Lomandra* sp. and timing of the survey is critical in the determining factor of presence or absence. Even daily weather conditions need consideration.	Only to be surveyed in the preferred sampling season (late February to early April) which is consistent with the known biology of the species (Bishop, Williams *et al.* 2009). Changes to this now restrict the survey period to six sampling events in the month of March (Bishop *et al* 2010).

3.2 DATABASE SEARCHES

A comprehensive desktop review was undertaken and included all available local and regional published and unpublished reports, databases and spatial data. Relevant environmental databases and maps were also reviewed to identify significant species that may occur within the project area. The following databases were reviewed:

- EPBC Act protected matters database within the coordinates 32.07361,115.793, -32.07361,115.8549, -32.1075,115.8549, -32.1075,115.793 (+1km buffer);
- DEC Threatened Fauna database within the coordinates 32.0737°S 115.7930°E/32.1074°S 115.8552°E;
- DEC NatureMap within the coordinates 115°47' 35"E, 115°51' 20"E, 32°04' 25"S, 32°06' 25"S;
- WAM arachnid and myriapod database within the coordinates 115°47' 35"E, 115°51' 20"E, 32°04' 25"S, 32°06' 25"S.

3.3 HABITAT ASSESSMENT

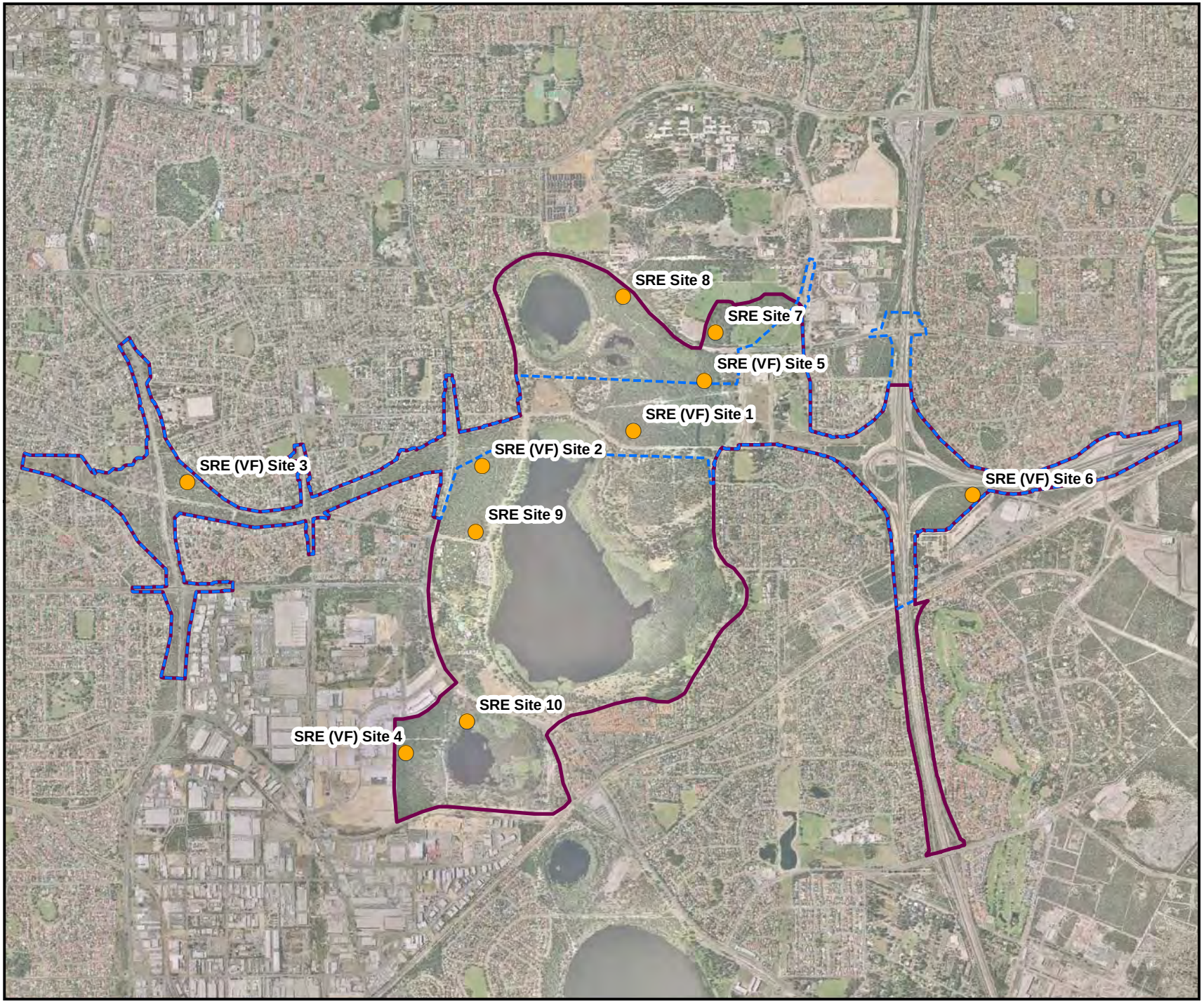
A review of aerial photography, topographic maps, GIS data and fauna databases prior to mobilisation did not identify many prospective SRE habitats or known SRE species within the study area. Database interrogation however did identify a number of conservation significant species whose presence within the study area could not be immediately discounted due to the paucity of information concerning invertebrate distribution in the Perth Metropolitan Area and more specifically, the southern Metropolitan Area. Field-based habitat assessments were therefore considered prudent.

Previous survey reports, aerial photographs and maps were reviewed to define the potential invertebrate fauna habitats of the study area. These habitats were ground-truthed in the initial field surveys for each survey type (SRE, TIA and GSM, described in 3.4 and 3.5), and traversed in an effort to identify any other potential habitats that were not identified in the desktop survey.

The broad habitat types identified appeared to be relatively continuous throughout their extent, within each of the three study areas. They largely consisted of Jarrah-Marri-*Banksia* associations with and without *Allocasuarina fraseriana* (AECOM 2010). There were also small pockets of restricted vegetation, which were typically associated with deeper, peatier soils in areas of seasonal water accumulation (e.g. Roe Swamp).

Although short-range endemism is not considered prevalent in many invertebrate taxa on the Swan Coastal Plain, small pockets of restricted vegetation identified in the site selection field phase were considered the most likely to support or have facilitated the formation of short-range endemism among the resident invertebrate fauna. These were chosen for the placement of traps (Figure 3-1). Other typical SRE habitats within the Swan Coastal Plain include (but are not limited to) isolated mesic vegetation pockets, gullies or limestone/calcrete outcrops, wet areas around springs and seeps, closed woodlands and drainage line riparian zones and depressions.

The TIA and GSM survey sites were chosen from areas containing plant species known to be associated with each targeted species, such as *Lomandra hermaphrodita* and *L. maritima* for the Graceful Sun-moth. Survey sites were also chosen for their relevance to the habitat preference of each species, for example the native bee species *Neopasiphae simplicior* is known to inhabit *Banksia* woodland and favours plant species in the Goodeniaceae and Lobeliaceae families (Figure 3-2; Figure 3-4, Figure 3-4).



Location of Short-Range Endemic Trapping Sites

Figure 3-1

0 0.25 0.5 0.75 1

Kilometres

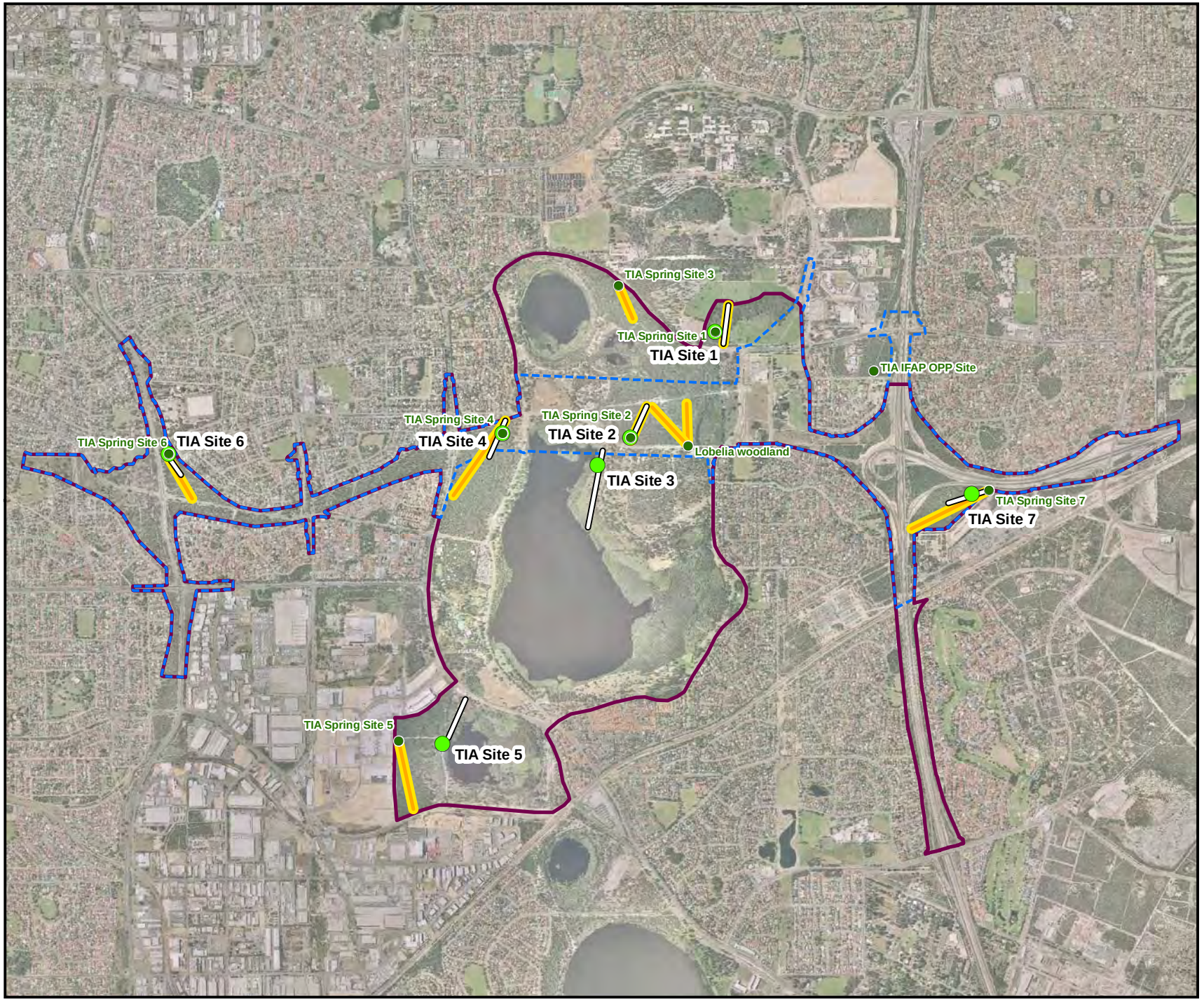
1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- SRE Dry Pitfall Trapping Sites
- Project Area
- Study Area

Date Modified: 15/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 3-1 - Location of Short-range Endemic Trapping Sites.mxd



Location of Targeted Invertebrate Assessment Sites

Figure 3-2

0 0.25 0.5 0.75 1

Kilometres

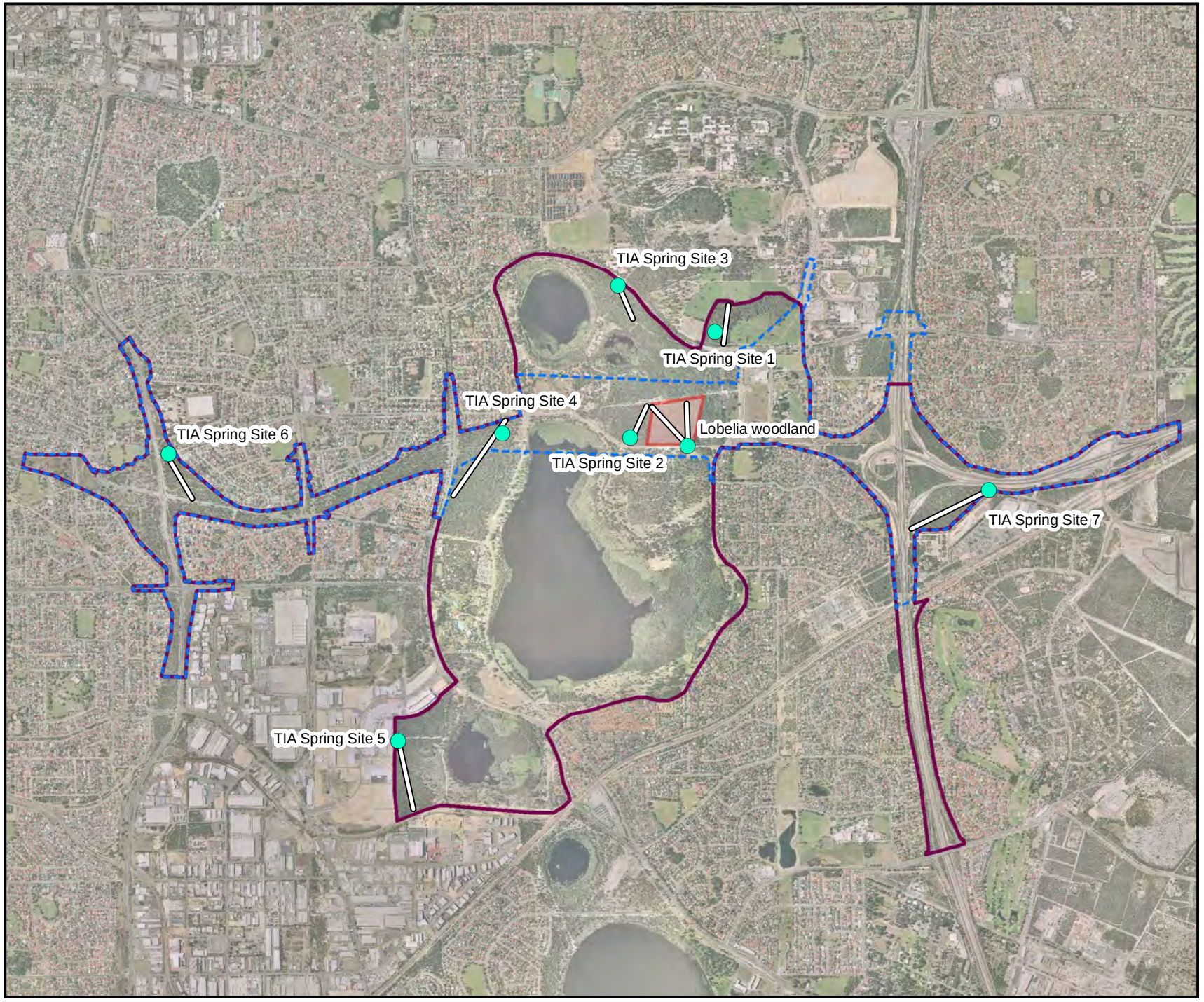
1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- TIA Spring Survey Sites
- TIA Dry Pitfall and Bait Station Sites
- TIA Spring Survey Transects
- TIA Netting Transects
- Study Area
- Project Area

Date Modified: 15/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 3-2 - Location of targeted invertebrate assessment sites.mxd



Location of *Lobelia* Woodlands and Targeted Bee Transects

Figure 3-3

0 0.25 0.5 0.75 1

Kilometres

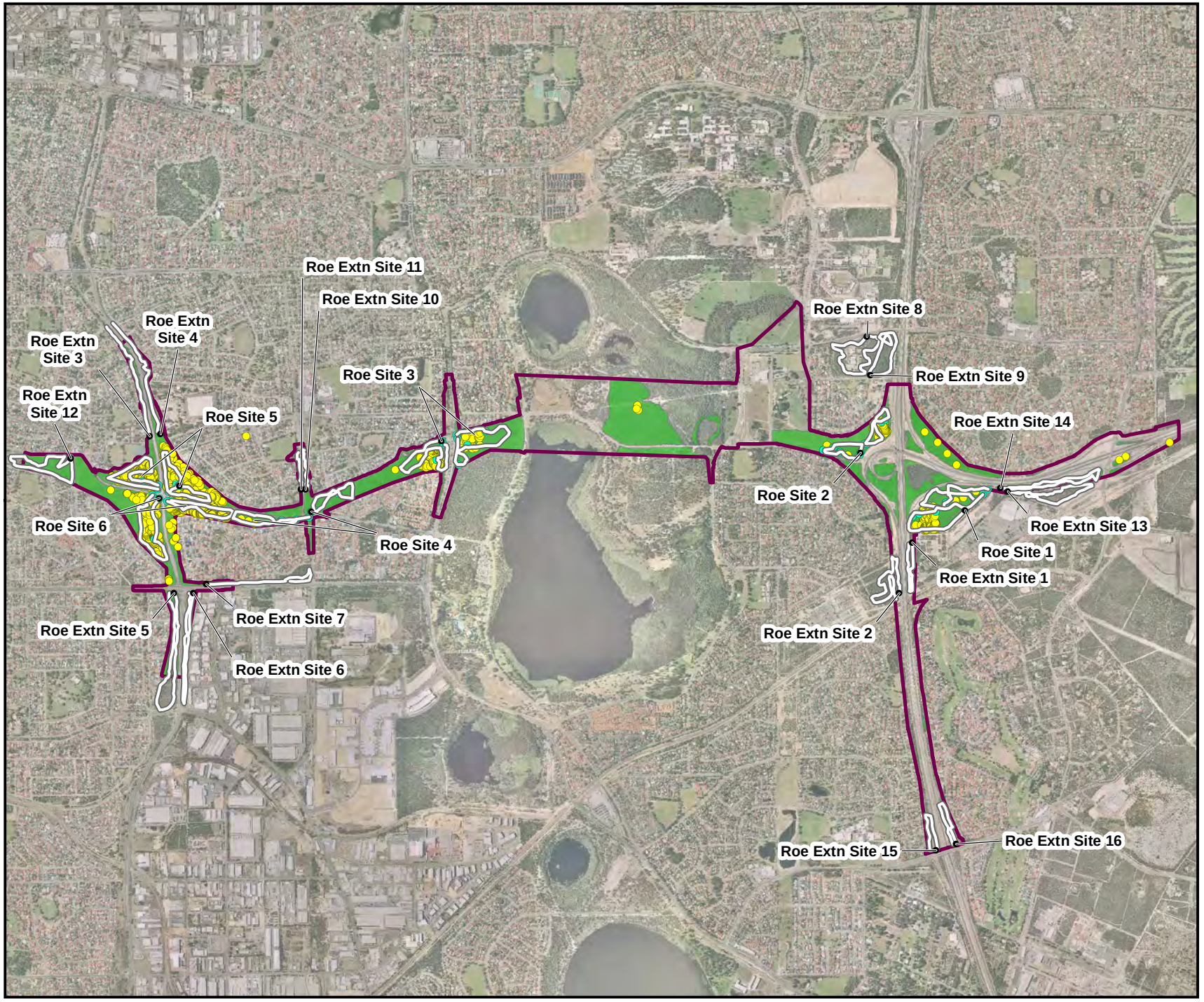
1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- Trapping Sites
- Targeted Bee Transects
- Targeted *Lobelia* Woodland Survey Area
- Project Area
- Study Area

Date Modified: 9/03/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 3-3 - Location of the Lobelia woodland and Targeted bee transects Spring 2010.mxd



Location of Graceful Sun-Moth Transects and Habitat

Figure 3-4

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

Graceful Sun-moth Habitat and Transects

- *Lomandra hermaphrodita* Record
- *Lomandra* sp. Record
- Graceful Sun-moth Transect
- Study Area
- Possible Graceful Sun-Moth Habitat (vegetation communities in which *Lomandra hermaphrodita* was recorded - post survey 2010)

Date Modified: 9/03/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 3-4 - Location of Graceful Sun-moth transects and habitat.mxd

3.4 SAMPLING METHODOLOGY – SHORT-RANGE ENDEMIC SPECIES

A number of taxonomic groups include a considerable proportion of SRE species (Harvey 2002) and were therefore targeted in the study area:

- Araneae (spiders), in particular Mygalomorphae (trap-door spiders);
- Scorpiones (scorpions);
- Pseudoscorpiones (pseudoscorpions);
- Diplopoda (millipedes);
- Chilopoda (centipedes);
- Gastropoda (land snails); and
- Isopoda (slaters).

The invertebrate field surveys consisted of three proven, industry-recognised sampling techniques, which target SRE taxa: dry pitfall trapping; active searches (foraging); and the collection and sieving of leaf litter samples.

3.4.1 Dry Pitfall Trapping

Dry pitfall trapping was conducted at ten sites, comprising five sites within the project area (including a 100m buffer) and five reference sites outside of the project area (Figure 3-1).

Ten trap lines were established at each of the ten sites. Six of the ten sites employed the standard vertebrate fauna trapping assembly, modified to assist in invertebrate collection (Trap B from Figure 3-5). This comprised a trap line of 6m long with a 30cm high aluminium drift fence bisecting a combination of alternating PVC pipes (inserted with a funnel-bucket collector) and 20L buckets, in the centre of each trap line.

The remaining four trap sites were identical in scale, the difference being that three 0.75L plastic containers with a 170mm diameter (Trap A from Figure 3-5) were used. The buckets were installed 1 to 3cm below the level of the substrate, at the centre and at each end of a 6m long, 300mm high aluminium drift fence.

All trapping containers were partly filled with a small amount of leaf litter or bark to shield any vertebrate by-catch. The traps were left open for a period of five nights in each survey round and checked twice daily to remove potential vertebrate by-catch. A total sample size of 3,900 trap nights was attained over the seven sampling rounds (Table 3-2).

Trapping was conducted for a period of six days (five trap nights) every month from February 2010 to September 2010, totalling nine months of trapping in the preferred autumn and spring cycles. During survey periods, which experienced rainfall or inclement weather (SRE Rounds 2, 5, 6, and 7), an additional trap night was added to the survey time, totalling 7 days of survey (six trap nights).

This program excluded the winter month of June for SRE trapping, as it was considered more important to capture the change of seasons, into and out of winter. Traps opened in March 2010, were subsequently drowned and washed up from the ground by the hail storm. These traps had to be drained and dug back into the ground, and the survey re-commenced, for that period. Similarly, heavy rainfall in the study area during the survey rounds SRE Round 4 (May) and SRE Round 6 (August) required additional survey nights to drain and rest the trap lines.

Opportunistic collections were also made during the concurrent Vertebrate Fauna surveys and these sites are recorded as Site A, Site F, and Site I in the results of this report.

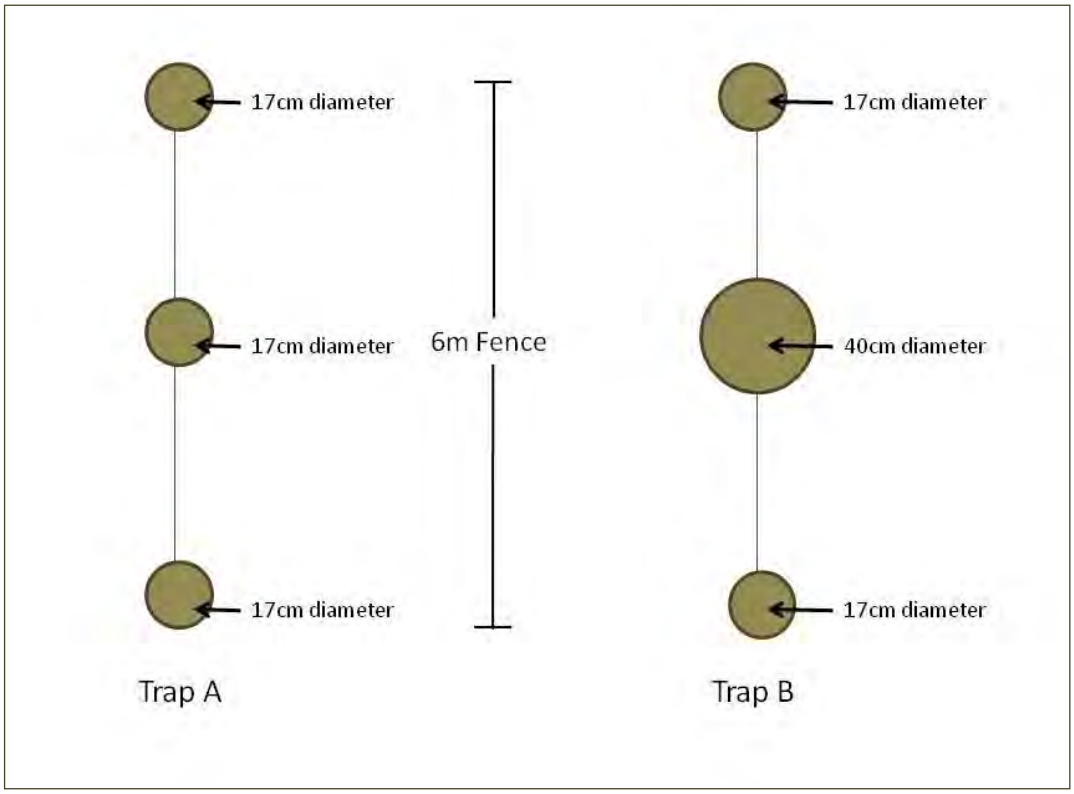


Figure 3-5 SRE trapping schematic diagram.

Table 3-2 Sampling effort for the Roe Highway SRE survey.

Techniques	No. Sites[a]/ Samples[b]	No. Traps	No. Nights	Total Sample Size (N)
Dry pitfall trapping	10[a]	10	39*	3900 trap nights
Leaf litter samples	10[b]	n/a	n/a	10

*39 nights over seven rounds undertaken 3 x 5 trap nights and 4 x 6 trap nights

3.4.2 Leaf Litter Sampling and Active Foraging

Leaf litter samples were taken at each of the ten SRE sites in an effort to target pseudoscorpions, which appeared to be absent from the dry pitfall traps in the first few rounds. The collection of leaf litter samples was not standardized (either volumetrically or by weight) due to the high variability of the soil and leaf litter depth throughout the study area. However, collections were made from a 300mm x 300mm area from an average of five trees per sample site. These collections were undertaken during SRE survey Round 5 (Table 3-3).

Table 3-3 Roe Highway sampling effort timing for each round of SRE survey.

Survey Round	No. Nights	Date Started	Date Finished
SRE Survey 1 – February	5	Monday 15 February	Saturday 20 February
SRE Survey 2 – March	6*	Wednesday 24 March	Wednesday 31 March
SRE Survey 3 – April	5	Thursday 29 April	Tuesday 04 May
SRE Survey 4 – May	5	Monday 17 May	Saturday 22 May
SRE Survey 5 – July	6*	Sunday 18 July	Saturday 24 July
SRE Survey 6 – August	6*	Wednesday 11 August	Tuesday 17 August
SRE Survey 7 – September	6*	Sunday 19 September	Saturday 25 September

*An additional night was included due to rainfall or inclement conditions and emptying/resetting of trap buckets

3.4.3 SRE Survey Effort

Site descriptions, vegetation, and sampling activity were recorded at representative sites (Appendix 1). The coordinates of each site were recorded by a hand held GPS device (Appendix 2). All data was recorded in WGS-84 datum.

3.5 SAMPLING METHODOLOGY – TARGETED INVERTEBRATE SPECIES

The preliminary invertebrate fauna assessment in October 2009 identified a number of priority invertebrate taxa considered likely to be present within the Beeliar Regional Park wetlands and surrounds, namely:

- Graceful Sun-moth (*Synemon gratiosa*) (Lepidoptera: Castniidae);
- Scorpion Fly (*Austromerope poultoni*) (Mecoptera: Meropeidae);
- Native cricket species (*Throscodectes xiphos* and *Austrosaga spinifer)* (Orthoptera: Tettigoniidae); and
- A number of native bee species (*Leioproctus bilobatus, L. contrarius, L. douglasiellus, Neopasiphae simplicior*) (Hymenoptera: Colletidae).

The Yellow Admiral Butterfly (*Vanessa itea*; Lepidoptera: Nymphalidae) has subsequently been identified as potentially occurring within the Beeliar Regional Park. This species is common in the southern half of Australia and also occurs in New Zealand. It is therefore not a priority or listed species but is considered locally significant from a community perspective as it is used in school and community group surveys.

3.5.1 TIA Survey Considerations

The priority invertebrates, which may potentially occur in the study area, are mostly flying insects. They typically require different survey techniques to those of SRE taxa (Table 3-4). Generally, large aerial sweep nets are used to collect these taxa on the wing. Due to their delicate nature they are immediately preserved using cyanide or ethyl acetate.

Table 3-4 Targeted priority invertebrate species survey timing, techniques and considerations.

Taxa	Season/Month	Collecting Technique	Considerations	Preservation Techniques
Graceful Sun-moth (*Synemon gratiosa*)	February, March, April	800m – 1,100m transects along tracks bisecting *L. hermaphrodita* locations.	Found only on *L. hermaphrodita*	Segregated cyanide/ ethyl acetate bottles and pinned
Scorpion Fly (*Austromerope poultoni*)	Spring / November	Small test tube sized pitfall traps, foraging and dry pitfall effort, bait stations with non-chemical fly and wasp attractants	Ground dwelling	Preserved in ethanol
Native cricket species (e.g. *Throscodectes xiphos* and *Austrosaga spinifer*)	Spring / November	Large aerial sweep nets amongst flowering shrubs, pitfall trapping, foraging, night spotting	Although they can fly, are more likely to be caught near the ground amongst shrubs and grasses.	Cyanide/ethyl acetate bottles and pinned
Native bee species (e.g. *Leioproctus biliobatus, L.contraries, L. douglasiellus, Neopasiphae simplicior*)	Spring / November	Large aerial sweep nets. Sweeping amongst flowering shrubs, bait stations with sugar syrup attractant	Nectar feeding, low flying	Ethyl Acetate (not cyanide bottles) and pinned
Yellow Admiral Butterfly (*Vanessa itea*)*	Spring / November	Large aerial sweep nets amongst flowering shrubs	Nectar feeding, low flying over heath and shrubs and in open track areas	Segregated cyanide/ ethyl acetate bottles

* Locally significant, not priority

3.5.2 GSM Survey Considerations

Previous survey reports and project boundary maps were reviewed to define potential habitats of the Graceful Sun-moth within the study area. An initial six transects (Table 3-6) comprising three major vegetation types that were known to contain *Lomandra* species were targeted at the beginning of the sampling (Bennett 2004). These included:

AfBa Low woodland of *Allocasuarina fraseriana*, *Banksia attenuata* and *B. menziesii* with occasional *Eucalyptus marginata* over an open low open heath dominated of *Leucopogon conostephioides*, *Eremaea pauciflora* and *Anigozanthos humilis* in grey sand.

Ba1 Low woodland of *Banksia attenuata, B. menziesii* with occasional *Eucalyptus marginata* over a tall open shrubland of *Allocasuarina humilis* and *Hibbertia hypericoides* over a very open sedgeland of *Mesomelaena pseudostygia* in grey- brown to yellow sand.

EmBa Low woodland of *Eucalyptus marginata* and *Banksia attenuata* over a tall open shrubland of *Allocasuarina humilis, Xanthorrhoea preissii* and *Hibbertia hypericoides* over a very open sedgeland of *Mesomelaena pseudostygia* in grey to yellow sand.

The vegetation data available were not of sufficient detail to target individual *Lomandra* plants. At the time of survey mobilization, it was only known that certain vegetation units had recorded *Lomandra* during the flora surveys, but not necessarily where the plants were located. AECOM subsequently undertook *Lomandra* mapping (Figure 3-4 and Appendix 3), as required by the GSM survey guidelines (Bishop, Williams *et al.* 2009). This mapping occurred after the initial sampling and could therefore not be used for initial site selection. However, the mapping confirmed that all suitable habitat had been sampled.

Subsequent to the initial GSM survey planning, the project area footprint was expanded and therefore an additional 16 transects were added. A total of 22 GSM survey transects were sampled.

Four primary criteria were used during transect design:

1. Proximity to *Lomandra* species (where known);
2. Proximity to paths and sunlit areas (GSMs are known to be more active around access tracks);
3. Proximity to hills, rises and otherwise elevated areas in a particular block of remnant bushland (GSMs are known to be more abundant in such areas); and
4. Coverage of as much of the study area as possible (in areas where *Lomandra* were previously recorded), due to a paucity of flora data with respect to *Lomandra.*

3.5.3 Pitfall Trapping

A series of five, 5cm diameter specimen vials for dry pitfall trapping were inserted at each of the seven TIA sites to target the scorpion fly and native cricket species (Figure 3-1). The 5cm vials replaced the larger SRE trapping buckets to reduce the potential for vertebrate by-catch and collection of larger non-target invertebrate specimens. Similar to the SRE dry pitfall trapping, all traps were left open for a period of five days in two survey rounds (spring and autumn) and checked daily to remove the specimens. A total sample size of 3,000 trap nights was attained (Table 3-5).

3.5.4 Bait Stations

A sampling method targeting both the scorpion fly and native cricket species were bait stations, utilizing chemical free insect attractant. One was hung in a tree and the other set on the ground in areas of dense scrub and long grasses. In addition, to further target the native bee species, a bait station of sugar syrup was hung from flowering trees or shrubs at each of the seven sites. Bait stations were established at each of the seven TIA sites and left open for a period of two weeks from 05 December 2009 to 20 December 2009, attaining a total sample size of 420 trap nights (Table 3-5).

3.5.5 Leaf Litter Sampling and Active Foraging

Foraging in the two sampling seasons (summer 2009 and autumn 2010) incorporated the inspection of logs, larger plant debris, under the bark of larger trees and the underside of larger rocks (outcrops) at each of the seven TIA sites (Figure 3-2). Methodical searches were also conducted amongst the leaf litter of shade-bearing tall shrubs and trees when establishing the bait stations. On average a total of 75 minutes was spent foraging at each site in the first two sampling seasons.

Leaf litter samples were taken from sites where target taxa were not recorded during the foraging component but where there was potential for occurrence. The collection of leaf litter samples was not standardized (either volumetrically or by weight) due to the high variability of the soil and leaf litter depth throughout the study area. However, collections were made from a 300mm x 300mm area from an average of three trees per sample.

A temporally and spatially standardised approach was undertaken in the spring 2010 sampling season, whereby each of the seven sites were sampled for 60 to 90 minutes within a 50m x 50m area (30 to 45min x two people; 75min average). This equates to 12.5 hours of hand searching, and a total search area of 2.5 hectare (Table 3-5). Intensive sampling, including collection of leaf litter in six 1m x 1m quadrats for 10mins was undertaken during the TIA Spring 2010 survey round at each of the seven sites from within the 50m x 50m areas in each location. This totalled 1hr of intensive sampling at each site in the preferred spring sampling period.

3.5.6 Sweep Netting

In the interests of investigating whether ecological linkages are important for any of these taxa which may potentially be found within the study area, two 500m transects (comprised of two surveyors walking 250m transect lines, or a 500m transect in one direction) were conducted using sweep nets for each sampling event. These transects were surveyed through bushland and riparian zones at each of the seven TIA sites (Figure 3-2).

During each sweep net sampling event, sampling techniques such as beating flowering plants and grass sweeping in cleared areas were employed to better target the known foraging and habitat preferences of each target species. This methodology is preferential for collection of the Yellow Admiral Butterfly, native cricket and bee species and in areas of *Lomandr*a populations, the Graceful Sun-moth.

3.5.7 Targeted Sweep Netting for Native Bees

Further sweep netting events were undertaken in the TIA Spring 2010 survey round and in the TIA Late Spring 2010 survey round. These two survey events conducted during 20 to 25 September 2010 and 17 to19 November 2010 specifically targeted preferential habitat (flowering plants of the Families Goodenaceae, Fabaceae and Lobeliaceae) and active flight times (warm sunny days in spring to early summer) for the native bee species which had the potential to occur in the project area.

Within the project area, a small section of habitat (7.5 ha) was identified (*Lobelia* woodland) which had the greatest potential to host the Schedule 1 native bee species *Neopasiphae simplicitor* (Figure 3-3). Similarly the native bee species *Leioproctus contrarius* also has the potential to occur within a number of vegetation complexes of the project area (totaling 118.7ha). This species was targeted at each of the seven TIA sites in both survey events (September and November). The other target native bee species were not considered to have as high a potential to occur based on the floristic composition of the project area; however these species were also targeted during the survey of all TIA transects undertaken.

During the survey events the seven TIA transects and suitable habitat for *N. simplicitor* (*Lobelia* woodland), were walked at least once a day in favourable weather conditions. Due to its high potential to support target invertebrates, the *Lobelia* woodland was targeted twice daily.

Two 750m transect surveys (two surveyors walking a single transect line in one direction) were conducted using sweep nets for each sampling event. These transects were systematically surveyed for 60 minutes at each site through bushland to target flowering plants in prime flight periods at each of the seven TIA sites and the *Lobelia* woodland (Figure 3-3). The sample size (N) was 120 minutes daily at each trapping site, totaling 18 targeted sweep netting hours for native bees (at least 60 minutes searching by two people during the two sampling events of six days and three days).

A single opportunistic collection was also made during the November 2010 survey round at the bushland on Farrington road adjacent to the IFAP (Industrial Foundation for Accident Prevention) building. This site is listed in the results and identified on the maps as TIA IFAP OPP.

3.5.8 Targeted Sweep Netting for GSM

The sampling methodology was consistent with Bishop (Bishop, Williams *et al.* 2009). Survey transects for sweep netting were pre-determined using a range of GIS applications. These transects were loaded into GPS devices so that each surveyor could follow the pre-determined route. The location of any GSM individuals was recorded using the GPS device. All data were recorded in WGS-84 datum.

Daily weather forecasts were also monitored closely so transect assessments could be undertaken on the most prospective days:

- Warm sunny weather (25 to 32°C);
- Optimum time of day (1000hrs and 1500hrs), with transects being rotated so that each was conducted at least once during this optimal time frame; and
- Calm conditions (wind <18km/h).

The surveys were undertaken for a period of two days at the survey transects and conducted over four to five sampling weeks to cover the period of activity known as the ‘flight-period’ of the adult sun moths (Table 3-6 Table 3-7a and b). The initial survey round began in the first week of March and was conducted for five weeks at six sites (Roe Sites 1-6). The subsequent additional sites (Roe Extn Sites 1-16) began surveying in the third week of March and concluded four weeks later in the second week of April.

As the moths hatch and mature at different times throughout the 'flight-period', the surveys must be undertaken in prospective survey conditions over a minimum four week period to cover the potential for early and late flight periods. The climate parameters for the GSM surveys undertaken were all within the prospective climate parameters (Bishop, Williams *et al.* 2009).

3.5.9 Night Spotting

Night searches were undertaken at six of the seven TIA sites (excluding *Melaleuca* Swamp, TIA site 1 due to night access restrictions, being within Murdoch University grounds) to detect the presence of nocturnal species. Nocturnal searches generally began at sunset and concluded between 2200hrs and 2300hrs. The nocturnal surveys predominantly consisted of searches of the study sites using head torches, black lights, and spotlights, with collections also made from a fixed light trapping station at each site.

Each fixed station was kept active for a period of 90 minutes with collections occurring through two moon phases: half-full moon and moon dark. Night searches were undertaken in the autumn (August) 2010 survey round, and spring (early November) 2010. The sample size (N) was 2160mins at each trapping site, totaling 36 light trapping hours (90mins searching by two people in two sampling events).

3.5.10 TIA and GSM Survey Effort

The coordinates of each site were recorded by a hand held GPS device (Appendix 2).

Table 3-5 Sampling effort for the Roe Highway targeted Invertebrate survey.

Techniques	No. Sites	No. Traps[a] /Area[b] (m^2)/Samples[c]	No. Nights[d]/Event[e]/Time (mins) [m]	Total Sample Size (N)
Dry pitfall trapping	10	30[a]	10[d]	3,000 trap nights
Bait stations	10	3	14	420 trap nights
Foraging	10[f] 10[g]	2500[b]	75 [m]	1500min[h] ; 750min[i] 25,000m^2 [bb]
Leaf litter samples	14	2[c]	n/a	28
TIA sweep netting	7	10,000[b j]	120[m]	840min; 70,000m^2
Targeted bee sweep netting	9[l]	15,000[b n]	120[m]	1080min; 135,000m^2
GSM sweep netting	22	10,000[b k]	9[e]	940,000m^2
Night spotting	6	n/a	180[m]	2160min

bb - foraging by area was only undertaken in the last sampling round, spring 2010.

f - number of sites at each summer 2009 and autumn 2010 sites per survey round

g - autumn 2010 sites

h - undertaken, combined summer 2009 and autumn 2010 total

i - spring 2010

j - sweep netting 500m x 2 transects x 10m wide, undertaken in summer 2009 only

k - sweep netting of 1000m transect x 10m wide, undertaken in March/April 2010 only

l - sweep netting of 7 TIA transects areas and 2x *Lobelia* woodland site daily

n - sweep netting of 750m transect x 10m wide, x 2 transects undertaken 6 days September 2010 and 3 days November 2010

Table 3-6 GSM transect survey dates.

Transect (T)	Roe Site 1	Roe Site 2	Roe Site 3	Roe Site 4	Roe Site 5	Roe Site 6
Location Description	Western Power Bushland	Hope Road Bushland/ Freeway	Bibra Lake/Nth Lake rd area	Coolbellup Road /Forrest road area	Stock Road/Forrest Road Intersection North	Stock Road/Forrest Road Intersection South
Survey Date T1	03 March 2010	03 March 2010	05 March 2010	03 March 2010	05 March 2010	05 March 2010
Survey Date T2	10 March 2010	10 March 2010	10 March 2010	10 March 2010	10 March 2010	10 March 2010
Survey Date T3	17 March 2010	17 March 2010	17 March 2010	17 March 2010	17 March 2010	17 March 2010
Survey Date T4	24 March 2010	24 March 2010	24 March 2010	24 March 2010	24 March 2010	24 March 2010
Survey Date T5	30 March 2010	29 March 2010	29 March 2010	29 March 2010	29 March 2010	29 March 2010

Table 3-7a Additional GSM transect survey dates.

Transect (T)	Roe Extn Site 1	Roe Extn Site 2	Roe Extn Site 3	Roe Extn Site 4	Roe Extn Site 5	Roe Extn Site 6	Roe Extn Site 7
Location Description	Western Power bushland, top that is parallel to fwy	Bushland opposite WP near Dowell Place	Roadside veg corridor Nth of Stock/Forrest (West Side)	Roadside veg corridor Nth of Stock/Forrest (East Side)	Roadside veg corridor south of Stock/Phoenix (West Side)	Roadside veg corridor south of Stock/Phoenix (East Side)	Roadside veg corridor Phoenix Rd
Survey Date	19 March 2010	19 March 2010	19 March 2010	19 March 2010	19/ March 2010	19 March 2010	19 March 2010
Survey Date	27 March 2010	27 March 2010	25 March 2010	25 March 2010	25 March 2010	25 March 2010	25 March 2010
Survey Date	30 March 2010	30 March 2010	30 March 2010	30 March 2010	30 March 2010	30 March 2010	30 March 2010
Survey Date	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010

Table 3-7b Additional GSM transect survey dates.

Transect (T)	Roe Extn Site 8	Roe Extn Site 9	Roe Extn Site 10	Roe Extn Site 11	Roe Extn Site 12	Roe Extn Site 13 & 14	Roe Extn Site 15 & 16
Location Description	Bushland between IFAP and Fwy south of Farrington	IFAP Private Bushland south of Farrington	East side of Coolbellup Road bush reserve	West Side of Coolbellup Road bush reserve	Parkland cleared Bushland south Blackwell Ave	Western Power site east of Roe1 Hope/Karel Ave	Western Power site east of Roe1 Hope/Karel Ave
Survey Date T1	19 March 2010	19 March 2010	19 March 2010	19 March 2010	19 March 2010	19 March 2010	19 March 2010
Survey Date T2	24 March 2010	25 March 2010	25 March 2010	25 March 2010	25 March 2010	27 March 2010	27 March 2010
Survey Date T3	29 March 2010	29 March 2010	30 March 2010	30 March 2010	30 March 2010	30 March 2010	30 March 2010
Survey Date T4	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010	07 April 2010

3.6 PERSONNEL

Personnel involved in the SRE and TIA surveys are listed in Table 3-8. Invertebrate taxonomists are detailed in Table 3-9.

Table 3-8 Survey personnel.

Person	Title	Qualifications
Mr Jarrad Clark	Senior Invertebrate Zoologist	BSc. Env. Mgt
Ms Mary-Anne Clunies-Ross	Zoologist	BSc. Env. Mgt
Ms Conor O'Neill	Environmental Scientist	BSc. Sust. Dev. Env. Sci.
Ms Andrea Bending	Biologist	BSc. Marine – Env. Mgt
Mr Jason Nolthenius	Zoologist	Cert. IV Env. Mgt
Mr Stanley Bowes	Biologist	BSc. Cons. Biol.
Mr Ryan Ellis	Biologist	Cert. IV CALM

Table 3-9 Taxonomists.

Person	Title	Taxonomic group
Dr Mark S. Harvey	Head of Department of Terrestrial Zoology, WAM	Pseudoscorpiones
Dr Volker W. Framenau	Curator – Terrestrial Invertebrates, Department of Terrestrial Zoology, WAM; Senior Invertebrate Scientist, Phoenix Environmental Sciences	Araneae (Mygalomorphae, Araneomorphae), Diplopoda, Chilopoda
Dr Erich S. Volschenk	Senior Invertebrate Manager, Phoenix Environmental Sciences; Taxonomic consultant (Scorpion ID)	Scorpiones
Mr Simon Judd	Taxonomic consultant	Isopoda
Dr Terry Houston	Senior Curator (Entomology) – Department of Terrestrial Zoology, WAM	Native bees (Hymenoptera), some Orthoptera and Diptera
Corey Whisson	Assistant Curator – Department of Aquatic Zoology, WAM	Mollusca
Conor O'Neill	Environmental Scientist	Lepidoptera, some Orthoptera

3.7 LIMITATIONS

The limitations of the survey were considered (Table 3-10).

Table 3-10 Survey limitations.

Potential Limitations	Limitation in this survey?	Comments
Competency/experience of the consultant carrying out the survey.	No	Phoenix has extensive experience in SRE surveys, invertebrate habitat assessments and desktop reviews throughout the Pilbara, Midwest, Southwest, Kimberley and Goldfields regions of W.A.; considerable taxonomic expertise in house and use of WAM personnel for identification of some taxonomic groups.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions, e.g. pitfall trapping in waterlogged soils or inability to use pitfall traps.)	No	The survey comprehensively targeted all groups known to include SREs and known conservation significant invertebrate species potentially occurring within the study area. Foraging efforts supplemented the trapping programs to ensure that groups such as pseudoscorpions were represented in the survey.
Proportion of fauna identified, recorded and/or collected.	Yes	Due to the paucity of knowledge concerning SREs and invertebrates in general, it is usually almost impossible to know for sure that all species have been recorded. It is Phoenix's experience that wet-pitfall trapping programs are more effective at collecting cryptic species.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Yes	There is little historic data concerning terrestrial invertebrates in the Bibra Lake area. Records of the targeted species were acquired from the DEC records and other papers in the Swan Coastal Plain IBRA Region.
Timing/weather/season/cycle.	No	The surveys were undertaken in the appropriate seasons. Timing was a critical factor in the design of each survey component. Rain fell during some of the SRE surveys however extended sampling was undertaken to address this limitation.
The proportion of the task achieved and further work which might be needed.	No	The study area was relatively small and was adequately traversed and examined for SRE fauna and target conservation significant species.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No	No major disturbance was encountered.
Intensity (in retrospect, was the intensity adequate?)	No	The study area was relatively small and thus intensity was/is considered adequate.
Completeness (was relevant area fully surveyed?)	Yes	The study area was fully surveyed for all target species / groups with the exception of the Graceful Sun-moth. Limited habitat data was available at the time of the GSM survey. Further surveys will be undertaken in the 2011 survey season for this species
Remoteness and/or access problems.	No	Not relevant to this survey.
Availability of contextual (e.g. biogeographic) information on the region.	No	The biota of the Swan Coastal Plain IBRA region is relatively well documented (compared to other areas of WA). However, this is not as true with regard to some SRE groups, e.g. millipedes, pseudoscorpions and isopods.

4.0 RESULTS

4.1 SUMMARY OF HABITAT DATA

4.1.1 SRE and TIA Site Habitats

Five major invertebrate habitat types were identified in vegetation complexes of the study area. These comprise:

- Bassendean - *Eucalyptus/Banksia* woodland
- Bassendean/Herdsman border - *Eucalyptus/Melaleuca* riparian zone
- Karrakatta - Open Eucalypt Forest *Eucalyptu*s Woodland with *Banksia*
- Karrakatta/Bassendean border - *Eucalyptus/Xanthorrhoea* woodland
- Karrakatta/Cottesloe border - *Eucalyptus/Xanthorrhoea* woodland with *Banksia*

Four of these habitats were sampled in the TIA surveys and four were sampled in the SRE surveys (Table 4-1 and Table 4-2). The TIA and SRE sites intersect the Bassendean and Karrakatta vegetation associations and fall on the borders of the Karrakatta/Cottesloe, the Karrakatta/Bassendean complexes and the Bassendean/Herdsman complexes (Figure 4-1). For the purpose of the SRE and TIA surveys, the Bassendean complex was divided into two habitat types, *Eucalyptus/Banksia* woodland and *Eucalyptus/Banksia* woodland with *Melaleuca* riparian, as the 'peat' soil profile pockets in the latter habitat type could potentially facilitate endemism.

Eucalyptus/Banksia woodland was the most commonly sampled habitat type in the surveys, because it is a key component of the Bassendean vegetation complex which covers the majority of the study area. This habitat is fairly homogenous in terms of vegetation composition and only expresses more prospective SRE habitat in areas adjacent to the Herdsman and Karrakatta vegetation complexes.

The habitat data provide some context for the SRE species identified in the surveys (Table 4-1 to Table 4-4). The Bassendean vegetation complex habitats supported the majority of specimens recorded during the survey rounds, including the majority of the specimen records from families considered to contain SRE taxa (Mygalomorphae, Diplopoda, Pseudoscorpiones, Isopoda). This result might have been influenced to some extent by the fact that habitats within the Bassendean vegetation complex were the most commonly sampled.

Table 4-1 Vegetation complex and habitat type of the TIA sites.

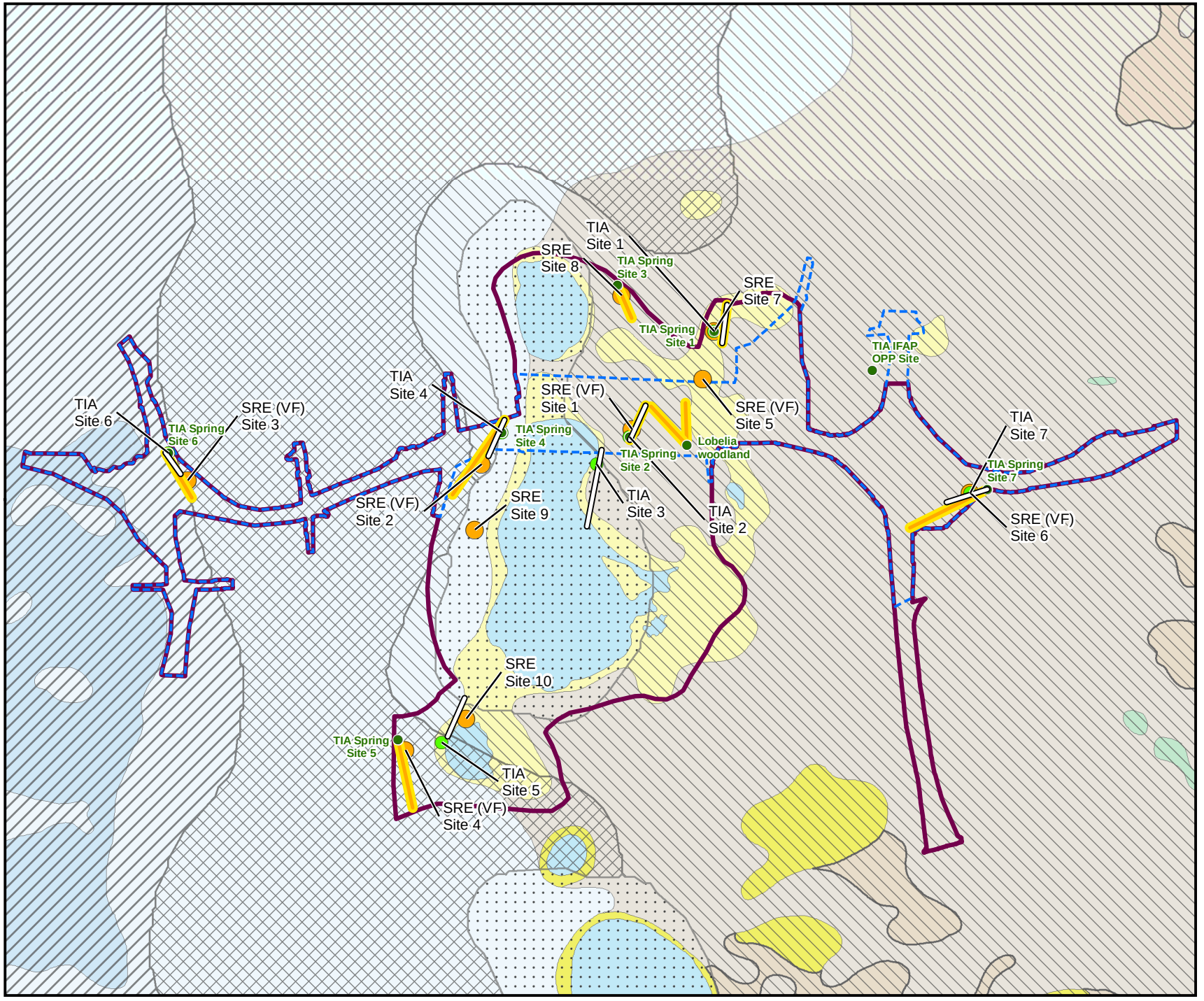
Vegetation Complexes	Bassendean	Karrakatta/Cottesloe border	Karrakatta/ Bassendean border	Bassendean/ Herdsman border
Site	*Eucalyptus/Banksia* woodland	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland	*Eucalyptus/ Melaleuca* riparian zone
TIA Site 1 (SRE 7)	✓◆			
TIA Site 2 (SRE 1)	✓			
TIA Site 3				✓
TIA Site 4				✓
TIA Site 5			✓	
TIA Site 6		✓		
TIA Site 7 (SRE 6)	✓			
TIA Spring Site 1 (SRE 7)	✓◆			
TIA Spring Site 2 (TIA 2)	✓			
TIA Spring Site 3 (SRE 8)	✓			
TIA Spring Site 4 (TIA 4)				✓
TIA Spring Site 5 (SRE 4)			✓	
TIA Spring Site 6 (TIA 6)		✓		
TIA Spring Site 7 (TIA 7)	✓			
TIA Lobelia Woodland	✓◆			
Total	**3**	**1**	**1**	**2**

◆ denotes the Bassendean peaty vegetation with *Melaleuc*a riparian zone of small swamp.

Table 4-2 Vegetation complex and habitat type of the SRE sites.

Vegetation Complexes	Bassendean	Karrakatta	Karrakatta/ Bassendean border	Bassendean/ Herdsman border
Site	*Eucalyptus Banksia* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus Xanthorrhoea* woodland	*Eucalyptus* riparian zone
SRE (VF) Site 1 (TIA 2)	✓			
SRE (VF) Site 2			✓	
SRE (VF) Site 3		✓		
SRE (VF) Site 4		✓		
SRE (VF) Site 5	✓◆			
SRE (VF) Site 6 (TIA 7)	✓			
SRE Site 7 (TIA 1)	✓◆			
SRE Site 8	✓			
SRE Site 9				✓
SRE Site 10				✓
Total	**5**	**2**	**1**	**2**

◆ denotes the Bassendean* peaty vegetation with *Melaleuca* riparian zone of small swamp.



Vegetation Complexes of the SRE and TIA Habitats

Figure 4-1

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- TIA Spring Survey Transects
- TIA Netting Transects
- TIA Spring Survey Sites
- TIA Dry Pitfall and Bait Station Sites
- SRE Dry Pitfall Sites

Soil Types

- Cps - Peaty clay
- Mps - Peaty silt
- Ms5 - Sandy silt
- S7 - Pale yellow-brown sand
- LS1 - Limestone
- S8 - Light grey sand (LGS)
- S10 - LGS over brown silt/clay
- Water

Vegetation Complexes

- Bassendean complex
- Cottesloe complex
- Herdsman complex
- Karrakatta complex
- Project Area
- Study Area

Date Modified: 15/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-1 - Vegetation complexes of the SRE and TIA habitats.mxd

4.1.2 GSM Site Habitats

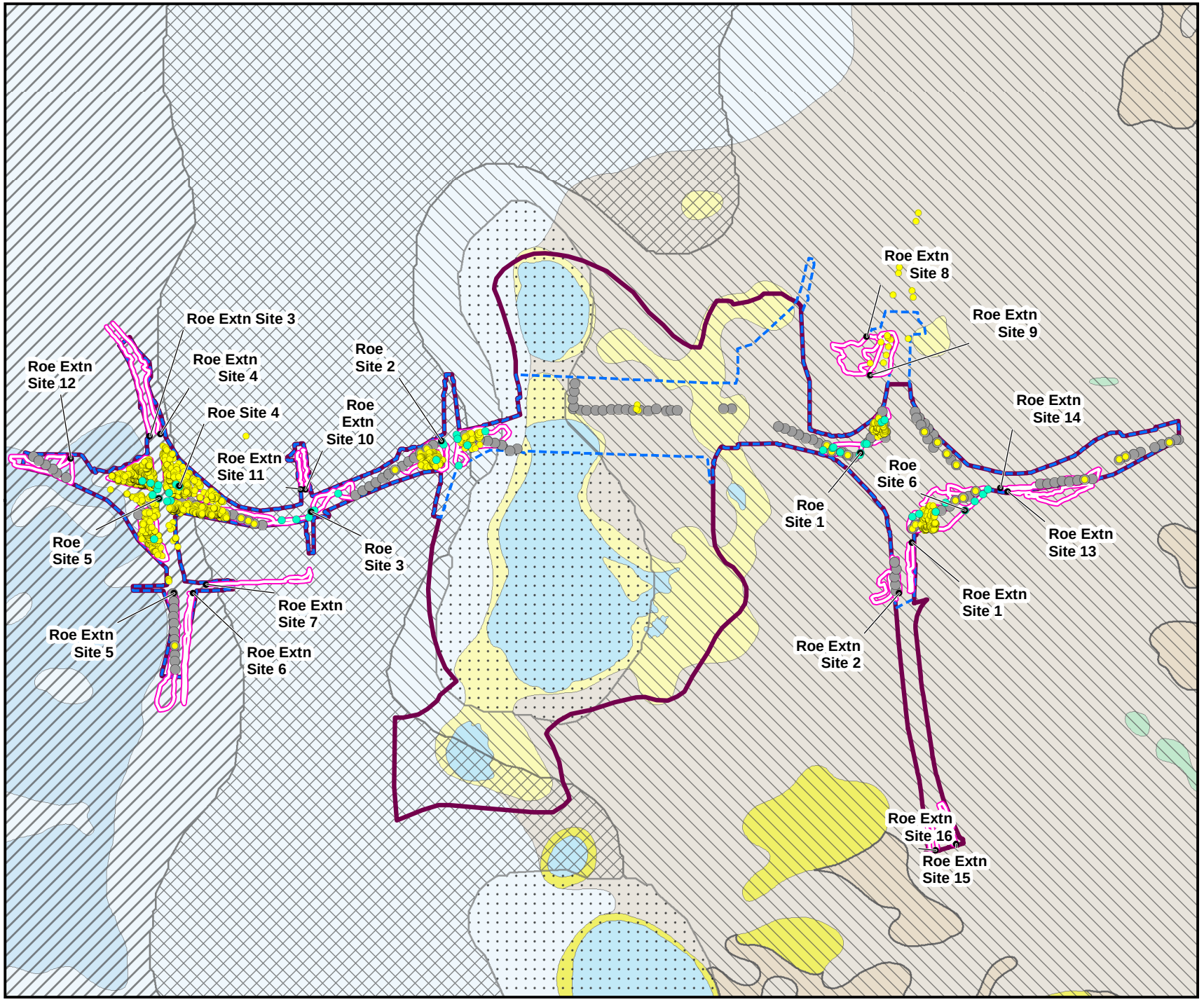
The sweep netting transects for the targeted GSM survey (containing *Lomandra* sp.) occurred across all four major habitat types within the study area. A number of these transects were traversed solely within the vegetation complexes of Bassendean, Karrakatta and Cottesloe and they crossed the border zone of vegetation changes between the Karrakatta/Bassendean and Karrakatta/Cottesloe complexes (Table 4-3; Table 4-4 and Figure 4-2).

Table 4-3 Vegetation complex and habitat type of the GSM Roe sites.

Vegetation Complexes	Bassendean	Karrakatta/Bassendean border	Karrakatta	Karrakatta/Cottesloe border
Site	*Eucalyptus/Banksia* woodland	*Eucalyptus/Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus Xanthorrhoea* woodland with *Banksia*
Roe Site 1	✓			
Roe Site 2	✓			
Roe Site 3		✓		
Roe Site 4			✓	
Roe Site 5				✓
Roe Site 6				✓
Total	**2**	**1**	**1**	**2**

Table 4-4 Vegetation complex and habitat type of the GSM Roe Extension sites.

Vegetation Complexes	Bassendean	Karrakatta/Cottesloe border	Karrakatta	Cottesloe
Site	*Eucalyptus/Banksia* woodland	*Eucalyptus/Xanthorrhoea* woodland with *Banksia*	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	Open *Eucalyptus* Woodland with closed heath and *Xanthorrhoea*
Roe Extn Site 1	✓			
Roe Extn Site 2	✓			
Roe Extn Site 3				✓
Roe Extn Site 4		✓		
Roe Extn Site 5				✓
Roe Extn Site 6				✓
Roe Extn Site 7		✓		
Roe Extn Site 8	✓			
Roe Extn Site 9	✓			
Roe Extn Site 10			✓	
Roe Extn Site 11			✓	
Roe Extn Site 12				✓
Roe Extn Site 13	✓			
Roe Extn Site 14	✓			
Roe Extn Site 15	✓			
Roe Extn Site 16	✓			
Total	**8**	**2**	**2**	**4**



Vegetation Complexes of Graceful Sun-moth Habitat

Figure 4-2

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

- Graceful Sun-moth Transect
- Quadrat Locations
- *Lomandra hermaphrodita* Record
- *Lomandra* sp. Record

Soil Types

- Cps - Peaty clay
- Mps - Peaty silt
- Ms5 - Sandy silt
- S7 - Pale yellow-brown sand
- LS1 - Limestone
- S8 - Light grey sand (LGS)
- S10 - LGS over brown silt/clay
- Water

Vegetation Complexes

- Bassendean complex
- Cottesloe complex
- Herdsman complex
- Karrakatta complex
- Project Area
- Study Area

Date Modified: 9/03/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-2 - Vegetation Complexes of Graceful Sun-moth Habitat_NEW.mxd

4.2 SUMMARY OF FAUNAL DATA

The potential SRE status of each of the target taxa recorded was assessed on the basis of key factors that delineate SRE species, namely (Harvey 2002):

- Known or likely distribution;
- Diversity and type of habitats; and
- Adaptive biological or morphological attributes of either the genus or the species.

Three species of spiders and four species of millipedes found during the surveys are considered to be SRE of the Perth Metropolitan Area (PMA SRE) with conservation significance. One of these millipedes requires further taxonomical assessment to confirm its status as SRE. The species identified were:

Araneae (spiders):

- *Synothele michaelseni* (Mygalomorphae: Barychelidae); known only from Swan Coastal Plain around Perth and few localities on the Darling Escarpment; found at SRE sites 3 and 4;
- *Kwonkan* `MYG225` (Mygalomorphae: Nemesiidae); putative SRE; taxonomically poorly resolved genus and difficult to establish if the three males from this survey are conspecific with other specimens found around Perth, found at SRE sites 6 and 9; and
- *Tinytrema yarra* (Araneomorphae: Trochanteriidae); considered SRE; very rare, in addition to the male from this survey (SRE site 10), currently only known from a single female on the Darling Escarpment approximately 60km east of survey area.

Diplopoda (millipedes):

- *Antichiropus* `UBS2` (Polydesmida: Paradosoxosomatidae); considered SRE; only known from the Swan Coastal Plain from Hepburn Heights in the north to Rockingham in the south (based on WAM database), found at SRE sites 2, 3 and 5 and TIA site 5;
- *Antichiropus* `UBS3` (Polydesmida: Paradoxosomatidae); considered SRE; rare, only known from Bold Park, Mt Claremont, Brookdale and now Bibra Lake (based on WAM database); found at SRE sites 1 to 4, 6 and 8;
- Siphonotidae sp. (Polyzoniida); considered SRE; single specimen in our survey (SRE site 3); on Perth Coastal Plan this family is only known from a population at Woodman Point and unspecified historical localities in “Perth”; taxonomically poorly resolved; comparison with WAM specimens not possible as all of these are currently on loan; and
- *Podykipus collinus* (Spirostreptida: Iulomorphidae): possibly SRE; taxonomically poorly resolved genus and difficult to establish if the specimens recorded from this survey are conspecific with other specimens found around Perth, including the five sites where an unidentified spirostreptidan species was obtained during the WAM UBS survey. It was collected from six SRE sites (SRE 1 to 5 and 8); this species appears locally abundant and widespread throughout the vegetation complexes of the study area.

Short-range endemics of the Swan Coastal Plain (SCP SRE’s) collected from the study area, but with no or limited conservation significance for the proposed project, include:

- *Idiosoma sigillatum* (Mygalomorphae: Idiopidae) (trapdoor spider);
- *Notiasemus glauerti* (Chilopoda: Scolopendridae) (centipede);
- *Cormocephalus novaehollandiae* (Chilopoda: Scolopendridae) (centipede);
- *Buddelundia ?nigripes* and *Buddelundia* sp. (SJ #7) (Isopoda: Oniscoidea) (slater);
- ?*Spherillo* sp. (SJ #2) (Isopoda: Oniscoidea) (slater); and
- *Bothriembryon bulla* and *B. kendricki* (Gastropoda: Bulimidae) (land snails).

Of the targeted conservation significant species (TIA surveys), only the Graceful Sun-moth (*Synemon gratiosa*) has been confirmed from the surveys. Only groups containing target taxa have been identified beyond order level in this report.

4.3 ARANEAE: MYGALOMORPHAE (TRAPDOOR SPIDERS)

Mygalomorph ("trapdoor") spiders represent one of the focal groups in surveys of short-range endemic taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum*, *Kwonkan eboracum*, *Moggridgea tingle*, are listed on Schedule 1 ("Fauna that is rare or likely to become extinct") of the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2) of the Western Australian Government.

The Western Australian mygalomorph fauna is vast and remains taxonomically poorly known for many families and genera (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*). The best taxonomic features to distinguish mygalomorph spiders are found within the genitalia of males. The Western Australian Museum under guidance of Dr Volker Framenau has recently initiated a reference collection of male mygalomorph morphospecies to facilitate an assessment of distribution patterns of these spiders. Mygalomorph morphospecies are consecutively numbered ("MYG001", "MYG002" etc.) to allow a comparison of taxa between different surveys and these designations are being followed here.

The surveys recorded at least seven species of mygalomorph spiders in six different genera and four families. *Synothele michaelseni* (Barychelidae) and *Kwonkan* `MYG225` (Nemesiidae) are considered PMA SRE's, although the taxonomy of the latter species is poorly resolved. *Idiosoma sigillatum* (Idiopidae) is the only SCP SRE.

4.3.1 Actinopodidae (Mouse Spiders)

In Australia, the trapdoor spider family Actinopodidae is represented only by the genus *Missulena*. Spiders within this family are medium to large spiders with an extremely raised head region and widely spaced eyes (in contrast to most other trapdoor spider families in which the eyes are grouped closely together). Actinopodids can be found in a variety of habitats from open-forest to semi-arid shrubland.

***Missulena* (Mouse Spiders)**

Spiders of the genus *Missulena* are commonly known as "Mouse Spiders". With the exception of a single species from Chile, the genus is restricted to the Australian mainland, where currently 10 species are described (Faulder 1995b; Platnick 2011). Western Australia is the centre of diversity for the genus with seven named species, however, many more undescribed species, in particular from the arid northern and central parts of the state are present in the WAM morphospecies collection.

Whilst females are generally uniformly black in colour, males are often strikingly coloured with a distinctly red cephalic area and chelicerae, contrasting against a black thoracic part and abdomen, although some species have a black cephalic region. The abdomen itself often has a velvety shine. The entrance of the burrow of *Missulena* is ovoid in shape and equipped with two neighbouring doors (Main 1956). Emergent juveniles of some *Missulena* species have been reported to disperse via ballooning (Faulder 1995a), therefore potentially allowing them to disperse large distances and thereby reducing the predisposition for short-range endemism.

***Missulena granulosa* (Rugose Mouse Spiders)**

Missulena granulosa (Plate 1) can be identified by the extremely rugose carapace. Red colouration on fangs and frontal carapace margin in males is variable and uniformly black spiders do occur. The embolus tip is spatulate. *Missulena granulosa* is a Western Australian endemic but is widely spread throughout the southwestern parts of the state and is therefore not an SRE.

The species appears to only occur infrequently on the Swan Coastal Plain as it was only recovered at a single site of the WAM UBS (Harvey, Waldock *et al.* 1997). Similarly, *M. granulosa* was only collected from single site in this survey (SRE Site 4), in a Karrakatta vegetation complex (Table 4-5; Appendix 4).

Plate 1 *Missulena granulosa.* Male from SRE site 4 (July 2010) in dorsal (left) and ventral view (right).

4.3.2 Barychelidae (Brush-footed Trapdoor Spiders)

Barychelid spiders, commonly called Brush-footed Trapdoor Spiders, are small to fairly large in size. They differ from the second mygalomorph spider family with claw tufts, Theraphosidae ("Tarantulas"), by the much shorter apical segment of the spinnerets. In Western Australia, the genera *Aurecocrypta*, *Idiommata, Mandjelia* and *Synothele* are known to occur from the Southwest region into the Pilbara region and *Moruga* has been found in the Kimberleys (Raven 1994). Of all trapdoor spiders, few are as cryptic as the Barychelidae. Their burrows tend to be less than 60cm deep and often lack the firm thick door of the Ctenizidae or the extensive webs of Dipluridae. Some species survive very well in highly disturbed inner-city suburban gardens, such as Brisbane *Seqocrypta jakaka* in Brisbane (Raven 1994).

Synothele

The genus *Synothele* can be identified by the low number of maxillary cuspules in combination with the lack of lyra (specialised clubbed setae) on the maxillae and the often mottled abdomen (uniformly dark in the similar *Aurecocrypta*). The genus is widespread throughout Western (21 species) and South Australia (3 species) (Raven 1994). In addition, the WAM Mygalomorphae reference collection holds a number of undescribed morphospecies, in particular from the northern parts of the state.

Synothele michaelseni

Synothele michaelseni (Plate 2) must be considered an SRE from the Perth Metropolitan Area as there are very few nearby records on the Darling Escarpment (Raven 1994). The species was listed from Bold Park only in the WAM UBS (How, Harvey et al. 1996).

Two male *Synothele michaelseni* were recorded in the survey area at SRE sites 3 and 4, both of which are located in the Karrakatta vegetation complex (Table 4-5; Appendix 4). Both males were found in pitfall traps between March and May, suggesting reproductive activity in autumn.

Plate 2 *Synothele michaelseni*. Male from SRE site 4 (March 2010) in dorsal (left) and ventral view (right).

4.3.3 Idiopidae (True Trapdoor Spiders)

The Idiopidae are the True Trapdoor Spiders as they usually cover their burrow entrance with a lid. In Western Australia, the most common genera include those of the tribe Aganippini, i.e. the genera *Aganippe*, *Idiosoma*, *Eucyrtops* and *Anidiops* (incl. *Gaius*).

***Aganippe* sp. (juv.)**

A total of 15 species of *Aganippe* are described from Australia, of which four occur in Western Australia. *Aganippe* are easily identified by the four similarly sized sigillae on the abdomen. Male pedipalp have a small finger-like process on the retrolateral side of the tibia in addition to a much stouter "burr" (Main 1985b). Based on the WAM mygalomorph reference collection the genus is fairly diverse in WA despite the low number of described species.

Aganippe is one of the most widespread genera of Trapdoor Spiders in Australia south of the Tropic of Capricorn and most abundant in woodland and semi-arid regions (Main 1985b). The WAM UBS discovered three different species in the Perth area at three different sites including the widespread *A. raphiduca* (How, Harvey *et al.* 1996). Despite this it is impossible to provide a species identification for the immature specimens from our survey (site 8, Bassendean vegetation complex) (Table 4-5; Appendix 4). Based on our current knowledge of the local fauna, they are unlikely to represent short-range endemic species.

Idiosoma sigillatum

Idiosoma sigillatum can be recognised by the large abdominal sigillae and males by small cuspules on the finger-like process of the pedipalp tibia. The species is fairly widespread on the Swan Coastal Plain and adjacent areas from Dandaragan in the North to Bridgetown in the south (WAM database, January 2011).

This species is considered an SCP SRE. A single male was recovered from the study area, from SRE site 3 in Karrakatta vegetation/habitat (Table 4-5; Appendix 4).

Plate 3 *Idiosoma sigillatum*. Male from SRE Site 3 (August 2010).

4.3.4 Nemesiidae (Wishbone Spiders)

Nemesiidae gained their common name, Wishbone Spiders, through the shape of the burrow, which is, in some species, Y-shaped with two entrances. Taxonomic revisions of Australian Nemesiidae have been predominantly of Queensland species where 47 species in 4 genera are currently named (Raven 1981; Raven 1982a; Raven 1982b; Raven 1983; Raven 1984a; Raven 1985a; Raven 1985b; Raven 1994). In Western Australia, although there have been numerous studies for this group (Main 1972; Main 1975; Main 1977; Main 1982a; Main 1982b; Main 1983a; Main 1985a; Main 1986; Main 1991; Main 1994; Main 2004; Main 2008), few have dealt with species outside the south-west land division. As a result, many species from large parts of Western Australia remain formally undescribed.

Nemesiids are well represented in Western Australia by several genera, including *Aname* (8 described species), *Kwonkan* (5), *Merredinia* (1), *Pseudoteyl* (1), *Swolnpes* (2), *Teyl* (1) and *Yilgarnia* (2), (Main and Framenau 2009). *Chenistonia* and *Stanwellia* occur in the state, but no species have so far been formally described. Nemesiids usually dig burrows in the soil and do not cover their burrow entrances with lids.

The family reaches its highest diversity in Australia with sometimes high level of endemicity. Species of rainforest genera in eastern Australia tend to have highly localised distributions, often being restricted to one or two adjacent mountain tops. Species belonging to genera that dominate in drier forest to desert habitats (e.g. *Aname*) have generally wider distributions; however depending on the biogeographical history of the area, they may still have narrow and disjunct ranges.

The genus *Aname* and its relatives (e.g. *Kwonkan*) have diversified strongly in Western Australia and show higher degrees of endemism than those genera in eastern Australia (Raven personal communication). In the Swan Coastal region there are eight *Aname* species endemic to the Swan NRM Region (ANHAT 2009). The WAM UBS recovered 4 species of *Aname* and one each of *Kwonkan* and *Teyl* (How, Harvey *et al.* 1996).

Aname

The genus *Aname* currently includes 33 named species in Australia and is well represented by four named and numerous unnamed species from many different regions in Western Australia. *Aname* currently represent a highly diverse array of species of very small to large spiders. Males generally have a spur and spine on the first tibia of males opposing an often incrassate metatarsus. Members of the genus *Aname* are believed to be most common in sclerophyll forest, but are also known from rainforests and deserts (Raven 1981). *Aname* regularly belongs to the most diverse mygalomorph genera in biological spider surveys and with 12 species the DEC Pilbara survey resulted in a similar number as found during the Carnarvon Basin survey (13 species) (Durrant, Harvey *et al.* 2010; Main, Sampey *et al.* 2000).

***Aname mainae* (Black Wishbone Spider)**

Aname mainae, commonly known as the Black Wishbone Spider, is found in many mesic habitats of the Southwest Region from Esperance to north of Perth and is therefore not a short-range endemic species. It is one of the most commonly collected species of *Aname* throughout the southwest land division based on the collection of the WAM, however morphological evidence (i.e. great variation in male pedipalp morphology)

suggests that many of the specimen identified as *A. mainae* represent different, closely related species. As such it is not considered to be an SRE species.

A single specimen of *A. mainae* (Plate 4) was recorded from SRE Site 2 located just outside the project area within the 100m buffer zone on the border of Karrakatta/Bassendean vegetation (Table 4-5; Appendix 4).

Plate 4 *Aname mainae.* Male from SRE site 2 (December 2009) in dorsal (left) and ventral view (right).

***Aname tepperi* (Tepper's or Golden Trapdoor Spider)**

The currently valid placement of this species by Raven (1984b) in *Aname* is contentious. It was previously placed in *Chenistonia* (Main 1982a). *Aname tepperi* (Plate 5) is widespread in southwest Western Australia and is also found into South Australia. It was also recovered from a number of sites in Perth region during the WAM UBS (How, Harvey *et al.* 1996). This species is not an SRE.

Two individuals were recorded during the survey from SRE sites 2 and 5 on Karrakatta/Bassendean and Bassendean with peat (Table 4-5; Appendix 4).

Plate 5 *Aname tepperi*. Male from SRE site 5 (July 2010) in dorsal (left) and ventral view (right).

***Aname* sp. (juv.)**

A total of three early juvenile *Aname* were found at SRE site 8 (Bassendean vegetation) and SRE site 10 (Bassendean/Herdsman) (Table 4-5; Appendix 4). Species identification is not possible in juvenile mygalomorphs and therefore the distribution and conservation status of these spiders cannot be assessed.

Kwonkan

The genus *Kwonkan* is restricted to Western Australia and currently includes six named species (Main 1983b; Platnick 2011). While all of these are currently known from their type specimens, only *Kwonkan eboracum* from the York region is listed on Schedule 1 ("Fauna that is rare or likely to become extinct") of the Wildlife Conservation (Specially Protected Fauna) Notice 2010(2). *Kwonkan* includes those nemesiid spiders that have spines on their pedal tarsi although this simple concept ignores much more informative genitalic characters. *Kwonkan* was first recorded with a single species from the Swan Coastal Plain during the WAM UBS (How, Harvey *et al.* 1996).

***Kwonkan* `MYG225`**

Three male *Kwonkan* MYG225 (Plate 6) were recovered during the survey from two different SRE sites (6 and 9) covering two different vegetation types (Bassendean and Bassendean/Herdsman) (Table 4-5; Appendix 4). Very similar species have been found during the WAM UBS and these have been reviewed for the purpose of this report. However, it is currently not possible, based on the limited number of specimens at hand, to properly judge putative intra- and interspecific variation.

Whilst the specimens from this survey have unique setae arrangements on their pedipalp tibiae, these may not warrant recognizing a different species compared to more commonly observed morphotypes in the WAM UBS material. It is possible that *Kwonkan* MYG225 represents a short-range endemic species, but the species complex appears to be fairly widespread throughout the Perth metropolitan area.

Solving the taxonomic problems within this genus may require the application of genetic methods as morphology currently fails to allow clear species separation.

Plate 6 *Kwonkan* `MYG225`. Male from SRE site 6 (September 2010) in dorsal view.

Table 4-5 Mygalomorphae records by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Mygalomorphae	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Missulena granulosa					✓	
Synothele michaelseni					✓	
Aganippe sp. (juv.)	✓					
Idiosoma sigillatum					✓	
Aname mainae				✓		
Aname tepperi		✓		✓		
Aname sp. (juv.)	✓		✓			
Kwonkan `MYG225`	✓		✓			

4.4 ARANEAE: ARANEOMORPHAE (MODERN SPIDERS)

Araneomorph spiders are generally not targeted in SRE surveys although some putative relictual Gondwanan species have recently been shown to display extremely narrow distributions along the south coast of Western Australia (Framenau, Moir *et al.* 2008). Recent systematic studies on araneomorph spider family Micropholcommatidae has also shown significant levels of localized speciation on the Swan Coastal Plain (Rix, Harvey *et al.* 2010).

The surveys recovered approximately 30 araneomorph spider species in more than 20 genera and 16 families (Appendix 4). The infraorder included a small species of conservation significance in the family Trochanteriidae, *Tinytrema yarra*. This species was so far only known from a single female on the Darling Escarpment about 60km from the study area. Based on these two records, *T. yarra* must be considered a PMA SRE.

4.4.1 Araneidae (Orb-weaving Spiders)

The Araneidae are one of the most diverse and conspicuous spider families world-wide. In Australia, the subfamily Araneinae makes up the bulk of the approximately 150 described species.

Araneinae (True Orb-weavers)

This subfamily represents the 'typical' orb-weavers. Medium-sized to large spiders weave a conventional orb-web, generally at night. It is the most diverse subfamily of orb-weaving spiders in Australia with many undescribed genera and species. Some members of this subfamily have been shown to display short-range endemism along the south coast of WA (Framenau, Moir *et al.* 2008). A single male of *Backobourkia* heroine was recovered from SRE site 6 (Appendix 4). This species is common throughout Australia (Framenau, Dupérré *et al.* 2010) and not an SRE.

Argiopinae (St Andrews Cross Spiders)

This family includes two genera in Australia, *Argiope* and Gea. The members of these genera are generally diurnal, i.e. spiders can be found in their webs during the day. They add a variety of silk web-decorations into their webs that have been proposed to attract prey or provide camouflage against potential predators and prey. Most species are fairly widespread, including the single species recovered from the Roe Highway extension surveys, *Argiope protensa* (SRE site 3) (Appendix 4). This species can be found Australia-wide, in Papua New Guinea, New Caledonia and New Zealand (Levi 1983). It is not an SRE.

Arkyinae (Triangular Spiders)

This subfamily of orb-weaving spider is restricted to the Australasian region and has recently been reviewed to only include a two genera, *Arkys* and *Demadiana* (Framenau, Scharff *et al.* 2010). These spiders do not build an orb-web, but catch it in vegetation with their heavily spined forelegs. The single species collected during the current survey, *Arkys walckenaeri* (the Triangular Spider), is not uncommon in south-western Western Australia, but also occurs along the east coast of Australia and in Tasmania (Framenau, Scharff *et al.* 2010). It is therefore not an SRE.

Gasteracanthinae (Jewel Spiders)

The members of this subfamily are easily recognized by their spiny abdomen. The genus *Gasteracantha* mainly occurs along the north-eastern and northern costs of Australia, whereas *Austracantha* with its sole species *A. minax* (Christmas Spider) occurs throughout the country (Waldock and Scharff 2000). The species was recovered at number of sites and is not an SRE.

4.4.2 Corinnidae (Swift Spiders)

Swift spiders include ground-dwelling, very fast runners. The taxonomy of this family is poorly understood but subject to a current revision by R.J. Raven (Queensland Museum). The genus *Supunna* consists of small to medium-sized spiders, black in colouration with conspicuous white spots in a species specific pattern. Two species were recovered during the Roe Highway extension project, *S. picta* (SRE site 3) and *S. albopunctata* (SRE sites 3 and 4) (Appendix 4). Both appear to be widespread in Australia and are not considered SRE's.

4.4.3 Deinopidae (Net-casting Spiders)

The Net-casting Spiders are easily recognized by their enormously enlarged posterior median eyes and their unique predatory behavior: they suspend a small web between their legs and cast it over approaching prey. The genus consists of two genera, *Deinopis* and *Menneus*, which are currently under revision by M. Kuntner and J. Coddington (Smithsonian Institution). The single species recovered at three sites during the Roe Highway extension survey, *D. subrufa*, occurs Australia-wide and is not an SRE (M. Kuntner pers. comm. to VWF).

4.4.4 Gnaphosidae (Ground Spiders)

The Ground Spiders are a mega-diverse but taxonomically poorly resolved spider family in Australia, although some genera, such as *Eilica*, received some taxonomic attention ((Platnick 1975; Platnick 1978; Platnick 1985; Platnick 1988). The family is under revision by V. Ovtsharenko (New York). Ground spiders can be recognized by their oval posterior median eyes and the cylindrical spinnerets.

The genus *Encoptarthria*, recovered from seven SRE or TIA sites, can be recognized by the presence of a scape on the female epigyne and currently includes only a single described species, *E. serventyi* (Main 1954). Many undescribed species are known from the collection of the WA Museum, most with fairly wide distributions. It is unlikely that the species recovered during this survey represents an SRE.

4.4.5 Lycosidae (Wolf Spiders)

Wolf Spiders are one of the most conspicuous ground-dwelling spider families in Australia and world-wide. They occur in almost every terrestrial ecosystem from coastal shore-lines to the nival zones of alpine mountains. Wolf spiders have a characteristic eye pattern with a single row of four small eyes on the front of their carapace and a rectangular setup of four large eyes on top.

The mobile reproductive behavior of female lycosids is unique within spiders. They attach their eggsac to their spinnerets and are able to carry it around wherever they go. After hatching, the young spiderlings will climb onto the back of their mother where they remain for another week or so until they disperse. Many species are known to disperse via ballooning allowing them to disperse over vast distances.

On the other hand, wolf spiders are often very habitat-specific hampering their long distance dispersal. Wolf spiders are adapted to a variety of hunting strategies, from sheetweb-building, to vagrant hunting to sit-and-wait predation in self-excavated burrows.

Wolf spiders invariably belong to one of the most dominant spider groups in pitfall trap studies in Australia. Four subfamilies are known from Australia, including the diverse Lycosinae which includes many of the burrowing lycosids in the arid zone. The family has received some considerable taxonomic attention over the last decade by V.W. Framenau (WA Musuem), but in particular the taxonomy of the Lycosinae remains poorly resolved.

Artoriinae

This subfamily includes small to medium-sized, generally vagrant wolf spiders from mesic environments. The Artoriinae have been studied in some detail and include nine described and some additional undescribed genera (Framenau 2007; Framenau 2010). The largest genus, *Artoria*, includes more than 20 Australian species. *Artoria flavimanus* was the only species in the Artoriinae recovered from the Roe Highway extension project (SRE site 1and 7). It is common across southern Australia and a winter-active species that can also be found in Tasmania (Framenau 2002; Framenau 2005). It is not an SRE.

Lycosinae. *Venatrix pullastra* (SRE sites 1, 7 and 10) and *Hogna immansueta* (SRE sites 1, 8, 9 and 10) (Appendix 4) are both Western Australian endemics species, however with a fairly wide distribution in the south-western land division. They are extremely common throughout the Perth metropolitan area (e.g. Framenau and Vink 2001).

In contrast, the undescribed species in the *Lycosa ariadnae*-group (SRE sites 1, 3 & 6) (Appendix 4) appears to be restricted to the Swan Coastal Plain (SCP SRE), whereas its sister species, *Lycosa ariadnae* occurs throughout the WA Wheatbelt (V.W. Framenau, unpublished data). None of the Lycosinae recorded from the study area are SRE.

4.4.6 Miturgidae (False Wolf Spiders or Prowling Spiders)

Miturgid spiders are ground hunting spiders and males are commonly caught in pitfall trap studies throughout Western Australia. The local fauna is diverse but remains taxonomically poorly known. Whilst some miturgid species appear to have a very limited distribution (Raven 2009) many appear to be widespread. For example, *Mituliodon tarantulinus*, found at SRE site 5 (Appendix 4), occurs throughout the country (Raven and Stumkat 2003). None of the miturgids collected during this survey are likely to be SRE.

4.4.7 Oxyopidae (Lynx Spiders)

Oxyopidae are easily recognised by their characteristic, diamond-shaped eye pattern and strongly spined legs. They generally hunt in the vegetation without building a prey-capture web. The taxonomy of the Lynx Spiders is poorly resolved in Australia; however spiders appear to disperse very well limiting the tendency for short-range endemism in the group. A single specimen was collected at SRE site 5 (Appendix 4) which is not considered to represent an SRE.

4.4.8 Pholcidae (Daddy Long-legs)

Pholcidae, the Daddy Long-legs, are fairly easily distinguished by their long thin legs. Spiders build an irregular tangle-web and other spiders belong to their favourite prey. Many pholcids are synanthropic, i.e. live in close association with humans which probably is one of the reasons that many species are cosmopolitan in their distribution. Australian pholcids are moderately well known with a fairly recently published revision (Huber 2001). A single species was found during the survey (SRE sites 2 & 4) (Appendix 4), *Smeringopus natalensis*, a species originally described from South Africa and is not an SRE.

4.4.9 Salticidae (Jumping Spiders)

Jumping Spiders are the most diverse group of spiders based on the number of species in Australia, but also world-wide (Platnick 2011). Their large frontal eyes in combination with their visual hunting strategy allows for an easy identification of this group of spiders. Despite a large number of reviews of Australian genera, mainly by M. Zabka (Poland), Salticidae remain taxonomically poorly known. Many species are widespread and the group is not considered to include many, if any short-range endemics.

A single specimen in the genus *Opisthoncus* was recovered from the survey (SRE site 3) (Appendix 4). While identification beyond genus level is impossible, this specimen is not considered to be an SRE.

4.4.10 Sparassidae (Huntsmen Spiders)

Sparassidae include small to very large, often dorso-ventrally flattened spiders that live under rocks and the bark of trees. The Australian fauna is vast and despite some revisionary work mainly by D. Hirst (formerly South Australian Museum), many species remain undescribed (e.g., Hirst 1990; Hirst 1989; Hirst 1991; Hirst 1992; Hirst 1999).

A single female in the genus *Neosparassus* was recovered from SRE site 5 (Appendix 4). The genus is very diverse but poorly known in Western Australia, but is unlikely to include any SRE.

4.4.11 Stiphidiidae (Platform Spiders)

Platform spiders gain their name from the large sheet-webs that they construct in the lower parts of vegetation. They include mainly two genera in Australia, *Baiami* and *Corasoides*. A single female of *Corasoides* was found at SRE site 1 (Appendix 4) which could not be identified to species level due to a lack of taxonomic research in the genus. Currently two morphospecies are known in Western Australia and both are wide-spread, therefore not SREs.

4.4.12 Tetragnathidae (Long-jawed Spiders)

Tetragnathidae are related to the Orb-weaving Spiders (Araneidae) and similarly, they disperse very well. Therefore, the single specimen of *Leucauge* found at site TIA 1 (Appendix 4) is not considered an SRE.

4.4.13 Thomisidae (Crab or Flower Spiders)

Crab Spiders are a very diverse group of active hunters that do not build a web. The legs are directed more or less sideways in a typical crab-like fashion. Some species appear to be semi-social (Evans 1995). The taxonomy of the group is poorly resolved, but with most currently name species being fairly widespread, the likelihood of short-range endemism in this family is low.

A single *Diaea* female was recorded from SRE site 3 (Appendix 4) but is not considered to be an SRE.

4.4.14 Trochanteriidae (Flattened Ground Spiders)

The Trochanteriidae belong to one of the taxonomically best known spider families in Australia having been extensively revised only recently to include more than ten genera (Platnick 2002). They comprise small to fairly large dorso-ventrally flattened spiders that are predominantly found under rocks and bark.

Tinytrema

Tinytrema currently includes five Australian species of which only two occur in Western Australia. *Tinytrema sandy* is widespread in southern Australia, including Western Australia; however the second species in this state, *T. yarra*, has only ever been found once. Spiders in this genus are very small (less than 4mm long) and extremely flat. Anecdotal evidence suggests that they mimic ants (Platnick 2002).

Tinytrema yarra

The identification of the male specimen as *T. yarra* (Plate 7) found at SRE site 10 (Bassendean/Herdsman vegetation complex) (Table 4-6; Appendix 4) in March 2010 must be tentatively considered to be an SRE, as this species was previously known from a single female only, collected along Great Southern Highway at Yarra Road junction (31°51'S, 116°28'E). This locality is approximately 60km from the survey site on the Darling Escarpment. Taxonomic confirmation requires finding males and females at the same locality.

Based on the current assumed conspecificity, this small spider must be considered to be a PMA SRE.

Plate 7 *Tinytrema yarra* (Trochanteriidae). Male (dorsal view) from SRE site 10 (March 2010).

4.4.15 Zodariidae (Ant-eating Spiders)

Ant-eating spiders are a dominant element of the Australian ground-dwelling spider fauna. These spiders can easily be identified by their eye-pattern and often have distinct light or red spots on a dark background of the abdomen. The Zodariidae of Australia are moderately well-known based on recent revisionary work by Barbara Baehr (Newcastle University, formerly Queensland Museum) (Baehr 2004; Baehr and Churchill 2003; Baehr and Jocqué 1994; Baehr and Raven 2009) although many genera such as *Habronestes*, require extensive revision in particular in Western Australia.

Many zodariids are arid-adapted and as such wide-spread; the family is not known to include any SRE.

4.4.16 Zoridae (Wandering Spiders)

Zoridae are ground living spiders with poorly resolved taxonomy in Australia.

They are not known to include any SRE's; some species within the genus *Argoctenus* appear to be very widely distributed.

Table 4-6 Araneomorphae (SRE only) records by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Araneomorphae	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Tinytrema yarra			✓			

4.5 SCORPIONES

A total of three scorpion species were recorded in the SRE and TIA survey rounds representing three families and three genera (Table 4-7 and Figure 4-3).

None are considered to be SRE's.

4.5.1 Bothriuridae

In Australia, the family Bothriuridae is represented by the single genus *Cercophonius*. This genus contains seven described and a number of undescribed species. *Cercophonius* appears to be widespread in most mesic habitats of southern Australia. They are most commonly recorded in temperate forests with a moderate to well-balanced supply of moisture. It has been suggested that some species in the genus appear to be susceptible to habitat disturbance and hence may be useful indicators of successful habitat rehabilitation (Volschenk 2010).

Cercophonius sulcatus

Whilst the taxonomy the genus is poorly resolved, there is confidence that the species represented in the collection are *Cercophonius sulcatus* (Plate 8). This species is widely recorded from the south-west of Western Australia and is often associated with old growth forests and/or forests that have not experienced burning for long periods (Volschenk 2010). *Cercophonius sulcatus* is not an SRE.

This species was recorded from six sites in four of the habitat types (Table 4-7; Appendix 4). It was most commonly recorded in the SRE dry pitfall trapping rounds, where 43 specimens were recorded at a single site in the SRE Round 3 survey. Three adult specimens were also collected from a single site, TIA Site 4 in the night spotting TIA survey in May 2010 (Appendix 4). The locations from which it has not yet been recorded are the drier SRE sites positioned solely within the Bassendean complex and on the Karrakatta/Cottesloe border.

Plate 8 *Cercophonius sulcatus.* Dorsal (left) and ventral view (centre) and specimen in motion (right).

4.5.2 Buthidae

Members of the Buthidae include the most common scorpions across Australia. In Western Australia three of the five genera have been recorded: *Isometrus*, *Isometroides* and *Lychas*. Of these genera, species of *Lychas* are abundant and show increasing diversity across all of mainland Australia (Koch 1977a), as well as adjacent parts of south-eastern Asia. All *Lychas* are generally quite small with slender pedipalps and mottled colouration.

***Lychas* 'austroccidentalis'**

Lychas 'austroccidentalis' (manuscript name by E.S. Volschenk) (Plate 9) is found commonly throughout the south west corner of Western Australia. It has been recorded in virtually all environments of the south west, including disturbed habitats (Volschenk 2010). It is not an SRE. *Lychas 'austroccidentalis'* was the most commonly collected scorpion within the study area. This species was present at eight of the seventeen sites surveyed within four of the six habitats (Table 4-7; Appendix 4).

Plate 9 *Lychas 'austroccidentalis'*. Dorsal (left) and ventral view (right).

4.5.3 Urodacidae

The scorpion genus *Urodacus* is endemic to mainland Australia where 20 named species (Koch 1977b; Volschenk, Smith *et al.* 2000) and at least 70 unnamed species (E. Volschenk, unpublished data) occur. The Western Australian fauna is extremely diverse with high numbers of new species and, although numerous SRE species are known, others are more widespread with relatively wide distributions.

Urodacus novaehollandiae

Urodacus novaehollandiae (Plate 10) is widely distributed throughout the south west of Western Australia and therefore not an SRE. It displays pigmentation changes in its form relative to habitat type. The rocky habitat form is very darkly pigmented and the coastal plains form is pale. The specimens collected during the SRE and TIA survey rounds were of the pale form and were obtained from two sites (SRE Site 1 and SRE Site 4) within the Bassendean and Karrakatta vegetation complexes which are both well represented throughout the study area (Table 4-7; Appendix 4).

Plate 10 ***Urodacus novaehollandiae*** **(dorsal view).**

Table 4-7 Scorpiones records by vegetation complex/habitat type.

Specimens recorded	**Bassendean (5 mixed sites, 3 of them unique)**	**Bassendean* with peat (3 mixed sites, 2 unique)**	**Bassendean/ Herdsman border (4 mixed sites, all unique)**	**Karrakatta/ Bassendean border (2 unique mixed sites)**	**Karrakatta (2 SRE sites, both of them unique)**	**Karrakatta/ Cottesloe border (1 unique TIA site)**
Scorpiones	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Cercophonius sulcatus		✓	✓	✓	✓	
Lychas 'austroccidentalis'	✓		✓	✓	✓	
Urodacus novaehollandiae	✓				✓	

4.6 PSEUDOSCORPIONES

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families (Harvey 2009). They are found in a variety of habitats, but can be most commonly collected under the bark of trees, under rocks, or from leaf litter.

4.6.1 Chthoniidae

Members of the Chthoniidae are small pseudoscorpions with comparatively large chelicerae. Five indigenous genera have been reported from Australia, and each is widespread (Edward and Harvey 2008). Chthoniidae are especially common in leaf litter and under rocks in high rainfall areas of eastern and south-western Australia.

Austrochthonius

Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of southwestern Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Moulds 2006). The taxonomy of the Western Australian species is not resolved but there are clearly several species represented in the collections of the Western Australian Museum. Recent molecular analyses showed deep genetic divergences within the genus, but this is not reflected in their morphology and species identification is extremely difficult (M.S. Harvey, personal communication).

A single species of *Austrochthonius* (Plate 11) from SRE sites 1 and 2 and three TIA sites representing three different vegetation complexes (Bassendean, Karrakatta/Bassendean border and Karrakatta/Cottesloe) was recovered during the surveys (Table 4-8; Appendix 4). Due to the difficulties to identify the specimens beyond genus level, it is currently impossible to say if these represent an SRE (M.S. Harvey, personal communication).

Plate 11 ***Austrochthonius*. Male from SRE site 7 (June 2010).**

Table 4-8 Pseudoscorpiones records by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Pseudoscorpiones	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Austrochthonius	✓			✓		✓

4.7 OPILIONES (HARVESTMEN)

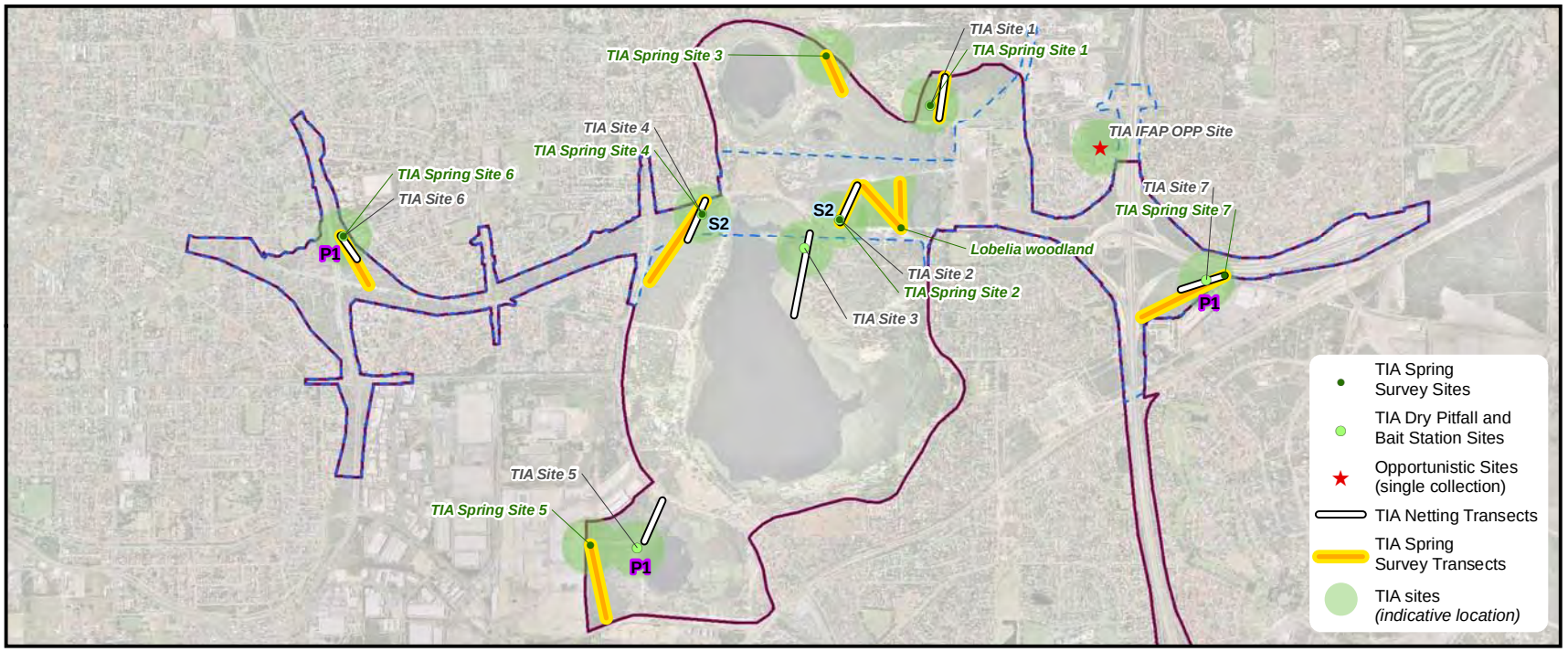
The survey recovered a single, unidentified specimen of harvestmen in the genus *Nunciella* (family Triaenonychidae).

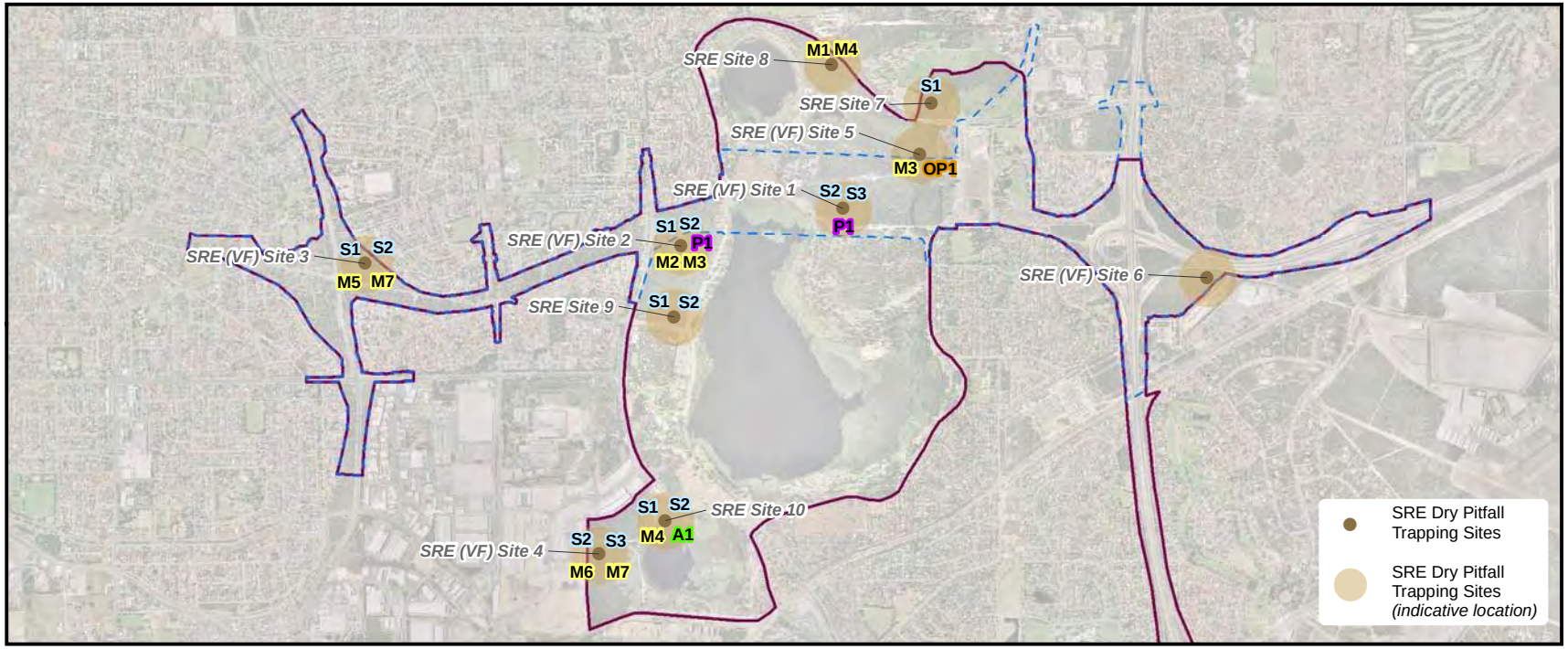
4.7.1 Triaenonychidae

Triaenonychidae are the dominant family of harvestmen in Australia with some 135 species in 43 genera (Framenau, Moir *et al.* 2008). *Nunciella* currently includes 12 species in Australia, of which two*, N. aspersa and N. karriensis*, are known from Western Australia (Hunt 1971).

Both appear to be widespread in southwestern Western Australia (Framenau, Moir *et al.* 2008). The WAM UBS recorded unidentified *Nunciella* from Perth and Jandakot airports (How, Harvey *et al.* 1996).

The surveys recovered a single specimen of this genus at SRE site 5 (Appendix 4). It is not considered to be an SRE.





Records of Arachnida

Figure 4-3

0 0.25 0.5 0.75 1

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Mygalomorphae

- M1 *Aganippe* sp. (juv.)
- M2 *Aname mainae*
- M3 *Aname tepperi*
- M4 *Aname* sp. (juv.)
- M5 *Idiosoma sigillatum*
- M6 *Missulena granulosa*
- M7 *Synothele michaelseni*

Araneomorphae (SRE only)

- A1 *Tinytrema yarra*

Scorpiones

- S1 *Cercophonius sulcatus*
- S2 *Lychas* 'austroccidentalis'
- S3 *Urodacus novaehollandiae*

Pseudoscorpiones

- P1 *Austrochthonius* sp.

Opiliones

- OP1 *Nunciella* sp.

Date Modified: 16/02/2011
Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-3 Records of Arachnida.mxd

4.8 MYRIAPODA: DIPLOPODA (MILLIPEDES)

Diplopoda (Millipedes) are a diverse group of arthropods and include eight orders within Australia. They are herbivores and scavengers that generally inhabit cool, moist environments. Millipedes were the most commonly collected group of arthropods throughout the SRE surveys with collections (native and introduced) from every site.

Millipede identification is largely based upon differences in the structure of the male gonopods. These are modified legs on the seventh abdominal segment that are used to store sperm prior to mating. The shape of the gonopod of each millipede species is different, making the identification of individual species in many groups a relatively simple task. Differences in gonopod morphology have been used in millipede taxonomy for 150 years, and have been shown to be good indicators of valid biological species.

Seven millipede species were collected in the surveys (Table 4-9; Figure 4-4).

4.8.1 Julida

Currently no native members of the millipede order Julida have been recorded from Australia and therefore all members of its nominal family Julidae in Australia are introduced (Mesibov 2006). Only two species have so far been reported from Western Australia, the common Portuguese Millipede (*Ommatoiulus moreleti*) and an unassigned species in the genus ?*Cylindroiulus*, apparently restricted to the southwest coast (Framenau, Moir *et al.* 2008).

***Ommatoiulus moreleti* (Portuguese Millipede)**

Ommatoiulus moreleti (Portuguese Millipede) (Plate 12) is an introduced species that can reach plague proportions in urban areas of southern Australia (incl. W.A.) in autumn (and sometimes spring). It was collected from all survey sites except SRE site 5 (Table 4-9; Appendix 4). This species is widely considered a pest species.

As an introduced cosmopolitan species, *O. moreleti* is not an SRE.

Plate 12 ***Ommatoiulus moreleti* (Portuguese Millipede), an introduced (pest) species. Male from SRE site 2 (August 2010).**

4.8.2 Polydesmida

Paradoxosomatidae

Members of the family Paradoxosomatidae are abundant and occur widely within Australia. They differ from the other two Australian families within the Polydesmida, Dalodesmidae and Haplodesmidae, by the separated bases of the male gonopods. Although there are hundreds of undescribed species, many from diverse habitats, most appear to have small ranges and many parts of Australia have not been sampled.

Many genera contain short-range endemic taxa although they may be locally abundant. Many paradoxomatids are relatively large with adults that range from 20 to 40mm in length (Mesibov 2006).

Antichiropus

The genus *Antichiropus* is the most abundant and diverse millipede genus in Western Australia and occurs throughout most of the state; however, the genus is most diverse in the southwest. *Antichiropus* was initially named in 1911 for seven species (Attems 1911) and two additional species were added by Jeekel (1982) and Shear (1992). Scientific field surveys, collections from environmental assessment studies and taxonomic work at the Western Australian Museum, have led to the genus now being known to consist of over 120 species, ranging as far north as the Kimberley, and extending onto the Nullarbor Plain and the Eyre Peninsula in South Australia.

With the exception of *Antichiropus variabilis*, which inhabits the Jarrah and Marri forests of south-western WA and *Antichiropus* 'PM1' from the northern Wheatbelt and the Geraldton sandplain, all species of the genus are known to be short-range endemics and many are known from only a few hundred square kilometers (Wojcieszek, Harvey *et al.* 2011).

Although the vast majority of *Antichiropus* species currently lack formal taxonomic descriptions and scientific names, Mark Harvey and collaborators have spent the past decade comparing different species of the genus and assigning temporary codes, such as `UBS1`, `UBS2` etc., to each of the species. The WAM UBS recovered five species of *Antichiropus* and one of these, *Antichiropus* `UBS1`, is currently only known from Woodman Point Reserve (How, Harvey *et al.* 1996).

***Antichiropus variabilis* (Marri Millipede)**

The Marri Millipede is the most widespread species of *Antichiropus* and not considered a short-range endemic species (Wojcieszek, Harvey *et al.* 2011). Most recently this species has been the subject of intensive studies of genital variation and speciation at the University of Western Australia (e.g., Wojcieszek and Simmons 2009). The WAM UBS recovered the species from Perth Airport and Tuart Hill but populations where also known from Kings Park and Bibra Lake (Wojcieszek, Harvey *et al.* 2011).

Large populations of *Antichiropus variabilis* (Plate 13) were collected from all SRE dry pitfall trapping sites except site 7 (Table 4-9; Appendix 4) indicating high plasticity in habitat choice for this species.

Plate 13 *Antichiropus variabilis* (Marri Millipede). Male from site 6 (July 2010).

The male gonopods can be seen as yellow structures on the venter of the animal.

***Antichiropus* `UBS2`**

Antichiropus `UBS2` (Plate 14) was initially recognised as distinct species from two sites of the WAM UBS, Talbot Road and Mt Henry (How, Harvey *et al.* 1996). It was subsequently found at additional sites around Perth and the currently known distribution based on the database of the Western Australian Museum stretches from Hepburn Heights (approximately 31°49`S, 115°46`E) in the north to Rockingham (approximately 32°16`S, 115°46`E) in the south.

Antichiropus `UBS2` must be considered a PMA SRE because records to date are confined to the PMA, although it appears moderately common throughout the bushlands of Perth. It was collected in the study area at SRE sites 2, 3 and 5 and TIA site 5 covering with Bassendean with peat, Bassendean/Karrakatta and Karrakatta vegetation complexes (Table 4-9; Appendix 4) the most common habitat types with good linear connection.

Plate 14 ***Antichiropus* `UBS2`. Male from SRE site 3 (April to May 2010).**

***Antichiropus* `UBS3`**.

Similar to the previous species, *Antichiropus* `UBS3` (Plate 15) was initially recognised from two sites of the WAM UBS, Jandakot Airport and Bold Park (How, Harvey *et al.* 1996). The known range now includes Bold Park in the north (approximately 31°57`S, 115°46`E) to Brookdale (approximately 32°09`S, 115°57`E) in the south.

Antichiropus `UBS3` is a PMA SRE and much less commonly collected than *Antichiropus* `UBS2`. *Antichiropus* `UBS3` was found within the study area at SRE sites 1, 2, 3, 4, 6 and 8 covering Bassendean, Bassendean/Karrakatta and Karrakatta vegetation complexes (Table 4-9; Appendix 4) and therefore similar habitats as *Antichiropus* `UBS2`.

Plate 15 ***Antichiropus* `UBS3`. Male from SRE site 8 (April to May 2010).**

Akamptogonus novarae

Akamptogonus novarae (Plate 16) is superficially similar to a second introduced species, *Oxidus gracilis*, but males can easily be separated by their gonopod morphology (Shelley and Lehtinen 1998). The species is probably native to eastern Australia or New Zealand, but is now widespread throughout southern Australian and the Pacific (Shelley and Lehtinen 1998). The northernmost records from W.A. are from Eneabba, and

species has previously been found in the Perth region (How, Harvey *et al.* 1996) but also further south in the state (Framenau, Moir *et al.* 2008). As an introduced species, *Akamptogonus novarae* is not an SRE.

Akamptogonus novarae was recovered from the study area at sites 5, 7, 9 and 10, representing Bassendean with peat and Bassendean/Herdsman vegetation complexes (Table 4-9; Appendix 4). This species appears to favour moderately moist environments.

Plate 16 *Akamptogonus novarae*. Male from SRE site 9 (September 2010).

4.8.3 Polyzoniida (Sucking Millipedes)

Siphonotidae

Polyzoniida are millipedes that are hemispherical in cross-section (Plate 17), the head narrows anteriorly and the mouthparts are greatly reduced. The Australian species of the order, comprising only of the family Siphonotidae, was revised in a Ph.D. thesis (Black 1994) but papers arising from this work have not been published and an identification of Australian Sucking Millipedes is difficult.

In Western Australia, polyzoniidan millipedes are generally restricted to the wet western region of the south coast (Framenau, Moir *et al.* 2008); however the Western Australian Museum holds specimens from Marvel Loch and the Great Victoria Desert. Sucking millipedes are very rarely collected on the Swan Coastal Plan, and the Western Australian Museum only holds specimens from Woodman Point and unspecified ”Perth”.

Siphonotidae sp. 1 was recorded from site 3 (Karrakatta vegetation complex) (Table 4-9; Appendix 4). Comparison with WAM specimens was not possible as all specimens are on loan. It is very likely the specimens from this survey represent PMA SREs.

Plate 17 Siphonotidae sp. (Polyzoniida). Vertebrate site 3 (May2010).

4.8.4 Spirostreptida

Iulomorphidae

The Iulomorphidae is a Gondwanan millipede family with currently nine genera described from Australia. Four of these, *Atelomastix*, *Podykipus*, *Samichus* and *Dinocambala* were established by Attems (1911) in his monograph on the millipedes of the Michaelsen & Hartmeyer expedition of the Hamburg University to southwest Western Australia in 1905 (Michaelsen and Hartmeyer 1908). The family is taxonomically poorly known with the exception of the genus *Atelomastix* which was recently revised for Australia (Edward and Harvey 2010).

Podykipus

Podykipus is currently only known from three species in Western Australia, although more undescribed species are known from the collection of the W.A. Museum. Males have reduced pairs of first legs and a characteristic gonopod structure (Attems 1911).

No systematic studies have been conducted on the genus since its original description. This lack of taxonomic knowledge in combination with the fact that the specimens in the collection of the Western Australian Museum have never been critically reviewed, make generating conclusions on the distribution of any of the species in the genus difficult.

Podykipus collinus

Podykipus collinus was originally described from Subiaco (Attems 1911) and the WAM currently has specimens from the type locality and Rottnest Island on its database. A single unidentified spirostreptidan millipede species was recovered from the WAM UBS survey at five sites (How, Harvey *et al.* 1996) and may be the same as reported here.

Specimens collected in the survey were identified as *Podykipus collinus* (Plate 18), mainly based on the close match of the morphology of the first pair of legs with the illustrations by Attems (1911). *Podykipus collinus* was collected from six SRE sites (1-5, 8), which are located within four vegetation complexes: Bassendean, Bassendean with peat, Karrakatta/Bassendean and Karrakatta (Table 4-9; Appendix 4).

Gonopod morphology of the specimens collected in this survey differs somewhat from the original illustrations and more research into the variability of these structures is required for an accurate identification. *Podykipus collinus* must be considered a PMA SRE pending a review of the *Podykipus* material collected in Western Australia.

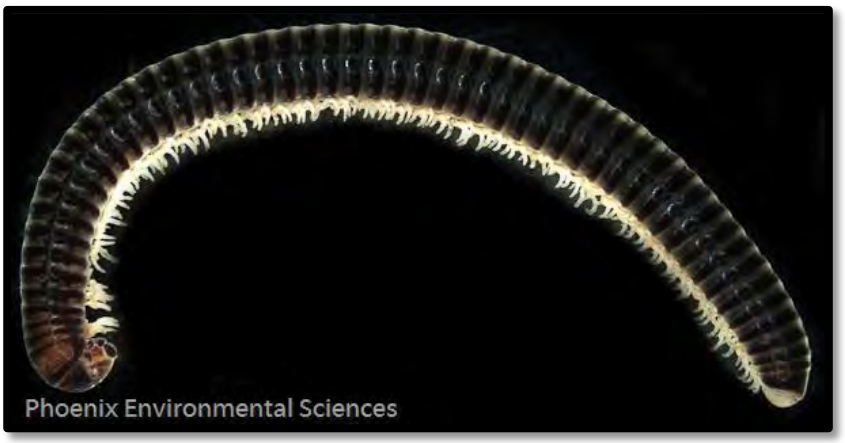


Plate 18 ***Podykipus collinus*. Male from SRE site 2 (July 2010).**

Table 4-9 Diplopoda (Millipedes) by vegetation complex/habitat type.

Specimens recorded	**Bassendean (5 mixed sites, 3 of them unique)**	**Bassendean* with peat (3 mixed sites, 2 unique)**	**Bassendean/ Herdsman border (4 mixed sites, all unique)**	**Karrakatta/ Bassendean border (2 unique mixed sites)**	**Karrakatta (2 SRE sites, both of them unique)**	**Karrakatta/ Cottesloe border (1 unique TIA site)**
Diplopoda*	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Julida						
Ommatoiulus moreleti	✓	✓	✓	✓	✓	
Polydesmida						
Antichiropus variabilis	✓	✓	✓	✓	✓	
Antichiropus `UBS2`		✓		✓	✓	
Antichiropus `UBS3`	✓			✓	✓	
Akamptogonus novarae		✓	✓			
Polyzoniida						
Siphonotidae sp. 1*					✓	
Spirostreptida						
Podykipus collinus	✓	✓		✓	✓	

4.9 MYRIAPODA: CHILOPODA (CENTIPEDES)

Three orders of centipedes, Geophilida, Scolopendrida and Scutigerida were reported during the surveys of which only the Geophilida may include potential short-range endemics (Harvey 2002). However, the scolopendridans *Notiasemus glauerti* and *Cormocephalus novaehollandiae* are also discussed in detail as they are mainly known from the Swan Coastal Plain (Koch 1983b; Koch 1985a) fulfilling the criteria of short-range endemism applied by Harvey (2002) (Table 4-10;Figure 4-4).

All other scolopendridan millipedes (three additional species of *Cormocephalus*, two species of *Scolopendra* and a single species of *Ethmostigmus*) and the scutigerid *Allothereua maculata* (Table 4-10) are widespread in Australia and not further dealt with here (e.g., Koch 1982; Koch 1983a; Koch 1983b; Koch 1983c; Koch 1985b; Koch and Burgman 1984).

Geophilida

***Chilenophilidae* sp.**

Two specimens of Chilenophilidae (Plate 19) family were recorded at two locations (SRE Sites 9 and 10) in the Bassendean/Herdsman vegetation complex.

As species-level identification was not possible, no comment can be made on the SRE status of this species.

Plate 19 Chilenopodidae sp. from SRE site 10 (May 2010).

4.9.1 Scolopendrida

Scolopendridae

Cormocephalus novaehollandiae

Cormocephalus novaehollandiae is a small to medium-sized centipede with a very long posterior anal-leg coxopleural process. It was originally described from Fremantle and its distribution ranges from the Perth Metropolitan Area to Yanchep (Koch 1983b).

Cormocephalus novaehollandiae is considered to be an SCP SRE. During this survey *Cormocephalus novaehollandiae* was recorded from two SRE sites (3 & 5) covering Bassendean with peat and Karrakatta vegetation complexes (Table 4-10; Appendix 4).

Notiasemus glauerti

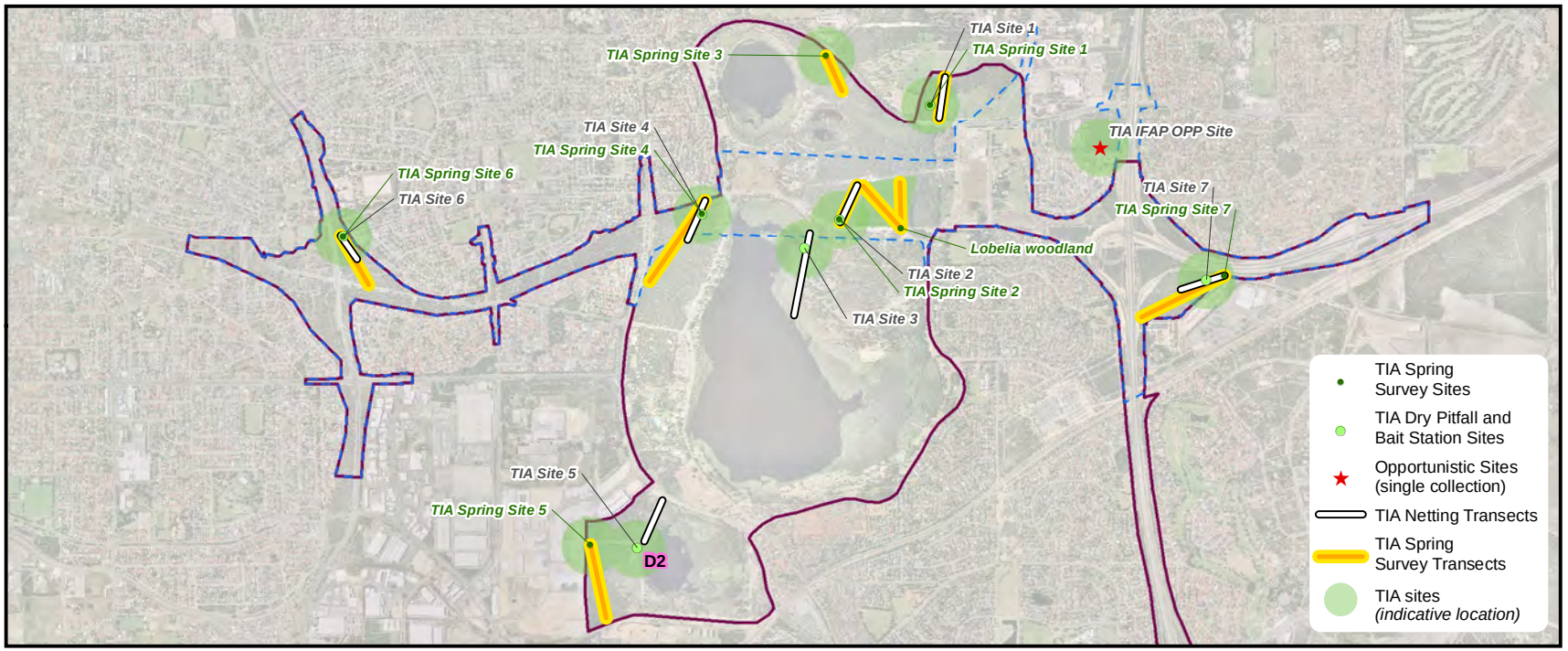
Notiasemus glauerti (Plate 2) is a comparatively small centipede with a short posterior tooth on the anal leg-coxopleura. It was describe based on a specimen from Applecross; it's distribution ranges from the Perth Metropolitan area to Dandaragan, approximately 135km north of Perth (Koch 1985a). The species appears to have a fairly wide habitat tolerance.

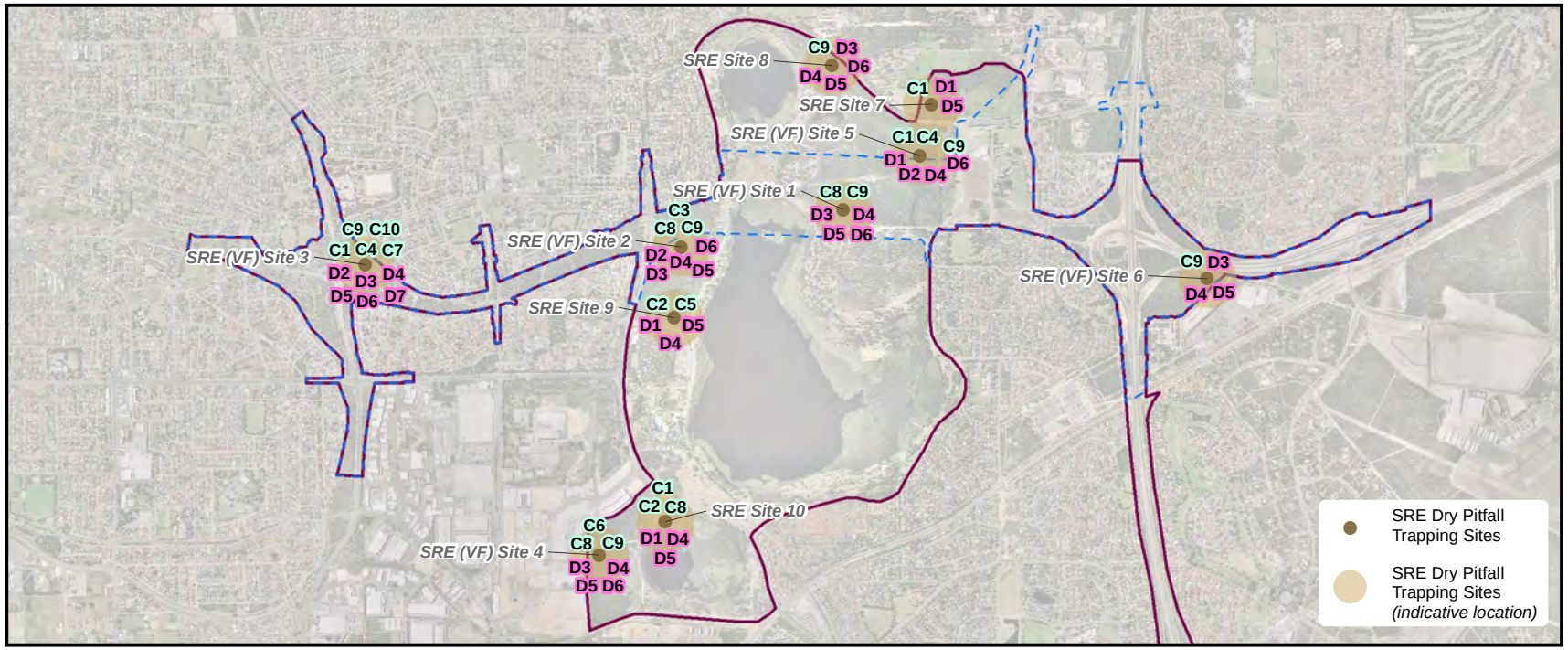
During this survey *Notiasemus glauerti* was recorded from four SRE sites (1, 2, 4 & 10) covering four different vegetation complexes (Table 4-10; Appendix 4). It is considered to be an SCP SRE.

Plate 20 ***Notiasemus glauerti* from SRE site 1 (August 2010)**

Table 4-10 Chilopoda by vegetation complex/habitat type.

Specimens recorded	**Bassendean (5 mixed sites, 3 of them unique)**	**Bassendean* with peat (3 mixed sites, 2 unique)**	**Bassendean/ Herdsman border (4 mixed sites, all unique)**	**Karrakatta/ Bassendean border (2 unique mixed sites)**	**Karrakatta (2 SRE sites, both of them unique)**	**Karrakatta/ Cottesloe border (1 unique TIA site)**
Chilopoda	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Chilenophilidae sp.			✓			
Scolopendra laeta	✓	✓		✓	✓	
Scolopendra morsitans			✓		✓	
Cormocephalus novaehollandiae		✓			✓	
Cormocephalus rubriceps			✓			
Cormocephalus turneri					✓	
Cormocephalus aurantiipes				✓		
Ethmostigmus rubripes	✓				✓	
Notiasemus glauerti	✓		✓	✓	✓	
Allothereua maculata		✓	✓		✓	





Records of Myriapoda

Figure 4-4

0 0.25 0.5 0.75 1

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Chilopoda

- C1 *Allothereua maculata*
- C2 *Chilenophilidae* sp.
- C3 *Cormocephalus aurantiipes*
- C4 *Cormocephalus novaehollandiae*
- C5 *Cormocephalus rubriceps*
- C6 *Cormocephalus turneri*
- C7 *Ethmostigmus rubripes*
- C8 *Notiasemus glauerti*
- C9 *Scolopendra laeta*
- C10 *Scolopendra morsitans*

Diplopoda

- D1 *Akamptogonus novarae*
- D2 *Antichiropus* `UBS2`
- D3 *Antichiropus* `UBS3`
- D4 *Antichiropus variabilis*
- D5 *Ommatoiulus moreleti*
- D6 *Podykipus collinus*
- D7 *Siphonotidae* sp.

4.10 MALOCOSTRACA: ISOPODA: ONISCOIDEA (SLATERS, WOODLICE)

Slaters (Oniscoidea) are often restricted to mesic environments with a dense layer of leaf litter. The taxonomy of this group in Australia is poorly resolved but it is believed that many native species of slaters will eventually be shown to represent short-range endemic species (Harvey 2002).

Three families of isopods were collected during the survey, Armadillidae, Philosciidae and Porcellionidae (Table 4-11; Figure 4-5). They include two widespread introduced species, *Armadillum vulgare*, Armadillidae (Plate 21) and *Porcellio scaber*, Porcellionidae (Plate 22).

Some of the native species may be considered SCP SREs but all are common along the Swan Coastal Plain and onto the Darling Escarpment.

Plate 21 ***Armadillum vulgare*** **(Armadillidae) from SRE site 10 (March 2010).**

Plate 22 ***Porcellio scaber*** **(Porcellionidae) from SRE site 7 (May 2010).**

Armadillidae

Buddelundia ?nigripes

The distribution of *Buddelundia nigripes* extends along the coast from Yanchep to Augusta but there is also a population in the wetter forests around Collie (S. Judd personal communication). The specimens from the Perth population are morphologically somewhat different from those around Bunbury (from where the species was originally described) and further to the south. Therefore the identification here is considered tentative. The conservation status of the Perth morphotype of *Buddelundia ?nigripes* (Plate 23) cannot be assessed until a detailed taxonomic appraisal has been completed (S. Judd personal communication).

If a species separation is warranted in the future due to further taxonomic clarifications it must be considered a PMA SRE, however if it remains in the same species group it would be considered an SCP SRE. This species was only collected at SRE sites 3, 4 and 6 in the Bassendean and Karrakatta/Bassendean vegetation complexes (Table 4-11; Appendix 4).

Plate 23 ***Buddelundia ?nigripes*** **(Armadillidae) from SRE site 6 (February 2010).**

Buddelundia **sp. (SJ #7)**

Buddelundia sp. (SJ #7) (Plate 24) is considered an SCP SRE but is widely distributed on the Swan Coastal Plain (S. Judd personal communication).

The species was collected at SRE sites 1 and 6 and TIA site 2, exclusively on Bassendean vegetation (Table 4-11; Appendix 4).

Plate 24 ***Buddelundia*** **sp. (SJ #7) from TIA site 2 (August 2010).**

?Spherillo **sp. (SJ #2)**

?Spherillo sp. (SJ #2) (Plate 25) is is considered an SCP SRE but is distributed widely on the Swan Coastal Plain, further to the northeast in comparison with *Buddelundia* sp. (SJ #7) (S. Judd personal communication). This species was found at SRE sites 1 and 8 and TIA site 2 on Bassendean and Bassendean/Karrakatta vegetation (Table 4-11; Appendix 4).

Plate 25 ?*Spherillo* sp. Female from TIA site 2 (August 2010).

Philosciidae

***Laevophiloscia* sp.**

The taxonomy of Laevophiloscia is poorly understood and no species diagnosis can currently be provided. *Laevophiloscia* are common everywhere in the southwest of Western Australia.

The *Laevophiloscia* species collected during the survey is considered an SCP SRE but is common on the Swan Coastal Plain (S. Judd personal communication). It was collected at SRE sites 1, 3, 5 and 10 and TIA site 3 covering a wide range of vegetation types, but was apparently most common on the Bassendean/Herdsman complex (Table 4-11; Appendix 4).

Table 4-11 Isopoda by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Isopoda*	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus /Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Armadillum vulgare			✓			
Buddelunida ?nigripes	✓			✓		
Buddelundia sp. (SJ #7)	✓					
?*Spherillo* sp. (SJ #2)	✓			✓		
Laevophiloscia	✓	✓	✓	✓		

4.11 MOLLUSCA: GASTROPODA (LANDSNAILS)

Landsnails belong to the target groups for short-range endemic surveys due to their limited dispersal capabilities in combination with often strict dependencies on particular soil (Harvey 2002).

Three different landsnail species in two families were recorded during the SRE and TIA surveys (Table 4-12; Figure 4-5). The White Italian Snail (*Theba pisana*, family Helicidae) (Plate 26) and the Pointed Snail (*Cochlinella acuta*; family Hygromiidae) are introduced pest-species and were commonly seen in and around the study area (Appendix 4).

Plate 26 ***Theba pisana*** **(Helicidae), an introduced pest species from Europe.**

Bulimulidae

The family Bulimulidae is of Gondwanan derivation and the extant Australian tax occupy Tasmania and southern areas of Western Australia and South Australia with some representatives also in central Australia and the Pilbara (Corey Whisson pers. comm.)

Bothriembryon bulla

Bothriembryon bulla is restricted to the Swan Coastal Plain and the adjacent Darling Escarpment with a fairly wide distribution from Guilderton in the North to Mandurah in the South (Hill, Johnson *et al.* 1983). This species is therefore considered to be an SCP SRE. *Bothriembryon bulla* was recovered from two SRE sites (SRE site 2 and site 6) in May and August 2010 (Table 4-12; Appendix 4). It was recorded in both the Bassendean and Karrakatta/Bassendean vegetation complexes .

Plate 27 ***Bothriembryon bulla*** **ventral (left) and dorsal (right) vew from SRE site 2 (May 2010).**

Bothriembryon kendricki

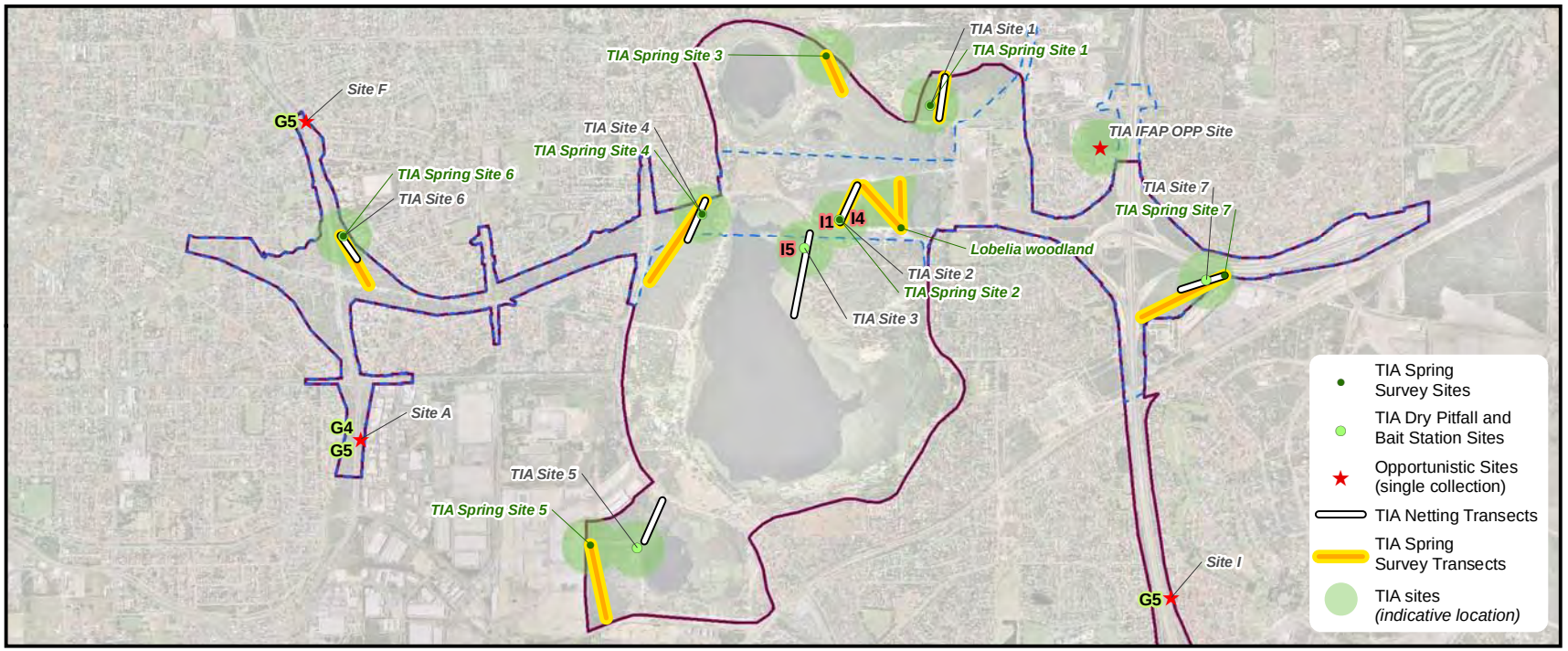
Bothriembryon kendricki is morphologically very similar to *B. bulla* and has a similar distribution (Hill, Johnson *et al.* 1983). It is considered to be an SCP SRE.

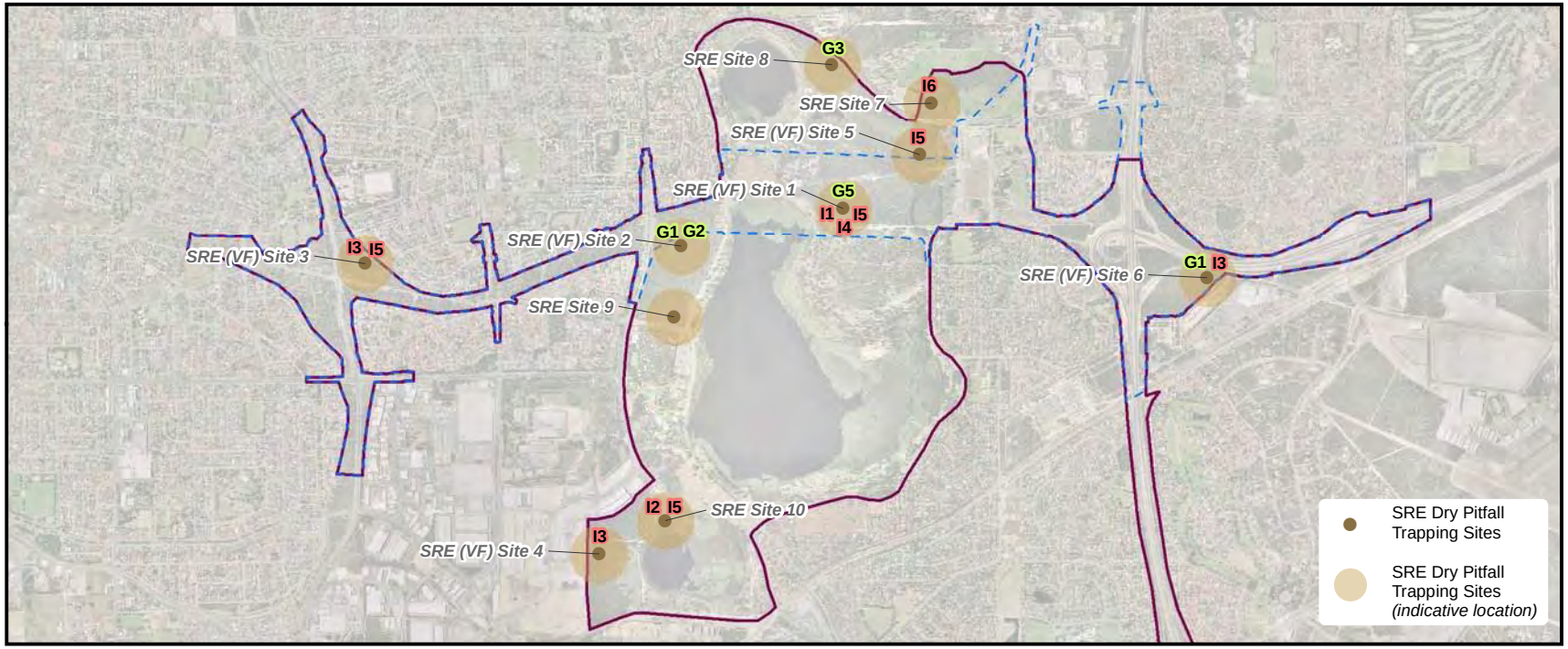
Bothriembryon kendricki was collected from a single SRE site (SRE site 2) in May 2010 from the Karrakatta/Bassendean vegetation complex (Table 4-12; Appendix 4).

Plate 28 ***Bothriembryon kendriki* from SRE site 2 (May 2010).**

Table 4-12 Mollusca by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Mollusca[c]	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Theba pisana	✓					
Cochlicella acuta	✓		✓		✓	
Bothriembryon bulla	✓			✓		
Bothriembryon kendricki				✓		





Records of Isopoda and Gastropoda

Figure 4-5

0 0.25 0.5 0.75 1

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Gastropoda

- G1 *Bothriembryon bulla*
- G2 *Bothriembryon kendricki*
- G3 *Bothriembryon* sp. (juv.)
- G4 *Cochlicella acuta*
- G5 *Theba pisana*

Isopoda

- I1 *?Spherillo* sp. (SJ #2)
- I2 *Armadillum vulgare*
- I3 *Buddelundia ?nigripes*
- I4 *Buddelundia* sp. (SJ #7)
- I5 *Laevophiloscia* sp.
- I6 *Porcellio scaber*

Date Modified: 16/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-5 Records of Isopoda and Gastropoda.mxd

4.12 INSECTA – LEPIDOPTERA (BUTTERFLIES AND MOTHS)

The TIA surveys collected a diverse range of genera of Lepidoptera in all five broad vegetation complexes surveyed. TIA surveys were not undertaken in the Karrakatta complex as this complex was covered by SRE sites and was not deemed to provide suitable habitat for the Graceful Sun-moth or the Yellow Admiral Butterfly (Table 4-14).

4.12.1 Castniidae (Sun Moths)

Most members of the Castniidae, in Australia commonly known as Sun Moths, are medium to large diurnally active moths. Members of this family have drab forewings and brightly coloured hind wings. They lay their eggs near the base of the food plant required by their larvae. Adults do not feed and only live for up to ten days. Many Australian Sun Moths are threatened or listed as critically endangered species (DSE 2003).

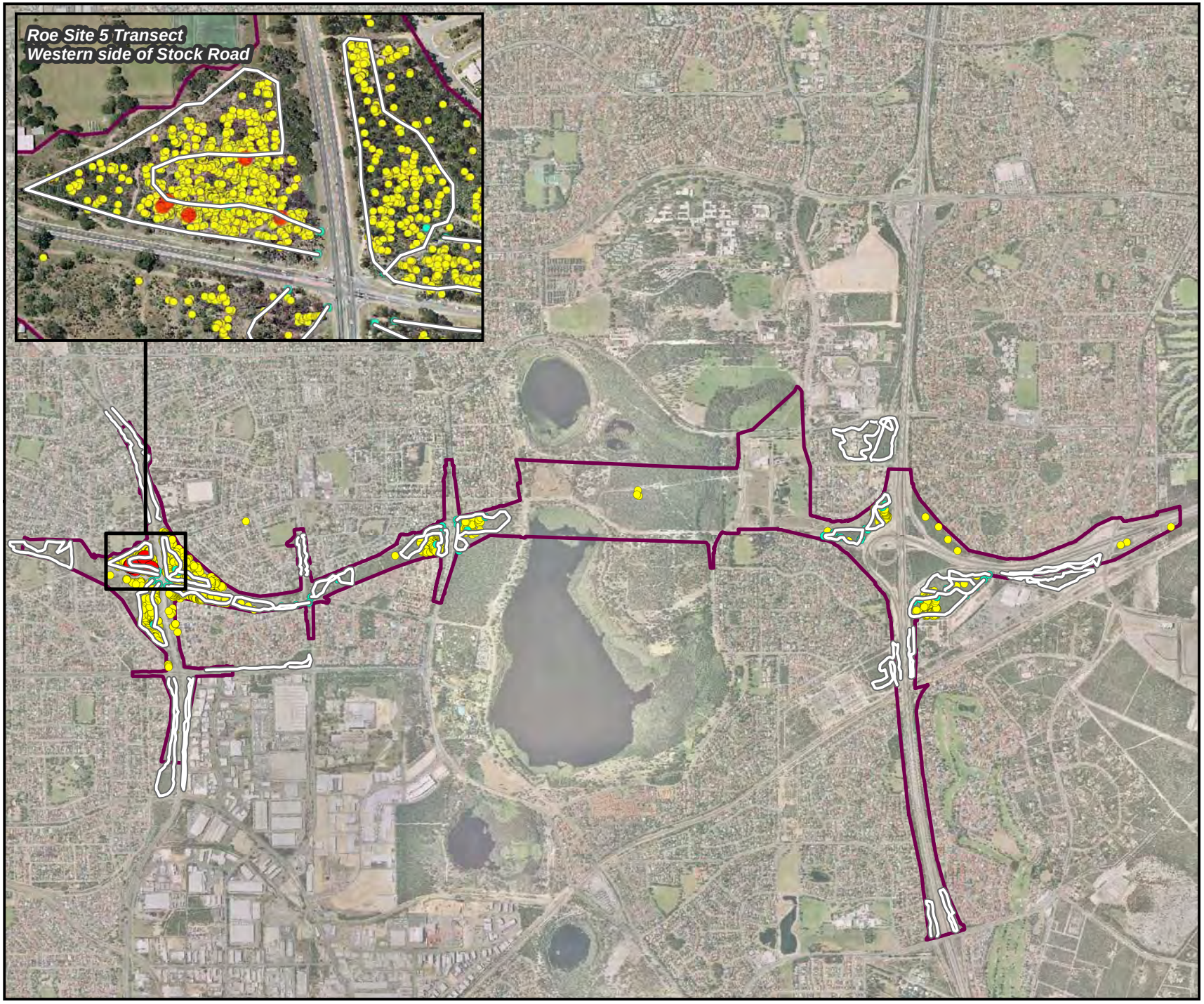
***Synemon gratiosa* (Graceful Sun-moth)**

Six specimens of Graceful Sun-moth (Plate 29) were recorded from Transect 5 of the 'Roe Highway' surveys in the study area in March 2010 (Table 4-13). This transect is located in the north-western quadrant of the Stock Road and Forrest Road intersection (Figure 4-6). Three of these specimens were captured and delivered to DEC for genetic testing; the other three were released at the time of survey.

Of the specimens recorded two were observed mating in flight and landed on a grass tree, *Xanthorrhoea preissii*. These specimens were not collected so as to not disturb the population. The species was not recorded from any other transect.

Initial records of *Lomandra* populations known from vegetation reports of the area were used to determine the survey transects. As requested by DEC, a *L. hermaphrodita* and *L. maritima* density survey was subsequently undertaken in April 2010 by AECOM (Appendix 3; Figure 3-4). This data was collected concurrently to and after the Graceful Sun-moth surveys but was not available for use in the initial planning.

Plate 29 ***Synemon gratiosa*, the Graceful Sun-moth.**



Graceful Sun-moth Records and Habitat

Figure 4-6

0 0.25 0.5 0.75 1

Kilometres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

Graceful Sun-moth Records and Habitat

- Graceful Sun-moth Record
- *Lomandra hermaphrodita* Record
- *Lomandra* sp. Record
- Graceful Sun-moth Transect
- Study Area

Date Modified: 16/02/2011
Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-6 Graceful Sun-moth habitats and records.mxd

Table 4-13 Graceful Sun-moth records from the survey.

Records	Date	Transect	Easting	Northing
GSM1	5 March 2010	Roe 5 west side	386405	6449314
GSM2	5 March 2010	Roe 5 west side	386341	6449250
GSM3	5 March 2010	Roe 5 west side	386445	6449247
GSM4	10 March 2010	Roe 5 west side	386312	6449260
GSM5&GSM6 MATING	10 March 2010	Roe 5 west side	386317	6449266
GSM5&GSM6 MATING	10 March 2010	Roe 5 west side	386317	6449266

4.12.2 Lepidoptera - other

None of the other Lepidoptera specimens collected were among the target species. None of these are SRE or of any other conservation significance (Table 4-14; Figure 4-7). Three specimens of Geometridae?, Herminiidae? and *Lepidoscia* sp. (Psychidae) could not be identified to species level using the Australian field guides (Braby 2005; Zborowski and Edwards 2005), but are not likely to be of conservation significance.

The locally-significant target species *Vanessa itea* (Yellow Admiral Butterfly), a target species, was not recorded.

Table 4-14 Lepidoptera records by vegetation complex/habitat type.

Specimens recorded	Bassendean (5 mixed sites, 3 of them unique)	Bassendean* with peat (3 mixed sites, 2 unique)	Bassendean/ Herdsman border (4 mixed sites, all unique)	Karrakatta/ Bassendean border (2 unique mixed sites)	Karrakatta (2 SRE sites, both of them unique)	Karrakatta/ Cottesloe border (1 unique TIA site)
Lepidoptera	*Eucalyptus/ Banksia* woodland	*Eucalyptus/ Banksia* woodland with Melaleuca riparian	*Eucalyptus/ Melaleuca* riparian zone	*Eucalyptus/ Xanthorrhoea* woodland	Open Eucalypt Forest *Eucalyptus* Woodland with *Banksia*	*Eucalyptus/ Xanthorrhoea* woodland with *Banksia*
Achaea janata?			✓			
Geitoneura klugii	✓	✓	✓	✓		✓
Geitoneura minyas			✓	✓		
Geometridae? sp.			✓			
Helicoverpa punctigera?	✓					
Herminiidae? sp.		✓				
Heteronympha merope	✓		✓	✓		
Lampides boeticus			✓	✓		
Lepidoscia sp.			✓			
Pieris rapae	✓	✓	✓	✓		
Utetheisa pulchelloides						✓
Zizina labradus	✓	✓	✓			

? Denotes some taxonomic identification is pending in this family/genus

4.13 INSECTA – ORTHOPTERA

Three families of grasshoppers and crickets were recovered from the study area, Acrididae, Tettigoniidae and Gryllidae (Figure 4-7; Appendix 4). Neither of the target native cricket species were recorded although suitable habitat is present. Only these are discussed below.

***Austrosaga spinifer* (Tettigoniidae)**

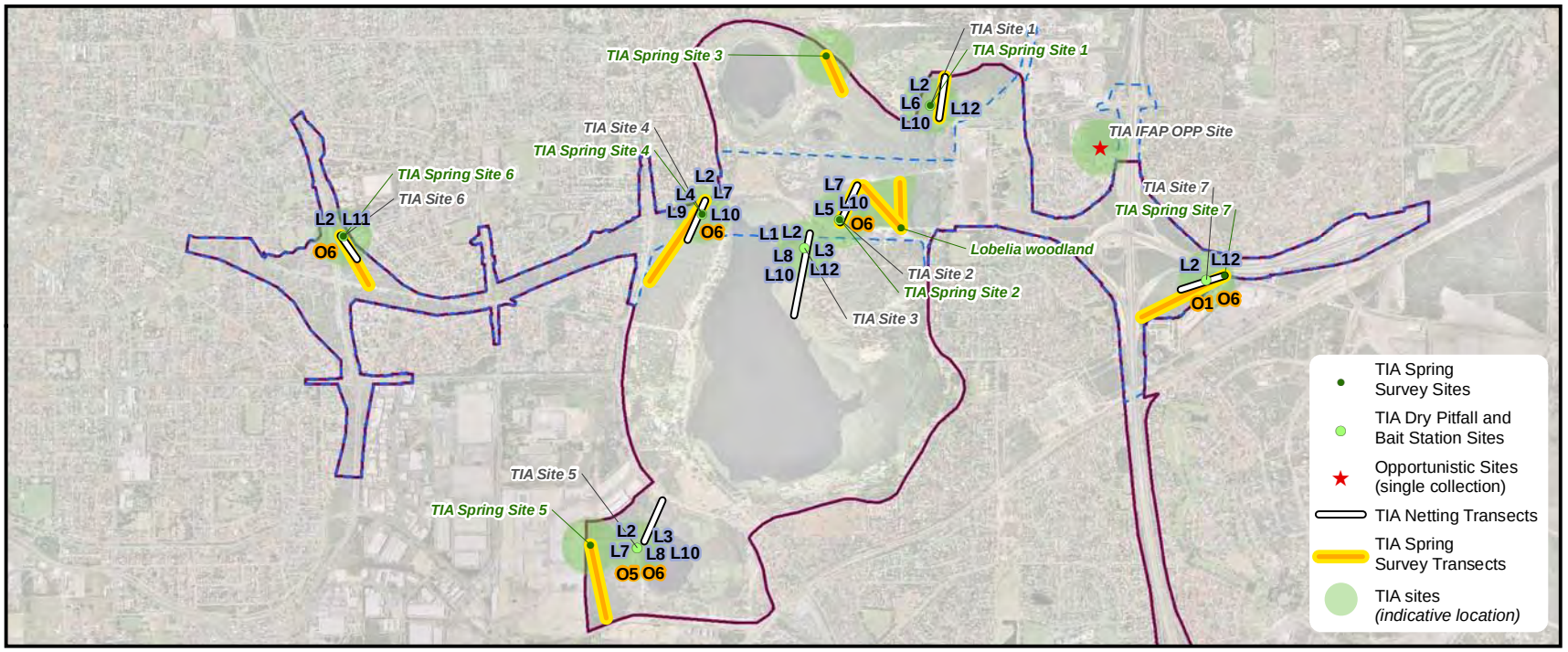
The native cricket species *Austrosaga spinifer* has previously been recorded from *Banksia* woodland in the northern Perth Metropolitan area in the City of Wanneroo. It is known from four records all within Neerabup National Park and currently thought to be endemic to this area (DEC and CCWA 2010).

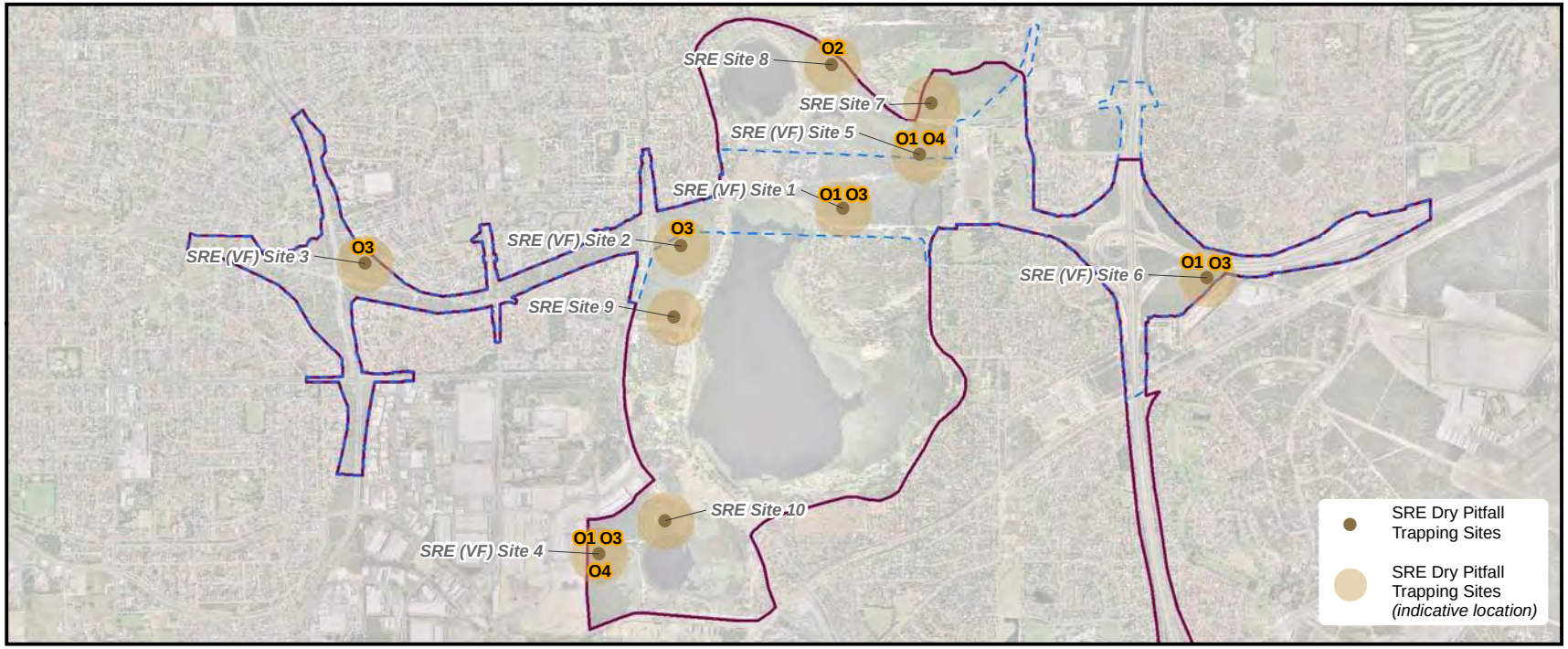
Austrosaga spinifer was not collected during the surveys although *Banksia* woodland and *Banksia* heath vegetation associations occur in the study area.

***Throscodectes xiphos* (Tettigoniidae)**

Throscodectes xiphos was described from a specimen was collected from *Banksia* woodland located at Cutler Road, Jandakot on the Bassendean complex similar to habitat within the eastern half of the study area (Rentz 1999).

The species was not recorded during the surveys in the study area.





Records of Lepidoptera and Orthoptera

Figure 4-7

0 0.25 0.5 0.75 1

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Lepidoptera

- L1 *Achaea janata?*
- L2 *Geitoneura klugii*
- L3 *Geitoneura minyas*
- L4 *Geometridae?* sp.
- L5 *Helicoverpa punctigera?*
- L6 *Herminiidae?* sp.
- L7 *Heteronympha merope*
- L8 *Lampides boeticus*
- L9 *Lepidoscia* sp.
- L10 *Pieris rapae*
- L11 *Utetheisa pulchelloides*
- L12 *Zizina labradus*

Ortoptera

- O1 *Acrididae* sp.
- O2 *Cedariniasp.*
- O3 *Gryllidae* sp.
- O4 *Gryllidae* sp.
- O5 *Heteropternis obscurella*
- O6 *near Bobilla*
- O7 *Tettigoniidae*

Date Modified: 16/02/2011
Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-7 Records of Lepidoptera and Orthoptera.mxd

4.14 INSECTA – HYMENOPTERA

Seven families of Hymenoptera were collected from the study area, including ants (Formicidae), introduced and native bees (Apidae, Colletidae, Halactidae and Megachilidae) and wasps (Ichneumonidae and Eumenidae) (Figure 4-8; Appendix 4). Only the native bees are discussed as four bees species were targeted in the survey.

Leioproctus (Glossurocolletes) bilobatus

Leioproctus (Glossurocolletes) bilobatus, family Colletidae, is associated with Jarrah/Wandoo Forest nominally off the Swan Coastal Plain. Collections have been made from as far east as Christmas Tree Well off Brookton Highway and on the South Coast within the Stirling Ranges (Terry Houston pers. comm. to C. O'Neill, 08/2010). *Leioproctus (Glossurocolletes) bilobatus* has so far been collected solely from the yellow flowering pea, *Gompholobium aristatum*.

This native bee species was not recorded during the TIA surveys. No *Gompholobium aristatum* were recorded within the study area during the flora and vegetation surveys for the project (AECOM 2010).

Leioproctus contrarius

Leioproctus contrarius, family Colletidae, is apparently dependent on flowers of Goodeniaceae and possibly *Lechenaultia stenosepala*, which are not recorded within the study area. Although it has been found at Forrestdale Lake in 1952 and 1954, suitable habitat may not exist within the study area to support this species (ATA 2006).

This native bee species was not recorded during the TIA surveys.

Leioproctus douglasiellus

The native bee species *Leioproctus douglasiellus*, family Colletidae, is apparently dependent upon *Goodenia filiformis* and *Anthotium junctiforme* (Cardno 2005). These plants are not recorded within the study area (AECOM 2010). Although it has been found at Forrestdale Lake in 1988, suitable habitat may not exist within the study area to support this species (Terry Houston pers. comm. to C. O'Neill, 08/2010).

This native bee species was not recorded during the TIA surveys.

Leioproctus* (*Protomorpha*) *plautus

Leioproctus (*Protomorpha*) *plautus* was described on the basis of several males, all from *Banksia* woodland at *Melaleuca* Conservation Park NE of Wanneroo (Maynard 1991). Additional specimens were later found further to the north, including specimens 50km NE of Kalbari (T.F. Houston, pers. comm.).

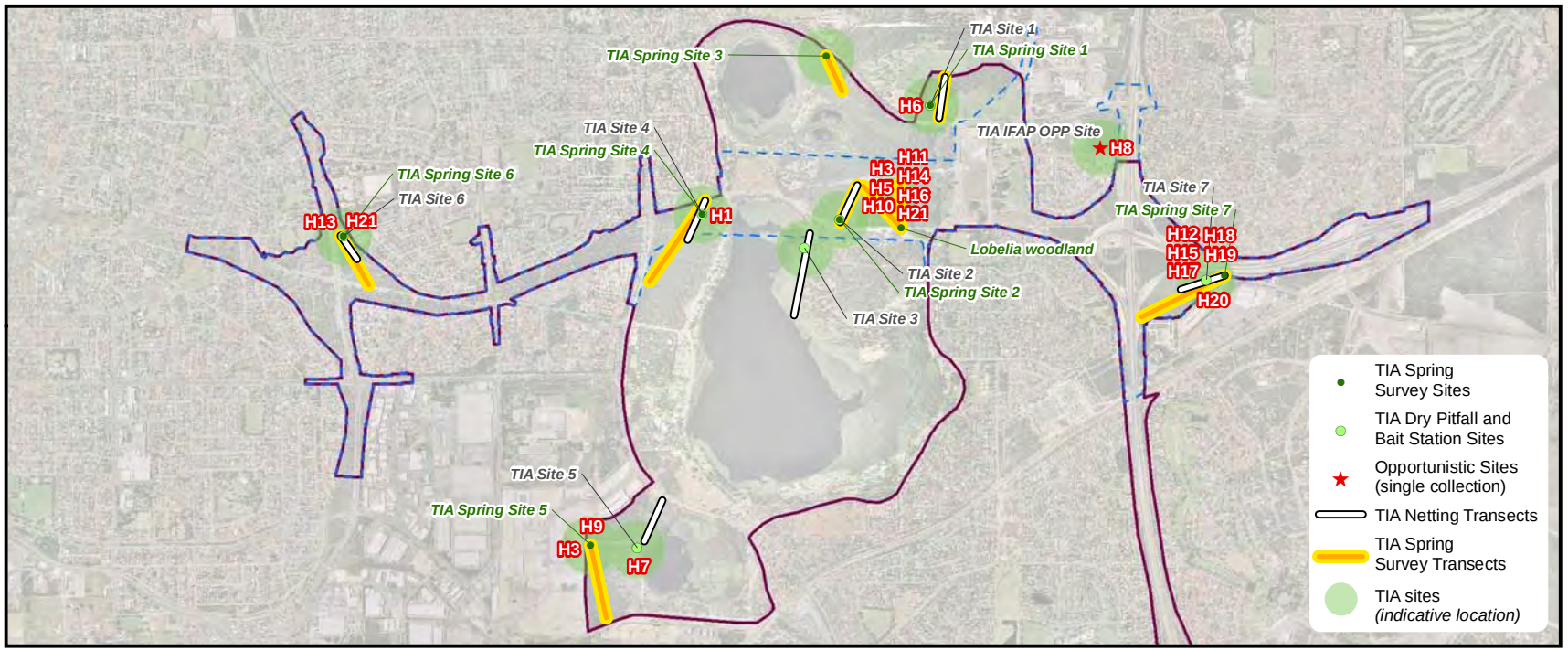
A female specimen was collected from an opportunistic site at the Farrington road bushland adjacent to the IFAP building (Appendix 4). It is tentatively considered conspecific with *Leioproctus plautus*, as the subgenus *Protomorpha* does not otherwise occur in the vicinity of Perth (T.F Houston, pers. comm.).

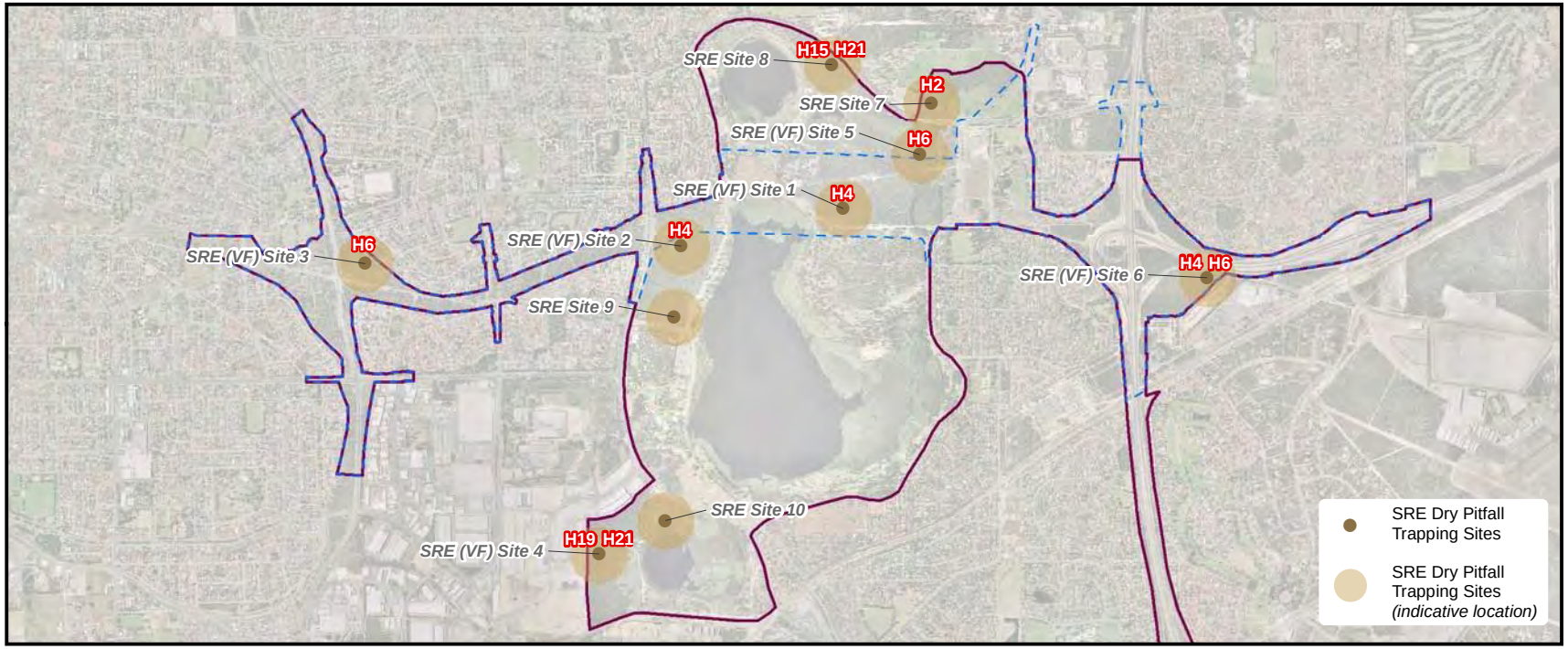
The species was not a target species and is not considered an SRE.

Neopasiphae simplicior

Lobelia tenuior, one of the four plant species of native bee species *Neopasiphae simplicior* (Colletidae), is present in some of the *Eucalyptus/Melaleuca* woodland in the project area, this native bee species could have been expected in the study area. It has also been recorded from as close as Cannington and Forrestdale golf courses feeding on *Lobelia tenuior*, *Goodeenia filiformis* and *Angianthus preissiannus*.

This native bee species was not recorded during the surveys.





Records of Hymenoptera

Figure 4-8

0 0.25 0.5 0.75 1

Kilometres

1:42,500 (A4)

Datum: GDA94 Projection: MGA z50

Hymenoptera

- H1 *Abispa ephippium*
- H2 *Apis millfera*
- H3 *Exoneura* (E.) sp.
- H4 *Formicidae* indet.
- H5 *Hyleus rufipes*
- H6 *Hymenoptera* indet.
- H7 *Ichneumonidae* sp.
- H8 *Leioproctus* (P.) *plautus?*
- H9 *Leioproctus* sp.
- H10 *Lipotriches* (A.) sp. (M104)
- H11 *Lipotriches* (A.) sp. 1
- H12 *Megachile* (A..?) sp. 1
- H13 *Megachile* (E.) *chrysopyga*
- H14 *Megachile* (E.) *obtusa*
- H15 *Megachile* (H.) *fultoni*
- H16 *Megachile* (H.) *ignita?*
- H17 *Megachile* (H.) *leeuwinensis?*
- H18 *Megachile* (H.) sp. 1
- H19 *Megachile* (H.) sp. 2 (F366)
- H20 *Megachile* (H.) sp. 3
- H21 *Megachile* (H.) *speluncarum*

Date Modified: 16/02/2011

Author: unknown J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\#2011\Technical_Reports\SRE and Inverts Baseline Survey\Figure 4-8 Records of Hymenoptera.mxd

4.15 INSECTA – MECOPTERA (SCORPIONFLIES)

***Austromerope poultoni* (Meropeidae)**

The small scorpion fly family Meropeidae contains only two species worldwide with extremely disjunct distributions. *Austromerope poultoni* is endemic to Western Australia and *Merope tuber* is only recorded from the United States of America. Both species are considered cryptic, rare and secretive insects; adults are rarely encountered (Byers 1991). *Austromerope poultoni* has only been collected in the vicinity of Perth from beneath leaf litter and logs and in pitfall traps.

Despite survey efforts in sites adjacent to water bodies and in the drier habitats of the study area, *Austromerope poultoni* was not recorded in larval or adult form.

5.0 DISCUSSION

5.1 SHORT-RANGE ENDEMICS

Short-range endemic taxa have been afforded special attention in the context of environmental impact assessment, because of their restricted distributions, narrow habitat preferences and poor dispersal capabilities (both within and between habitats). These factors put SRE species at risk from large scale developments that overlap the ranges of these species.

For the purpose of this report, two levels of short-range endemism were distinguished. On a larger scale, there are a number of nominal Swan Coastal Plain SRE's with ranges smaller than the nominal 10,000km^2 (Harvey 2002). These are often reasonably abundant along the Swan Coastal Plain and of low or no conservation significance.

In contrast, a number of species are restricted to the Perth Metropolitan Area (PMA SRE's) with much smaller known ranges than those above. These species are potentially threatened by further urbanization, particularly if urban bushland remnants that harbor these species are in danger of being developed (Harvey, Dell *et al.* 1997; How, Harvey *et al.* 1996). Conservation measures as part of environmental assessments should consider known populations outside project study areas and critically review the sustainability of these populations.

Eight short-range endemics of the Swan Coastal Plain (SCP SREs) were recorded in the surveys:

- *Idiosoma sigillatum* (Mygalomorphae: Idiopidae);
- *Notiasemus glauerti* (Chilopoda: Scolopendridae);
- *Cormocephalus novaehollandiae* (Chilopoda: Scolopendridae);
- *Buddelundia ?nigripes* and *Buddelundia* sp. (SJ #7) (Isopoda: Oniscoidea);
- ?*Sphellio* sp. (SJ #2) (Isopoda: Oniscoidea); and
- *Bothriembryon bulla* and *B. kendricki* (Gastropoda: Bulimidae).

These species are not considered to be of conservation significance and have not been considered further.

Seven short-range endemics of the Perth Metropolitan Area (PMA SREs) were recorded in the surveys (Table 5-1). All seven species have known ranges much smaller than, for example, the Graceful Sun-moth. Two species of PMA SREs are of particular concern as they were previously known from a single specimen only (*Tinytrema yarra*) or, putatively, have not previously been recorded (Siphonotidae sp.).

The record of *Tinytrema yarra* was not from the project area but from the wider study area, therefore this population may not be impacted by the proposed project.

In contrast, the unidentified sucking millipede species (Siphonotidae sp.) was found exclusively in the project area (SRE Site 3). Without any previous known records, this species warrants particular attention. Unfortunately, the siphonotid millipede cannot be further evaluated taxonomically as the collection of the WAM is currently on loan to a millipede specialist. Siphonotidae are rarely found in the Perth Metropolitan Area (the WAM has records from Woodman Point and unspecified historical localities in "Perth" only). Morphological comparison of the specimen from Site 3 with other Perth siphonotid records is an immediate step that would assist in assessing the distribution and conservation significance of this species.

Podykipus collinus was recorded from five sites across the study area, including two sites outside the project area (SRE sites 4 and 8). It is therefore considered to be locally abundant in different habitat types within the study area. Further taxonomic studies are required to establish or reject conspecifity with *Podykipus* specimens collected at five WAM UBS survey sites (Harvey *et al.* 1996). This would assist in determining if the species is restricted to the study area and surrounds.

Four PMA SRE's (both Mygalomorphae and both *Antichiropus* millipedes) recorded in the surveys appear to have populations in currently protected areas within the Perth Metropolitan Area, such as Bold Park or Kings Park. These protected populations should be assessed to assist with evaluating the effects of potential losses of subpopulations in the study area in relation to the survival of the species. All four species are found both in the project area and other sites throughout the study area (Table 5-1).

Table 5-1 Short-range endemics of the Perth Metropolitan Area recorded in the surveys and previous records.

Species	Project area	Study area	Previous known distribution	Latest record prior to this survey	Reference
Mygalomorphae					
Synothele michaelseni	SRE site 3	SRE site 4	Bindoon, Bold Park, Hamersley, Jarrahdale, John Forrest NP, Kings Park, Murdoch, Swanbourne, Tenilba, Wembley,	2004	WAM database, (Raven 1994)
Kwonkan `MYG225`	SRE site 6	SRE site 9	Bold Park, Tuart Hill, Jandakot Airport, Woodman Point, Landsdale Farm School	1996	
Araneomorphae					
Tinytrema yarra		SRE site 10	Single female: Great Southern Highway and Yarra Road Junction (31°51°S, 116°28°E)	1994	(Platnick 2002)
Polydesmida					
Antichiropus `UBS2`	SRE sites 2, 3, 5	TIA site 5	Cardup, Brookdale, Bushmead, Coolbellup, East Rockingham, Forestfield, Hepburn Heights, Mt Henry, Parmelia, Perth Airport, Martin, Warwick, Wexcombe	2005	WAM database
Antichiropus `UBS3`	SRE sites 1-3, 6	SRE sites 4, 8	Bold Park, Mt Claremont, Brookdale	1996	WAM database
Polyzoniidae					
Siphonotidae sp.	SRE site 3		unknown		
Spirostreptida					
Podykipus collinus	SRE site 1-5, 8		unknown		

5.2 TARGETED INVERTEBRATE ASSESSMENTS

Of the target invertebrate species in the TIA assessment, only the Graceful Sun—moth was recorded. Six individuals were recorded within a small remnant bushland patch (approximately 5ha) in the north-western quadrant of the Stock Road and Forrest Road intersection.

The site contains a high density of *Lomandra hermaphrodita*. This host plant has also been recorded in several other locations within the study area. While most of these locations were surveyed, no additional Graceful Sun-moth records were collected. The *L. hermaphrodita*/*L. maritima* mapping undertaken by AECOM was incomplete at the time of the survey (Appendix 3) and additional populations of Graceful Sun-moth may occur within the project area. Further *L. hermaphrodita* mapping and GSM surveys will be undertaken in 2011.

While no records were made, suitable habitat exists within the study area for the native bee species, *Neopasiphae simplicitor*, the native cricket species *Thoscodectes xiphos*, the scorpion fly *Austromerope poultoni*.

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APPENDIX 1 SRE AND TIA SURVEY SITE DESCRIPTIONS

Habitat Description	Site photos
SRE Site 1 – Bassendean Vegetation Complex ***Eucalyptus/Banksia* Woodland** Hope Road, opposite the Cockburn Wetland centre. Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus marginata* over an Open Heath of *Hibbertia hypericoides* and *Xanthorrhoea preissii* over an Open Sedgeland of *Mesomelaena pseudostygia*.	 
SRE Site 2 – Karrakatta/ Bassendean Border Vegetation Complex ***Eucalyptus/Xanthorrhoea* Woodland** On the east side of North Lake Road. Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over a Low Open Shrubland of *Xanthorrhoea preissii, Macrozamia riedlei, Daviesia divaricata* and *Hibbertia hypericoides* over an Open Grassland of *Ehrharta calycina (introduced)* on grey sand over yellow sand.	 

Habitat Description	Site photographs
SRE Site 3 – Karrakatta Vegetation Complex Open Eucalypt forest/*Eucalyptus* woodland with Banksia Northern end of remnant bush near Stock Road. Open forest to open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low shrubland to low open shrubland, with *Xanthorrhoea preissii* common. Low Shrubland of *Xanthorrhoea preissii, Macrozamia riedlei* and *Hibbertia hypericoides* over an Open Herbland of **Oxalis pes-caprae* and *Sowerbaea laxiflora* over an Open Grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam. *introduced	 
SRE Site 4 – Karrakatta Vegetation Complex Open Eucalypt forest/*Eucalyptus* woodland with Banksia South Lake Industrial Park bushland. Open forest to open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low shrubland to low open shrubland, with *Xanthorrhoea preissii* common. Densities of various tree species varied across the site; some groves of Sheoak. Substrate of sandy soil.	 

Habitat Description	Site photographs
SRE Site 5 – Bassendean with Peat Vegetation Complex ***Eucalyptus/Banksia* woodland with *Melaleuca* riparian** Wetland near Hope Road. Low Open Forest of *Eucalyptus rudis* and *Melaleuca preissiana* over a Tall Open Shrubland of *Astartea fascicularis* and *Kunzea glabrescens* over an Open Shrubland of **Pteridium esculentum* over a Sedgeland of *Lepidosperma angustifolium* on brown clayey-loam flats.	 
SRE Site 6 – Bassendean Vegetation Complex ***Eucalyptus/Banksia* Woodland** Roe Interchange Bushland near Western Power. Open Woodland of occasional *Eucalyptus marginata* over a Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* over an Open-heath of *Allocasuarina humilis, Conostephium minus* and *Eremaea pauciflora* over an Open Grassland/Sedgeland of *Amphipogon turbinatus* and *Mesomelaena pseudostygia* on grey sand.	 

Habitat Description	Site photos
SRE Site 7 – Bassendean with Peat Vegetation Complex ***Eucalyptus/Banksia* woodland with *Melaleuca* riparian** *Melaleuca* swamp at Murdoch University Low Open Forest of *Eucalyptus rudis* and *Melaleuca preissiana* over a Tall Open Shrubland of *Astartea fascicularis* and *Kunzea glabrescens* over an Open Shrubland of **Pteridium esculentum* over a Sedgeland of *Lepidosperma angustifolium* on brown clayey-loam flats.	
SRE Site 8 – Bassendean Vegetation Complex ***Eucalyptus/Banksia* Woodland** East of North Lake (Farrington Road). Open Woodland of occasional *Eucalyptus marginata* over a Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* over an Open-heath of *Allocasuarina humilis, Conostephium minus* and *Eremaea pauciflora* over an Open Grassland/Sedgeland of *Amphipogon turbinatus* and *Mesomelaena pseudostygia* on grey sand.	 

Habitat Description	Site photos

SRE Site 9 – Bassendean/Herdsman Border Vegetation Complex

***Eucalyptus/Banksia* woodland and *Melaleuca* riparian zone**

Southern end of the bushland on the west side of Birbra Lake. Open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low open shrubland of occasional *Xanthorrhoea preissii,* many *Macrozamia riedlei* and *Hibbertia hypericoides* over an open herbland of **Oxalis pes-caprae* and *Sowerbaea laxiflora* over an open grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam.

The riparian zone at this site is adjacent to Bibra Lake and contains *Melaleuca* and riparian species.

*introduced

Habitat Description	Site photos
Site 10 – Herdsman/Bassendean Border Vegetation Complex **Eucalyptus/Melaleuca riparian zone** South Lake riparian zone. Open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low open shrubland of occasional *Macrozamia riedlei* and *Hibbertia hypericoides* over a Sedgeland of *Lepidosperma angustifolium* of **Briza maxima* and **Ehrharta calycina* on brown sandy loam. The riparian zone at this site is adjacent to South Lake and contains *Melaleuca* and riparian species. *introduced	 

Habitat Description	Site photos
TIA Site 1 – Bassendean with Peat Vegetation Complex ***Eucalyptus/Banksia* woodland with *Melaleuca* riparian** *Melaleuca* swamp at Murdoch University. Low Open Forest of *Eucalyptus rudis* and *Melaleuca preissiana* over a Tall Open Shrubland of *Astartea fascicularis* and *Kunzea glabrescens* over an Open Shrubland of **Pteridium esculentum* over a Sedgeland of *Lepidosperma angustifolium* on brown clayey-loam flats.	 
TIA Site 2 – Bassendean Vegetation Complex ***Eucalyptus/Xanthorrhoea* Woodland** Bushland opposite the Wetland Centre, Hope Road. Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over a Low Open Shrubland of *Xanthorrhoea preissii, Macrozamia riedlei, Daviesia divaricata* and *Hibbertia hypericoides* over an Open Grassland of *Ehrharta calycina (introduced)* on grey sand over yellow sand.	 

Habitat Description	Site photos
TIA Site 3 – Herdsman/Bassendean Border Vegetation Complex ***Eucalyptus/Banksia* woodland and *Melaleuca* riparian zone** The riparian zone at this site is adjacent to the east side of Bibra Lake and contains *Melaleuca* and riparian species. It is within the TIA transect. The adjacent vegetation is the Open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low open shrubland of occasional *Xanthorrhoea preissii,* over an open grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam *introduced	

Habitat Description	Site photos
TIA Site 4 – Bassendean/Herdsman Border Vegetation Complex ***Eucalyptus/Banksia* woodland and *Melaleuca* riparian zone** Bushland at northern end of vegetation adjacent to Bibra Lake west side. Open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low open shrubland of occasional *Xanthorrhoea preissii,* many *Macrozamia riedlei* and *Hibbertia hypericoides* over an open herbland of **Oxalis pes-caprae* and *Sowerbaea laxiflora* over an open grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam. The riparian zone at this site is adjacent to the west side of Bibra Lake and contains *Melaleuca* and riparian species. It is 300-500m from the TIA transects downslope *introduced	 

Habitat Description	Site photos
TIA Site 5 – Bassendean /Herdsman Border Vegetation Complex ***Eucalyptus/Xanthorrhoea* Woodland** East - north east zone of bushland at South Lake. Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over a Low Open Shrubland of *Xanthorrhoea preissii, Macrozamia riedlei, Daviesia divaricata* and *Hibbertia hypericoides* over an Open Grassland of *Ehrharta calycina (introduced)* on grey sand over yellow sand.	 
TIA Site 6 – Karrakatta/ Cottesloe Border Vegetation Complex **Open Eucalypt forest/*Eucalyptus* woodland with Banksia** Remnant bushland (south) near Stock Road intersection. Open forest to open woodland with *Eucalyptus marginata*, *Banksia*, *Corymbia calophylla* & Allocasuarina over low shrubland to low open shrubland, with *Xanthorrhoea preissii* common. Low Shrubland of *Xanthorrhoea preissii, Macrozamia riedlei* and *Hibbertia hypericoides* over an Open Herbland of **Oxalis pes-caprae* and *Sowerbaea laxiflora* over an Open Grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam. *introduced	

Habitat Description	Site photos
TIA Site 7 – Bassendean Vegetation Complex ***Eucalyptus/Banksia* Woodland** Roe Highway Interchange bushland near Western Power. Open Woodland of occasional *Eucalyptus marginata* over a Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* over an Open-heath of *Allocasuarina humilis, Conostephium minus* and *Eremaea pauciflora* over an Open Grassland/Sedgeland of *Amphipogon turbinatus* and *Mesomelaena pseudostygia* on grey sand.	

APPENDIX 2 GPS SITE COORDINATES

Description of Trapping Sites Location	Site No.	Easting	Northing
SRE Sites			
Hope Road opposite Wetland Centre eastern end	SRE Site 1	389626	6449596
Opposite Bibra Lake, west side northern end (adjacent to TIA Site 4)	SRE Site 2	388630	6449366
Remnant bush near Stock Road intersection, south end (TIA Site 6)	SRE Site 3	386685	6449258
South Lake Industrial Park Bushland	SRE Site 4	388126	6447475
Wetland near Hope Road	SRE Site 5	390096	6449929
Roe Interchange bushland near Western Power (TIA Site 7)	SRE Site 6	391865	6449174
Melaleuca Swamp at Murdoch Uni (TIA Site 1)	SRE Site 7	390168	6450246
East of North Lake (Farrington Road, across from School)	SRE Site 8	389557	6450481
Southern end of Bushland west side of Bibra Lake	SRE Site 9	388587	6448933
South Lake Riparian	SRE Site 10	388531	6447681
TIA Sites			
Melaleuca Swamp at Murdoch Uni (SRE Site 7)	TIA Site 1	390168	6450246
Marri Jarrah Bushland (directly opposite Wetland Centre, Hope Rd)	TIA Site 2	389610	6449544
Bibra Lake (East Side riparian zone)	TIA Site 3	389393	6449366
Marri Banksia Bushland (West side, Northern end of Bibra Lake)	TIA Site 4	388763	6449575
South Lake (North East riparian zone east – north east of lake	TIA Site 5	388366	6447525
Northern end of Remnant Bushland, near Stock Road intersection	TIA Site 6	386558	6449440
Roe Interchange, bushland near Western Power (SRE Site 6)	TIA Site 7	391865	6449174
Opportunistic collections			
Opportunistic collection during fauna survey	Opp Site A	386667	6448195
Opportunistic collection during fauna survey	Opp Site I	391651	6447218
Opportunistic collection during fauna survey	Opp Site F	386332	6450147

Description of Transect Site Location	Site	Easting	Northing
Roe Highway GSM Sites – transect start and end points			
Western Power Bushland (gated)	Roe Site 1 T1 Start	391129	6449446
	Roe Site 1 T1 Finish	391122	6449433
	Roe Site 1 T2 Start	391155	6449506
	Roe Site 1 T2 Finish	391170	6449504
Hope Road Bushland/Freeway	Roe Site 2 T1 Start	388362	6449522
	Roe Site 2 T1 Finish	388376	6449500
	Roe Site 2 T2 Start	388462	6449565
	Roe Site 2 T2 Finish	388467	6449537
Between Bibra Lake/Nth Lake rd area	Roe Site 3 T1 Start	387501	6449056
	Roe Site 3 T1 Finish	387520	6449068
	Roe Site 3 T2 Start	387486	6449019
	Roe Site 3 T2 Finish	387402	6449007
Coolbellup Road /Forrest road area	Roe Site 4 T1 Start	386630	6449224
	Roe Site 4 T1 Finish	386561	6449183
	Roe Site 4 T2 Start	386485	6449205
	Roe Site 4 T2 Finish	386489	6449231
Stock/Forrest Intersection North	Roe Site 5 T1 Start	386497	6449145
	Roe Site 5 T1 Finish	386452	6449165
	Roe Site 5 T2 Start	386573	6449130
	Roe Site 5 T2 Finish	386550	6449128
Stock/Forrest Intersection South	Roe Site 6 T1 Start	391820	6449064
	Roe Site 6 T1 End	391938	6449172
	Roe Site 6 T2 Start	391971	6449203
	Roe Site 6 T2 End	391885	6449124
Roe Extension GSM Sites – transect start and end points			
Western Power bushland, top that is parallel to fwy.	Roe Extn Site 1 Start	391470	6448853
	Roe Extn Site 1 Finish	391447	6448843
Bushland opposite WP near Dowell Place	Roe Extn Site 2 Start	391385	6448518
	Roe Extn Site 2 Finish	391364	6448478
Roadside veg corridor Nth of Stock/Forrest (West Side)	Roe Extn Site 3 Start	386434	6449554
	Roe Extn Site 3 Finish	386145	6450278
Roadside veg corridor Nth of Stock/Forrest (East Side)	Roe Extn Site 4 Start	386504	6449568
	Roe Extn Site 4 Finish	386189	6450300
Roadside veg corridor Sth of Stock/Phoenix (West Side)	Roe Extn Site 5 Start	386593	6448517
	Roe Extn Site 5 Finish	386559	6448520
Roadside veg corridor Sth of Stock/Phoenix (East Side)	Roe Extn Site 6 Start	386723	6448516
	Roe Extn Site 6 Finish	386692	6448513
Roadside veg corridor Phoenix Road	Roe Extn Site 7 Start	386808	6448575
	Roe Extn Site 7 Finish	387359	6448595

Description of Transect Site Location	Site	Easting	Northing
Roe Extension GSM Sites – transect start and end points			
Bushland between IFAP and Fwy. Sth of Farrington	Roe Extn Site 8 Start	391172	6450213
	Roe Extn Site 8 Finish	391187	6450216
IFAP Private Bushland Sth of Farrington	Roe Extn Site 9 Start	391194	6449957
	Roe Extn Site 9 Finish	391209	6449961
East side of Coolbellup Road bush reserve	Roe Extn Site 10 Start	387463	6449202
	Roe Extn Site 10 Finish	387451	6449463
West Side of Coolbellup Road bush reserve	Roe Extn Site 11 Start	387433	6449205
	Roe Extn Site 11 Finish	387414	6449449
Parkland cleared Bushland Sth Blackwell Ave	Roe Extn Site 12 Start	385913	6449410
	Roe Extn Site 12 Finish	385909	6449419
Western Power site east of Roe1 Hope/Karel Ave	Roe Extn Site 13 Start	392100	6449191
	Roe Extn Site 13 Finish	392133	6449191
Western Power site east of Roe1 Hope/Karel Ave	Roe Extn Site 14 Start	392053	6449213
	Roe Extn Site 14 Finish	392105	6449216
Kwinana Freeway/Berrigan Interchange	Roe Extn Site 15 Start	391626	6446819
	Roe Extn Site 15 Finish	391589	6446820
Kwinana Freeway/Berrigan Interchange	Roe Extn Site 16 Start	391760	6446859
	Roe Extn Site 16 Finish	391748	6446854

APPENDIX 3 *LOMANDRA* SURVEY REPORT

Lomandra hermaphrodita Survey

Graceful Sun Moth Habitat Assessments

Lomandra hermaphrodita Survey

Graceful Sun Moth Habitat Assessments

Prepared for

South Metro Connect

Prepared by

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Quality Information

Document Lomandra hermaphrodita Survey

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Prepared by Alexandra Sleep

Reviewed by Kellie Honczar

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
A	24-Aug-2010	Draft for Internal Review		
0	28-Oct-2010	For Technical Reference	Kellie Honczar Senior Environmental Scientist	

Table of Contents

Executive Summary

Main Roads Western Australia (MRWA) is proposing to extend Roe Highway from its current terminus at Kwinana Freeway, to Stock Road in Coolbellup and have commissioned AECOM as part of the South Metro Connect project development team to undertake surveys to determine the extent and density of *Lomandra* species (spp.) that are thought to provide important breeding habitat for the specially protected Graceful Sun Moth (GSM) within the project area.

The GSM is a small day-flying moth endemic to south west Western Australia and is currently only known from the Swan Coastal Plain. *Lomandra hermaphrodita* and *Lomandra maritima* are two closely related species on which GSM larvae feed. Surveys for *Lomandra* and GSM were carried out in the project area and a population of GSM were recorded by Phoenix Environmental Sciences during March 2010 and *Lomandra hermaphrodita* was recorded within the project area.

The *Lomandra* survey was carried out in three phases. Firstly a *Lomandra* density survey as per Department of Environment and Conservation (DEC) guidelines was carried out to determine an approximate density of *Lomandra* across remnant vegetation of the project area. In addition to this density survey, selected areas were surveyed in detail to determine specific numbers and locations of *Lomandra hermaphrodita* plants.

The surveys for *Lomandra* which are covered in this report found that *Lomandra hermaphrodita* occurs throughout the project area, probably in greatest densities at the both the western and eastern ends of the project area. *Lomandra hermaphrodita* appears to be restricted to remnant upland vegetation types, which are less disturbed and less sever introduced species (weed) invasion.

1.0 Introduction

1.1 Background

Roe Highway is an important link in Perth's Primary Regional Road network, providing a high standard east-west connection. Seven sections of the highway have been completed to date, culminating with the connection to the Kwinana Freeway, north of Berrigan Drive. Main Roads Western Australia (MRWA) is proposing to extend Roe Highway from its current terminus at Kwinana Freeway, to Stock Road in Coolbellup and have commissioned AECOM as part of the South Metro Connect project team to undertake surveys to determine the extent and density of *Lomandra* spp. that are thought to provide important breeding habitat for the specially protected Graceful Sun Moth (GSM) within the project area.

1.1.1 Graceful Sun Moth

The GSM is a small day-flying moth endemic to south west Western Australia and is currently only known from the Swan Coastal Plain. The GSM is known from two vegetation types:

- *Banksia* woodland/*Adenanthos* on deep sands in the Northern suburbs of Perth on the Swan Coastal Plain where *Lomandra hermaphrodita* occurs.
- Open areas of herbland, heathland and shrubland on Quindilup soils (sand and limestone) close to the coast where *Lomandra maritima* is present.

The GSM is declared specially protected fauna under the WA *Wildlife Conservation Act 1950*, as it is rare or likely to become extinct. It is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The presence of possible GSM habitat will be a component of State and Commonwealth impact assessment of development proposals.

1.1.2 *Lomandra hermaphrodita* and *Lomandra maritima*

Lomandra hermaphrodita and *Lomandra maritima* are two closely related species on which GSM larvae feed. **Table 1** includes a description of both species.

Table 1 Description of *Lomandra hermaphrodita* and *Lomandra maritima*

Species	Description	Flowering Period	Habitat	Distribution
Lomandra hermaphrodita	Dioecious rhizomatous, caespitose perennial, herb. 0.06–0.2m high, clumps to 0.2m wide. Flowers purple, yellow	April – June.	White or grey sand, laterite	Southwest Botanical District: Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain and Warren.
Lomandra maritima	Dioecious rhizomatous, caespitose perennial, herb, 0.2–0.6m high, clumps to 0.2m wide. Flowers purple, yellow.	August – November	White or grey sand, limestone. Coastal areas: sand dunes, hills.	Eremaean Botanical Province: Canarvon Southwest Botanical Province: Geraldton Sandplains, Swan Coastal Plain.

1.1.3 Other Studies

A full, detailed GSM survey, in accordance with DEC guidelines was carried out by Phoenix in March 2010. The results of this report provide the basis for that assessment.

2.0 Objectives

The aim of *Lomandra* density surveys is to determine fine scale *Lomandra* presence, density, extent and dominant plant species at each site and thus determine potential GSM habitat. Once GSM surveys were conducted, areas of actual GSM habitat were gridded to determine in further detail the presence of *Lomandra hermaphrodita*, and selected areas where GSM surveys were carried out, but GSM not recorded were also surveyed in detail to determine if any variation in *Lomandra* populations was evident.

3.0 Methodology

The *Lomandra* survey was carried out in three phases.

Firstly a *Lomandra* density survey as per DEC guidelines was carried out to determine an approximate density of *Lomandra* across remnant vegetation of the project area.

In areas where GSM was recorded, detailed survey for *Lomandra hermaphrodita* was carried out to establish the exact number and location of each and every plant to obtain an impression of the extent and size of the *L. hermaphrodita* population.

Finally, areas were selected for detailed survey, where GSM survey had been carried out, but GSM was not recorded. An assessment identical to that described above was carried out in these selected areas.

Detailed methodologies for the three surveys are described in the sections below.

3.1 *Lomandra* Density Survey

A *Lomandra* density survey for the Roe Highway Extension (Kwinana Freeway to Stock Road) project area was carried out between April and June 2010 (29 April, 6-7 May, 18 and 22 June). The survey was conducted using guidelines provided by DEC.

The site was surveyed using two by two metre replicate quadrats, spaced at fifty metres along transects placed throughout areas of remnant vegetation within the project area (DEC, 2009). The total area of remnant vegetation within the project area was calculated to be 193.05 hectares, based on analysis of aerial imagery and vegetation mapping previously carried out (see AECOM, 2010; *Roe Highway Extension: Kwinana Freeway to Stock Road: Flora and Vegetation Assessment*). A total of 151 quadrats were sampled based a formula provided by DEC to determine number of quadrats for project areas over 100 hectares (Bishop, *pers comm,* 2010).

At each quadrat the number of *Lomandra hermaphrodita* was recorded, along with other information including: location, aspect, slope, bare ground, position in the landscape, vegetation structure, vegetation condition, surface and subsurface soil description and dominant species cover. The total number of *Lomandra hermaphrodita* and *Lomandra maritima* from the quadrats assessed was used to calculate an approximate density of plants per hectare for the entire project area.

3.2 Detailed *Lomandra hermaphrodita* Survey

In order to determine the population extent and size at the location where GSM was recorded, a detailed survey of the surrounding area was carried out. This survey involved recording the location of every individual *Lomandra hermaphrodita* using a handheld GPS. In order to capture this data as accurately as possible, field personnel with experience in identifying *Lomandra* species walked side by side in a grid to ensure that all ground was covered.

To get an indication of the *Lomandra hermaphrodita* population in areas where GSM was not recorded, but was surveyed for, areas of approximately 150 metres by 100 metres across the project area were surveyed in detail. In general, these survey areas were selected on the basis of intersection with a GSM transect, however one extra area in low-lying vegetation was also surveyed to determine the extent to which *Lomandra hermaphrodita* was present in those habitats. Areas were gridded by field personnel with experience in identifying *Lomandra* species and the location of each was recorded using a handheld GPS.

4.0 Results

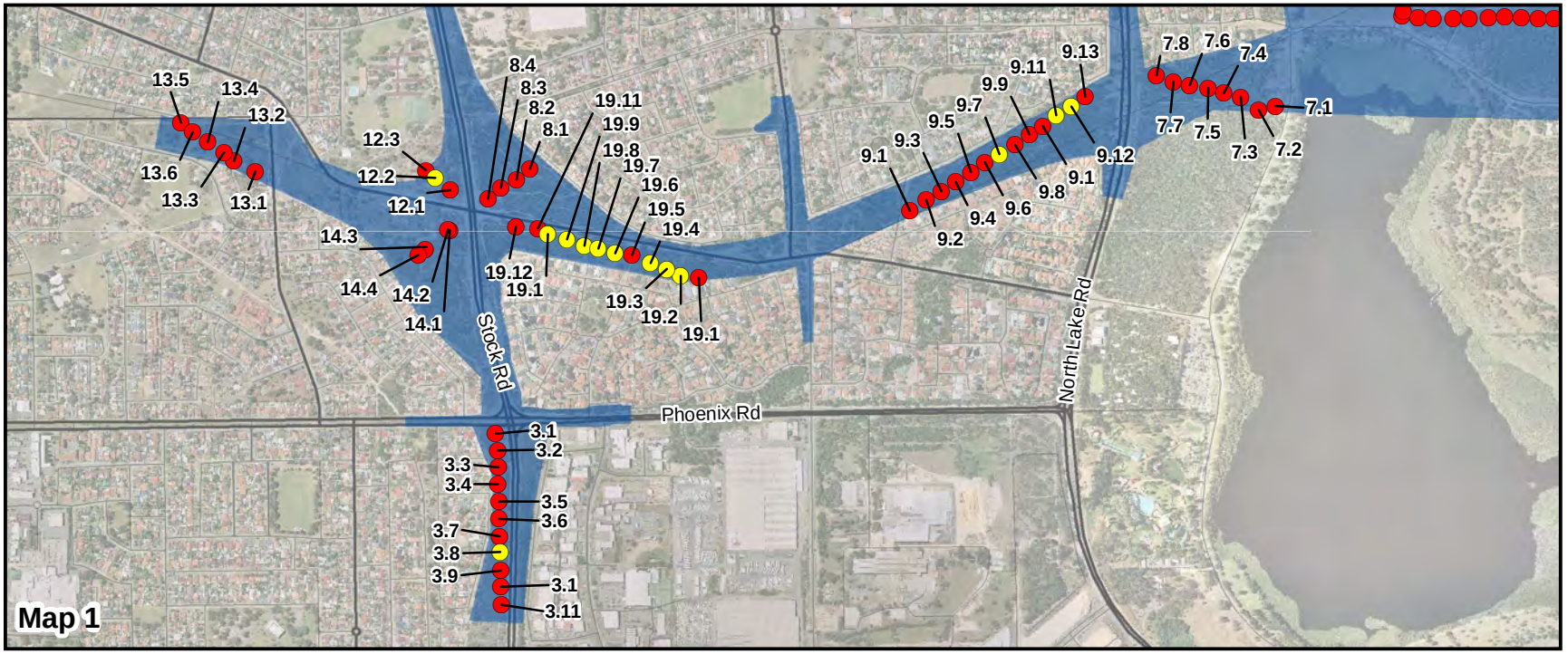
4.1 *Lomandra* Density Survey

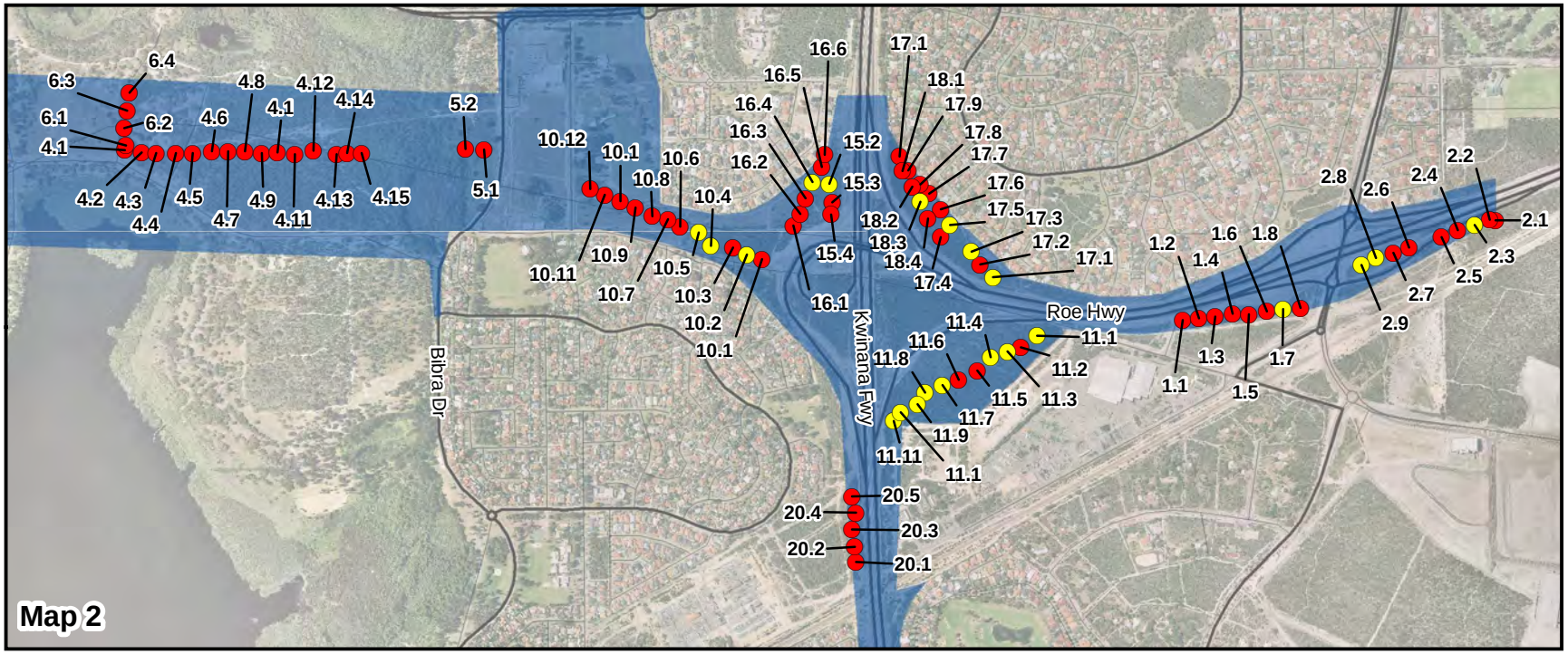
Lomandra hermaphrodita was recorded from areas of remnant woodland. The density of *Lomandra hermaphrodita* in the remnant bushland areas of the Roe Extension project area has been calculated as 2,119 plants per hectare, based on 128 individual plants being located in 151 quadrats along 20 transects.

Figure 1 shows the locations of quadrats where *Lomandra hermaphrodita* was recorded. These are located at the eastern and western ends of the project area. *Lomandra hermaphrodita* was not recorded from the lower lying areas in the mid section of the project area.

Mapped vegetation communities described in AECOM (2010) where the majority of quadrats recording *Lomandra hermaphrodita* were recorded are BAtS, BHhW, and CcXpMrS. Vegetation Community descriptions are provided in **Appendix C**.

No populations of *Lomandra maritima* were recorded from the project area, as the project area does not include the preferred habitat of this species (i.e. coastal dunes). Quadrat Data is provided as **Appendix A** and vegetation structure data for each quadrat is provided as **Appendix B**. The location of quadrats is shown in **Figure 1**.





Lomandra Density Survey

Figure 1

0 250 500 750

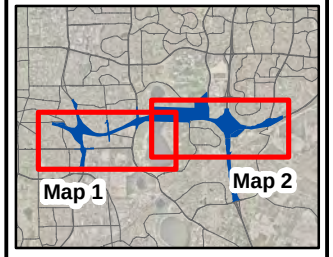
Metres

1:20,000 (A4)

Datum: GDA94 Projection: MGA z50

Quadrat Locations

- *Lomandra hermaphrodita* present
- *Lomandra hermaphrodita* not present



AECOM

Date Modified: 14/09/2010

Author: KEJ J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Lomandra_Density_Survey.mxd

4.2 Detailed Gridding

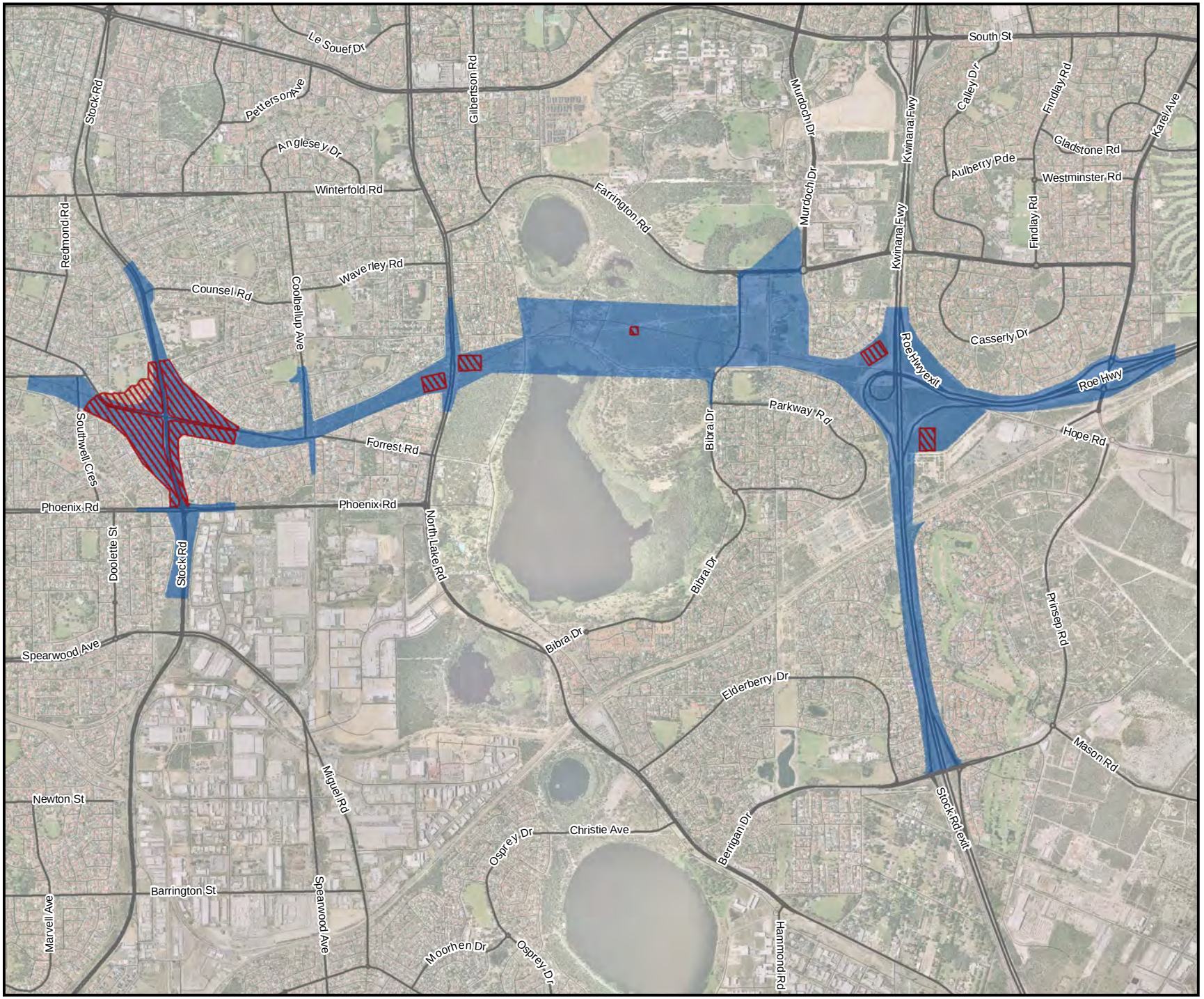
Phoenix recorded a small population of GSM near the existing Stock Road interchange. In order to determine the size and extent of the *Lomandra hermaphrodita* population in this area, the remnant bushland was searched in detail via foot traverses in a gridding fashion, over the entire local area, in order to record the location of each individual *Lomandra hermaphrodita.* The area that was gridded in detail is shown in **Figure 2**.

In total, 2,587 *Lomandra hermaphrodita* plants were recorded from this area which is 33.5 hectares in size. Locations of *Lomandra hermaphrodita* are shown in **Figure 3**. Mapped vegetation communities from which *Lomandra hermaphrodita* was recorded included: EgXpS, EmApS, CcXpMrS and EmXpS (see **Appendix C** for vegetation community descriptions).

Four sites which were intersected by a GSM transect were also gridded in detail. An additional site (L3) where a transect was not recorded was also gridded in detail. These sites are shown in **Figure 2**. The number of *Lomandra hermaphrodita* recorded from each site is shown in **Table 2** and in **Figure 4**.

Table 2 *Lomandra hermaphrodita* recorded from detailed gridding sites

Site Name	Area (hectares)	Number of *Lomandra hermaphrodita* recorded	Vegetation Community
L1	1.49	220	CcXpMrS
L2	1.49	50	CcXpDdS
L3	0.25	3	BXpW
L4	1.49	111	BHhW
L5	1.50	285	MpBaS / BaTs



Detailed Gridding Extent

Figure 2

0 400 800 1,200

Metres

1:35,000 (A4)

Datum: GDA94 Projection: MGA z50

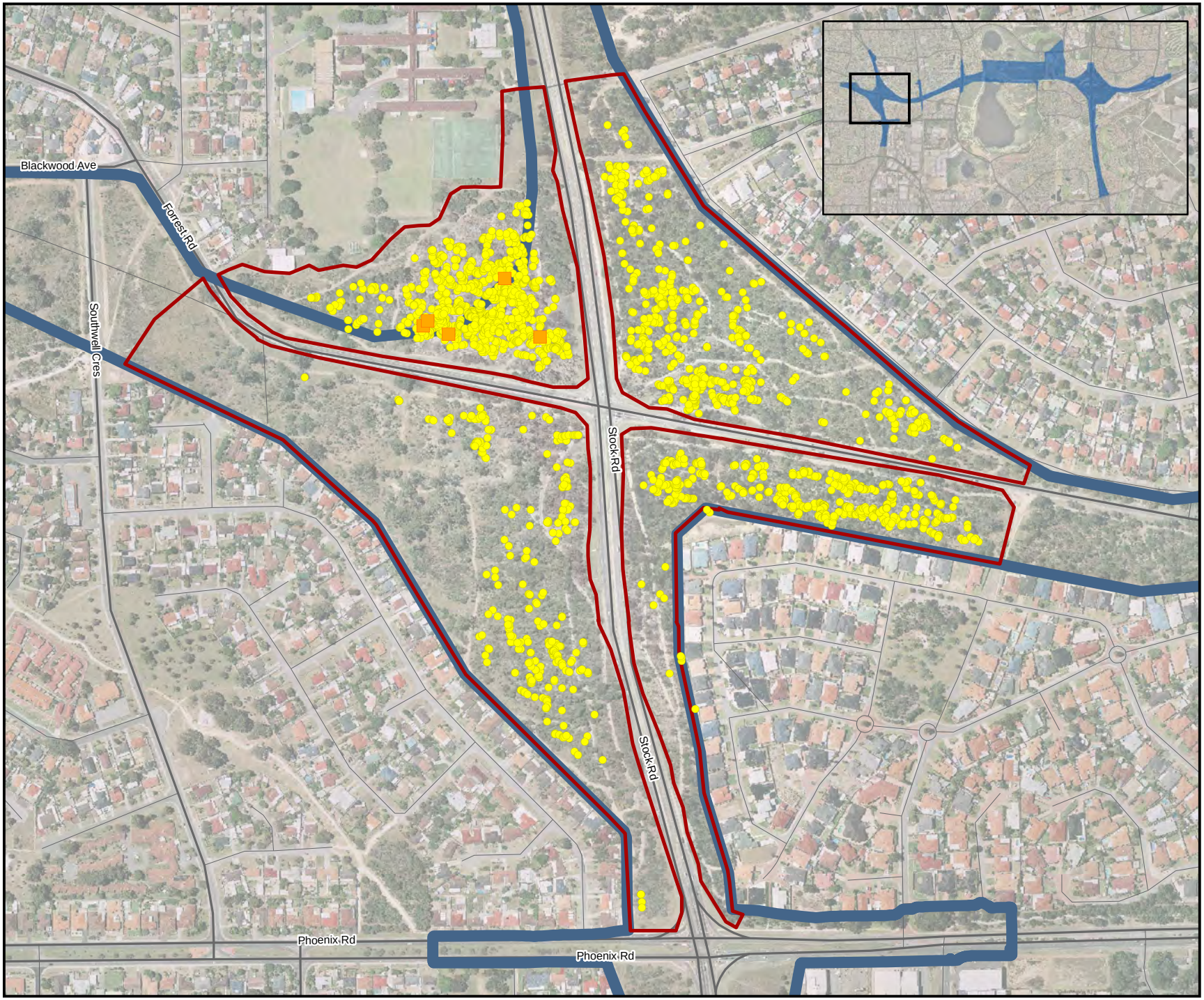
Project Area

Extent of Detailed Gridding Areas

AECOM

Date Modified: 14/09/2010

Author: CBB J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Detailed_Gridding_Extent.mxd



Stock Road Interchange *Lomandra hermaphrodita* locations

Figure 3

0 50 100 150 200

Metres

1:6,000 (A4)

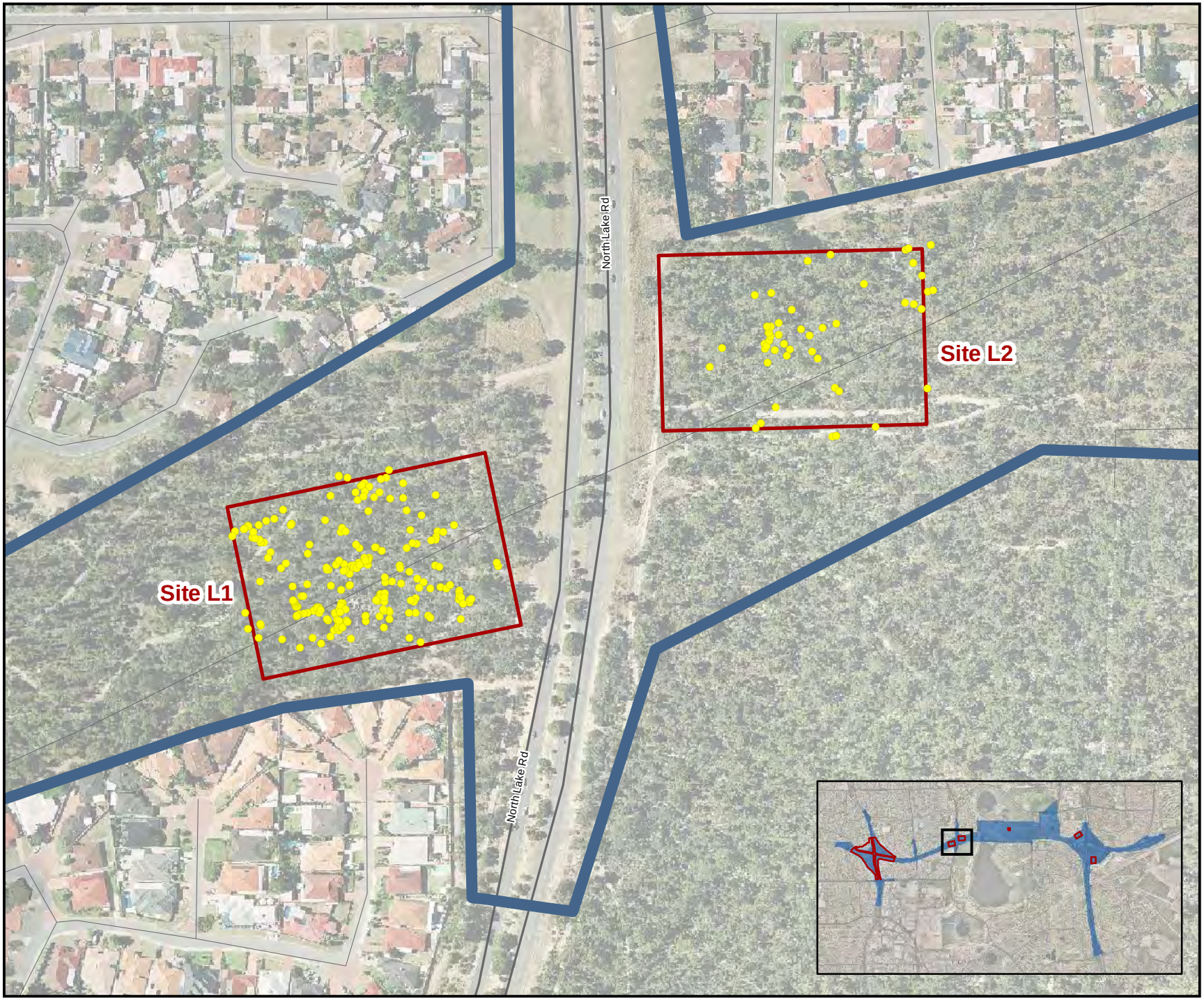
Datum: GDA94 Projection: MGA z50

- Project Area
- Extent of Detailed Gridding Areas
- Locations of *Lomandra hermaphrodita*
- Locations where Graceful Sun Moth was recorded

AECOM

Date Modified: 14/09/2010

Author: CBB J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Stock Road Interchange Lomandra hermaphrodita locations.mxd



Detailed Gridding *Lomandra hermaphrodita* locations

Figure 4.1

0 25 50 75 100

Metres

1:3,000 (A4)

Datum: GDA94 Projection: MGA z50

Project Area

Extent of Detailed Gridding Areas

Locations of *Lomandra hermaphrodita*

AECOM

Date Modified: 1/11/2010

Author: CBB J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Detailed Gridding Lomandra hermaphrodita locations_1.mxd

Detailed Gridding *Lomandra hermaphrodita* locations

Figure 4.2

0 25 50 75 100

Metres

1:3,000 (A4)

Datum: GDA94 Projection: MGA z50

Project Area

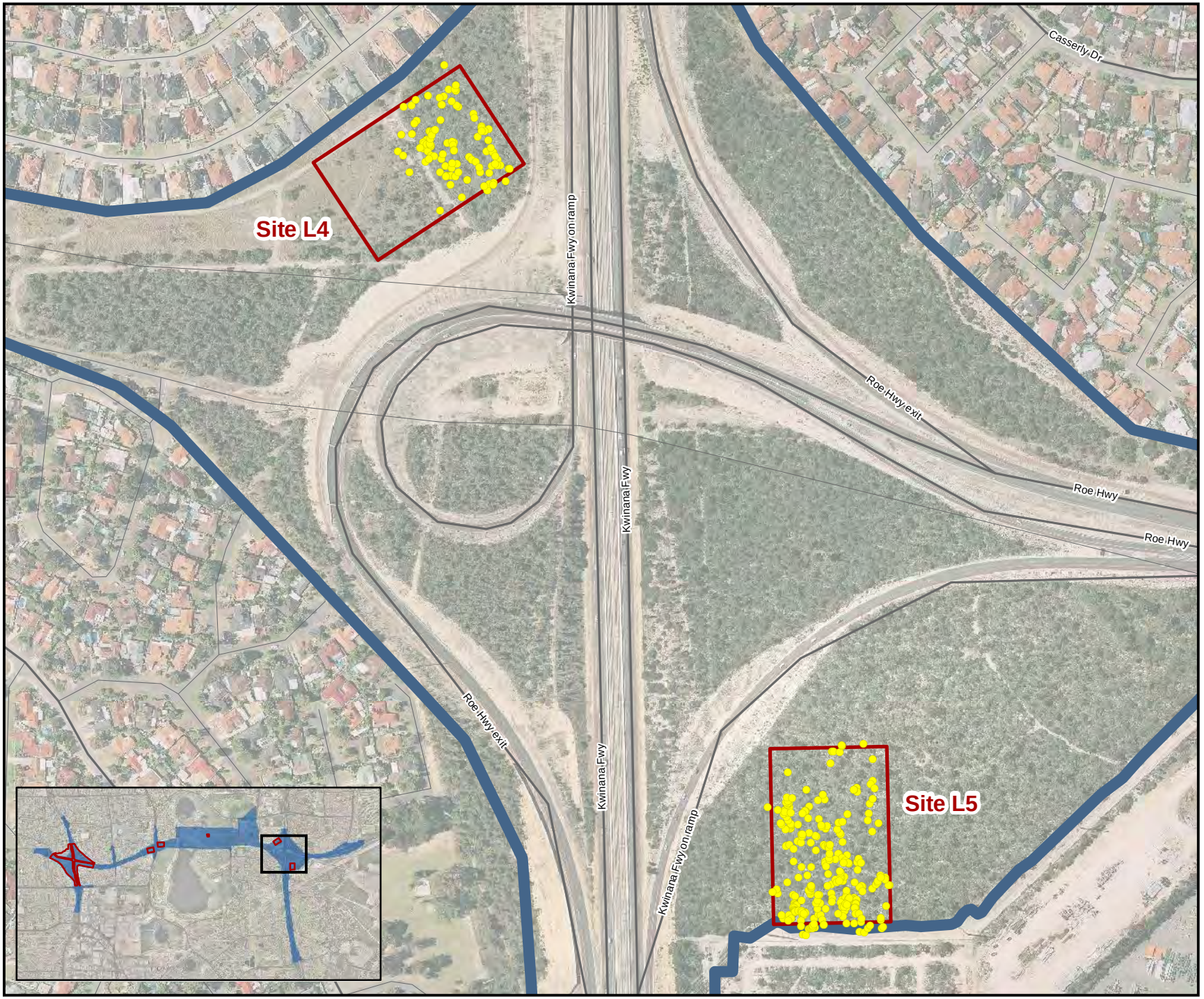
Extent of Detailed Gridding Areas

Locations of *Lomandra hermaphrodita*

AECOM

Date Modified: 1/11/2010

Author: CBB J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Detailed Gridding Lomandra hermaphrodita locations_2.mxd



Detailed Gridding *Lomandra hermaphrodita* locations

Figure 4.3

0 50 100 150

Metres

1:4,500 (A4)

Datum: GDA94 Projection: MGA z50

- Project Area
- Extent of Detailed Gridding Areas
- Locations of *Lomandra hermaphrodita*

AECOM

Date Modified: 1/11/2010

Author: CBB J:\Client_Data\Main_Roads\60100953_Roe_Extension\Workspaces\2010_09_14__Lomandra_Report_Alex\Detailed Gridding Lomandra hermaphrodita locations_3.mxd

5.0 Discussion

Lomandra density surveys carried out in accordance with DEC guidelines, determined that the density of *Lomandra hermaphrodita* (no *Lomandra maritima* were recorded) to be 2,119 plants per hectare. This figure is an approximation based on extrapolation of the areas that were sampled (see **Section 3**).

Due to a population of GSM being recorded from the project area, the remnant bushland in the immediate vicinity was gridded (see **Section 3**) to more accurately define the population of *Lomandra hermaphrodita* in that particular area. A total of 2,587 *Lomandra hermaphrodita* were recorded from area adjacent to the Stock Road interchange (**Figure 3**). The total area surveyed in this location was 33.5 hectares. The north west corner of the interchange, where GSM was recorded comprised the highest proportion of *Lomandra hermaphrodita* with 1,148 plants, making up 44% of the total plants recorded as part of detailed grid searches. The mapped vegetation community of this area is EgXpS (see **Appendix C**).

It was found that *Lomandra hermaphrodita* was unlikely to occur in areas where the growth of introduced grasses was dense (for example the western portion of the south west corner of the interchange survey area), it was also found that in most cases *Lomandra hermaphrodita* did not occur along the edges of existing roads where disturbance is high. The remnant vegetation in the north west quadrant adjacent to the interchange has recently been burnt (within the last two years) and infestation of weeds is less sparse in this area in comparison with the more open sandy areas around *Xanthorrhoea preissii*, where *Lomandra hermaphrodita* was found to be most dense.

Five additional areas across the project area were also gridded (**Section 3** and **Figure 2**). In these areas *Lomandra hermaphrodita* appears to be restricted to areas of vegetation in 'Degraded to Good 'condition or better, with the site recording the highest number of *Lomandra hermaphrodita* in 'Very Good' and 'Good to Very Good' condition.

The area in low lying *Banksia* woodland that was surveyed recorded a very sparse population of *Lomandra hermaphrodita*, indicating that large populations of the species are more likely to be found in upland vegetation. Overall, *Lomandra hermaphrodita* was found to occur in all areas of remnant upland vegetation throughout the project area. Its occurrence does appear to be restricted by weed invasion, with it not being recorded in large numbers where density of ground covering introduced species is high.

6.0 Conclusions

Lomandra hermaphrodita, a plant which appears to be important to the lifecycle of GSM has been found to occur within most upland vegetation that is not subject to high weed infestation throughout the project area. The density within these areas of occurrence does vary somewhat. It has been inferred that the greater densities probably occur at the both the western and eastern ends of the project area (see **Figure 3** and **Figure 4**).

Lomandra maritima has not been recorded in the project area.

In order to accurately map the occurrence of individual plants of *Lomandra hermaphrodita* throughpout the project area, more detailed gridding surveys are required and these are planned to be carried out during late 2010, to supplement results presented in this report.

Furthermore, DEC have advised that a repeated density survey, in accordance with DEC guidelines should also be carried out, which will also be undertaken during late spring 2010.

7.0 References

AECOM. (2010) *Roe Highway Extension: Kwinana Freeway to Stock Road: Draft Flora and Vegetation Assessment.*

Bishop, C. (2010) *personal communication.* DEC Science Division.

DEC. (2009). *Graceful Sun-moth information kit and survey methods.*

Appendix A
Quadrat Data

Roe Extension
Lomandra Density Survey

Site name	Date	Site code	Quadrat	Easting	Northing	Slope	Vegetation condition	Aspect	Position	Surface soil	Sub-surface soil	% bare ground	LOM HER	LOM MAR
Roe Extension	20-Apr-10	ROEEXT	1.1	392318	6449239	2°	Very Good - Good	SW	Mid Slope	Pale Grey Sand	Dark Grey Sand	30	0	0
Roe Extension	20-Apr-10	ROEEXT	1.2	392365	6449244	1°	Very Good	SW	Mid Slope	Pale Grey Sand	Pale Grey Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	1.3	392412	6449249	2°	Very Good	N	Mid Slope	Pale Grey Sand	Grey Sand	15	0	0
Roe Extension	20-Apr-10	ROEEXT	1.4	392463	6449257	2°	Very Good	SW	Mid Slope	Pale Grey Sand	Brown/Grey Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	1.5	392510	6449256	1°	Very Good	W	Mid Slope	Grey Sand	Grey Sand	20	0	0
Roe Extension	20-Apr-10	ROEEXT	1.6	392563	6449265	2°	Good	SE	Upper Slope	Pale Grey Sand	Grey Sand	15	0	0
Roe Extension	20-Apr-10	ROEEXT	1.7	392611	6449271	1°	Very Good	W	Ridgetop	Pale Grey Sand	Grey-Brown Sand	30	3	0
Roe Extension	20-Apr-10	ROEEXT	1.8	392661	6449274	1°	Good	SW	Mid Slope	Pale Grey Sand	Grey Sand	40	0	0
Roe Extension	20-Apr-10	ROEEXT	2.1	393231	6449531	0°	Very Good	-	Flat	Pale Grey Sand	Pale Grey Sand	8	0	0
Roe Extension	20-Apr-10	ROEEXT	2.2	393214	6449532	0°	Degraded	-	Flat	White Sand	Dark Grey Sand	90	0	0
Roe Extension	20-Apr-10	ROEEXT	2.3	393170	6449517	0°	Very Good	-	Flat	Pale Grey Sand	Dark Grey Loamy Sand	10	2	0
Roe Extension	20-Apr-10	ROEEXT	2.4	393120	6449501	0°	Very Good - Good	-	Flat	Pale Grey Sand	Dark Grey Loamy Sand	20	0	0
Roe Extension	20-Apr-10	ROEEXT	2.5	393073	6449481	0°	Good	-	Flat	Pale Grey Sand	Dark Grey-Brown Sandy Loam	30	0	0
Roe Extension	20-Apr-10	ROEEXT	2.6	392979	6449450	10°	Degraded - Completely Degraded	NW	Mid Slope	Grey Sand	Grey Sand	90	0	0
Roe Extension	20-Apr-10	ROEEXT	2.7	392933	6449436	10°	Good	N	Lower Slope	Grey Sand	Pale Grey Sand	45	0	0
Roe Extension	20-Apr-10	ROEEXT	2.8	392882	6449421	2°	Good	SE	Mid Slope	Grey Sand	Grey Sand	15	3	0
Roe Extension	20-Apr-10	ROEEXT	2.9	392839	6449400	2°	Very Good - Good	SE	Mid Slope	Pale Grey Sand	Grey Sand	18	4	0
Roe Extension	20-Apr-10	ROEEXT	3.1	386586	6448515	1°	Degraded - Completely Degraded	E	Mid Slope	Grey Sand	Grey-Brown Sand	20	0	0
Roe Extension	20-Apr-10	ROEEXT	3.10	386600	6448068	1°	Degraded	W	Mid Slope	Grey Sand	Grey Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	3.11	386602	6448015	0°	Degraded - Completely Degraded	-	Flat	Grey Sand	Brown-Grey Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	3.2	386593	6448465	1°	Degraded	NW	Mid Slope	Grey Sand	Brown-Grey Sand	80	0	0
Roe Extension	20-Apr-10	ROEEXT	3.3	386594	6448416	1°	Good	W	Mid Slope	Brown-Grey Sand	Brown-Grey Sand	18	0	0
Roe Extension	20-Apr-10	ROEEXT	3.4	386592	6448367	0°	Degraded - Completely Degraded	-	Flat	Grey-Brown Sand	Pale yellow Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	3.5	386595	6448317	0°	Degraded - Completely Degraded	NE	Mid Slope	Grey Brown Sand	Grey Brown Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	3.6	386595	6448266	1°	Degraded	N	Mid Slope	Grey Sand	Grey-Yellow Sand	20	0	0
Roe Extension	20-Apr-10	ROEEXT	3.7	386597	6448215	1°	Degraded	SW	Mid Slope	Grey Sand	Grey Sand	10	0	0
Roe Extension	20-Apr-10	ROEEXT	3.8	386599	6448169	2°	Good - Degraded	E	Mid Slope	Grey-Brown Sand	Grey-Brown Sand	15	2	0
Roe Extension	20-Apr-10	ROEEXT	3.9	386601	6448115	1°	Degraded - Completely Degraded	N	Mid Slope	Brown-Grey Sand	Brown-Grey Sand	20	0	0
Roe Extension	6-May-10	ROEEXT	4.1	389231	6449735	0°	Completely Degraded	-	Flat	Brown-Grey Sand	Brown -Grey Sand	65	0	0
Roe Extension	6-May-10	ROEEXT	4.10	389675	6449728	flat	Degraded - Completely Degraded	-	flat	pale grey-yellow sar	light brown sand with organic matter	98%	0	0
Roe Extension	6-May-10	ROEEXT	4.11	389727	6449724	1°	Good	NE	Lower Slope	pale grey sand	pale brown-grey sand	80	0	0
Roe Extension	6-May-10	ROEEXT	4.12	389781	6449734	1°	Completely Degraded	SE	Lower Slope	brown sand	dark brown damp sand	100	0	0
Roe Extension	6-May-10	ROEEXT	4.13	389849	6449723	1°	Good - Degraded	N	Lower Slope	grey sand	brown-grey sand	10	0	0
Roe Extension	6-May-10	ROEEXT	4.14	389878	6449727	0°	Very Good - Good	-	flat	grey brown peaty sa	grey brown peaty sand	70	0	0
Roe Extension	6-May-10	ROEEXT	4.15	389921	6449726	0°	Very Good - Good	-	flat	grey brown peaty sa	grey brown peaty sand	50	0	0
Roe Extension	6-May-10	ROEEXT	4.2	389279	6449729	0°	Degraded	-	Flat	Grey-Brown Sand	Grey-Brown Sand	30	0	0
Roe Extension	6-May-10	ROEEXT	4.3	389322	6449727	0°	Good	-	Flat	Grey Sand	Grey Sand	98	0	0
Roe Extension	6-May-10	ROEEXT	4.4	389380	6449727	0°	Good	-	Flat	Brown-Grey Loamy	Dark Brown Loamy Sand (damp)	100	0	0
Roe Extension	6-May-10	ROEEXT	4.5	389428	6449727	0°	Completely Degraded	-	Flat	Grey Sand	Brown-Grey Sandy Loam, organic matter	98	0	0

Site name	Date	Site code	Quadrat	Easting	Northing	Slope	Vegetation condition	Aspect	Position	Surface soil	Sub-surface soil	% bare ground	LOM HER	LOM MAR
Roe Extension	6-May-10	ROEEXT	4.6	389484	6449731	0°	Completely Degraded	-	Flat	Brown-Grey Sand	Brown-Grey Sand	60	0	0
Roe Extension	6-May-10	ROEEXT	4.7	389531	6449732	1°	Good	SE	Lower Slope	Grey Sand	Grey-Brown Sand, lots of Organic matter	50	0	0
Roe Extension	6-May-10	ROEEXT	4.8	389581	6449731	1°	Good - Degraded	W	Lower Slope	Pale Grey Sand	Pale Grey Sand	40	0	0
Roe Extension	6-May-10	ROEEXT	4.9	389630	6449727	1°	Good	SE	Lower Slope	brown-grey sand	brown-grey sand	20	0	0
Roe Extension	6-May-10	ROEEXT	5.1	390278	6449737	0°	Degraded - Completely Degraded	-	flat	grey sand	peaty grey sand	90	0	0
Roe Extension	6-May-10	ROEEXT	5.2	390224	6449739	0°	Good - Degraded	-	flat	brown-grey sand	brown-grey sand	30	0	0
Roe Extension	6-May-10	ROEEXT	6.1	389234	6449749	0°	Degraded - Completely Degraded	-	flat	grey sandy loam	grey sandy loam	10	0	0
Roe Extension	6-May-10	ROEEXT	6.2	389229	6449800	0°	Degraded - Completely Degraded	-	flat	brown sand	brown sand	10	0	0
Roe Extension	6-May-10	ROEEXT	6.3	389237	6449851	0°	Degraded - Completely Degraded	-	flat	grey sand	grey sand	60	0	0
Roe Extension	6-May-10	ROEEXT	6.4	389243	6449903	0°	Good - Degraded	-	flat	brown sand	brown sand	30	0	0
Roe Extension	6-May-10	ROEEXT	7.1	388862	6449472	2°	Degraded	SE	Lower Slope	grey sand	grey sand	5	0	0
Roe Extension	6-May-10	ROEEXT	7.2	388813	6449460	1°	Degraded - Completely Degraded	SW	Mid Slope	brown sand	brown sand	2	0	0
Roe Extension	6-May-10	ROEEXT	7.3	388760	6449498	1°	Degraded	NE	Mid Slope	grey sand	grey sand	2	0	0
Roe Extension	6-May-10	ROEEXT	7.4	388712	6449509	1°	Degraded	NE	Mid Slope	pale brown sand	pale brown sand	2	0	0
Roe Extension	6/05/2010	ROEEXT	7.5	388665	6449524	1°	Good	NW	Mid Slope	pale brown sand	pale brown sand	3	0	0
Roe Extension	6/05/2010	ROEEXT	7.6	388612	6449532	1°	Good	SE	Mid Slope	pale brown sand	pale brown sand	20	0	0
Roe Extension	6-May-10	ROEEXT	7.7	388564	6449543	1°	Good	N	Upper Slope	grey sand	grey sand	80	0	0
Roe Extension	6-May-10	ROEEXT	7.8	388515	6449561	1°	Degraded - Completely Degraded	N	Upper Slope	grey-brown sand	grey-brown sand	30	0	0
Roe Extension	6-May-10	ROEEXT	8.1	386686	6449289	2°	Good	SE	Mid Slope	grey sand	grey sand	30	0	0
Roe Extension	6-May-10	ROEEXT	8.2	386646	6449257	1°	Good - Degraded	NE	Mid Slope	brown-grey sandy lo	brown-grey sandy loam	30	0	0
Roe Extension	6-May-10	ROEEXT	8.3	386601	6449233	1°	Good	NE	Mid Slope	grey sand	grey sand	30	0	0
Roe Extension	6-May-10	ROEEXT	8.4	386563	6449201	1°	Degraded - Completely Degraded	SW	Mid Slope	pale brown sand	pale brown sand	30	0	0
Roe Extension	7-May-10	ROEEXT	9.1	387795	6449166	1°	Good	SE	Lower Slope	dark brown sandy lo	dark brown sandy loam	10	0	0
Roe Extension	7-May-10	ROEEXT	9.10	388182	6449412	1°	Degraded	W	Mid Slope	Pale Grey Sand	grey sand	60	0	0
Roe Extension	7-May-10	ROEEXT	9.11	388222	6449444	1°	Good	E	Mid Slope	grey sand	grey sand	20	1	0
Roe Extension	7-May-10	ROEEXT	9.12	388266	6449470	1°	Good - Degraded	NE	Mid Slope	yellow-grey sand	yellow-grey sand	10	4	0
Roe Extension	7-May-10	ROEEXT	9.13	388307	6449499	1°	Good - Degraded	SW	Mid Slope	grey sand	grey sand	2	0	0
Roe Extension	7-May-10	ROEEXT	9.2	387842	6449197	1°	Good	W	Mid Slope	grey sand	grey brown loamy sand	2	0	0
Roe Extension	7-May-10	ROEEXT	9.3	387887	6449222	1°	Good	W	Mid Slope	Grey-Brown Sand	Grey-brown sand	50	0	0
Roe Extension	7-May-10	ROEEXT	9.4	387929	6449250	1°	Good	S	Mid Slope	grey sand	grey-brown sandy loam	20	0	0
Roe Extension	7-May-10	ROEEXT	9.5	387972	6449279	1°	Good	NW	Mid Slope	brown sandy loam	brown sandy loam	20	0	0
Roe Extension	7-May-10	ROEEXT	9.6	388014	6449308	1°	Good - Degraded	NE	Mid Slope	grey sand	brown grey sandy loam	25	0	0
Roe Extension	7-May-10	ROEEXT	9.7	388055	6449331	1°	Good - Degraded	N	Mid Slope	pale grey-yellow sar	dark brown-grey sand	30	1	0
Roe Extension	7-May-10	ROEEXT	9.8	388102	6449358	1°	Good - Degraded	NW	Mid Slope	pale grey sand	brown-grey sand	30	0	0
Roe Extension	7-May-10	ROEEXT	9.9	388143	6449389	1°	Very Good - Good	S	Mid Slope	grey sand	grey sand	5	0	0
Roe Extension	7-May-10	ROEEXT	10.1	391089	6449416	1°	Very Good - Good	S	Mid Slope	yellow-grey sand	yellow-grey sand	10	0	0
Roe Extension	7-May-10	ROEEXT	10.10	390676	6449586	1°	Completely Degraded	SE	Mid Slope	grey sand	pale brown sand	5	0	0
Roe Extension	7-May-10	ROEEXT	10.11	390631	6449605	1°	Completely Degraded	SW	Mid Slope	grey sand	grey sand	3	0	0
Roe Extension	7-May-10	ROEEXT	10.12	390588	6449621	1°	Completely Degraded	SE	Upper Slope	grey sand	dark brown sand	30	0	0
Roe Extension	7-May-10	ROEEXT	10.2	391045	6449430	1°	Very Good - Good	SW	Mid Slope	brown-grey sand	brown-grey sand	2	2	0
Roe Extension	7-May-10	ROEEXT	10.3	391005	6449450	1°	Very Good - Good	NE	Mid Slope	grey sand	grey-brown sand	1	0	0
Roe Extension	7-May-10	ROEEXT	10.4	390940	6449455	0°	Very Good - Good	-	flat	grey sand	grey sand	20	7	0

Site name	Date	Site code	Quadrat	Easting	Northing	Slope	Vegetation condition	Aspect	Position	Surface soil	Sub-surface soil	% bare ground	LOM HER	LOM MAR
Roe Extension	7-May-10	ROEEXT	10.5	390906	6449494	1°	Degraded	NW	Mid Slope	Grey-Brown Sand	grey-brown sand	35	3	0
Roe Extension	7-May-10	ROEEXT	10.6	390851	6449511	1°	Degraded - Completely Degraded	NE	Mid Slope	brown-grey sand	brown-grey sand	20	0	0
Roe Extension	7-May-10	ROEEXT	10.7	390816	6449534	1°	Completely Degraded	NW	Mid Slope	grey sand	brown-grey sand	10	0	0
Roe Extension	7-May-10	ROEEXT	10.8	390769	6449542	1°	Degraded - Completely Degraded	N	Mid Slope	grey sand	grey sand	20	0	0
Roe Extension	7-May-10	ROEEXT	10.9	390720	6449567	1°	Completely Degraded	NE	Mid Slope	grey sand	grey sand	20	0	0
Roe Extension	18-Jun-10	ROEEXT	11.1	391892	6449194	1°	Good	NE	Upper Slope	Pale grey sand	grey-brown sand	70	2	0
Roe Extension	18-Jun-10	ROEEXT	11.10	391495	6448970	1°	Very Good - Good	NE	Lower Slope	white sand	pale brown sand	20	4	0
Roe Extension	18-Jun-10	ROEEXT	11.11	391474	6448945	0°	Very Good - Good	W	Lower Slope	brown-grey sand	brown sand	20	2	0
Roe Extension	18-Jun-10	ROEEXT	11.2	391845	6449160	1°	Good	NE	Upper Slope	Pale grey sand	grey-brown sand	50	0	0
Roe Extension	18-Jun-10	ROEEXT	11.3	391807	6449148	0°	Very Good - Good	N	Upper Slope	pale grey sand	grey sand	30	3	0
Roe Extension	18-Jun-10	ROEEXT	11.4	391757	6449130	1°	Very Good - Good	W	Upper Slope	grey-brown sand	grey sand	5	1	0
Roe Extension	18-Jun-10	ROEEXT	11.5	391719	6449092	0°	Very Good - Good	S-SW	Upper Slope	pale brown sand	pale brown sand	38	0	0
Roe Extension	18-Jun-10	ROEEXT	11.6	391664	6449064	0°	Degraded	-	Flat	pale yellow-brown s	pale yellow-brown sand	80	0	0
Roe Extension	18-Jun-10	ROEEXT	11.7	391616	6449050	1°	Good	E	Mid Slope	grey sand	grey sand	30	1	0
Roe Extension	18-Jun-10	ROEEXT	11.8	391565	6449028	1°	Very Good - Good	NE	Mid Slope	grey sand	grey sand	5	1	0
Roe Extension	18-Jun-10	ROEEXT	11.9	391544	6448993	1°	Very Good	S	Mid Slope	grey sand	grey sand	5	2	0
Roe Extension	18-Jun-10	ROEEXT	12.1	386453	6449226	0°	Good	-	Lower Slope	pale brown-yellow s	brown sand	65	0	0
Roe Extension	18-Jun-10	ROEEXT	12.2	386409	6449262	0°`	Good - Degraded	-	Lower Slope	pale brown-yellow s	brown sand	81	9	0
Roe Extension	18-Jun-10	ROEEXT	12.3	386382	6449284	1°	Good - Degraded	-	Mid Slope	pale brown-yellow s	brown sand	60	0	0
Roe Extension	18-Jun-10	ROEEXT	13.1	385884	6449281	0°	Good - Degraded	-	Flat	dark brown sand	dark brown sand	5	0	0
Roe Extension	18-Jun-10	ROEEXT	13.2	385821	6449311	1°	Good - Degraded	SE	Mid Slope	brown sand	brown sand	25	0	0
Roe Extension	18-Jun-10	ROEEXT	13.3	385793	6449337	1°	Degraded	SW	Mid Slope	brown sand	brown sand	35	0	0
Roe Extension	18-Jun-10	ROEEXT	13.4	385745	6449367	0°	Degraded	SE	Mid Slope	white-pale brown sa	pale brown sand	75	0	0
Roe Extension	18-Jun-10	ROEEXT	13.5	385667	6449422	1°	Degraded - Completely Degraded	NW	Mid Slope (D	brown sand	brown sand	2	0	0
Roe Extension	18-Jun-10	ROEEXT	13.6	385702	6449395	1°	Degraded - Completely Degraded	E-NE	Upper Slope	pale brown sand	brown sand	65	0	0
Roe Extension	18-Jun-10	ROEEXT	14.1	386452	6449110	1°	Degraded - Completely Degraded	NE	Mid Slope	pale brown sand	grey-brown sand	88	0	0
Roe Extension	18-Jun-10	ROEEXT	14.2	386446	6449111	1°	Degraded	S	Mid Slope	brown sand	brown sand	1	0	0
Roe Extension	18-Jun-10	ROEEXT	14.3	386380	6449052	1°	Good - Degraded	S	Mid Slope	pale brown-yellow s	brown sand	30	0	0
Roe Extension	18-Jun-10	ROEEXT	14.4	386360	6449037	0°	Degraded	N-NE	Mid Slope	brown sand	brown sand	60	0	0
Roe Extension	29-Apr-10	ROEEXT	15.1	391289	644967	1°	Very Good - Good	NW	mid slope	grey/brown sand	grey/brown sand		0	0
Roe Extension	29-Apr-10	ROEEXT	15.2	391286	6449637	1°	Very Good - Good	S	mid slope	grey sand	grey sand		5	0
Roe Extension	29-Apr-10	ROEEXT	15.3	391294	6449583	1°	Good	E	mid slope	brown grey sand	brown grey sand	20	0	0
Roe Extension	29-Apr-10	ROEEXT	15.4	391291	6449547	0°	Good - Degraded	-	flat	grey brown sand	grey brown sand	40	0	0
Roe Extension	29-Apr-10	ROEEXT	16.1	391181	6449515	0°	Degraded - Completely Degraded	-	flat	brown sandy loam	brown sandy loam	5	0	0
Roe Extension	29-Apr-10	ROEEXT	16.2	391201	6449549	0°	Degraded - Completely Degraded	-	flat	grey brown sand	grey brown sand	2	0	0
Roe Extension	29-Apr-10	ROEEXT	16.3	391217	6449595	1°	Completely Degraded	NW	lower slope	grey sand	grey brown sand	80	0	0
Roe Extension	29-Apr-10	ROEEXT	16.4	391237	6449642	1°	Very Good - Good	SE	mid slope	grey sand	grey sand	30	8	0
Roe Extension	29-Apr-10	ROEEXT	16.5	391264	6449686	1°	Very Good - Good	NW	mid slope	grey sand	brown/grey sand	30	0	0
Roe Extension	29-Apr-10	ROEEXT	16.6	391273	6449721	2°	Very Good - Good	E	upper slope	brown grey sand	brown grey sand		0	0
Roe Extension	29-Apr-10	ROEEXT	17.10	391492	6449717	1°	Good - Degraded	N	mid slope	grey sand	brown grey sand	3	0	0
Roe Extension	29-Apr-10	ROEEXT	17.1	391764	6449364	0°	Very Good - Good	-	flat	grey sand	grey/brown sand		2	0
Roe Extension	29-Apr-10	ROEEXT	17.2	391727	6449401	1°	Good	NE	lower slope	grey brown sand	brown grey sand	40	0	0
Roe Extension	29-Apr-10	ROEEXT	17.3	391701	6449438	1°	Good - Degraded	NE	lower slope	grey brown sand	grey brown sand	45	7	0
Roe Extension	29-Apr-10	ROEEXT	17.4	391612	6449481	2°	Very Good - Good	SE	upper slope	pale grey sand	pale grey sand	30	0	0

Site name	Date	Site code	Quadrat	Easting	Northing	Slope	Vegetation condition	Aspect	Position	Surface soil	Sub-surface soil	% bare ground	LOM HER	LOM MAR
Roe Extension	29-Apr-10	ROEEXT	17.5	391638	6449517	3°	Very Good - Good	NE	upper slope	brown grey sand	brown grey sand	20	1	0
Roe Extension	29-Apr-10	ROEEXT	17.6	391611	6449563	1°	Very Good - Good	SW	upper slope	grey sand	grey sand	20	0	0
Roe Extension	29-Apr-10	ROEEXT	17.7	391577	6449608	1°	Good	W	mid slope	pale grey sand	grey sand	30	0	0
Roe Extension	29-Apr-10	ROEEXT	17.8	391553	6449636	1°	Completely Degraded	N	mid slope	grey sand	grey sand	50	0	0
Roe Extension	29-Apr-10	ROEEXT	17.9	391517	6449676	1°	Completely Degraded	W	mid slope	grey sand	grey sand	2	0	0
Roe Extension	29-Apr-10	ROEEXT	18.1	391500	6449675	1°	Good	N	lower slope	grey sand	grey sand	1	0	0
Roe Extension	29-Apr-10	ROEEXT	18.2	391529	6449628	1°	Very Good - Good	NE	mid slope	grey sand	grey brown sand	30	0	0
Roe Extension	29-Apr-10	ROEEXT	18.3	391553	6449584	1°	Very Good - Good	NE	mid slope	grey sand	grey sand	5	1	0
Roe Extension	29-Apr-10	ROEEXT	18.4	391574	6449536	1°	Very Good - Good	NE	mid slope	grey sand	grey sand	20	0	0
Roe Extension	22-Jun-10	ROEEXT	19.1	387178	6448970	0°	Good - Degraded	N-NW	mid slope	grey sand	grey sand	40	0	0
Roe Extension	22-Jun-10	ROEEXT	19.10	386738	6449097	1°	Good	E	Lower Slope	brown sand	brown sand	30	1	0
Roe Extension	22-Jun-10	ROEEXT	19.11	386710	6449115	1°	Good	NE	Lower Slope	pale brown sand	brown sand	30	0	0
Roe Extension	22-Jun-10	ROEEXT	19.12	386644	6449120	1°	Completely Degraded	S	mid slope	grey sand	brown sand	40	0	0
Roe Extension	22-Jun-10	ROEEXT	19.2	387126	6448975	1°	Degraded - Completely Degraded	N-NW	mid slope	grey sand	pale brown sand	40	4	0
Roe Extension	22-Jun-10	ROEEXT	19.3	387085	6448996	1°	Good	N	mid slope	brown sand	brown sand	38	5	0
Roe Extension	22-Jun-10	ROEEXT	19.4	387038	6449013	1°	Very Good - Good	N	mid slope	brown sand	brown sand	2	7	0
Roe Extension	22-Jun-10	ROEEXT	19.5	386984	6449036	1°	Completely Degraded	N-NE	mid slope	limestone road base	brown sand	5	0	0
Roe Extension	22-Jun-10	ROEEXT	19.6	386934	6449041	1°	Good	E	mid slope	grey sand	dark brown sand	30	5	0
Roe Extension	22-Jun-10	ROEEXT	19.7	386886	6449055	<1°	Good	N	mid slope	grey sand	brown sand	75	15	0
Roe Extension	22-Jun-10	ROEEXT	19.8	386844	6449064	0°	Degraded	-	flat	grey sand	brown sand	90	6	0
Roe Extension	22-Jun-10	ROEEXT	19.9	386794	6449082	1°	Good	E-SE	Lower Slope	grey sand	grey-brown sand	88	4	0
Roe Extension	22-Jun-10	ROEEXT	20.1	391364	6448533	<1°	Very Good - Good	SW	mid slope	pale brown sand	brown sand	10	0	0
Roe Extension	22-Jun-10	ROEEXT	20.2	391361	6448577	1°	Good	SW	mid slope	grey brown sand	grey brown sand	70	0	0
Roe Extension	22-Jun-10	ROEEXT	20.3	391353	6448628	1°	Good	W	mid slope	brown-yellow sand	brown sand	25	0	0
Roe Extension	22-Jun-10	ROEEXT	20.4	391365	6448677	<1°	Good	W	mid slope	brown sand	brown sand	28	0	0
Roe Extension	22-Jun-10	ROEEXT	20.5	391353	6448724	1°	Good	E	mid slope	grey sand	brown sand	20	0	0
													128	

Life Form/Height Class	Canopy Cover	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1
	Very sparse 2-10%	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
	Absent 0%	1	1	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Sparse 10-30%	0	1	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0
	Very sparse 2-10%	1	0	0	0	0	0	1	0	1	1	0	0	0	1	0	1	1
	Absent 0%	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	1
	Sparse 10-30%	1	1	0	1	1	0	0	0	0	0	1	1	0	0	0	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0
	Absent 0%	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
	Very sparse 2-10%	0	1	1	0	0	1	0	0	1	1	0	0	1	0	0	0	1
	Absent 0%	1	0	0	0	1	0	1	1	0	0	1	1	0	1	1	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0
	Absent 0%	1	1	1	1	1	1	0	1	1	0	1	1	1	0	0	1	1
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
	Very sparse 2-10%	0	1	1	1	1	0	1	1	1	0	1	0	0	0	0	1	1
	Absent 0%	0	0	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0

Life Form/Height Class	Canopy Cover	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	4.1	4.2	4.3	4.4	4.5	4.6
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	0	0	1	1	1	1	0	1	1	1	1	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Absent 0%	1	1	0	1	1	1	0	0	0	0	0	1	1	1	1	1	1
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0
	Absent 0%	0	1	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0
Grasses	Dense 70-100%	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
	Sparse 10-30%	0	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0
	Absent 0%	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	1	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0
	Absent 0%	0	0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0
	Absent 0%	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Life Form/Height Class	Canopy Cover	4.7	4.8	4.9	4.10	4.11	4.12	4.13	4.14	4.15	5.1	5.2	6.1	6.2	6.3	6.4	7.1	7.2
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	1
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	0	1	1	1	1	1	1	0	1	0	0	1	1	0	0
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
	Sparse 10-30%	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
	Absent 0%	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	0	0	0	1	0	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
	Absent 0%	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0
	Absent 0%	0	0	0	0	0	1	1	0	0	1	1	1	1	1	1	1	1
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
	Absent 0%	1	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
	Mid-Dense 70-30%	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
	Sparse 10-30%	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	1	1	0	0	0	1	1	1	1	0	0	1	0	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1
	Absent 0%	1	0	0	1	1	0	1	1	1	0	1	1	0	0	0	1	0
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0
	Absent 0%	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1	0	1

Life Form/Height Class	Canopy Cover	7.3	7.4	7.5	7.6	7.7	7.8	8.1	8.2	8.3	8.4	9.1	9.2	9.3	9.4	9.5	9.6	9.7
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0
	Sparse 10-30%	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	0	0	0	0	0	1	1	1	1	1	0	0	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	1	0	1	1	1	0	1	1	0	0	1	1	1	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
	Very sparse 2-10%	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	0	1	1	0	1	1	1	1	1	0	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Sparse 10-30%	0	0	0	1	0	1	1	1	0	0	0	0	1	1	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0
Shrubs under 1m	Dense 70-100%	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	0	1	0	1	0	0	0	1	1	1	1	0
	Sparse 10-30%	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
	Absent 0%	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	1	0	1	0	1	0	0	0	1	1	1	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Absent 0%	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0	0	0
	Very sparse 2-10%	1	1	0	1	0	1	0	0	0	0	0	0	0	1	1	1	0
	Absent 0%	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Very sparse 2-10%	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	1
	Absent 0%	0	0	0	0	1	1	0	0	1	1	1	0	1	0	1	0	0

Life Form/Height Class	Canopy Cover	9.8	9.9	9.10	9.11	9.12	9.13	10.1	10.2	10.3	10.4	10.5	10.6	10.7	10.8	10.9	10.10	10.11
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	0	1	0	0	0	0	1	1	0	1	1	1	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
	Absent 0%	1	1	0	1	0	0	0	1	1	0	0	1	1	0	1	1	1
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0
	Absent 0%	1	0	0	0	0	1	0	0	0	1	0	0	1	1	0	1	1
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0
	Very sparse 2-10%	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1
	Absent 0%	0	1	1	1	0	0	0	1	1	0	0	1	1	1	1	1	0
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0
	Very sparse 2-10%	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Absent 0%	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1

Life Form/Height Class	Canopy Cover	10.12	11.1	11.2	11.3	11.4	11.5	11.6	11.7	11.8	11.9	11.10	11.11	12.1	12.2	12.3	13.1	13.2
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Sparse 10-30%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1
Trees under 10m	Dense 70-100%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	0	1	1	0	1	1	1	1	0	1	0	1	1	1	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	0	1	1	0	1	1	1	0	0	0	1	0	0
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0
	Very sparse 2-10%	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Mid-Dense 70-30%	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0
	Very sparse 2-10%	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	0	0	1	1	1	0	1	1	1	0	1	0	1	0	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Very sparse 2-10%	0	1	0	0	1	0	1	0	0	1	0	0	0	1	1	0	1
	Absent 0%	1	0	1	1	0	1	0	1	1	0	1	1	0	0	0	0	0
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	1	1	0	1	0	1	0	0	0	0	1	0	1
	Very sparse 2-10%	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
	Absent 0%	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0

Life Form/Height Class	Canopy Cover	13.3	13.4	13.5	13.6	14.1	14.2	14.3	14.4	14.5	15.1	15.2	15.3	15.4	16.1	16.2	16.3	16.4
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
	Sparse 10-30%	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	1
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	0	0	1	0	1	1	1	0	0	0	1	1	0
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Very sparse 2-10%	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	0	1	1	0	0	0	1	1	1	1	0
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0
	Mid-Dense 70-30%	1	1	0	1	0	0	1	1	0	0	0	1	1	0	0	0	0
	Sparse 10-30%	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	1	1	1	0	0	0	0	1	1	0	0	0	1	0	0	0
	Very sparse 2-10%	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	1	1
	Absent 0%	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
	Absent 0%	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0	0

Life Form/Height Class	Canopy Cover	16.5	16.6	16.7	17.1	17.2	17.3	17.4	17.5	17.6	17.7	17.8	17.9	18.1	18.2	18.3	18.4	19.1
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
	Very sparse 2-10%	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0
	Absent 0%	1	1	0	1	0	0	1	0	0	0	1	1	0	1	0	1	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Very sparse 2-10%	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Absent 0%	0	1	0	0	1	0	1	0	1	0	1	0	1	1	1	1	1
Shrubs under 1m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Mid-Dense 70-30%	1	1	0	1	0	0	1	1	1	1	0	0	1	1	0	1	0
	Sparse 10-30%	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
	Very sparse 2-10%	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Grasses	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Sparse 10-30%	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0
	Very sparse 2-10%	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	1	0
	Absent 0%	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	1	1	1	1	0	1	1	1	1	0	0	1	0	0	0	0
	Absent 0%	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	1	1
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
	Very sparse 2-10%	0	0	0	0	0	1	1	1	0	1	0	0	1	0	1	0	0
	Absent 0%	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	1

Life Form/Height Class	Canopy Cover	19.2	19.3	19.4	19.5	19.6	19.7	19.8	19.9	19.10	19.11	19.12	20.1	20.2	20.3	20.4	20.5
Trees over 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Trees 10 - 30m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Trees under 10m	Dense 70-100%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
	Sparse 10-30%	0	1	1	0	0	0	0	0	1	0	0	0	1	0	1	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	0	1	1	1	1	0	0	0	1	0	0	1	0	1
Shrubs over 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs 1 - 2m	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	1	0	1	1	0	1	1	0	0	1	1	1	1	1	1
Shrubs under 1m	Dense 70-100%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0
	Sparse 10-30%	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1
	Very sparse 2-10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Absent 0%	1	0	0	1	0	1	1	1	1	0	1	0	0	0	0	0
Mat plants	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Sparse 10-30%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Very sparse 2-10%	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Absent 0%	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1
Grasses	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Sparse 10-30%	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	Very sparse 2-10%	0	0	0	0	0	0	0	1	1	1	1	0	1	0	1	0
	Absent 0%	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	0
Herbs	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Sparse 10-30%	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
	Very sparse 2-10%	0	1	0	0	0	1	1	1	1	1	1	0	1	0	0	0
	Absent 0%	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0
Sedges	Dense 70-100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mid-Dense 70-30%	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Sparse 10-30%	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1
	Very sparse 2-10%	1	0	0	0	1	1	1	1	0	0	0	0	0	1	0	0
	Absent 0%	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0

Appendix C Vegetation Communities

Vegetation Community Code	Vegetation Community Description
CcXpMrS	Woodland to Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over an Open to Low Shrubland of *Xanthorrhoea preissii*, *Macrozamia riedlei* and *Hibbertia hypericoides* over an Open Herbland of **Oxalis pes-caprae* and *Sowerbaea laxiflora* over an Open Grassland of **Briza maxima* and **Ehrharta calycina* on brown sandy loam.
CcXpDdS	Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over a Low Open Shrubland of *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Daviesia divaricata* and *Hibbertia hypericoides* over an Open Grassland of **Ehrharta calycina* on grey sand over yellow sand.
BXpW	Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus marginata* over an Open Heath of *Hibbertia hypericoides* and *Xanthorrhoea preissii* over an Open Sedgeland of *Mesomelaena pseudostygia* on grey sand.
BHhW	Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus marginata* and *Nuytsia floribunda* over a Shrubland of *Allocasuarina humilis* and *Hibbertia hypericoides* with occasional *Allocasuarina fraseriana* and *Jacksonia furcellata* over a Grassland of **Ehrharta calycina* and *Mesomelaena pseudostygia* on pale brown sand.
MpBaS	Open Forest of *Corymbia calophylla*, *Eucalyptus rudis* and *Banksia littoralis* over a Tall Shrubland of *Melaleuca preissiana* and *Kunzea glabrescens* with occasional *Melaleuca rhaphiophylla* over a Closed Sedgeland of *Baumea articulata* fringing wetlands on brown sandy loam.
BaTs	Low Open Woodland of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus marginata* over an Open -Heath of *Allocasuarina humilis*, *Conostephium minus* and *Eremaea pauciflora* over an Open Grassland/Sedgeland of *Amphipogon turbinatus* and *Mesomelaena pseudostygia* on grey sand.
EgXpS	Open Woodland of *Eucalyptus gomphocephala* and *Eucalyptus marginata* over a Low Open Woodland of *Banksia attenuata* over a Tall Open Shrubland of *Xanthorrhoea preissii* over an Open Sedgeland of *Mesomelaena pseudostygia* on yellow sand.
EmXpS	Low Open Woodland of *Eucalyptus marginata*, *Banksia attenuata* and *Banksia menziesii* over a Low Open Shrubland of *Xanthorrhoea preissii* with occasional *Banksia sessilis* in degraded areas, on brown-yellow sand.
EmApS	Open Woodland to Low Open Woodland of *Eucalyptus marginata* and *Banksia attenuata* over Low Shrubland of *Acacia pulchella*, *Hibbertia hypericoides*, *Macrozamia riedlei* and *Xanthorrhoea preissii* over **Briza maxima* on yellow sand.

APPENDIX 4 RESULTS FOR THE SRE AND TIA SURVEY ROUNDS

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Mygalomorphae (Trapdoor Spiders)																								
Actinopodidae	*Missulena*	*granulosa*[SW WA]				3																	3	1
Barychelidae	*Synothele*	*michaelseni*			1	1																	2	2
Idiopidae	*Aganippe*	sp. (juv.)								5													5	1
	Idiosoma	*sigillatum*			1																		1	1
Nemesiidae	*Aname*	*mainae*[SW WA]		1																			1	1
	Aname	*tepperi*[SW WA into SA]		1			1																2	2
	Aname	sp. (juv)								1		2											3	2
Araneomorphae (Modern Spiders)																								
Araneidae	*Arkys*	*walckenaeri*[AUS]											1			1							2	2
	Austracantha	*minax*[AUS]		1	1	2	2																6	4
	Argiope	*protensa*[AUS]			1																		1	1
	Backobourkia	*heroine*[AUS]						1															1	1
Corinnidae	*Supunna*	*albomaculata*[AUS]			1	1																	2	2
	Supunna	*picta*[AUS]			1																		1	1
Deinopidae	*Deinopis*	*subrufa*[AUS]		1	1	1																	3	2
Gnaphosidae	*Encoptarthria*	sp.[WA]	2		1	2	3																8	4
	indet.	sp. (juv.)	2				1																3	2
Lycosidae	*Artoria*	*flavimanus*[AUS]	1						1														2	2
	Hogna	*Immansueta*[SW WA]	1							1	2	1	11										5	4
	Venatrix	*pullastra*[SW WA]	2						14			1											17	3
	Ariadnae-group	sp. nov..[SCP SRE]	4		2			2															8	3
	indet.	sp. (juv.)		2			5			2		1											10	4

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Miturgidae	*Mituliodon*	*tarantulinus*[AUS]					3																3	1
	indet.	sp. nov.	2		5	3																	10	3
	Indet.	sp. (juv.)		1			2																3	2
Oxyopidae	*Oxyopes*	sp.					1																1	1
Pholcidae	*Smeringopus*	*natalensis*[INTRO]		3		1																	4	2
Salticidae	*Opisthoncus*	sp.			1	1																	1	1
Sparassidae	*Neosparassus*	sp.					1																1	1
Stiphidiidae	*Corasoides*	sp.[AUS]	1																				1	1
Tetragnathidae	*Leucauge*	sp.[AUS]											1										1	1
Thomisidae	*Diaea*	sp.[AUS]			1																		2	2
Trochanteriidae	*Tinytrema*	*yarra*[PMAN SRE]										1											1	1
Zodariidae	*Habronestes*	sp. 1					1	1		2	4	6											14	5
	Habronestes	sp. 2	1	4		1			16			1											23	5
	Habronestes	sp. 3						1															1	1
	Habronestes	sp. 4				1		1			1												3	3
	Asteron-complex	sp. 1					3																3	1
	Storosa	sp. 1				1																	1	1
	indet.	sp. (juv.)	5	3	5	3	11	3		1							1						32	8
Zoridae	*Argoctenus*	sp.	1																				1	1
	indet.	sp.	1	3	1	5	1	1	1														13	7
Opiliones (Harvestmen)																								
Triaenonychidae	*Nunciella*	sp.[SW WA]					1																1	1
Pseudoscorpiones (Pseudoscorpions)																								
Chthoniidae	*Austrochthonius*	sp.1	2	1													3	1	1				8	5

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Scorpiones (Scorpions)																								
Bothriuridae	*Cercophonius*	*sulcatus* SW WA		3	3				1		43	11				3							64	6
Buthidae	*Lychas*	'austrocc.' SW WA	3	3	3	9					1	1		1		1							22	8
Urodacidae	*Urodacus*	*novaeholl.* SW WA	8			1																	9	2
Diplopoda (Millipedes)																								
Iulomorphidae	*Podykipus*	*collinus* PMAN SRE	4	4	2	8	4			4													26	6
Julidae	*Ommatoiulus*	*moreleti* INTRO	10	61	33	6		44	10	18	45	45											272	9
Paradoxosomatidae	*Antichiropus*	*variabilis* SW WA	8	7	21	4	5	13		10	9	6											83	9
	Antichiropus	`UBS2` PMAN SRE		1	3		1										1						6	4
	Antichiropus	`UBS3` PMAN SRE	3	1	2	4		2		17													29	6
	Akamptogonus	*novarae* INTRO					2		1		3	3											9	4
Siphonotidae	indet.	*sp.* PMAN SRE			1																		1	1
Chilopoda (Centipedes)																								
Chilenophilidae	indet.										1	1											2	2
Scolopendridae	*Cormocephalus*	*aurantiipes* AUS		1																			1	1
	Cormocephalus	*novaeholl.* SCP SRE			1		2																3	2
	Cormocephalus	*rubriceps* AUS									2												2	1
	Cormocephalus	*turneri* AUS				1																	1	1
	Ethmostigmus	*rubripes* AUS			2				6														8	2
	Notiasemus	*glauerti* SCP SRE	1	2		2						1											6	4
	Scolopendra	*laeta* AUS	6	2	1	9	3	7		2													30	7
	Scolopendra	*morsitans* AUS			2						1	1											4	3
	Scolopendra	sp. (juv.)	1					3		2		2											8	4
	Ostigmatinae	sp. (juv.)	3	3							10												16	3
Scutigeridae	*Allothereua*	*maculata* AUS			1		6		3			5											15	4

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Isopoda (Slaters)																								
Armadillidae	*Armadillum*	*vulgare*[INTRO]										5											5	1
	Buddelundia	*?nigripes*[SW WA]			2	3		5															10	3
	Buddelundia	sp. (SJ #7)[SCP SRE]	4					3						1									8	3
	?Spherillo	sp. (SJ #2)[SCP SRE]	2							1				1									4	3
Philosciidae	*Laevophiloscia*	sp.[SW WA]	1		1		1					5			2								10	5
Porcelliidae	*Porcellio*	*scaber*[INTRO]							4														4	1
Gastropoda (Land Snails)																								
Bulimidae	*Bothriembryon*	*bulla*[SCP SRE]		2				2															4	2
	Bothriembryon	*kendricki*[SCP SRE]		2																			2	1
	Bothriembryon	sp. (juv.)[SCP SRE]								1													1	1
Helicidae	*Theba*	*pisana*[INTRO]	3																	2	1	1	7	4
Hygromiidae	*Cochlicella*	*acuta*[INTRO]																		6				
Insecta – Hymenoptera (Bees, Wasps, Ants)																								
Apidae	*Apis*	*mellifera*[INTRO]							1									1					2	2
	Exoneura	sp.[L,T]																					2	2
Colletidae	*Hylaeus (Rhodohylaeus)*	*rufipes*[L]																					2	1
	Leioproctus (Protomorpha)	*plautus?*[SW WA, GSM]																					1	1
	Leioproctus	sp.[B]																					2	1
Eumenidae (wasp)	*Abispa*	*ephippium*														1							1	1
Formicidae (ants)	indet.		6	8				1															15	3
Halactidae	*Lipotriches (Austronomia)*	sp. (M104)[L]																					1	1
	L. (Austronomia)	sp. 1[L]																					3	1

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Ichneumonidae (wasp)	Indet.																2						2	1
Megachilidae	*Megachile (Austrochile?)*	sp. 1																	2				2	1
	Megachile (Eutricharaea)	*chrysopyga*																1					1	1
	M. (Eutricharaea)	*obtusa* [L]																					2	1
	Megachile (*Hackeriapis*)	*fultoni* [L]								1									1				7	3
	M. (*Hackeriapis*)	*ignita*? [L]																					2	1
	M. (*Hackeriapis*)	*leeuwinensis*?																	1				1	1
	M. (*Hackeriapis*)	sp. 1																	1				1	1
	M. (*Hackeriapis*)	sp. 2 (F366)				1													2				3	2
	M. (*Hackeriapis*)	sp. 3																	1				1	1
	M. (*Hackeriapis*)	*speluncarum* [L]				1				2								1					7	4
Hymenoptera	indet.				1		1	1					2										5	4
Insecta - Lepidoptera (Butterflies and Moths)																								
Arctiidae	*Utetheisa*	*pulchelloides*																1					1	1
Geometridae?		sp.														1							1	1
Herminiidae?		sp.											3										3	1
Lycaenidae	*Lampides*	*boeticus*													1		1						2	2
	Zizina	*labradus*											1		1				3				5	3
Noctuidae	*Achaea*	*janata*?													1								1	1
	Helicoverpa	*punctigera?*												2									2	1
Nymphalidae	*Geitoneura*	*klugii*											1	2		5	2	4	2				16	6
	Geitoneura	*minyas*													1		1						2	2
	Heteronympha	*merope*												1		1	2						4	3

Family	Genus	Species	SRE1	SRE2	SRE3	SRE4	SRE5	SRE6	SRE7	SRE8	SRE9	SRE10	TIA1	TIA2	TIA3	TIA4	TIA5	TIA6	TIA7	Site A	Site F	Site I	TOTAL No.	No. SITES
Insecta – Lepidoptera (continued)																								
Pieridae	*Pieris*	*rapae*											1	1	1	1	2						6	5
Psychidae	*Lepidoscia*	sp.														1							1	1
Insecta – Orthoptera (Grasshoppers and Crickets)																								
Acrididae	*Cedarinia*									1													1	1
	Heteropternis	*obscurella*				1	1																2	2
Acrididae			1			5	2	3											2				13	5
Gryllidae	near *Bobilla*																1						1	1
Gryllidae			6	1	5	1		1															14	5
Tettigoniidae														1		2	2	3	2				11	6 [L]
Insecta - others																								
Blattodea (Cockroaches)			3	5	1	2	5	1	4			1		1									23	9
Coleoptera (Beetles)			8	14	13	6	10	11	7	2	10	17			1	1							100	12
Demaptera (Earwigs)			5	2	3	6	5		10	1	1	5											38	9
Diptera (Flies)													2	1	3	2	4	5	4				21	7
Hemiptera (Bugs)					3	3	13	1				1											21	5
Mantodea (Praying Mantids)			4		1		2			1				2									10	5
Odonata (Dragonflies, Damselflies)								1					4	5	1	2	4	5	1				23	8
Phasmatodea (Stick Insects)						2		1															3	2
Thysanura (Silverfish)			1			1	3				1	3											9	5
Insecta (others, incl. larvae)					1							1	1										9	5

INTRO Introduced to WA (from eastern states or overseas)

AUS Australia-wide

SW WA Southwestern Western Australia

SCP SRE	Short-range endemic to the Swan Coastal Plain
PMA SRE	Short-range endemic to Perth Metropolitan Area
c	Denotes opportunistic collections, targeted survey to be undertaken August 2010
L	Also found at Lobelia Woodland Site
T	Also found at new TIA Site
B	Also found at new TIA Bee Site
GSM	Also found at GSM site 8/9 IFAP