Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
	WB38624)				
Fabaceae	*Acacia tetragonophylla*			1	1
Fabaceae	*Acacia thoma*			1	1
Fabaceae	*Gastrolobium laytonii*			1	1
Fabaceae	*Leptosema chambersii*			1	
Fabaceae	*Mirbelia rhagodioides*			1	1
Fabaceae	*Muelleranthus trifoliolatus*			1	
Fabaceae	*Senna artemisioides*		No subspecies specified	1	
Fabaceae	*Senna artemisioides* subsp. *filifolia*			1	1
Fabaceae	*Senna artemisioides* subsp. *helmsii*			1	1
Fabaceae	*Senna artemisioides* subsp. *helmsii*			1	1
Fabaceae	*Senna artemisioides* subsp. *petiolaris*				1
Fabaceae	*Senna artemisioides* subsp. *x artemisioides*		Previously reported as S. artemisioides subsp. sturtii	1	1
Fabaceae	*Senna charlesiana*			1	1
Fabaceae	*Senna glaucifolia*				1
Fabaceae	*Senna glutinosa*		No subspecies specified	1	
Fabaceae	*Senna glutinosa* subsp. *chatelainiana*				1
Fabaceae	*Senna manicula*			1	1
Fabaceae	*Senna* sp. Austin (A. Strid 20210)		Undescribed, Common and Widespread		1
Fabaceae	*Senna* sp. Meekatharra (E. Bailey 1-26)		Undescribed, Common and Widespread. Previously reported as *S. artemisioides* subsp. *sturtii*		1
Fabaceae	*Swainsona formosa*			1	
Frankeniaceae	*Frankenia laxiflora*		Some records previously reported as *F. georgei*	1	1
Frankeniaceae	*Frankenia pauciflora*			1	
Frankeniaceae	*Frankenia setosa*			1	1
Geraniaceae	*Erodium cygnorum*			1	
Goodeniaceae	*Brunonia australis*			1	
Goodeniaceae	*Goodenia havilandii*			1	
Goodeniaceae	*Goodenia macroplectra*			1	
Goodeniaceae	*Goodenia occidentalis*			1	1

Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
Goodeniaceae	*Scaevola spinescens* (broad leaf non-spiny form)		Undescribed, Common and Widespread	1	1
Goodeniaceae	*Scaevola spinescens* (narrow leaf spiny form)		Undescribed, Common and Widespread	1	1
Goodeniaceae	*Scaevola spinescens* terete leaf spiny form)		Undescribed, Common and Widespread	1	
Goodeniaceae	*Scaevola spinescens* (undefined form)			1	1
Goodeniaceae	*Velleia rosea*			1	1
Haloragaceae	*Haloragis odontocarpa*		Three possible forms	1	
Haloragaceae	*Haloragis trigonocarpa*			1	
Hemerocallidaceae	*Dianella revoluta* var. *divaricata*		Previously reported as *Dianella revoluta*	1	1
Juncaceae	*Juncus aridicola*		Some previously reports as *J. subsecundus*	1	1
Lamiaceae	*Hemigenia exilis*	PRIORITY 4		1	1
Lamiaceae	*Lachnostacys verbascifolia*			1	
Lamiaceae	*Prostanthera althoferi* subsp. *althoferi*				1
Lamiaceae	*Prostanthera campbellii*		Part of a complex requiring taxonomic revision	1	
Lamiaceae	*Prostanthera wilkieana*			1	
Lamiaceae	*Spartothamnella teucriiflora*			1	1
Loranthaceae	*Amyema fitzgeraldii*		*Amyema fitzgeraldii*		1
Loranthaceae	*Amyema gibberula* var. *gibberula*		Parasitic on *Grevillea berryana*		1
Loranthaceae	*Amyema hilliana*		Parasitic on *Acacia pruinocarpa*	1	
Loranthaceae	*Amyema miquelii*		Parasitic on *Eucalyptus*	1	
Loranthaceae	*Lysiana murrayi*		*Amyema fitzgeraldii*		1
Malvaceae	*Abutilon cryptopetalum*			1	1
Malvaceae	*Abutilon otocarpum*			1	
Malvaceae	*Abutilon oxycarpum* subsp. Prostrate (A.A. Mitchell PRP1266)		Undescribed, Common and Widespread	1	1
Malvaceae	*Androcalva luteiflora*		Previously reported as *Rulingia luteiflora*	1	
Malvaceae	*Brachychiton gregorii*			1	

Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
Malvaceae	*Hibiscus burtonii*			1	1
Malvaceae	*Hibiscus krichauffianus*	PRIORITY 3			1
Malvaceae	*Hibiscus solanifolius*			1	1
Malvaceae	*Hibiscus* sp. Indeterminate				1
Malvaceae	*Hibiscus sturtii* var. grandiflorus			1	1
Malvaceae	*Keraudrenia velutina*		Either subsp. *elliptica* or subsp. *velutina*	1	
Malvaceae	*Sida calyxhymenia*				1
Malvaceae	*Sida cardiophylla*			1	
Malvaceae	*Sida ectogama*		Some previous records as *S. calyxhymenia*	1	1
Malvaceae	*Sida fibulifera*				1
Malvaceae	*Sida picklesiana*	PRIORITY 3		1	1
Malvaceae	*Sida* sp. dark green fruits (S. van Leeuwen 2260)		Undescribed, Common and Widespread	1	1
Malvaceae	*Sida* sp. Excedentifolia (J.L. Egan 1925)		Undescribed, Common and Widespread	1	
Malvaceae	*Sida* sp. Golden calyces glabrous (H.N. Foote 32)		Undescribed, Common and Widespread		1
Malvaceae	*Sida* sp. spiciform panicles (E. Leyland s.n. 14/8/90)		Undescribed, Common and Widespread		1
Malvaceae	*Sida* sp. tiny glabrous fruit (A.A. Mitchell PRP1152)		Undescribed, Common and Widespread	1	
Malvaceae	*Sida* sp. verrucose glands (F.H. Mollemans 2423)		Undescribed, Common and Widespread	1	1
Marsileaceae	*Marsilea drummondii*			1	
Myrtaceae	*Calytrix desolata*			1	1
Myrtaceae	*Calytrix erosipetala*				1
Myrtaceae	*Calytrix uncinata*			1	1
Myrtaceae	*Eucalyptus camaldulensis* subsp. *obtusa*			1	1
Myrtaceae	*Eucalyptus carnei*			1	1
Myrtaceae	*Eucalyptus gypsophila*			1	1
Myrtaceae	*Eucalyptus kingsmillii*		Likely subsp. *kingsmillii*	1	1
Myrtaceae	*Eucalyptus kochii*		Either subsp. *amaryssia* or subsp. *plenissima*	1	
Myrtaceae	*Eucalyptus leptopoda* subsp. *elevata*				1
Myrtaceae	*Eucalyptus lucasii*			1	
Myrtaceae	*Eucalyptus oldfieldii*			1	

Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
Myrtaceae	*Eucalyptus trivalva*			1	
Myrtaceae	*Melaleuca leiocarpa*			1	1
Myrtaceae	*Micromyrtus flaviflora*			1	
Myrtaceae	*Micromyrtus sulphurea*			1	1
Myrtaceae	*Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362)	PRIORITY 3		1	1
Myrtaceae	*Verticordia jamiesonii*	PRIORITY 3		1	1
Oleaceae	*Jasminum calcareum*			1	1
Ophioglossaceae	*Ophioglossum lusitanicum*			1	
Pittosporaceae	*Pittosporum angustifolium*			1	1
Plantaginaceae	*Plantago drummondii*				1
Plantaginaceae	*Stemodia florulenta*				1
Poaceae	*Aristida contorta*			1	1
Poaceae	*Aristida ?jerichoensis* var. *subspinulifera*	PRIORITY 3	Range Extension		1
Poaceae	*Austrostipa elegantissima*				1
Poaceae	*Austrostipa nitida*				1
Poaceae	*Cenchrus ciliaris* *		Weed		1
Poaceae	*Cenchrus setiger* *		Weed		1
Poaceae	*Chloris truncata*			1	
Poaceae	*Cymbopogon ambiguus*			1	1
Poaceae	*Dactyloctenium radulans*			1	
Poaceae	*Digitaria brownii*			1	1
Poaceae	*Enneapogon caerulescens*			1	1
Poaceae	*Enneapogon cylindricus*			1	1
Poaceae	*Enneapogon polyphyllus*			1	
Poaceae	*Enneapogon* sp. (Indeterminate)				1
Poaceae	*Enteropogon ?ramosus*				1
Poaceae	*Enteropogon ramosus*				1
Poaceae	*Eragrostis dielsii*			1	1
Poaceae	*Eragrostis eriopoda*			1	1
Poaceae	*Eragrostis falcata*				1
Poaceae	*Eragrostis kennedyae*			1	1
Poaceae	*Eragrostis leptocarpa*			1	
Poaceae	*Eragrostis pergracilis*			1	
Poaceae	*Eragrostis setifolia*			1	1
Poaceae	*Eragrostis* sp. (Indeterminate)				1
Poaceae	*Eriachne flaccida*			1	
Poaceae	*Eriachne helmsii*				1
Poaceae	*Eriachne mucronata* (typical form)			1	1
Poaceae	*Eriachne mucronata* (Arid Form)		Some records previously reported as *Eragrostis desertorum*	1	1

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Family	**Species Name**	**Cons Status**	**Notes**	**Prior Record**	**2016 Collection**
Poaceae	*Eriachne pulchella* subsp. *dominii*			1	1
Poaceae	*Eriachne pulchella* subsp. *pulchella*			1	1
Poaceae	*Eulalia aurea*			1	
Poaceae	*Iseilema ?eremaeum*			1	1
Poaceae	*Monachather paradoxus*			1	1
Poaceae	*Neurachne minor*			1	1
Poaceae	*Neurachne munroi*			1	1
Poaceae	*Panicum decompositum*			1	1
Poaceae	*Paspalidium aff. distans*	PRIORITY 3			1
Poaceae	*Paspalidium constrictum*				1
Poaceae	*Paspalidium gracile*				1
Poaceae	*Perotis rara*			1	
Poaceae	Poaceae sp. (Indeterminate)				1
Poaceae	*Setaria dielsii*				1
Poaceae	*Themeda avenacea*			1	
Poaceae	*Themeda triandra*				1
Poaceae	*Thyridolepis multiculmis*				1
Poaceae	*Triodia basedowii*			1	1
Poaceae	*Tripogon loliiformis*				1
Polygalaceae	*Polygala isingii*			1	
Polygoniaceae	*Rumex vesicarius* *		Weed		1
Portulacaceae	*Anacampseros* sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248)	PRIORITY 1		1	
Portulacaceae	*Calandrinia ptychosperma*			1	
Portulacaceae	*Calandrinia* sp.				1
Portulacaceae	*Portulaca oleracea*			1	
Primulaceae	*Lysimachia arvensis* *		Weed		1
Proteaceae	*Grevillea berryana*		Formerly reported as *G. nematophylla* at MKS	1	1
Proteaceae	*Grevillea deflexa*				1
Proteaceae	*Grevillea inconspicua*	PRIORITY 4			1
Proteaceae	*Grevillea juncifolia*		Either subsp. *juncifolia* or subsp. *temulenta*	1	
Proteaceae	*Hakea arida* subsp. *arida*				1
Proteaceae	*Hakea leucoptera* subsp. *sericipes*			1	1
Proteaceae	*Hakea lorea* subsp. *lorea*			1	1
Proteaceae	*Hakea minyma*			1	1
Proteaceae	*Hakea preissii*			1	1
Proteaceae	*Hakea recurva* subsp. *recurva*		Some previous records as *Hakea arida* subsp. *arida*	1	1

Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
Pteridaceae	*Cheilanthes brownii*				1
Pteridaceae	*Cheilanthes sieberi* subsp. *sieberi*			1	1
Rubiaceae	*Psydrax latifolia*			1	1
Rubiaceae	*Psydrax rigidula*		Some previous records as *P. attenuata*	1	1
Rubiaceae	*Psydrax suaveolens*			1	1
Rutaceae	*Philotheca tomentella*			1	
Santalaceae	*Exocarpos aphyllus*			1	1
Santalaceae	*Exocarpos sparteus*			1	1
Santalaceae	*Santalum lanceolatum*			1	1
Santalaceae	*Santalum spicatum*			1	1
Sapindaceae	*Dodonaea petiolaris*			1	1
Sapindaceae	*Dodonaea rigida*			1	1
Sapindaceae	*Dodonaea viscosa* subsp. *angustissima*			1	
Sapindaceae	*Dodonaea viscosa* subsp. *spatulata*		Formerly reported as *D. viscosa*	1	1
Scrophulariaceae	*Eremophila clarkei*			1	
Scrophulariaceae	*Eremophila conglomerata*				1
Scrophulariaceae	*Eremophila decipiens* subsp. *decipiens*			1	1
Scrophulariaceae	*Eremophila exilifolia*			1	1
Scrophulariaceae	*Eremophila flabellata*				1
Scrophulariaceae	*Eremophila foliosissima*				1
Scrophulariaceae	*Eremophila forrestii* subsp. *forrestii*		Some previous records as *E. forrestii*	1	1
Scrophulariaceae	*Eremophila galeata*			1	1
Scrophulariaceae	*Eremophila galeata* x *platycalyx* subsp. Neds Creek		Previously reported as *E. galeata* x *platycalyx* subsp. "acuticalyx" Hybrid (G. Cockerton & K. Stratford 32741)	1	
Scrophulariaceae	*Eremophila gilesii* subsp. *variabilis*			1	1
Scrophulariaceae	*Eremophila glabra*		Likely subsp. *glabra*	1	
Scrophulariaceae	*Eremophila glutinosa*			1	1
Scrophulariaceae	*Eremophila granitica*			1	1
Scrophulariaceae	*Eremophila homoplastica*			1	1
Scrophulariaceae	*Eremophila jucunda* subsp. *jucunda*			1	1
Scrophulariaceae	*Eremophila latrobei*		Unspecified form	1	1

Family	**Species Name**	**Cons Status**	**Notes**	**Prior Record**	**2016 Collection**
Scrophulariaceae	*Eremophila latrobei* subsp. *filiformis*		Some previous reports as *E. latrobei* subsp. *filifolia*	1	1
Scrophulariaceae	*Eremophila latrobei* subsp. *glabra*			1	1
Scrophulariaceae	*Eremophila latrobei* var. *tuberculosa*				1
Scrophulariaceae	*Eremophila longifolia* (green foliage form)		Previous records as *E longifolia*	1	1
Scrophulariaceae	*Eremophila mackinlayi*		Likely subsp. *spathulata*	1	
Scrophulariaceae	*Eremophila maculata* subsp. *brevifolia*			1	1
Scrophulariaceae	*Eremophila malacoides*			1	1
Scrophulariaceae	*Eremophila margarethae*			1	1
Scrophulariaceae	*Eremophila oldfieldii* subsp. *angustifolia*			1	1
Scrophulariaceae	*Eremophila oppositifolia* subsp. *angustifolia*			1	1
Scrophulariaceae	*Eremophila pantonii*			1	1
Scrophulariaceae	*Eremophila platycalyx*		Subspecies not defined	1	
Scrophulariaceae	*Eremophila platycalyx* subsp. Neds Creek (N.H. Speck 1228)		Undescribed	1	1
Scrophulariaceae	*Eremophila platythamnos subsp. platythamnos*			1	1
Scrophulariaceae	*Eremophila ramiflora*			1	1
Scrophulariaceae	*Eremophila serrulata*				1
Scrophulariaceae	*Eremophila simulans* subsp. *lapidensis*		Some previous reports as *E. simulans*	1	
Scrophulariaceae	*Eremophila* sp. Leinster (RJ Cranfield 6767)			1	1
Scrophulariaceae	*Eremophila* sp. long pedicels (G. Cockerton 1975)		Undescribed, of limited distribution	1	1
Scrophulariaceae	*Eremophila spectabilis* subsp. *brevis*		Some previous records as *Eremophila spectabilis*	1	1
Scrophulariaceae	*Eremophila youngii subsp. youngii*			1	1
Solanaceae	*Nicotiana occidentalis*		Either subsp. *obliqua* or subsp. *occidentalis*	1	
Solanaceae	*Solanum cleistogamum*		Some previous reports as *S. ellipticum*	1	1
Solanaceae	*Solanum ferocissimum*			1	
Solanaceae	*Solanum lachnophyllum*		Unlikely, if present would represent a slight range extension	1	

Family	Species Name	Cons Status	Notes	Prior Record	2016 Collection
Solanaceae	*Solanum lasiophyllum*			1	1
Solanaceae	*Solanum nummularium*			1	1
Stylidiaceae	*Stylidium induratum*			1	
Thymelaeaceae	*Pimelea microcephala* subsp. *microcephala*		Previously reported as *Pimelea microcephala*	1	1
Violaceae	*Hybanthus floribundus* subsp. *chloroxanthus*	PRIORITY 3	Some previous records as *H. floribundus*	1	1
Zygophyllaceae	*Tribulus adelacanthus*	PRIORITY 3	Some previous reports as *T. cistoides*	1	
Zygophyllaceae	*Tribulus astrocarpus*			1	
Zygophyllaceae	*Zygophyllum aurantiacum*		May be subsp. *aurantiacum*	1	
Zygophyllaceae	*Zygophyllum compressum*		Previously reported as *Z. apiculatum*	1	
Zygophyllaceae	*Zygophyllum eremaeum*			1	
Zygophyllaceae	*Zygophyllum iodocarpum*			1	1
			Totals	279	301

Flora Statistics	Families	51	
	Genera	140	
	Species	393	
	# Species to 2015	280	
	# Species in 2016	301	
	Number of species recorded in both data sets	177	
Dominant Families			
	Fabaceae	76	
	Poaceae	47	
	Chenopodiaceae	46	
	Scrophulariaceae	37	
	Asteraceae	30	
	Malvaceae	22	
	Myrtaceae	20	
Dominant Genera			
	Acacia	53	
	Eremophila	37	
	Maireana	18	
	Senna	14	
	Sida	11	
	Eragrostis	7	
Weeds	Weed Species	6	
	Mulga Varieties	31	Incl. potential hybrids
	Mulga species	13	Excl. hybrids
Note:	263 species reported in WB860 (Sept 2016) review		

Appendix 2. Priority Flora Descriptions

Aristida jerichoensis var. *subspinulifera* – *Priority 3*

Aristida jerichoensis var. *subspinulifera* P3 is an upright perennial grass to 0.8m. It was recorded at one location within the bed of Jones Creek at 51J 261412 mE, 6965908 mN on the north-eastern edge of the Proposal Study Area, Figure 16.

The identification and conservation status of the specimen was not determined until after field works were concluded and therefore there is no contextual information for the species at this site.

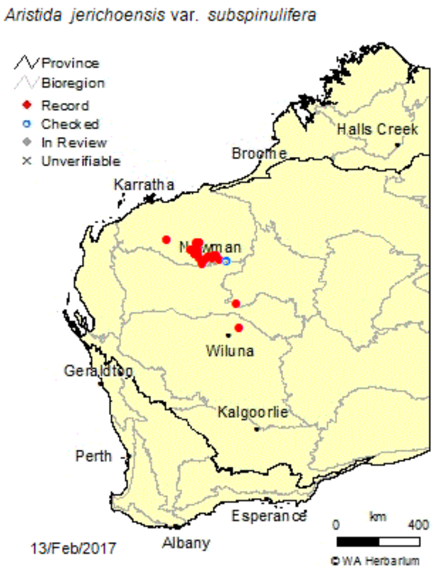
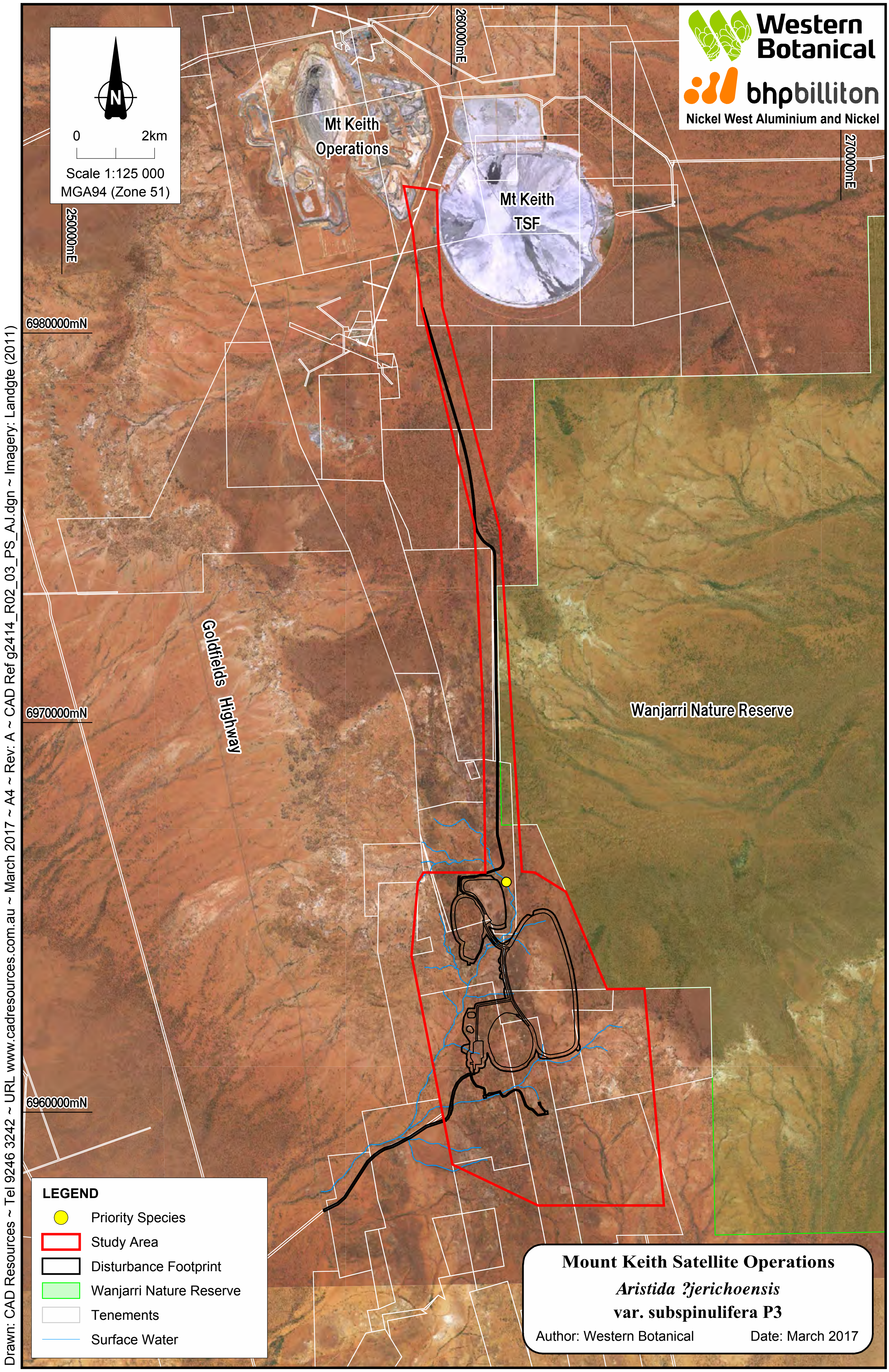


Figure 15. Distribution of *Aristida jerichoensis* var. *subspinulifera* P3 in Western Australia.

The record within the MSKO Proposal Study Area represents a slight range extension to the south, Figure 15, Figure 16.

Figure 16. Distribution of *Aristida jerichoensis* var. *subspinulifera* P3 within the MKS Proposal Study Area



Western Botanical
bhpbilliton
Nickel West Aluminium and Nickel
N
0
2km
Scale 1:125 000
MGA94 (Zone 51)
250000mE
260000mE
270000mE
6980000mN
6970000mN
6960000mN
Mt Keith Operations
Mt Keith TSF
Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Priority Species
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Aristida ?jerichoensis
var. subspinulifera P3
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_AJ.dgn ~ Imagery: Landgte (2011)

Anacampseros sp. Eremaean ((F. Hort, J. Hort & J. Shanks 3248) Priority 1

Anacampseros sp. Eremaean (F. Hort, J. Hort & J. Shanks 3248) is a small, succulent, erect herbaceous perennial to 10 cm tall. It has crowded, rounded, succulent basal leaves and a subterranean tuber. Flowers are terminal, solitary, on short ascending stems with 5 white petals (Plate 1). It occurs in small, discrete populations within pockets of sandy soil that collects in the pitted surface of the weathered Achaean granite breakaways and on granite outcrops. The above ground parts are ephemeral.

Anacampseros sp. Eremaean is a relatively newly recognised taxon in Western Australia and is the only species of *Anacampseros* known in Western Australia. WA Herbarium records show that the species is known from 6 specimens, representing 4 populations from Menzies, Yakabindie, Lake Mason and Coolcalalaya Stations (Figure 17). Given the diminutive stature, distribution and habitat specificity of *Anacampseros* sp. Eremaean, it may be more widespread and numerous at all locations where it has been recorded than figures indicate to date.

No *Anacampseros* sp. Eremaean plants have been recorded within the MKS Development Envelope and only one population is known in the eastern portion of the MKS Proposal Study Area. Several populations have been noted in the region near the MKS project and the species is always found associated with the granitoid landscapes. Within and nearby the MKS Proposal Study Area, it is known to be associated with shallow soils around the base of granite outcrops and on the breakaway plateaux (BRX habitat unit), (Figure 18).

Two populations (45 individuals in total) of *Anacampseros* sp. Eremaean were noted within the Sir Samuel block, now ceded into the Wanjarri Nature Reserve. One population of six plants was high in the landscape on an Archaean granite breakaway (BRX habitat unit) at the NW corner of the project area and the other, larger population at the foot of a granite rock, in the southern central part of the Sir Samuel block (Plate 1). At the first location, the species is associated with *Calytrix uncinata* P3 and *Dodonaea peteolaris* while on the lower lying granite rock, *Acacia quadrimarginea* and grasses including *Aristida contorta*, *Eriachne pulchella* and *Cymbopogon ambiguous are present.* Western Botanical also recorded a population of approximately 50 plants at Niagara Dam, ~15km NE of Menzies, in April 2006 (Plate 1).

No plants of *Anacampseros* sp. Eremaean are known within the proposed Development Envelope of the MKS project though the breakaway habitat is known to support the species close by.

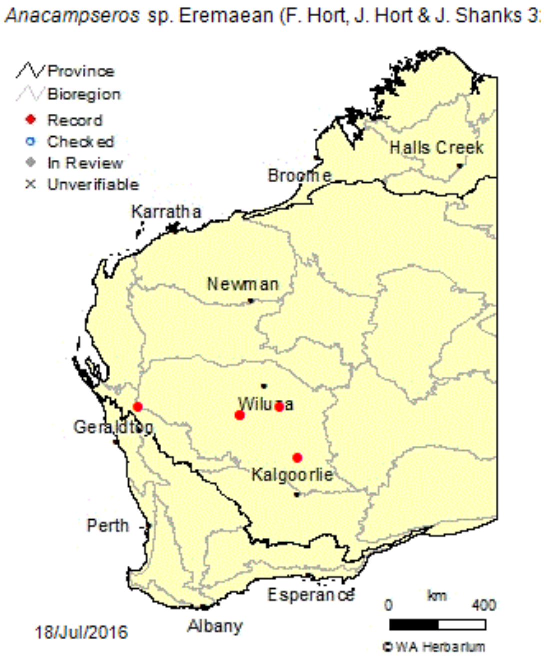


Figure 17. Distribution of *Anacampseros* sp. Eremaean in Western Australia (Florabase, July 2016).

a

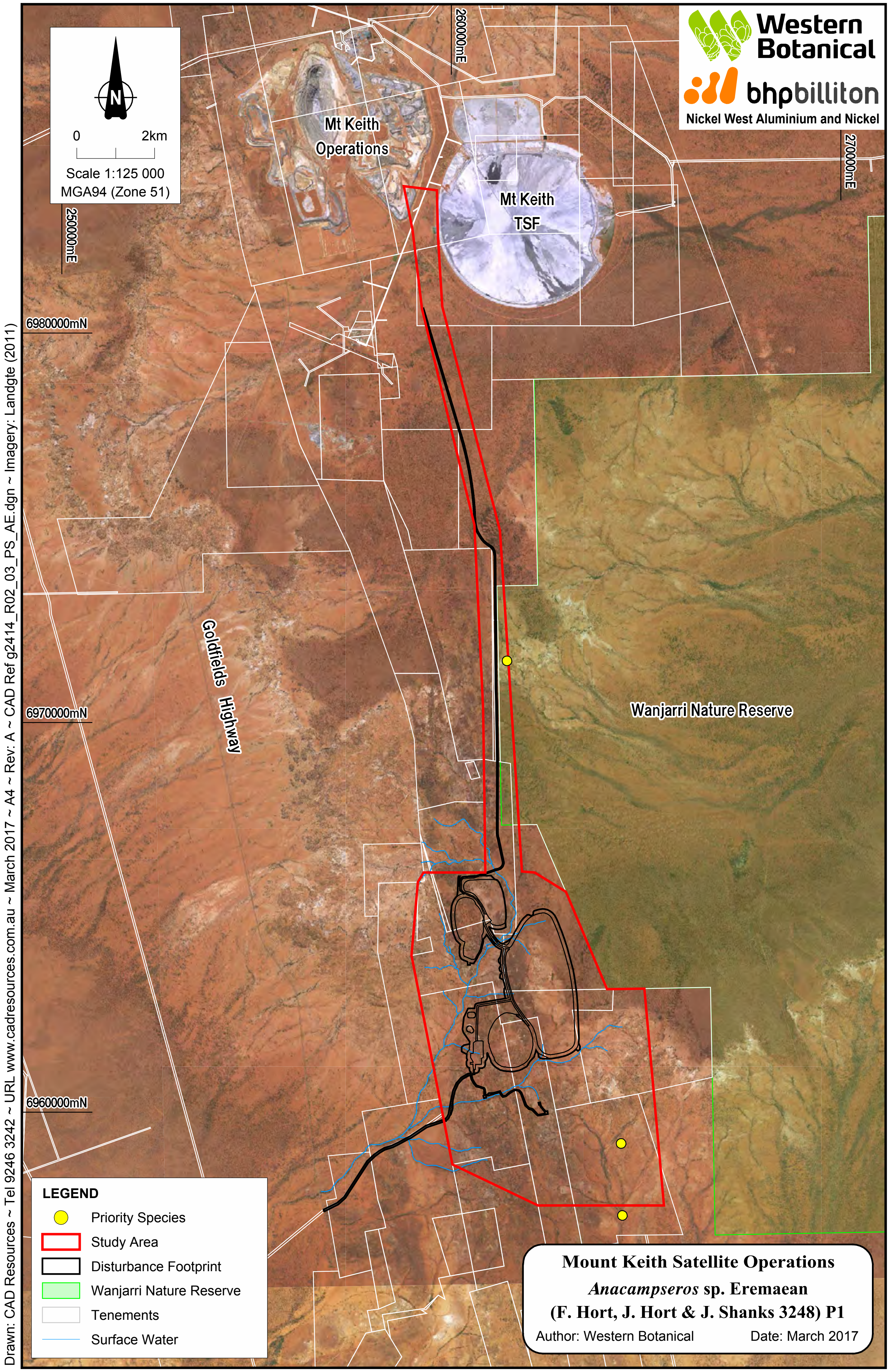
b

c


d

Plate 1. a, b, c. *Anacampseros* sp. Eremaean, plants in situ, Sir Samuel Block, now within Wanjarri Nature Reserve; d. (Niagara Dam north of Menzies).

Figure 18. Known distribution of *Anacampseros* sp. Eremaean within and adjacent to the MKS Proposal Study Area.



Western Botanical
bhpbilliton
Nickel West Aluminium and Nickel
N
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2km
Scale 1:125 000
MGA94 (Zone 51)
250000mE
260000mE
270000mE
6980000mN
6970000mN
6960000mN
Mt Keith Operations
Mt Keith TSF
Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Priority Species
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Anacampseros sp. Eremaean
(F. Hort, J. Hort & J. Shanks 3248) P1
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_AE.dgn ~ Imagery: Landgte (2011)

Cratystylis centralis Priority 3

Cratystylis centralis sens. lat. Priority 3, is a long lived dense domed shrub to 1m high x 1m wide with blue-grey foliage and tightly constricted terminal flowers, Plate 2. It is known from few populations in Western Australia (Yakabindie Station and near Laverton in the Murchison biogeographic region; near Norseman and near Kambalda in the Coolgardie biogeographic region. Specimens from populations in Western Australia are curated under *Cratystylis centralis* sens. lat. which is more commonly recorded in the central southern Northern Territory (Figure 19).

Plate 2. *Cratystylis centrals* ,west of the MKS Proposal Study Area, May 2016.

Wilson & Albrecht (2002) note that the Western Australian specimens differ in the number of florets in the flowering head (capitula) from those in the Northern Territory, however, the lack of good flowering material made it difficult to separate the two groups adequately. They record the species as a putative hybrid between *C. conocephala* and *C. microphylla* with a Western Australian distribution. The species, while currently considered within *C. centralis* sens. lat. and with a P3 conservation listing in W.A. due to the distribution in W.A. and N.T., remains of taxonomic and conservation interest (Mike Hislop, pers. comm.). It is more likely that the Western Australian species is a new taxon and worthy of a revised conservation ranking.

Preliminary investigations undertaken by WB in August 2016 on specimens housed at the WA Herbarium have shown the WA species (Armstrong, P.G. (07/970)) has two flowers per capitula (flower head) while those from the Northern Territory (specimen on loan from NT Herbarium, collected by P.K. Latz) have four. This is considered a significant difference (P. Wilson pers. comm.) and indicates that the WA taxon requires further taxonomic investigation.

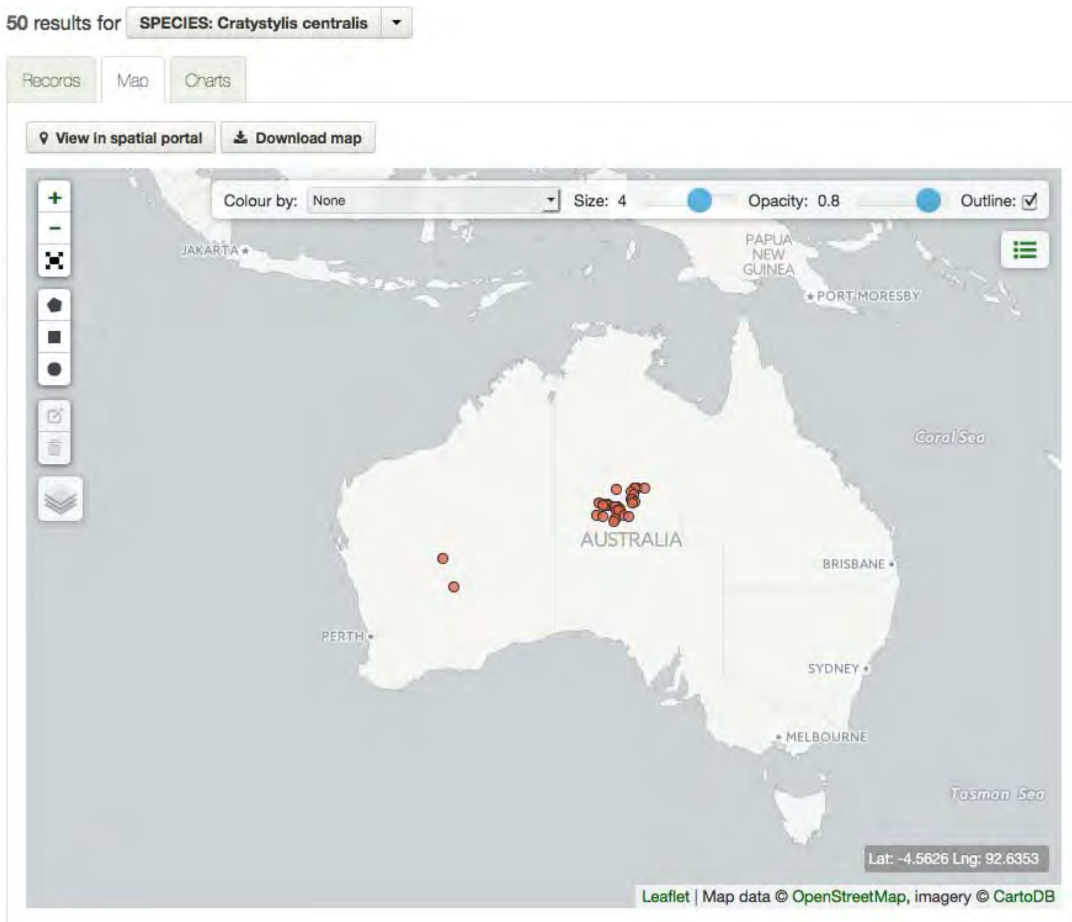
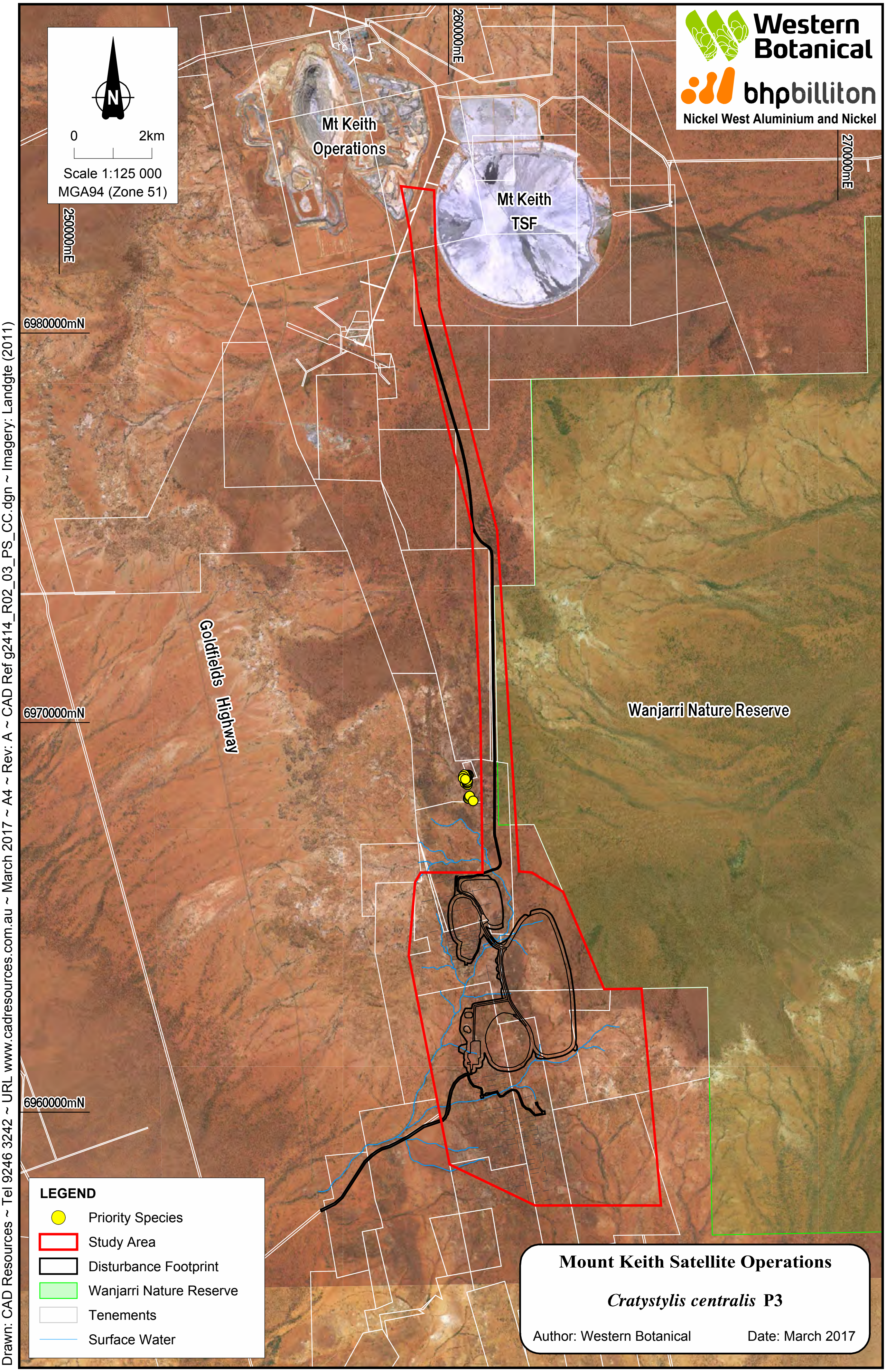


Figure 19. Distribution of *Cratystylis centralis* sens. lat. in Western Australia and the Northern Territory (Australia's Virtual Herbarium, July 2016)

Cratystylis centralis sens. lat. is known from the carbonate influenced soils within the *Eucalyptus gypsophila – Eremophila pantonii* Woodland (EGPW) community west of the proposed haul road alignment, north of the MKS's Six Mile orebody area (Figure 20).

While no *Cratystylis centralis* are known to exist within the MKS Development Envelope, it has been included in this assessment as it occurs near the western margin of the proposed haul road to Mt Keith and further assessments in the appropriate habitats may record the species within the MKS Proposal Study Area.

Figure 20. Distribution of *Cratystylis centralis* sens. lat. near the MKS Proposal Study Area.



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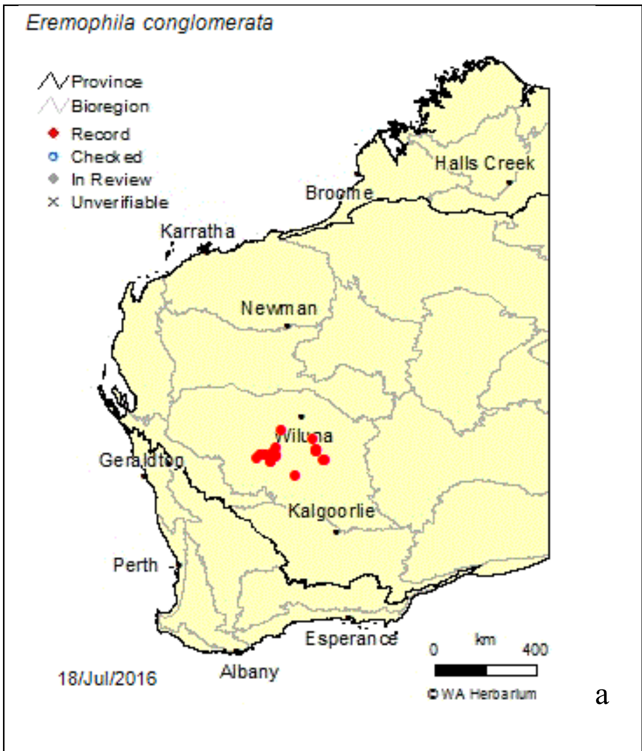
Wanjarri Nature Reserve
LEGEND
Priority Species
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Cratystylis centralis P3
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_CC.dgn ~ Imagery: Landgte (2011)

Eremophila pungens Priority 4 (including *Eremophila* sp. Leinster RJ Cranfield 6767)

Eremophila sp. Leinster (RJ Cranfield 6767) is an erect, viscid shrub, which grows between 0.5-1.5m high and produces purple or violet flowers during July-August, (Plate 3). It occurs on plains, ridges and breakaways and prefers sandy loam and clayey sand over laterite.

The taxon present within the MKS Proposal Study Area is a new species, which was until recently circumscribed under *Eremophila pungens* P4 and is therefore discussed here. It was reassessed recently and curated under *Eremophila conglomerata* (Det: Andrew Brown, 16th June 2009), (Figure 21). However, the authors remain concerned over it's identity and the species should be regarded as a new taxon until the group is fully revised. The taxon and its close relatives are in need to thorough taxonomic review.



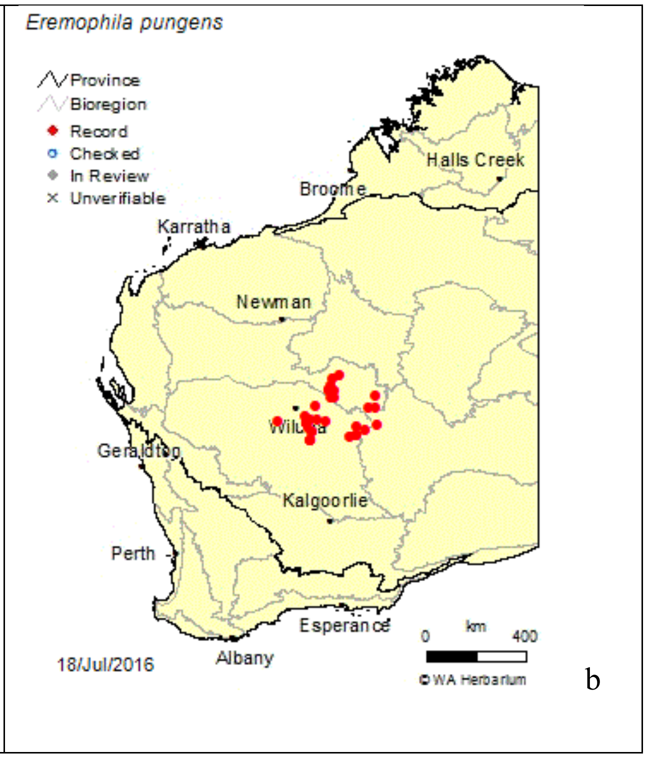


Figure 21. (a) Distribution of *Eremophila conglomerata* and (b) *Eremophila pungens* P4 in Western Australia, (Florabase, July 2016).

Eremophila sp. Leinster (RJ Cranfield 6767) is common between Leinster and Mt Keith on ironstone and occasionally on granitoid landforms. The population of *Eremophila* sp. Leinster (RJ Cranfield 6767) within the MKS Proposal Study Area has been estimated at 1,986 plants, the majority being north-west of the Six Mile orebody area and on the western edge of the proposed transport corridor (Figure 22).

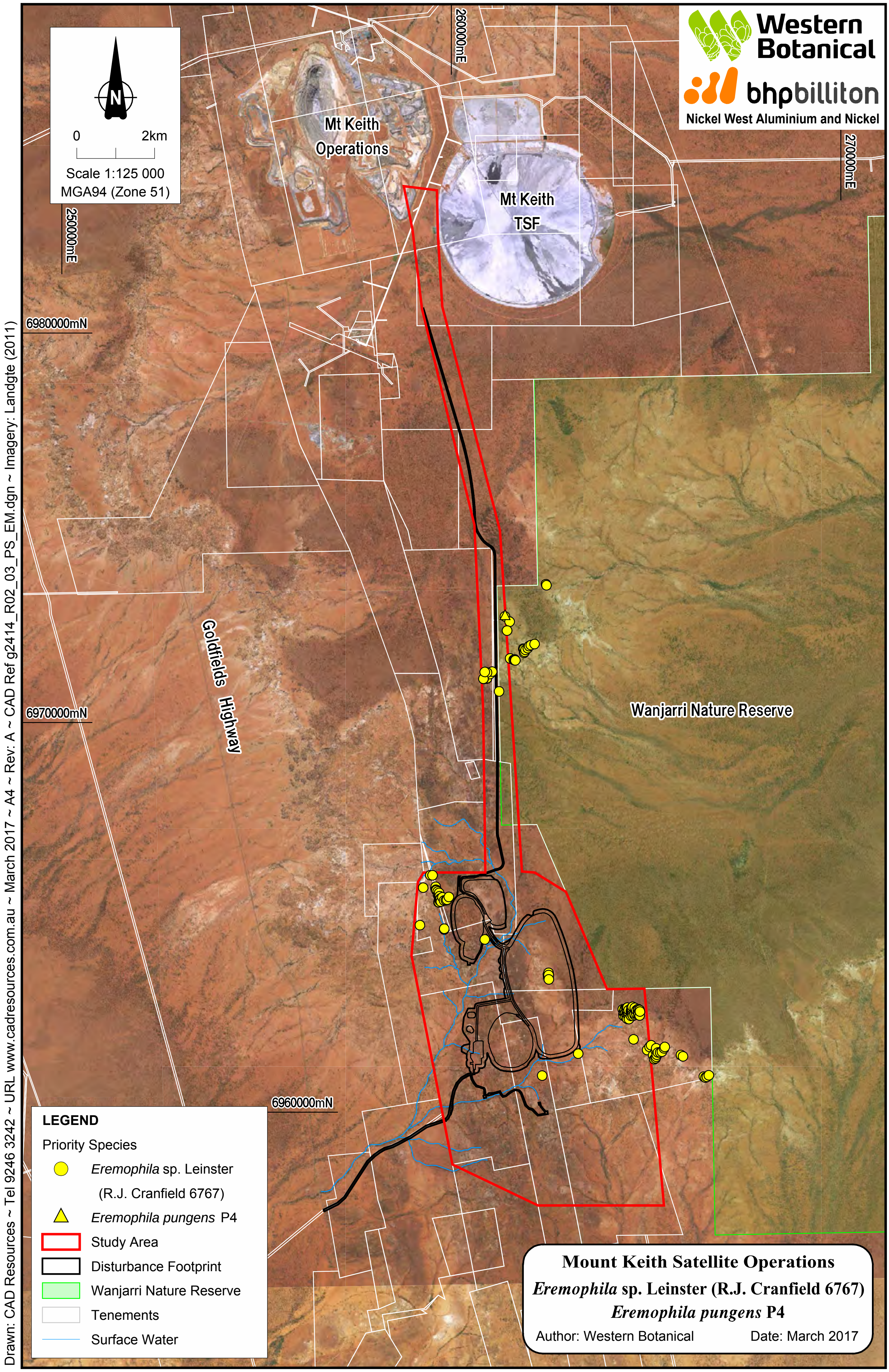
Plate 3. *Eremophila* sp. Leinster (RJ Cranfield 6767)

Chinnock (2007) prepared a monograph of *Eremophila*. In this document he described *Eremophila pungens* from a specimen collected north-east of Wiluna on Carnegie Station (RJ Chinnock 4672) but then illustrated the species using a specimen from the same region (RJ Chinnock 4720) (pages 371 to 373). He then presented a photograph of another specimen. The specimen photographed by Chinnock is regarded as being conspecific with *Eremophila* sp. Leinster (RJ Cranfield 6767).

A review of the *Eremophila* sp. Leinster / *E. pungens* group in 2009 was conducted by Western Botanical using available WA Herbarium records of *E. pungens*. The review suggested splitting *E. pungens* into three taxa: *Eremophila pungens sensu stricto* with prominent pungent spines on the leaf tips; *Eremophila* sp. Meekatharra (D.J. Edinger 4430) with very small leaves and calyx lobes, and *Eremophila* sp. Leinster (RJ Cranfield 6767) which lacks the pungent spines of the type species. *Eremophila* sp. Meekatharra has already been cleaved off as a separate species and is listed as a Priority 1 taxon (https://florabase.dpaw.wa.gov.au/browse/profile/34600). The distribution of the two remaining species within *Eremophila pungens* (*Eremophila pungens* sensu stricto and *Eremophila* sp. Leinster (RJ Cranfield 6767) as discerned in the above review by Western Botanical is presented in Figure 23.

Twenty four plants of *Eremophila* sp. Leinster are known within the MKS Development Envelope. In comparison to the regional population enumerated to date of 3,922 plants (considered a significant under-estimate), this represents a proportional impact of less than 0.61% on the known number of individuals of this species.

Figure 22. Populations of *Eremophila* sp. Leinster (R.J. Cranfield 6767), within and nearby the MKS Proposal Study Area



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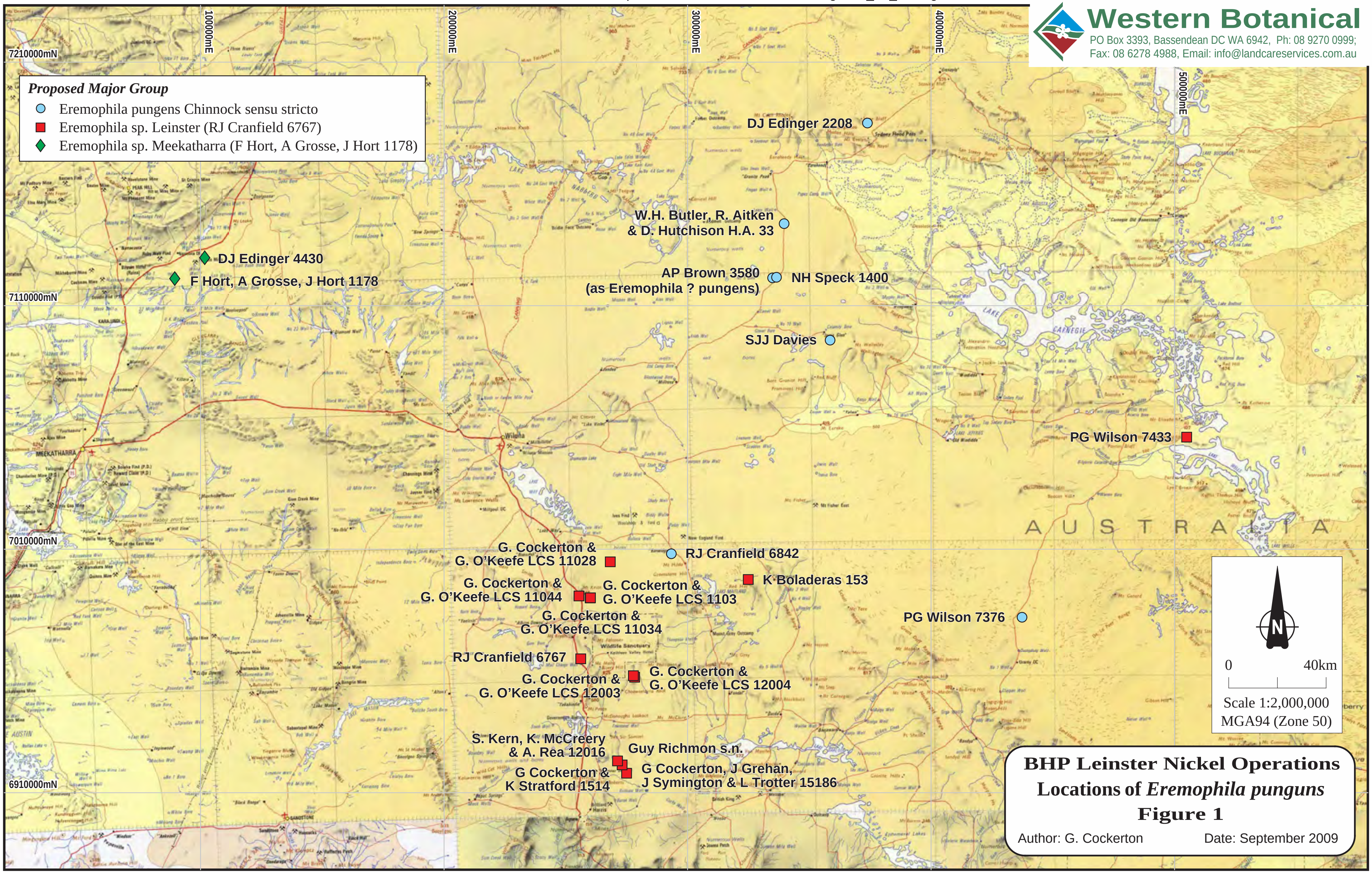
Mt Keith TSF
Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Priority Species
Eremophila sp. Leinster (R.J. Cranfield 6767)
Eremophila pungens P4
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Eremophila sp. Leinster (R.J. Cranfield 6767)
Eremophila pungens P4
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_EM.dgn ~ Imagery: Landgte (2011)

Figure 23. Populations of *Eremophila pungens* P4 group (inclusive of *E*. sp. Leinster (R.J. Cranfield 6767) in north-eastern Goldfields region.

Author: G. Cockerton ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ Sept 2009 ~ A4 ~ Rev: A ~ CAD Ref g1067_drf_001.dgn



Grevillea inconspicua – Priority 4

Grevillea inconspicua is an intricately branched, spreading shrub, which grows 0.6 – 2 m high and produces white or pink flowers between June and August (Western Australian Herbarium), (Plate 4). It has simple leaves 10 - 45 mm long and 0.5 - 1.5 mm wide. It occurs on gravel and loam, along drainage lines, on rocky outcrops and along creek lines and is distributed through the Murchison Biogeographic Region (Western Australian Herbarium), (Figure 24).

Plate 4. *Grevillea inconspicua* at Leinster, 2006, within the Bevon Land System and SIMS habitat unit.

In the Leinster – Mt Keith – Mt Magnet regions, Western Botanical has encountered *Grevillea inconspicua* in close association with metabasalt geology of the greenstone ranges and subcropping or outcropping basalt rocks are always present where the plants exist.

An estimated 413 plants of *Grevillea inconspicua* are scattered sparsely throughout the western and southern portions of the MKS Proposal Study Area (Figure 25). This value is considered an incomplete census of the species within the MKS Development Envelope. At MKS, this species is associated with outcropping/subcropping metabasalts in the Bevon and Violet Land Systems within the Violet Range Priority Ecological Community. Significant populations of this species are associated with the Violet Range, south-west of the MKS Proposal Study Area though they have not been assessed in detail and no population numbers are available. Estimates made in

1991 (ecologia 1991) suggest a regional population of 9,000 plants. The DPaW TPFL database records a total population of 8,263 plants known regionally. It is estimated that up to 159 plants (128 TPFL database, 31 WB counts) of *Grevillea inconspicua* may be impacted by development of the MKS project, representing 1.77% of the total regional population.

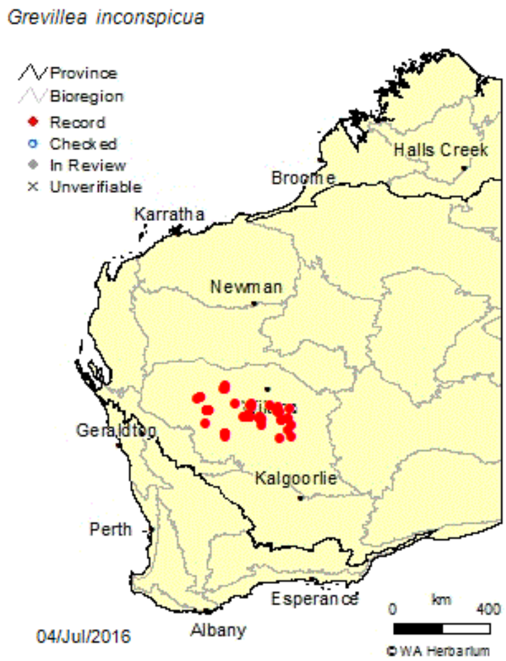
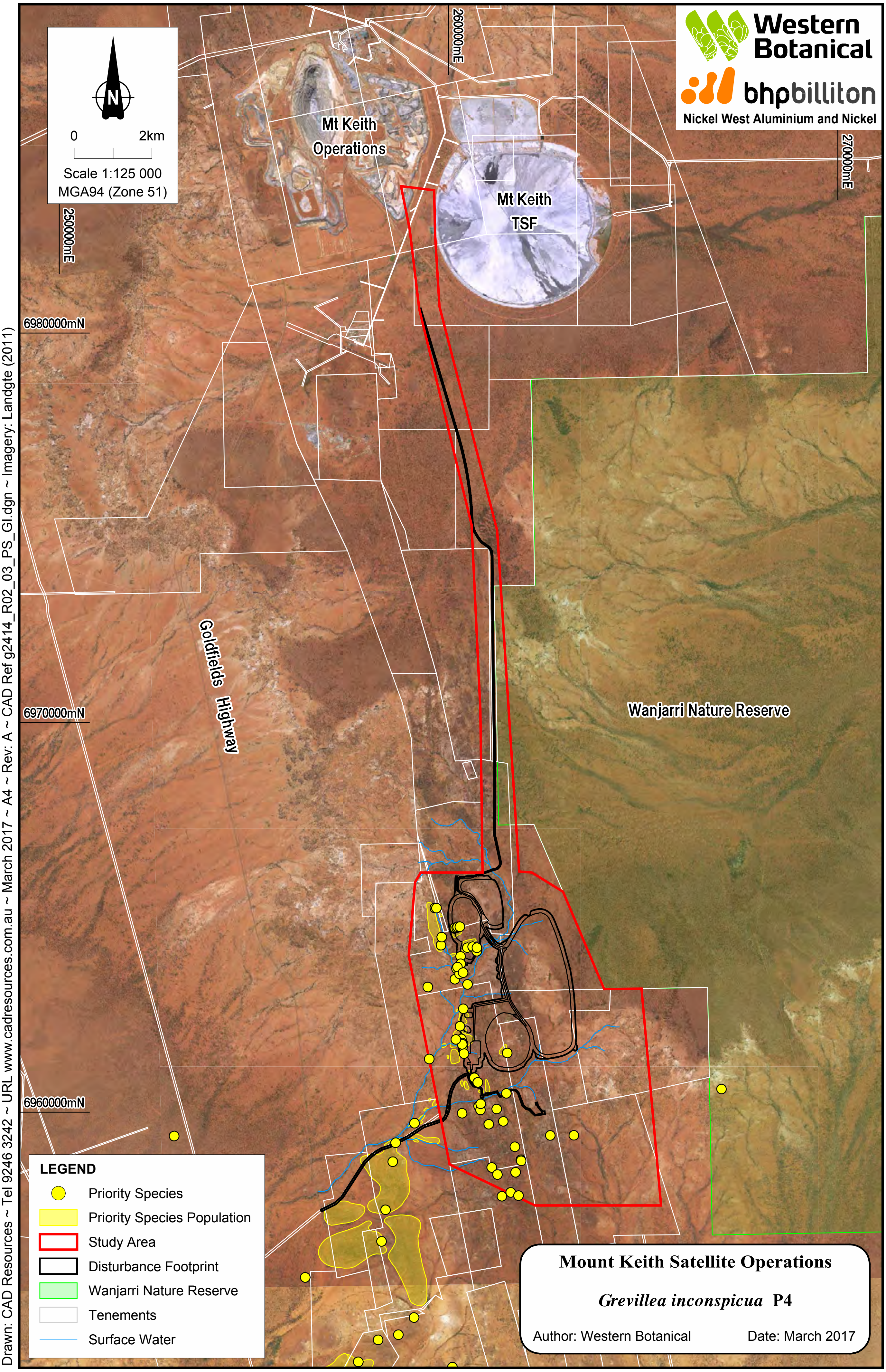


Figure 24. Distribution of *Grevillia inconspicua* (P4) within Western Australia (Florabase, July 2016).

Figure 25. Populations of *Grevillea inconspicua* (P4) within and near the MKS Proposal Study Area.



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Mt Keith Operations
Mt Keith TSF
Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Priority Species
Priority Species Population
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Grevillea inconspicua P4
Author: Western Botanical
Date: March 2017
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***Hemigenia exilis* Priority 4**

Hemigenia exilis is a shrub 0.5 to 1.5 m in height with an open, divaricately branched habit with paired lateral stems and decussate lanceolate leaves (Plate 5). It typically grows in Stony Ironstone Low Shrublands (SILS) habitat in the Proposal Study Area. Florabase records show almost all collections have occurred within the north-eastern Goldfields, between Leonora and Wiluna in the Murchison IBRA region (Figure 26). The western-most record of *Hemigenia exilis* is near Cue (D. Brearley s.n., 10/3/2009) is uncharacteristic for the species and until reviewed, the occurrence here is considered unreliable.

Plate 5. *Hemigenia exilis* within the transport corridor of the MKS Proposal Study Area with Glenda Pickersgill, former Environmental Manager at Mt Keith Operation.

It is known that northern and southern populations of *Hemigenia exilis* have a natural disjunction south of Yakabindie. Work conducted by Botanic Gardens and Parks Authority (Mattner *et al*, 2002) show that the southern and northern populations of *Hemigenia exilis* differ to a significant degree at the genetic level.

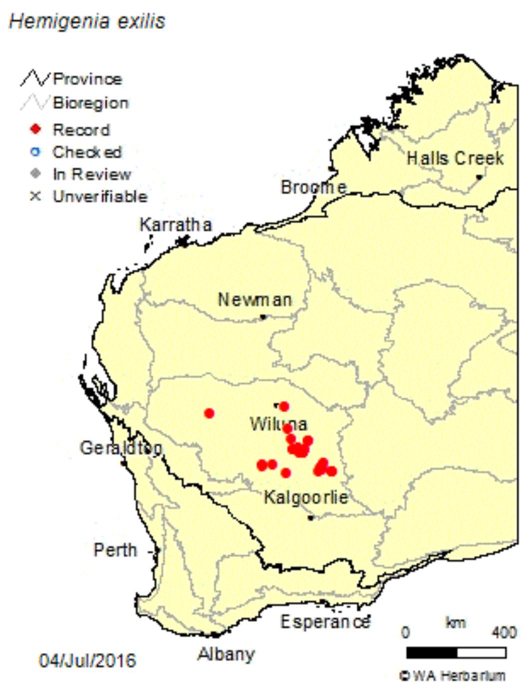
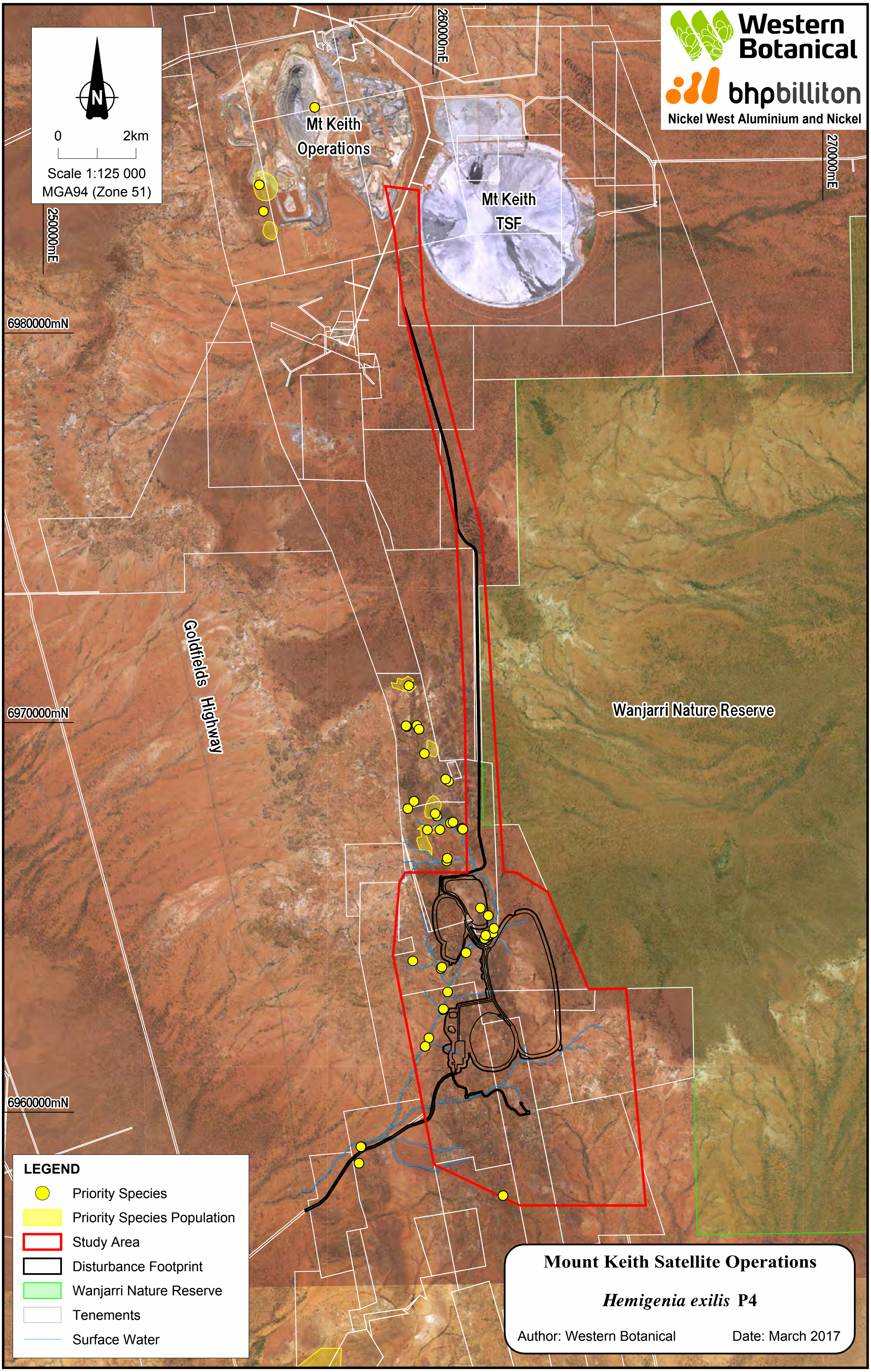


Figure 26. Regional distribution of *Hemigenia exilis* (WA Herbarium, 2011)

The populations of *Hemigenia exilis* known within the MKS Proposal Study Area is presented in Figure 27. Here it is associated primarily with Jones Creek in the Violet, Bevon and Nubev Land Systems. Between the MKS Proposal Study Area and Mt Keith, major populations of *Hemigenia exilis* are associated with the Windarra and Bevon Land Systems.

The TPFL Database records 70 plants within the MKS Development Envelope. The regional assessment of *Hemigenia exilis* reported in Cockerton & Stratford (1997), ref:LCS55, tallied 22,862 plants over 49 populations. The plants to be taken in development of the MKS represent 0.31% of this original population estimate.

Figure 27. Populations of *Hemigenia exilis* P4, within the MKS Proposal Study Area



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Hybanthus floribundus subsp. chloroxanthus – Priority 3

Hybanthus floribundus subsp. *chloroxanthus* is a multi-stemmed shrub growing to 0.7 m tall with blue-green foliage in the cooler / wetter months turning yellow-green in summer, blue and white flowers from August to October (Plate 6). It is typically found in rocky areas, creek banks, and along drainage lines in dark red-brown soil rich in iron oxide. Apart from the populations associated with the MKS Proposal Study Area, *Hybanthus floribundus* subsp. *chloroxanthus* is known from the south-eastern portion of the Murchison Biogeographic region (Figure 28). It is known from 19 specimens at the WA Herbarium representing two populations; Yakabindie Station and near the Murrin Murrin minesite some 35 km east of Leonora. A further population near Leinster has been recorded by Western Botanical but has not been vouchered.

Plate 6. *Hybanthus floribundus* subsp. *chloroxanthus* within the MKS Proposal Study Area.

Hybanthus floribundus subsp. *chloroxanthus* has been reported separately by Western Botanical (2004, 2008, 2012) and Mattiske Consulting (2011). Where anomalies arose between these two data sets, the greater number of plants has been accepted. An estimated 150 plants of *Hybanthus floribundus* subsp. *chloroxanthus* are known within the MKS Proposal Study Area, primarily in ephemeral drainage lines within and west of the proposed Six-mile orebody (Figure 29). A further 220 plants have been recorded approximately 5 km north of the MKS Proposal Study Area (WB May 2016 and Mattiske 2011) while an estimated 200 plants are known near the Murrin Murrin minesite (Rapallo, 2007).

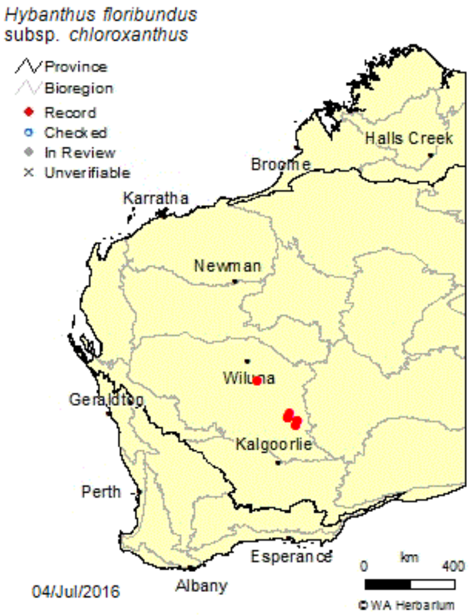
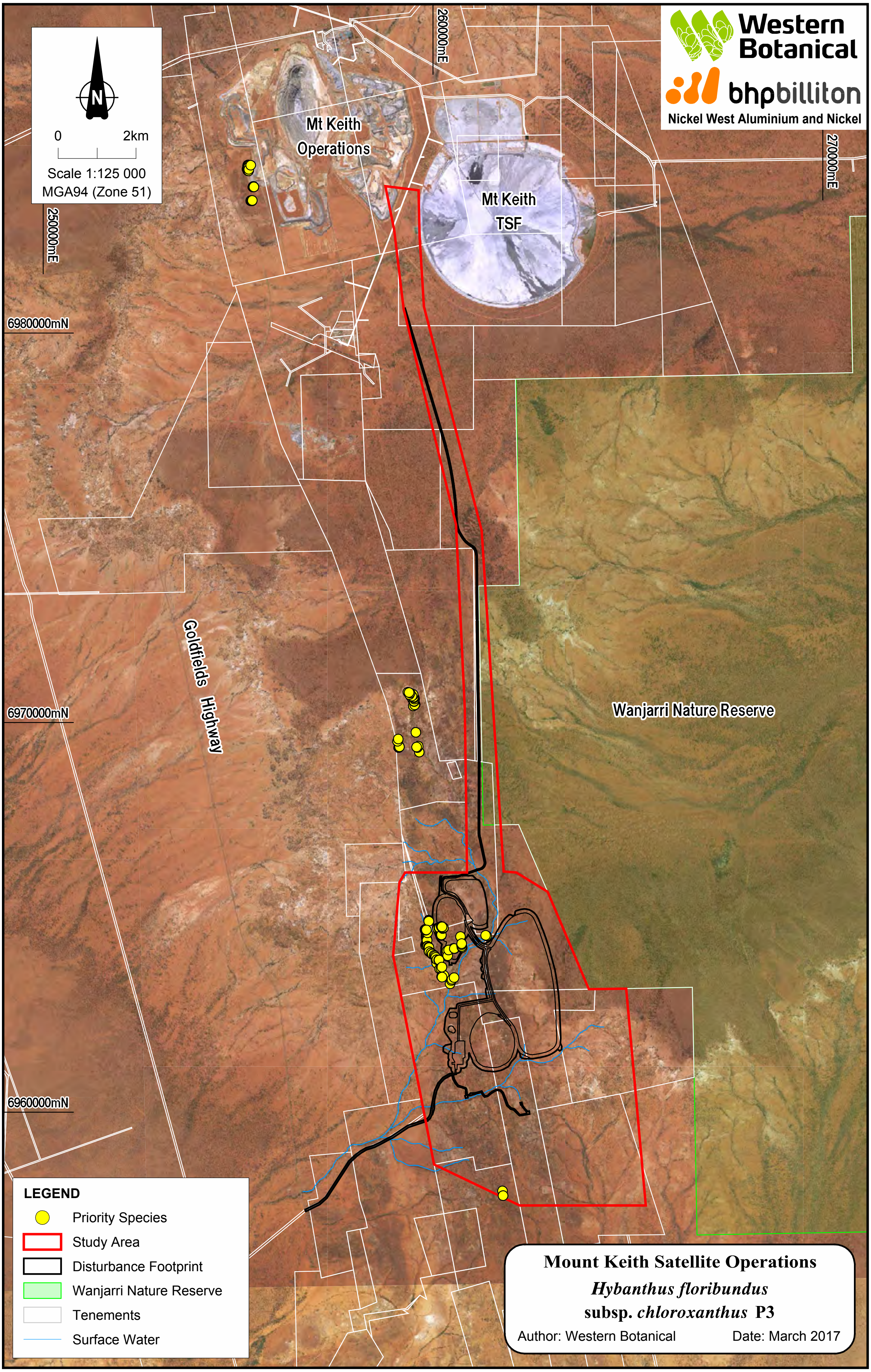


Figure 28. Distribution of *Hybanthus floribundus* subsp. *chloroxanthus* (P3) in Western Australia (Florabase, July 2016).

Figure 29. Populations of *Hybanthus floribundus* subsp. *chloroxanthus* (P3) within and near the MKS Proposal Study Area.



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Sida picklesiana – Priority 3

Sida picklesiana is a rounded, densely branched perennial shrub growing 0.4 to 1.0 m tall with yellow flowers following good rainfall (Markey *et al.* 2011), (Plate 7). It grows on banded ironstone hills north and west of Wiluna, and on weathered Archaean granite breakaways in the Sherwood Land System of the Barr-Smith Range south of Wiluna (Figure 30). It has been previously reported by Western Botanical as *Sida* sp. Mt Keith (G Cockerton & G O'Keefe 10489) and previously listed as *Sida* sp. Wiluna (A. Markey & S. Dillon 4126).

Plate 7. *Sida picklesiana* at Mt Keith.

Within the MKS Proposal Study Area, a population of 273 *Sida picklesiana* plants is found on isolated low breakaways traversed by the transport corridor (Figure 31). An additional plant has been recorded approximately 5 km north of the MKS Proposal Study Area. Within the wider local region *Sida picklesiana* is infrequently encountered on the kaolinised slopes and weathered plateaux of Archaean granite breakaways on Yakabindie, Albion Downs, and Mt Keith Stations and while restricted to these landforms, is not uncommon. No *Sida picklesiana* are to be impacted by the development of the haul road to Mt Keith.

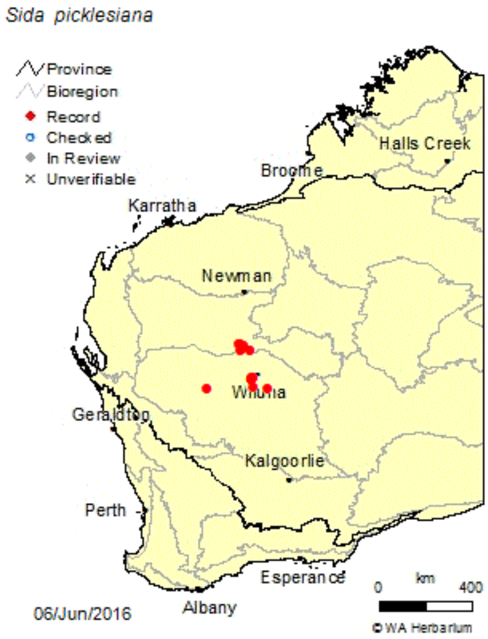
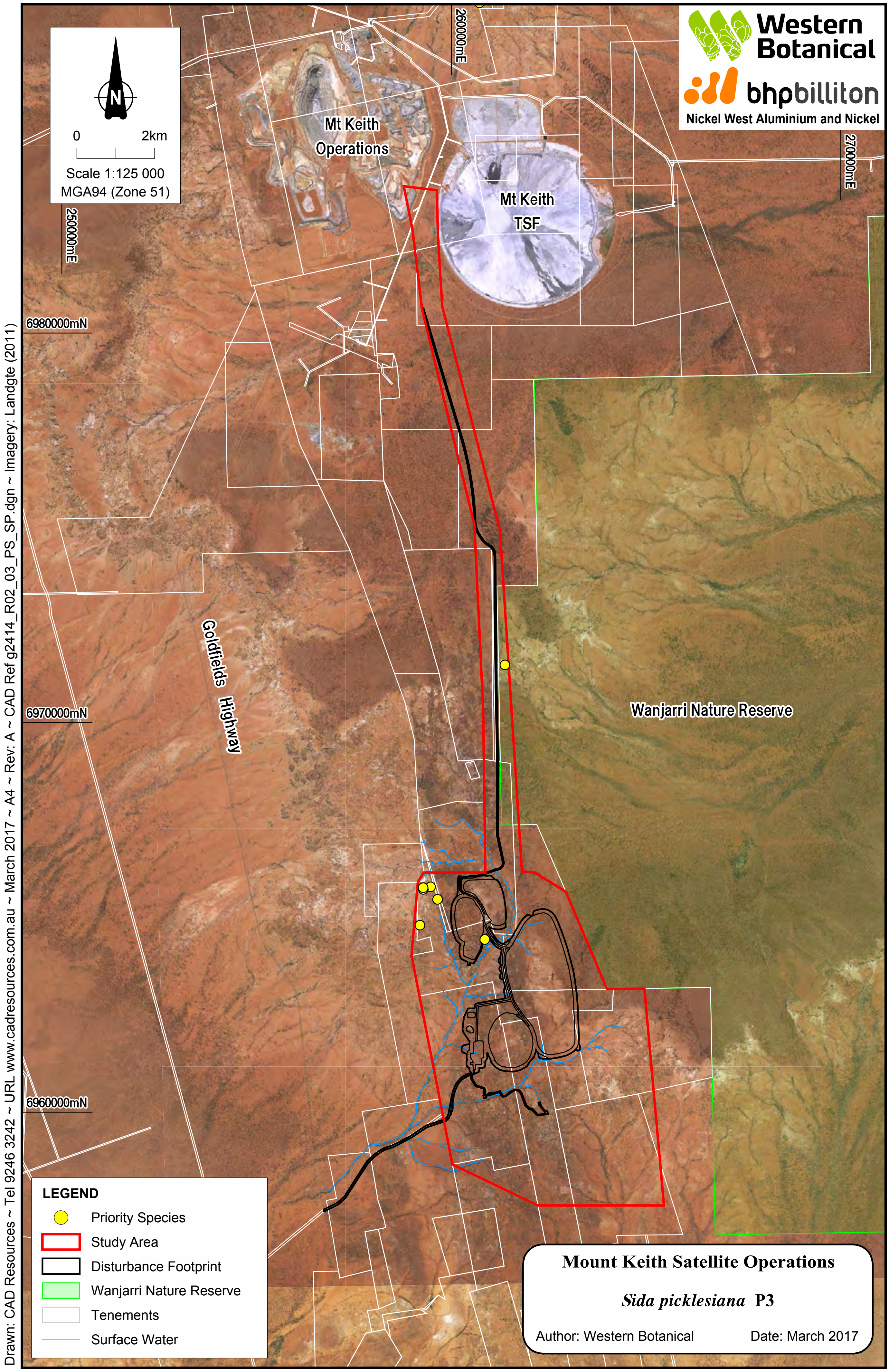


Figure 30. Distribution of *Sida picklesiana* (P3) within Western Australia (Florabase).

Figure 31. Populations of *Sida picklesiana* (P3) within and near the MKS Proposal Study Area.



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Sida picklesiana P3
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_SP.dgn ~ Imagery: Landgte (2011)

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) – Priority 3

Thryptomene sp. Leinster (B.J. Lepschi & L.A. Craven 4362) is an upright to sprawling shrub to 2.5 m in height, producing white to pink flowers from October to December (Plate 8). It is known to occur on rocky Archaean granite breakaways, stony rises and rocky granite outcroppings, in association with *Acacia aneura* (sens. lat.). Since the previous NDS1 report (Western Botanical, 2012) the conservation status of *Thryptomene* sp. Leinster has been downgraded from Priority 1 to Priority 3.

Plate 8. _Thryptomene_ sp. Leinster, foliage and old flowers.

Known primarily from a narrow distribution in the eastern Murchison Biogeographic region, there are currently 19 voucher collections listed on Florabase (Western Australian Herbarium, 1998-), (Figure 32). *Thryptomene* sp. Leinster is typically associated with the Archaean granites of the Barr-Smith Range, which extends from the south of Wiluna to approximately 60 km south of Leinster.

Populations of *Thryptomene* sp. Leinster within the MKS Proposal Study Area (Figure 33) are estimated to contain a total of 10,552 plants and the regional population is estimated at 57,880 individuals. The majority of these occur within the northwest portion of the MKS Proposal Study Area. A cluster of populations estimated at 117 plants is known to occur approximately 5 km north of the MKS Proposal Study Area, and another cluster estimated at 4,121 plants occurs

2 km north-west of the MKS Proposal Study Area. Significant populations are also known near Leinster townsite. The development of the MKS project will impact around 689 plants, representing 1.19% of the known regional population of this species.

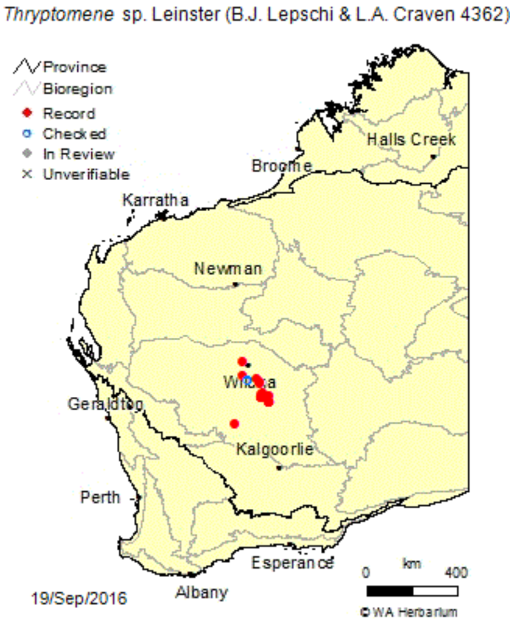
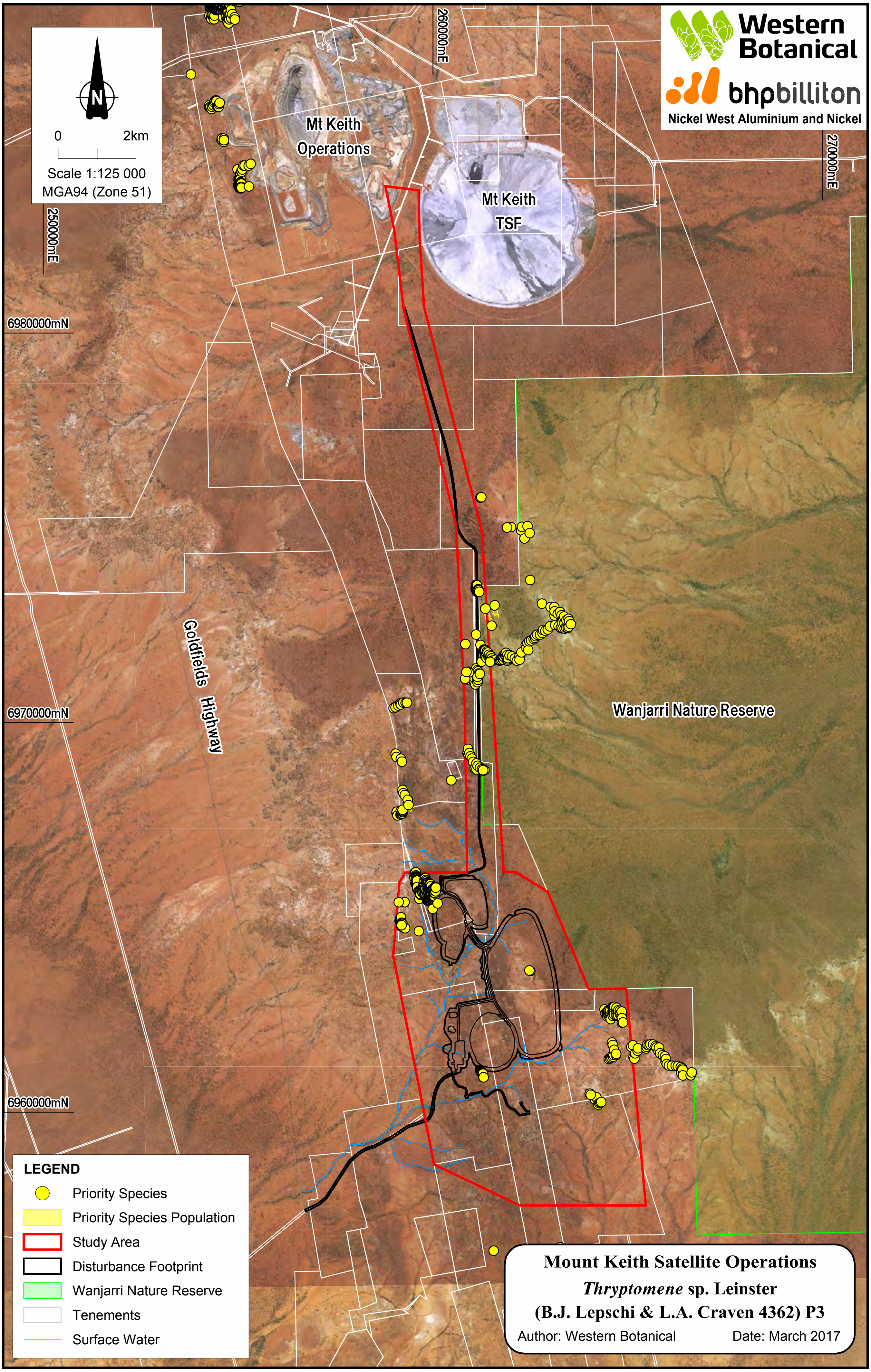


Figure 32. Distribution of *Thryptomene* sp. Leinster (B.J. Lepschi & L.A. Craven 4362) (P3) in Western Australia (Florabase, July 2016)

Figure 33. Populations of *Thryptomene* sp. Leinster (B.J. Lepschi & C.A. Craven 4362) (P3) within and near the MKS Proposal Study Area.



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***Verticordia jamiesonii* – Priority 3**

Verticordia jamiesonii is a perennial shrub that grows between 0.2 - 0.6m high and produces white or pink flowers during September to October (Western Australian Herbarium, 1998-), (Plate 9). It occurs on lateritic and granite breakaways and is distributed though the Gibson Desert, Murchison, and Yalgoo Biogeographic Regions (Figure 34). Within the north-eastern Goldfields, *Verticordia jamiesonii* is found on the plateaus of weathered Archaean granite breakaways of the Sherwood Land System. It may occur in small groups or in more substantial populations of 50 to 100 individuals but remains uncommon.

Plate 9. *Verticordia jamiesonii* north of Mt Keith, 2006.

One population of approximately 500 plants of *Verticordia jamiesonii* occurs on the low breakaways within the south-east portion of the MKS Proposal Study Area (Figure 35). Outside the MKS Proposal Study Area, a fragmented population of approximately 326 *Verticordia jamiesonii* plants occurs roughly 4.5 km north of MKS Proposal Study Area, on Mount Keith Station. Additional populations north of Mt Keith containing unquantified number of plants are also known to Western Botanical. A small population of about 10 plants of *Verticordia jamiesonii* plants lies within the breakaway traversed by the proposed haul road and may be impacted by the development of the MKS project.

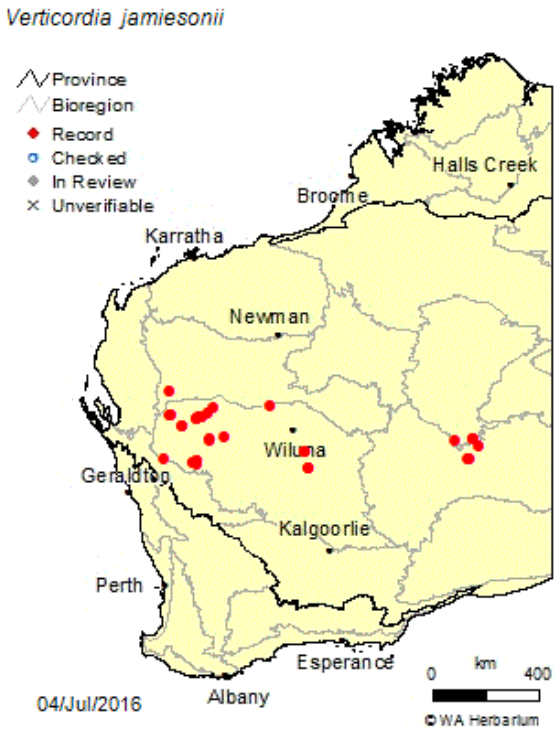
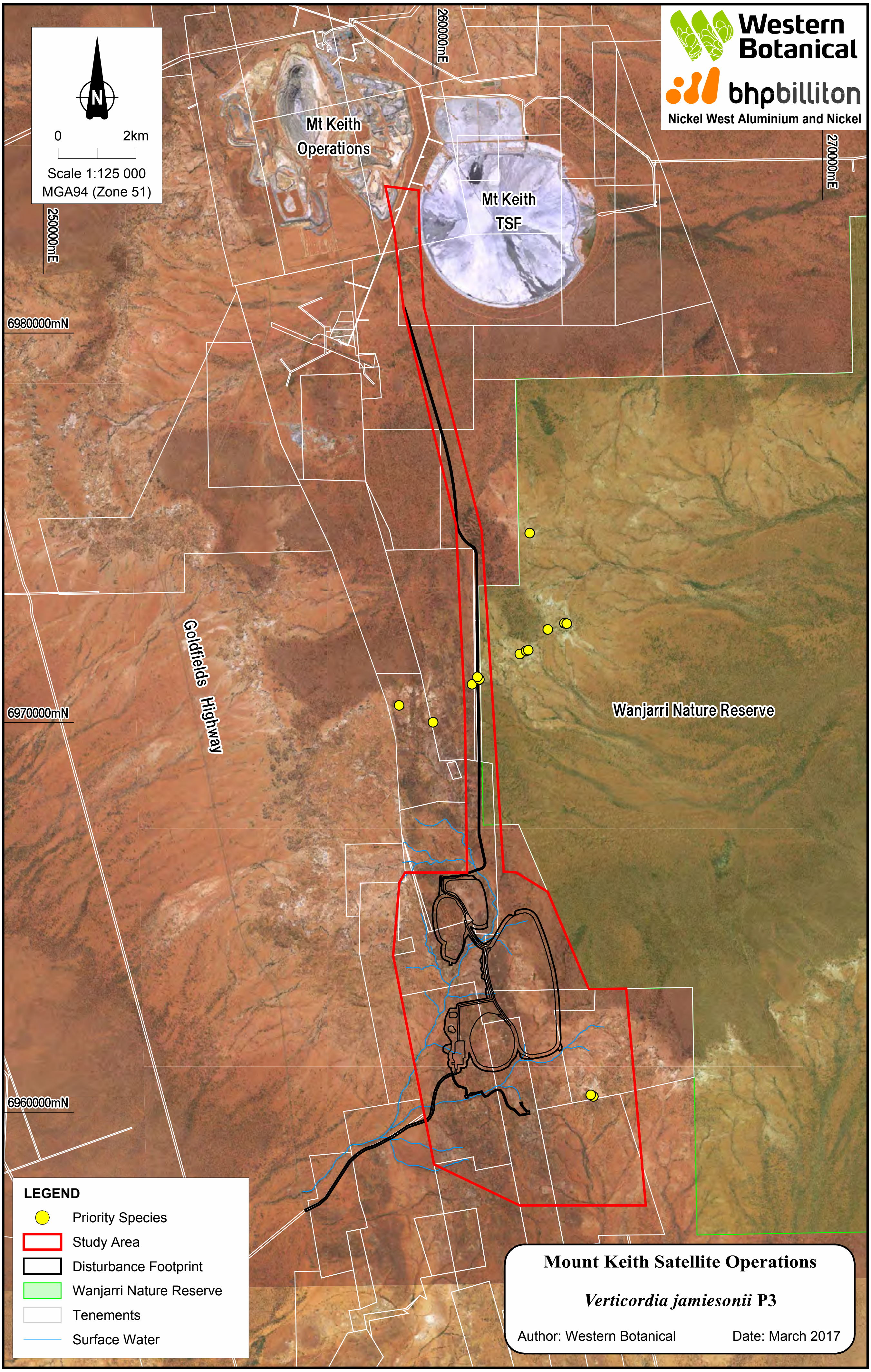


Figure 34. Distribution of *Verticordia jamiesonii* (P3) within Western Australia (Florabase, July 2016).

Figure 35. Populations of *Verticordia jamiesonii* (P3) within and near the MKS Proposal Study Area.



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Tribulus adelacanthus Priority 3

Tribulus adelacanthus P3 is a prostrate annual herb with distinctive fruits (Plate 10). A relatively newly described species, it is similar to *Tribulus cistoides* and was incorrectly identified at the time of the earlier surveys (Western Botanical 2006). The taxonomy of this group is still confused (Barker, 1998).

Plate 10. Scan of *Tribulus adelacanthus* P3, about actual size.

Tribulus adelacanthus P3 is known from 14 specimens, representing 6 populations in WA (Figure 36). A collection within the Mt Keith Operation's Caprock borefield is vouchered at the WA Herbarium and other vouchers range from Mt Magnet to the Jack Hills and Mount Gould, north-west of Meekatharra (Figure 37).

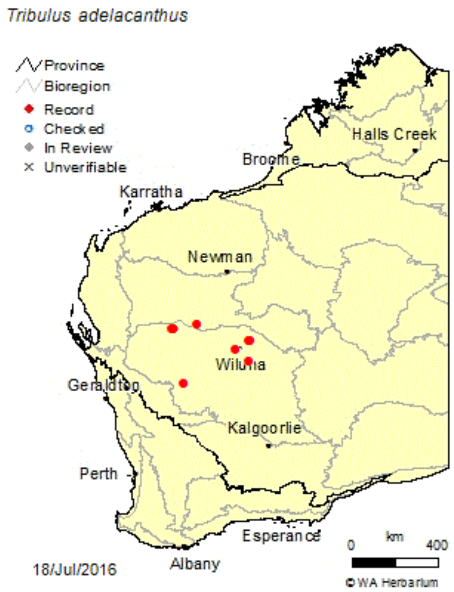
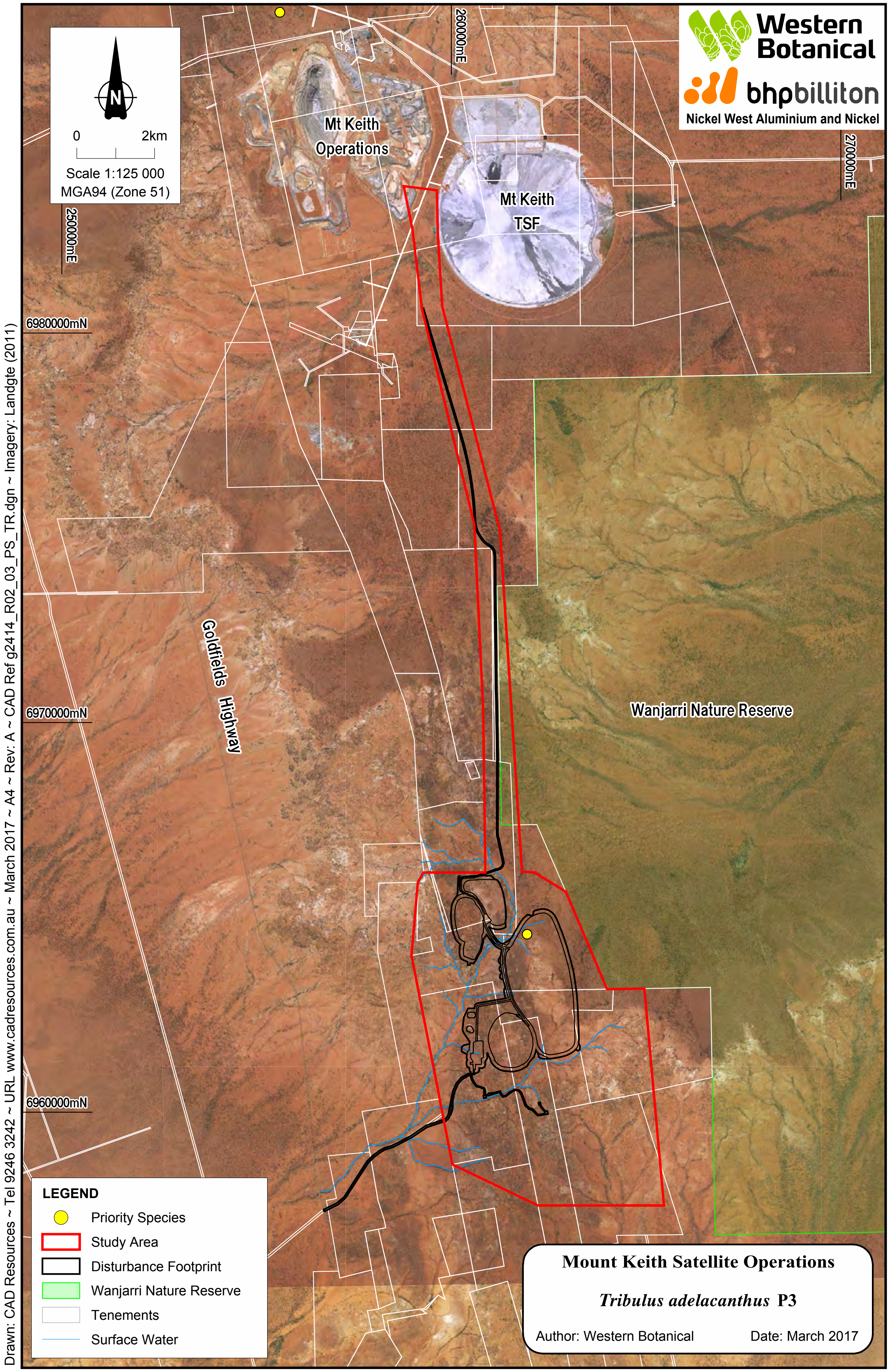


Figure 36. The Distribution of *Tribulus adelacanthus* P3 in WA (Florabase, July 2016)

One record of *Tribulus adelacanthus* P3 is known within the MKS (Figure 37). It is highly likely this species is more prevalent within the MKS Proposal Study Area than the current data indicates, however, surveys for this annual species need to occur following adequate rainfall, to determine the extents and numbers of the local population. From the WA Herbarium data, it is clear that *Tribulus adelacanthus* has been commonly recorded in association with limonitic landforms and therefore is regarded as being highly likely that the species is more widespread within the Perseverance Greenstone Belt than the current data indicates.

Given the scant nature of information on this species, no firm impact assessment on *Tribulus adelacanthus* can be made at this stage.

Figure 37. Records of *Tribulus adelacanthus* within and nearby the MKS Proposal Study Area.



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Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Priority Species
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Tribulus adelacanthus P3
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_03_PS_TR.dgn ~ Imagery: Landgte (2011)

Appendix 3. Species of Interest within the MKS Proposal Study Area

Undescribed species with limited distribution

Eremophila sp. long pedicels (G. Cockerton 1975)

Eremophila sp. long pedicels (G. Cockerton 1975) is a species that was first discovered at the Mt Keith Nickel Operation (NMK) in 1996 by Geoff Cockerton & Kirsty Stratford. It is known primarily from the area both upstream (small population) and downstream (much larger population) of the Mt Keith Operation's Central Discharge Tailings Storage Facility (CDTSF) and would have also occurred within the bounds of this infrastructure.

It is a domed shrub to 0.7m in height x 1 to 1.5m diameter (Plate 11) with glabrous, dark green, glossy filiform leaves with a prominent ventral groove. Purple (rarely white) flowers are held on long sinusoidal pedicels to 20 mm long (Plate 12) and fruits are to 8mm diameter with prominent simple hairs on the pericarp. It is found associated with sheet flow dependent habitats (SAMU, HPMS, DRMS) at Mt Keith, within the drainage line that extends eastwards from the NMK CDTSF and which eventually is absorbed by the sandplains to the east. A small population is also known in a narrow drainage line on the northern shore of the eastern part of Lake Way and there are a few isolated records in catchments of Lake Maitland.

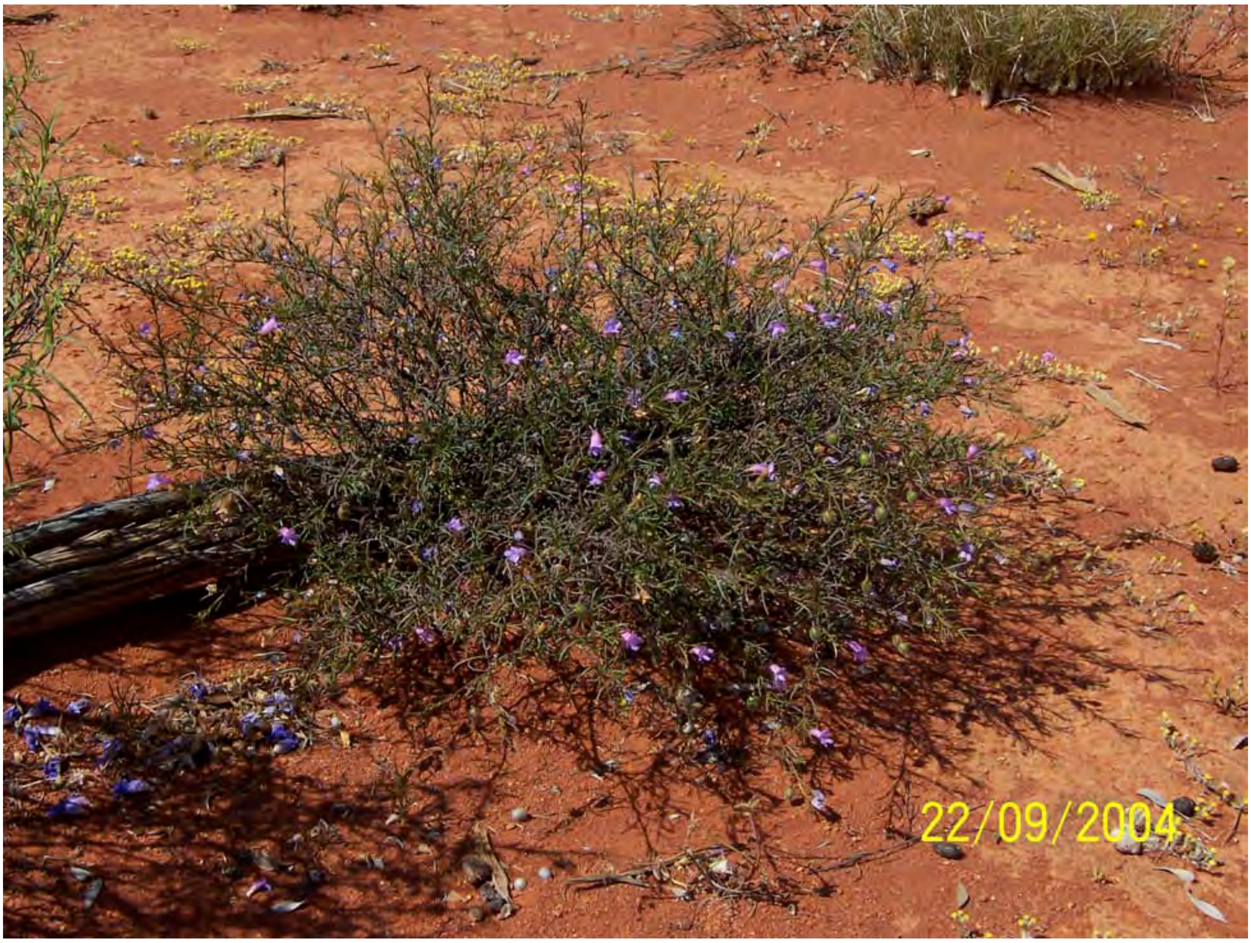


Plate 11. *Eremophila* sp. long pedicels (G Cockerton 1975) at Mt Keith.

The drainage line heading eastwards from the NMK CDTSF intrudes into the Wanjarri Nature Reserve's northern boundary. A small number of *Eremophila* sp. long pedicels is known to exist within this limited area within the WNR though the population here has not been assessed.

Plate 12. *Eremophila* sp. long pedicels (G Cockerton 1975), foliage, flower and fruit detail.

The northern extent of the proposed MKS Haul Road intercepts the small population of *Eremophila* sp. long pedicels on the south-western perimeter of the NMK CDTSF within a SMAU habitat. While the species has not been quantified at NMK, it considered locally abundant downstream of the CDTSF and the loss of a few individuals due to Haul Road construction is not considered a significant impact on the species.

The known distribution of *Eremophila* sp. long pedicels is presented in Figure 38, Figure 39 and Figure 40. While the regional population of *Eremophila* sp. long pedicels has been estimated at a minimum of 37,011 plants (Western Botanical), the number within the proposed Disturbance Envelope have not been assessed in detail. It is expected, however, that the number of plants at the northern end of the MKS proposed haul road are low, fewer than 200, and the overall impacts will be insignificant.

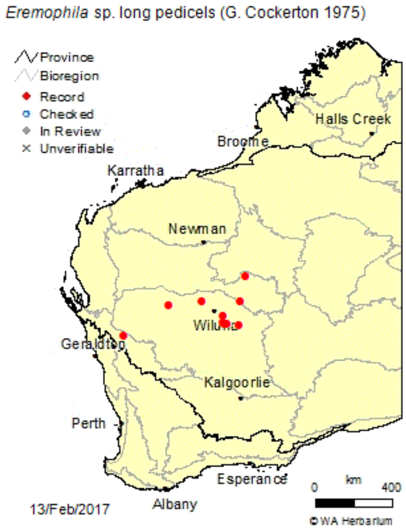
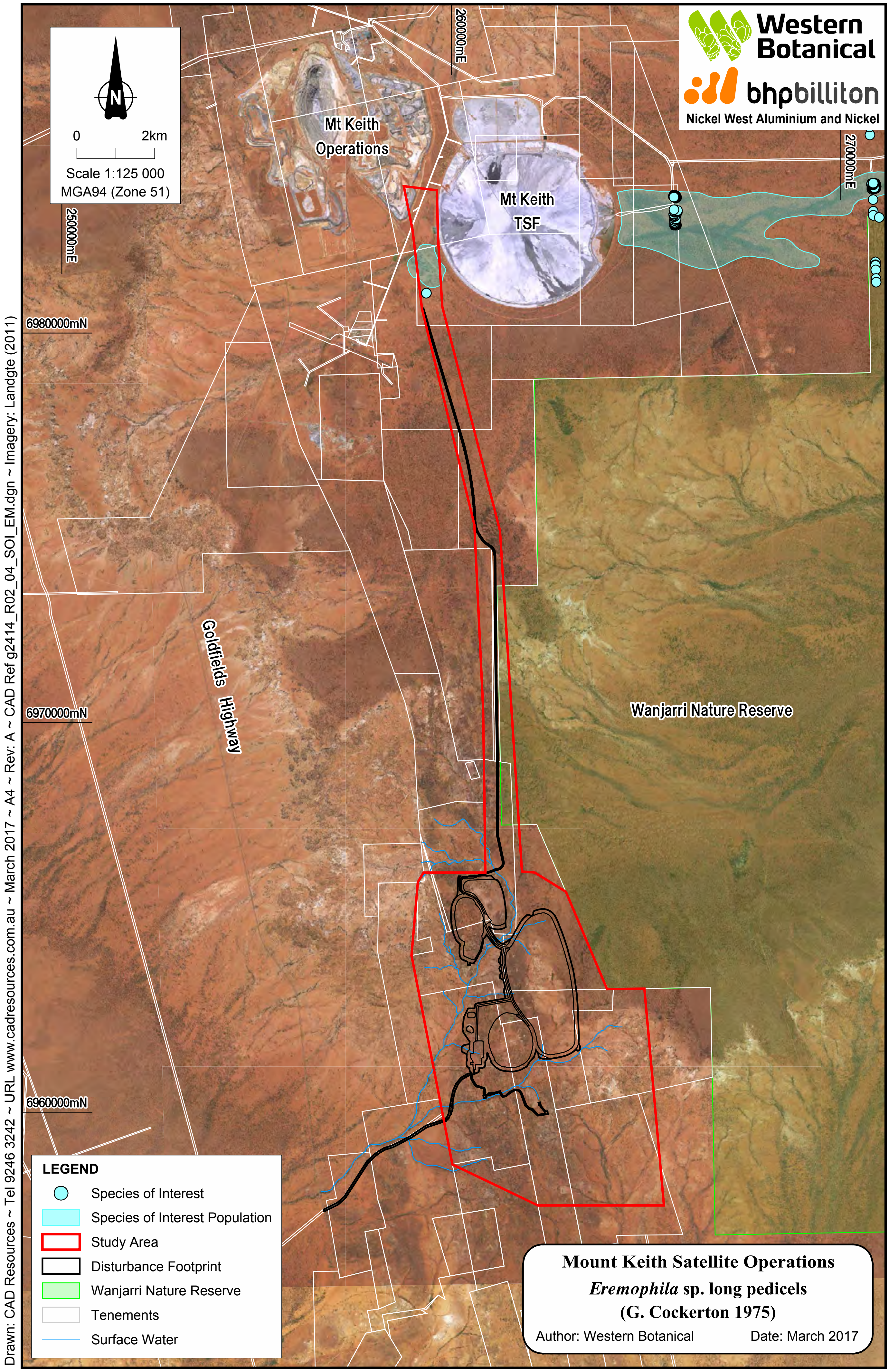


Figure 38. Distribution of *Eremophila* sp. long pedicels (G Cockerton 1975) in Western Australia (Florabase, February 2017) inclusive of specimens that likely do not represent this species.

Figure 39. Distribution of *Eremophila* sp. long pedicels (G Cockerton 1975) in Western Australia (AVH, February 2017), focussed on the specimens that do represent the species.

Figure 40. Known distribution of *Eremophila* sp. long pedicels (G Cockerton 1975) within the MKS Haul Road alignment and at Mt Keith.



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Mt Keith TSF
Goldfields Highway
Wanjarri Nature Reserve
LEGEND
Species of Interest
Species of Interest Population
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Eremophila sp. long pedicels
(G. Cockerton 1975)
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_04_SOI_EM.dgn ~ Imagery: Landgte (2011)

Species with uncertain taxonomic status, requiring further review

Acacia aff. *doreta* (narrow pod form) (G. Cockerton & S. Cockerton WB38633)

Acacia aff. *doreta* has been previously reported as *Acacia grasbyi* between Leinster and Mt Keith to date in all previous reports. It is a small tree to 6 m high with terete foliage to 8 cm long and narrow flat pods to 3 mm wide and red Miniritchie bark, Figure 41. The updated taxonomy follows description of *A. doreta* in Maslin (2014). However, the fruits of the plants between Leinster and Yakabindie, occurring on the basalt which is dominant in parts of the Mt Keith – Perseverance fault line and both within and outside the Violet Range PEC, are significantly narrower than those of the described species. Further the substrate on which the plants obligately occur here contrasts strongly with the sandplains and limonitic landforms of other collections housed at the WA Herbarium.

Figure 41. *Acacia* aff. *doreta*, Yakabindie Station, MKS Proposal Study Area, October 2016.

Acacia doreta is itself widespread, Figure 42, however, the characteristics of the species found at Yakabindie is warranted. A review by Mr. Bruce Maslin of the abundant material collected on Yakabindie Station in late spring 2016 is under way in March 2016.

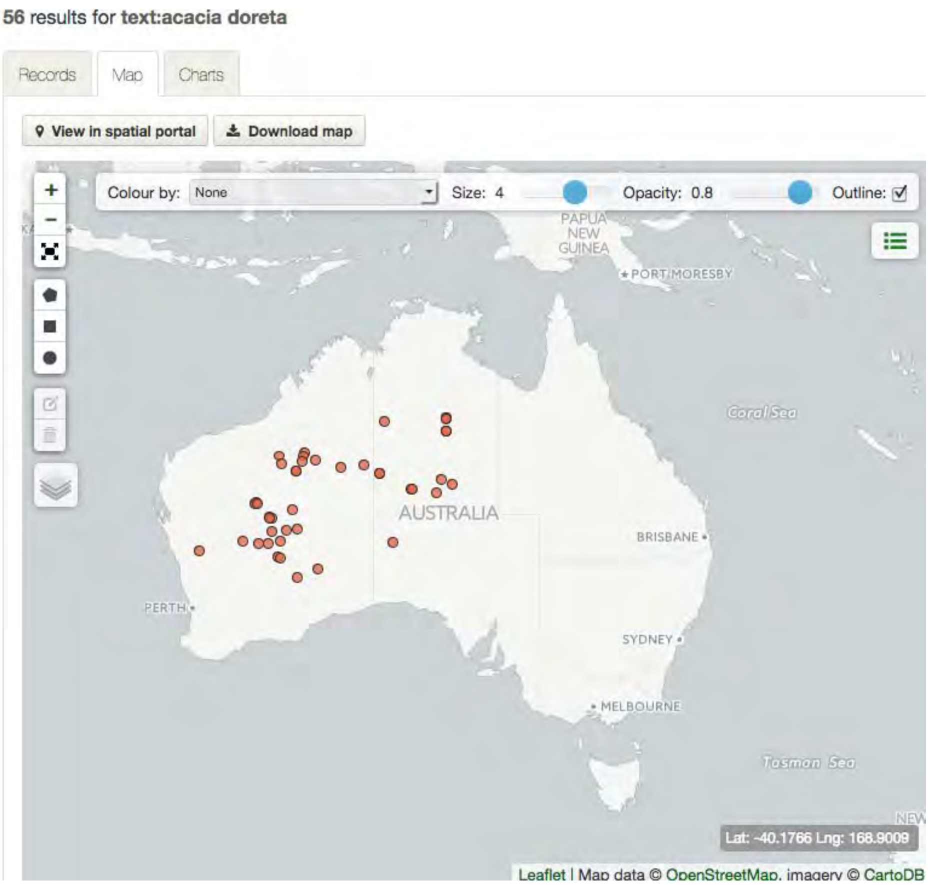


Figure 42. Distribution of *Acacia doreta* in Australia (AVH, February 2017)

***Acacia* aff. *subtessarogona* (flat pod form) (G. Cockerton WB38658);**

Acacia aff. *subtessarogona* (flat pod form) (G Cockerton WB38658) is a multi-stemmed shrub to 4 m high with pale green flat phyllodes to 12 cm long x 12 mm wide and notably flat pods to 8 cm long x 8 mm wide, Plate 13.

A review of specimens held at the WA Herbarium found that typical *A. subtessarogona* has a pod that is markedly quadrangular in cross section, compared with the flat pod of the specimens at Yakabindie, Wiluna and Meekatharra. Further, there is a strong disjunction in the distribution of the two forms, with the typical form being common between Exmouth and Carnarvon in the western Gascoyne, while the flat pod form is known form a few scattered collections near Meekatharra, Yakabindie Station, Wiluna and one in the Gt Sandy Desert, Figure 43.

Plate 13. *Acacia* aff. *subtessarogona* (flat pod form) (G Cockerton WB38658), Yakabindie Station, adjacent to the Kalgoorlie – Wiluna Highway, 2010.

The flat pod form of *Acacia* aff. *subtessarogona* is uncommon on Yakabindie Station and is mostly associated with gritty sandy plains down slope of the Archaean granite breakaways of the Barr-Smith Range. However, a few individuals are also known south of the proposed MKS Development Envelope, within the Proposal Study Area, Figure 44.

No *Acacia* aff. *subtessarogona* lie within any proposed Development Envelope within the MKS Proposal Study Area.

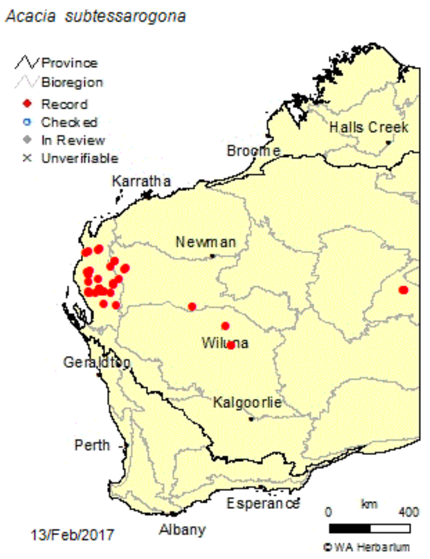
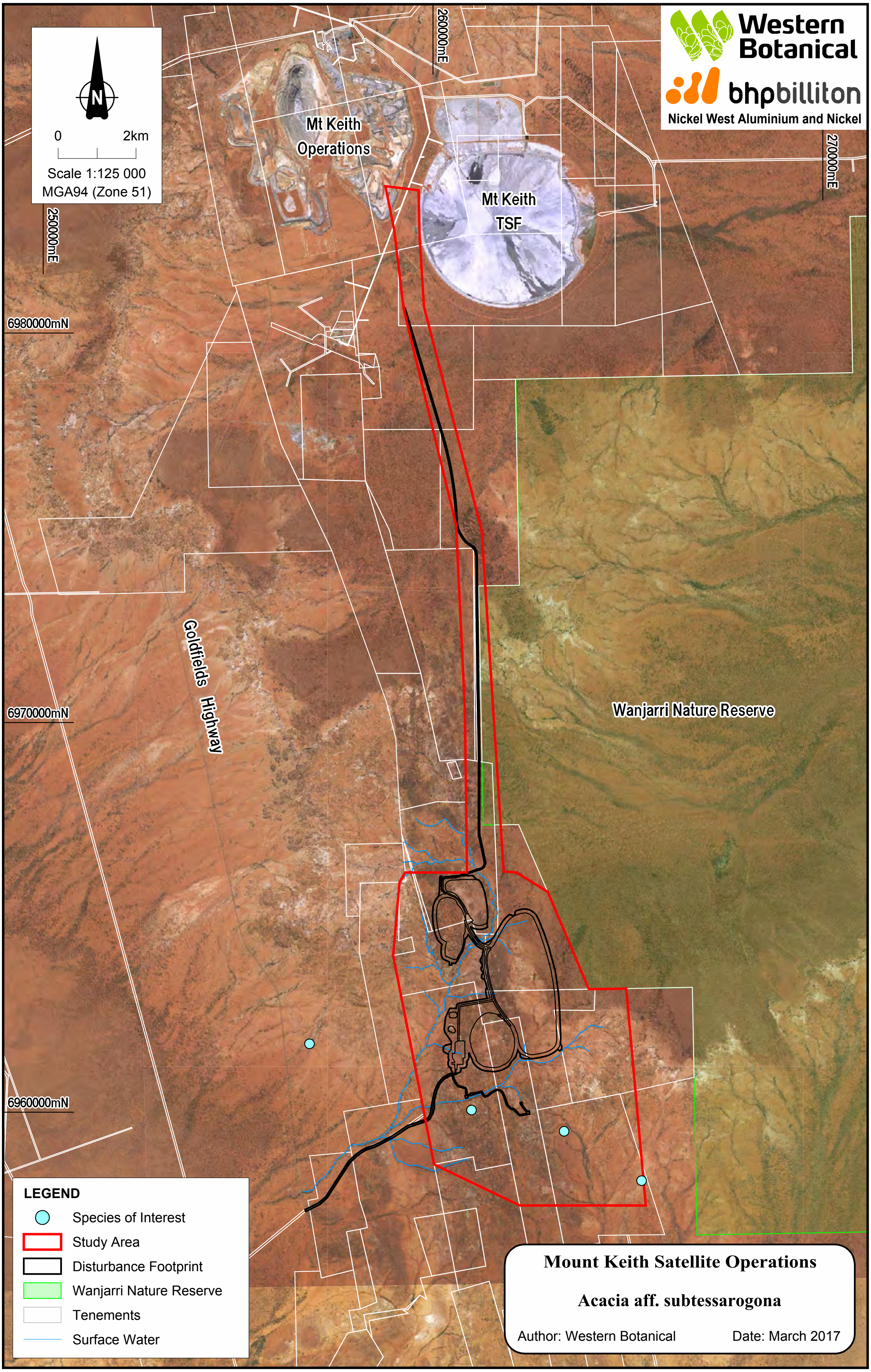


Figure 43. Distribution of *Acacia subtessarogona* in Western Australia.

Populations near the coast represent the typical form while the scattered points between Meekatharra and the N.T. border represent the flat pod form.

Figure 44. Known locations of *Acacia* aff. *subtessarogona* within and near the MSKO Proposal Study Area



Mount Keith Satellite Operations

Acacia aff. subtessarogona

Author: Western Botanical

Date: March 2017

Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_04_SOI_AS.dgn ~ Imagery: Landgte (2011)

Acacia aff. _xanthocarpa_ (terete to flat phyllode, resinous margins complex, inclusive of _Acacia_ sp. East Murchison Basalt (G. Cockerton 38064))

Acacia xanthocarpa was described from specimens collected near Meekatharra and is currently mapped as occurring as far south-east as near Leonora, within the Murchison biogeographic region (Cowan & Maslin, 1995), Figure 45. It has terete to subterete phyllodes and lacks any red glandular margins. It has a characteristically hairy pod.

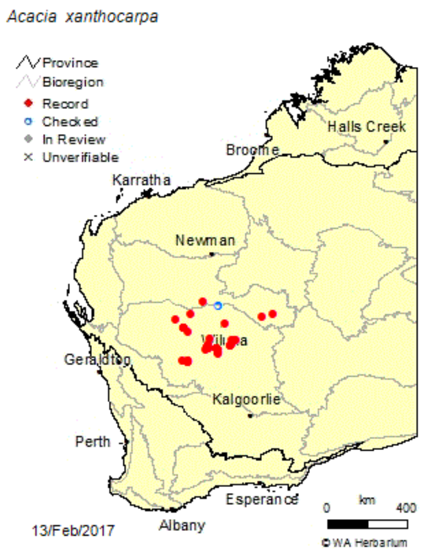


Figure 45. Distribution of _Acacia xanthocarpa_ in Western Australia

In field assessments on Yakabindie Station in May 2016, specimens of *Acacia* '*xanthocarpa'* were observed to have distinctly red margins on the phyllodes, which also varied in shape from terete to subterete to clearly flat (to 3 mm wide). Further collections made in October 2016 found pods were either characteristically hairy, as in typical *A. xanthocarpa*, or were markedly less hairy and flattened (rather than raised over the seeds) as in the typical form.

The terete leaved, red margined, hairy pod form of *Acacia 'xanthocarpa'* is common and widespread on the basalt geology of the Mt Keith – Perseverance fault line on Yakabindie Station. However, the flat leaved, red-margined form with flat non-hairy, resinous pods is only known from within the proposed MKS wastedump footprint and from two small populations, one on Barwidgee Station, some 100 km north of Yakabindie Station east of Wiluna and one south of Lake Miranda. This is here termed *Acacia* sp. East Murchison Basalt (G Cockerton WB38064).

A review of specimens held at the WA Herbarium in January 2017 found no records of '*Acacia* sp. East Murchison Basalt (G Cockerton WB38064) flat leaved, red margined, non-hairy resinous pod form' known from elsewhere.

In order to clarify the taxonomy and the conservation status of the species, a thorough review of the *Acacia xanthocarpa* complex, inclusive of *Acacia* sp. East Murchison Basalt (G Cockerton WB38064), is required. A start will be made on this in March 2017 by Mr. Bruce Maslin.

This is by far the most challenging group of *Acacia* to deal with in the MKS Proposal Study Area. Either there are three separate species with closely related phyllode and pod characteristics or there are two species with possible significant hybridisation occurring on the basalt geology of the Mt Keith – Perseverance fault line and in the Violet Range PEC.

The formal description of *Acacia xanthocarpa* is presented in Nuytsia Vol 10: 58-59 (1995). A description of *Acacia* sp. East Murchison Basalt (G. Cockerton WB38064) is presented below.

Acacia sp. East Murchison Basalt (G. Cockerton WB38064)

Acacia sp. East Murchison Basalt (G. Cockerton WB38064) is a newly recognised species, which is found growing in two small sub-populations within the MKS Proposal Study Area.

Acacia sp. East Murchison Basalt is a single trunked small tree 2 to 5 m high x 2 to 6 m wide (Plate 14). Bark rough, grey on trunk and major branches; smooth grey on distal branches and twigs. Phyllodes glossy, dark green, glabrous, linear, flat to quadrangular, 1.5 to 3 mm wide x 80 to 120 mm long, gland on dorsal surface 2 to 3 mm from pulvinus, tip acute, yellow to brown, strongly hooked, two major leaf margins with discontinuous red resin droplets, mid vein prominent on both surfaces making narrower phyllodes appear quadrangular in cross section (hence earlier confusion with *A. resinimarginea*). Pods are flat, to 100 mm long x 7 to 8 mm wide with slightly raised margins and slightly swollen over the seeds; surface is sparsely hairy with simple white hairs and the surface of the pods is covered in clear resin.

Acacia sp. East Murchison Basalt is known from three locations on basalt (greenstone) hills between Menzies and Wiluna, Figure 46. The largest population known to date, estimated at several hundred plants occurring over an estimated 2.96 ha occurs within the MKS Proposal Study Area, on the margin of the Golaith orebody pit area and the eastern wastedump (indicative point 51J 261927, 6962350), Figure 47. A small population of fewer than 50 plants is known from a small basalt rise on Barwidgee Station (51J 278048, 7021419) while a small population of a dozen or so plants is known from an area south-west of the MKS Proposal Study Area, south of Lake Miranda (51J 264461, 6929273).

Plate 14. Tree to 4m high x 6m wide, Yakabindie Station, 2016, growing on footslope of low basalt shale ridge.

Plate 15. Rounded tree in centre of image to 4m growing on low basalt shale ridge, Yakabindie Station, 2016

Plate 16. Foliage and flowers, Yakabindie Station, 2016

Plate 17. Immature fruit, Barwidgee Station, 2005

Plate 18. a & b. Basalt shale rock supporting *Acacia* sp. East Murchison Basalt, Yakabindie Station 2016.

Similar species: Acacia* aff. *resinimarginea

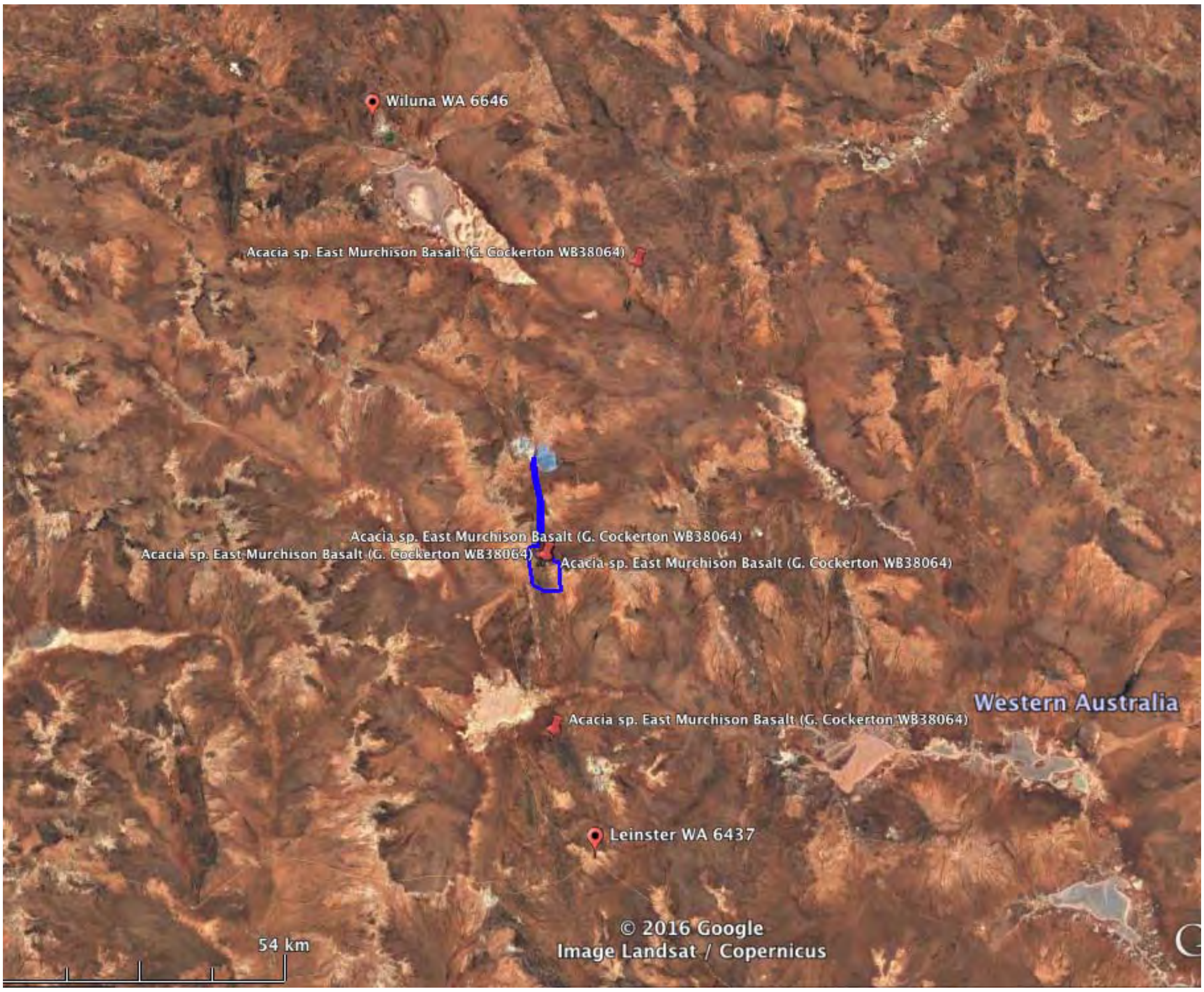
A similar species, *Acacia* aff. *resinimarginea,* is known from six specimens held at the WA Herbarium and ranges from south of Leinster to near Menzies. It's phyllodes are quadrangular cross section when dried, resembling phyllodes of *Acacia resinimarginea*. *Acacia resinimarginea* is a tree 4 to 6m tall which grows on yellow gravely sandplains and has dull grey-green phyllodes which are clearly quadrangular in cross section. Specimens of *Acacia* aff. *resinimarginea* held at the WA Herbarium are largely vegetative with only one having flowers. No fruit were present on any specimens.

The 6 records of *Acacia* aff. *resinimarginea* noted in Western Botanical (2016), have since been reviewed by Mr. Bruce Maslin at the WA Herbarium. This review found that the species listed under this name is a separate taxon closely related to *Acacia quadrimarginea* and *A. xanthocarpa* and the relationship of that species to *Acacia* sp. East Murchison Basalt (G Cockerton WB38064) at MKS remains unclear. Further review of the species complexes is planned in March 2017.

The fruit characteristics are key distinguishing features of this group of species and are necessary for differentiation from other superficially similar or related taxa (*Acacia quadrimarginea*, *A. lapidosa* P1, *A. xanthocarpa*).

Figure 46. Known regional distribution of *Acacia* sp. East Murchison Basalt (G Cockerton WB38064).

Insert map


Wiluna WA 6646
Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
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Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
Western Australia
Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
Leinster WA 6437
54 km
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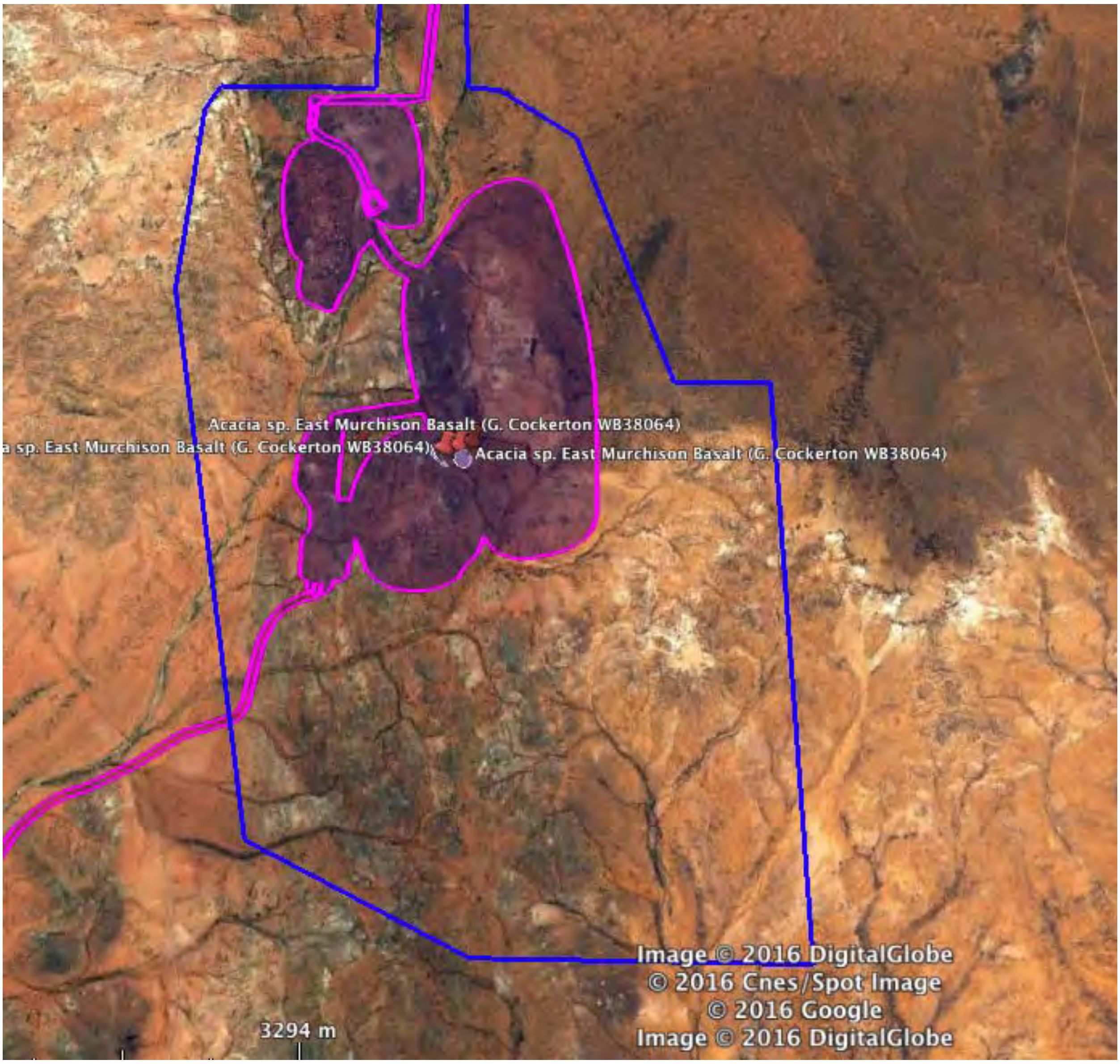
Image Landsat / Copernicus

Figure 47. Known occurrence of *Acacia* sp. East Murchison Basalt (G Cockerton WB38064) within the MKS Proposal Study Area.

Insert map


Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
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Acacia sp. East Murchison Basalt (G. Cockerton WB38064)
Image © 2016 DigitalGlobe
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Image © 2016 DigitalGlobe
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***Hibbertia* sp. Sherwood Breakaways aff. *H. exasperata* (G Cockerton & G O'Keefe 11911)**

The *Hibbertia exasperata* group requires further taxonomic work and the complex is acknowledged as containing several entities. The small population of *Hibbertia* sp. Sherwood Breakaways aff. *exasperata* in the MKS Proposal Study Area represents one of the most northerly population of the broader *H. exasperata* complex and is disjunct from other populations of *Hibbertia exasperata* in W.A. (Figure 48).

Hibbertia sp. Sherwood Breakaways aff. *H. exasperata* is a shrub to 1m high with dark green, glabrous, glossy pungent needle-like leaves to 15 mm long and large yellow flowers (Plate 19, Plate 20).

Plate 19. Habitat and shrub of *Hibbertia* sp. Sherwood Breakaways aff. *exasperata*.

Plate 20. Foliage and post-anthesis flower of *Hibbertia* sp. Sherwood Breakaways aff. *exasperata*.

Hibbertia sp. Sherwood Breakaways aff. *exasperata* is known from 67 plants on low breakaways in the transport corridor (Sherwood Land System) within the Proposal Study Area with a further 25 plants known from west of this site (Bevon Land System), outside the Proposal Study Area (Figure 49).

Another taxon, here termed *Hibbertia* aff. *arcuata*, is also known from the lateritic landforms north-west of the MKS Proposal Study Area. The two species closely resemble each other and their relationship to each other is not clearly understood. It is possible that the 25plants of *Hibbertia* found west of the MKS Proposal Study Area are actually the latter, *Hibbertia* aff. *arcuata*.

Further complicating the issue is that a specimen collected by Ray Cranfield in 1988 (RJ Cranfield 6771, PERTH 03040909) has been curated as *Hibbertia arcuata.* This is another of the pungent leaved *Hibbertia* species with a very broad and disjunct distribution in the south-west of W.A. This specimen and *H. pungens* more broadly, should be included in any review of the *Hibbertia* of inland W.A.

Taxonomic clarification of the Hibbertia species in the Mt Keith region, inclusive of those at the MKS Proposal Study Area, require the collection of additional flowering and fruiting material, and review by a competent *Hibbertia* expert, before their status can be verified. Any review of the species within and near MKS will by necessity include a review of similar species within the *H. exasperata, H. arcuata* and *H. pungens* groups. It is possible that the taxa are more widespread on the Barr-Smith Range and the Bevon Land System in the region between Wiluna and Leinster.

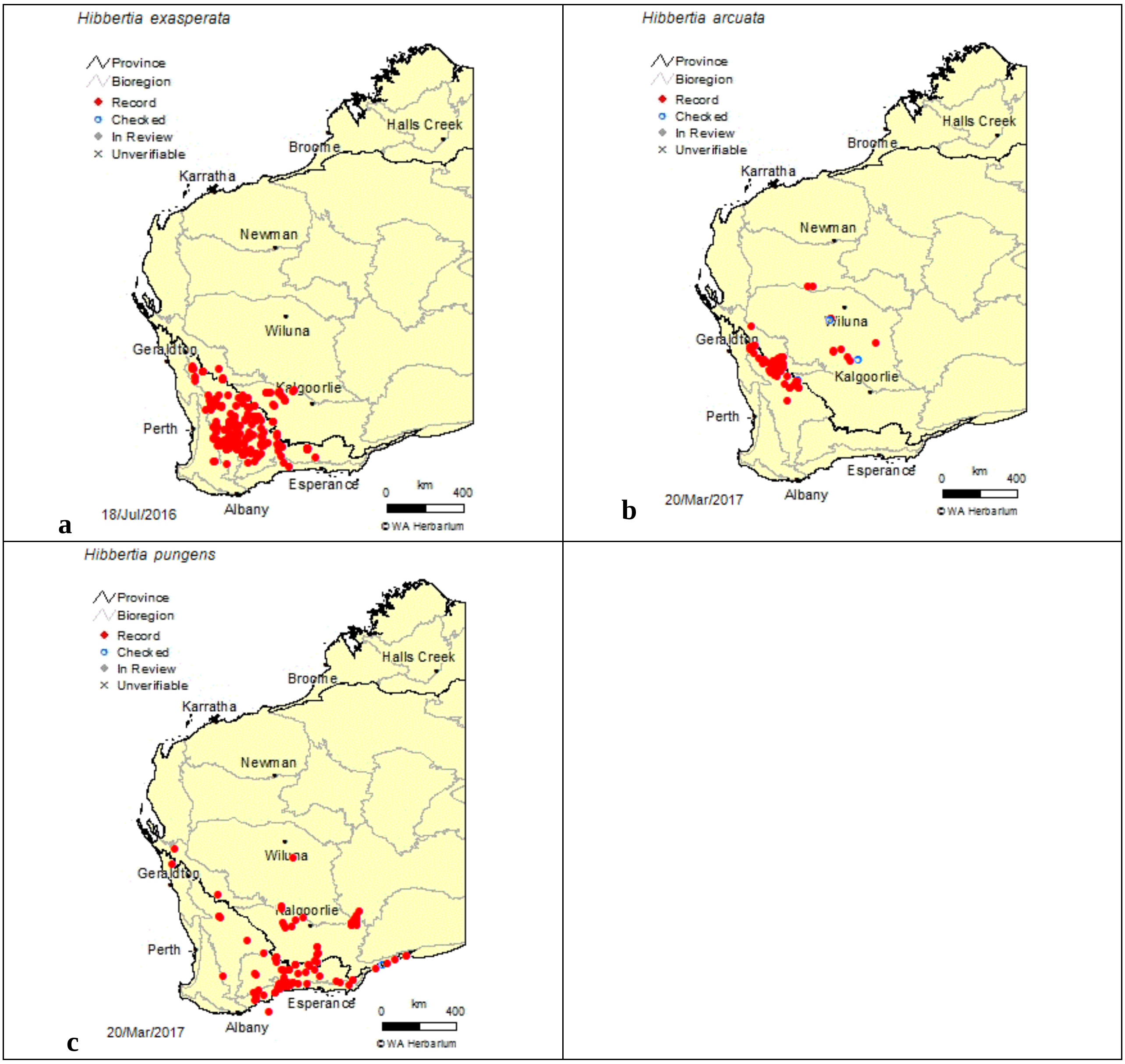


Figure 48. Distribution of the (a) *Hibbertia exasperata*, (b) *Hibbertia arcuata* and (c) *Hibbertia pungens* groups in WA (WA Herbarium, 2017).

Further collections of flowering and fruiting material need to be made and referred to a specialist taxonomist for finalisation of the species description.

Correspondence on this species, referred to at that time as "*Hibbertia* glabrous calyx lobes", from Dr. Kevin Thiele, WA Herbarium, 3rd February 2012, is presented below.

"*Hibbertia* glabrous calyx lobes" appears to be a member of the *H. exasperata* (Steud.) Briq. group of species, which includes *H. pungens* Benth. and *H. uncinata* (Benth.) F.Muell. This is a poorly understood group, with the boundary between *H. exasperata* and *H. pungens* particularly problematic. However, the specimens of "*H.* glabrous calyx lobes" you provided appear to differ from both these species, and may represent a new taxon.

Both *H. exasperata* and *H. pungens* have distinctly pedicellate flowers with a series of large, deciduous, brown bracts surrounding the base of the pedicel. The filaments of their stamens are free[3]. While it is difficult to tell from the material available, "*H.* glabrous calyx lobes" appears to have sessile flowers, perhaps without subtending bracts. The staminal filaments are clearly fused so that the stamens are grouped into five bundles of three stamens each. This is an important and diagnostic character in *Hibbertia*.

The rare and poorly understood species *H. uncinata* (three specimens only at PERTH, all with uncertain determinations) is recorded as having fused staminal filaments, but differs in its leaf dimensions and morphology.

Unfortunately, the available material of "*Hibbertia* glabrous calyx lobes" is in poor condition with very few flowers, all detached. This prevents a full analysis of its morphology and relationship with members of the *H. exasperata* group.

I have assessed all material at PERTH of *H. exasperata* and *H. pungens* and have found only one other specimen (*R.J. Cranfield 6771*, 8 km W of Wanjarri Homestead, PERTH3040909) that appears to match the material of "*H.* glabrous calyx lobes". This was also collected from very close to the Mount Keith mine site. Together, these represent a disjunct population well inland from the main range of *H. exasperata*. Unfortunately, *Cranfield 6771* also has very few flowers and is an inadequate specimen for detailed examination.

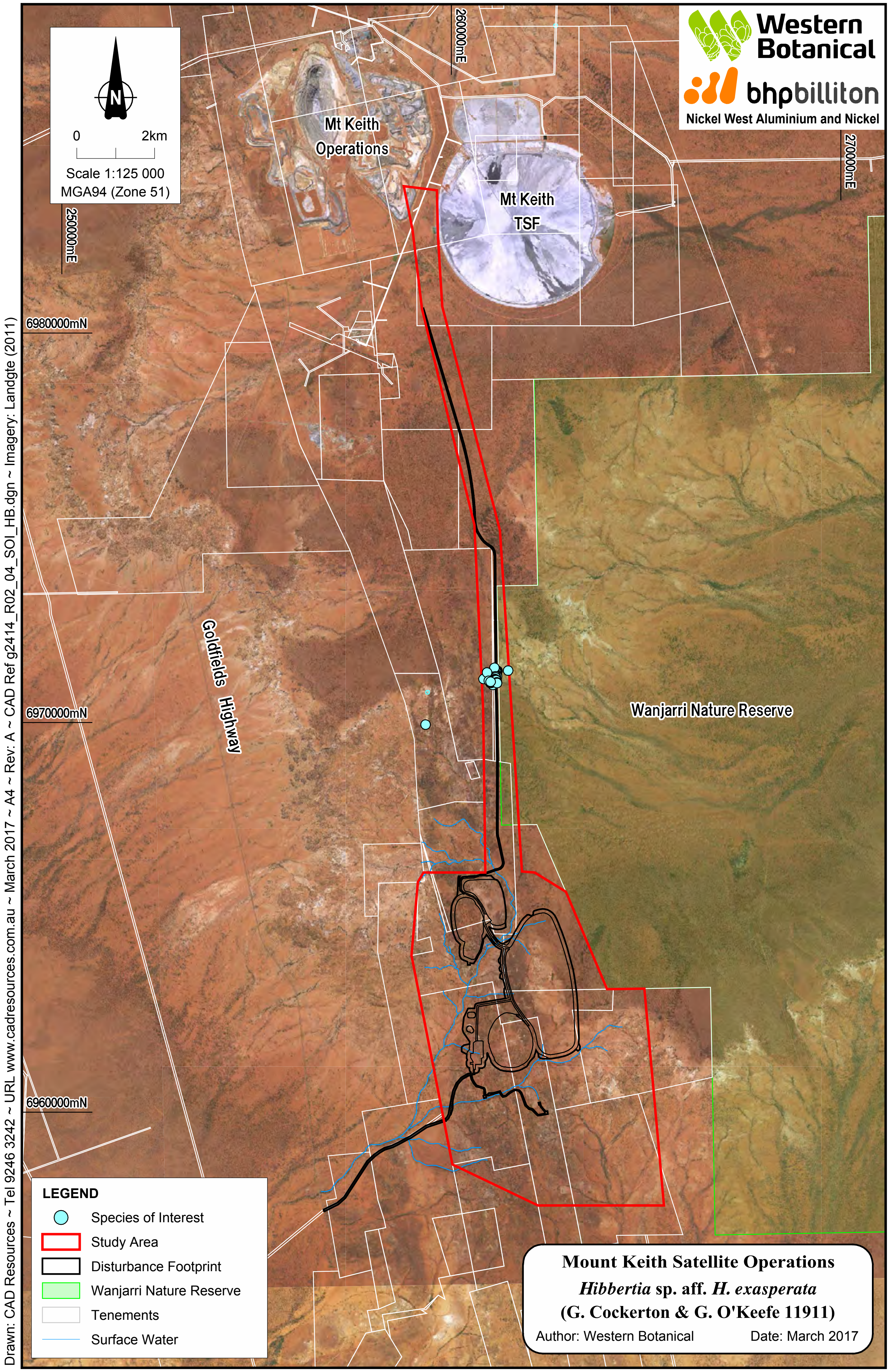
I recommend that "*Hibbertia* glabrous calyx lobes" should provisionally be regarded as a potentially new and rare taxon. However, I am not planning to phrase-name it on the Western Australian Census until better material can be obtained. I would encourage you to conduct surveys in spring to collect good flowering material and to estimate the abundance and distribution of the populations at the site.

For advice relating to proposed environmental impacts on "*Hibbertia* glabrous calyx lobes" I suggest you contact Dan Coffey from the Department of Environment and Conservation's Environmental Management Branch."

[3] Note that this refers to the entity currently accepted as *H. exasperata* at the Western Australian Herbarium. While this has free stamens, the species is described by De Candolle as having fused staminal filaments. It is possible that the taxon called *H. exasperata* at PERTH may not match the type of that species.

The known distribution of *Hibbertia* sp. Sherwood Breakaways aff. *H. exasperata* (G Cockerton & G O'Keefe 11911) is presented in Figure 49. Some or all of the 67 known plants within the proposed Development Envelope (within the proposed MKS haul road) may be taken in development. Regional surveys for this species have not yet been undertaken.

Figure 49. The known distribution of *Hibbertia* sp. Sherwood Breakaways aff. *H. exasperata* (G Cockerton & G O'Keefe 11911) within and nearby the MKS Proposal Study Area.



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Hibbertia sp. aff. *H. exasperata*
(G. Cockerton & G. O'Keefe 11911)
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_04_SOI_HB.dgn ~ Imagery: Landgte (2011)

Olearia sp. Sherwood Breakaways (A. Taylor 25552)

Olearia sp. Sherwood Breakaways (A. Taylor 25552) is a shrub to 0.7 m high, commonly no more than 0.3 m high, x 0. 3m wide with small hairy, dentate grey-green leaves and small purple flowers on short terminal stalks (Plate 22, Plate 23). It is found exclusively on the breakaway plateaux of the Sherwood Land System in the Leinster – Wiluna region but is also known from low Banded Ironstone Hills west of Menzies. It is currently curated within *Olearia stuartii*, a group that is in dire need of formal taxonomic revision.

Olearia sp. Sherwood Breakaways was first recorded on the breakaway plateaux of the Barr-Smith Range (Plate 21) west of NMK in 1996 and has since been irregularly encountered on rocky landforms within and outside the MKS Proposal Study Area.

Plate 21. Low breakaway of Archaean granite, Sherwood Land System, Mt Keith, July 2007, supporting *Olearia* sp. Sherwood Breakaways (A Taylor LCH 25552).

Plate 22. Shrub of *Olearia* sp. Sherwood Breakaways, around 0.7m high

In the local region, *Olearia* sp. Sherwood Breakaways has fewer than 1,000 individuals known and is associated with a very specific parent rock, soil and landscape position. In the Mt Keith to Leinster area, it is associated with a range of species with limited distribution including *Calytrix uncinata*, *Calytrix erosipetala*, *Sida picklesiana* P3, *Baeckea* sp. Melita Station, *Thryptomene* sp. Leinster P3, *Stenanthemum mediale* P1 as well as more common species such as the native Cypress Pine *Callitris columellaris*, *Acacia thoma* and Mulga (*Acacia aneura*). *Olearia* sp. Sherwood Breakaways is known from low Archaean granite outcrops and breakaways within and outside the MKS Proposal Study Area.

No direct impacts to *Olearia* sp. Sherwood Breakaways are likely from the MKS Project (Figure 50).

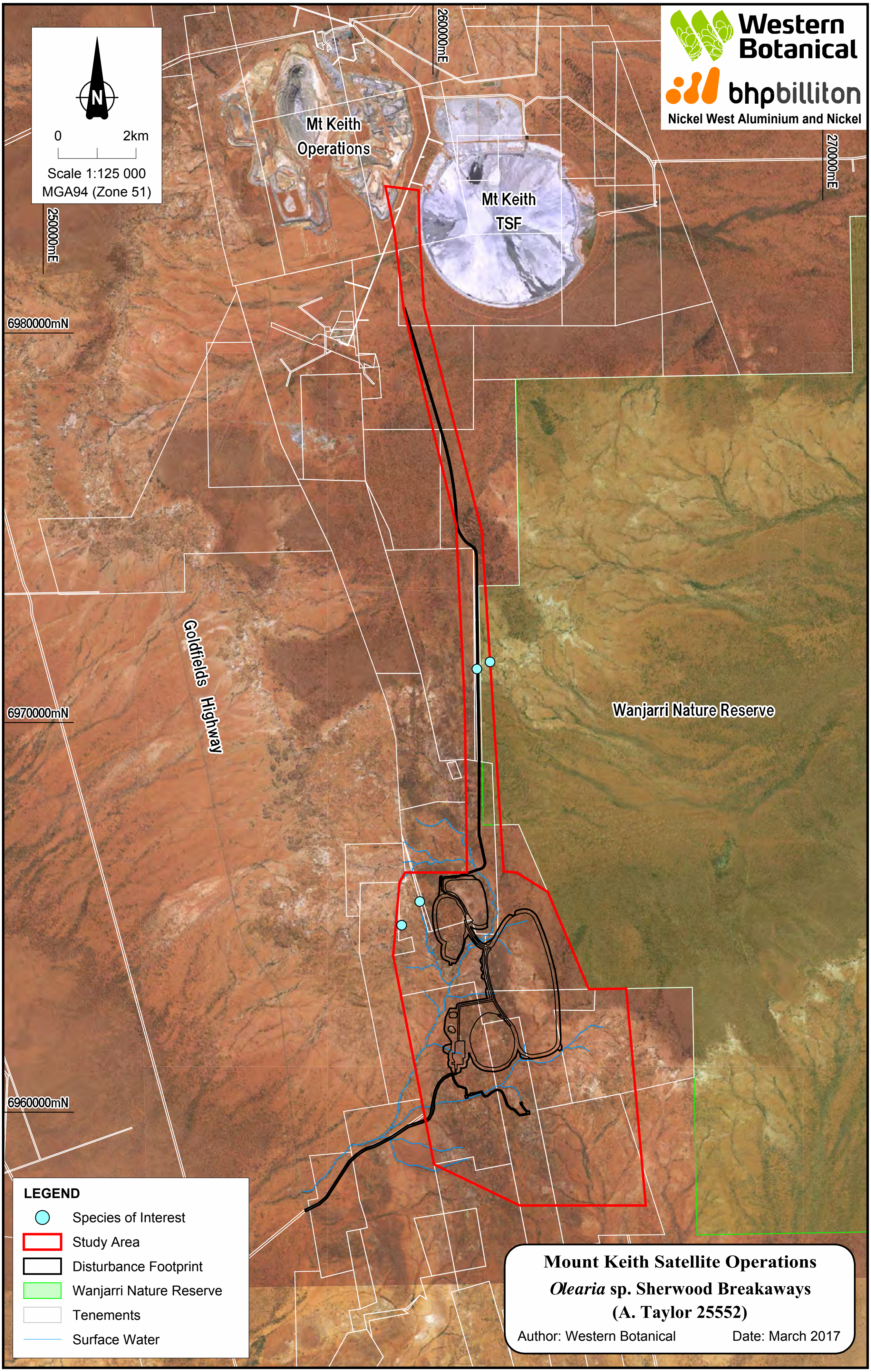
Plate 23. a. Flower, lateral view, about actual size; b. Flower, view from above, about actual size.

The *Olearia* sp. Sherwood Breakaways known from the Sherwood Land System, Archaean granite breakaways between Albion Downs Station, Yakabindie Station and Leinster Downs Station. It is also likely to occur on Weebo Station and other occurrences of the Sherwood Land System in this region. The species has also been collected by Jonathan Warden (Western Botanical) at Mt Alfred, on Perrinvale Station, west of Menzies.

The distribution of *Olearia* sp. Sherwood Breakaways within and nearby the MKS Proposal Study Area is presented in Figure 50.

A preliminary investigation into the *Olearia stuartii* complex as well as *O. humilis* at the WA Herbarium by Geoff Cockerton and subsequently by Dr. Steven Dillon (WA Herbarium), proved inconclusive in dealing with *Olearia* sp. Sherwood Breakaways though did confirm it's close relationship to *O. stuartii* in the Pilbara of W.A. This review did effectively separate other species that had misidentified within the two groups reviewed. A detailed analysis of WA Herbarium held material, likely incorporating other closely related taxa, is required to progress this species.

Figure 50. Known distribution of *Olearia* sp. Sherwood Breakaways within and outside the MKS Proposal Study Area.



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Olearia xerophila sens. lat. (G. Cockerton & P. Goodman WB38116)

In May 2016, specimens of an *Olearia* were collected on the eastern border of the MKS Proposal Study Area, Plate 24. These were identified as *Olearia xerophila*, matching material held at the WA Herbarium under that name that had been widely collected in the Pilbara region. Two records from between Wiluna and Meekatharra made by A.R. Fairall in 1966 represent occurrences in the Murchison biogeographic region. A review of the highly disjunct distribution of *Olearia xerophila* across Australia (Figure 51) led to a closer review of material held at the WA Herbarium's Research Collection in January 2017 where it was found that the TYPE collection for *O. xerophila* was taken from north-eastern Qld and that the WA entity differed significantly from that in the eastern part of it's distribution (Dr. Steven Dillon pers. comm.).

The review of the taxonomy of this group will require a Herbarium based review of the wider *Olearia xerophila* group. It is satisfactory at this stage to determine that the species located on the eastern margin of the MKS Proposal Study Area, outside any areas of proposed disturbance, fits within the species that is common in the Pilbara of WA and uncommon in the Murchison biogeographic region. In discussion with Dr. Steven Dillon at the WA Herbarium, who kindly reviewed the material held at the WA Herbarium, it has been resolved to label the WA material as *Olearia xerophila sens. lat*., awaiting further taxonomic revision of this group at a later stage.

Plate 24. _Olearia xerophila sens. lat._ shrub, MKS Proposal Study Area, May 2016.

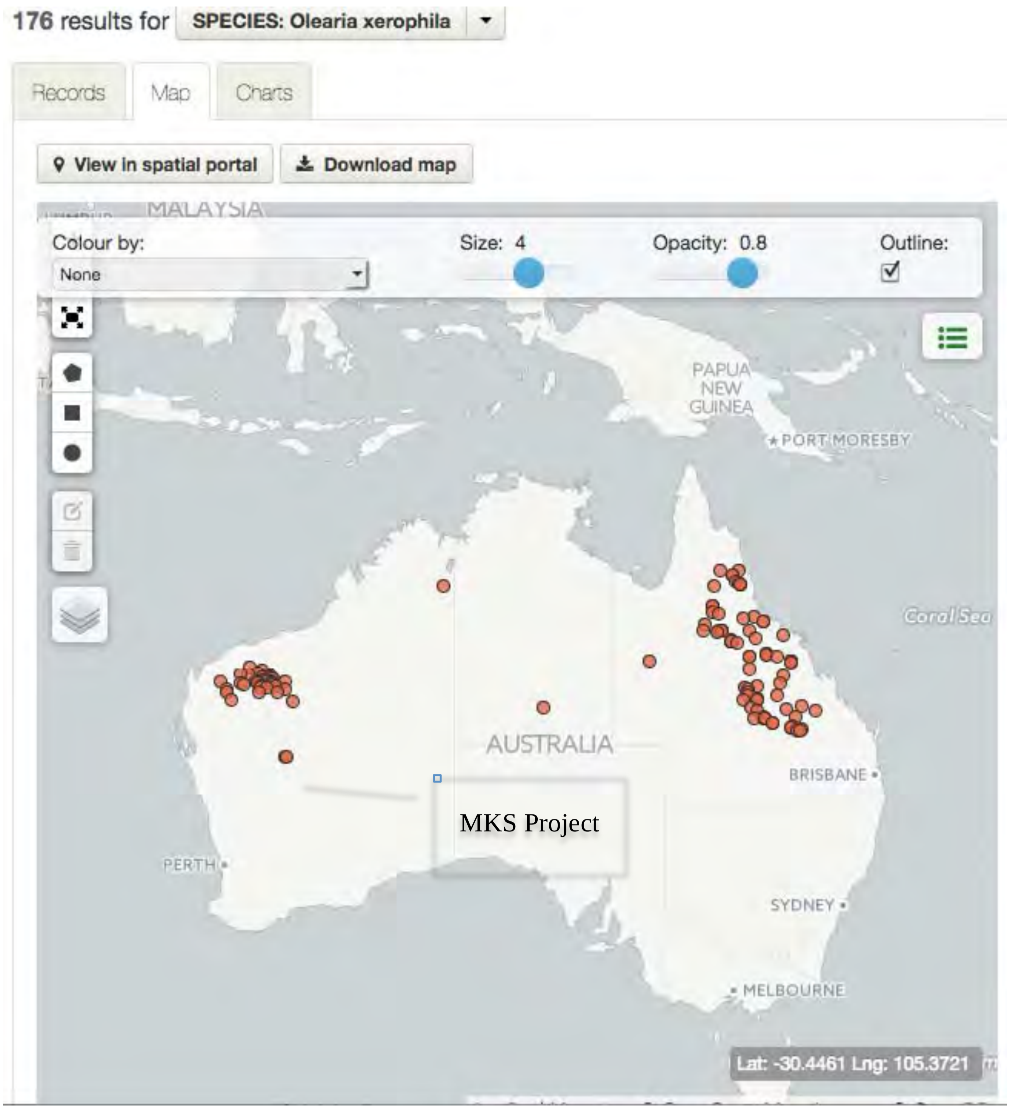
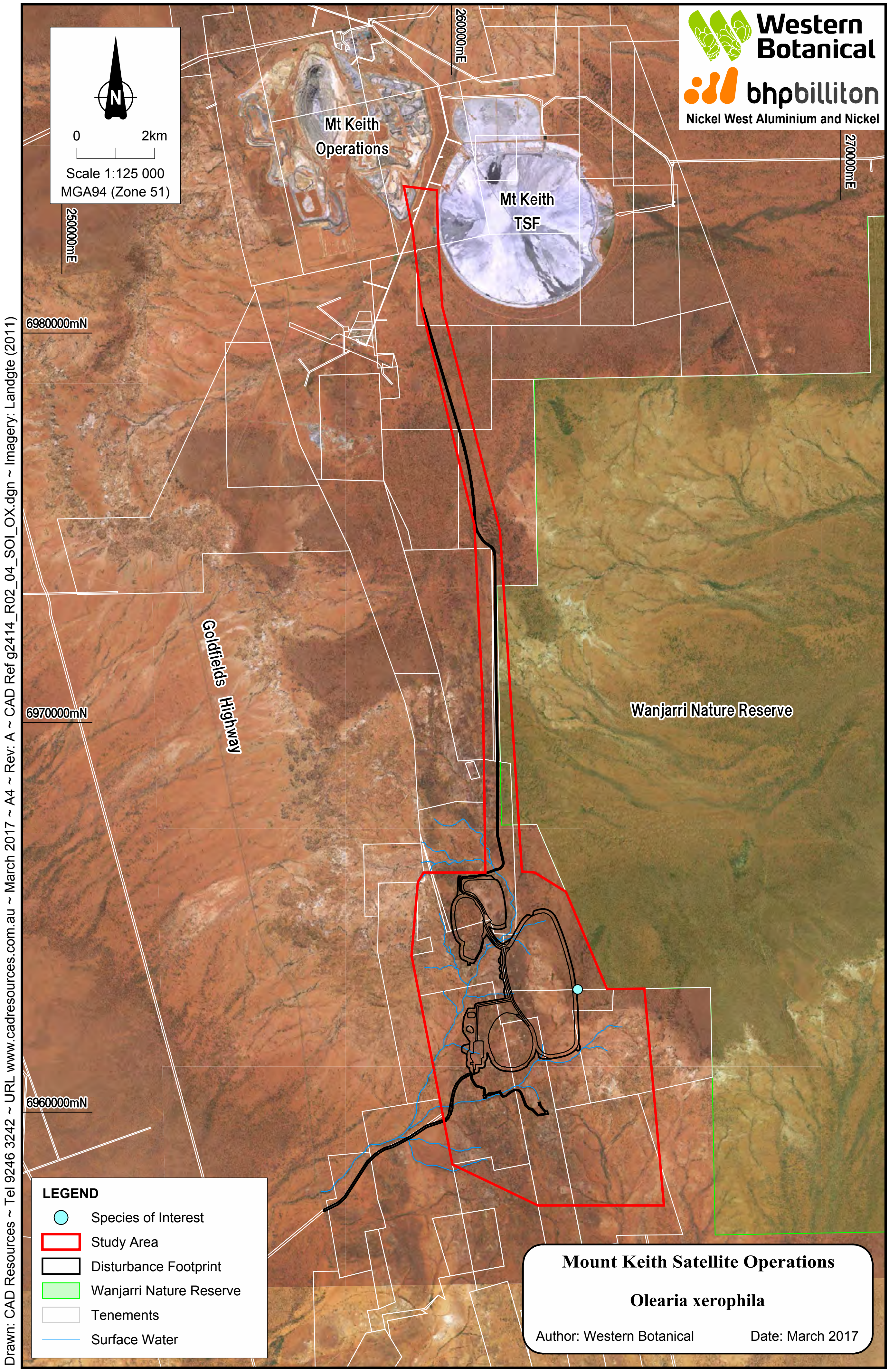


Figure 51. Distribution of *Olearia xerophila sens. lat*, in Australia.

The population of *Olearia xerophila sens. lat*. occurs on the eastern margin of the wastedump footprint, Figure 52. The extent of the population here has not been assessed as yet.

One collection of this taxon has also been made by Western Botanical in 1996 at Leinster. Though not impacted by the MKS project, the occurrence of *Olearia xerophila sens. lat*. at the MKS Proposal Study Area and at Leinster represents a poorly collected species (in this region) at the limit of it's known disjunct range and a slight range extension, hence the species is discussed as a Species of Interest.

Figure 52. Known location of *Olearia xerophila* sens. lat. at the MKS Proposal Study Area



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Wanjarri Nature Reserve
LEGEND
Species of Interest
Study Area
Disturbance Footprint
Wanjarri Nature Reserve
Tenements
Surface Water
Mount Keith Satellite Operations
Olearia xerophila
Author: Western Botanical
Date: March 2017
Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ March 2017 ~ A4 ~ Rev: A ~ CAD Ref g2414_R02_04_SOI_OX.dgn ~ Imagery: Landgte (2011)

Appendix 4. Habitat Descriptions for the MKS Proposal Study Area

Insert Appendix

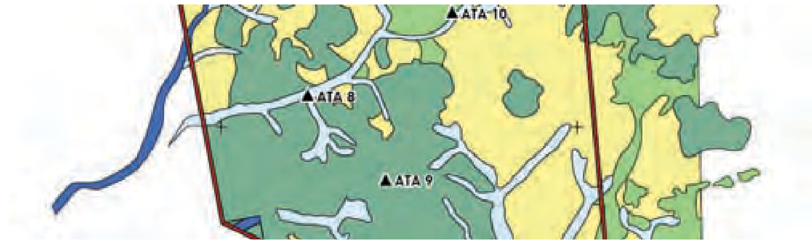
Western Botanical

P (08) 9270 0999
F (08) 6278 4988

E info@westernbotanical.com.au
www.westernbotanical.com.au

Biota Environmental Sciences

Yakabindie Section 18 Fauna Assemblage and Habitats Review



Prepared for BHP Billiton

June 2016

ABN 49 092 687 119
Level 1, 228 Carr Place
Leederville Western Australia 6007
Ph: (08) 9328 1900 Fax: (08) 9328 6138

Job No.: 1194

Prepared by: R. Teale

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Yakabindie Section 18 Fauna Review

Contents

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1.0 Executive Summary

The Section 18 area of the Yakabindie proposal is located 22 km south of the Mt Keith mine, in the northeastern Goldfields and adjacent to the Wanjarri Nature Reserve. The location has been the focus of a number of biological surveys associated with the proposed development and this document summarises the findings of the vertebrate fauna elements of those studies. It also draws upon a number of other documented studies for regional developments (e.g. Mt Keith, Wanjarri Land Swap, Albion Downs Borefield and Yeelirrie) that primarily span a period from 2005 to 2015. Both the local and regional studies have utilised sampling techniques appropriate to current inventory surveys methods for Environmental Impact Assessment. The total sampling effort in the broader locality is substantial (e.g. over 16,000 pit-nights) and spans well over a decade (given historic sampling of Wanjarri Nature Reserve by Government institutions) indicating that the vertebrate fauna assemblage is well documented.

Trapping within the Section 18 area has yielded one vertebrate species with an elevated conservation status, the Priority 4 listed Crest-tailed Mulgara *Dasycercus blythi*. This species does not require any particular management or further studies, though known populations should be avoided. Regionally, the documentation of scats and sightings of the Schedule 2 Black-footed Rock-wallaby *Petrogale l. lateralis* does warrant additional consideration. Records of this species came from a rock shelter in a breakaway approximately 25 km to the north-west of the proposed mine area and a contiguous section of the same breakaway is intersected by the Section 18 transport corridor. Searches of the breakaway in the vicinity of the Section 18 area should be made for this species. Similarly, records of the Schedule 3 Malleefowl *Leipoa ocellata* from areas of suitable habitat within the broader locality (though outside of the Section 18 area) should be acknowledged within any proposed management plan, given the reasonable likelihood that individuals may move between documented populations in Yeelirrie and Wanjarri Nature Reserve.

Two features intersected by the Section 18 area are identified has having elevated conservation value as habitat for some species. The breakaway feature (an extension of the Barr Smith Range) associated with both the Hills and Slopes, Sclerophyll Shrublands habitat (BRX – Breakaway Plateaux Mulga Shrublands vegetation type) and the Undulating Plains – Chenopod Shrublands habitat (BCP – Breakaway Chenopod Plains vegetation type) is considered to be potential habitat for the Black-footed Rock-wallaby. The area of isolated groved mulga (GRMU) within the Areas of Internal Drainage – Mulga habitat is the best example of this vegetation type in the locality, and is considered locally significant both in the context of vertebrate fauna (predominantly avifauna) and invertebrate fauna (particularly potential Short Range Endemics).

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2.0 Introduction

2.1 Background to Study

The Yakabindie Nickel Project is located 10 km south of the Mt Keith mine, in the northeastern Goldfields and in close proximity to the Wanjarri Nature Reserve. Given this location, the region has been the focus of a number of biological surveys associated with the proposed development. Additional biological surveys, naturalist observations and targeted Threatened species survey work have also been conducted in the region. The Wanjarri Nature Reserve itself has also been the focus of cat baiting trials, with associated systematic fauna trapping.

Given the extent of previous survey work in the region, Biota Environmental Sciences (Biota) was commissioned in 2010 to prepare a desktop review summarising the fauna information relevant to the Section 18 area of the Yakabindie proposal (Biota 2010), hereafter referred to as the project area. This current document updates the 2010 report with current taxonomy and conservation rankings, and also provides further discussion of records of the Black-footed Rock-wallaby from the Barr Smith Range. The broad geographic area considered for this review (including Wanjarri, Albion, Mt Keith, Lake Way and Yeelirrie) is hereafter referred to as the study area. The disturbance footprint represents the current mine plan as of 30 June 2016.

2.2 Previous Regional Surveys

The original Yakabindie proposal and subsequent amendments required a number of systematic fauna surveys to be conducted. These comprised:

- a biological assessment of the Yakabindie Nickel Mine Project: Six Mile Well – Sir Samuel Blocks 33 (Ecologia Environmental Consultants (Ecologia) 1990);
- an ecological assessment of the Yakabindie Nickel Mine Project: Six Mile Well / Mount Pascoe (Ecologia 1995);
- a fauna assessment of the Yakabindie area (ATA Environmental (ATA) 2005a and 2005b); and
- surveys associated with the Wanjarri Nature Reserve Land Swap Proposal (Biota 2006a).

In addition to these, a number of other fauna surveys have been carried out either in Wanjarri Nature Reserve, or in the vicinity. These include:

- Part 10 (Sandstone–Sir Samuel and Laverton–Leonora study areas) of the biological survey of the Eastern Goldfields of Western Australia (Hall et al. 1994);
- a fauna survey of the Lake Way Borefields near Mount Keith (Biota 2006b);
- a fauna survey of the Mount Keith Mine expansion area (Biota 2006c);
- a survey of fauna habitats and the fauna assemblage of the Albion Downs Borefield Pipeline area (Biota 2008); and
- a detailed fauna assessment of the Yeelirrie project area in 2009 and 2010 (Bamford Consulting Ecologists (BCE) 2011).

The locations of the trapping sites established as part of the surveys undertaken by Biota, ATA and BCE are discussed in more detail in Section 4.2, and shown in context with vegetation mapping completed by Western Botanical (most recently in 2009).

With respect to avifauna, Moriarty (1972) recorded birds at the Wanjarri Nature Reserve across three decades and produced one of the most complete avifauna assemblages for an arid zone location.

Early records of the then Schedule 1 Mulgara[1] from the Wanjarri Nature Reserve (Ecologia 1990) resulted in numerous Mulgara surveys being undertaken in the locality, particularly on Mt Keith, Albion Downs and Barwidgee Stations (Halpern Glick Maunsell 1997a, 1997b, 1999, 2000; Biota 2004, 2006d; and ATA 2005b). Several of the Mulgara populations recorded during the pre-2000 surveys subsequently became the focus of a four-year study by the then Department of Conservation and Land Management (CALM), which was coordinated by Dr Dave Pearson. Later, the Mt Keith Fire and Biodiversity Study (coordinated by Dr Jane Prince of the University of Western Australia) investigated the impact of fire on Mulgaras and biodiversity in general.

[1] The taxonomy and conservation status of this species have both recently been reviewed. Evidence suggests that the *Dasycercus* species at Mt Keith is *D. blythi,* which is listed as Priority 4.

3.0 Existing Environment

3.1 IBRA Bioregions

The Interim Biogeographic Regionalisation of Australia (IBRA) recognises 85 bioregions (Environment Australia 2000). The Yakabindie study area is located within the East Murchison subregion of the Murchison bioregion. This bioregion is diverse in both floral and faunal assemblages, and is characterised by low levels of endemism; most taxa are widespread through adjacent regions (Cowan 2001).

3.2 Conservation Reserves in the Locality

There is one formally gazetted conservation reserve in the vicinity of the Yakabindie project area:

- Wanjarri Nature Reserve (53.2ha) is located less than 2 km to the east.

The Department of Parks and Wildlife also currently manages two stations in the vicinity of the Mt Keith Operation: these are Lorna Glenn Station to the north, and Lake Mason Station to the southwest.

3.3 Main Landforms

The main landforms of the project area can be described using a landform classification developed by Newbey and Milewski (Hall and Milewski 1994). Of the 10 units described by Newbey and Milewski, five occur in the project area:

- Sandplains: areas of freely-draining red sand, often associated with dunefields, and characterised by gradients of less than 2° and internal relief not exceeding 15 m.
- Undulating Plains: consisting of minor ridges with slopes less than 10°, and colluvial flats 50 to 500 m wide and up to 5 m below the ridges. The flats are typically drained by faint creeklines. Shallow to deep calcareous or red earths form a mantle over all features.
- Broad Valleys: up to 15 km in breadth and barely discernible due to internal relief of less than 20 m and inclines under 2°. They are characterised by deep red loamy soils with superficial gravel traces. Drainage lines are small and indistinct.
- Breakaways: described as common throughout the Sandstone-Sir Samuel area, these comprise weathered granite faces up to 3 m in height punctuated by shallow caves and overhangs (Hall and Milewski 1994).
- Granite Exposures: outcrops of granite of varying size. Characterised by bare rock with an apron of granite-derived soils, often occurring at the base of breakaways.

3.4 Land Systems

The then Department of Agriculture Western Australia prepared land system mapping for the North-Eastern Goldfields region (Pringle et al. 1994). This mapping displays broad units, each consisting of a series of “land units” that occur on characteristic physiographic types within the land system.

The Yakabindie project area directly intersects 14 of the 59 land systems occurring in the North-Eastern Goldfields (Pringle et al. 1994) (Table 3.1).

Table 3.1: Land systems in the Yakabindie project area.

Land System	Description
Ararack	Broad plains with mantles of ironstone gravel supporting mulga shrublands with wanderrie grasses.
Bevon	Irregular low ironstone hills with stony lower slopes supporting mulga shrublands.
Bullimore	Extensive sandplains supporting spinifex hummock grasslands.
Jundee	Hardpan plains with ironstone gravel mantles and occasional sandy banks supporting mulga shrublands.
Monk	Hardpan plains with occasional sandy banks, supporting mulga tall shrublands and wanderrie grasses.
Nubev	Gently undulating stony plains, minor limonitic rises and drainage floors, supporting mulga and halophytic shrublands.
Sherwood	Granite breakaways and extensive stony granitic plains with mulga shrublands and minor halophytic shrublands.
Sunrise	Stony plains supporting mulga shrublands.
Tiger	Gravelly hardpan plains and sandy banks with mulga shrublands and wanderrie grasses.
Violet	Undulating stony and gravely plains and low rises, supporting mulga shrublands.
Windarra	Stony plains with quartz mantles supporting *Acacia-Eremophila* shrublands.
Wilson	Large creeks with extensive distributary fans, supporting mulga and halophytic shrublands.
Wyarri	Granite domes, hills and tor fields with gritty-surfaced fringing plains, supporting mulga and granite wattle shrublands.
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak grooving.

4.0 Methods

4.1 Data Reviewed

Various database searches were commissioned in 2016, including searches of:

- Biota's own Fauna Database (Appendix 1);
- the Department of Parks and Wildlife's NatureMap database (using the bounding coordinates 120°14'14"E, -27°07'41"S and 120°57'13"E, -27°45'50"S) (Appendix 2); and
- the Commonwealth Department of the Environment's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters database (using a 50 km buffer around the coordinates 120°34'29"E, -27°24'07"S) (Appendix 3).

In addition, data available from the previous relevant surveys were also reviewed, specifically those references listed in Section 2.2.

4.2 Previous Survey Effort

Across the four major surveys conducted by Biota (2006a, 2006b, 2006c and 2008), 65 systematic trapping sites were established. The general layout of these sites comprised two trap lines spaced 100 m apart. Each line had six pit traps (20 litre buckets alternating with PVC tubes of 150 mm diameter x 700 mm depth) connected by a 60 m long, 30 cm high flywire drift fence (Figure 4.1). Two pairs of funnel traps were also placed towards the end of each line at some sites, however this did not include any of the sites within the current study area. Traps were typically left open for six consecutive nights.

Different trap types were used at some sites. At site YAK15E, 50 Elliott traps were deployed along a breakaway and opened for five nights. At site YAKHARP5, a single harp trap was deployed for six nights to target bat species.

Four of the sites sampled by Biota were located within the Yakabindie project area (YAK12, YAK13, YAK15E and YAKHARP5) (Table 4.1; Plate 4.1 and Plate 4.2). These four sites yielded a trap effort of 288 pit trap nights (across two seasons), 300 Elliott trap nights and six harp trap nights.

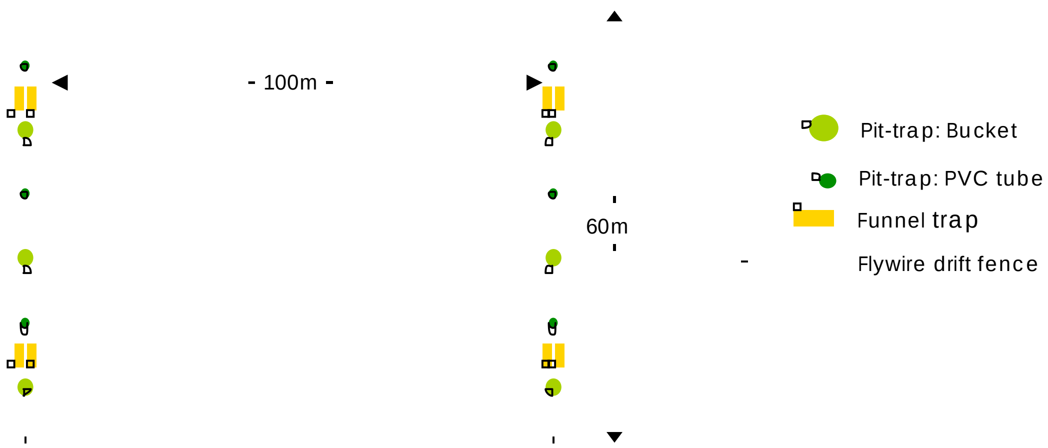

Figure 4.1: Fauna sampling grid design.

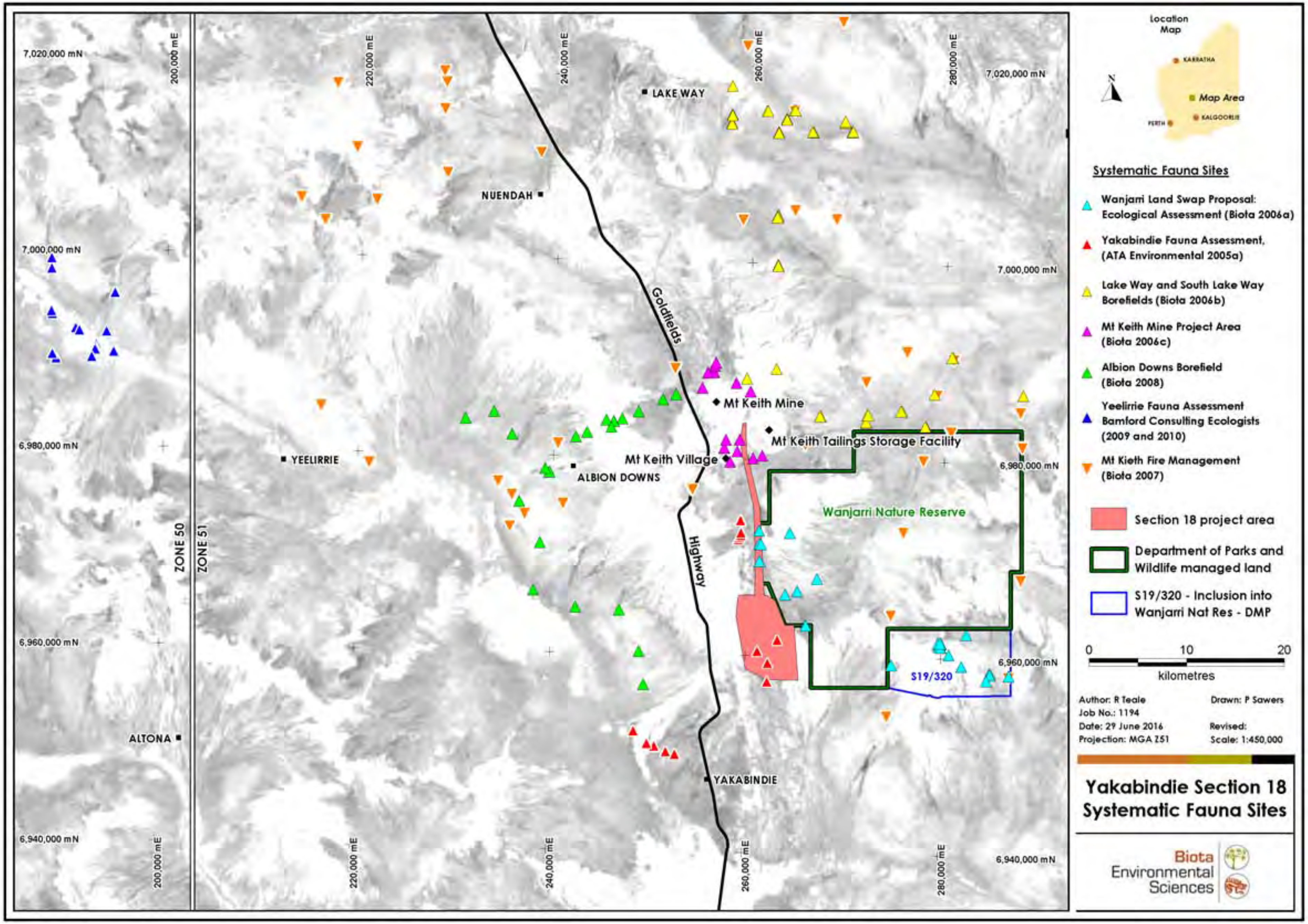

Figure 4.2: Trapping grids established in the Mt Keith region coded by project.

Table 4.1: Locations of each of the Biota trapping grids and overall trap effort for the Yakabindie Project.

Site	Trap Type	Date Opened	Date Closed	Nights Open	No. of Traps	Trap Effort (Trap Nights)
YAK06	Pit traps	30/11/2005	06/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK07	Pit traps	30/11/2005	06/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK08	Pit traps	30/11/2005	06/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK09	Pit traps	29/11/2005	05/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK12*	Pit traps	29/11/2005	05/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK13*	Pit traps	30/11/2005	06/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK14	Pit traps	30/11/2005	06/12/2005	6	12	72
		7/3/2006	13/3/2006	6	12	72
YAK15E*	Elliott traps	30/11/2005	06/12/2005	6	50	300
YAKHARP5*	Harp trap	8/3/2006	14/3/2006	6	1	6
					Pit nights	1,008
					Elliott nights	300
					Harp nights	6
					Total	1,314

* denotes trap sites located within the Yakabindie project area.

Plate 4.1: YAK12 in Breakaway Chenopod Plain (BCP) habitat.

Plate 4.2: YAK13 in Stony Ironstone Mulga Shrublands (SIMS) habitat.

Thirty sites of similar design were also established as part of the Mt Keith Fire and Biodiversity study (UWA unpublished data; Figure 4.2 to Figure 4.5). In addition, numerous dedicated Elliott trap sites, funnel trap sites and over 20 bat sampling locations have been established in the area. Pit trap effort alone exceeds 15,000 nights, and Elliott trapping effort is likely to be much greater.

ATA established 16 sites as part of the Yakabindie appraisal (ATA 2005a), including three within the Section 18 project area (ATA8, ATA9 and ATA10; see Figure 4.2 to Figure 4.5). ATA's trap effort within the Section 18 project area comprised 260 pit trap nights, 520 funnel nights, 130 Elliott nights and 78 cage nights (Table 4.2). In Addition, ATA conducted a five day trapping program targeting Mulgara in December 2004, which used 460 Elliott traps deployed over four consecutive nights (ATA Environmental 2005b).

Table 4.2: Trap effort at ATA sites within and adjacent to the infrastructure corridor.

Site	Pit Trap Nights	Funnel Trap Nights	Elliott Trap Nights	Cage Trap Nights
ATA1	100	200	50	30
ATA2	100	200	50	30
ATA3	100	200	50	30
ATA4	90	180	45	27
ATA5	90	180	45	27
ATA6	90	180	45	27
ATA7	90	180	45	27
ATA8 *	90	180	45	27
ATA9 *	90	180	45	27
ATA10 *	80	160	40	24
ATA11	100	200	50	30
ATA12	100	200	50	30
ATA13	100	200	50	30
ATA14	100	200	50	30
ATA15	100	200	50	30
ATA16	100	200	50	30
Total	1,520	3,040	760	456

* denotes trap sites located within the Yakabindie project area.

BCE undertook vertebrate fauna assessments of the Yeelirrie project area in 2009 (BCE 2011, 2015), which included desktop reviews, database searches and field investigations. A further survey was conducted in March of 2015 and targeted Malleefowl, Slender-billed Thornbill, Striated Grasswren, Black-footed Rock-wallabies and the Shield-backed Trapdoor Spider (BCE 2015). Site locations for systematic sites are shown in Figure 4.2. Fifteen survey sites were established in March 2009 and surveyed again in November 2009. An additional five sites were established and run only in November 2009. A combination of pit traps, funnel traps, Elliott traps and cage traps were used at each site, yielding a total of 2,745 trap nights across both survey phases (BCE 2011). Motion-sensitive cameras were deployed at five sites within the project area and bat-call detectors were placed at eight sites.

In respect of birds, Moriarty (1972) recorded birds on Wanjarri from 1940 through to 1970, and the site is still the most intensively surveyed arid zone site in WA.

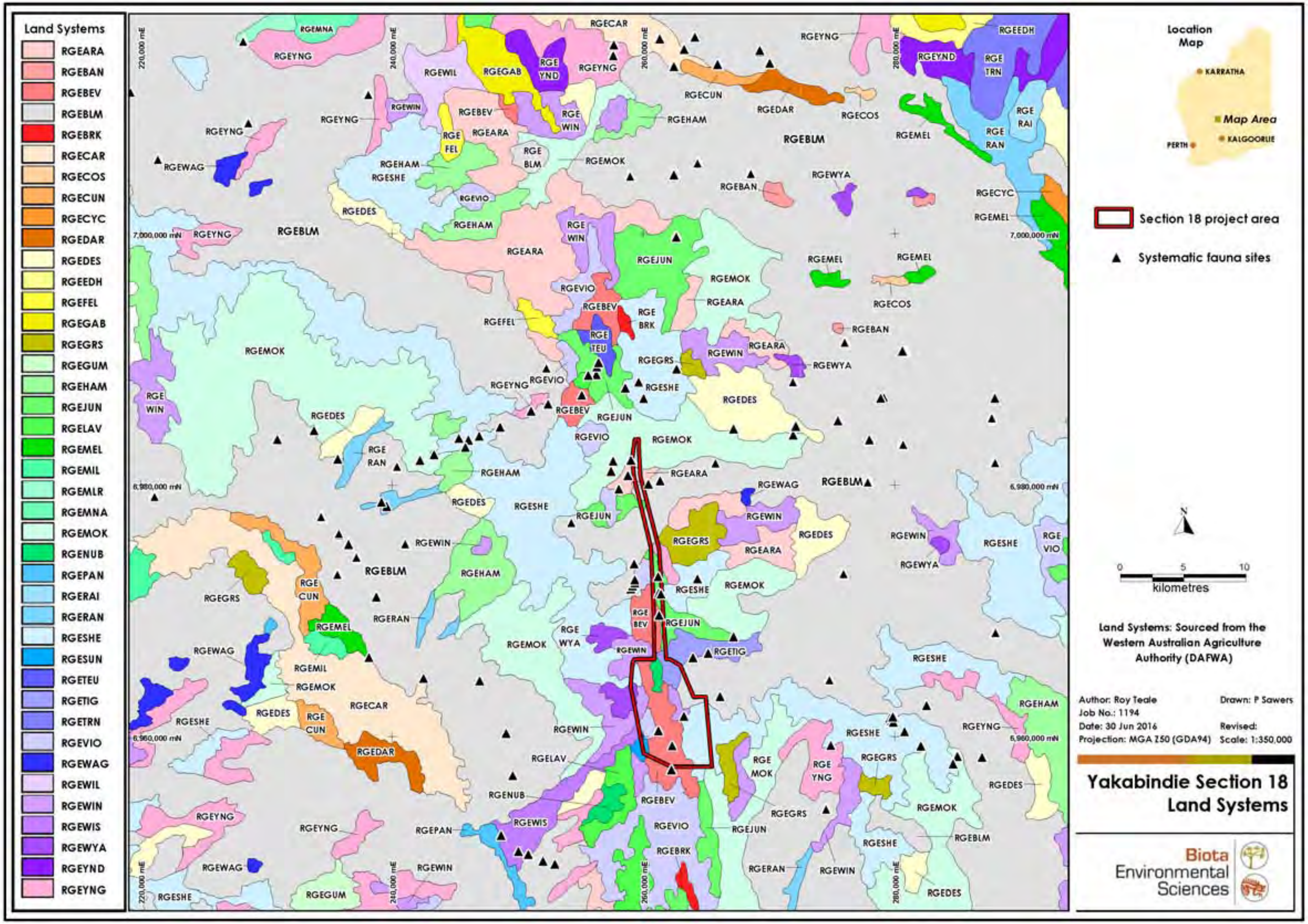

Figure 4.3: Trapping grids established in the Mt Keith region including the Section 18 project area, shown overlain on Land Systems.

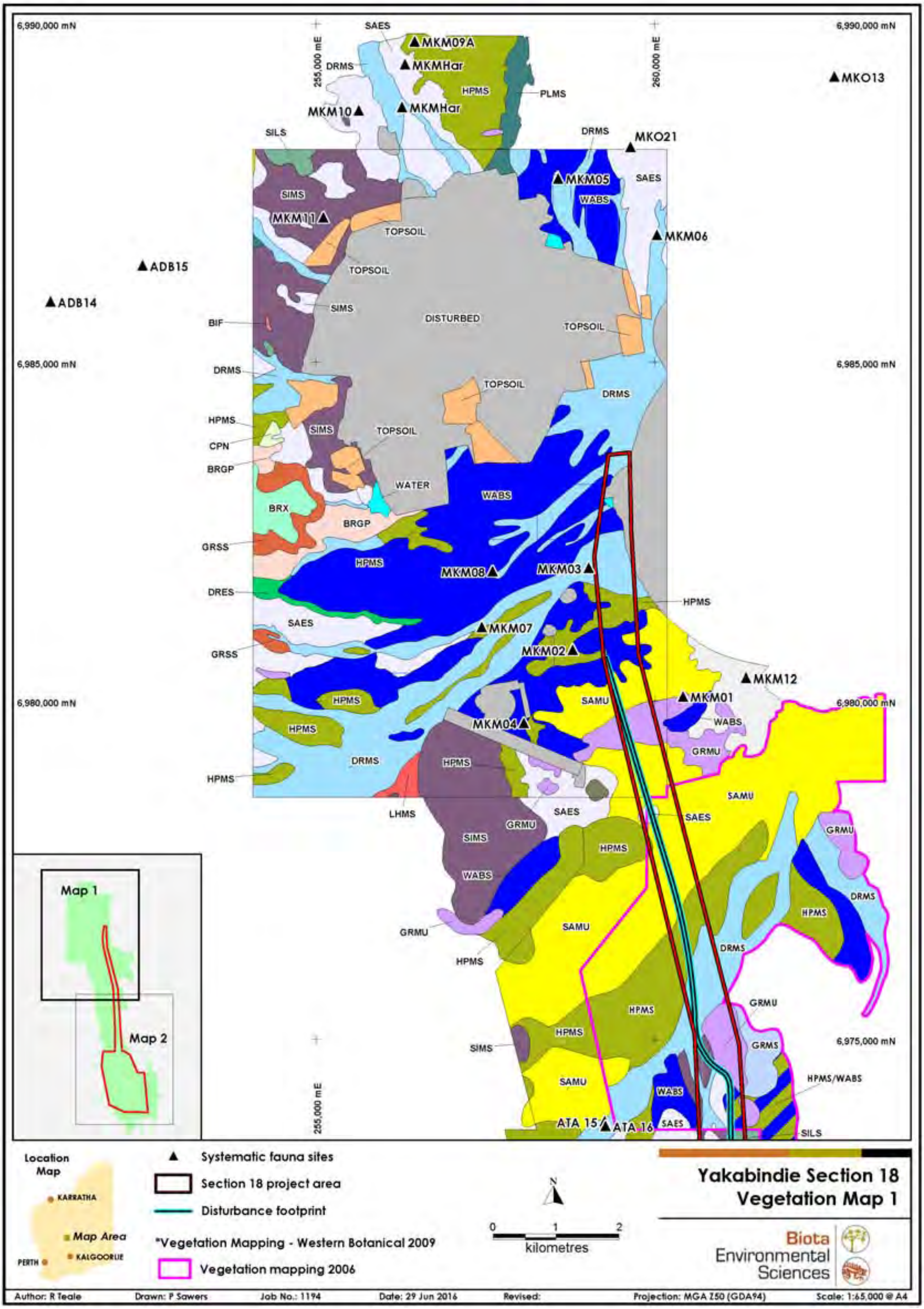

Figure 4.4: Trapping grids established in the Mt Keith region, including the Section 18 project area, shown overlain on Western Botanical vegetation mapping (northern section).

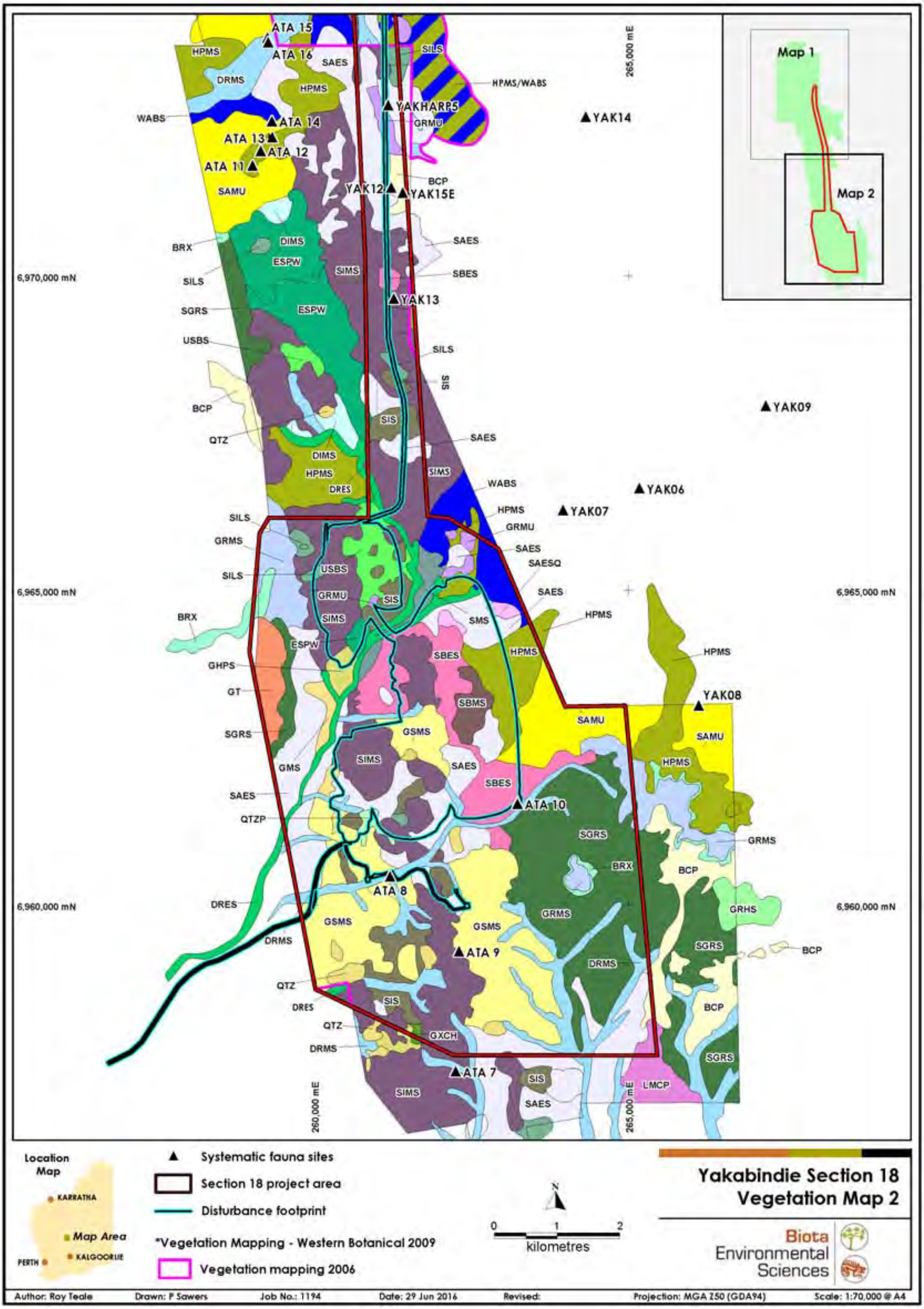

Figure 4.5: Trapping grids established in the Mt Keith region, including the Section 18 project area, shown overlain on Western Botanical vegetation mapping (southern section).

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5.0 Vertebrate Fauna

5.1 The Overall Assemblage

To date, the survey work carried out in the vicinity of the Section 18 project area (as reviewed by this document) has recorded 215 vertebrate species, comprising 36 mammals, 106 birds, 67 reptiles and six frogs. Each of the major vertebrate groups is addressed in the following sections, with particular emphasis on species of conservation significance and areas of data deficiency.

The State conservation rankings are described in Appendix 4.

5.2 Mammals

The complete list of mammal species recorded from the broader study area (including Wanjarri Nature Reserve, Albion Downs, Mt Keith Station, Lake Way Station and Yeelirrie) is provided in Appendix 5.

5.2.1 Regional Endemism and Restricted Taxa

At a bioregional level, the area is not known to support any endemic mammal taxa.

5.2.2 Unresolved Species Complexes and Taxonomy

Sminthopsis macroura is a widespread species across arid WA, however according to Ms. Norah Cooper (WA Museum, pers. comm. 2005) it may be a species complex of at least two taxa and possibly three. This taxonomy remains unresolved.

5.2.3 Species of Conservation Significance

Four mammal species with an elevated conservation ranking have been recorded from the broader study area; the Schedule 2 Black-footed Rock-wallaby (*Petrogale lateralis lateralis*), and the Priority 4 Brush-tailed Mulgara (*Dasycercus blythi*), Long-tailed Dunnart (*Sminthopsis longicaudata*) and Central Long-eared Bat (*Nyctophilus major tor*). A search of the Department of Parks and Wildlife's Threatened Fauna Database also yielded records of the Schedule 4 Boodie (*Bettongia lesueur*), which is now considered extinct on the mainland.

Additional survey effort is warranted for the Schedule 2 Black-footed Rock-wallaby to better define its distribution in the vicinity of the project area. Given their Priority 4 ranking, none of the three Priority species that do or may occur would require any additional studies, nor specific management. However, known populations should be avoided if possible. The species are discussed in greater detail below.

- Boodie (*Bettongia lesueur grayii*) Schedule 4

Distribution: The Boodie or Burrowing Bettong was once distributed through much of the continent west of the Great Dividing Range and south of the tropical savanna. Although not recorded from Queensland, it was widespread in other mainland States and Territories, except in areas of dense vegetation and higher rainfall. The species had one of the largest geographic ranges of any Australian mammal, but is now extinct through mainland Australia and on Dirk Hartog Island. It remains only on Bernier and Dorre Islands in Shark Bay (*Bettongia lesueur lesueur*), and on Barrow and Boodie Islands (unnamed subspecies) off the Pilbara coast of Western Australia (Woinarski et al. 2014). However, several "soft" (enclosure style) reintroductions have been initiated at various mainland localities including at Lorna Glen (northeast of Wiluna), where both extant subspecies have been released.

Ecology: The Boodie is the only macropod to inhabit burrows on a regular basis. The burrow in which it spends the day may be a simple structure consisting of one or two entrances and a short, shallow curving tunnel; more often there are many entrances to complex warrens with interconnecting deep passageways. On the mainland, warrens were constructed in most types of country where the soil was deep enough. The Boodie is nocturnal and gregarious. On the mainland, the species ate tubers and bulbs as well as seeds, nuts and the green parts of some plants (Strahan 1983).

The species' decline began in the nineteenth century and it had disappeared from Victoria by 1863, but persisted in some parts of Australia until the 1930s and 1940s. The decline seems to have coincided with the establishment of foxes and cats (Strahan 1983).

Likelihood of Occurrence: As the Boodie is presumed extinct on the mainland (outside of re-introductions), it is highly improbable that this species occurs within the project area. Numerous old mounds are evident throughout the broader region, particularly in calcareous soils. This suggests that some habitat types may again be important for this species, should re-introductions succeed at places like Lorna Glen.

- Black-footed Rock-wallaby (*Petrogale lateralis laterals*) Schedule 2

Distribution: The Black-footed Rock-wallaby is known from a series of isolated, patchily distributed populations in Western Australia and the Northern Territory (Woinarski et al. 2014).

Ecology: This nocturnal species requires shelter in the form of caves, cliffs and boulder screes during the day. It is susceptible to predation by foxes and cats and habitat degradation by introduced herbivores.

Likelihood of Occurrence: Sightings made by Geoff Cockerton (Western Botanical) led to the discovery of scats in a small cave 12 km west of the northern end of the project area, and 25 km northwest of the proposed mine (120°27'0.54"E, 27°14'27.81"S). The scats were confirmed to belong to this species. It is unclear whether the species occurs in other suitable habitat adjacent to or within the project area.

- Brush-tailed Mulgara (*Dasycercus blythi*) Priority 4

Distribution: The Brush-tailed Mulgara, *Dasycercus blythi*, is a medium sized (60-120 g) carnivorous marsupial exhibiting a patchy distribution throughout arid Queensland, the Northern Territory and Western Australia.

Ecology: *Dasycercus blythi* was previously referred to as *D. cristicauda*. Woolley (2005) has addressed the taxonomic discrepancy and distinguishes the two species based on the form of the tail, the number of upper premolar teeth in each jaw, and in the female, by the number of nipples in the pouch.

Dasycercus blythi is currently listed as Priority 4 by the Department of Parks and Wildlife. Maxwell et al. (1996) indicate that the preferred habitat for the Brush-tailed Mulgara largely comprises immature hummock grassland and that larger colonies coincide with better watered areas such as paleo-drainage channels or drainage lines in sandplain or sand-dune habitats. This latter description is perhaps more applicable to the situation in the Northern Territory than in the Goldfields region of Western Australia.

An assessment of the status of the Mulgara on parts of the Mt Keith, Albion Downs, Tarmoola, Weebo and Yeelirrie pastoral leases by the author found that the Spinifex Sandplain unit of the Bullimore land system (Pringle et al. 1994) comprised the primary habitat for the Mulgara (Halpern Glick Maunsell 2000). Vegetation typically comprised sparse eucalypts and/or *Acacia* species over open *Triodia basedowii*. The Bullimore land system occurs widely throughout the region, with an estimated 3 million hectares across the region encompassed by the Sandstone, Youanmi, Sir Samuel, Duketon, Leonora, Laverton, Menzies and Edjudina 1:250,000 map sheets.

Likelihood of Occurrence: Burrows, tracks and scats of this species have been recorded from the

Bullimore land system in the northern part of the Section 18 project area (Biota 2006d). The current status of this population is uncertain.

- Long-tailed Dunnart (*Sminthopsis longicaudata*) Priority 4

Distribution: This species inhabits rocky, rugged habitat from the Pilbara and adjacent upper Gascoyne region in the west, to the central Northern Territory and South Australia.

Ecology: Records have come from plateaus near breakaways, and from scree slopes and rugged boulder-strewn screes. Mark Cowan has recorded moderate numbers (in excess of 50) in the Goldfields region from mostly stony substrates, particularly from fractured to weathered mudstone/siltstone but also from breakaways (Mark Cowan, Department of Parks and Wildlife, pers. comm. 2004).

Likelihood of Occurrence: A single individual was recorded from a site to the west of the Mt Keith Mine and within the Albion Downs Borefield project area. This species may well occur in the Section 18 project area.

- Central Long-eared Bat (*Nyctophilus major tor*) Priority 4

Distribution: The Central Long-eared Bat has a range that encompasses the southern half of Western Australia and much of southwestern South Australia and is perhaps more common than records indicate (see references in Woinarski et al. 2014).

Ecology: This species has been recorded from woodlands and mallee, especially near granite outcrops and old dams, and is likely to roost in tree crevices and beneath exfoliating bark (see references in Woinarski et al. 2014).

Likelihood of Occurrence: BCE (2015) recorded this species from Yeelirrie; based on this record it is considered likely that it would occur in the project area.

5.2.4 Knowledge Gaps and Additional Survey Requirements

In respect of the Section 18 project area, with the exception of the presence of the Black-footed Rock-wallaby, there are no other significant knowledge gaps in our understanding of the likely mammalian assemblage. The majority of extant non-volant species known for the bioregion have been recorded from the broader study area surrounding Section 18, and this includes those species with an elevated conservation status (i.e. the Priority 4 species *Dasycercus blythi* and *Sminthopsis longicaudata*). *Dasycercus blythi* has been recorded from the Bullimore land system in the northwestern corner of the Section 18 project area, however the current status of the population is uncertain. *Sminthopsis longicaudata* was recorded from immediately west of the Mt Keith Mine, and may well occur on the stony plains within the Section 18 project area. Neither of these species would require additional survey effort, nor targeted management, given that they are Priority 4 listed species. Sightings and scats of Black-footed Rock Wallabies *Petrogale lateralis lateralis* have been made along the Barr Smith Range (Geoff Cockerton, Western Botanical, pers. comm. 2016; Roy Teale, Biota, pers. obs.; and BCE 2015).

Whilst less well surveyed than the terrestrial assemblage, the bat assemblage is still well represented and known to support one Priority listed species, *Nyctophilus major tor*. The Priority 4 ranking of this species means that it is not regarded as threatened or endangered and no additional studies are therefore warranted. Woinarski et al. (2014) identify the conservation ranking for this species as Least Concern.

5.3 Birds

The complete list of bird species recorded from the broader study area (i.e. from Wanjarri, Albion, Mt Keith, Lake Way and Yeelirrie) is provided in Appendix 5.

5.3.1 Species of Conservation Significance

Two species of conservation significance and two Priority 4 listed species have been recorded in the vicinity of the study area or may occur there based on their known distribution: these comprise the Malleefowl (*Leipoa ocellata*), Peregrine Falcon (*Falco peregrinus*), Princess Parrot (*Polytelis alexandrae*) and Striated Grasswren (*Amytornis striatus striatus*). Moriarty (1972) recorded all of these species from Wanjarri Nature Reserve. In addition, a number of Migratory species were returned from the EPBC Act Protected Matters database search. Although they may visit ephemeral pools and nearby salt lakes following heavy rains, and some have been recorded from the Mount Keith tailings facility (Donato 2006), these species are unlikely to be dependent on the habitats of the Section 18 project area. The migratory species are therefore not addressed individually below.

- Malleefowl (*Leipoa ocellata*) Schedule 3

Distribution: The Malleefowl was once broadly distributed across the southern half of the Australian continent, but has undergone a significant range reduction over several decades. It is now restricted to the southwest of Western Australia and southern areas of South Australia and New South Wales.

Ecology: Considered uncommon and sedentary, the species is omnivorous and typically has a large home range in woodlands or shrublands that have a deep layer of leaf litter, which the species uses to build nesting mounds. Mounds are up to 5 m in diameter and 1.5 m in height. Breeding occurs from September to April, with chicks emerging seven weeks after hatching. Malleefowl are usually found where there is a sandy substrate and an abundance of leaf litter, either from *Acacia* species (including Mulga woodland) or Eucalypts (particularly mallee-form species). The understorey can comprise heath, shrubs (particularly *Melaleuca uncinata*) or *Triodia* species, and can vary in density from dense to sparse. Their habitat must normally also contain food plants such as leguminous shrubs and herbs.

Likelihood of Occurrence: Records from both the Department of Parks and Wildlife and WA Museum confirm the presence of this species at Mt Keith and in the nearby Wanjarri Nature Reserve. Moriarty (1972) notes old mounds and tracks of this species in Wanjarri Nature Reserve, and Roy Teale recorded tracks in the reserve in 1997 (although these were outside of the Section 18 project area). The species is also known from Yeelirrie (Angela Sanders, private consultant, pers. comm. 2006; BCE 2015). In the Mt Keith area, Malleefowl could be present in any habitat with the attributes noted above, but their presence is less likely if the habitat has been grazed or if it has been burnt within the past 10-20 years. It is considered unlikely that any core habitat for Malleefowl occurs in the Section 18 project area.

- Peregrine Falcon (*Falco peregrinus*) Schedule 7

Distribution: The Peregrine Falcon has an almost cosmopolitan distribution, but is absent from most deserts and the Nullarbor Plain (Johnstone and Storr 1998). The only subspecies in Australia (*macropus*) is widespread throughout Australia and Tasmania (Marchant and Higgins 1993) and is not considered as threatened by Garnett et al. (2011).

Ecology: This species inhabits a wide range of habitats including forest, woodlands, wetlands and open country (Pizzey and Knight 2001). Home ranges are probably defended year round and are variable in size, though not typically less than 480 ha (Marchant and Higgins 1993). The species typically nests on ledges in cliffs, granite outcrops and quarries, but also in hollow trees and in old nests constructed by other species such as Wedge-tailed Eagles and Ravens (Johnstone and Storr 1998). Breeding typically occurs between August and November (Johnstone and Storr 1998). Their diet consists almost exclusively of birds such as pigeons, parrots and passerines, which are captured in flight (Johnstone and Storr 1998). Mammals such as possums and rabbits have also been recorded as prey items (Marchant and Higgins 1993).

Likelihood of Occurrence: This species was recorded by Moriarty (1972), who reported seeing it occasionally in good seasons, and it has also been recorded over the Mt Keith mine office (Roy Teale, Biota, pers. obs.) and from the Barr Smith Range (BCE 2015). The species may occur in the Section 18 project area, particularly along drainage features and breakaways.

- Princess Parrot (*Polytelis alexandrae*) Priority 4

Distribution: This species occupies the eastern deserts of Western Australia, extending into South Australia. There are records from as far west as Wiluna, Wanjarri Nature Reserve, Sandstone and Laverton.

Ecology: This highly nomadic species prefers lightly wooded habitat including open mallee/spinifex and open marble gum woodlands (Johnstone and Storr 1998). Its diet includes *Triodia* and wattle seeds, and it has also been observed feeding from *Hakea* and *Grevillea* (Johnstone and Storr 1998).

Likelihood of Occurrence: There has been one possible sighting of the Princess Parrot near Wanjarri Nature Reserve (Ms Leisa Turner, Environmental Advisor Mt Keith Operations, pers. comm. 2005). Moriarty (1972) collected one specimen from near the Wanjarri shearing shed in 1964.

- Striated Grasswren (*Amytornis striatus striatus*) Priority 4

Distribution: This species occurs from the central arid zone of Western Australia to the southwestern Northern Territory and down through central South Australia, as well as in three small areas of Victoria and New South Wales.

Ecology: This subspecies occurs in *Triodia*-dominated habitat on sandy to loamy plains, where it feeds on insects and seeds, but may also be found in shrubby *Acacia* on dunes and inter-dunes. Typically occurring in pairs or family groups, the species can be locally common but is normally scarce to moderately common. Breeding and reproduction occur in March and April.

Likelihood of Occurrence: Both the Department of Parks and Wildlife and WA Museum database searches produced records of the Striated Grasswren from the vicinity of Mt Keith, including two from Wanjarri Nature Reserve. Moriarty (1972) considered the species "plentiful in Spinifex country". Craig and Chapman (2003) recorded a single individual from spinifex habitat in the Wanjarri Nature Reserve. BCE (2015) did not record this species during studies at Yeelirrie, however there are records from the area.

5.3.2 Knowledge Gaps and Additional Survey Requirements

In respect of the Section 18 project area, there are no significant knowledge gaps in our understanding of the likely avian assemblage. Given that the Wanjarri Nature Reserve represents the most intensely surveyed arid zone site for which published data is available, it is expected that most species likely to occur in the region have been recorded.

5.4 Herpetofauna

The complete list of recorded herpetofauna (reptiles and frogs) species from the broader study area (i.e. Wanjarri Nature Reserve, Albion, Mt Keith, Lake Way and Yeelirrie) is provided in Appendix 5.

5.4.1 Regional Endemism

The only known vertebrate considered endemic to the Murchison bioregion is the Spotted Mulga Snake (*Pseudechis butleri*) (Storr et al. 2002). This species was observed within the Albion Downs study area by a BHP Billiton employee (Mr Craig Pollock, pers. comm. 2008).

This species has not been recorded from Mt Keith or Wanjarri Nature Reserve, although it is known from Booylgoo Spring (Hall et al. 1994).

5.4.2 Unresolved Species Complexes and Taxonomy

A number of specimens recorded during surveys in the area belong to species complexes that remain unresolved (e.g. *Ctenotus quattuordecimlineatus* and *Menetia greyii*). Establishing the conservation significance of populations is extremely difficult where taxonomy remains unresolved, as distributional extent cannot be circumscribed with any confidence.

5.4.3 Species of Conservation Significance

No species of conservation significance have been recorded from the surveys of Mt Keith and the surrounds (ATA 2005a; Biota 2006a, 2006b, 2006c, unpublished data). The trapping effort across these surveyed areas (i.e. the Mt Keith Fire and Biodiversity Study area, Mt Keith Mine area, South Lake Way, Lake Way, Sir Samuel and Six Mile) tallies over 14,000 trap nights (including pits, funnels and Elliotts). There is one historical record of the Giant Desert Skink (*Liopholis kintorei*) from Kathleen Station.

- Giant Desert Skink (*Liopholis kintorei*) Schedule 3

Distribution: This species is patchily distributed in the Great Sandy Desert, Gibson Desert and Tanami Desert. The western extremity of its range approaches the Mt Keith area.

Ecology: *Liopholis kintorei* occurs in a variety of desert habitats on sandy, clay and loamy soils (Storr et al. 1999). Although poorly documented, it is known to inhabit burrow complexes which (when active) can be identified by regular defecation sites.

Likelihood of Occurrence: Suitable habitat for this species was found throughout the project area. Both the Department of Parks and Wildlife and the WA Museum have a sole record of an animal trapped at Kathleen Station. It is therefore possible that this species occurs in the project area, although this is considered unlikely.

5.4.4 Knowledge Gaps and Additional Survey Requirements

There are no major knowledge gaps for herpetofauna, taking into account the relatively intensive survey effort across the broader region around Mt Keith (including the Section 18 project area). No additional survey effort is considered warranted.

5.5 Summary

Table 5.1 provides a summary of the species with an elevated conservation ranking that were returned from the database searches. Migratory species have been excluded, as there is little (if any) appropriate habitat in the project area for any species with the exception of the Rainbow Bee-eater. The latter species is not discussed further as it is not considered to have an elevated conservation ranking (ranked as Least Concern).

Table 5.1: Species with elevated conservation rankings returned from the database searches (excluding migratory species).

Species	Status under the Wildlife Conservation Act [EPBC Act]	Suitable Habitat Units in Project Area	Locality of Records	Recorded from Project Area
Boodie (*Bettongia lesueur grayii*)	Schedule 4 [Extinct]	NA (extinct)	NA (extinct)	NA (extinct)
Black-footed Rock-wallaby (*Petrogale lateralis laterals*)	Schedule 2 [Endangered]	Breakaway formations in Hills and Slopes, Sclerophyll Shrublands	Barr Smith Range – South Albion Downs Borefield	No
Malleefowl (*Leipoa ocellata*)	Schedule 3 [Vulnerable]	Drainage Line Areas of Internal Drainage – Mulga	Wanjarri Nature Reserve and numerous locations at Yeelirrie	No
Giant Desert Skink (*Liopholis kintorei*)	Schedule 3 [Vulnerable]	Undulating Plains Grass Dominated	Kathleen Station	No
Peregrine Falcon (*Falco peregrinus*)	Schedule 7 [NA]	Drainage Line	Mt Keith	No
Brush-tailed Mulgara (*Dasycercus blythi*)	Priority 4 [NA]	Undulating Plains Grass Dominated	Widespread	Yes
Long-tailed Dunnart (*Sminthopsis longicaudata*)	Priority 4 [NA]	Hills and Slopes, Sclerophyll Shrublands	Mt Keith and Albion Downs Borefield	No
Central Long-eared Bat (*Nyctophilus major tor*)	Priority 4 [NA]	Drainage Line Areas of Internal Drainage - Mulga	Yeelirrie	No
Princess Parrot (*Polytelis alexandrae*)	Priority 4 [NA]	Drainage Line Areas of Internal Drainage – Mulga	Wanjarri Nature Reserve	No
Striated Grasswren (*Amytornis striatus striatus*)	Priority 4 [NA]	Undulating Plains Grass Dominated	Wanjarri Nature Reserve	No

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6.0 Short-Range Endemic Invertebrates

6.1 Overview

Taxonomic groups of invertebrates with naturally small distributions are described as Short-Range Endemics (SREs) and are in part characterised by poor dispersal capabilities, confinement to disjunct habitats and low fecundity (Harvey 2002, Ponder and Cogan 2002). Given the importance of short-range endemism to the conservation of biodiversity, the assessment of such invertebrate taxa is a potentially important component of any environmental impact assessment.

Examples of taxonomic groups that show high levels of short-range endemism in this respect include mygalomorph spiders (Castalanelli et al. 2014), millipedes, pseudoscorpions and freshwater and terrestrial molluscs (Harvey et al. 2011).

A number of invertebrate specimens have been collected during the field surveys in the study area. All invertebrates have been sorted to morphotype and lodged with the WA Museum. Only groups known to support SREs or those of particular interest to the WA Museum are discussed further, which in this locality essentially comprises the mygalomorph (trapdoor) spiders.

6.2 Mygalomorph Spiders

Whilst this group is regularly collected in the bioregion, much of the taxonomy has only been resolved to the level of genus. This group is known to support a number of taxa with very limited distributions, and several species are included as Schedule fauna in the latest Wildlife Conservation (Specially Protected Fauna) Notice 2015, or are recognised as Priority listed species (e.g. *Kwonkan moriartii* from Kathleen Valley).

Ongoing molecular investigations are also underway for the mygalomorph genus *Gaius*. This work has continued on from an UWA Honours project conducted by Schmidt (2007), which investigated a number of samples of this genus from the Mt Keith area.

During the recent Albion Downs Borefield survey, over 220 mygalomorph spiders from 24 species were recorded following a significant rain event. All specimens recorded were males and could therefore confidently be ascribed to known taxa or to species level by WA Museum curatorial staff. The collection included several specimens of *Idiosoma nigrum*, a Schedule 3 listed species.

6.2.1 Species of Conservation Significance

- Shield-backed Trapdoor Spider (*Idiosoma nigrum*) Schedule 3

Distribution: This species occurs broadly in a belt between Mandurah in the south and Shark Bay in the north, extending as far inland as Mt Keith and Merredin.

Ecology: This species builds a twig-lined burrow entrance, often at the base of shrubs or small trees. Males emerge after rain events to mate.

Likelihood of Occurrence: Several males of this species were recorded from the Albion Downs Borefield study area, and *Idiosoma nigrum* may well occur in the Section 18 project area.

- *Kwonkan moriartii* Priority 2

Distribution: Very little is known about this mygalomorph spider species. The only recorded specimens were collected from Kathleen Valley Station near Wiluna in 1962.

Ecology: Nothing is known of the ecology of this species.

Likelihood of Occurrence: Given the proximity of the Section 18 project area to Kathleen Valley, it is possible that this species may occur in the current project area.

6.2.2 Knowledge Gaps and Additional Survey Requirements

There are clearly substantial knowledge gaps in our understanding of the potential SRE invertebrate assemblage of the Section 18 project area and the greater Mt Keith region. Whilst additional targeted surveys would be beneficial, they may not be required depending on the location of direct impacts within the Section 18 project area.

In respect of SREs, the Environmental Protection Authority (EPA) expects that the following objectives will be met, as far as is practicable:

- ensure the protection of key habitats for SRE species;
- maintain the distribution, abundance and productivity of populations of SRE taxa; and
- ensure that the conservation status of SRE taxa is not changed as a result of development proposals (EPA 2009).

For poorly known species such as most SREs, meeting these objectives can be difficult to clearly demonstrate, primarily due to the absence of contextual information on broader distributions. The EPA has recognised this key limitation and has recommended that an assessment can proceed on the basis of a risk assessment in which the following criteria are considered:

- the relationship between habitat and taxon distribution;
- the local distribution of that habitat based on available thematic layers; e.g. geology, soils, vegetation and drainage (vegetation units may be preferable, as these are often mapped at the finest scale); and
- the proportion of suitable habitat that may be disturbed by project proposal (EPA 2009).

However, the risk assessment can only proceed once reasonable effort has been expended in assessing the likelihood of the occurrence of SREs, and once any appropriate database searches and/or surveys have been conducted. In this particular case, the assessment of the study site suggests that the broad habitats within it are not confined to the Section 18 project area. The project area is therefore unlikely to support any highly restricted (i.e. at the scale of the project area) terrestrial fauna species. It should be noted, however, that the transport corridor currently bisects an isolated and particularly good quality stand of the Mulga Groves on Hardpan Plains vegetation type (GRMU; see Section 7.0). This is one of the best examples of this vegetation in the vicinity of the project area, and is considered to be locally significant.

7.0 Fauna Habitats

7.1 Overview

Fauna habitats may be of conservation significance because they are uncommon, support unique vegetation or faunal assemblages, support fauna (or flora) of special conservation significance, or any combination of these three factors. They may also be important because they maintain local ecosystem processes (nitrogen fixation, nutrient turnover etc.), or are important to regional ecosystem function (transfer of energy and matter through the abiotic and biotic components of the ecosystem). An example of the latter might be broad catchment areas servicing a significant drainage feature. With current data and practicable survey methods, we are some way off being able to resolve the latter in most cases.

A limitation of any habitat classification system is that it does not cover all habitats available to the entire assemblage of vertebrate and invertebrate fauna, as this would be difficult to resolve and logistically impractical to sample. Rather, the classifications provide a convenient framework within which to summarise species occurrence (with a strong bias towards vertebrates) and are often determined by the observer's experience. To work around this, we have used a two-tiered classification system that makes use of existing published descriptions in the form of land system mapping. The two tiers comprise the land system and the habitat, with the latter being equivalent to the vegetation units of Western Botanical and the Site Types of Pringle et al. (1994). However, the relatively recent emergence of SREs (particularly invertebrates) as an important component of the faunal assessment process (in terms of identifying conservation imperatives) challenges the usefulness of broad habitat categories. It may be that a functional perspective that considers the evolutionary driving forces which have shaped current patterns of phytogeography will prove more appropriate for this group of fauna.

Given that any classification of habitats is somewhat arbitrary, we have chosen to adopt the physiographic classification used by Western Botanical, largely to provide uniformity within an assessment framework between the two thematic layers vegetation and fauna habitats. In addition, the Western Botanical physiographic classification broadly aligns with the land unit classification of the land system mapping, which in turn provides a much broader context for the occurrence of physiographic units and therefore habitats. The physiographic approach is broadly relevant to most vertebrate fauna groups within the limitations already discussed above.

7.2 Distribution of Habitats

The project area encompasses 14 land systems (Table 7.1), which were found to encompass 28 vegetation types (Table 7.2). This latter classification was provided by Western Botanical (Mr Geoff Cockerton, pers. comm.) and in turn encompassed 10 physiographic types (or habitats in the context of this report) (Table 7.2).

All habitat types are more broadly represented in the region and for the most part are broadly contiguous (see Figure 7.1 and Figure 7.2). A notable exception is the relatively large stand of groved Mulga that is bisected by the proposed transport route.

The conservation value of habitats is discussed in greater detail in Section 7.3.

Table 7.1: Description and areal extent of land systems occurring in the Section 18 project area (from Pringle et al. 1994).

Land System	Extent		
	Total Area in NE Goldfields	Extent of Land System Encompassed by Project Area	% of the North-Eastern Goldfields Survey Area
Ararack	2,012 km^2	0.63 km^2	0.03%
Bevon	1,921 km^2	17.86 km^2	0.93%
Bullimore	24,013 km^2	5.42 km^2	0.02%
Jundee	2,658 km^2	3.42 km^2	0.13%
Monk	8,162 km^2	1.07 km^2	0.01%
Nubev	1,045 km^2	2.02 km^2	0.19%
Sherwood	3,875 km^2	10.89 km^2	0.28%
Sunrise	362 km^2	0.69 km^2	0.19%
Tiger	1,106 km^2	3.35 km^2	0.30%
Violet	1,611 km^2	2.36 km2	0.15%
Windarra	1,938 km^2	4.66 km^2	0.24%
Wilson	447 km^2	0.11 km^2	0.02%
Wyarri	871 km^2	0.63 km^2	0.07%
Yanganoo	868 km^2	0.62 km^2	0.07%

Table 7.2: Landforms / habitats and associated vegetation types within the Section 18 project area.

Physiographic Unit / Habitat	Vegetation Description	Extent in Project Area (hectares)
Hills and Slopes, Sclerophyll Shrublands	• SILS – Stony Ironstone Low Shrublands • SIMS – Stony Ironstone Mulga Shrublands • BRX – Breakaway Plateaux Mulga Shrublands • ESPW – *Eucalyptus striaticalyx - Pantonii* Woodland • GHPS – Greenstone *Hakea - Pantonii* Shrublands • GRMS – Granite Ridge Mixed Shrublands • GSMS – Greenstone Stony Mulga Shrublands • GT – Granite Tor • GXCH – Greenstone *Xanthocarpa - Calytrix* Heath • QTZ – Quartz Outcrop • SIS – Stony Ironstone *Senna* Shrublands	41.5 884.9 24.6 16.4 29.4 141.0 640.7 70.3 3.3 39.2 199.2
Undulating Plains Sclerophyll Shrubland	• HPMS – Hardpan Mulga Shrublands • SAES – Stony Plain *Acacia - Eremophila* Shrublands • GMS – Granitic Mulga Shrublands • QTZP – Quartz Stony Plains • SAESQ – Stony Plain *Acacia - Eremophila* Shrublands • SGRS – Sandy Granitic *Acacia* Shrublands • SMS – Stony Mulga Shrublands	221.3 761.9 34.9 14.1 17.8 595.9 42.3
Undulating Plains Grass Dominated	• SAMU – Sandplain Mulga - Spinifex Shrublands • WABS – Wanderrie Bank Grassy Shrublands	317.6 120.8
Drainage tract – Mulga	• DRMS – Drainage Tract Mulga Shrubland/Woodlands	439.6
Areas of Internal Drainage – Mulga	• GRMU – Mulga Groves on Hardpan Plains	119.2
Drainage Line	• DRES – Drainage Tract Eucalypt Shrubland/Woodlands	97.9
Hills and Slopes, Chenopod Shrublands	• USBS – Upper Slope Bluebush Shrublands	74.6
Undulating Plains – Chenopod Shrublands	• BCP – Breakaway Chenopod Plains • LMCP – Loamy Mulga Chenopod Plains • SBES – Stony Bluebush - *Eremophila* Shrublands • SBMS – Stony Bluebush Mixed Shrublands	34.6 11.4 274.6 48.9
Disturbed	• Disturbed	26.8
Water	• Water	1.5
Unmapped	• Unmapped	13.4
	Total	5372.6

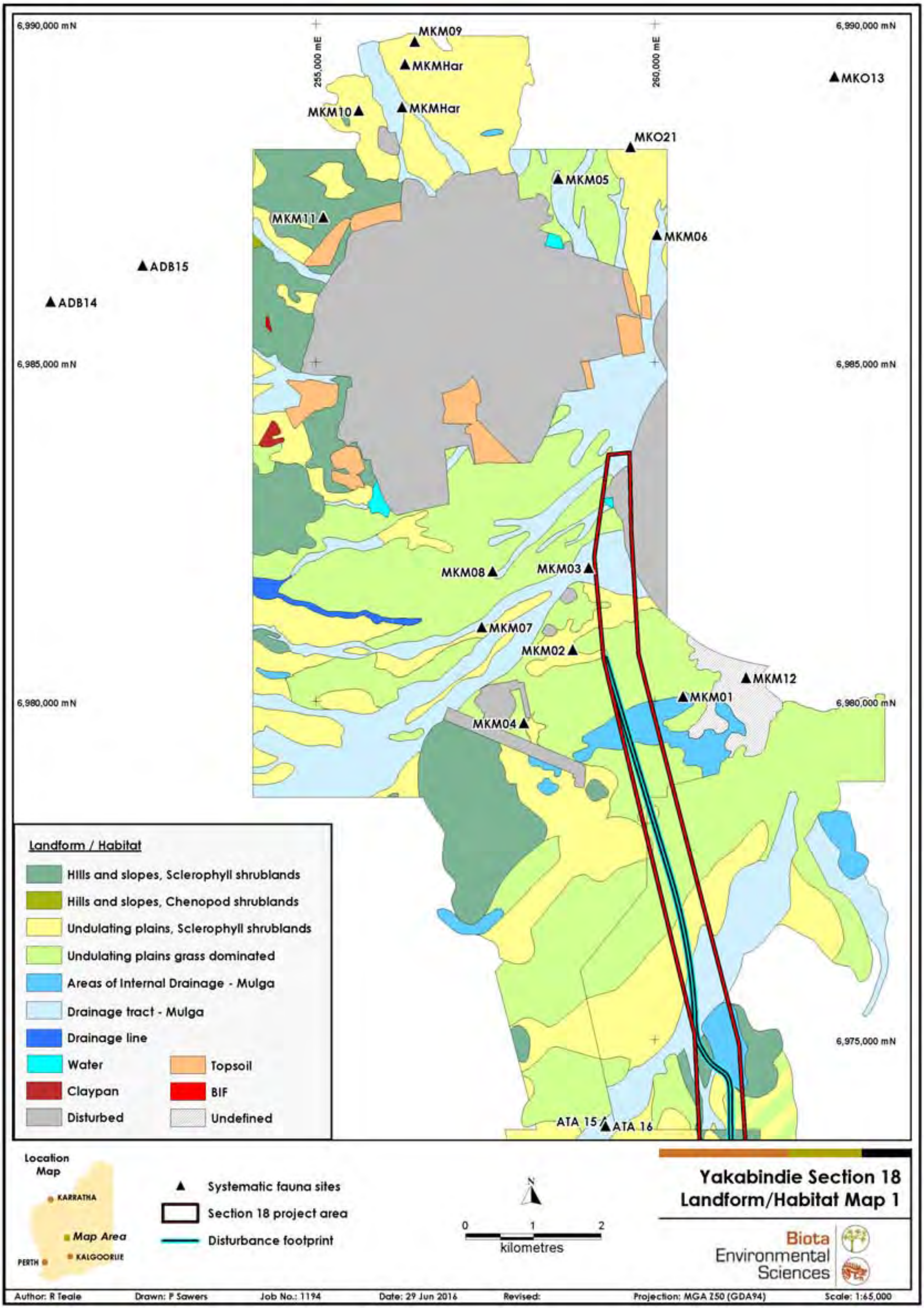

Figure 7.1: Fauna habitats of the Section 18 project area and surrounds, based on vegetation mapping by Western Botanical (northern section).

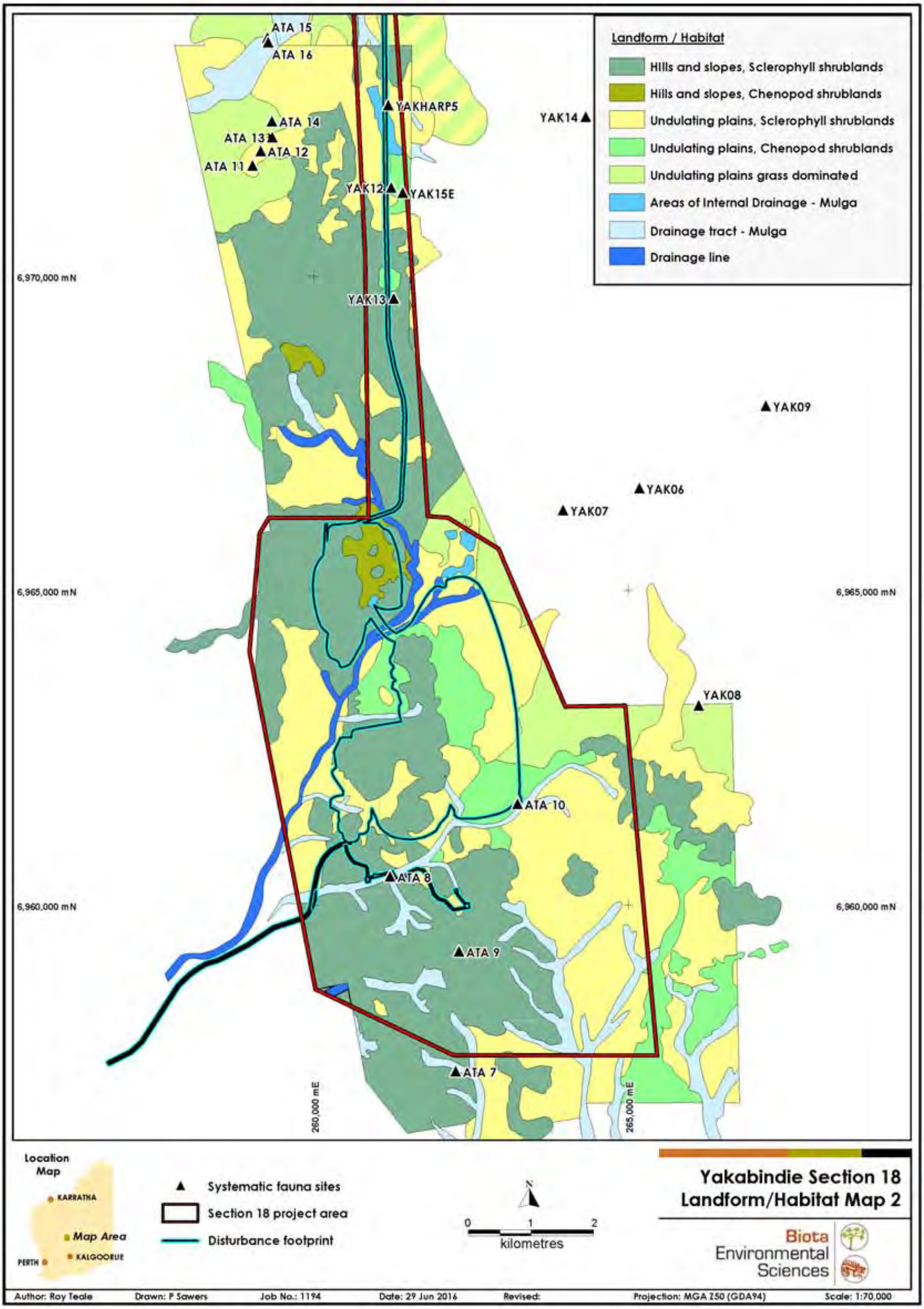

Figure 7.2: Fauna habitats of the Section 18 project area and surrounds, based on vegetation mapping by Western Botanical (southern section).

7.3 Conservation Values

None of the fauna habitats within the study area are restricted to the Section 18 project area, based on the broader distribution of vegetation communities and land system types.

There are no Threatened Ecological Communities (TECs) within the current project area. The only TEC currently listed for the Murchison bioregion is the Depot Springs stygofauna community, located over 40 km southwest of the project area. This TEC relates to subterranean invertebrate fauna, which are beyond the scope of the current review. There are also several stygofaunal Priority Ecological Communities known from the region, which are similarly outside the scope of this review.

While the area of each land system and its distribution within the northeastern Goldfields can be appreciated by examining Pringle et al. (1994), there is no equivalent mapping of habitat / vegetation units. Unfortunately, therefore, there is little opportunity to determine regional context at the most useful tier in terms of classifying fauna habitats (i.e. the vegetation unit, or Site Type). However, an appraisal by Pringle et al. (1994) and a conservation assessment by van Vreeswyk (1995) do provide some guidance as to the relative conservation significance of Site Types and land systems respectively.

Van Vreeswyk (1995) ascribed a conservation value (very high, high, moderate, low and very low) to land systems in the vicinity of Mt Keith according to cumulative scores across a range of contributing attributes (e.g. association with rare flora, whether it is reserved in the Wanjarri Nature Reserve, resource condition and extent of distribution). She determined that the Bevon, Bullimore, Sunrise, Violet, Wilson, Wyarri and Yanganoo land systems had a “Moderate” conservation value, while Sherwood, Tiger and Windarra land systems had a “Low” value, and the Ararak, Jundee, Monk and Nubev land systems had a “Very Low” conservation value.

Van Vreeswyk (1995) also noted that these conservation classifications may alter depending on the weight given to other attributes, such as the occurrence of threatened fauna and their importance as refugia. For example, Craig and Chapman (2003) suggested that mulga groves (characteristic of the Monk and Bullimore land systems) may act as refugia during climactically harsh periods. These authors reiterated Morton’s (1990) opinion that degradation of these drought refugia may compromise the local persistence of species dependent on them (noting that Morton referred only to mammals). Craig and Chapman (2003) suggested that in relation to arid-zone avifauna conservation “.... there should be a strong focus in arid-zone management to conserve areas of groving and creekline mulga....”. Whilst the author agrees with the general sentiment, it must be noted that the conservation of these mulga communities requires that the specific catchments are also conserved and that processes of drainage are not interrupted. In this way conservation efforts should be directed at a landscape function level and not based solely on an arbitrary classification of habitats.

The isolated area of groved mulga (GRMU) that is intersected by the transport corridor is the best example of this vegetation type in the locality, and is considered locally significant both in the context of vertebrate fauna (predominantly avifauna based on the assessment above) and invertebrate fauna. Within the Pilbara bioregion, where sampling for terrestrial invertebrate SREs has been undertaken relatively more intensively (e.g. Castalanelli et al. 2014), mulga groves yield the highest diversity of potential SREs (R. Teale, Biota, pers. obs.).

Whilst breakaways extend broadly throughout the region (e.g. the Barr Smith Range), they comprise narrow linear features and consequently occupy a comparatively small area. Within the current study area, the breakaway features include the vegetation of the plateaux (i.e. BRX) as well as the plains immediately below (i.e. BCP). The discovery of Black-footed Rock-wallabies at a locality approximately 25 km to the northwest of the proposed mine significantly increases the potential conservation value of this habitat type in the project area. Numerous large shelters and caves also occur along breakaways and these may be important for cave-roosting bats.

Table 7.3: Fauna habitats in the project area assessed as has having an elevated conservation ranking.

Habitat / Vegetation Type	Rationale for Elevated Conservation Status
Areas of Internal Drainage – Mulga: GRMU Mulga Groves on Hardpan Plains vegetation type	Locally isolated. Identified by Craig and Chapman (2003) as being of conservation significance to avifauna. Also likely to support a diverse assemblage of potential SRE taxa.
Hills and Slopes, Sclerophyll Shrublands: BRX – Breakaway Plateaux Mulga Shrublands vegetation type Undulating Plains – Chenopod Shrublands: BCP – Breakaway Chenopod Plains vegetation type	Sightings of Black-footed Rock-wallabies from this habitat in the locality (25 km northwest of the proposed mine) significantly elevate the importance of rock screes, shelters and caves characteristic of breakaways in the project area. Caves and deep shelters may also be locally important as communal roosts for some bat species.

8.0 Glossary

EPA	Environmental Protection Authority of Western Australia.
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
SRE	Short-Range Endemic.

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9.0 References

ATA Environmental (2005a). Fauna Assessment, Western Mining Corporation, Yakabindie. Unpublished report for SKM Consulting/BHP Billiton.

ATA Environmental (2005b). Mulgara (*Dasycercus cristicauda*) Fauna Assessment Western Mining Corporation, Yakabindie. Unpublished report for SKM Consulting/BHP Billiton.

Bamford Consulting Ecologists (2011). Vertebrate Fauna Assessment Yeelirrie Project. Baseline Report. Unpublished report for URS Australia Pty Ltd.

Bamford Consulting Ecologists (2015). Yeelirrie Terrestrial Vertebrate Fauna Report. An unpublished report for Cameco Australia Pty Ltd.

Biota Environmental Sciences (2004). An Assessment of the Distribution of the Mulgara *Dasycercus cristicauda* within the Cliffs Tenement. An unpublished report for Sinclair Knight Merz.

Biota Environmental Sciences (2006a). Wanjarri Land Swap Proposal: Ecological Assessment. Unpublished report for SKM Consultants/BHP Billiton.

Biota Environmental Sciences (2006b). BHP Billiton Northern Nickel Projects Development. Fauna and Habitats of the Lake Way and South Lake Way Borefields. Unpublished report for SKM Consultants/BHP Billiton.

Biota Environmental Sciences (2006c). Fauna Habitat and Fauna Assemblage of the Mt. Keith Mine Project Area. Unpublished report for BHP Billiton Nickel West.

Biota Environmental Sciences (2006d). Northern Nickel Projects Mulgara (*Dasycercus cristicauda*) Survey and Management Plan. Unpublished report for SKM Consultants/BHP Billiton.

Biota Environmental Sciences (2008). Fauna Habitats and Fauna Assemblage Survey of the Albion Downs Borefield. Unpublished report for Nickel West.

Biota Environmental Sciences (2010). Yakabindie Section 18 Fauna Assemblage and Habitats Review. Unpublished report prepared for Western Botanical on behalf of BHP Billiton.

Castalanelli, M.A., Teale, R., Rix, M.G., Kennington, J. & Harvey, M. (2014). 'Barcoding of mygalomorph spiders (Araneae : Mygalomorphae) in the Pilbara bioregion of Western Australia reveals a highly diverse biota' *Invertebrate Systematics*, 28: 375-385.

Cowan, M. (2001). Murchison 1 (MUR 1 – East Murchison subregion). *In* J.E. May and N.L. McKenzie (eds) (2003). *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2003.* Department of Conservation and Land Management.

Craig, M.D. and A. Chapman (2003). Effects of short-term drought on the avifauna of Wanjarri Nature Reserve: What do they tell us about drought refugia? *Journal of the Royal Society of Western Australia*, 86:133-137.

Donato, D.B. (2006). Mt Keith Operations Tailings Storage Facility and Water Storage Areas: Wildlife Interactions and Risks. Donato Environmental Services, Darwin.

Ecologia Environmental Consultants (1990). Yakabindie Nickel Mine Project: Six Mile Well – Sir Samuel Blocks 33 Biological Assessment Survey. Unpublished Report for Dominion Mining Limited.

Ecologia Environmental Consultants (1995). Yakabindie Nickel Mine Project. Six Mile Well – Mount Pascoe Blocks Environmental Assessment. Unpublished Report for Dominion Mining Limited.

Environment Australia (2000). *Revision of the Interim Biogeographic Regionalisation for Australia (IBRA) and Development of Version 5.1, Summary Report.* Environment Australia, November 2000.

Environmental Protection Authority (2009). *Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986) No. 20: Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia.* May 2009.

Garnett, S.T., J.K. Szabo and G. Dutson (2011). *The Action Plan for Australian Birds 2010.* Commonwealth Scientific and Industrial Research Organization Publishing.

Hall, N.J., N.L. McKenzie and G.J. Keighery (1994). *The Biological Survey of the Eastern Goldfields of Western Australia. Part 10: Sandstone – Sir Samuel and Laverton – Leonora Study Areas.* Western Australian Museum, Perth, Western Australia.

Hall and Milewski (1994). In: *The Biological Survey of the Eastern Goldfields of Western Australia. Part 10: Sandstone – Sir Samuel and Laverton – Leonora Study Areas.* (eds: Hall N.J. McKenzie N.L. and Keighery G.J.). Western Australian Museum, Perth Western Australia.

Halpern Glick Maunsell (1997a). Mt Keith Mulgara *Dasycercus cristicauda* Survey. An unpublished report prepared for Western Mining Corporation.

Halpern Glick Maunsell (1997b). Barwidgee Pastoral Lease Mulgara *Dasycercus cristicauda* Survey. An unpublished report for Great Central Mines Limited.

Halpern Glick Maunsell (1999). Mulgara *Dasycercus cristicauda* Confirmation Survey. An unpublished report prepared for WMC Resources Limited and Great Central Mines Limited.

Halpern Glick Maunsell (2000). Lease Wide Mulgara *Dasycercus cristicauda* Survey. An unpublished report prepared for WMC Leinster Nickel Operations.

Harvey, M.S. (2002). Short-range endemism among Australian fauna: some examples from nonmarine environments. *Invertebrate Systematics* 16: 555-570.

Harvey, M.S., Rix, M.G., Framenau, V.W., Hamilton, Z.R., Johnson, M.S., Teale, R.J., Humphreys, G. and Humphreys, W.F. (2011). Protecting the innocent: studying short-range endemic taxa enhances conservation outcomes. *Invertebrate Systematics*, 25, pp. 1–10.

Johnstone, R.E. and G.M. Storr (1998). *Handbook of Western Australian Birds. Volume 1 – Nonpasserines (Emu to Dollarbird).* Western Australian Museum, Perth WA.

Marchant, S. and P.J. Higgins (1993). *Handbook of Australian, New Zealand & Antarctic Birds Volume 2: Raptors to Lapwings.* Oxford University Press, South Melbourne.

Maxwell, S., A.A. Burbidge and K. Morris (1996). *The 1996 Action Plan for Australian marsupials and monotremes.* Wildlife Australia, Canberra.

Moriarty, T.K. (1972). Birds of Wanjarri. *The Emu,* 72(1): 1-7.

Morton (1990). *Cited in* Craig, M.D. and A. Chapman (2003). Effects of short-term drought on the avifauna of Wanjarri Nature Reserve: What do they tell us about drought refugia? *Journal of the Royal Society of Western Australia*, 86:133-137.

Ponder, W.F. and D.J. Colgan (2002). What makes a narrow-range taxon? Insights from Australian fresh-water snails. *Invertebrate Systematics,* 16: 571-582.

Pizzey, G. and F. Knight (2001). *The Graham Pizzey and Frank Knight field guide to the birds of Australia.* Harper Collins Publishers.

Pringle, H.J.R., A.M.E. van Vreeswyk and S.A. Gilligan (1994). *An inventory and condition survey of the north-eastern goldfields, Western Australia.* Technical Bulletin No. 87. Department of Agriculture, Western Australia.

Schmidt, T. (2007). *Geographical and Spatial Structuring of Genetic Variation in Trapdoor Spiders (Idiopidae) of the Western Australian Goldfields*. Honours Thesis, University of Western Australia.

Storr G.M., L.A. Smith and R.E. Johnstone (1999). *Lizards of Western Australia. I. Skinks.* Western Australian Museum.

Storr, G.M., L.A. Smith and R.E. Johnstone (2002). *Snakes of Western Australia*. Revised edition. Western Australian Museum.

Strahan, R. (1983). *The Mammals of Australia.* Reed Publishers.

van Vreeswyk, S. (1995). The Sensitivity and Conservation Value of Land in the Region of Western Mining Corporation's Operations in the North-eastern Goldfields, Western Australia. A report to Western Mining Corporation. Natural Resource Management Services Agriculture Western Australia.

Woinarski J. C. Z., Burbidge A. A. & Harrison P. (2014). The action plan for Australian mammals 2012. CSIRO Publishing, Melbourne. Ecological Society of Australia.

Woolley, P.A. (2005). The species of *Dasycercus* Peters, 1875 (Marsupialia: Dasyuridae). *Memoirs of Museum Victoria*, 62(2): 213-221.

Appendix 1

Search Results from Biota Database

MAMMALS

TACHYGLOSSIDAE
- Echidna *Tachyglossus aculeatus*

DASYURIDAE
- Woolley's Pseudantechinus *Pseudantechinus woolleyae*
- Brush-tailed Mulgara *Dasycercus blythi**
- Wongai Ningaui *Ningaui ridei*
- Kultarr *Antechinomys laniger*
- Fat-tailed Dunnart *Sminthopsis crassicaudata*
- *Sminthopsis ooldea/dolichura?*
- Hairy-footed Dunnart *Sminthopsis hirtipes*
- Long-tailed Dunnart *Sminthopsis longicaudata*
- Stripe-faced Dunnart *Sminthopsis macroura*
- Ooldea Dunnart *Sminthopsis ooldea*

MACROPODIDAE
- Euro *Osphranter robustus*
- Red Kangaroo *Osphranter rufus*

VESPERTILIONIDAE
- Lesser Long-eared Bat *Nyctophilus geoffroyi*
- Gould's Long-eared Bat *Nyctophilus gouldii*
- Inland Broad-nosed Bat *Scotorepens balstoni*
- Inland Forest-bat *Vespadelus baverstocki*
- Finlayson's Cave-bat *Vespadelus finlaysoni*

MURIDAE
- Spinifex Hopping Mouse *Notomys alexis*
- Bolam's Mouse *Pseudomys bolami*
- Desert Mouse *Pseudomys desertor*
- Sandy Inland Mouse *Pseudomys hermannsburgensis*
- House Mouse *Mus musculus*

CANIDAE
- Dog/Dingo *Canis lupus*

FELIDAE
- Cat *Felis catus*

LEPORIDAE
- Rabbit *Oryctolagus cuniculus*

BOVIDAE
- Cattle *Bos taurus*
- Goat *Capra hircus*

AVIFAUNA

CASUARIIDAE
- Emu *Dromaius novaehollandiae*

PHASIANIDAE
- Brown Quail *Coturnix ypsilophora*

ANATIDAE
- Australian Shelduck *Tadorna tadornoides*
- Grey Teal *Anas gracilis*
- Pacific Black Duck *Anas superciliosa*
- Hardhead *Aythya australis*

PODICIPEDIDAE
- Hoary-headed Grebe *Poliocephalus poliocephalus*
- Great Crested Grebe *Podiceps cristatus australis*

PHALACROCORACIDAE
- Little Black Cormorant *Phalacrocorax sulcirostris*

ARDEIDAE
- White-necked Heron *Ardea pacifica*
- White-faced Heron *Ardea novaehollandiae*

ACCIPITRIDAE
- Black-shouldered Kite *Elanus caeruleus axillaris*
- Black-breasted Buzzard *Hamirostra melanosternon*
- Brown Goshawk *Accipiter fasciatus didimus*
- Collared Sparrowhawk *Accipiter cirrocephalus cirrocephalus*
- Little Eagle *Aquila morphnoides morphnoides*
- Wedge-tailed Eagle *Aquila audax*

FALCONIDAE
- Brown Falcon *Falco berigora berigora*
- Australian Kestrel *Falco cenchroides cenchroides*
- Australian Hobby *Falco longipennis longipennis*

RALLIDAE
- Black-tailed Native-hen *Gallinula ventralis*

OTIDIDAE
- Australian Bustard *Ardeotis australis*

TURNICIDAE
- Little Button-quail *Turnix velox*

CHARADRIIDAE
- Banded Lapwing *Vanellus tricolor*
- Black-fronted Dotterel *Charadrius melanops*
- Red-kneed Dotterel *Erythrogonys cinctus*

COLUMBIDAE
- Common Bronzewing *Phaps chalcoptera*
- Crested Pigeon *Ocyphaps lophotes*
- Diamond Dove *Geopelia cuneata*
- Peaceful Dove *Geopelia striata placida*

PSITTACIDAE
- Galah *Cacatua roseicapilla*
- Cockatiel *Nymphicus hollandicus*
- Australian Ringneck *Platycercus zonarius*
- Mulga Parrot *Platycercus varius*
- Bourke's Parrot *Neophema bourkii*
- Budgerigar *Melopsittacus undulatus*

CUCULIDAE
- Pallid Cuckoo *Cuculus pallidus*
- Black-eared Cuckoo *Chrysococcyx osculans*
- Horsfield's Bronze Cuckoo *Chrysococcyx basalis*

AEGOTHELIDAE
- Australian Owlet-nightjar *Aegotheles cristatus*

MEROPIDAE
- Rainbow Bee-eater *Merops ornatus*

CLIMACTERIDAE
- White-browed Treecreeper *Climacteris affinis*

MALURIDAE
- Splendid Fairy-wren *Malurus splendens*
- Variegated Fairy-wren *Malurus lamberti*
- White-winged Fairy-wren *Malurus leucopterus*
- Rufous-crowned Emu-wren *Stipiturus ruficeps ruficeps*

PARDALOTIDAE
- Striated Pardalote *Pardalotus striatus*

ACANTHIZIDAE
- Redthroat *Pyrrholaemus brunneus*
- Weebill *Smicrornis brevirostris*
- Western Gerygone *Gerygone fusca fusca*
- Broad-tailed Thornbill *Acanthiza apicalis*
- Slaty-backed Thornbill *Acanthiza robustirostris*
- Chestnut-rumped Thornbill *Acanthiza uropygialis*
- Yellow-rumped Thornbill *Acanthiza chrysorrhoa*
- Southern Whiteface *Aphelocephala leucopsis*

MELIPHAGIDAE
- Brown Honeyeater *Lichmera indistincta indistincta*
- Black Honeyeater *Certhionyx niger*
- Pied Honeyeater *Certhionyx variegatus*
- Singing Honeyeater *Lichenostomus virescens*
- Grey-fronted Honeyeater *Lichenostomus plumulus*
- White-plumed Honeyeater *Lichenostomus penicillatus*
- White-fronted Honeyeater *Phylidonyris albifrons*
- Yellow-throated Miner *Manorina flavigula*
- Spiny-cheeked Honeyeater *Acanthagenys rufogularis*
- Crimson Chat *Epthianura tricolor*

PETROICIDAE
- Red-capped Robin *Petroica goodenovii*
- Hooded Robin *Petroica cucullata*

POMATOSTOMIDAE
- Grey-crowned Babbler *Pomatostomus temporalis*
- White-browed Babbler *Pomatostomus superciliosus*

CINCLOSOMATIDAE
- Chestnut Quail-thrush *Cinclosoma castanotus*
- Chestnut-breasted Quail-thrush *Cinclosoma castaneothorax*

NEOSITTIDAE
Varied Sittella *Daphoenositta chrysoptera*

PACHYCEPHALIDAE
Crested Bellbird *Oreoica gutturalis*
Rufous Whistler *Pachycephala rufiventris*
Grey Shrike-thrush *Colluricincla harmonica*

DICRURIDAE
Willie Wagtail *Rhipidura leucophrys*
Magpie-lark *Grallina cyanoleuca*

CAMPEPHAGIDAE
Black-faced Cuckoo-shrike *Coracina novaehollandiae*
Ground Cuckoo-shrike *Coracina maxima*
White-winged Triller *Lalage tricolor*

ARTAMIDAE
Masked Woodswallow *Artamus personatus*
Black-faced Woodswallow *Artamus cinereus*
Little Woodswallow *Artamus minor*

CRACTICIDAE
Grey Butcherbird *Cracticus torquatus*
Pied Butcherbird *Cracticus nigrogularis*
Australian Magpie *Cracticus tibicen*
Grey Currawong *Strepera versicolor*
Torresian Crow *Corvus orru*
Little Crow *Corvus bennetti*
Australian Raven *Corvus coronoides*

PTILONORHYNCHIDAE
Western Bowerbird *Ptilonorhynchus maculatus*

HIRUNDINIDAE
White-backed Swallow *Cheramoeca leucosternus*
Welcome Swallow *Hirundo neoxena*
Tree Martin *Hirundo nigricans*
Fairy Martin *Hirundo ariel*

SYLVIIDAE
Rufous Songlark *Cincloramphus mathewsi*
Brown Songlark *Cincloramphus cruralis*

PASSERIDAE
Zebra Finch *Taeniopygia guttata*

MOTACILLIDAE
Australian Pipit *Anthus australis*

HERPETOFAUNA

HYLIDAE
Cyclorana maini
Cyclorana platycephala
Litoria rubella

LIMNODYNASTIDAE
Neobatrachus sp
Notaden nichollsi

AGAMIDAE
Ctenophorus caudicinctus mensarum
Ctenophorus isolepis gularis
Ctenophorus nuchalis
Ctenophorus reticulatus
Ctenophorus salinarum
Ctenophorus scutulatus
Lophognathus longirostris
Moloch horridus
Pogona minor minor
Tympanocryptis cephala

DIPLODACTYLIDAE
Diplodactylus conspicillatus
Diplodactylus granariensis granariensis
Diplodactylus pulcher
Diplodactylus squarrosus
Rhynchoedura ornata
Strophurus elderi
Strophurus strophurus
Strophurus wellingtonae

CARPHODACTYLIDAE
Nephrurus laevissimus
Nephrurus vertebralis

GEKKONIDAE
Gehyra variegata
Heteronotia binoei

PYGOPIDAE
Delma butleri
Delma nasuta
Lialis burtonis
Pygopus nigriceps

SPENOMORPHIDAE*
Ctenotus ariadnae
Ctenotus atlas
Ctenotus calurus
Ctenotus grandis
Ctenotus hanloni
Ctenotus helenae
Ctenotus leonhardii
Ctenotus pantherinus
Ctenotus quattuordecimlineatus
Ctenotus schomburgkii
Ctenotus uber uber
Eremiascincus richardsonii
Lerista bipes
Lerista desertorum
Lerista rhodonoides

EUGONGYLIDAE*
Menetia greyii

EGERNIIDAE*
Egernia depressa
*Liopholis inornata**
Tiliqua multifasciata
Tiliqua occipitalis

VARANIDAE
Varanus brevicauda
Varanus caudolineatus
Varanus eremius
Varanus giganteus
Varanus gouldii
Varanus panoptes rubidus
Varanus tristis tristis

TYPHLOPIDAE
*Anilios hamatus**
*Anilios waitii**

BOIDAE
Antaresia stimsoni

ELAPIDAE
Brachyurophis fasciolata
Brachyurophis semifasciata
Furina ornata
Parasuta monachus
Pseudechis australis
Pseudonaja modesta
*Pseudonaja mengdeni**
Simoselaps bertholdi
Suta fasciata

MYGALOMORPHAE

ACTINOPODIDAE
Missulena 'MYG048'
Missulena 'MYG049'

BARYCHELIDAE
Idiommata 'sp. (female)'
Mandjelia 'MYG056'
Synothele 'MYG055'
Synothele 'MYG057'

CTENIZIDAE
Cethegus 'MYG050'

IDIOPIDAE

Aganippe 'MYG014'
Aganippe 'MYG015'
Aganippe 'MYG017'
Aganippe 'MYG019'
Aganippe 'MYG020'
Eucyrtops 'MYG016'
Eucyrtops 'MYG029'
Eucyrtops 'MYG032'
Gaius 'sp. (female)'
Idiosoma nigrum

NEMESIIDAE

Aname 'MYG030'
Aname 'MYG031'
Aname 'sp. (female)'
Aname tepperi
Teyl 'MYG025'
Teyl 'MYG053'

THERAPHOSIDAE

Selenotholus foelschei

* Species or taxonomic nomenclature that have undergone taxonomic changes since the Biota 2010 report.

Appendix 2

NatureMap Search Results

NatureMap Species Report
Created By Guest user on 16/05/2016
Search Area 'By Rectangle': 120° 14' 14'' E, 120° 57' 13'' E, 27° 45' 50'' S, 27° 07' 41'' S

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5
1 For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.
NatureMap is a collaborative project of the Department of Parks and Wildlife and the Western Australian Museum.

MAMMALS

Dasyuridae
276. 24087 *Antechinomys laniger (Kultarr)*
277. 30903 *Dasycercus blythi (Brush-tailed Mulgara, Ampurta)* P4
278. *Dasycercus sp.*
279. 24094 *Ningaui ridei (Wongai Ningaui)*
280. 24106 *Pseudantechinus woolleyae (Woolley's Pseudantechinus)*
281. 24108 *Sminthopsis crassicaudata (Fat-tailed Dunnart)*
282. 24109 *Sminthopsis dolichura (Little long-tailed Dunnart)*
283. 24114 *Sminthopsis hirtipes (Hairy-footed Dunnart)*
284. 24116 *Sminthopsis macroura (Stripe-faced Dunnart)*
285. 24117 *Sminthopsis ooldea (Ooldea Dunnart)*
286. *Sminthopsis sp.*

Macropodidae
483. 25489 *Macropus robustus (Euro)*
484. 24135 *Macropus robustus subsp. erubescens (Euro, Biggada)*
485. 24136 *Macropus rufus (Red Kangaroo, Marlu)*
486. 24142 *Petrogale lateralis subsp. lateralis (Black-flanked Rock-wallaby, Black-footed Rockwallaby)* T

Muridae
532. 24223 *Mus musculus (House Mouse)* Y
533. 24224 *Notomys alexis (Spinifex Hopping-mouse)*
534. *Notomys sp.*
535. 24230 *Pseudomys albocinereus (Ash-grey Mouse)*
536. 24232 *Pseudomys bolami (Bolam's Mouse)*
537. 24235 *Pseudomys desertor (Desert Mouse)*
538. 24237 *Pseudomys hermannsburgensis (Sandy Inland Mouse)*

Tachyglossidae
843. 24207 *Tachyglossus aculeatus (Short-beaked Echidna)*

Molossidae
531. 24185 *Tadarida australis (White-striped Freetail-bat)*

Vespertilionidae
884. 24186 *Chalinolobus gouldii (Gould's Wattled Bat)*
885. 24194 *Nyctophilus geoffroyi (Lesser Long-eared Bat)*
886. 24199 *Scotorepens balstoni (Inland Broad-nosed Bat)*
887. 24202 *Vespadelus baverstocki (Inland Forest Bat)*
888. 24203 *Vespadelus caurinus (Western Cave Bat)*
889. 24205 *Vespadelus finlaysoni (Finlayson's Cave Bat)*
890. 24206 *Vespadelus regulus (Southern Forest Bat)*

AVIFAUNA

Acanthizidae

2. *Acanthiza (Geobasileus) uropygialis*
3. *Acanthiza (Milligania) robustirostris*
4. 24260 *Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*
5. 24261 *Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*
6. 24264 *Acanthiza robustirostris (Slaty-backed Thornbill)*
7. 24265 *Acanthiza uropygialis (Chestnut-rumped Thornbill)*
8. 25528 *Aphelocephala leucopsis (Southern Whiteface)*
9. 24269 *Calamanthus campestris (Rufous Fieldwren)*
10. 25530 *Gerygone fusca (Western Gerygone)*
11. 24271 *Gerygone fusca subsp. fusca (Western Gerygone)*
12. 24278 *Pyrrholaemus brunneus (Redthroat)*
13. 30948 *Smicrornis brevirostris (Weebill)*

Accipitridae

23. *Accipiter (Paraspizias) cirrocephalus subsp. cirrocephalus*
24. 25535 *Accipiter cirrocephalus (Collared Sparrowhawk)*
25. 25536 *Accipiter fasciatus (Brown Goshawk)*
26. 24285 *Aquila audax (Wedge-tailed Eagle)*
27. 24289 *Circus assimilis (Spotted Harrier)*
28. 24295 *Haliastur sphenurus (Whistling Kite)*
29. *Lophoictinia isura*
30. 25542 *Milvus migrans (Black Kite)*

Aegothelidae

31. 25544 *Aegotheles cristatus (Australian Owlet-nightjar)*

Anatidae

62. 24312 *Anas gracilis (Grey Teal)*
63. 24316 *Anas superciliosa (Pacific Black Duck)*
64. 24322 *Cygnus atratus (Black Swan)*
65. 24331 *Tadorna tadornoides (Australian Shelduck, Mountain Duck)*

Anhingidae

66. *Anhinga novaehollandiae*

Ardeidae

70. 24341 *Ardea pacifica (White-necked Heron)*
71. *Egretta novaehollandiae*

Artamidae

74. *Artamus (Angroyan) minor subsp. minor*
75. 25566 *Artamus cinereus (Black-faced Woodswallow)*
76. 24355 *Artamus minor (Little Woodswallow)*
77. 24356 *Artamus personatus (Masked Woodswallow)*

Burhinidae

165. 24359 *Burhinus grallarius (Bush Stone-curlew)*

Cacatuidae

167. *Eolophus roseicapillus*

Campephagidae

172. 24361 *Coracina maxima (Ground Cuckoo-shrike)*
173. 25568 *Coracina novaehollandiae (Black-faced Cuckoo-shrike)*
174. 24362 *Coracina novaehollandiae subsp. novaehollandiae (Black-faced Cuckoo-shrike)*
175. 24367 *Lalage tricolor (White-winged Triller)*

Caprimulgidae

178. 24368 *Eurostopodus argus (Spotted Nightjar)*

Casuariidae

180. 24470 *Dromaius novaehollandiae (Emu)*

Charadriidae

187. 24377 *Charadrius ruficapillus (Red-capped Plover)*
188. 24386 *Vanellus tricolor (Banded Lapwing)*

Cinclosomatidae

243. *Cinclosoma (Samuela) castaneothorax subsp. marginatum*
244. 25580 *Cinclosoma castaneothorax (Chestnut-breasted Quail-thrush)*
245. 24390 *Psophodes occidentalis (Western Wedgebill, Chiming Wedgebill)*

Climacteridae

247. 25581 *Climacteris affinis (White-browed Treecreeper)*

Columbidae

250. 24401 *Geopelia cuneata (Diamond Dove)*
251. 24407 *Ocyphaps lophotes (Crested Pigeon)*
252. 24409 *Phaps chalcoptera (Common Bronzewing)*

Corvidae
260. 24416 *Corvus bennetti (Little Crow)*
261. 25593 *Corvus orru (Torresian Crow)*
262. *Corvus sp.*
Cracticidae
263. 24420 *Cracticus nigrogularis (Pied Butcherbird)*
264. 25595 *Cracticus tibicen (Australian Magpie)*
265. 25596 *Cracticus torquatus (Grey Butcherbird)*

Cuculidae
267. 42307 *Cacomantis pallidus (Pallid Cuckoo)*

Dicruridae
288. 24443 *Grallina cyanoleuca (Magpie-lark)*
289. 25614 *Rhipidura leucophrys (Willie Wagtail)*

Estrilidae
310. 30870 *Taeniopygia guttata (Zebra Finch)*

Falconidae
386. 25621 *Falco berigora (Brown Falcon)*
387. 25622 *Falco cenchroides (Australian Kestrel)*
388. 25623 *Falco longipennis (Australian Hobby)*
389. 25624 *Falco peregrinus (Peregrine Falcon)* S

Halcyonidae
429. 42351 *Todiramphus pyrrhopygius (Red-backed Kingfisher)*
430. 25549 *Todiramphus sanctus (Sacred Kingfisher)*

Hirundinidae
437. *Cheramoeca leucosterna*
438. 24491 *Hirundo neoxena (Welcome Swallow)*

Maluridae
487. 25647 *Amytornis striatus (Striated Grasswren)*
488. 24539 *Amytornis striatus subsp. striatus (Striated Grasswren (inland))* P4
489. *Malurus (Musciparus) leucopterus subsp. leucopterus*
490. 25651 *Malurus lamberti (Variegated Fairy-wren)*
491. 25652 *Malurus leucopterus (White-winged Fairy-wren)*
492. 25654 *Malurus splendens (Splendid Fairy-wren)*

Megapodiidae
514. 24557 *Leipoa ocellata (Malleefowl)* T

Meliphagidae
515. 24559 *Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*
516. 24561 *Anthochaera carunculata (Red Wattlebird)*
517. *Certhionyx (Certhionyx) variegatus*
518. 24564 *Certhionyx variegatus (Pied Honeyeater)*
519. *Epthianura (Parepthianura) tricolor*
520. 24567 *Epthianura albifrons (White-fronted Chat)*
521. 24568 *Epthianura aurifrons (Orange Chat)*
522. 24570 *Epthianura tricolor (Crimson Chat)*
523. 42314 *Gavicalis virescens (Singing Honeyeater)*
524. 25661 *Lichmera indistincta (Brown Honeyeater)*
525. *Manorina (Myzantha) flavigula*
526. 24583 *Manorina flavigula (Yellow-throated Miner)*
527. *Phylidonyris (Meliornis) novaehollandiae subsp. longirostris*
528. 42344 *Purnella albifrons (White-fronted Honeyeater)*
529. 42310 *Sugomel niger (Black Honeyeater)*

Meropidae
530. 24598 *Merops ornatus (Rainbow Bee-eater)* IA

Neosittidae
581. *Daphoenositta (Neositta) chrysoptera*
582. *Daphoenositta (Neositta) chrysoptera subsp. pileata*
583. 25673 *Daphoenositta chrysoptera (Varied Sittella)*

Otididae
590. 24610 *Ardeotis australis (Australian Bustard)*

Pachycephalidae
591. *Colluricincla (Colluricincla) harmonica*
592. 25675 *Colluricincla harmonica (Grey Shrike-thrush)*
593. 24618 *Oreoica gutturalis (Crested Bellbird)*
594. 25680 *Pachycephala rufiventris (Rufous Whistler)*

Pardalotidae
595. 24627 *Pardalotus rubricatus (Red-browed Pardalote)*
596. 25682 *Pardalotus striatus (Striated Pardalote)*

Pelecanidae
611. 24648 *Pelecanus conspicillatus (Australian Pelican)*

Petroicidae
614. *Petroica (Petroica) goodenovii*
615. 24659 *Petroica goodenovii (Red-capped Robin)*

Phalacrocoracidae
616. 24667 *Phalacrocorax sulcirostris (Little Black Cormorant)*

Phasianidae
617. 24671 *Coturnix pectoralis (Stubble Quail)*

Podargidae
655. 25703 *Podargus strigoides (Tawny Frogmouth)*

Podicipedidae
656. 25705 *Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*

Pomatostomidae
659. *Pomatostomus (Morganornis) superciliosus*
660. 24683 *Pomatostomus superciliosus (White-browed Babbler)*
661. 25706 *Pomatostomus temporalis (Grey-crowned Babbler)*

Psittacidae
694. *Barnardius zonarius*
695. *Cacatua sp.*
696. 24736 *Melopsittacus undulatus (Budgerigar)*
697. 24740 *Neophema splendida (Scarlet-chested Parrot)*
698. *Neopsephotus bourkii*
699. 24742 *Nymphicus hollandicus (Cockatiel)*
700. 24752 *Polytelis alexandrae (Princess Parrot)* P4
701. 30854 *Polytelis anthopeplus subsp. westralis (Regent Parrot)*

Ptilonorhynchidae
710. *Ptilonorhynchus guttatus subsp. guttatus*

Rallidae
716. 25727 *Fulica atra (Eurasian Coot)*
717. 24770 *Porzana pusilla subsp. palustris (Baillon's Crake)*
718. *Tribonyx ventralis*

Recurvirostridae
719. 24774 *Cladorhynchus leucocephalus (Banded Stilt)*
720. 25734 *Himantopus himantopus (Black-winged Stilt)*
721. 24776 *Recurvirostra novaehollandiae (Red-necked Avocet)*

Strigidae
838. 25748 *Ninox novaeseelandiae (Boobook Owl)*

Sylviidae
841. 24833 *Cincloramphus cruralis (Brown Songlark)*
842. 24834 *Cincloramphus mathewsi (Rufous Songlark)*

Threskiornithidae
859. 24845 *Threskiornis spinicollis (Straw-necked Ibis)*

Turnicidae
866. 24851 *Turnix velox (Little Button-quail)*

HERPETOFAUNA

Hylidae
439. 25375 *Cyclorana maini (Sheep Frog)*
440. 25376 *Cyclorana platycephala (Water-holding Frog)*
441. 25392 *Litoria rubella (Little Red Tree Frog)*

Limnodynastidae
464. 25422 *Neobatrachus aquilonius (Northern Burrowing Frog)*
465. 25425 *Neobatrachus kunapalari (Kunapalari Frog)*
466. *Neobatrachus sp.*
467. 42303 *Neobatrachus sudellae (Desert Trilling Frog)*
468. 25427 *Neobatrachus sutor (Shoemaker Frog)*
469. 25428 *Neobatrachus wilsmorei (Plonking Frog)*

Carphodactylidae
179. 24971 *Nephrurus vertebralis*

Diplodactylidae
291. 24926 *Diplodactylus conspicillatus (Fat-tailed Gecko)*
292. 24930 *Diplodactylus granariensis subsp. rex*
293. 24940 *Diplodactylus pulcher*
294. 42415 *Lucasium squarrosum*

295. 24982 *Rhynchoedura ornata (Western Beaked Gecko)*
296. 24927 *Strophurus elderi*
297. 24946 *Strophurus strophurus*
298. 24949 *Strophurus wellingtonae*

Gekkonidae

401. 24958 *Gehyra punctata*
402. 24959 *Gehyra variegata*
403. 24961 *Heteronotia binoei (Bynoe's Gecko)*
404. 24983 *Underwoodisaurus milii (Barking Gecko)*

Agamidae

32. 30833 *Amphibolurus longirostris (Long-nosed Dragon)*
33. 25458 *Ctenophorus caudicinctus (Ring-tailed Dragon)*
34. 24867 *Ctenophorus caudicinctus subsp. infans (Ring-tailed Dragon)*
35. 24869 *Ctenophorus caudicinctus subsp. mensarum (Ring-tailed Dragon)*
36. 24875 *Ctenophorus isolepis subsp. gularis (Central Military Dragon)*
37. 24882 *Ctenophorus nuchalis (Central Netted Dragon)*
38. 24886 *Ctenophorus reticulatus (Western Netted Dragon)*
39. 24888 *Ctenophorus salinarum (Salt Pan Dragon)*
40. 24889 *Ctenophorus scutulatus (Lozenge-marked Dragon)*
41. 24904 *Moloch horridus (Thorny Devil)*
42. 24907 *Pogona minor subsp. minor (Dwarf Bearded Dragon)*
43. 30814 *Tympanocryptis cephalus (Pebble Dragon)*

Varanidae

869. 25210 *Varanus brevicauda (Short-tailed Pygmy Monitor)*
870. 25211 *Varanus caudolineatus*
871. 25212 *Varanus eremius (Pygmy Desert Monitor)*
872. 25216 *Varanus giganteus (Perentie)*
873. 25218 *Varanus gouldii (Bungarra or Sand Monitor)*
874. 25223 *Varanus panoptes subsp. rubidus*

Scincidae

746. 25025 *Ctenotus ariadnae*
747. 25032 *Ctenotus calurus*
748. 25041 *Ctenotus grandis subsp. grandis*
749. 25045 *Ctenotus helenae*
750. 25052 *Ctenotus leonhardii*
751. 25064 *Ctenotus pantherinus subsp. ocellifer (Leopard Ctenotus)*
752. 25066 *Ctenotus quattuordecimlineatus*
753. 25074 *Ctenotus schomburgkii*
754. *Ctenotus sp.*
755. 25092 *Egernia depressa (Southern Pygmy Spiny-tailed Skink)*
756. 25094 *Egernia formosa*
757. 25109 *Eremiascincus richardsonii (Broad-banded Sand Swimmer)*
758. 25125 *Lerista bipes*
759. 25130 *Lerista desertorum*
760. 25155 *Lerista muelleri*
761. 42411 *Lerista timida*
762. 41411 *Liopholis inornata (Desert Skink)*
763. 41412 *Liopholis kintorei (Great Desert Skink, Tjakura)* T
764. 41417 *Liopholis striata (Night Skink)*
765. 25184 *Menetia greyii*
766. 25190 *Morethia butleri*
767. 25202 *Tiliqua multifasciata (Central Blue-tongue)*
768. 25203 *Tiliqua occipitalis (Western Bluetongue)*

Pygopodidae

711. 24997 *Delma butleri*
712. 25001 *Delma nasuta*
713. 25003 *Delma petersoni*
714. 25005 *Lialis burtonis*
715. 25009 *Pygopus nigriceps*

Boidae

149. 25448 *Antaresia stimsoni (Stimson's Python)*

Elapidae

302. 25243 *Acanthophis pyrrhus (Desert Death Adder)*
303. 42381 *Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*
304. 25254 *Parasuta monachus*
305. 25261 *Pseudechis australis (Mulga Snake)*
306. 42416 *Pseudonaja mengdeni (Western Brown Snake)*
307. 25263 *Pseudonaja modesta (Ringed Brown Snake)*
308. 25266 *Simoselaps bertholdi (Jan's Banded Snake)*
309. 25269 *Suta fasciata (Rosen's Snake)*

INVERTEBRATES

Barychelidae

147. *Synothele longbottomi*
148. *Synothele meadhunteri*

Nemesiidae

578. *Aname mainae*
579. *Aname tepperi*
580. 33919 *Kwonkan moriartii (trapdoor spider)* P2 Y

Theraphosidae

857. *Selenotholus foelschei*

Buthidae

166. *Isometroides vescus*

Appendix 3

EPBC Act Protected Matters Database Search

Australian Government

Department of the Environment

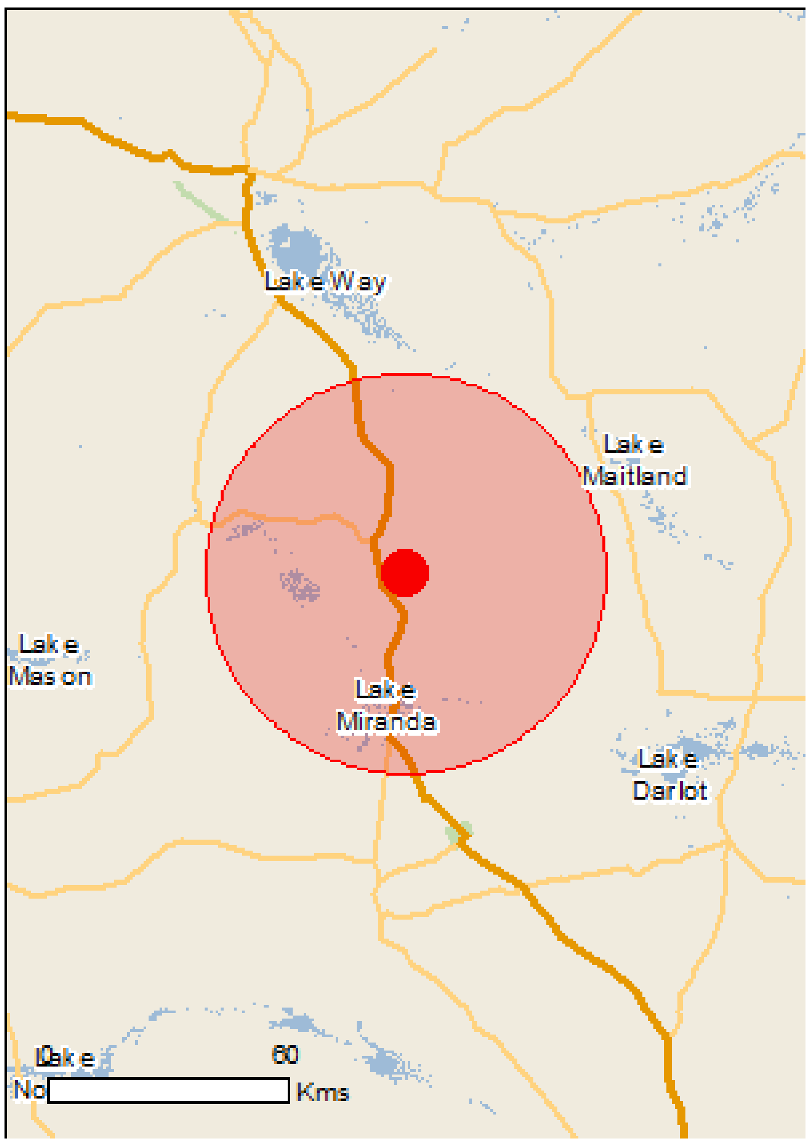
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

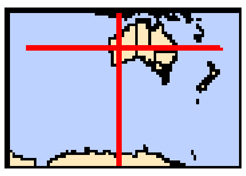
Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 23/06/16 13:57:52



Coordinates

Buffer: 50.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	5
Listed Migratory Species:	3

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	5
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	10
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat known to occur within area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Plants		
Atriplex yeelirrie [88538]	Endangered	Species or species habitat known to occur within area
Reptiles		
Liopholis kintorei Great Desert Skink, Tjakura, Warrarna, Mulyamiji [83160]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Migratory Wetlands Species		
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Wanjarri	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Carrichtera annua Ward's Weed [9511]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-27.40194 120.57472

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Parks and Wildlife Commission NT, Northern Territory Government
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of the Environment
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111

Appendix 4

Description of Conservation Rankings

Department of Parks and Wildlife

CONSERVATION CODES

For Western Australian Flora and Fauna

Specially protected fauna or flora are species* which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such.

Categories of specially protected fauna and flora are:

T Threatened species

Published as Specially Protected under the *Wildlife Conservation Act 1950,* and listed under Schedules 1 to 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora).

Threatened fauna is that subset of 'Specially Protected Fauna' declared to be 'likely to become extinct' pursuant to section 14(4) of the Wildlife Conservation Act.

Threatened flora is flora that has been declared to be 'likely to become extinct or is rare, or otherwise in need of special protection', pursuant to section 23F(2) of the Wildlife Conservation Act.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR Critically endangered species

Threatened species considered to be facing an extremely high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EN Endangered species

Threatened species considered to be facing a very high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

VU Vulnerable species

Threatened species considered to be facing a high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EX Presumed extinct species

Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.

IA Migratory birds protected under an international agreement

Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice.

CD Conservation dependent fauna

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice.

OS Other specially protected fauna

Fauna otherwise in need of special protection to ensure their conservation. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

P Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

1 Priority 1: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

2 Priority 2: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

3 Priority 3: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

4 Priority 4: Rare, Near Threatened and other species in need of monitoring

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.
(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.
(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

*Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Appendix 5

Combined Species List from all Studies Considered by this Review

MAMMALS

TACHYGLOSSIDAE
- Echidna *Tachyglossus aculeatus*

DASYURIDAE
- Wooley's Pseudantechinus *Pseudantechinus woolleyae*
- Brush-tailed Mulgara *Dasycercus blythi*
- Wongai Ningaui *Ningaui ridei*
- Kultarr *Antichinomys laniger*
- Fat-tailed Dunnart *Sminthopsis crassicaudata*
- *Sminthopsis ooldea/dolichura?*
- Hairy-footed Dunnart *Sminthopsis hirtipes*
- Long-tailed Dunnart *Sminthopsis longicaudata*
- Stripe-faced Dunnart *Sminthopsis macroura*
- Ooldea Dunnart *Sminthopsis ooldea*

MACROPODIDAE
- Euro *Osphranter robustus*
- Red Kangaroo *Osphranter rufus*
- Black-footed Rock-wallaby *Petrogale lateralis*

EMBALLONURIDAE
- Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris*
- Hill's Sheath-tailed Bat *Taphozous hilli*

MOLLOSIDAE
- White-striped Free-tailed Bat *Austronomus australis*
- Inland Free-tailed Bat *Ozimops* sp.

VESPERTILIONIDAE
- Gould's Long-eared Bat *Nyctophilus gouldii*
- Lesser Long-eared Bat *Nyctophilus geoffroyi*
- Greater Long-eared Bat *Nyctophilus major tor*
- Inland Broad-nosed Bat *Scotorepens balstoni*
- Inland Forest-bat *Vespadelus baverstocki*
- Finlayson's Cave-bat *Vespadelus finlaysoni*
- Southern Forest-bat *Vespadelus regulus*

MURIDAE
- Spinifex Hopping Mouse *Notomys alexis*
- Bolam's Mouse *Pseudomys bolami*
- Desert Mouse *Pseudomys desertor*
- Sandy Inland Mouse *Pseudomys hermannsburgensis*
- House Mouse *Mus musculus*

CANIDAE
- Dog/Dingo *Canis lupus*

FELIDAE
- Cat *Felis catus*

LEPORIDAE
- Rabbit *Oryctolagus cuniculus*

BOVIDAE
- Cattle *Bos taurus*
- Goat *Capra hircus*

CAMELIDAE
- Camel *Camelus dromedarius*

HERPETOFAUNA

HYLIDAE
- Cyclorana maini
- *Cyclorana platycephala*
- *Litoria rubella*

LIMNODYNASTIDAE
- *Neobatrachus* sp
- *Notaden nichollsi*

MYOBATRACHIDAE
- *Pseudophryne occidentalis*

AGAMIDAE
- *Ctenophorus caudicinctus mensarum*
- *Ctenophorus isolepis gularis*
- *Ctenophorus nuchalis*
- *Ctenophorus reticulatus*
- *Ctenophorus salinarum*
- *Ctenophorus scutulatus*
- *Lophognathus longirostris*
- *Moloch horridus*
- *Pogona minor minor*
- *Tympanocryptis cephala*

DIPLODACTYLIDAE
- *Diplodactylus conspicillatus*
- *Diplodactylus granariensis granariensis*
- *Diplodactylus pulcher*
- *Diplodactylus squarrosus*
- *Rhynchoedura ornata*
- *Strophurus elderi*
- *Strophurus strophurus*
- *Strophurus wellingtonae*

CARPHODACTYLIDAE
- *Nephrurus laevissimus*
- *Nephrurus vertebralis*

GEKKONIDAE
- *Gehyra variegata*
- *Heteronotia binoei*

PYGOPIDAE
- *Delma butleri*
- *Delma nasuta*
- *Lialis burtonis*
- *Pygopus nigriceps*

SPENOMORPHIDAE
- *Ctenotus ariadnae*
- *Ctenotus atlas*
- *Ctenotus calurus*
- *Ctenotus grandis*
- *Ctenotus hanloni*
- *Ctenotus helenae*
- *Ctenotus leonhardii*
- *Ctenotus pantherinus*
- *Ctenotus quattuordecimlineatus*
- *Ctenotus schomburgkii*
- *Ctenotus uber uber*
- *Eremiascincus richardsonii*
- *Lerista bipes*
- *Lerista desertorum*
- *Lerista rhodonoides*

EUGONGYLIDAE
- *Cryptoblepharus buchananii*
- *Menetia greyii*
- *Morethia butleri*

EGERNIIDAE
- *Egernia depressa*
- *Liopholis inornata*
- *Tiliqua multifasciata*
- *Tiliqua occipitalis*

VARANIDAE
- *Varanus brevicauda*
- *Varanus caudolineatus*
- *Varanus eremius*
- *Varanus giganteus*
- *Varanus gouldii*
- *Varanus panoptes rubidus*
- *Varanus tristis tristis*

TYPHLOPIDAE
- *Anilios hamatus*
- *Anilios waitii*

BOIDAE
- *Antaresia stimsoni*

ELAPIDAE
- *Brachyurophis fasciolata*
- *Brachyurophis semifasciata*
- *Furina ornata*
- *Parasuta monachus*
- *Pseudechis australis*
- *Pseudonaja modesta*
- *Pseudonaja mengdeni*
- *Simoselaps bertholdi*
- *Suta fasciata*

AVIFAUNA

CASUARIIDAE
- Emu *Dromaius novaehollandiae*

PHASIANIDAE
- Brown Quail *Coturnix ypsilophora*

ANATIDAE
- Australian Shelduck *Tadorna tadornoides*
- Grey Teal *Anas gracilis*
- Australian Wood Duck *Chenonetta jubata*
- Pacific Black Duck *Anas superciliosa*
- Hardhead *Aythya australis*

PODICIPEDIDAE
- Hoary-headed Grebe *Poliocephalus poliocephalus*
- Great Crested Grebe *Podiceps cristatus australis*

PHALACROCORACIDAE
- Little Black Cormorant *Phalacrocorax sulcirostris*

ARDEIDAE
- White-necked Heron *Ardea pacifica*
- White-faced Heron *Ardea novaehollandiae*

ACCIPITRIDAE
- Black-shouldered Kite *Elanus caeruleus axillaris*
- Black-breasted Buzzard *Hamirostra melanosternon*
- Whistling Kite *Haliastur sphenurus*
- Brown Goshawk *Accipiter fasciatus didimus*
- Collared Sparrowhawk *Accipiter cirrocephalus cirrocephalus*
- Little Eagle *Aquila morphnoides morphnoides*
- Wedge-tailed Eagle *Aquila audax*

FALCONIDAE
- Brown Falcon *Falco berigora berigora*
- Australian Kestrel *Falco cenchroides cenchroides*
- Australian Hobby *Falco longipennis longipennis*

RALLIDAE
- Black-tailed Native-hen *Gallinula ventralis*

OTIDIDAE
- Australian Bustard *Ardeotis australis*

TURNICIDAE
- Little Button-quail *Turnix velox*

CHARADRIIDAE
- Banded Lapwing *Vanellus tricolor*
- Black-fronted Dotterel *Charadrius melanops*
- Red-kneed Dotterel *Erythrogonys cinctus*
- Red-capped Plover *Charadrius ruficapillus*

LARIDAE
- Gull-billed Tern *Gelochelidon nilotica*

COLUMBIDAE
- Common Bronzewing *Phaps chalcoptera*
- Crested Pigeon *Ocyphaps lophotes*
- Diamond Dove *Geopelia cuneata*
- Peaceful Dove *Geopelia striata placida*

PSITTACIDAE
- Galah *Cacatua roseicapilla*
- Cockatiel *Nymphicus hollandicus*
- Australian Ringneck *Platycercus zonarius*
- Mulga Parrot *Platycercus varius*
- Bourke's Parrot *Neophema bourkii*
- Elegant Parrot *Neophema elegans*
- Budgerigar *Melopsittacus undulatus*

CUCULIDAE
- Pallid Cuckoo *Cuculus pallidus*
- Black-eared Cuckoo *Chrysococcyx osculans*
- Horsfield's Bronze Cuckoo *Chrysococcyx basalis*

AEGOTHELIDAE
- Australian Owlet-nightjar *Aegotheles cristatus*

APODIDAE
- Fork-tailed Swift *Apus pacificus*

MEROPIDAE
- Rainbow Bee-eater *Merops ornatus*

CLIMACTERIDAE
- White-browed Treecreeper *Climacteris affinis*

MALURIDAE
- Splendid Fairy-wren *Malurus splendens*
- Variegated Fairy-wren *Malurus lamberti*
- White-winged Fairy-wren *Malurus leucopterus*
- Rufous-crowned Emu-wren *Stipiturus ruficeps ruficeps*

PARDALOTIDAE
- Striated Pardalote *Pardalotus striatus*

ACANTHIZIDAE
- Redthroat *Pyrrholaemus brunneus*
- Rufous Fieldwren *Calamanthus campestris*
- Weebill *Smicrornis brevirostris*
- Western Gerygone *Gerygone fusca fusca*
- Broad-tailed Thornbill *Acanthiza apicalis*
- Slaty-backed Thornbill *Acanthiza robustirostris*
- Chestnut-rumped Thornbill *Acanthiza uropygialis*
- Yellow-rumped Thornbill *Acanthiza chrysorrhoa*
- Southern Whiteface *Aphelocephala leucopsis*

MELIPHAGIDAE
- Brown Honeyeater *Lichmera indistincta indistincta*
- Black Honeyeater *Certhionyx niger*
- Pied Honeyeater *Certhionyx variegatus*
- Singing Honeyeater *Lichenostomus virescens*
- Grey-fronted Honeyeater *Lichenostomus plumulus*
- White-plumed Honeyeater *Lichenostomus penicillatus*
- White-fronted Honeyeater *Phylidonyris albifrons*
- Yellow-throated Miner *Manorina flavigula*
- Spiny-cheeked Honeyeater *Acanthagenys rufogularis*
- Crimson Chat *Epthianura tricolor*

PETROICIDAE
- Red-capped Robin *Petroica goodenovii*
- Hooded Robin *Petroica cucullata*

POMATOSTOMIDAE
- Grey-crowned Babbler *Pomatostomus temporalis*
- White-browed Babbler *Pomatostomus superciliosus*

CINCLOSOMATIDAE
- Chestnut Quail-thrush *Cinclosoma castanotus*
- Chestnut-breasted Quail-thrush *Cinclosoma castaneothorax*

NEOSITTIDAE
- Varied Sittella *Daphoenositta chrysoptera*

PACHYCEPHALIDAE
- Crested Bellbird *Oreoica gutturalis*
- Rufous Whistler *Pachycephala rufiventris*
- Grey Shrike-thrush *Colluricincla harmonica*

DICRURIDAE
- Willie Wagtail *Rhipidura leucophrys*
- Magpie-lark *Grallina cyanoleuca*

CAMPEPHAGIDAE
- Black-faced Cuckoo-shrike *Coracina novaehollandiae*
- Ground Cuckoo-shrike *Coracina maxima*
- White-winged Triller *Lalage tricolor*

ARTAMIDAE
- Masked Woodswallow *Artamus personatus*
- Black-faced Woodswallow *Artamus cinereus*
- Little Woodswallow *Artamus minor*

CRACTICIDAE
- Grey Butcherbird *Cracticus torquatus*
- Pied Butcherbird *Cracticus nigrogularis*
- Australian Magpie *Cracticus tibicen*
- Grey Currawong *Strepera versicolor*
- Torresian Crow *Corvus orru*
- Little Crow *Corvus bennetti*
- Australian Raven *Corvus coronoides*

PTILONORHYNCHIDAE
- Western Bowerbird *Ptilonorhynchus maculatus*

HIRUNDINIDAE
- White-backed Swallow *Cheramoeca leucosternus*
- Welcome Swallow *Hirundo neoxena*
- Tree Martin *Hirundo nigricans*
- Fairy Martin *Hirundo ariel*

SYLVIIDAE
- Rufous Songlark *Cincloramphus mathewsi*
- Brown Songlark *Cincloramphus cruralis*

PASSERIDAE
- Zebra Finch *Taeniopygia guttata*

MOTACILLIDAE
- Australian Pipit *Anthus australis*

BUILDING A BETTER WORLD

REPORT

Mt Keith Satellite Operations: Short-range Endemic Invertebrate Fauna Impact Assessment

Prepared for BHP Nickel West

August 2016

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Brooke Hay	Paul Bolton

PREPARED BY	
Paul Bolton	29/06/2016
CHECKED BY	
Chris Knuckey	30/06/2016
REVIEWED BY	
Fiona Taukulis	30/06/2016
APPROVED FOR ISSUE BY	
Fiona Taukulis	30/06/2016

PERTH
41 Bishop Street, Jolimont , WA 6014
TEL +61 (08) 9388 8799, FAX : +61 (08) 9388 8633

REVISION SCHEDULE

Rev No	Date	Description	Signature or Typed Name (documentation on file).			
			Prepared by	Checked by	Reviewed by	Approved by
1.0	30/06/16	Draft Report	PB	CK	AS	AS
2.0	18/08/16	Final Report	PB	KM	PB	PB

Executive Summary

BHP Billiton Nickel West (Nickel West) commissioned MWH to undertake a terrestrial short-range endemic (SRE) invertebrate fauna assessment of the proposed Mt Keith Satellite Operations (the Project). The Project is located within the Yakabindie and Mt Keith pastoral leases, approximately 25 km south of the existing Mt Keith Nickel Operation and immediately west of the Wanjarri Nature Reserve in the Northern Goldfields region of Western Australia.

This report documents the results of a terrestrial SRE invertebrate fauna assessment of the Study Area which covers 5,422 hectares. The assessment was informed by a survey of a baseline survey area encompassing 5,675 ha, a survey of Wanjarri Nature Reserve encompassing 52,563 ha to provide regional perspective, a targeted survey of Jones Creek encompassing 1,679 and a desktop study which included both database searches and a literature review.

The specific objectives of this terrestrial SRE invertebrate fauna assessment were to:

- assess the occurrence and likely distribution of SRE invertebrate fauna within the Study Area;
- identify, describe and map potential terrestrial SRE invertebrate fauna habitat and any significant habitat within the Study Area;
- assess survey findings in the regional context by comparisons with available data from other localities within the Murchison bioregion; and
- assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and habitat in the Study Area.

The field survey was conducted in accordance with the Western Australia Environmental Protection Authority's *Guidance Statement No 20. Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia*. The invertebrate collection methods used were previously endorsed by the then WA Department of Environment and Conservation (DEC; now Department of Parks and Wildlife). The invertebrate collection methods included wet pitfall trapping, leaf litter processing in Tullgren funnels, soil sieving and targeted searching.

In total the combined surveys comprised 17,600 trapping nights, 149 hours of targeted searching, the collection of 90 soil samples and 90 leaf litter samples. An SRE invertebrate fauna habitat assessment was conducted over the Study Area, which involved characterising habitat according to condition, complexity and suitability for invertebrate taxa prone to short-range endemism.

Drawing on Outback Ecology's previous experience in the Murchison bioregion and subsequent to consultation with invertebrate SRE specialists, the following invertebrate groups prone to short-range endemism were targeted during this assessment: mygalomorph spiders, scorpions, pseudoscorpions, millipedes, slaters and terrestrial snails.

The surveys yielded a total of 1,682 invertebrate specimens from target groups from 49 species. Slaters were the most numerous group to be collected (832 specimens from 8 species), followed by pseudoscorpions (439 specimens from 11 species), scorpions (195 specimens from 9 species), mygalomorph spiders (168 specimens from 15 species), millipedes (38 specimens from two species) and snails (10 specimens from 4 species). Database and literature reviews identified an additional 42 potential SRE species occurring within 50 km of the Project.

Based on current scientific knowledge of species collected within the Study Area, two were considered by experts as Confirmed SRE species, four as Likely SRE species and 23 as Potential SRE species (**ES Table 1**).

ES Table 1: Confirmed and Likely SRE species from the Study Area

SRE Status	Taxa	Group
Confirmed	*Antichiropus 'DIP002'*	Millipede
	Antichiropus 'DIP003'	Millipede
Likely	*Aname 'MYG235'*	Mygalomorph spider
	Synsphyronus `sp. PSE023'	Pseudoscorpion
	Family Armadillidae 'yakabindie b'	Slater
	Pseudodiploexochus 'yakabindie'	Slater

With regards to Project impacts to SRE taxa; one confirmed, one Likely and 14 Potential SRE species have been collected from within disturbance area. However, none of these species have been collected exclusively from within the proposed disturbance area. All species collected within the disturbance area for the Project have also been collected outside the proposed disturbance area.

With respect to habitats, nine broad habitats were identified across the Baseline Survey Area, Targeted Survey Area and Wanjarri Nature Reserve. All of these habitats, excluding Spinifex Sandplain were identified within the Study Area for this assessment. With respect to SRE species, the Creekline and Internal Drainage habitats have a high potential of supporting SRE species. Approximately 4.5 % of Creekline and 14.6 % of Internal Drainage habitat within the Study Area will be directly impacted upon by the Project. From the Baseline and Targeted surveys, it is known that additional Creekline habitat and Internal Drainage habitat occurs outside of the Study Area and will not be directly impacted by the Project. Within the total area mapped for this study, only 1.4 % of Creekline habitat and 1.3 % of Internal Drainage Line habitat will be directly impacted by the Project. Secondary impacts to the Creekline habitat are likely to be minimal, provided that adequate controls of secondary impacts downstream of the Project are implemented and managed appropriately.

Breakaway, Stony Hills and Slopes and Drainage Line habitats were considered to have a medium potential of supporting SRE species. Of these, the Project will have the largest impacts on the stony hills and slope habitat, where 34 % of this habitat in the Study Area will be impacted upon by the Project. No invertebrate habitat was found to be restricted exclusively to the proposed disturbance area. The proposed disturbance area largely comprises habitats with a medium or low potential to support SRE species.

BHP Nickel West

Mt Keith Satellite Operations: Short-range Endemic Invertebrate Fauna Impact Assessment

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APPENDICES

1 Introduction

1.1 Project Location and Description

BHP Billiton Nickel West (Nickel West) commissioned MWH Australia (MWH) to conduct a terrestrial short-range endemic (SRE) invertebrate fauna assessment (this Assessment) of the proposed Mt Keith Satellite Operations (the Project). The Project is located within the Yakabindie and Mt Keith pastoral leases, approximately 25 km south of the existing Mt Keith Nickel Operation and immediately west of the Wanjarri Nature Reserve in the Murchison region of Western Australia (WA) (**Figure 1-1**).

Broadly, the Project comprises two open cut pits, Six-Mile pit and Goliath pit, and an associated waste rock landform. Nickel West proposes to mine both these pits as satellite to the Mt Keith Processing Hub. The Project will be connected to the existing Mt Keith Operations via a haul road which intersects the Yakabindie and Mt Keith pastoral leases.

Five areas are defined for the purposes of this Assessment (**Figure 1-2**). They include:

- The **Study Area**: The Study Area is defined as a 5,422 hectare (ha) parcel of land which encompasses the Project and will be used for the purposes of this Assessment.
- The **Baseline Survey Area**: The Baseline Survey Area encompasses a 5,675 ha parcel of land that was surveyed during a baseline survey in 2011 (**Section 4.1**). This survey area largely aligns with the Study Area.
- The **Wanjarri Nature Reserve**: The Wanjarri Nature reserve comprises approximately 52,563 ha of land managed by the Department of Parks and Wildlife (DPaW) and lies adjacent to the Baseline Survey Area. The Wanjarri Nature Reserve was surveyed concurrently with the baseline survey to provide regional context. A portion of the nature reserve overlaps the Study Area.
- The **Targeted Survey Area**: The targeted survey area comprises a 1,679 ha parcel of land which encompasses the creek line habitat within the Jones Creek system that was the focus of a targeted millipede survey in 2012 (**Section 4.2**). A portion of the Targeted Survey Area overlaps the Study Area and the Baseline Survey Area.
- The **Disturbance Area**: The disturbance area comprises approximately 1,125 ha and makes up the entire area of disturbance required to develop the Project. Direct clearing associated with these footprints and potential secondary impacts associated with the operation of the Project will be the focus of this Assessment. The vast majority of the disturbance area (1,109 ha) occurs within the Study Area used for this assessment with the remainder (16ha) comprising of proposed access road to the Great Northern Highway which extends outside the Study Area.

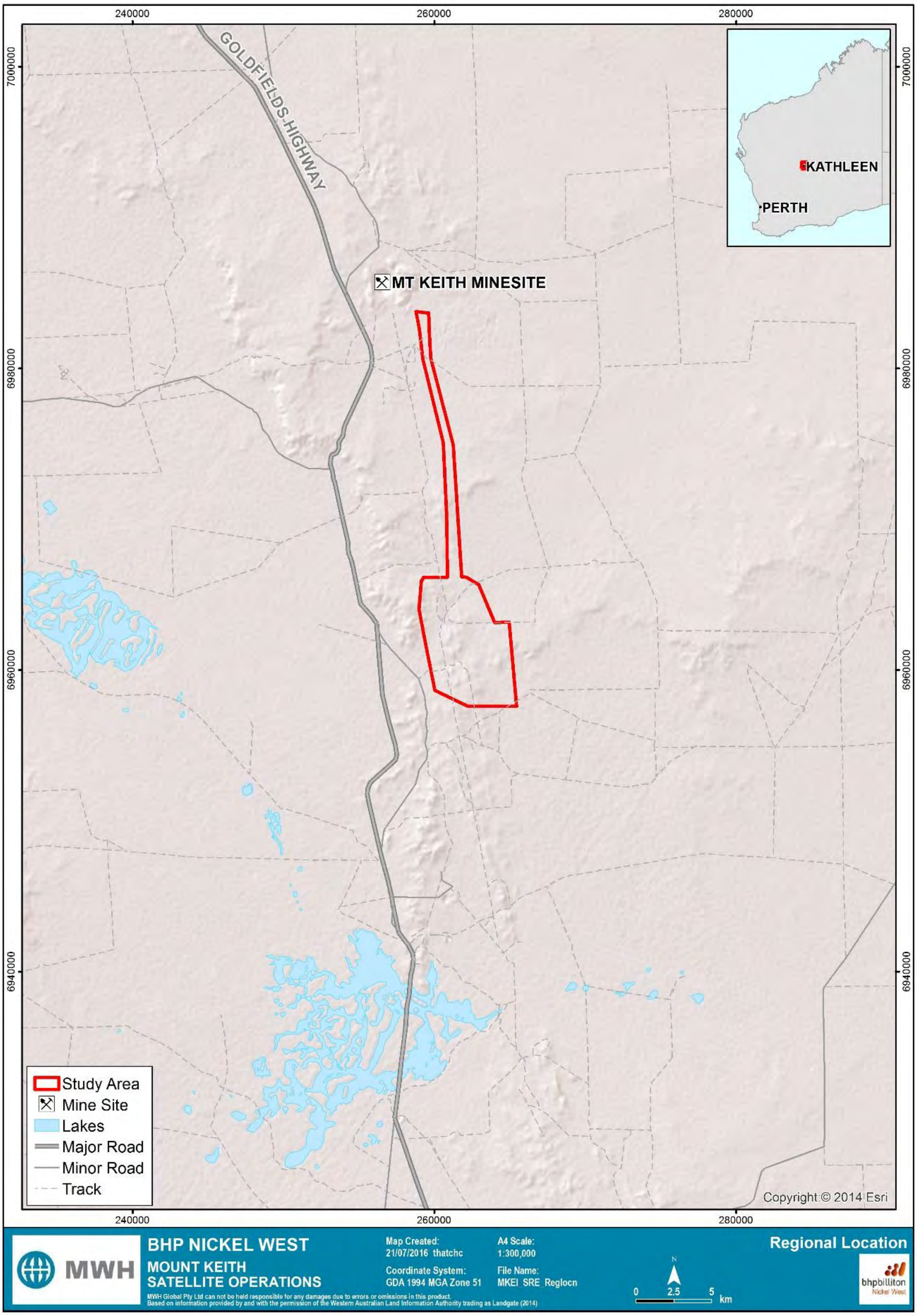

Figure 1-1: Regional location of the Study Area

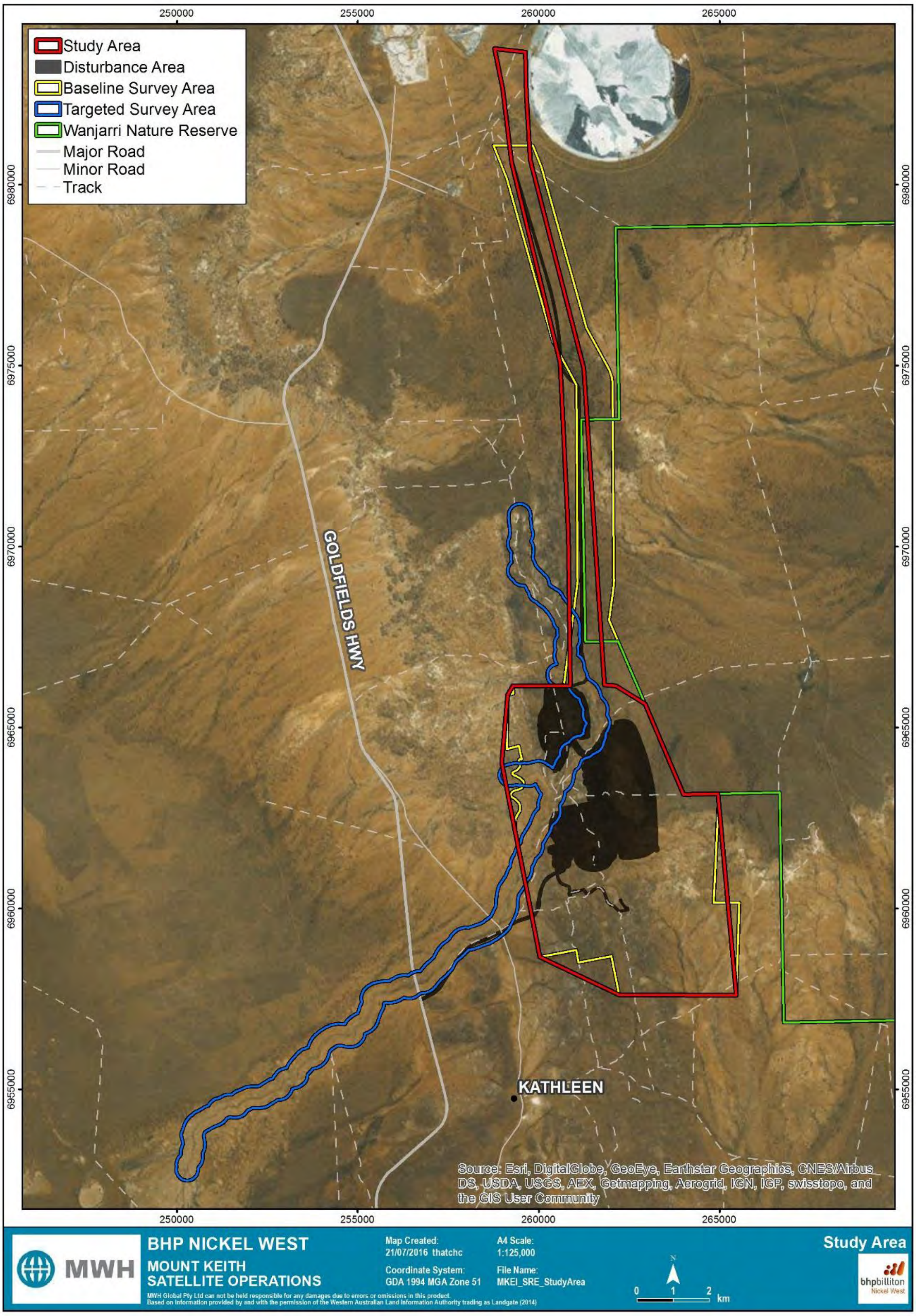

Figure 1-2: The Study Area, Survey Areas and conceptual Project layout

1.2 Assessment Scope and Objectives

The specific objectives of this terrestrial SRE invertebrate fauna assessment were to:

- assess the occurrence and likely distribution of SRE invertebrate fauna within the Study Area;
- identify, describe and map potential terrestrial SRE invertebrate fauna habitat and any significant habitat within the Study Area;
- assess survey findings in the regional context by comparisons with available data from other localities within the Murchison bioregion; and
- assess the potential impacts of the Project on terrestrial SRE invertebrate fauna and SRE habitat in the Study Area.

This assessment comprised a desktop study, an invertebrate fauna field survey that was conducted over two phases between 10 January and 8 April 2011 and a targeted invertebrate fauna survey conducted over two phases between 16 December 2011 and 29 March 2012. For local and regional context, this report also presents a summary of results from previous terrestrial SRE invertebrate fauna surveys that have been conducted in the Study Area and surrounds.

The survey was designed and conducted in accordance with:

- WA Environmental Protection Authority (EPA) Guidance No. 20, Sampling of Short-range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia (EPA 2009);
- EPA Guidance No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (EPA 2004); and
- EPA Position Statement No. 3, Terrestrial Biological Surveys as an Element of Biodiversity Protection (EPA 2002).

The field sampling methodology used during the surveys has been previously endorsed by the then Department of Conservation (now DPaW).

1.3 Short-Range Endemic Invertebrate Taxa

Endemism refers to the restriction of a species to a particular area, at a continental, national or local scale (Allen *et al.* 2002). Harvey (2002) defines a restricted range as a species with a maximum range of 10,000 km². Comprehensive systematic reviews of different faunal groups often reveal the presence of SRE invertebrate species (Harvey 2002). Some better known SRE species have been listed under State or Commonwealth legislation. However, the majority of SRE species have not been listed under legislation, often due to lack of taxonomic knowledge (EPA 2009). SRE invertebrates in general are considered relevant to environmental impact assessment as habitat loss and degradation can decrease their prospects for persistence (EPA 2009).

Invertebrate groups prone to short-range endemism that have potential to occur within the Murchison and are regularly targeted during SRE surveys include: mygalomorph spiders, selenopid spiders, scorpions, pseudoscorpions, millipedes, slaters and terrestrial snails. Additional invertebrate groups have potential to include SRE species (see Harvey 2002) however these groups are generally considered beyond the requirements of fauna surveys for EIA.

Taxonomists (i.e. Western Australian Museum [WAM] and Phoenix Environmental) have developed criteria for explaining the degree of certainty surrounding the SRE status of a specimen where specific knowledge gaps exist, such as:

- unknown geographic distribution of a species due to patchy/limited sampling;
- limited taxonomic resolution due to limited knowledge of a particular group or a lack of specialist skills; and
- specimens are of an inappropriate life stage or sex to allow for accurate identification to species level.

These categories will be used to provide context to specimens collected during surveys (**Table 1-1**).

Table 1-1: Categories for status with respect to short-range endemism

Status	Criteria
Pseudoscorpions and Millipedes (WAM)	
Confirmed	• A known distribution of < 10 000 km2. • The taxonomy is well known. • The group is well represented in collections and / or via comprehensive sampling.
Potential	• Patchy sampling has resulted in incomplete knowledge of the geographic distribution of the group. • Incomplete taxonomic knowledge. • The group is not well represented in collections. • This category is most applicable to situations where there are gaps.
Widespread	• A known distribution of > 10 000 km^2. • The taxonomy is well known. • The group is well represented in collections and / or via comprehensive sampling.
Unknown	• Specimens belonging to known SRE groups, that cannot be accurately identified to species level due to an inappropriate sex or life stage.
Mygalomorph Spiders, Scorpions and Isopods (Phoenix Environmental)	
Confirmed	• Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published). • Group well represented in collections, in particular from the region in question. • High levels of endemism in documented species i.e. *Antichiropus* millipedes (Paradoxosomatidae) and scorpions in the genus *Aops* (Urodacidae). • Inference is often possible from immature specimens.
Likely	• Taxonomically poorly resolved group. • Unusual morphology for the group (i.e. some form of troglomorphism). • Often singleton in survey and few, if any, regional records. • Opiliones in the genus *Dampetrus*.

Status	Criteria
Potential	• Taxonomically poorly resolved group. • Often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records. • Congeners often widespread. • Specimens belonging to known SRE groups, that cannot be accurately identified to species level due to an inappropriate sex or life stage.
Widespread	• Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2).

2 Existing Environment

2.1 Biogeographic Region

The Study Area is located within the Murchison bioregion (**Figure 2-1**), as defined by the Interim Biogeographic Regionalisation for Australia (IBRA) classification system (Thackway and Cresswell 1995). Landscapes of the Murchison bioregion typically comprise low hills and mesas separated by flat colluvium and alluvial plains. The vegetation is dominated by low Mulga woodlands (*Acacia aneura* complex) on plains reduced to scrub on hills, with tree steppe of *Eucalyptus* sp., *Triodia* sp. on sandplains, saltbush shrubland on calcareous soils and saline areas with samphire (Beard 1990, Thackway and Cresswell 1995). The bioregion is rich and diverse in both its flora and fauna although most species are wide-ranging and usually occur in adjoining regions.

Within the Murchison Bioregion, the Study Area is located within the Eastern Murchison subregion, characterised by its internal drainage and extensive areas of elevated red desert sandplains with minimal dune development, salt lake systems associated with the occluded palaeodrainage system as well as broad plains of red-brown soils, breakaways and red sandplains (Cowan *et al.* 2001). Vegetation is dominated by Mulga Shrublands, often rich in ephemerals, hummock grasslands, saltbush shrublands and *Tecticornia* spp. shrublands (Cowan *et al.* 2001).

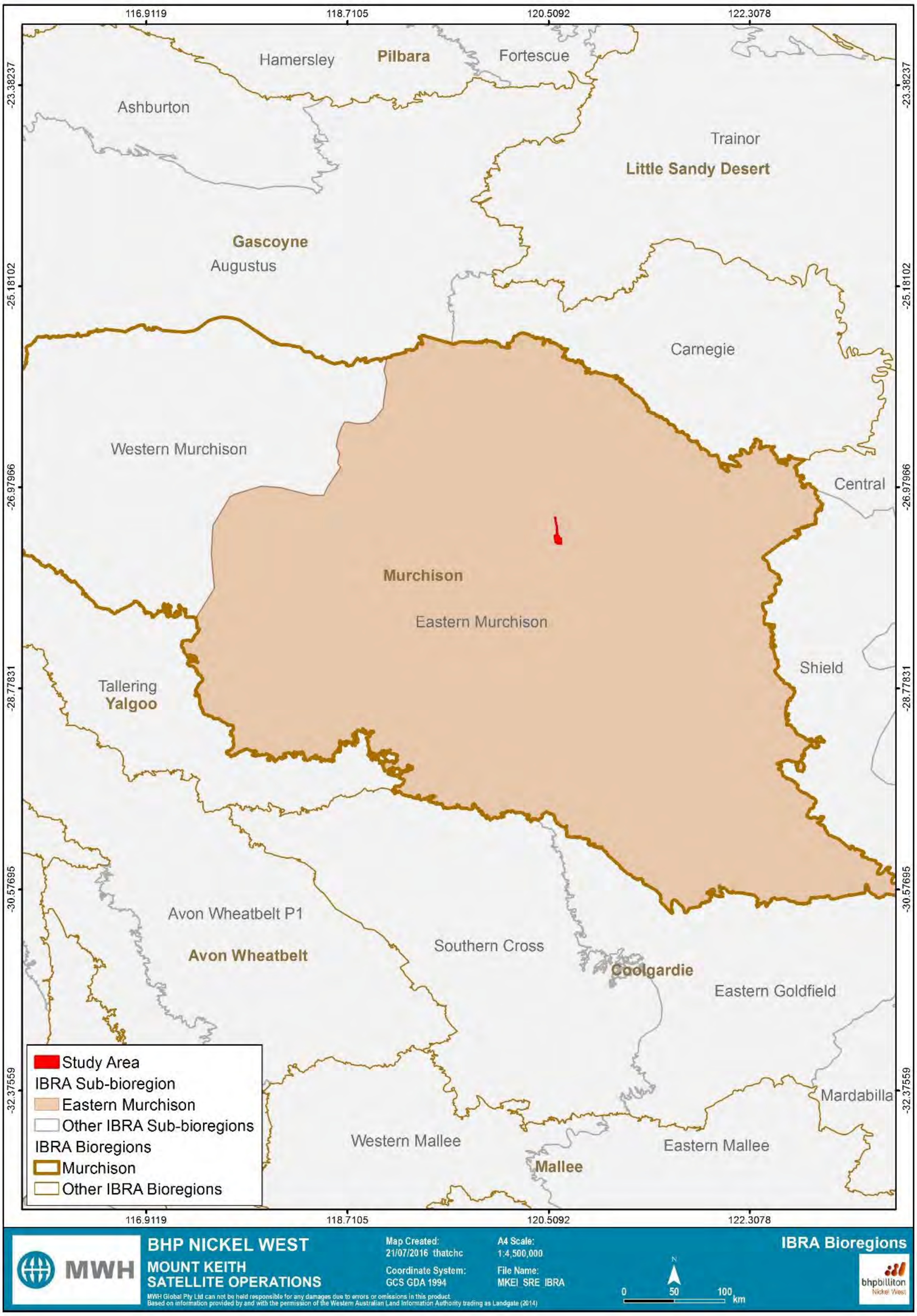

Figure 2-1: Location of the Study Area with respect to IBRA sub-bioregions

2.2 Land Systems

A regional survey was undertaken in the Murchison bioregion by the Department of Agriculture (now the Department of Agriculture and Food) and the Department of Land Administration (now Landgate) to develop a comprehensive description of the biophysical resources and assess the vegetation composition and soil condition within the region (Pringle *et al.* 1994). This information was used to classify and map the land systems of the region according to similarities in landform, soil, vegetation, geology and geomorphology. An assessment of land systems provides an indication of the occurrence and distribution of fauna habitats present within and surrounding the Study Area. The Study Area comprises fourteen land systems, with the majority of the Study Area falling within the Bevon and Sherwood land systems (**Table 2-1**; **Table 2-1**).

Table 2-1: Land systems occurring within the Study Area

Land system	Brief description	Proportion of Study Area		Area in the Eastern Murchison subregion (ha)
		Ha	%	
Bevon	Irregular low ironstone hills with stony lower slopes supporting Mulga shrublands.	1785.86	32.94	224,793
Sherwood	Breakaways, kaolinised footslopes and extensive gently sloping plains on granite supporting Mulga shrublands and minor halophytic shrublands.	1089.39	20.09	1,109,448
Bullimore	Extensive sand plains supporting Spinifex hummock grasslands.	542.02	10.00	3,560,476
Windarra	Gently undulating stony plains and low rises with quartz mantles on granite, supporting acacia-eremophila shrublands.	465.75	8.59	227,973
Jundee	Hardpan plains with ironstone gravel mantles and occasional sandy banks supporting Mulga shrublands.	341.95	6.31	507,116
Tiger	Gravelly hardpan plains and sandy banks with Mulga shrublands and wanderrie grasses.	335.25	6.18	111,277
Violet	Gently undulating gravelly plains on greenstone, laterite and hardpan, with low stony rises and minor saline plains; supporting groved Mulga and bowgada shrublands and patchy halophytic shrublands.	235.86	4.35	441,473
Nubev	Gently undulating stony plains, minor limonitic low rises and drainage floors supporting Mulga and halophytic shrublands.	201.95	3.72	149,770
Monk	Hardpan plains with occasional sandy banks supporting Mulga tall shrublands and wanderrie grasses.	155.27	2.86	996,800
Sunrise	Stony plains supporting Mulga shrublands.	69.22	1.28	35,850
Ararak	Broad plains with mantles of ironstone gravel supporting Mulga shrublands with wanderrie grasses.	64.09	1.18	149,889

Land system	Brief description	Proportion of Study Area		Area in the Eastern Murchison subregion (ha)
		Ha	%	
Wyarri	Granite domes, hills and tor fields with gritty-surfaced fringing plains supporting Mulga and granite wattle shrublands.	62.72	1.16	88,609
Yanganoo	Almost flat hardpan wash plains, with or without small wanderrie banks and weak groving; supporting Mulga shrublands and wanderrie grasses on banks.	61.97	1.14	1,441
Wilson	Large creeks with extensive distributary fans, supporting Mulga and halophytic shrublands.	10.76	0.20	151,478

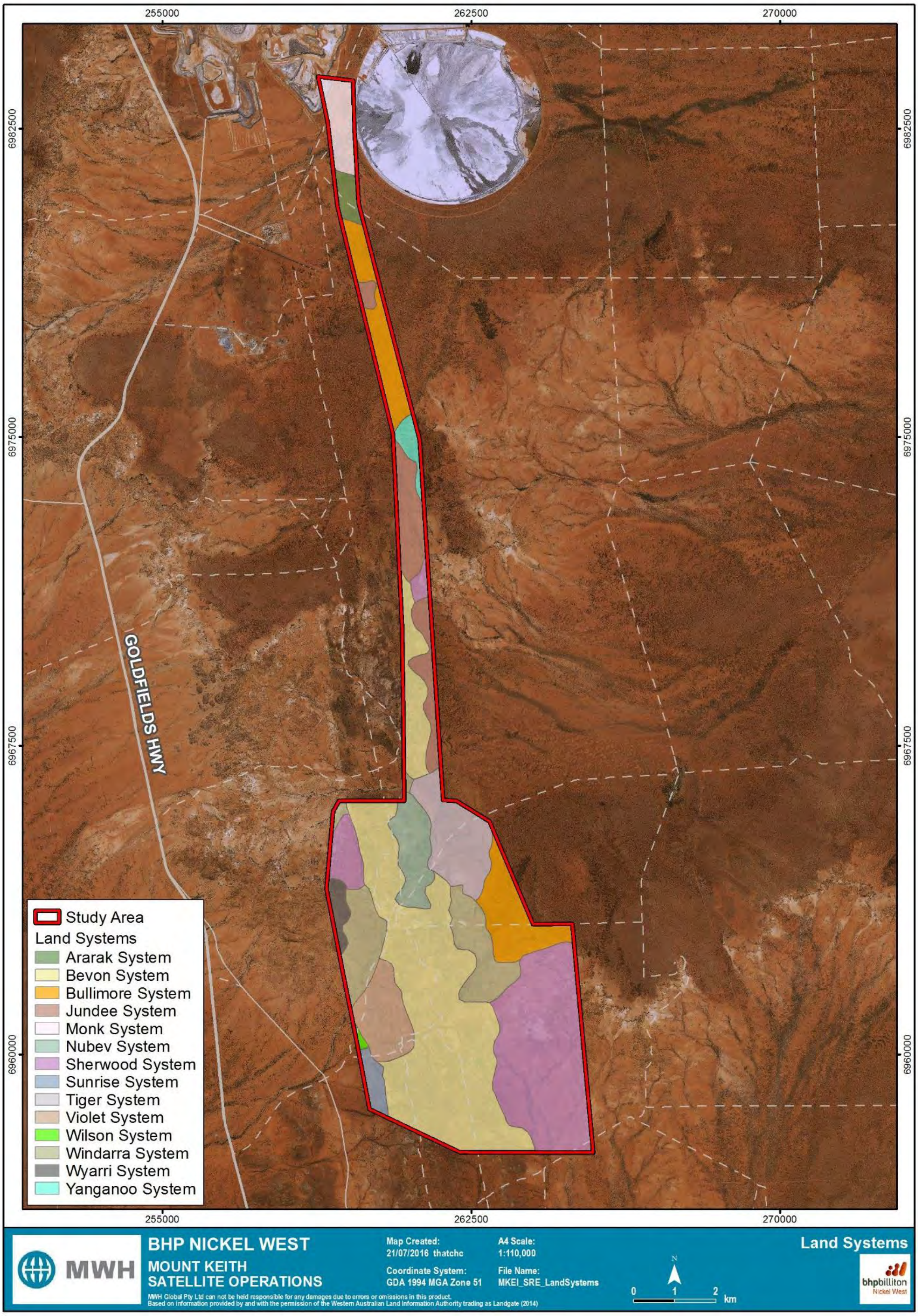

Figure 2-2: Land systems occurring within the Study Area

2.3 Land Use

Grazing of native pastures accounts for the vast majority of land use within the Eastern Murchison subregion (~85%), followed by Unallocated Crown Land (UCL) and Crown reserves which compose approximately 12% combined (Cowan *et al.* 2001). Mining activity within the region is considerable, dominated by nickel and gold mining, most of which are leases upon pastoral lands including the nearby Mt Keith Minesite. Only a small fraction of the subregion is protected within the conservation reserve system (<2%) and the subregion is not considered comprehensive or representative of ecosystems present (Cowan *et al.* 2001). Most conservation reserves are protected as Nature Reserves with only one National Park within the region, Goongarrie National Park, located 275 km south-east of the Study Area.

The Study Area is located on the Mt Keith and Yakabindie pastoral leases and borders the western edge of the Wanjarri Nature Reserve (**Figure 2-3**). The Wanjarri Nature Reserve encompasses approximately 53,000 ha, which comprises of mostly undulating sand plains, however, sand dunes, breakaways and low granite hills are also present. The Wanjarri Nature Reserve has a diverse vertebrate fauna, particularly birds, with 122 species recorded from the reserve (CALM 1996). The characteristics of the Wanjarri Nature Reserve that are of conservation value include:

- it being an arid land and desert landscape that supports a variety of habitats;
- the presence of Spinifex grasslands which characterise what most people perceive to be the deserts of the Australian inland;
- it representing a useful case study on the recovery of rangeland plant communities after grazing is discontinued; and
- the utilisation of particular habitats by threatened wildlife.

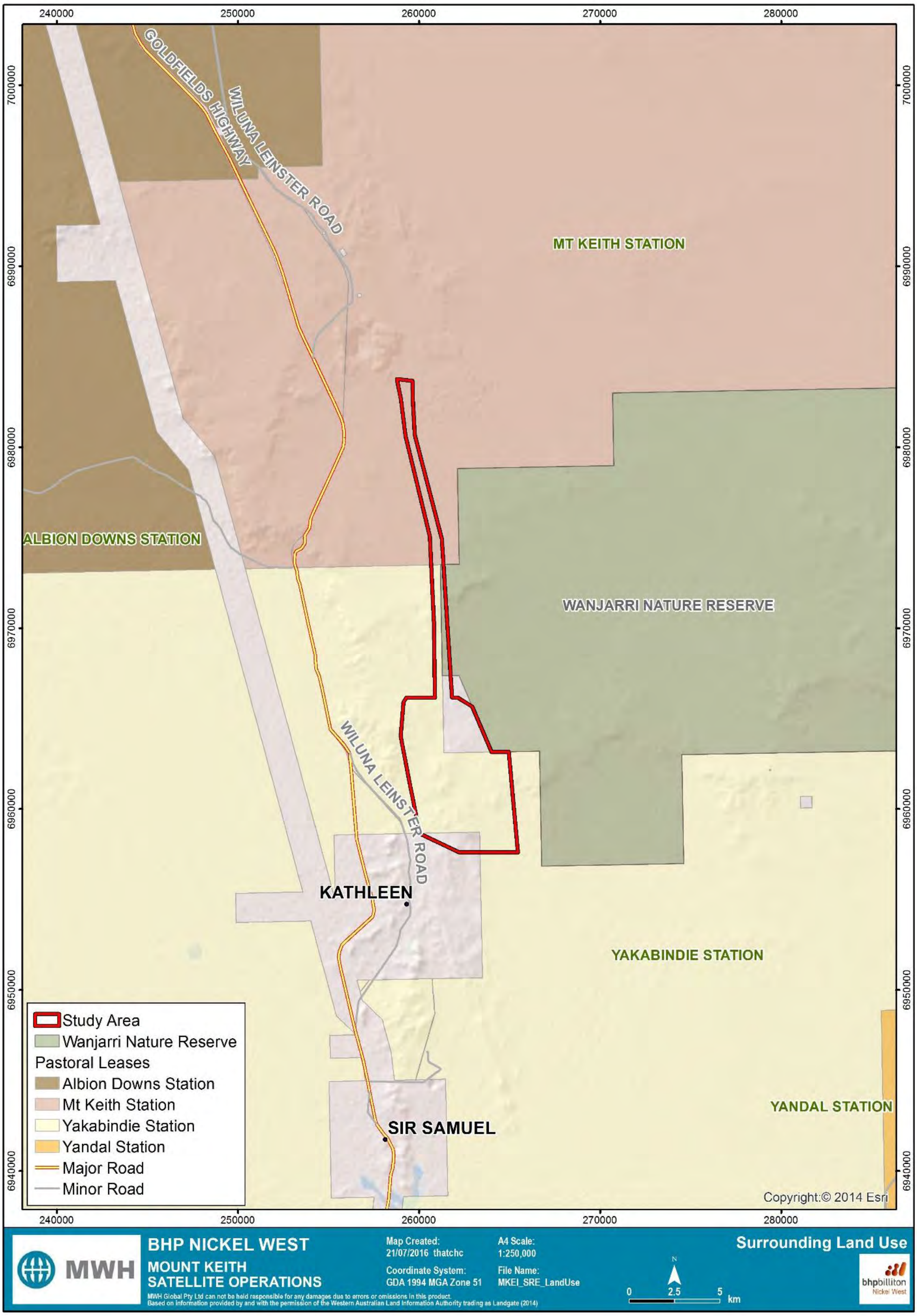

Figure 2-3: Land use within the Study Area and surrounds

2.4 Hydrology

The most prominent hydrology feature within the Study Area is Jones Creek. Jones Creek is a lateral tributary system, incised into the Barr-Smith Range, where the majority of runoff is received from the upper catchment, which covers an area of 64.1 km^2. During large flood events water is rapidly shed from this part of the catchment into the creek, aided by the rocky nature of the terrain and sparse vegetative cover. The terminus for the creek is a large floodplain area to the south-west of the Study Area, containing a number of claypans (Berry in prep). Beyond this, drainage becomes increasingly diffuse, before reaching Lake Miranda, located within the Carey Palaeodrainage system (Wetland Research and Management 2005).

Anecdotal evidence suggests that on average, Jones Creek flows once or twice a year, in response to moderate or high intensity rainfall of 25 mm or more (Berry in prep). The morphology of the channel leads to high energy flows, with a velocity of up to 1.7 m per second. In the terminal claypans (outside of the Study Area), depths of over two metres have been recorded following intensive rainfall. During large floods, the creek and associated claypans become connected, providing a mechanism for chemical and biological exchange (Berry in prep, Wetland Research and Management 2005).

Jones Creek is a freshwater system that, after flow events, rapidly dries to form a series of disconnected pools. Downstream of the Study Area, water is retained in the claypans for longer periods, supporting a predominantly freshwater ecosystem for several months or more (Berry in prep). The pools that form within Jones Creek, along with the claypans, provide an important refuge for aquatic biota within an arid landscape (Wetland Research and Management 2005).

2.5 Climate

The Murchison region is characterised as having an arid climate, with summer and winter rain and an annual rainfall in the range of 200 millimetres (mm) (Pringle *et al.* 1994). Rainfall over the Study Area is unreliable, with zero rainfall potentially recordable in any month (Pringle *et al.* 1994). Summer rainfall is typical of the region, however, most years experience a dry period that lasts from four to six months, typically commencing around October (Pringle *et al.* 1994).

The Yeelirrie meteorological station (station 012090) is the closest Bureau of Meteorology (BOM) weather station to the Study Area and is located approximately 60 km to the west (**Figure 1-1**). Meteorological data collected from the Yeelirrie meteorological station indicates that rainfall mainly occurs in the first half of the year (BoM 2016). The annual average rainfall recorded at the Yeelirrie meteorological station is approximately 239 mm with an average of 32 rain days recorded per annum (BoM 2016) (**Figure 2-4**). Peak temperatures are recorded from November to March. Mean daily maximum temperatures range from 37.9 °C in January to 19.3°C in July. Mean daily minimum temperatures range from 22.3 ºC in January to 3.5 ºC in June (BoM 2016).

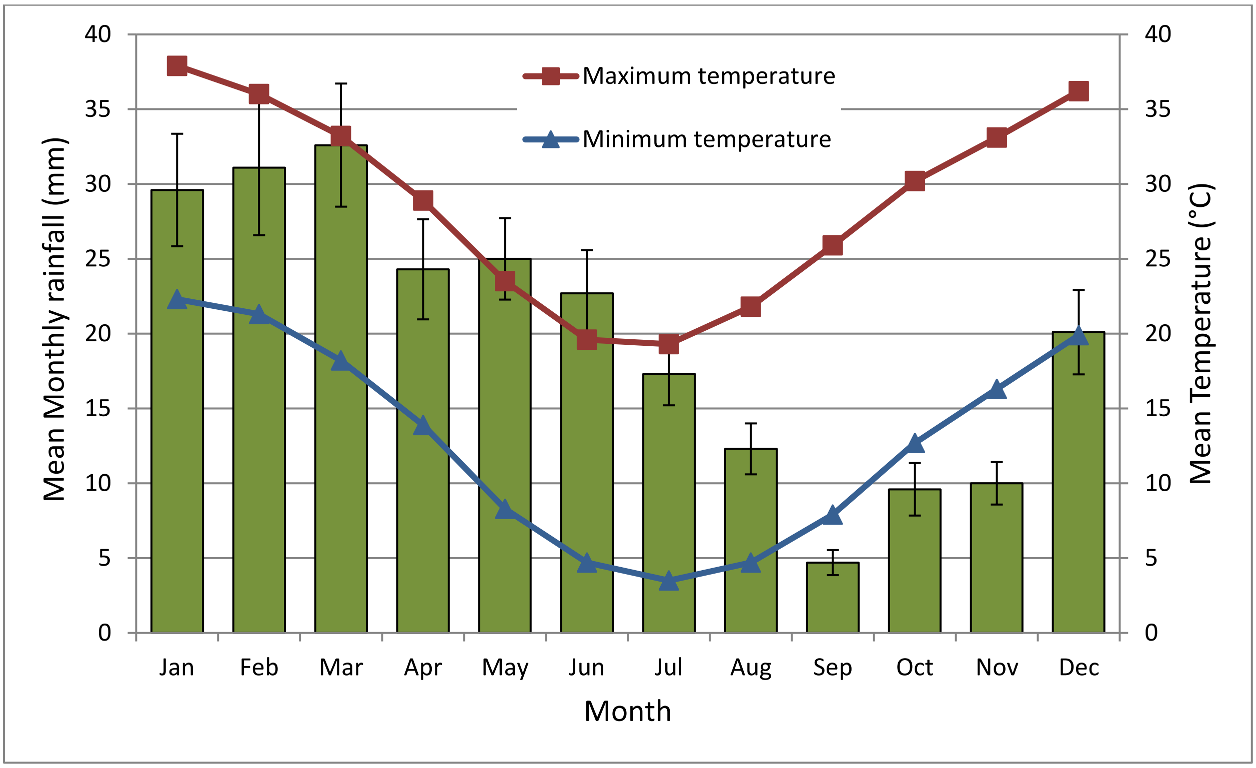

Figure 2-4: Mean rainfall and temperature data recorded from the Yeelirrie meteorological station (BoM 2016)

3 Desktop Study

3.1 Database Searches

A search of relevant databases and a literature review was undertaken prior to the field surveys in order to:

- determine the SRE taxa that have been previously collected in the region;
- facilitate the identification of SRE habitat within the Study Area; and
- assist with the assessment of the conservation significance of the invertebrate species collected.

Five database searches were conducted around a central coordinate (51J 261433 mE, 6965254 mS), with varying buffers as deemed appropriate (**Table 3-1**).

Table 3-1: Database searches

Custodian	Database	Reference	Buffer (km)
DPaW	Threatened and Priority Fauna	(DPaW 2016b)	100
DPaW	NatureMap	(DPaW 2016a)	40
Department of Environment (DoE)	Protected Matters	(DoE 2016)	50
WAM	Arachnids and Myriapod Database	(WAM 2016a)	100
WAM	Mollusc Database	(WAM 2016b)	100

The results of the database searches and literature review are presented in **Section 5.2**.

3.2 Literature Review

The literature review considered five previous SRE surveys of relevance to the Study Area (**Table 3-2**). Surveys considered were those that were publically available, recently conducted and in close proximity to the Study Area. As all specimens from SRE surveys are required to be lodged with the WAM, the majority of the records from the literature review were already captured in the WAM database searches.

Table 3-2: Key findings of SRE studies conducted within the vicinity of the Study Area

Reference	Study details	Proximity to Study Area	Survey Methods	Broad habitats	SRE fauna
(Outback Ecology 2012a)	Location: Yakabindie: Lake Way South Borefield Study Type: Level 1 Terrestrial Short-range Endemic Invertebrate Fauna Assessment Survey Date: April 2011	Adjacent to and north of the Study Area	• targeted searching • habitat mapping	8 broad fauna habitats including: • Spinifex Sandplain • Mulga over spinifex on sand plain • Salt lake mosaic • Sparse mulga woodland • Kopi dune • Sand dune • Drainage Line • Stony Hill and Slope	Potential SRE species: • *Aganippe* sp. • *Anidiops* sp. • *Cethegus* sp.
(Outback Ecology 2012b)	Location: Yakabindie: South East Borefield Study Type: Level 1 Terrestrial Short-range Endemic Invertebrate Fauna Assessment Survey Date: June 2012	Adjacent to and south of the Study Area	• targeted searching • habitat mapping	8 broad fauna habitats including: • Sparse Mulga Woodland • Playa • Drainage Line • Mulga over Wanderrie grass • Mulga over Spinifex on sandplain • Stony Plain • Calcrete plain • Acacia shrubland • Annual shrubland	n/a
Outback Ecology (2011)	Location: Lake Way Study Type: Wiluna Uranium Project: Terrestrial Fauna Assessment Survey Date: Autumn 2010	75 km north	• dry pitfall trapping • leaf litter collection • Tullgren funnels, • soil sieving, • ultraviolet (UV) spotlighting and	12 broad fauna habitats including: • open Mulga woodland over spinifex • Eucalypt woodland • mallee/Mulga complex over spinifex	Putative SRE • *Aname* MYG176 • *Aname* MYG177* • *Aname* MYG173* • *Kwonkan* MYG175* • *Urodacus* 'yeelirrie'

Reference	Study details	Proximity to Study Area	Survey Methods	Broad habitats	SRE fauna
			• targeted searching		
(Outback Ecology 2012a)	Location: Lake Way Study Type: Wiluna Uranium Project: Targeted Terrestrial Fauna Survey and Habitat Assessment Survey Date: March 2011	75 km north	• targeted searching • habitat mapping	12 broad fauna habitats including: • Mallee/Mulga Complex over Spinifex, • Melaleuca Stands • Eucalypt Woodland	Potential SRE • *Cethegus* sp. • *Aname* sp. • *Anidiops* sp. • *Urodacus* 'laverton 4' • *Urodacus* 'gibson 5'
(ecologia Environment 2011)	Location: Yeelirrie Study Type: SRE Invertebrate Fauna Baseline Survey Survey Date: • Searches: July 2009 • Wet pitfall trapping: Oct 2009 – Jan 2010 • Targeted survey: March 2010.	50 km west-northwest	• wet pitfall trapping, • leaf litter collection, • soil sieving and • targeted searching.	8 broad habitats including: • calcrete/calcrete outwash • chenopod shrubland • Breakaways • hardpan Mulga • shrubland of spinifex sandplain	Three Confirmed SRE: • *Idiosoma* sp., • *Pseudolaureola* sp. • Platyarthridae/Barthytropidae 13 potential SRE: • *Aganippe* sp., • *Aname* 'MYG170', • *Aname* 'MYG212', • Barychelidae, • Cheridiidae, • *Cubaris* sp. 1, • *Cubaris* sp. 2*, • Geophilida, • *Kwonkan* 'MYG171', • *Kwonkan* 'MYG172', • *Kwonkan* 'MYG210', • *Kwonkan* 'MYG211'; and • *Urodacus* 'yeelirrie'

* no longer considered to be a SRE species

4 Methods

Two surveys were conducted over the Study Area:

- the Baseline Survey (consisting of the Baseline Survey Area and Wanjarri Nature Reserve); and
- a Targeted Survey for a millipede for a millipede (*Antichiropus* 'DIP003') that had been collected during the Baseline Survey.

Methods for each survey are presented in **Section 4.1** and **Section 4.2**, respectively. Coverage of these surveys with respect to the Study Area is presented in **Figure 1-2**. Some areas of the Study Area extend outside of areas surveyed during the Baseline and Targeted Survey (**Figure 1-2**). For these additional areas, habitat mapping was extrapolated based on aerial imagery with reference to mapping from both the Baseline Survey and the Targeted survey.

4.1 Baseline Survey

4.1.1 Survey Timing

The baseline survey was conducted over two phases between 10 January and 8 April 2011. Two trapping phases were conducted during the survey period due to a considerable rainfall event in February, which caused widespread flooding throughout the Study Area (**Section 4.1.2**). The flooding raised concerns that the wet pitfall traps deployed in phase 1 were compromised due to inundation by water and the dilution of the preserving agent. In an attempt to counter any losses caused by flooding, the phase 2 survey traps were deployed upon collection of the phase 1 traps. Upon examination, almost all specimens collected from the phase 1 traps were well preserved and suitable for identification.

The two survey phases were conducted as follows:

- Phase 1: phase 1 wet pitfall traps were deployed from 10 to 21 January 2011 and collected between 2 and 11 March 2011. Targeted searches and systematic trapping were conducted at each survey site. Habitat mapping was also completed; and
- Phase 2: phase 1 wet pitfall traps replaced with phase 2 wet pitfall traps from 2 to 11 March 2011. The phase 2 wet pitfall traps were collected between 4 and 8 April 2011.

4.1.2 Weather Conditions

The records from three Bureau of Meteorology (BOM) weather stations have been considered for the Study Area: Yakabindie Homestead, Yeelirrie and Leinster. The Yakabindie Homestead weather station is located approximately 10 km south west of the Study Area, with the Yeelirrie and Leinster weather stations located approximately 60 km west and 60 km south of the Study Area, respectively. Consideration of data collected from these three weather stations is useful in providing regional context given the localised nature of rainfall in the Murchison.

During the phase 1 survey, the daily maximum temperatures recorded from the Leinster weather station ranged between 21.0 ºC and 44.4 ºC, with minimum between 14.6 ºC and 29 ºC (BoM 2016). A mean maximum temperature of 33.6 ºC and mean minimum of 21.2 ºC over the survey period were recorded at the Leinster, which is similar to the long-term average (BoM 2016). In the six weeks prior to the phase 1 survey, 105.4 mm of rain was recorded at Leinster, 83.2 mm from Yeelirrie and 103.0 mm from Yakabindie (**Figure 4-1**). During the Phase 1 survey period 64.2 mm of rain was recorded from Leinster, 185.7 mm from Yeelirrie and 204.5 mm from Yakabindie (**Figure 4-2**). The rainfall recorded prior to and during the phase 1 survey was substantially above the long-term average for the period which ranges from 30-33 mm per month from January to March (**Figure 2-4**)(BoM 2016).

During phase 2, the daily maximum temperatures recorded from the Leinster weather station during the survey period ranged between 21.7 ºC and 35.2 ºC, with minimum between 11.8 ºC and 21.7 ºC (BoM 2016). A mean maximum temperature of 29.7 ºC and mean minimum of 16.9 ºC over the survey period were recorded at the Leinster which is similar to the long-term average (BoM 2016). During the survey period, 1.6 mm of rainfall was recorded from Leinster, 13.8 mm from Yeelirrie and 9.8 mm from Yakabindie (**Figure 4-3**). The rainfall recorded during the phase 2 survey was below the long-term average for the period (BoM 2016).

Both the phase 1 and phase 2 surveys were conducted between November and April which is the optimum period for invertebrate surveys in the northern Goldfields (EPA 2009).

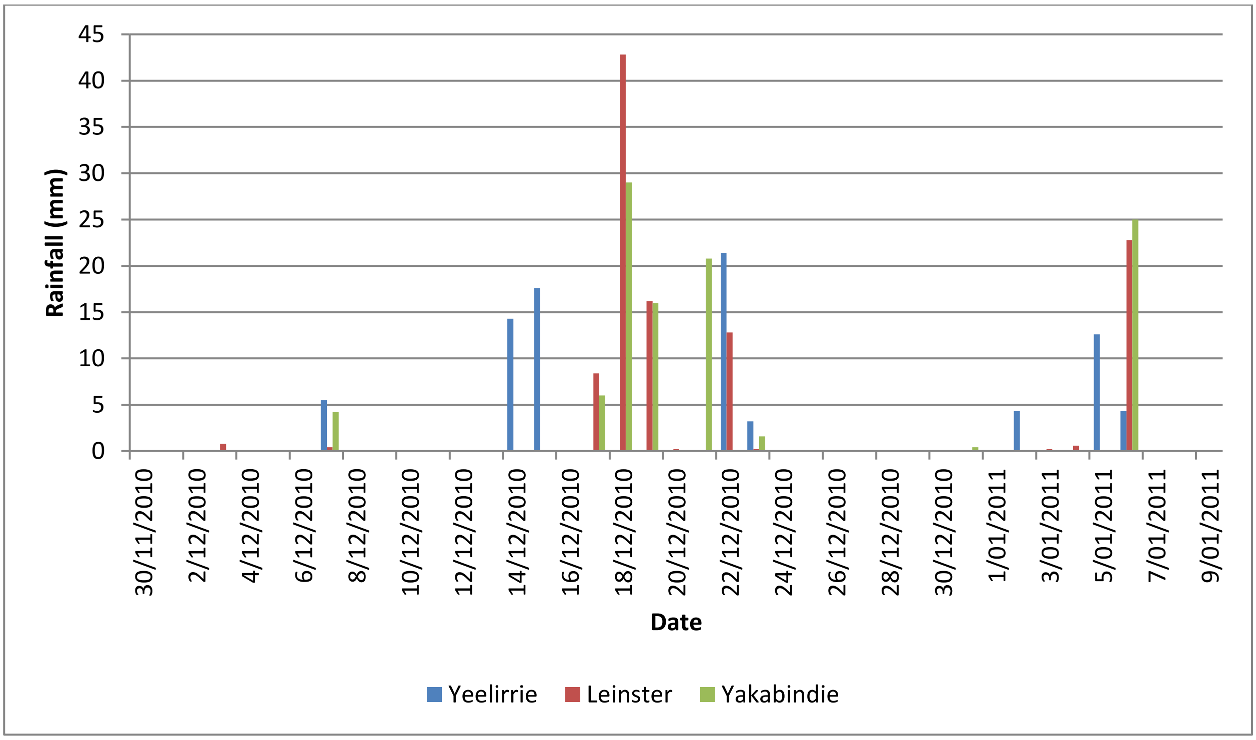

Figure 4-1: Rainfall recorded six weeks prior to the phase 1 survey

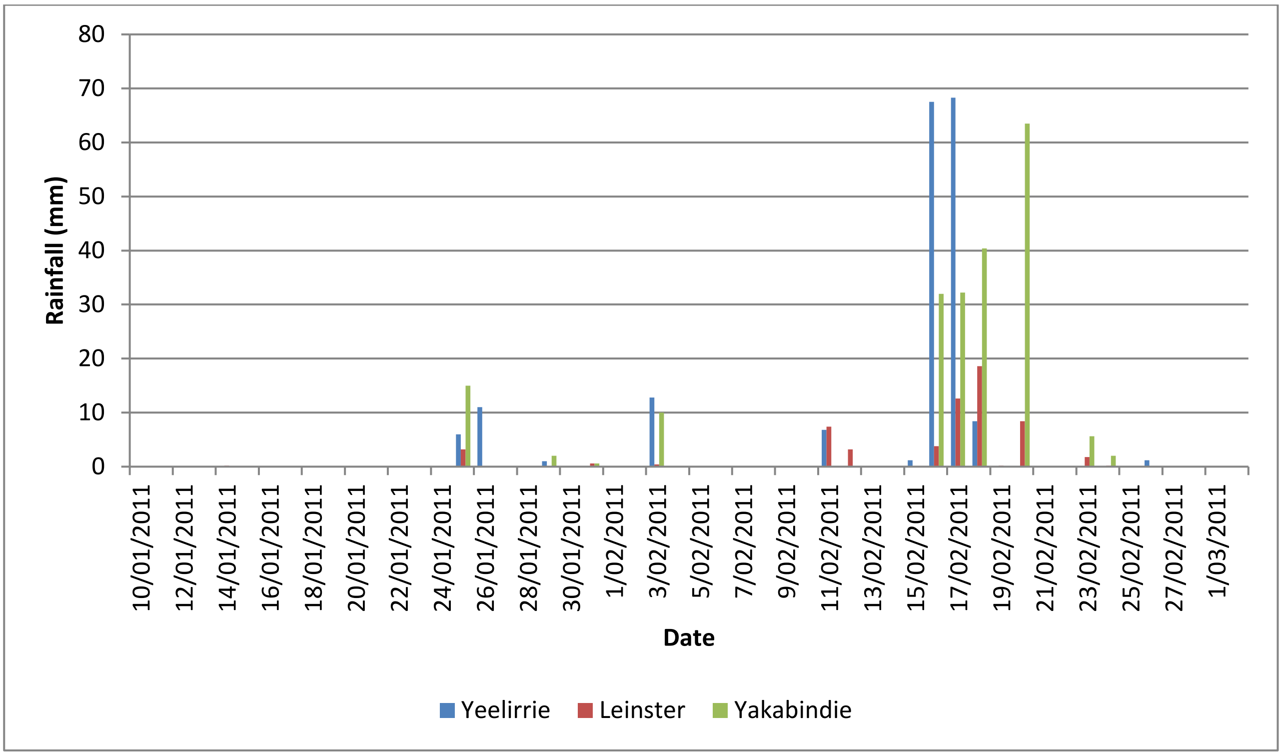

Figure 4-2: Rainfall recorded during the phase 1 survey

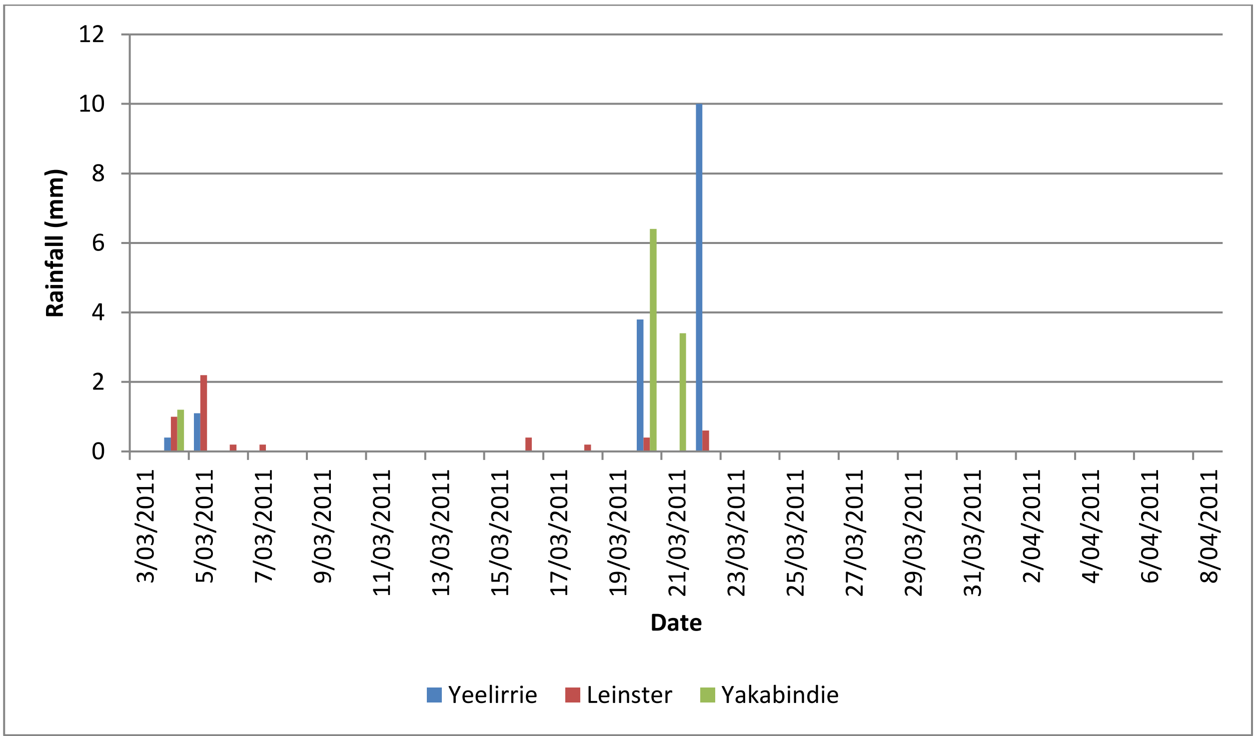

Figure 4-3: Rainfall recorded during the phase 2 survey

4.1.3 Survey Sites

Prior to the survey, a set of prospective survey sites were selected via a desktop analysis of aerial imagery. These sites were ground-truthed in the field and the optimal sites selected based on representation of the habitats present within the Study Area and vehicle accessibility at the time of survey.

A total of 30 systematic survey sites were sampled during the phase 1 survey (**Figure 4-4**; **Table 4-1**). Invertebrate collection methods employed at systematic survey sites comprised wet pitfall trapping, targeted searching, and soil and litter collection (**Section 4.1.5**). An additional eleven sites were target searched (Target 10 to Target 20) to gain improved geographical coverage during the phase 1 survey (**Figure 4-4**; **Table 4-2**). Phase 2 wet pitfall traps were redeployed at the same phase 1 systematic survey sites. Other invertebrate collection methods were not employed during the phase 2 survey. Where possible, survey sites were established in representative habitats both inside and outside of the proposed disturbance area (**Table 4-1**, **Table 4-2**). A site description for each of the survey sites is presented in **Appendix A**.

Table 4-1: Systematic survey sites sampled during phase 1 and phase 2 of the baseline survey

Site	Habitat	Inside disturbance area	Coordinates (GDA 94 MGA 51J)	
			Easting	Northing
Site 1	Drainage Line	No	260069	6963956
Site 2	Creekline	No	260911	6964243
Site 3	Stony Hill and Slope	Yes	260465	6964501
Site 4	Sparse Mulga Woodland	No	259961	6963678
Site 5	Stony Hill and Slope	Yes	261750	6962100
Site 6	Stony Hill and Slope	Yes	261501	6961523
Site 7	Stony Plain	No	263364	6960976
Site 8	Drainage Line	No	263236	6961464
Site 9	Stony Plain	Yes	262859	6962179
Site 10	Sparse Mulga Woodland	No	262053	6965091
Site 11	Stony Plain	Yes	262420	6963264
Site 12	Internal drainage	Yes	262584	6963485
Site 13	Stony Hill and Slope	Yes	261769	6963257
Site 14	Mulga over Spinifex Sandplain	No	263744	6962817
Site 15	Internal drainage	No	263462	6964221
Site 16	Stony Hill and Slope	No	260949	6959255
Site 17	Stony Hill and Slope	No	262683	6958525
Site 18	Stony Plain	No	264919	6958082
Site 19	Creekline	No	261585	6965583
Site 20	Drainage Line	No	261934	6960653
Site 21	Stony Hill and Slope	No	262236	6959963
Site 22	Drainage Line	No	260165	6961711
Site 23	Stony Plain	No	265955	6975664
Site 24	Internal drainage	No	262649	6978125
Site 25	Internal drainage	No	270876	6978638

Site	Habitat	Inside disturbance area	Coordinates (GDA 94 MGA 51J)	
			Easting	Northing
Site 26	Drainage Line	No	269627	6975479
Site 27	Mulga over Spinifex Sandplain	No	271770	6958826
Site 28	Mulga over Spinifex Sandplain	No	270827	6971413
Site 29	Sparse Mulga Woodland	No	265827	6972471
Site 30	Sparse Mulga Woodland	No	271730	6962668

Table 4-2: Targeted search sites sampled during phase 1 of the baseline survey

Site	Habitat	Inside disturbance area	Coordinates (GDA 94; MGA Zone 51J)	
			Easting	Northing
Target 10	Breakaway	Yes	261561	6961828
Target 11	Mulga over Spinifex over sand plain	No	259467	6980247
Target 12	Mulga over Spinifex over sand plain	No	261536	6973507
Target 13	Breakaway	No	261406	6971259
Target 14	Creekline	No	260535	6963476
Target 15	Creekline	No	259807	6961681
Target 16	Mulga over Spinifex over sand plain	No	266652	6964356
Target 17	Mulga over Spinifex over sand plain	No	266879	6964974
Target 18	Mulga over Spinifex over sand plain	No	269797	6963651
Target 19	Mulga over Spinifex over sand plain	No	271740	6967092
Target 20	Mulga over Spinifex over sand plain	No	271012	6979232

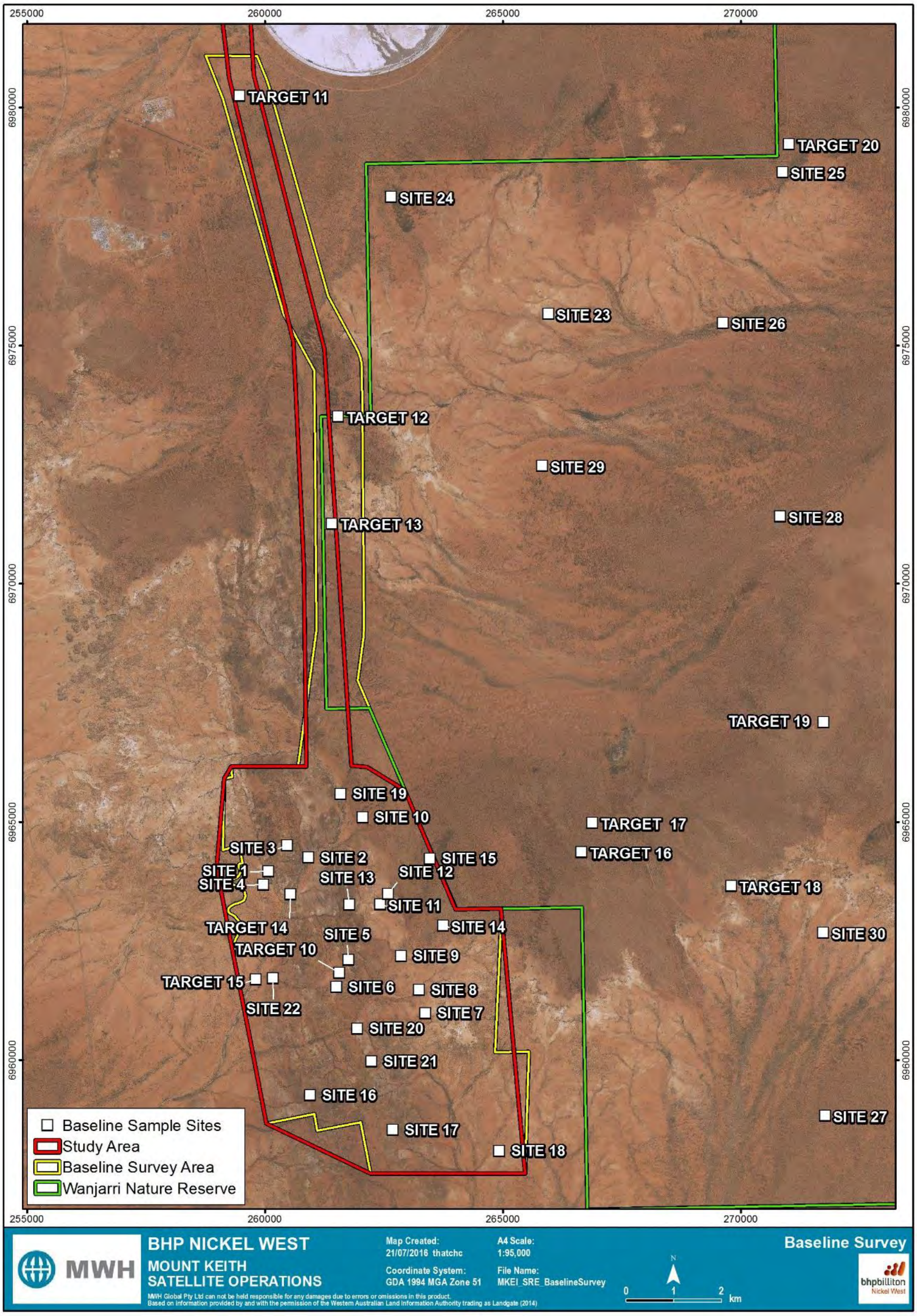

Figure 4-4: Location of systematic and targeted survey sites sampled during the Baseline Survey (phase 1 and phase 2)

4.1.4 SRE habitat assessment

Habitat assessments form an important part of the environmental impact assessment process as it relates to SRE invertebrate fauna. A habitat's potential for supporting SRE fauna can be used to identify habitats of conservation value and may also be used to identify the availability of suitable habitat for SRE species, outside of a disturbance area.

Potential terrestrial SRE habitats within the Baseline Survey Area and neighbouring Wanjarri Nature Reserve were identified and assessed in terms of complexity, quality, connectivity and extensiveness within the landscape. A SRE habitat assessment was conducted for each potential SRE habitat unit identified within the survey areas. This assessment entailed:

- establishment of habitat assessment reference points of suitable replication within representative habitat inside and outside of the disturbance area (where possible) to characterise the extent of SRE habitat in the area; and
- a standardised habitat assessment field sheet was completed for each site. The assessment was made in an area of approximately 50 m x 50 m. Landscape position, outcropping, soil type, broad vegetation type, litter cover, existing disturbance, extensiveness and physical connectivity within the landscape were recorded.

There are no prescriptive guidelines for identifying potential SRE habitats, though the most prospective habitats tend to be those that are sheltered, isolated or both (EPA 2009, Harvey 2002). Information resulting from the habitat assessments of the Baseline Survey Area has been incorporated into the descriptions of each broad habitat identified in the Study Area and is presented in **Section 5.1**.

4.1.5 Collection techniques

The techniques used for collecting SRE taxa during the Baseline survey are summarised in **Table 4-3** and described below. These methods are aligned with those specified by the EPA (2009) and endorsed by invertebrate SRE specialists of the WAM and DPaW (then Department of Conservation [DEC]).

Table 4-3: Summary of SRE sampling methods and effort for phase 1 and phase 2 survey of the Baseline Survey

Sampling technique	Target group	Sampling effort per site		Total effort
		Phase 1 survey	Phase 2 survey	
Wet pitfall trapping	All groups	5 traps open for a total of 60 nights (30 sites)	5 traps open for a total of 27 nights (30 sites)	13,050 trapping nights
Targeted searching	All groups	3 person hours (41 sites)	N/A	123 person hours
Litter collection	All groups	3 samples (30 sites)	N/A	90 samples
Soil sieving	Terrestrial snails	3 samples (30 sites)	N/A	90 samples

Wet pitfall trapping

The DPaW have suggested that wet pitfall trapping for terrestrial SRE invertebrate fauna is likely to be a more effective sampling method than dry pitfall trapping (Brad Durrant pers. comm. March 2010). Wet pitfall trapping involves a longer trapping period, with traps normally left open for up to six weeks. This increases the probability of trapping species that are active only briefly or sporadically, such as species which become active during periods of rainfall. Wet pitfall traps were left open for 60 nights during phase 1 and 27 nights during the phase 2 components of the Baseline Survey. Trapping effort totalled 13,050 trap nights over both phases; 9,000 trap nights in phase 1 and 4,050 trap nights in phase 2.

A wet pitfall trap comprises a plastic container that slots into a buried cylindrical PVC pipe (100 mm x 250 mm). Care was taken to ensure that the top of the container was flush with the top of the PVC pipe and the ground surface. The container was filled with approximately 500 millilitres (ml) of a preserving agent (100% propylene glycol) and a cover was suspended approximately 20 mm above the trap to reduce vertebrate by-catch and to limit rain entering the trap. To increase the effectiveness of the pitfall trap, two drift fences (flywire mesh) measuring approximately 75 centimetres (cm) in length and 15 cm in height were set on each side of the trap. The base of the fence was buried into the ground. Traps were placed at 5 to 10 metre (m) intervals where possible.

Upon the completion of the field survey, wet pitfall traps were removed, all holes back-filled and containers collected and sent back to the MWH (then Outback Ecology) laboratory. The contents of wet pitfall traps were examined using a dissecting microscope in the laboratory. Specimens from target taxa were removed and placed into vials containing 100% ethanol.

Vertebrates are sometimes collected in wet pitfall traps. All vertebrates were identified by Outback Ecology vertebrate fauna specialists. The records of invertebrates and vertebrates identified from both phases of the survey were forwarded to the DPaW (then DEC) as stipulated by the Fauna licenses under which these surveys were executed (Regulation 4 and Regulation 17).

Targeted searching

Each site was searched for SRE invertebrates for three person hours. Microhabitats searched included: leaf litter, beneath logs, bark and rocks, crevices, at the bases of shrubs and trees and beneath Spinifex hummocks. Burrows suspected to be those of mygalomorphs or scorpions were excavated and the occupants, if any, were collected. All specimens were placed into 100 % ethanol upon collection. A total of 123 person hours were spent targeted searching.

Leaf litter collection and Tullgren funnels

Three samples of leaf litter were collected from each site, with a total of 90 samples taken over both surveys. The samples were collected by scraping back the top layer of litter to reveal the decomposition layer above the soil. Leaf litter samples were sealed in plastic bags and kept cool during fieldwork and subsequent transportation to the MWH (then Outback Ecology) laboratory. Tullgren funnels were used to extract invertebrates from the leaf litter samples. Tullgren funnels use light and heat generated above the sample to encourage the downward movement of invertebrates. Eventually the invertebrates exit the funnel and fall into a container of 100 % ethanol. Leaf litter samples were left in the Tullgren funnels for at least 48 hours. After this time, the collection containers beneath the Tullgren funnels were examined for invertebrates using a binocular microscope. The leaf litter remaining in the funnels was searched for invertebrates using two times magnification.

Soil sieving

At each survey site, three soil samples, each approximately 2 L in volume, were collected and sieved. Areas targeted included potential terrestrial snail habitats, such as, under bushes and trees, at the base of Breakaways, under leaf litter and under rock ledge. Sieved soil (0.1-1.0 cm fraction) was collected and placed into sealed bags. The samples were transported and sorted under magnification at the MWH (then Outback Ecology) laboratory. A total of 90 soil samples were collected and processed over both phases of the Baseline Survey.

4.1.6 Specimen Processing and Identification

Specimens belonging to taxa prone to short-range endemism were delivered to WAM for registration and delivery to taxonomists. The taxonomists whom identified invertebrate specimens are shown in **Table 4-4**.

Table 4-4: Specialist invertebrate taxonomists engaged to identify specimens collected from the surveys

Invertebrate group	Taxonomists	Organisation
Mygalomorph spiders	Dr Volker Framenau	Phoenix Environmental Sciences
Pseudoscorpions and millipedes	Dr Mark Harvey Dr Mieke Burger Dr Catherine Car	Western Australian Museum
Scorpions	Dr Erich Volschenk	Scorpion ID
Snails	Dr Shirley Slack-Smith Mr Corey Whisson	Western Australian Museum
Slaters	Dr Simon Judd	Independent consultant
Genetic analysis	Dr Yvette Hitchen Dr Terrie Finston	University of Western Australia

4.1.7 SRE Baseline Survey Team and Licencing

The SRE Baseline Survey was conducted by experienced MWH invertebrate zoologists (**Table 4-5**).

Table 4-5: SRE Baseline Survey Team

Personnel	Qualifications	Role
Mr. Paul Bolton	B. Sc. (Marine Biology/Zoology) (Hons.)	Senior Environmental Scientist
Dr. Adrian Rakimov	B.Sc. (Zoology) (Hons.), Ph.D.	Senior Invertebrate Zoologist
Dr. Peter Langlands	B.Sc. (Zoology) (Hons), Ph.D.	Invertebrate Zoologist
Mr Matt Quinn	B.Sc (Marine Sci./Environ.Sci.)	Environmental Scientist
Mr. Brad Scanlon		Field Technician

The Baseline Survey was executed under the Licence to Take Fauna for Scientific Purposes (Regulation 17):

Licence No: SF008850
Date of issue: 10/01/2011
Valid from: 10/01/2011
Date of expiry: 09/01/2012

The Baseline Survey was also executed under the Licence to Take Fauna from the Wanjarri Nature Reserve for Scientific Purposes (Regulation 4):

Licence No: CE003099
Date of issue: 10/01/2011
Valid from: 10/01/2011
Date of expiry: 09/01/2012

4.2 Targeted Survey

The targeted survey was primarily conducted to better understand the distribution of a millipede species (*Antichiropus* 'DIP003') that had been collected during the Baseline Survey. The survey focused on the more mesic areas of creek line habitat within the Jones Creek system as this was considered the most favourable habitat for this taxa.

4.2.1 Survey Timing

The Targeted Survey was conducted over two phases between 16 December 2011 – 29 March 2012. This survey timing replicated the February 2011 (phase 1 and phase 2) survey timing when the millipede *Antichiropus* 'DIP003' was originally collected after a substantial rainfall event. These Targeted Survey phases are described as phase 3 and phase 4 to distinguish them from phase 1 and phase 2 conducted during the Baseline Survey. The two survey phases were conducted as follows:

- phase 3 survey: wet pitfall traps were deployed from 16 – 21 December 2011 and collected between 30 – 31 January 2012. Targeted searches and systematic trapping were conducted at each survey site. Habitat mapping was also completed; and
- phase 4 survey: phase 3 wet pitfall traps replaced with phase 4 wet pitfall traps on 1 February 2012. The phase 4 wet pitfall traps were collected on the 29 March 2012.

4.2.2 Weather Conditions

The records from the Yakabindie Homestead and Leinster Bureau of Meteorology weather stations were considered when assessing the weather conditions over the Targeted Survey period. Temperature and Rainfall data were sourced from the Leinster weather station, whereas only rainfall data was available from the Yakabindie Homestead weather station.

During phase 3, the daily maximum temperatures recorded from the Leinster weather station ranged between 20.5 ºC and 41.3 ºC, with minimum temperatures between 15.7 ºC and 27 ºC (BoM 2016). A mean maximum temperature of 34.2 ºC and mean minimum of 21.5 ºC were recorded at Leinster over the survey period, which is similar to the long-term average temperature for the period (BoM 2016). During phase 4, the daily maximum temperatures recorded from the Leinster weather station ranged between 19.4 ºC and 42.5 ºC, with minimum temperatures between 10.9 ºC and 27.6 ºC (BoM 2016). A mean maximum temperature of 35.6 ºC and mean minimum of 21.8 ºC over the survey period were recorded at the Leinster weather station which is similar to the long-term average for the period (BoM 2016). The phase 2, phase 3 and phase 4 survey periods experienced significantly less rainfall than that recorded during the phase 1 survey period.

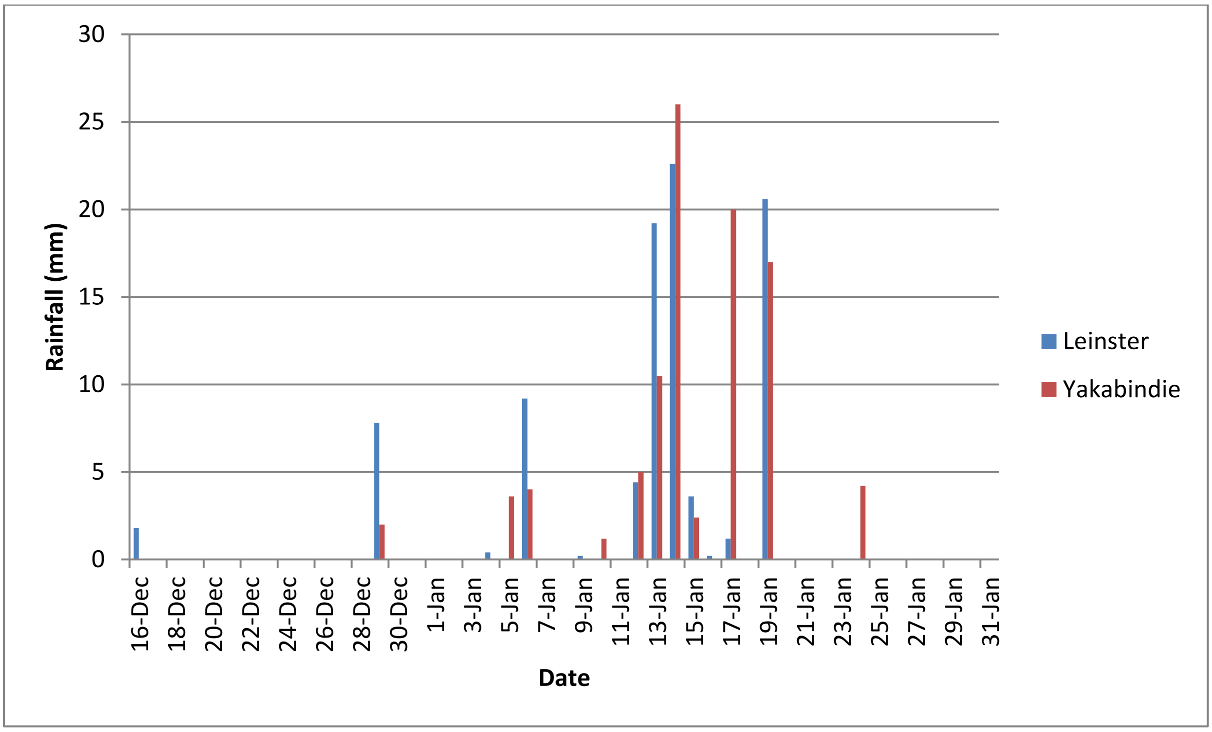

Figure 4-5: Rainfall recorded during the phase 3 survey

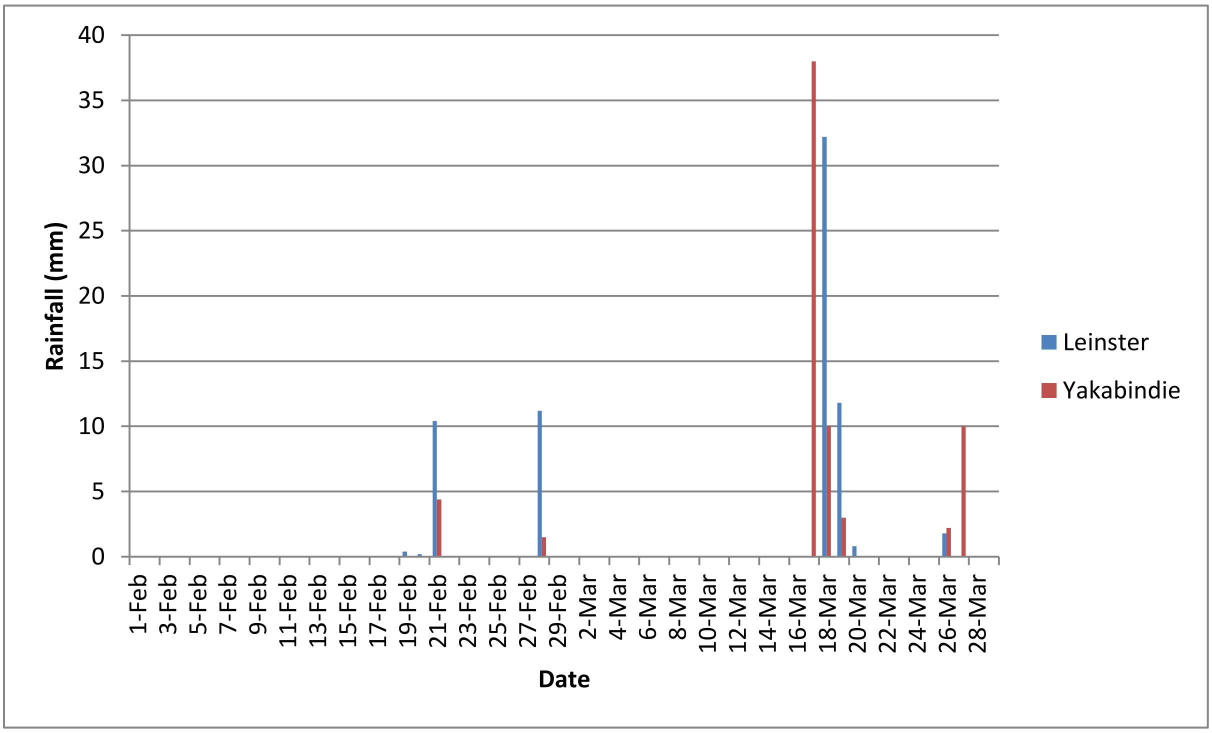

Figure 4-6: Rainfall recorded during the phase 4 survey

4.2.3 Survey Sites

A total of ten systematic survey sites were sampled during the Targeted Survey (**Table 4-6**, **Figure 4-7**). These sites were established in creek line habitat occurring within the Jones Creek system. Additionally, two sites in creek line habitat were target searched where it was not possible to use pitfall traps due to heritage restrictions on ground disturbance (**Table 4-6**, **Figure 4-7**). To test whether the conditions during the survey were suitable for the activity of *Antichiropus* 'DIP003'; Site 1 and Site 2 from the Baseline Survey (where *Antichiropus* 'DIP003' had been collected during phase 1) were re-established during the Targeted Survey. That way, if no specimens were collected at the new sites, it could be determined whether it was due to the absence of the species in these areas, or due to the lack of activity during the survey period. Invertebrate collection methods employed at systematic survey sites consisted of wet pitfall trapping and targeted searching (**Section 4.2.4**).

Table 4-6: Systematic and targeted survey site locations for the Targeted Survey

Site	Relation to proposed disturbance area	Coordinates (GDA 94 MGA 51J)	
		Easting	Northing
Site T1	Inside	261618	6965487
Site T2	Inside	257494	6958718
Site T3	Downstream	260196	6963614
Site T4	Downstream	258877	6959571
Site T5	Upstream	256695	6957971
Site T6	Upstream	259520	6970442
Site T7	Upstream	259486	6970034
Site T8	Upstream	259496	6969291
Site T9	Upstream	259952	6968635
Site T10	Downstream	259920	6969011
Target T1	Upstream	261042	6966463
Target T2	Upstream	260843	6967739
Target T3	Downstream	253941	6956169

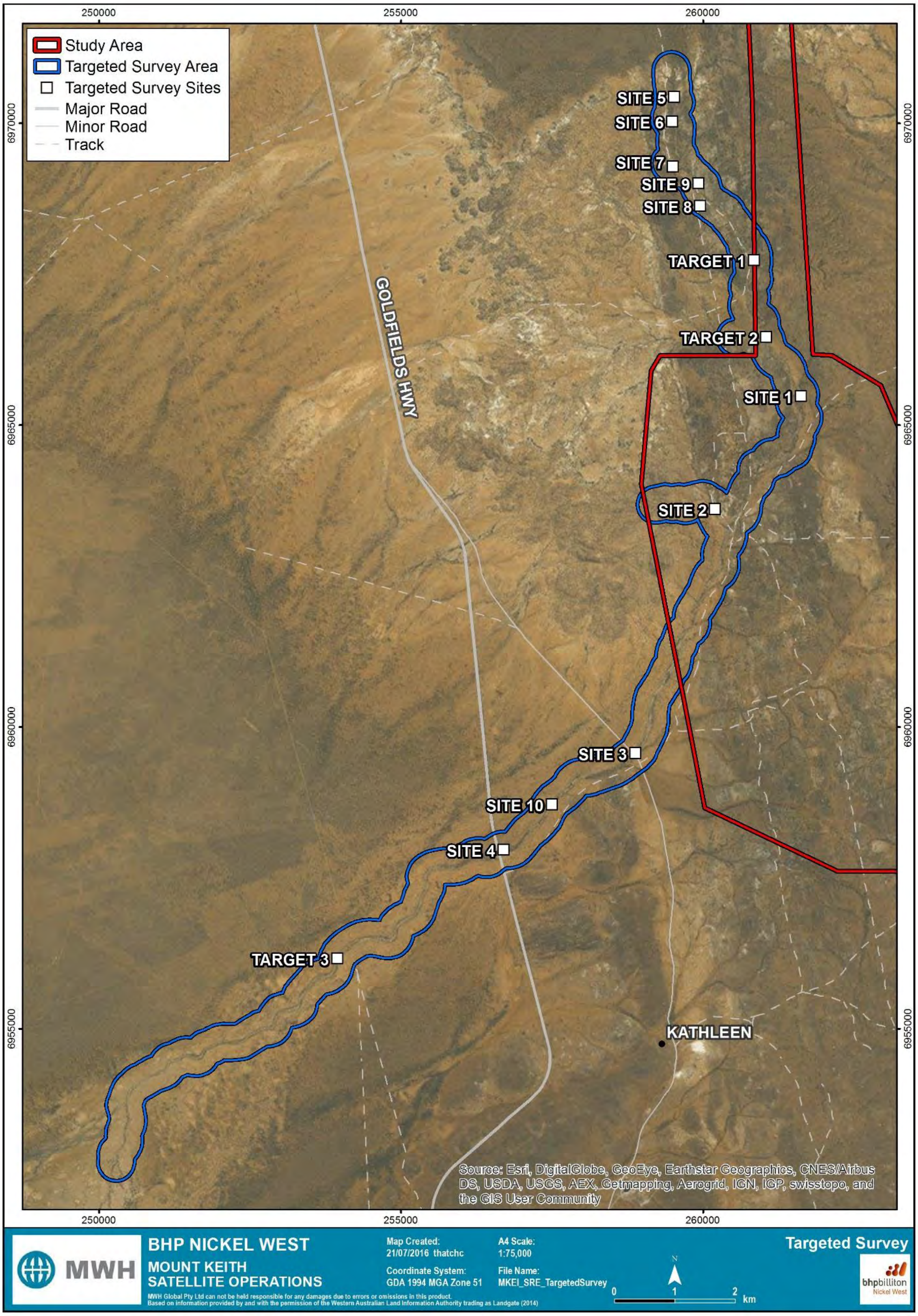

Figure 4-7: Survey sites for the Targeted Survey

4.2.4 Collection Techniques

Wet pitfall trapping and targeted searching were used for collecting SRE invertebrate fauna during this survey (**Table 4-7**). These methods are aligned with those used during phase 1 and phase 2 of the Baseline Survey.

Table 4-7: Summary of SRE sampling methods and effort for Phase 3 and Phase 4 surveys

Sampling technique	Target group	Sampling effort per site		Total effort
		Phase 3 survey	Phase 4 survey	
Wet pitfall trapping	All groups	5 traps open for a total of 47 nights (10 sites)	5 traps open for a total of 44 nights (10 sites)	4,550 trapping nights
Targeted searching	All groups	2 person hours (13 sites)	N/A	26 person hours

Wet Pitfall Trapping

During phase 1 and phase 2 of the Baseline survey, all 36 specimens of the millipede *Antichiropus* 'DIP003' collected from wet pitfall traps, hence, this technique was employed again for phase 3 and phase 4 of the Targeted Survey. Wet pitfall traps were left open for 47 nights during phase 3 and 44 nights during phase 4 of the Targeted Survey. Trapping effort totalled 4,550 trap nights over both phases; 2,350 trap nights in phase 3 and 2,200 trap nights in phase 4. All other aspects of the wet pitfall trapping followed those for methods for wet pitfall trapping outlined under **Section 4.1.5**.

Targeted Searching

Each site was searched for millipede taxa for two person hours. Microhabitats that were searched included: leaf litter, beneath logs, bark and rocks, crevices, at the bases of shrubs and trees and beneath Spinifex hummocks. Additionally, three sheets of cardboard (30 cm x 20 cm) were placed at each of the systematic trapping sites and weighted down with soil and rocks. Searching for millipedes was conducted beneath these sheets when collecting the pitfall traps. All specimens were placed into 100 % ethanol upon collection. A total of 26 person hours were spent targeted searching.

4.2.5 SRE habitat assessment

Habitat assessments were completed using the same habitat assessment form as was used during the Baseline Survey (**Section 4.1.4**). The specimens of *Antichiropus* 'DIP003' collected during phase 1 and phase 2 of the Baseline Survey occurred in association with creek line habitat within the Jones Creek system. Therefore, the extent of creek line habitat occurring within the Jones Creek system was quantified as part of this Targeted Survey. Creekline habitat within the Jones Creek system was identified and assessed in terms of complexity, quality, connectivity and extensiveness within the landscape.

4.2.6 Specimen Processing and Identification

Millipede specimens were delivered to the WA Museum for registration and delivery to taxonomists. The taxonomists whom identified invertebrate specimens are shown in **Table 4-4**.

Table 4-8: Specialist invertebrate taxonomists engaged to identify specimens collected from the surveys

Invertebrate group	Taxonomists	Organisation
millipedes	Dr Mark Harvey Dr. Catherine Car	Western Australian Museum

4.2.7 SRE Targeted Survey Team and Licensing

The SRE Targeted Survey was conducted experienced MWH invertebrate zoologists (**Table 4-9**).

Table 4-9: SRE Targeted Survey Team

Personnel	Qualifications	Role
Mr Matt Quinn	B.Sc (Marine Sci./Environ.Sci.)	Environmental Scientist
Mr Arnold Slabber	B.Sc (Aquatic Science) (Hons.)	Environmental Scientist

The surveys were executed under the Licence to Take Fauna for Scientific Purposes (Regulation 17):

Licence No: SF008382

Valid from: 15/12/2011

Date of expiry: 14/12/2012

5 Results and Discussion

The results of the Baseline Survey, the Targeted Survey and the Desktop Study are summarised within this section and discussed with respect to the Study Area. The occurrence of habitats within the Study Area was informed by the findings of the Baseline Survey and Targeted Survey (**Section 5.1**). The occurrence of SRE species within the Study Area was informed by the findings of the Baseline Survey, the Targeted Survey and the Desktop Study (**Section 5.2**).

5.1 Terrestrial SRE Invertebrate Fauna Habitats

The Baseline survey and Targeted survey identified a total of eight broad habitats occurring within the Study Area. One additional habitat type 'Spinifex Sandplain' was recorded in the neighbouring Wanjarri Nature Reserve. Areas of each habitat within the survey areas and within the Study Area are presented in **Table 5-1**, **Figure 5-1** and **Figure 5-2**. The areas of habitats from the survey areas are presented here to provide regional context to the Study Area, however, the habitats within the Study Area will be the focus of the Impact Assessment. Each of these habitats were broadly categorised as having a high, medium or low potential to support SRE species on the basis of forming sheltered microhabitats or by forming habitat isolates (**Section 4.1.4**). Habitat descriptions are provided in **Sections 5.1.1 - 5.1.9**.

As outlined in **Section 4**, some areas of the Study Area used for this assessment extend outside of areas surveyed during the Baseline and Targeted Survey (**Figure 1-2**). For these additional areas, habitat mapping was extrapolated based on aerial imagery with reference to mapping from the Baseline Survey and the Targeted survey.

Table 5-1: Assessment of habitats within the Baseline Survey Area, Wanjarri Nature Reserve and the Targeted Survey and their potential to support SRE taxa

Fauna Habitat	Potential to support SRE species	Area (ha) of habitat				Habitat Description
		Baseline Survey Area	Wanjarri Nature Reserve*	Targeted Survey Area*	Study Area	
Internal drainage	High	17.8	166.8	-	17.1	These areas of low elevation tend to form isolated, sheltered environments with elevated soil water content.
Creekline	High	77.2	-	251.2	76.7	Sheltered creek line with banked sides and unique riparian vegetation subject to ephemeral flows.
Breakaway	Medium	86.8	335.9	-	66.7	Breakaways provide sheltered areas that do not receive direct sunlight for much of the day. These habitats are isolated from other sheltered areas within the landscape.
Mulga over Spinifex Sandplain	Low	784.7	8,147.1	13.2	417.2	Leaf litter from Mulga trees provides an important habitat for species located within the Spinifex Sandplain habitat. However the habitat is relatively well represented in the surrounding landscape.
Stony Hill and Slope	Medium	1,818.7	18.3	431.3	1,928.7	Hill and slope were exposed for much of the day and provided limited sheltered areas for relictual species. However, the system of hill and slope in the Study Area is isolated from similar systems in the region.
Drainage Line	Medium	448.5	2,958.1	70.8	496.2	In general, drainage lines provide more shelter than surrounding habitats.
Sparse Mulga Woodland	Low	1,092.1	4,868.1	906.3	1034.7	Sparse Mulga Woodlands provide little shelter when compared to other habitats in the landscape.
Stony Plain	Low	1,349.0	13,481.0	-	1,292.8	Stony Plains were exposed for much of the day and provided limited sheltered areas for relictual species. Additionally, they form a habitat that is extensive and contiguous in the landscape.
Spinifex Sandplain	Low	-	22,586.9	5.8	-	The Spinifex Sandplain was exposed for much of the day and provided limited sheltered areas for relictual species. Additionally, they form a habitat that is extensive and contiguous within the Wanjarri Nature Reserve. This habitat does not occur within the Study Area.
Disturbance	Low	-	-	-	91.8	Areas cleared for mining. Largely present in the northern portion of the Study Area
Totals		**5,675**	**52,563**	**1,679**	**5,422**	

* Areas overlap the Study Area and Baseline Survey Area

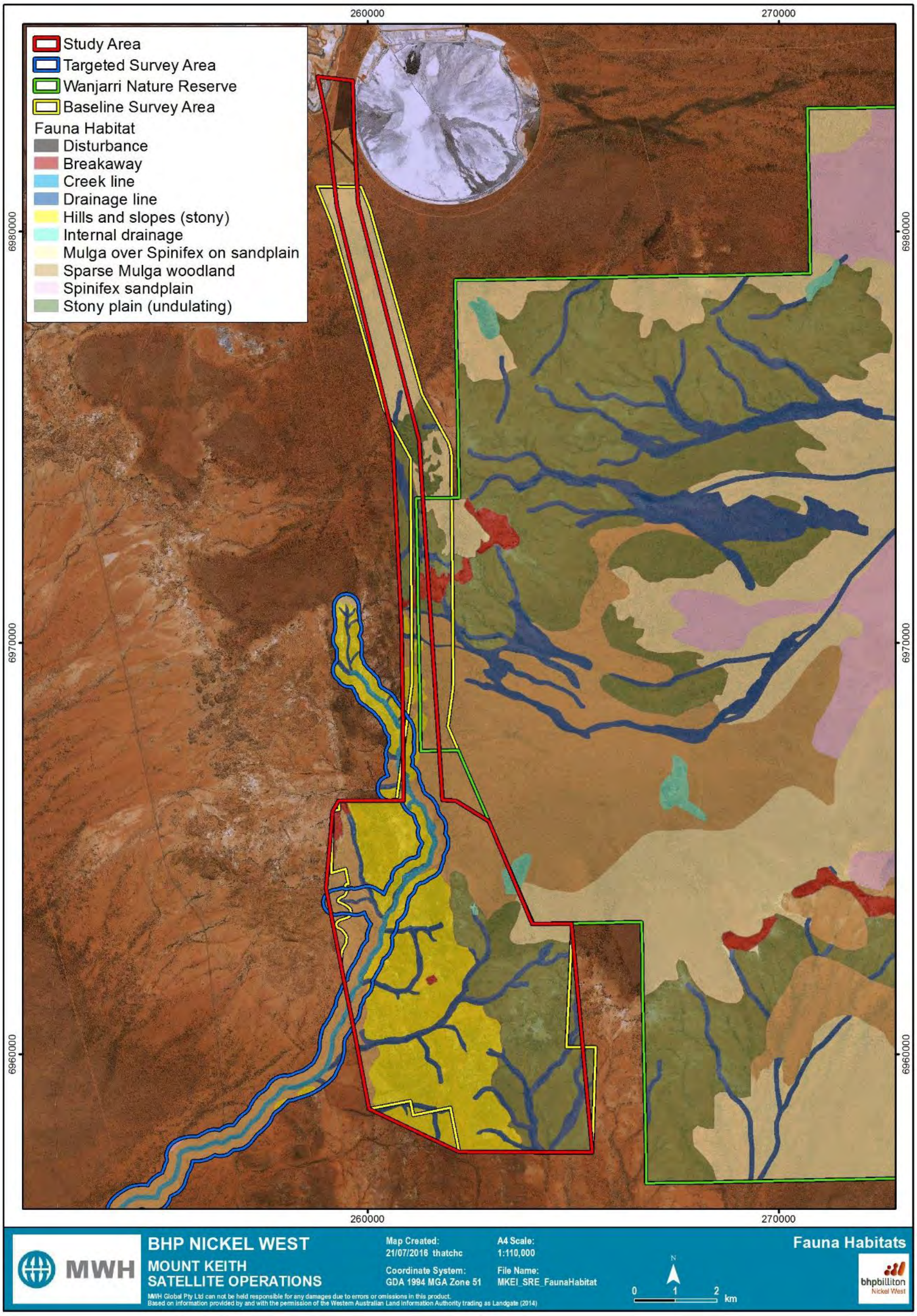

Figure 5-1: Habitat types within the Study Area

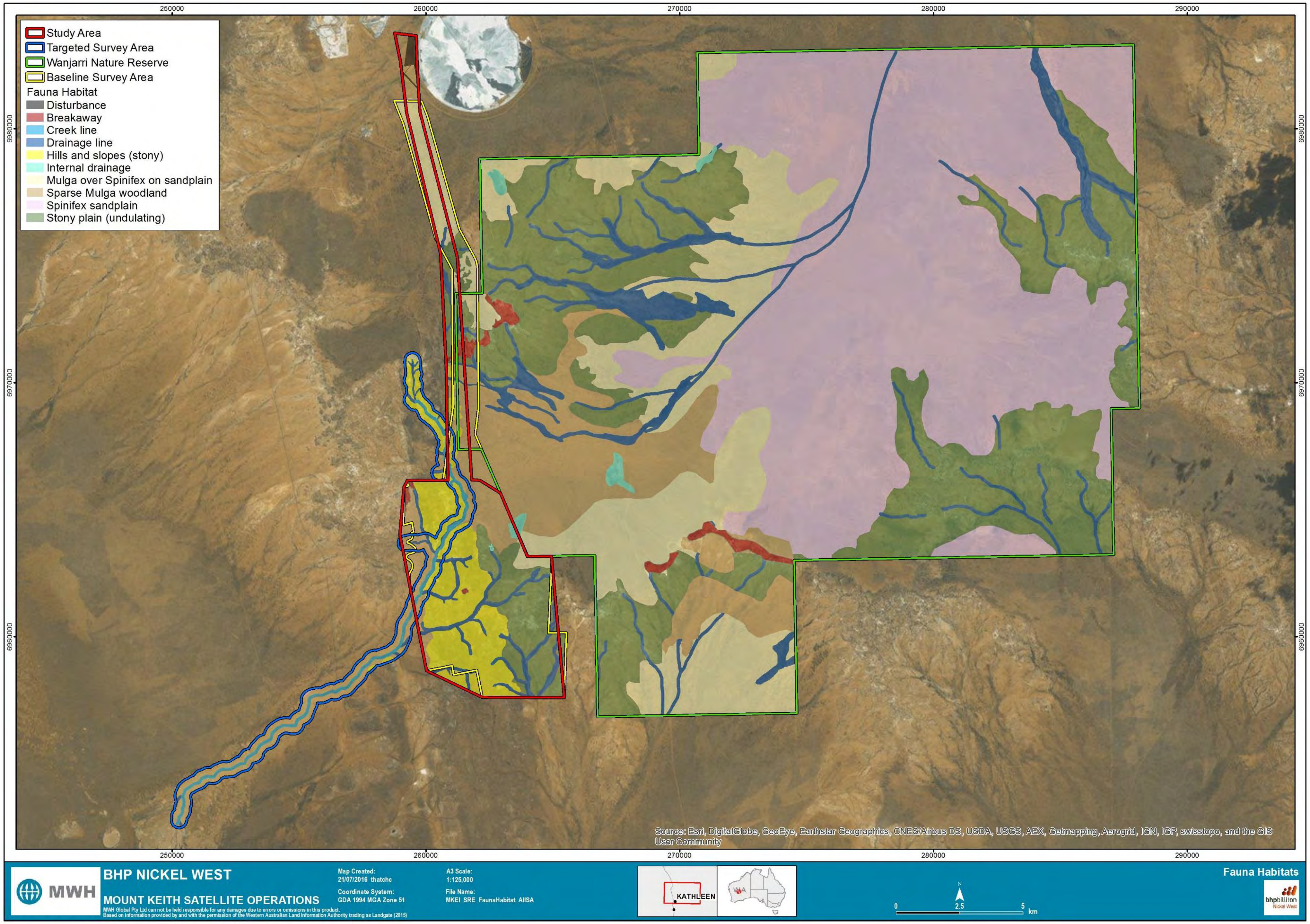

Figure 5-2: Habitats within the vicinity of the Study Area

5.1.1 Creekline

Creekline habitat has a high potential for supporting SRE species as this habitat has isolated, sheltered microhabitats with unique riparian vegetation. The habitat is characterised by alluvium with banked sides and riparian vegetation. The habitat is well connected throughout its extent, yet isolated from similar habitat in the surrounding landscape. The Creekline habitat is associated with areas of low topography and local overland flows.

Creekline habitat within the Study Area exits as part of the Jones Creek system which flows south west through the central portion of the Study Area (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat does not occur in the Wanjarri Nature Reserve, however it does occur both upstream and downstream of the Study Area. Upstream of the Study Area, the Jones Creek system flows from its headwaters in the Bar Smith range north of the Study Area. Downstream of the Study Area, Jones Creek flows in a south west direction for approximately 20 km to where it fans out and flows underground at a point approximately 6 km north west of the Yakabindie homestead. The water from Jones Creek then re-emerges approximately 7.5 km to the south of this point where it feeds into Lake Miranda.

Creekline habitat was assessed at two systemic survey sites and two targeted survey sites during the Baseline Survey (**Table 4-1, Table 4-2**, **Figure 4-4**) and at ten systematic and 3 targeted search sites during the Targeted Survey (**Table 4-6**, **Figure 4-7**).

Vegetation primarily comprised low woodlands of *Acacia aneura* with sparse *Eucalyptus camaldulensis* on the fringing banks, with an understorey of various *Acacia* species. Leaf litter accumulations were plentiful. The substrate consisted of alluvium and duplex soils, relictual, sandy red loams and gravels over clay, with naturally low nutrient and moisture content (Western Botanical 2011).

5.1.2 Internal Drainage

Internal drainage habitat has a high potential for supporting SRE species as this habitat forms isolated, sheltered environments that tend to have elevated soil moisture content. Connectivity is poor as this habitat forms in drainage basin landforms which are generally surrounded by areas of increased elevation. Vegetation in these habitats is typically denser when compared to habitats in the surrounding area. This vegetation provides increased levels of shelter and leaf litter accumulation which creates important invertebrate microhabitats.

Internal drainage habitat occurs in occurs in a small portion in the east of the Study Area. This habitat is also known to occur in the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at four systematic survey sites during the Baseline Survey (**Table 4-1**, **Figure 4-4**). Vegetation primarily comprised dense *Acacia aneura* with an understorey of *Eremophila* and *Triodia* species. The substrate consisted of sandy loam soils.

5.1.3 Breakaway

Breakaway habitat has a medium potential of supporting SRE species as this habitat forms isolate environments that provide sheltered areas that do not receive direct sunlight for much of the day. These areas may also serve as fire refuges. The habitat is characterised by quartz or lateritic Breakaways and associated scree slopes.

Breakaway habitat occurs in both the Study Area and the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at two targeted survey sites during the Baseline Survey (**Table 4-2**, **Figure 4-4**).

Vegetation was limited in this habitat, comprising sparse low woodlands of *Acacia aneura* with an understorey of various *Atriplex* and *Triodia* species. The substrate consisted of an eroded quartes sand and sandy loam soils.

5.1.4 Stony Hills and Slopes

Stony Hill and Slope habitat has a medium potential to support SRE species as this habitat is isolated from similar habitat in the surrounding landscape. The habitat is relatively well connected north to south through the Study Area. Disturbance was evident within this habitat, specifically the construction of recent exploration infrastructure such as roads and drill pads as well as the felling of large Mulga trees from historic mining activities. This habitat was exposed for much of the day and provided limited sheltered areas for relictual species. Stony Hills and Slopes tend to occur in association with the Bevon land system which is relatively uncommon in the Eastern Murchison sub-bioregion (**Table 2-1**).

Stony Hill and Slope habitat occurs within the Study Area, however, does not occur in the Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at seven systemic survey sites during the Baseline Survey (**Table 4-1**, **Figure 4-4**).

Vegetation typically comprised low open woodland of *Acacia aneura*, *Acacia quadrimarginea* and *Acacia pruinocarpa* with an understorey of *Eremophila*, *Prostanthera* and *Dodonaea* species. The substrate consisted of red sand and sandy loam soils with a surface layer that had a high coverage of loose lateritic material.

5.1.5 Mulga over Spinifex on Sandplain

Mulga over Spinifex Sandplain habitat has a low potential to support SRE species as the habitat is well connected and relatively well represented throughout the landscape. The deep sands provide a suitable substrate for burrowing invertebrate species. Additionally, leaf litter from Mulga trees provides an important habitat for species located within this habitat. Mulga over Spinifex Sandplain habitat tends to occur in association with the Bullimore land system which is relatively common in the Eastern Murchison sub-bioregion (**Table 2-1**).

Mulga over Spinifex Sandplain occurs in both the Study Area and the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at three systematic survey sites and seven targeted survey sites during the Baseline Survey (**Table 4-1, Table 4-2**, **Figure 4-4**).

Vegetation comprised of open low woodland of *Acacia aneura* and *Acacia quadrimarginea* with an understorey of hummock grassland dominated by *Triodia basedowii*. The substrate consisted of red sand and sandy loam soils.

5.1.6 Drainage Line

Drainage line habitat has a medium potential to support SRE species as it creates sheltered areas on a suitable substrate for burrowing species. The habitat is well connected throughout its extent, yet isolated from similar habitat in the surrounding landscape. Drainage Line habitats are associated with areas of low topography and local overland flows.

Drainage Line habitat occurs in both the Study Area and the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at five systematic survey sites during the Baseline Survey (**Table 4-1, Figure 4-4**).

Vegetation tended to comprise of low open woodland of *Acacia aneura* with a sparse understorey of various *Atriplex* and *Triodia* species. The substrate consisted of alluvium over red clay and sandy loam soils.

5.1.7 Sparse Mulga Woodland

Sparse Mulga Woodland habitat has a low potential to support SRE species as it creates limited sheltered areas for relictual species. The habitat is well connected throughout the surrounding landscape.

Sparse Mulga Woodlands habitat occurs in both the Study Area and the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at four systemic survey sites during the Baseline Survey (**Table 4-1, Figure 4-4**).

Vegetation comprised of low very open woodland of *Acacia aneura* with a sparse understorey of *Scaevola spinescens*, *Rhagodia drummondii* and *Eremophila exilifolia*. The substrate consisted of red sands and sandy loams with a surface layer of loose lateritic material.

5.1.8 Stony Plain

Stony Plain habitat has a low potential to support SRE species as it creates limited sheltered areas for relictual species. The habitat is well connected throughout the surrounding landscape.

Stony Plain habitat occurs in both the Study Area and the neighbouring Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). This habitat was assessed at five systematic survey sites during the Baseline Survey (**Table 4-1, Figure 4-4**).

Vegetation comprised of low open woodland of *Acacia aneura* and *Acacia tetragonophylla* with a very scattered shrub layer consisting of *Eremophila platycalyx*, *Rhagodia drummondii*, *Senna artemisioides* and *Sida ectogama*. The substrate primarily consisted of red sandy loams with a surface layer of loose lateritic material.

5.1.9 Spinifex Sandplain

Spinifex Sandplain habitat has a low potential to support SRE species as it creates limited sheltered areas for relictual species. The habitat is well connected throughout the surrounding landscape and appears to occur in association with the Bullimore land system which is relatively common in the Eastern Murchison sub-bioregion (**Table 2-1**).

Spinifex Sandplain habitat does not occur within the Study Area, however it comprises almost half of the Wanjarri Nature Reserve (**Table 5-1**, **Figure 5-1**, **Figure 5-2**). Vegetation generally comprised of low very open woodland of *Acacia aneura* with a closed grassland understorey dominated by *Triodia* sp. The substrate primarily consisted of red sand and clay soils.

5.2 Terrestrial SRE Invertebrate Fauna

Results from the Baseline Survey, Targeted Survey, Desktop Study and habitat mapping, combined with regional knowledge and ecological data, were used to inform the occurrence of SRE species within the Study Area. Detailed taxonomic reports completed in 2011 and 2012 have been reviewed by relevant taxonomists in April 2016 to ensure that all species listings are current i.e. that all specimens identified as SRE species were still considered to be SRE species and that all specimens identified as widespread species are still considered to belong to widespread species.

Key changes since the taxonomic reports were completed are summarised below:

- Arachnids (mygalomorphs) (**Appendix B** & **Appendix C**): No changes to taxonomy or SRE status (Tim Moulds WAM *pers comm*., 18/5/16).
- Scorpions (**Appendix D**): *Lychas annulatus* was previously considered a widespread species, but is now considered to be a Potential SRE (Data deficient see **Section 1.3**) following evidence from analysis of DNA sequences. No other changes (Erich Volschenk *pers comm*., 24/3/16).
- Pseudoscorpions and Millipedes (**Appendix E** & **Appendix F**): All pseudoscorpions of the Family Olpiidae are now considered Potential SRE (Data deficient see **Section 1.3**). No other changes (Tim Moulds WAM *pers comm*., 18/5/16)..
- Slaters (**Appendix G**): Substantial taxonomic revision of the families has occurred since the original taxonomic report. A new taxonomic report has been issued (Simon Judd *pers comm*., 17/6/16).
- Molluscs (**Appendix H**): No changes. All molluscs collected are still not considered to represent SRE species (Corey Whisson *pers comm*., 29/3/16).

5.2.1 SRE Species Recorded from the Baseline Survey Area, Wanjarri Nature Reserve and the Targeted Survey Area.

The survey of the Baseline Survey Area and Wanjarri Nature Reserve yielded a total of 1,680 invertebrate specimens from 48 species or morphospecies. Hereafter, the term ‘species’ will be used to refer to both species and morphospecies. A further 38 specimens from two species were recorded during the Targeted Survey. A summary of the number of specimens and species sampled from each of the targeted invertebrate taxa during the surveys are presented in **Table 5-2**. Slaters were the most numerous group to be collected, followed by pseudoscorpions, scorpions, mygalomorph spiders, millipedes and snails.

Table 5-2: Summary of invertebrates from SRE taxa collected from the Baseline Survey Area, Wanjarri Nature Reserve and the Targeted Survey Area.

Target group	Baseline Survey		Targeted Survey		Total	
	Number of specimens	Number of species	Number of specimens	Number of species	Number of specimens	Number of species
Mygalomorph spiders	168	15	-	-	168	15
Scorpions	195	9	-	-	195	9
Slaters	832	8	-	-	832	8
Snails	10	4	-	-	10	4
Pseudoscorpions	439	11	-	-	439	11
Millipedes	36	1	2	2	38	2
TOTAL	**1,680**	**48**	**38**	**2**	**1682**	**49**

Of all the invertebrates collected during the surveys, based on current known species distributions, two were considered by experts as Confirmed SRE species (two millipedes), four as Likely SRE species (one mygalomorph spider, one pseudoscorpion and two slaters) and 23 as Potential SRE species (**Table 5-3**, **Figure 5-3**). All of these species had specimens collected within the Study Area.

Of the potential SRE species, 10 were identified to species or morphospecies, while 13 could not be identified to this level due to being of an inappropriate age or sex for identification (assigned the suffix 'sp.' or 'indet'). As a conservative measure, these are included as potential SREs in **Table 5-3**. It is difficult to draw conclusions on the distributions of the unidentified specimens included in **Table 5-3** without undertaking comparative molecular analysis with reference collections. Additionally, it should be noted that unidentified specimens may also represent identified taxa included in **Table 5-3**.

Table 5-3: SRE species collected from the Study Area

Group	Taxa	SRE status
Mygalomorph spiders	*Aname* 'MYG235'	Likely SRE
	Idiosoma sp.	Potential SRE
	Cethegus sp.	Potential SRE
	Conothele sp.	Potential SRE
	Aganippe sp.	Potential SRE
	Anidiops sp.	Potential SRE
	Yilgarnia sp.	Potential SRE
Scorpions	*Urodacus* cf 'gibson 5'	Potential SRE
	Lychas annulatus	Potential SRE
Pseudoscorpions	*Synsphyronus* `sp. PSE023`	Likely SRE
	`Genus 7/4` sp.	Potential SRE
	Austrohorus sp.	Potential SRE
	Beierolpium `sp. 8/2`	Potential SRE
	Beierolpium `sp. 8/3`	Potential SRE
	Beierolpium `sp. 8/4 small`	Potential SRE
	Indolpium sp.	Potential SRE
	Linnaeolpium sp.	Potential SRE
Slaters	*Budddelundia* 96	Potential SRE
	Budddelundia 45	Potential SRE
	Cubaris yeelirrie1	Potential SRE
	Cubaris yeelirrie2	Potential SRE
	Pseudodiploexochus yakabindie	Likely SRE
	Armadillidae yakabindie a	Potential SRE
	Armadillidae yakabindie b	Likely SRE
	Armadillidae sp. indet.	Potential SRE
	Philosciidae sp. indet.	Potential SRE
	Trichorhina sp. indet.	Potential SRE
Millipedes	*Antichiropus* 'DIP003' (formerly *Antichiropus* 'sp. yakabindie')	Confirmed SRE
	Antichiropus 'DIP002'	Confirmed SRE

* *Yellow highlight:* Species not identified to species or morphospecies

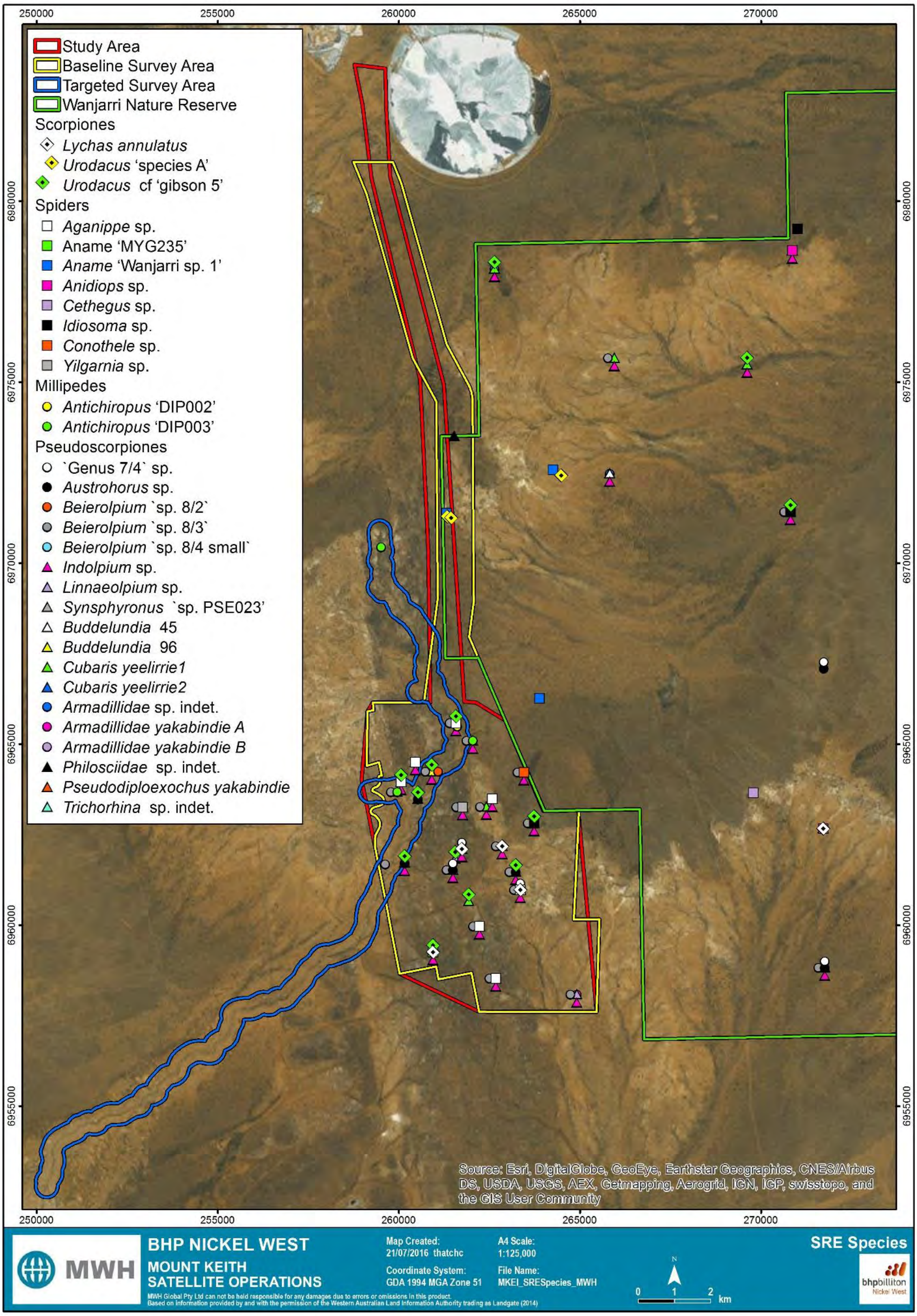

Figure 5-3: SRE species collected from the Study Area

5.2.2 SRE Species recorded during the desktop study from the wider region

The desktop study identified 42 potential SRE taxa occurring within 50 km of the Study Area. Of these, two were recorded within the Study Area (Biota 2006, WAM 2016a):

- *Aname* 'Wanjarri sp. 1' (mygalomorph spider) and;
- *Urodacus* 'species A' (scorpion).

Both of these species have also been recorded at a number of locations outside the Study Area in the adjoining Wanjarri Nature Reserve. These species are considered further in **Section 5.2.3.**

Additionally, four potential SRE species were recorded in close proximity (within 10 km) to the Study Area (**Figure 5-4**). These records include the mygalomorph spider *Kwonkan moriartii* which is listed as Priority 2 under the DPaW's Priority Species List. The potential SRE species recorded within 10 km of the Study Area included:

- *Aname* `Wanjarri sp.2`
- *Kwonkan moriartii*
- *Urodacus* `SCO009, Biota 2`
- *Urodacus* `species B (Biota)`

Database returns where specimens were not identified to species or morphospecies have been removed from the search results. This was because without a species or morphospecies, it is not possible to make an informative comparison with other specimens from the database or with specimens collected in this study.

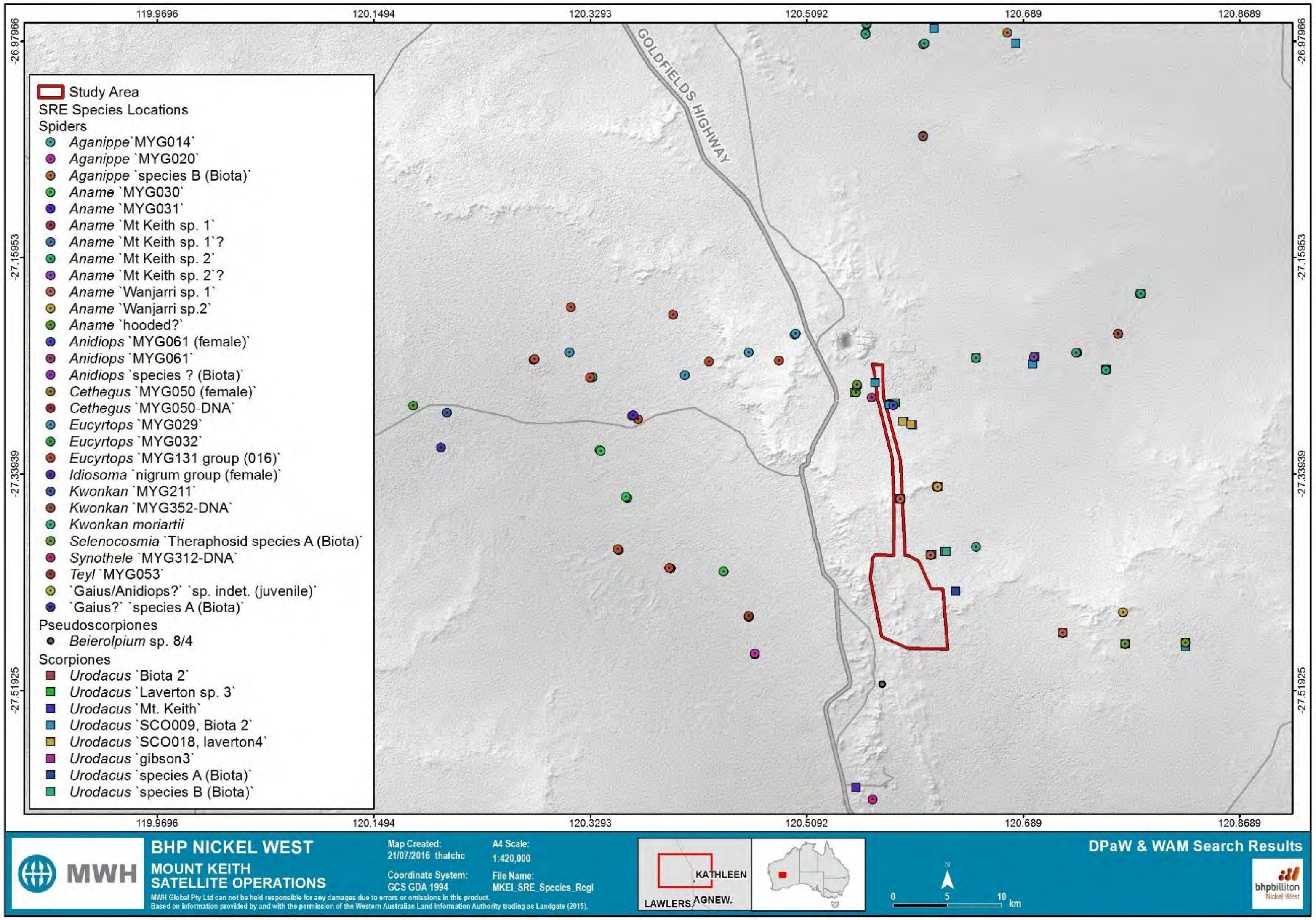

Figure 5-4: SRE species identified from the desktop study

5.2.3 SRE Species and habitat associations

In total, based on this study and previous studies, there are two Confirmed, four Likely and 25 Potential SRE species (23 from this study and two from the desktop study) that have been collected within the Study Area (**Table 5-4**). The two confirmed SRE species are the millipedes, *Antichiropus* 'DIP002' and 'DIP003'. The four Likely SRE species include the spider *Aname* 'MYG235', the pseudoscorpion *Synsphyronus* `sp. PSE023' and the slaters Armadillidae 'yakabindie b' and *Pseudodiploexochus* 'yakabindie'.

Millipede: *Antichiropus* 'DIP002'

Antichiropus 'DIP002' is a confirmed SRE species that is only represented by a single specimen collected during phase 3 (targeted survey). No other collection records of this species have been made since the surveys. The genus *Antichiropus* consists almost entirely of species with restricted distributions, where only two out of the approximately 160 species have widespread distributions (Car and Harvey 2014, Harvey 2002). Each species is distinguished by shape of the male gonopods. This method has been used in millipede taxonomy for 150 years and has been shown to be a good indicator of valid biological species (**Appendix E**). The single specimen was collected from within the Creekline habitat inside the Study Area (**Table 5-4**, **Figure 5-5**).

Millipede: *Antichiropus* 'DIP003'

Antichiropus 'DIP003' (formally known as 'sp. nov. Yakabindie') is a confirmed SRE species that has only been collected during the Baseline and Targeted surveys. *Antichiropus* 'DIP003' was collected from a total of six locations inside the Study Area (**Table 5-4**, **Appendix E**, **Appendix F**).

Of the 37 individuals collected during the baseline and targeted surveys, 35 specimens were collected during phase 1 of the baseline survey. Only a single specimen was collected during phase 2 survey of the baseline survey and a single specimen collected during phase 4 during the targeted survey. No specimens of *Antichiropus* 'DIP003' were collected during phase 3 survey. Rainfall during the phase 1 baseline survey was above average compared to previous years and was substantially higher than rainfall during the other survey periods (**Figure 4-2**). This suggests that the activity of this species is associated with significant rainfall events. Significant rainfall events typically occur between January and March each year (**Section 2.5**).

Of the six locations where this species has been recorded, two sites (21 specimens) were within the Creekline habitat, two sites (10 specimens) were within the Stony Hill and Slope habitat and two sites (6 specimens) were within the Sparse Mulga Woodland habitat (**Table 5-4**, **Figure 5-5**). However, it should be noted that all of these sites were in close proximity to Jones Creek and had drainage features that connected with the Creekline habitat. All but one of these six sites occur inside of the Study Area.

Mygalomorph spider: *Aname* 'MYG235'

The mygalomorph spider *Aname* 'MYG235' is a likely SRE species and is only know from the single record within the Study Area. No other collection records of this species have been made since the surveys.

This species was collected within the Stony Hills and Slopes habitat (**Table 5-4**, **Figure 5-5**). This habitat does not occur in the Wanjarri Nature Reserve, however, it does occur to the north and south of the Study Area (**Figure 5-5**).

Pseudoscorpion: *Synsphyronus* `sp. PSE023'

The pseudoscorpion *Synsphyronus* `sp. PSE023' is a likely SRE species known from a single record within the Study Area. No other collection records of this species have been made since the surveys. This species was collected in the Internal Drainage habitat which forms habitat isolates within the Study Area and the adjoining Wanjarri Nature Reserve (**Table 5-4**, **Figure 5-5**). Connectivity between these habitat isolates is poor and therefore this species may have a fragmented distribution. *Synsphyronus* `sp. PSE023' was not recorded at the three other Internal Drainage sites surveyed during the baseline survey.

Slater: Family Armadillidae 'yakabindie b'

This species from the family Armadillidae is considered a likely SRE species and is only known from a single specimen collected during the baseline survey inside the Study Area. The species has morphologically similar characteristics to a species collected in the jarrah forest and one from the Goldfields. The single specimen of this species was collected within the Stony Hills and Slopes habitat. This habitat does not occur in the Wanjarri Nature Reserve, however, it does occur to the north and south of the Study Area (**Figure 5-5**).

Slater: *Pseudodiploexochus* 'yakabindie'

The slater *Pseudodiploexochus* sp. nov. is considered a likely SRE species and is only known to occur within the Study Area and Wanjarri Nature Reserve (**Figure 5-5**). Species from the genus *Pseudodiploexochus* are usually associated with high rainfall areas in the south-west of Western Australia where almost all are SRE species (**Appendix G**). Specimens of *Pseudodiploexochus* sp. nov. were collected from the Creekline, Drainage Line, Stony Hill and Slope, Sparse Mulga Woodland, Stony Plain and Mulga Over Spinifex on Sand Plain habitats (**Table 5-4**). Although this species has only been recorded from a limited distribution, it appears to inhabit a variety of habitats.

Potential SRE Species

For Potential SRE species, there exists some uncertainty over whether the species has a restricted range. In these situations, habitat is a useful indicator to whether a Potential SRE species is likely to have a restricted range or not, as species are likely to have distributions that align with the habitats within which they were collected.

Of the 25 Potential SRE species that have been collected from the Study Area (23 from these surveys and 2 from the desktop study), only two were collected exclusively from habitats that were considered to have medium to high potential to support SRE species (**Table 5-4**; **Figure 5-5**). The remaining Potential SRE species are unlikely to represent true SRE species as they were collected from habitats that were widespread, well connected, and lacked microhabitats (**Table 5-1**). This suggests that the potential SRE status of these species may not represent restricted distributions but rather a lack of taxonomic resolution and/or regional records (**Table 1-1**). It should be noted that where specimens are grouped under ‘sp’ or ‘indet’, there exists the possibility that they comprise more than one species.

The two Potential SRE species collected exclusively from habitats with a high or medium potential to support SRE taxa were (**Table 5-4**; **Figure 5-5**):

- *Conothele* sp. (spider), and
- *Beierolpium* `sp. 8/2` (pseudoscorpion)

Mygalomorph spider: *Conothele* sp.

Mygalomorph spider specimens from the genus *Conothele* were collected at four locations during the baseline survey, all from within habitats with high or medium potential to support SRE species. It should be noted that because these specimens were females and juveniles, they could not be identified to species or morphospecies (**Appendix B**). Consequently, it is not known whether these specimens all represent the same species or comprise of more than one species. These specimens are considered to represent a potential SRE species given that the genus was found to be regionally diverse during the DEC Carnarvon Basin regional survey (**Appendix B**). Three of these species were recorded from the Internal Drainage habitat which forms habitat isolates within the Study Area and the adjoining Wanjarri Nature Reserve (**Table 5-4**; **Figure 5-5**). A single specimen was recorded from the Stony Hills and Slopes habitat which does not occur in the Wanjarri Nature Reserve, however, it does occur to the north and south of the Study Area (**Figure 5-5**).

Pseudoscorpion: *Beierolpium* `sp. 8/2`

The pseudoscorpion *Beierolpium* `sp. 8/2` is a potential SRE species and the single specimen was collected from the Creekline habitat which has a high potential to support SRE species. All of the Family Olpiidae have recently been considered to have potential to represent SRE species based on a lack of taxonomic information. This includes a number of genera that were collected during the baseline survey including *Austrohorus*, *Beierolpium*, *Indolpium, Linnaeolpium* and Genus ‘9/4’. Of these, three species from the genus *Beierolpium* were collected during the survey. All of these specimens from the family Olpiidae were collected from widespread and unrestricted habitats in the landscape with the exception of *Beierolpium* `sp. 8/2`. As *Beierolpium* `sp. 8/2` is a potential SRE species, it is possible that is restricted to the Creekline habitat. The Creekline habitat is restricted to Jones Creek which occurs in the central portion of the Study Area and extends both upstream and downstream of the Study Area.

Table 5-4: SRE species, collection location, number of specimens and habitat

Green indicates species collected from habitats with low potential to support SRE species. Orange indicates species collected from habitats with high or medium potential to support SRE species.

Taxonomic group			Spider								Scorpion			Pseudoscorpion								Slater										Millipede	
SRE Status			Likely	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Likely	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Potential	Likely	Potential	Likely	Potential	Potential	Confirmed	Confirmed
Habitat	Likelihood of supporting SRE Taxa	Site	*Aname* 'MYG235'	*Idiosoma* sp.	*Cethegus* sp.	*Conothele* sp.	*Aganippe* sp.	*Anidiops* sp.	*Yilgarnia* sp.	*Aname* 'Wanjarri sp.	*Urodacus* cf 'gibson 5'	*Lychas annulatus*	*Urodacus* 'species A'	Synsphyronus `sp. PSE023'	`Genus 7/4` sp.	Austrohorus sp.	Beierolpium `sp. 8/2`	Beierolpium `sp. 8/3`	Beierolpium `sp. 8/4 small'	Indolpium sp.	Linnaeolpium sp.	Buddelundia 96	Buddelundia 45	Armadillidae sp. indet.	Armadillidae yakabindie a	Philosciidae sp. indet.	Armadillidae yakabindie b	Cubaris yeelirrie2	Pseudodiploe xochus	Trichorhina sp. indet.	Cubaris yeelirrie1	Antichiropus 'DIP003'	Antichiropus 'DIP002'
Breakaway	Medium	Target 10									1					1					1												
		Target 13																															
		*								1			3																				
		*											1																				
Internal drainage	High	Site 12				2	1													6		30		1							5		
		Site 15				1								1		1		1		1	1		5							1			
		Site 24									2									15				58							5		
		Site 25						1								1				4				24	3						7		
Stony Hill and Slope	Medium	Site 3				1	1									1				3		4		7							27	9	
		Site 5										1			8					20						3			6		1		
		Site 6													1	1		7		44									2		3		
		Site 13							1							3		2		9											23	1	
		Site 16	1								4	3			3	2				3							1						
		Site 17					2									3		7		4									1		12		
		Site 21					1											6		5	1			1							3		
Drainage Line	Medium	Site 1					1		1		3									1		13			5			10					
		Site 8									2				1			6		4						2			1		13		
		Site 20									8																				5		
		Site 22									7				1	1				3				4	3						17		
		Site 26									7					2				3											3		
Mulga over spinifex on sand plain	Low	Site 14		3							5					1		9		1			13					1					
		Site 27													1	5		8		6								8	4	2			
		Site 28		3							2				1	3		5		9				3					7	3			
		Target 11																															
		Target 12																								1							
		Target 16																															
		Target 17																															
		Target 18			1																												
		Target 19													1	1																	
		Target 20		1					1																								
Stony Plain	Low	Site 7					1					1			4			2		14	1					5			3		42		
		Site 9										1						3		36		5				1					30		
		Site 11																1		11						17			6		41		
		Site 18																2		5	1				3				2		21		
		Site 23														2		3		16											56		
		*								1																							
		*											3																				
Sparse Mulga Woodland	Low	Site 4																1											3	1	8	2	
		Site 10																2	1	11		1			2						7	4	
		Site 29														1				3			2	3					1		13		
		Site 30						1				2				1													1		41		
		*								1																							
Creekline	High	Site 2									3					1	1	1		1		11				1					4		
		Site 19					1				2							2		2		2							1		4	20	
		Target 14									1				1							23											
		Target 15																1															
		Site T1																															1
		Site T5																														1	

* Collected by Biota (2006)

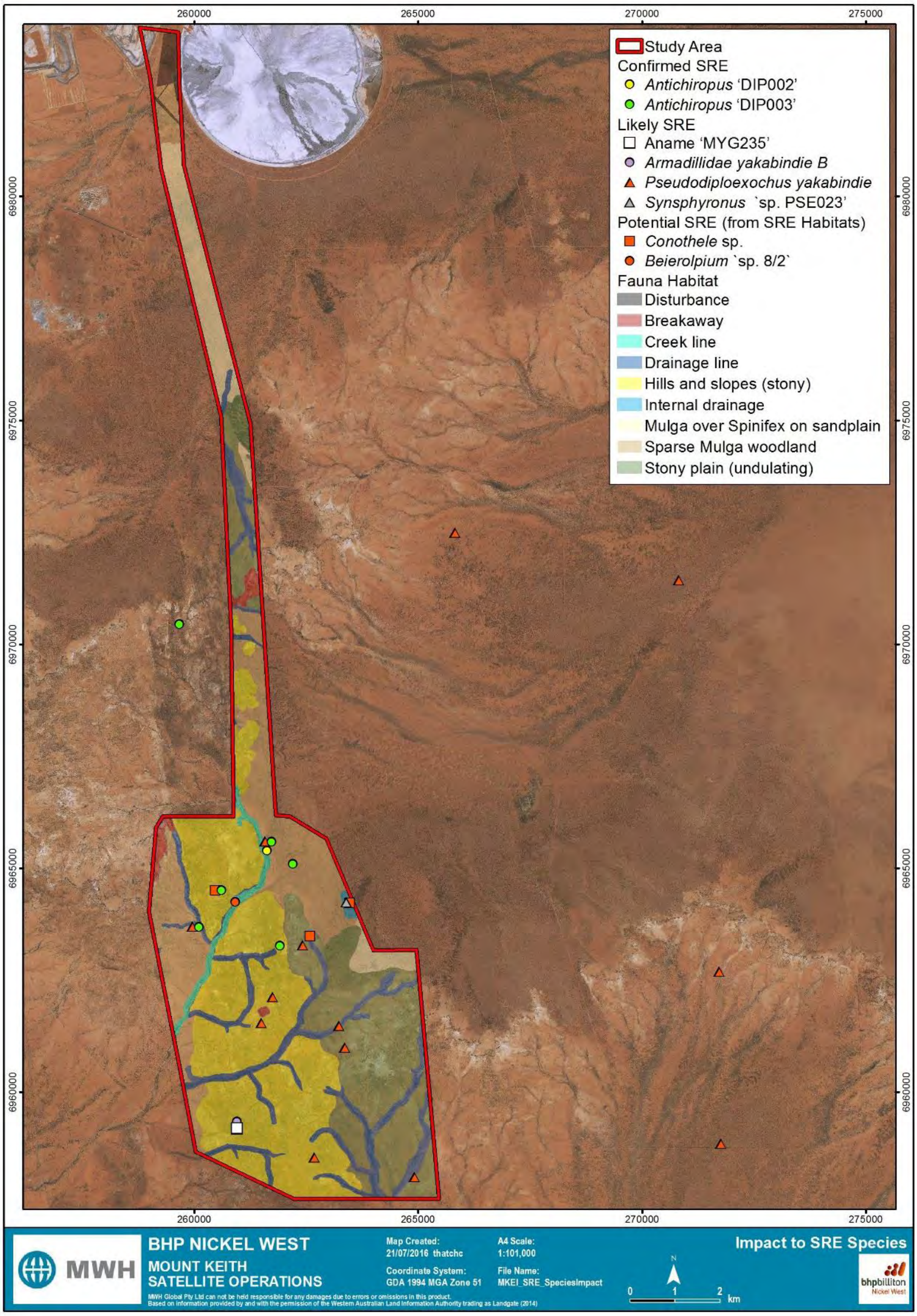

Figure 5-5: Collection locations of confirmed SRE species, likely SRE species and Potential SRE species collected from SRE habitats with respect to the Study Area

5.3 Survey limitations and constraints

A number of factors can influence the design and intensity of a fauna survey. The EPA (2004) lists possible limitations and constraints that can impinge on the adequacy of a fauna survey. These are assessed in **Table 5-5**. All fauna surveys are limited to some degree by time and seasonal factors and in an ideal situation several surveys would be undertaken over a number of years during different seasons. Nevertheless, all potential limitations and constraints identified by the EPA (2004) were considered and satisfied.

Table 5-5: Summary of potential survey limitations and constraints

Aspect	Limitation / Constraint?	Current survey
Competency/experience of consultants	no	All members of the survey team have several years of experience undertaking SRE invertebrate fauna surveys of this kind in WA (**Section 4.1.7** and **Section 4.2.7**). Invertebrate specimens were identified by recognised taxonomic experts (**Section 4.1.6** and **Section 4.2.6**).
Scope	no	Terrestrial SRE invertebrate fauna were assessed using established and standardised sampling techniques which have been endorsed by the DEC (now DPaW).
Proportion of fauna identified, recorded and/or collected	partial	The surveys (phase 1 & phase 2) of the Baseline survey area yielded a total of 1,680 invertebrate specimens from SRE groups which were identified to 48 species. Slaters were the most numerous group to be collected (832 specimens from 8 species), followed by pseudoscorpions (439 specimens from 11 species), scorpions (195 specimens from 9 species), mygalomorph spiders (168 specimens from 15 species), millipedes (36 specimens from one species) and snails (10 specimens from 4 species). Additionally, a subsequent targeted survey (phase 3 and phase 4) was conducted the following season. This resulted in the collection of two specimens of two species of millipede. One of these species was not collected during the baseline (phase 1 and phase 2) surveys. All specimens collected from groups prone to short-range endemism were submitted to the WAM or relevant taxonomists for identification. All specimens were identified down to the lowest taxonomic level possible. However, identifications could not always be made to the species level if the taxonomy of the group was not well resolved or if the life stage or sex required for identification were not collected. Database and literature reviews identified a total of 42 potential SRE species with potential to occur within the Study Area based on the proximity of records. Of these species, two had been recorded within the Study Area for this assessment. The survey was designed to maximise the collection of specimens belonging to target groups, however, it is recognised that surveys across years and seasons may be necessary to collect the majority of species in an area. The duration of the surveys (particularly the long term deployment of pitfall traps) provided a reasonable opportunity to cover the distinct climatic conditions that often influence SRE activity.

Aspect	Limitation / Constraint?	Current survey
Sources of information (e.g. previously available data as distinct from new data)	no	Previously available data relevant to this survey was obtained via database searches (**Section3.1**) and by undertaking a literature review (**Section 3.2**). New collection records resulting from this survey are presented in **Section 5.2.**
Proportion of task achieved, and further work which might be needed	no	Representative sites from all habitats in the Study Area were sampled using a range of collection methods. Specimens belonging to target SRE groups were collected from inside and outside of disturbance areas. All specimens from target groups were identified by relevant taxonomic experts. Habitats considered to have potential for supporting SRE species were considered as part of the impact assessment.
Timing, weather, season, cycle	no	All phases of survey work were conducted within the optimum survey period for the northern Goldfields (i.e. November to April) as recommended by the EPA (2009). A substantial rainfall event during the phase 1 survey resulted in ideal conditions for the activity of SRE species. These conditions resulted in the capture of a number of specimens of species that were not recorded during the subsequent phases of survey work (**Section 4.1.2** and **Section 4.2.2**).
Disturbances	no	Parts of the Study Area were disturbed by clearing and drilling activities associated with resource exploration however this did not hamper sampling coverage or adequacy. Evidence of fire was observed in the Study Area but was typical of the wider region. The baseline survey included the Wanjarri Nature reserve where recent disturbance was limited.
Intensity	no	During phase 1, all collection methods (wet pitfall traps, targeted searching, soil and litter collection) were employed at 30 sites and a further 11 sites were target searched during the phase 1 survey. Wet pitfall traps were deployed at 30 sites in the phase 2 survey. In total, both phases of the baseline survey resulted in trapping comprised 13,050 trapping nights, 123 hours of targeted searching, the collection of 90 soil samples and 90 leaf litter samples. During phase 3 of the targeted survey, wet pitfall trapping and targeted searching were employed at 10 sites and a further 3 sites were targeted searched. Wet pitfall traps were at the same 10 sites during the phase 4 survey. In total both phases of the targeted survey resulted in trapping comprising 4,550 trapping nights and 26 hours of targeted searching.
Completeness	partial	All habitats within the Study Area were adequately surveyed. However, some areas of habitat in the Study Area that potentially support SRE species (such as outcrop and creek line habitats) could not be sampled due to heritage listing. Additional areas of similar habitats were surveyed within the Wanjarri Nature Reserve to provide regional context.
Resources	no	Resources were adequate to complete the survey. Survey participants were competent in the collection of invertebrates and identification of the habitats encountered during the survey.
Remoteness and access problems	partial	Access was very good and adequate survey coverage was achieved throughout the Study Area and the adjacent Wanjarri Nature Reserve.
Availability of contextual information	no	Contextual information on the occurrence of SREs in the region was available and sourced through the WAM Database and through a literature review of regional SRE invertebrate fauna surveys. Additional information was also considered which included DEC's Threatened and Priority Fauna Database and DECs NatureMap database.

6 Impact Assessment

This section presents an assessment of the potential impacts of the Project on terrestrial SRE invertebrate fauna habitat and SRE species identified during the Baseline Survey, Targeted Survey and from the desktop study. The primary objectives of this section are to describe the relevant threatening processes associated with the Project (**Section 6.1**), and to examine the likely impact of these threatening processes on SRE invertebrate fauna habitat (**Section 6.2**) and SREs present in the Study Area (**Section 6.3**).

6.1 Threatening Processes

Threatening processes specifically associated with the Project can be categorised as either direct or indirect impacts. Direct impacts primarily occur through land clearing, whereas indirect impacts include inappropriate fire regimes, introduced flora and changes to surface hydrology (EPA 2009), increased noise, vibration, artificial light, and impacts of dust. The threatening processes that are potentially associated with the development of the Project are discussed below.

6.1.1 Land Clearing

Land clearing is likely to be the largest potential impact on SRE invertebrate fauna and habitat with approximately 1,115 ha being cleared to develop the Project within the Study Area (**Table 6-1**, **Figure 6-1**). Additional clearing may also be required during the life of the Project for the construction of infrastructure, additional access tracks, installation of pit crest and abandonment bunds and drainage control structures.

Land clearing will directly remove potential SRE invertebrate fauna habitat resulting in habitat contraction and potentially habitat fragmentation. By definition short-range endemic invertebrate fauna species typically have poor powers of dispersal (Harvey 2002) and are therefore unable to emigrate from land as it is being cleared. Land clearing will result in the loss of SRE species populations that occur within disturbance areas. Additionally, land clearing can result in habitat fragmentation and increase degradation through edge effects. Clearing of habitats with the potential to support SRE species (**Section 5.1**) should be limited where practicable.

6.1.2 Fire

The development and operation of the Project may alter the fire regime of the Study Area. Short-range endemic invertebrate habitats such as outcrops are often fire refuges (EPA 2009) which may not be burnt with the frequency of the surrounding landscape. Breakaway habitat has the potential to provide fire refuge within the Study Area (**Figure 5-1**). Increasing fire frequency in fire refuges is likely to be detrimental to SRE species which have evolved in the absence of fire. The impact of inappropriate fire regimes may be reduced through the implementation of an appropriate fire management plan.

6.1.3 Introduced Flora

The Project may result in the introduction of environmental weeds from mobile mining equipment. The invasion of weeds may have a negative impact on SRE species as it can fundamentally alter the composition and structure of vegetation communities on which SREs rely (Cowie and Werner 1993, Gordon 1998). Invasion by non-native species typically results in a decline in native plant species richness (Grice 2006). It is, therefore, important to implement management strategies to reduce the occurrence and spread of weeds during mining operations.

6.1.2 Changes to Surface Hydrology

The Project may result in changes to surface hydrology in the Study Area which may affect SRE habitat. The main drainage feature within the Study Area is Jones Creek which aligns with the Creekline habitat (**Figure 5-1**). Jones Creek is a highly ephemeral first-order stream which is incised into the Barr-Smith Range (MWH 2016). Within the creek, water flows from the north, through the Study Area and then to the southwest with the terminus for the creek as a floodplain containing a number of claypans (MWH 2016).

Impacts to Jones Creek are likely to comprise of direct disturbance in the form of two causeways that will be constructed across the creek to facilitate the transport of waste to the waste landform and to transport ore to Mt Keith for processing. Additional disturbance may be secondary in nature, where sediment may be carried into the creek from the nearby waste landform and from areas that have been cleared for the Project (**Figure 6-1**). Higher sediment loads in surface water runoff may result in sedimentation downstream.

Appropriate management of surface hydrology will be required by the Project to minimise impacts to the Creekline habitat that occurs along Jones Creek. This habitat has a high potential to support SRE species and is known to support the two confirmed SRE species recorded during this study.

6.1.5 Noise and Vibration

Noise and vibration from the Project will be associated with blasting, crushing and screening, haul trucks, road trains, diesel power generation and general machinery necessary for mine operation. Information on the potential effects of noise and vibration on SRE species is limited. A trial that tests the effect of exploration drilling on the SRE Shield-backed trapdoor spider has been conducted at Jack Hills in the Murchison by Crosslands Resources (DMP 2010). In the trial, spiders were observed in their burrows while vibration simulating drilling was produced. Preliminary results suggest that the effects of vibration on spiders may be limited, however, the intrusion of the burrows by endoscopic camera may also have influenced spider behaviour. Raven (2008), suggests that vibrations created by blasting and heavy earthmoving equipment may actually attract spiders and other arachnids, which subsequently places these individuals at risk of direct contact with mining activities. Without further research, it is not possible to predict and quantify the noise and vibration impacts on SRE species.

6.1.3 Light

The Project will result in an increase in the exposure of SRE invertebrate fauna to artificial light. Most SRE invertebrate fauna in the eastern Murchison are active during the hours of darkness and it is possible that artificial light will influence feeding and breeding behaviour. To reduce possible impacts of artificial light on SRE fauna, lighting should be designed to illuminate designated operations areas rather than the surrounding landscape.

6.1.4 Dust

The Project will potentially result in an increase in dust pollution resulting from blasting, the movement of light and heavy vehicles and the general use of equipment on site. Dust pollution may lead to the degradation of surrounding vegetation. High levels of dust pollution may reduce plant growth resulting in the degradation of the overall ecosystem and increased risk of disease in plants. Adequate dust suppression measures should be implemented to reduce the effects of dust on potential SRE habitats and SRE species.

6.2 Impact to SRE Habitat within the Study Area

Habitat loss is listed as a key threatening process under the EPBC Act, however, it is recognised that this is a necessary and typical outcome of the development of the Project. The removal of SRE habitat within the proposed disturbance area will result in the loss of SRE populations that reside in these habitats.

Nine broad habitats were identified across the Baseline Survey Area, Targeted Survey Area and Wanjarri Nature Reserve. All of these habitats, excluding Spinifex Sandplain were identified within the Study Area for this assessment. The area of each habitat in the Study Area that will be directly impacted upon by the Project is quantified in **Table 6-1** and shown in **Figure 6-1**.

The development of the Project will result in the loss of a total of 1,115 ha of habitat comprising 3.5 ha of creek line, 2.5 ha of Internal Drainage, 6.4 ha of Breakaway, 69.2 ha of Drainage Line and 18.1 ha of Mulga over Spinifex on Sandplain, 656.5 ha of Stony Hill and Slope, 147.5 ha Sparse Mulga Woodland and 211.3 ha of Stony Plain habitat present in the Study Area (**Table 6-1**; **Figure 6-1**). No SRE habitats were found to be restricted exclusively to the proposed disturbance area.

Creekline and Internal Drainage habitats are considered to have a high potential for supporting SRE species (**Table 5-1**, **Figure 5-1**). Approximately 14.6 % of Internal Drainage and 4.5 % of Creekline habitat occurring within the Study Area will be removed as a result of the Project (**Table 6-1**, **Figure 6-1**). Both the Internal Drainage and Creekline habitats are known to occur outside of the Study Area. Secondary impacts to the Creekline habitat are likely to be minimal, provided that adequate controls of secondary impacts downstream of the Project are implemented and managed appropriately.

Breakaway, Drainage Line and Stony Hill and Slope habitats are considered to have a medium potential for supporting SRE species (**Table 5-1**, **Figure 5-1**). Approximately 9.7 % of Breakaway and 13.9 % of

Drainage Line habitat will be removed as a result of the Project (**Table 6-1**, **Figure 6-1**). Breakaway and Drainage Line habitats tend to form isolates within the Study Area and their removal will reduce habitat availability at a localised level.

Mulga over Spinifex on Sandplain, Sparse Mulga Woodland and Stony Plain habitats are considered to have a low potential of supporting SRE taxa (**Table 5-1**, **Figure 5-1**). Approximately 4.3 % of Mulga over Spinifex on Sandplain, 14.3 % of Sparse Mulga Woodland and 16.3 % of Stony Plain habitat will be removed by the Project (**Table 6-1**, **Figure 6-1**). The removal of these habitats is unlikely to affect the biological diversity of SRE species within the Study Area.

Table 6-1: The extent of habitats within the proposed disturbance area with respect to the Study Area and the total area mapped for this study

Habitat	Area of habitat in disturbance area (ha)	Area of habitat in Study Area (ha)	Proportion of each habitat in Study Area (%)	Proportion of each habitat in the total areas mapped (%)
Internal Drainage	2.5	17.07	14.6	1.3
Creekline	3.5	76.68	4.5	1.4
Breakaway	6.4	66.73	9.7	1.7
Mulga over Spinifex on Sandplain	18.1	417.4	4.3	0.2
Stony Hill and Slope	656.5	1928.67	34.0	30.4
Drainage Line	69.2	496.21	13.9	2.0
Sparse Mulga Woodland	147.5	1034.69	14.3	2.2
Stony Plain	211.3	1292.83	16.3	1.4
Spinifex Sandplain	-	0	-	0.0
Disturbance	-	91.82	-	0.0
Total	**1,115**	**5,422**	**-**	**-**

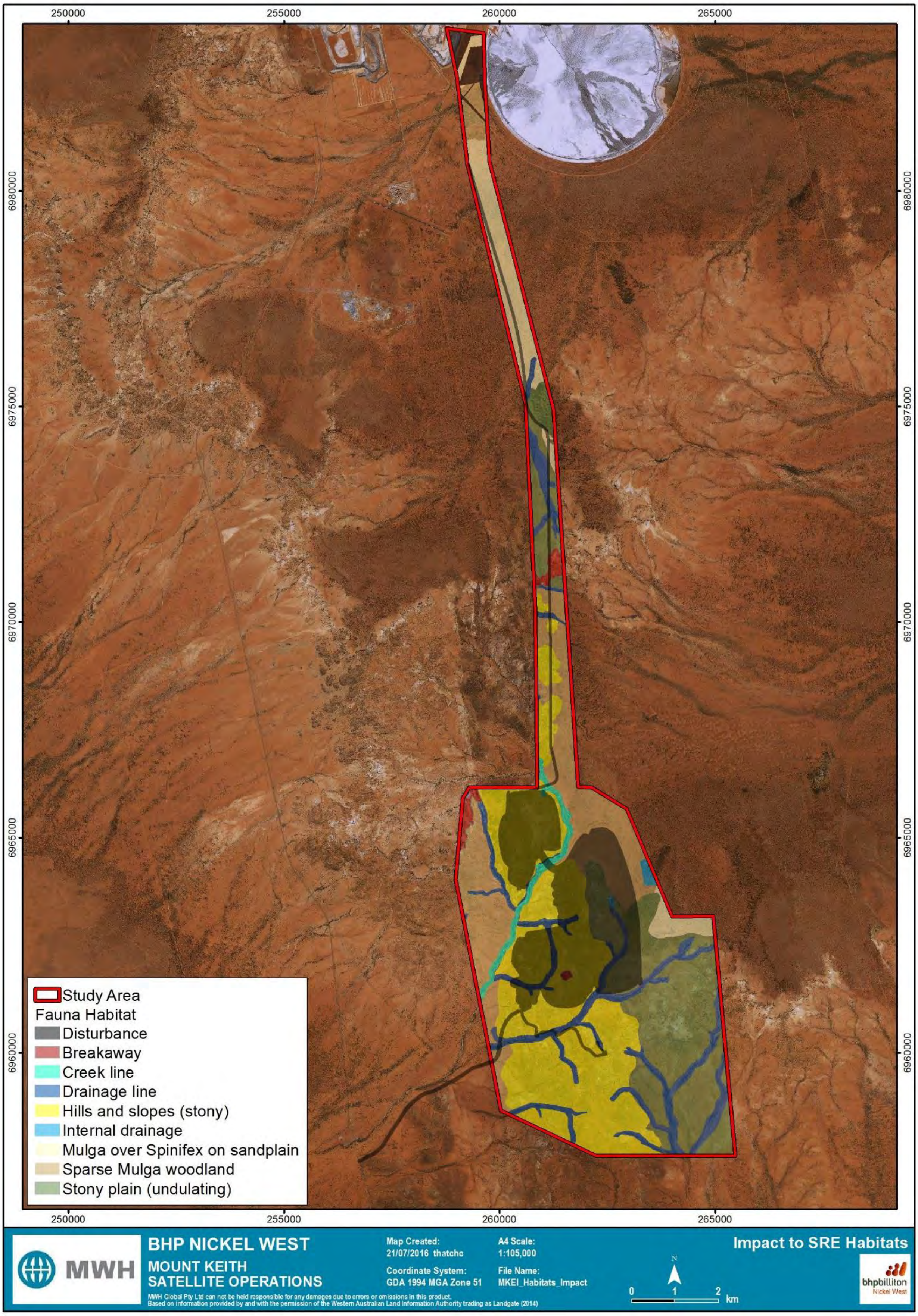

Figure 6-1: SRE habitat in relation to the proposed disturbance area

6.3 Impact to SRE species within the Study Area

The Baseline survey, Targeted survey and desktop study have identified two confirmed SRE species, four Likely SRE species and 25 Potential SRE species from within the Study Area. Of these species, one confirmed, one Likely and 14 Potential SRE species have been collected from within disturbance footprints (**Table 6-2**). However, none of these species have been collected exclusively from within the disturbance area. All species collected within the disturbance area for the Project have also been collected outside the disturbance area.

For brevity, only the Confirmed, Likely and Potential SRE species recorded within the disturbance area are discussed in the following sections (**Sections 6.3.1** – **6.3.3**). Those species only recorded outside the disturbance area are not discussed in this section. Impacts to these species only recorded outside the disturbance area are considered to be minimal as they are not known to occur within the area to be impacted by the Project and are known to have distributions that extend outside the disturbance area.

Table 6-2: SRE species in relation to the proposed disturbance area and habitat

Group	Taxa	SRE status	Recorded within disturbance area?	Recorded outside disturbance area?
Mygalomorph spiders	*Aname* 'MYG235'	Likely	No	Yes
	Idiosoma sp.	Potential	No	Yes
	Cethegus sp.	Potential	No	Yes
	Conothele sp.	Potential	Yes	Yes
	Aganippe sp.	Potential	Yes	Yes
	Anidiops sp.	Potential	No	Yes
	Yilgarnia sp.	Potential	Yes	Yes
	Aname 'Wanjarri sp. 1'*	Potential	No	Yes
Scorpions	*Urodacus* cf 'gibson 5'	Potential	Yes	Yes
	Lychas annulatus	Potential	Yes	Yes
	Urodacus 'species A'*	Potential	No	Yes
Pseudoscorpions	*Synsphyronus* \`sp. PSE023\`	Likely	No	Yes
	\`Genus 7/4\` sp.	Potential	Yes	Yes
	Austrohorus sp.	Potential	Yes	Yes
	Beierolpium \`sp. 8/2\`	Potential	No	Yes
	Beierolpium \`sp. 8/3\`	Potential	Yes	Yes
	Beierolpium \`sp. 8/4 small\`	Potential	No	Yes
	Indolpium sp.	Potential	Yes	Yes
	Linnaeolpium sp.	Potential	Yes	Yes
Slaters	*Budddelundia* 96	Potential	Yes	Yes
	Budddelundia 45	Potential	No	Yes
	Cubaris yeelirrie1	Potential	Yes	Yes
	Cubaris yeelirrie2	Potential	No	Yes
	Pseudodiploexochus yakabindie	Likely	Yes	Yes
	Armadillidae yakabindie a	Potential	No	Yes
	Armadillidae yakabindie b	Likely	No	Yes
	Armadillidae sp. indet.	Potential	Yes	Yes
	Philosciidae sp. indet.	Potential	Yes	Yes
	Trichorhina sp. indet.	Potential	No	Yes
Millipedes	*Antichiropus* 'DIP003'	Confirmed	Yes	Yes
	Antichiropus 'DIP002'	Confirmed	No	Yes

** Species identified from the desktop study*

** Yellow highlight:* Species not identified to species or morphospecies

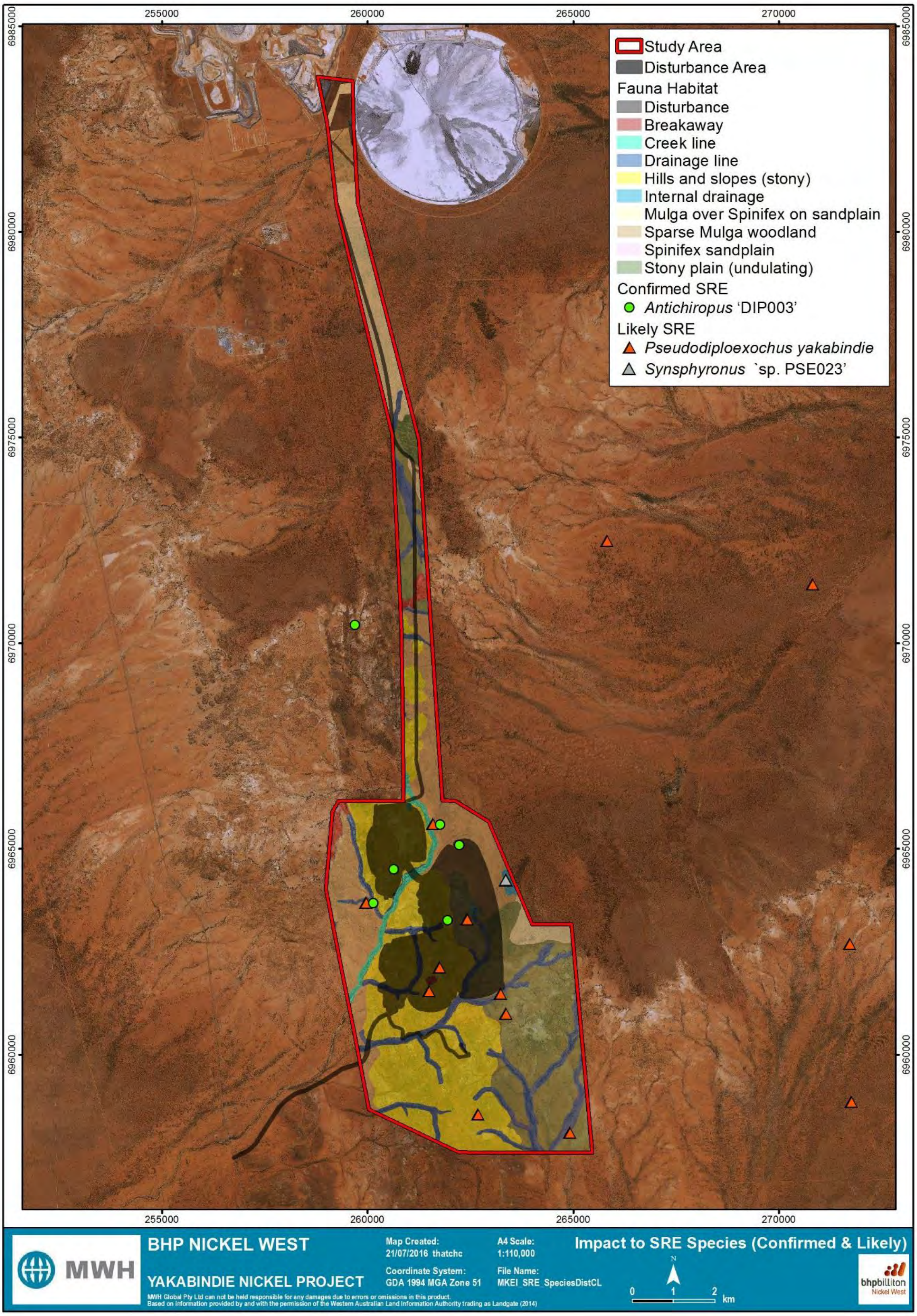

Figure 6-2: Confirmed and Likely SRE species that occur within the proposed disturbance area

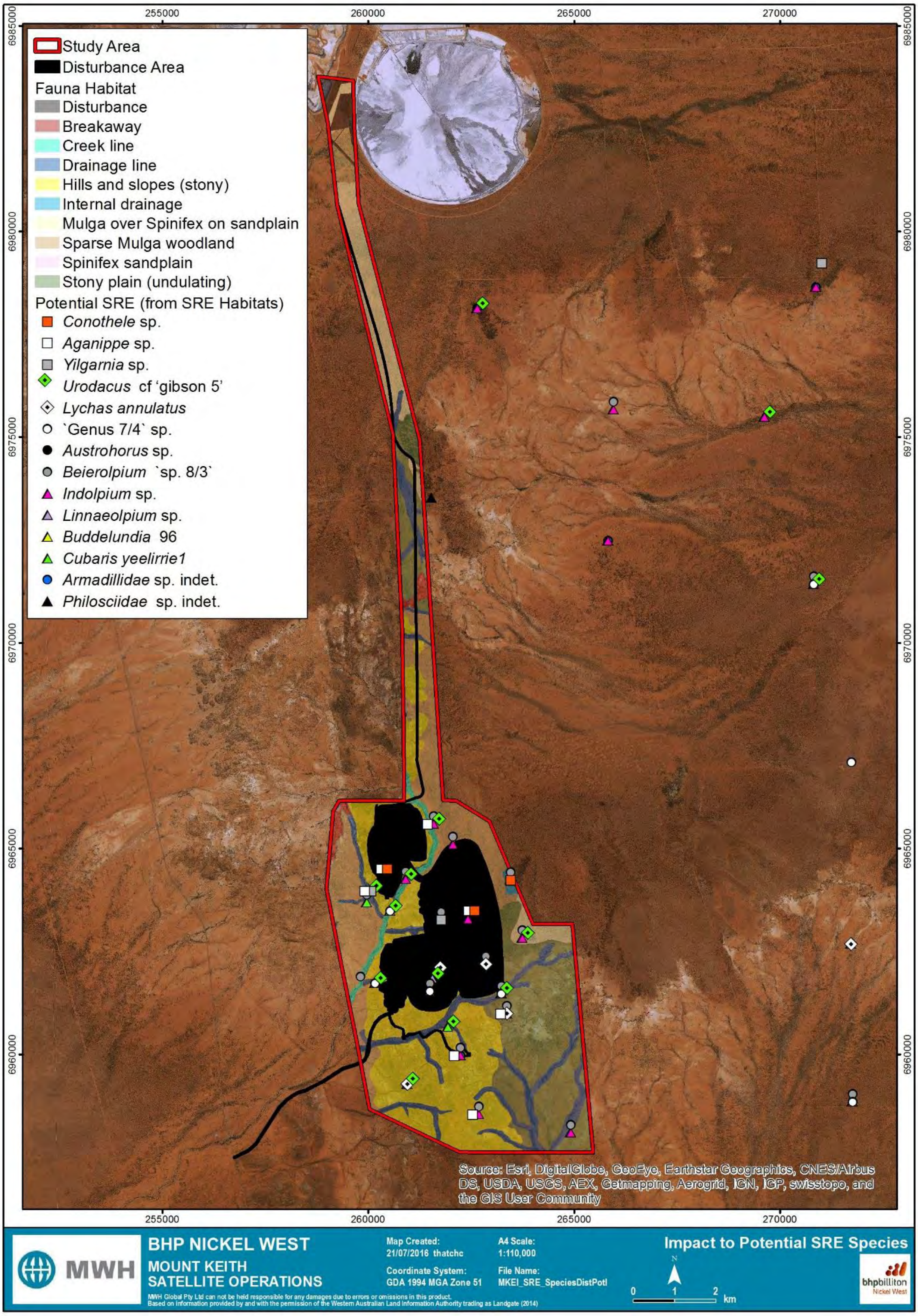

Figure 6-3: Potential SRE species that occur within the proposed disturbance area

6.3.1 Confirmed SRE species

***Antichiropus* 'DIP003'**

A total of 37 specimens of the millipede *Antichiropus* 'DIP003' were collected across six sites and three habitats (**Table 5-4**). The majority of these specimens (21) were collected from the Creekline habitat with all other collection sites occurring in close proximity to the Creekline habitat associated with Jones Creek. Consequently, Jones Creek and its associated drainage features appear to be an important habitat for this confirmed SRE species. Two of the six known locations for this *Antichiropus* 'DIP003' occur within the proposed disturbance area. However, since the Project largely avoids the Creekline habitat (**Figure 6-2**), and provided that secondary impacts to the creekline habitat are managed appropriately, it appears that impacts from the Project are unlikely to affect the long term persistence of this species.

6.3.2 Likely SRE species

***Pseudodiploexochus* 'yakabindie'**

A total of 38 specimens of the slater *Pseudodiploexochus* 'yakabindie' were collected across 13 sites and six habitats (**Table 5-4**). Given that only three of the 13 collection locations for this species occurs within the proposed disturbance area (**Figure 6-2**), it appears unlikely that the Project will affect the long term persistence of this species.

6.3.3 Potential SRE species

***Conothele* sp.**

A total of four specimens of the mygalomorph spider *Conothele* sp. were collected across three sites and two habitats (**Table 5-4**). Both of these habitats, Internal Drainage and Stony Hills and Slopes, have high and medium potential to support SRE species, respectively (**Section 5.1**). As specimens of this species were only collected from SRE habitats, this potential SRE has a higher likelihood of being restricted in its distribution than other potential SRE species collected in this study. Specimens of this species were collected at two sites within and one site outside the proposed disturbance area (**Figure 6-3**). Given that the species is known to occur outside the proposed disturbance area and given that both habitats are well distributed outside the proposed disturbance area (**Section 5.1**), it appears unlikely that the Project will affect the long term persistence of this species.

***Aganippe* sp.**

A total of 8 specimens of the mygalomorph spider *Aganippe* sp. were collected across seven sites and five habitats (**Table 5-4**). Six of these seven sites were within habitats likely to support SRE species suggesting that the species may be restricted in its distribution (**Section 5.1**). However, given that only two of the seven sites fall within the proposed disturbance area (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of this species.

***Yilgarnia* sp.**

A total of three specimens of the mygalomorph spider *Yilgarnia* sp. were collected from three locations across three habitats (**Table 5-4**). Only one of these three locations falls within the proposed disturbance area for the Project (**Figure 6-3**), and consequently, it appears unlikely that the Project will affect the long term persistence of this species.

***Urodacus* cf 'gibson 5'**

A total of 47 specimens of the scorpion *Urodacus* cf 'gibson 5' were collected from 13 locations from locations six habitats (**Table 5-4**). Given that only one of the 13 locations occurs within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

Lychas annulatus

A total of eight specimens of the scorpion *Lychas annulatus* were collected from five locations across three habitats (**Table 5-4**). Given that only two of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

`Genus 7/4` sp.

A total of 22 specimens of the pseudoscorpion `Genus 7/4` sp. (family Olpiidae) were collected across ten sites and five habitats (**Table 5-4**). Given that only two of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

***Austrohorus* sp.**

A total of 31 specimens of the pseudoscorpion *Austrohorus* sp. were collected across 18 sites and eight habitats (**Table 5-4**). This species appears to be associated with a diverse range of habitats. Given that only four of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

***Beierolpium* `sp. 8/3`**

A total of 69 specimens of the pseudoscorpion *Beierolpium* `sp. 8/3` were collected across 19 sites and seven habitats (**Table 5-4**). This species appears to be associated with a diverse range of habitats. Given that only four of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

***Indolpium* sp.**

A total of 240 specimens of the pseudoscorpion *Indolpium* sp. were collected from 27 sites across seven habitats (**Table 5-4**). Given that only seven of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

***Linnaeolpium* sp.**

A total of five specimens for the pseudoscorpion *Linnaeolpium* sp. were collected across five sites and four habitats (**Table 5-4**). Given that only one of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

***Budddelundia* 96**

A total of 89 specimens of the slater *Budddelundia* 96 were collected from eight sites across six habitats (**Table 5-4**). The majority of these specimens occurring in sheltered habitats with a high or medium potential to support SRE species: Internal Drainage (30), Drainage Line (13), Creekline (36). However, given that only three of these sites occur within the proposed disturbance area for the Project (**Figure 6-3**), and that these sheltered habitats will not be substantially impacted by the Project, it appears unlikely that the Project will affect the long term persistence of the species.

***Cubaris* yeelirrie1**

A total of 391 specimens of the slater *Cubaris* yeelirrie1 were collected across 24 sites and six habitats (**Table 5-4**). Given that only seven of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

Armadillidae sp. indet.

A total of 101 specimens of Armadillidae sp. indet. were collected across eight sites and five habitats (**Table 5-4**). These specimens likely belong to Armadillidae yakabindie a (**Appendix G**). Given that only two of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), it appears unlikely that the Project will affect the long term persistence of the species.

Philosciidae sp. indet.

A total of 30 specimens of Philosciidae sp. indet. were collected across seven sites and five habitats (**Table 5-4**). Given that three of these locations occur within the proposed disturbance area for the Project (**Figure 6-3**), and that the species occurs across a variety of habitats, it appears unlikely that the Project will affect the long term persistence of the species.

7 Conclusion

The survey of the Baseline Study Area, Wanjarri Nature Reserve and the Targeted Survey Area yielded a total of 1,682 invertebrate specimens from target groups that were identified to 49 species. Slaters were the most numerous group to be collected (832 specimens from 8 species), followed by pseudoscorpions (439 specimens from 11 species), scorpions (195 specimens from 9 species), mygalomorph spiders (168 specimens from 15 species), millipedes (38 specimens from two species) and snails (10 specimens from 4 species). Database and literature reviews identified an additional 42 potential SRE species occurring within 50 km of the Project.

Based on current scientific knowledge of species collected within the Study Area, two were considered by experts as Confirmed SRE species, four as Likely SRE species and 23 as Potential SRE species.

The two confirmed SRE species were:

- *Antichiropus* 'DIP002' (millipede)
- *Antichiropus* 'DIP003' (millipede)

The four likely SRE species were:

- *Aname* 'MYG235' (spider)
- *Synsphyronus* `sp. PSE023' (pseudoscorpion)
- Family Armadillidae 'yakabindie b' (slater)
- *Pseudodiploexochus* 'yakabindie' (slater)

For Potential SRE species, habitat can be a useful indicator to whether a species is likely to have a restricted range or be widely distributed, as species are likely to have distributions that align with the habitats within which they were collected. Of the 25 potential SRE species collected from the Study Area, only two were collected exclusively from habitats with a high or medium potential to support SRE taxa were:

- *Conothele* sp. (spider), and
- *Beierolpium* `sp. 8/2` (pseudoscorpion)

With regards to Project impacts to SRE taxa; one confirmed, one Likely and 14 Potential SRE species have been collected from within disturbance area. However, none of these species have been collected exclusively from within the disturbance footprints. All species collected within the disturbance area for the Project have also been collected outside the disturbance area.

With respect to habitats, nine broad habitats were identified across the Baseline Survey Area, Targeted Survey Area and Wanjarri Nature Reserve. All of these habitats, excluding Spinifex Sandplain were identified within the Study Area for this assessment. With respect to SRE species, the Creekline and Internal Drainage habitats have a high potential of supporting SRE species. Approximately 4.5 % of

Creekline and 14.6 % of Internal Drainage habitat within the Study Area will be directly impacted upon by the Project. From the Baseline and Targeted surveys, it is known that additional Creekline habitat and Internal Drainage habitat occurs outside of the Study Area and will not be directly impacted by the Project. Within the total area mapped for this study, only 1.4 % of Creekline habitat and 1.3 % of Internal Drainage Line habitat will be directly impacted by the Project. Secondary impacts to the Creekline habitat are likely to be minimal, provided that adequate controls of secondary impacts downstream of the Project are implemented and managed appropriately.

Breakaway, Stony Hills and Slopes and Drainage Line habitats were considered to have a medium potential of supporting SRE species. Of these, the Project will have the largest impacts on the stony hills and slope habitat, where 34 % of this habitat in the Study Area will be impacted upon by the Project. No invertebrate habitat was found to be restricted exclusively to the proposed disturbance area. The proposed disturbance area largely comprises habitats with a medium or low potential to support SRE species.

8 References

Allen, G. R., Midgley, S. H. and Allen, M. (2002) *Field Guide to the Freshwater Fishes of Australia.* CSIRO Publishing, Melbourne, Victoria.

Beard, J. S. (1990) *Plant Life of Western Australia.* Kangaroo Press, Kenthurst.

Berry, K. (in prep) *Mt Keith Satellite Operations: Impacts on hydrology of Jones Creek and terminal claypan.*, Unpublished report prepared for BHP Nickel West.

Biota, Environmental Sciences. (2006) *BHP Billiton Northern Nickel Projects Development: Fauna and Habitats ofthe Lake Way and South Lake Way Borefields*, Unpublished report prepared for BHP NIckel West.

BoM, Bureau of Meteorology (2016) *Climate Data Online*. Available online at www.bom.gov.au./climate/data/index.shtml.

CALM, Department of Conservation and Land Management. (1996) *Wanjarri Nature Reserve: Management Plan 1996-2006* Department of Conservation and Land Management, Prepared for the National Parks and Nature Conservation Authority, Perth, Western Australia.

Car, C. A. and Harvey, M. S. (2014) The millipede genus *Antichiropus* (Diplopoda: Polydesmida: Paradoxosomatidae), part 2: species of the Great Western Woodlands region of Western Australia. *Records of the West Australian Museum* 29: 020-077.

Cowan, M., Graham, G. and McKenzie, N. (2001) Murchison 1 (MUR1 - Eastern Murchison subregion). In: *A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002*. Department of Conservation and Land Management, Kensington, W.A., pp 466-479

Cowie, I. and Werner, P. (1993) Alien plant species invasive in Kakadu National Park, tropical northern Australia. *Biological Conservation* 63(2): 127-135.

DMP, Department of Mines and Petroleum (2010) *Golden Gecko Awards for Environmental Excellence.* . Available online at http://www.dmp.wa.gov.au/goldengecko/2010.asp.

DoE, Department of the Environment (2016) *Protected Matters Search Tool (custom search)*. Available online at www.environment.gov.au/erin/ert/epbc/index.html.

DPaW, Department of Parks and Wildlife (2016a) *NatureMap: Mapping Western Australia's Biodiversity (custom search)*. Available online at http://naturemap.dec.wa.gov.au./default.aspx.

DPaW, Department of Parks and Wildlife (2016b) *Threatened and Priority Fauna Database (custom search)*. Available online at http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals.

ecologia Environment. (2011) *Proposaed Yeelirrie Development: Short-range Endemic Invertebrate Baseline Survey (Phases 1-5)*, Unpublished report prepared for URS Australia Pty Ltd, on behlaf of BHP Billiton Yeelirie Development Company Pty Ltd.

EPA, Environmental Protection Authority. (2002) *Terrestrial Biological Surveys as an Element of Biodiversity Protection*, Position Statement No 3., Perth, Western Australia.

EPA, Environmental Protection Authority. (2004) *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia*, Guidance Statement No.56, Perth, Western Australia.

EPA, Environmental Protection Authority (2009) *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia*. Available online at.

Gordon, D. R. (1998) Effects of invasive, non-indigenous plant species on ecosystem processes: Lessons from Florida. *Ecological Applications* 8(4): 975-989.

Grice, A. C. (2006) The impacts of invasive plant species on the biodiversity of Australian rangelands. *The Rangeland Journal* 28(1): 27-35.

Harvey, M. S. (2002) Short range endemism in the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* 16: 555-570.

MWH, Australia. (2016) *Mt Keith Satellite Operations: Aquatic Ecology Impact Assessment*.

Outback Ecology. (2011) *Wiluna Uranium Project: Terrestrial Fauna Assessment 2010*, report prepared for Toro Energy Limited.

Outback Ecology. (2012a) *Yakabindie NDS1 Project Lake Way South Borefield: Level 1 Terrestrial Short Range Endemic Invertebrate Fauna Assessment*, Unpublished report prepared for BHP Billiton Nickel West.

Outback Ecology. (2012b) *Yakabindie NDS1 Project South East Borefield: Level 1 Terrestrial Short Range Endemic Invertebrate Fauna Assessment*, Unpublished report prepared for BHP Billiton Nickel West.

Pringle, H. J. R., Van Vreeswyk, A. M. E. and Gilligan, S. A. (1994) *An inventory and condition survey of the north-eastern Goldfields, Western Australia.* Department of Agriculture Western Australia, Perth, W.A.

Raven, R. J. (2008) *A report on the trapdoor spider: Aurecocrypta sp from the Chichester Range*, report prepared by the Queensland Museum for Ecologia Environment.

Thackway, R. and Cresswell, I. D. (1995) *An Interim Biogeographical Regionalisation for Australia.* Australian Nature Conservation Agency, Canberra, Australian Capital Territory.

WAM, Western Australian Museum, (2016a) *Arachnid and Diplopod Collection Database (custom search)*. Available online at http://www.museum.wa.gov.au.

WAM, Western Australian Museum, (2016b) *Mollusc Collection Database (custom search)*. Available online at http://www.museum.wa.gov.au.

Western Botanical. (2011) *Review and Statistical Analysis of the Flora and Vegetation of the Yakabindie NDS1 Project Area*, Prepared for BHP Billiton Nickel West Pty. Ltd.

Wetland Research and Management. (2005) *Baseline aquatic biology and water quality study of Jones Creek, including south-west claypan area*, Report prepared for Nickel West, BHP Billiton, Perth, Western Australia.

Appendix A Site descriptions

Site 1 **Habitat type:** Drainage line **Landform:** Drainage line **Vegetation:** Low open forest of Eucalyptus sp. over a low open forest of *Acacia aneura, Acacia quadrimarginea* and *Eremophila galeata* over sparse chenopod shrubland **Leaf litter:** 50% **Substrate:** Sandy clay loam **Disturbance:** Nil	
Site 2 **Habitat type:** Creek line **Landform:** Creek line **Vegetation:** Shrub mallee of Eucalyptus socialis over a open shrubland of *Acacia aneura, Acacia quadrimarginea* over chenopod comprising various Atriplex and *Maireana* species. **Leaf litter:** 50% **Substrate:** Silt loam **Disturbance:** Nil	
Site 3 **Habitat type:** Hills and slopes (stony) **Landform:** Slope **Vegetation**: Low open woodland of *Acacia aneura, Acacia quadrimarginea* over a low open shrubland of *Senna artemisioides*, *Corymbia* sp. *and Ptilotus obovatus* **Leaf litter:** <10% **Substrate:** Clay Loam **Disturbance:** Drilling activity	

Site 4 **Habitat type:** Sparse Mulga woodland **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura, Acacia quadrimarginea* over an open shrubland of *Acacia tetragonophylla* and other species **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Grazing	
Site 5 **Habitat type:** Hills and slopes (stony) **Landform:** Slope **Vegetation:** Low open woodland of *Acacia aneura, Acacia quadrimarginea* over an open shrubland of *Acacia tetragonophylla* and Eremophila sp. **Leaf litter:** <10% **Substrate:** Loam **Disturbance:** Drilling activity	
Site 6 **Habitat type:** Hills and slopes (stony) **Landform:** Plain **Vegetation:** Low open *Acacia aneura, Acacia quadrimarginea* woodland over an open shrubland dominated by *Senna artemisioides* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Drill lines	

Site 7 **Habitat type:** Stony plain (undulating) **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over an open shrubland of *Senna artemisioides, Maireana* sp **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	
Site 8 **Habitat type:** Drainage line **Landform:** Drainage line **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over a shrubland dominated by *Acacia tetragonophylla with sparse Maireana* sp. *Solanum lasiophyllum* **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	
Site 9 **Habitat type:** Stony plain (undulating) **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* over a shrubland of *Acacia tetragonophylla and sparse cover of Maireana* sp. and *Ptilotus obovatus* **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	

Site 10 **Habitat type:** Sparse Mulga woodland **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* over various *Acacia* species. **Leaf litter:** <10% **Substrate:** Clay loam **Disturbance:** Nil	
Site 11 **Habitat type:** Stony plain (undulating) **Landform:** Plain **Vegetation:** Open low shrubland of *Acacia aneura* and *Acacia tetragonophylla.* **Leaf litter:** <10% **Substrate:** Stones **Disturbance:** Nil	
Site 12 **Habitat type:** Internal drainage **Landform:** Basin **Vegetation:** Open woodland of *Eucalyptus socialis, and Acacia aneura* over shrubland of *Eragrostis eriopoda*. **Leaf litter:** 10-25% **Substrate:** Sandy clay loam **Disturbance:** Nil	

Site 13 **Habitat type:** Hills and slopes (stony) **Landform:** **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea over an open shrubland of Eragrostis eriopoda* over low shrubland of *Senna artemisioides* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Tracks	
Site 14 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over an open shrubland dominated by *Ptilotus obovatus over Triodia basedowii* **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	
Site 15 **Habitat type:** Internal drainage **Landform:** Basin **Vegetation:** Bands of low closed forest of *Acacia aneura* and *Acacia quadrimarginea* interspersed by clear patches of limited vegetation. **Leaf litter:** <10% **Substrate:** Clay loam **Disturbance:** Nil	

Site 16 **Habitat type:** Hills and slopes (stony) **Landform:** Slope **Vegetation:** Low woodland of *Acacia aneura* and *Acacia quadrimarginea* over sparse shrubland of *Acacia tetragonophylla* and *Senna artemisioides* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Some clearing of trees	
Site 17 **Habitat type:** Hills and slopes (stony) **Landform:** Slope **Vegetation:** Low woodland of *Acacia aneura* and *Acacia quadrimarginea* over sparse shrubland of *Senna artemisioides* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	
Site 18 **Habitat type:** Stony plain (undulating) **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over a sparse shrubland of *Acacia tetragonophylla over a sparse understorey of Ptilotus obovatus.* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Grazing	

<table>
<tr><td>Site 19

Habitat type: Creek line
Landform: Creek line
Vegetation: Eucalyptus camaldulensis along drainage line. Banks fringed with Acacia aneura, Acacia tetragonophylla, Acacia acuminate, and Eragrostis eriopoda
Leaf litter: 10-25%
Substrate: Sandy loam
Disturbance: Nil</td><td></td></tr>
<tr><td>Site 20

Habitat type: Drainage line
Landform: Drainage line
Vegetation: Low open Acacia aneura and Acacia quadrimarginea woodland along drainage with an understorey of scattered Acacia tetragonophylla
Leaf litter: <10%
Substrate: Sandy clay loam
Disturbance: Tracks</td><td></td></tr>
<tr><td>Site 21

Habitat type: Hills and slopes (stony)
Landform: Slope
Vegetation: Low open woodland of Acacia aneura and Acacia quadrimarginea over sparse shrubs of Senna artemisioides
Leaf litter: <10%
Substrate: Sand
Disturbance: Tracks</td><td></td></tr>
</table>

Site 22 **Habitat type:** Drainage line **Landform:** Drainage line **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia* over an open shrubland of *Senna artemisioides* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Grazing	
Site 23 **Habitat type:** Stony plain (undulating) **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over sparse shrubs of *Senna artemisioides Acacia tetragonophylla* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Grazing	
Site 24 **Habitat type:** Internal Drainage **Landform:** Basin **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over an open shrubland of *Acacia tetragonophylla and Eragrostis eriopoda* grasses. **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	

Site 25 **Habitat type:** Internal drainage **Landform:** Basin **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over scattered shrubs of *Acacia tetragonophylla and Eragrostis eriopoda* grasses. **Leaf litter:** <10% **Substrate:** Sandy clay loam **Disturbance:** Nil	
Site 26 **Habitat type:** Drainage line **Landform:** Drainage line **Vegetation:** Low woodland of *Acacia aneura* and *Acacia quadrimarginea* over sparse *Eragrostis eriopoda* grasses around the base of trees. **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	
Site 27 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over scattered *Ptilotus obovatus and Triodia basedowii.* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	

Site 28 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open woodland of *Acacia aneura* and *Acacia quadrimarginea* over an open grassland of *Triodia basedowii.* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	
Site 29 **Habitat type:** Sparse Mulga woodland **Landform:** Plain **Vegetation:** Open shrubland of *Acacia aneura* and *Acacia quadrimarginea* with some *Ptilotus obovatus interspersed.* **Leaf litter:** <10% **Substrate:** Sandy clay loam **Disturbance:** Grazing	
Site 30 **Habitat type:** Sparse Mulga woodland **Landform:** Plain **Vegetation:** Tall open shrubland of *Acacia aneura* and *Acacia quadrimarginea* with *Ptilotus obovatus and Eragrostis eriopoda* grasses **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Grazing and eroded tracks	

Target 10 **Habitat type:** Breakaway **Landform:** Breakaway **Vegetation:** Scattered Mulga (*Acacia aneura* and *Acacia quadrimarginea)* over *Atriplex codonocarpa* **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Dill line through habitat	
Target 11 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	
Target 12 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Historic grazing	

Target 13 **Habitat type:** Breakaway **Landform:** Breakaway **Vegetation:** Scattered Mulga (*Acacia aneura* and *Acacia quadrimarginea)* over *Atriplex codonocarpa with the occasional Acacia ramulosa.* **Leaf litter:** <10% **Substrate:** Loamy Sand **Disturbance:** Nil	
Target 14 **Habitat type:** Creek line **Landform:** Creek line **Vegetation:** Eucalyptus camaldulensis fringing banks with Acacia (*Acacia aneura dominated)* shrubland and some grasses **Leaf litter:** <10% **Substrate:** Sandy loam over clay **Disturbance:** Grazing	
Target 15 **Habitat type:** Creek line **Landform:** Creek line **Vegetation:** Rivergum (*Eucalyptus camaldulensis*)fringing creek line, banks with *Acacia aneura and Acacia ramulosa* and various grass species **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	

Target 16 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low Mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <10% **Substrate:** Sandy loam **Disturbance:** Nil	
Target 17 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low Mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <20% **Substrate:** Sandy loam **Disturbance:** Nil	
Target 18 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open Mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** Nil	

Target 19 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open Mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <20% **Substrate:** Sand **Disturbance:** NIl	
Target 20 **Habitat type:** Mulga over Spinifex on sandplain **Landform:** Plain **Vegetation:** Low open Mulga (*Acacia aneura* and *Acacia quadrimarginea)* woodland over *Triodia basedowii*. **Leaf litter:** <10% **Substrate:** Sand **Disturbance:** NIl	

Appendix B Trapdoor Spiders (Araneae: Mygalomorphae) from Yakabindie, Western Australia

PHOENIX
ENVIRONMENTAL SCIENCES

Trapdoor spiders (Araneae: Mygalomorphae) from Yakabindie, Western Australia

Prepared for Outback Ecology

August 2011

Taxonomic Report

Trapdoor spiders (Araneae: Mygalomorphae) from Yakabindie, Western Australia

Prepared for Outback Ecology

Taxonomic report

Author/s: Volker W. Framenau

Reviewer/s:

Date: 3 August 2011

Submitted to: Adrian Rakimov & Paul Bolton, Outback Ecology

Chain of authorship and review			
Name	**Task**	**Version**	**Date**
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Phoenix Environmental Sciences Pty Ltd

1/511 Wanneroo Rd BALCATTA WA 6021

P: 08 9345 1608

F: 08 6313 0680

E: admin@phoenixenv.com.au

Project code: T008

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EXECUTIVE SUMMARY

In July 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Outback Ecology (the Client) to identify trapdoor spiders (Mygalomorphae) collected at Yakabindie (central Western Australia). A total of 119 vials of spiders were identified and screened for short-range endemic (SRE) taxa.

There are uncertainties in determining the range-restrictions of many invertebrates in Western Australia due to lack of surveys, lack of taxonomic resolutions within target taxa and problems in identifying certain life stages. To account for these uncertainties Phoenix uses a three-tier categorisation for short-range endemism: confirmed SRE, likely SRE and potential SRE.

The material included one specimen that is here considered a likely SRE:

- *Aname* 'MYG235' (Nemesiidae – Wishbone Spiders): this species has not been recorded before and similar species in this distinct group of small *Aname* are known from very restricted ranges only.

The material included five potential SREs all represented by females or juveniles which could not be identified with certainty:

- *Conothele* sp. indet. (♀♀, juv.) (Ctenizidae): genus with high regional diversity.
- *Cethegus* sp. indet. (♀♀, juv.) (Dipluridae): genus with deep genetic divergence between populations in some regions suggesting low dispersal potential.
- *Aganippe* sp. indet. (♀♀, juv.) (Idiopidae – True Trapdoor Spiders): genus with many widespread, but also some range-restricted species
- *Anidiops* sp. indet. (♀♀, juv.) (Idiopidae – True Trapdoor Spiders): genus with many widespread, but also some range-restricted species
- *Yilgarnia* sp. indet. (juv.) (Nemesiidae – Wishbone Spiders): taxonomically poorly resolved genus with known range-restricted species.

The following species found at Yakabindie do not represent SREs:

- *Missulena* sp. indet. (juv.) (Actinopodidae – Mouse Spiders)
- *Mandjelia* 'MYG035' (Barychelidae – Brushfooted Trapdoor Spiders)
- *Synothele meadhunteri* Raven, 1994 (Barychelidae – Brushfooted Trapdoor Spiders)
- *Gaius* sp. indet. (♀♀, juv.) (Idiopidae – True Trapdoor Spiders)
- *Aname* 'MYG173' (Nemesiidae – Wishbone Spiders)
- *Aname* 'MYG177' (Nemesiidae – Wishbone Spiders)
- *Kwonkan* 'MYG175' (Nemesiidae – Wishbone Spiders)
- *Selenotholus foelschei* Hogg, 1902 (Theraphosidae – Tarantulas)

1 SCOPE OF WORKS

In May 2011, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Outback Ecology (the Client) to identify trapdoor spiders (Mygalomorphae) collected at Yakabindie (central Western Australia). A total of 119 records were screened for short-range endemic (SRE) taxa.

2 BACKGROUND

2.1.1 Short-range endemic invertebrates

Short-range endemic fauna (also known as narrow-range taxa) are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised (Harvey 2002; Ponder & Colgan 2002). Short-range endemism in terrestrial arthropods is believed to have evolved through two primary processes (Harvey 2002; Ponder & Colgan 2002):

- **Relictual short-range endemism**: relictual SREs are thought to have had wider distributions during more mesic geological periods. Australia's aridification over the last 60 million years resulted in a contraction of the ranges of these species into relatively small habitat pockets where moist conditions persist (relictual Gondwanan habitats). Evolutionary processes over long periods of isolation typically resulted in each population developing into a distinctive species. Millipedes and terrestrial snails are typical relictual SREs and they are generally found in deep gullies often on the south-facing slopes of mountains, hills and ridges. Relictual SREs often inhabit areas with: high rainfall, areas where topography induces fog, areas with permanent water (swamps, creek lines and river systems) or deep litter beds. Sometimes habitats have various combinations of these features.
- **Habitat specialisation**: habitat specialist SREs are restricted to specific isolated habitat types. Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than microclimatic, moist conditions. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or selenopid spiders are typical examples here), salt lakes (e.g. wolf spiders of the genus *Tetralycosa*) or isolated dune systems (species in the scorpion genus *Urodacus*).

Invertebrate groups that contain SRE taxa are generally well distributed across the Australian landscape and well adapted to semi-arid environments due to a variety of behavioural and morphological features that have developed to avoid desiccation and predation. They generally possess (Harvey 2002; Ponder & Colgan 2002):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

The current knowledge of SREs in WA is relatively poor and the rarity of collections from certain regions makes it difficult to assess the distribution and likely occurrence of SRE species. Habitats such as mountains containing gullies/gorges and south-facing slopes, wetlands and rivers often include unique habitat attributes set amongst a relatively homogeneous surrounding landscape. These isolated micro habitats often harbour SRE taxa (Harvey 2002). Potential SRE taxa include the following groups (EPA 2009):

- spiders and relatives (Arachnida)
    - spiders (Araneae), in particular trapdoor spiders (Mygalomorphae) and selected modern spiders (Araneomorphae) (here mainly Flat Rock Spiders, Selenopidae)
    - harvestmen (Opiliones)
    - false scorpions (Pseudoscorpiones)
    - true scorpions (Scorpiones)
    - whip spiders (Schizomida) (although the majority of SREs in this order are troglobites) (Harvey *et al.* 2008; Harvey *et al.* 2011)
- multipedes (Myriapoda)
    - centipedes (Chilopoda), mainly the order Geophilomorpha and the Cryptopidae in the order Scolopendromorpha; other Scolopendromorpha are generally widespread and are not considered target taxa (e. g. Colloff *et al.* 2005; Koch 1982, 1983a, b, c)
    - millipedes (Diplopoda)
- crustaceans (Crustacea)
    - slaters (Isopoda)
- snails and relatives (Mollusca)
    - land snails (Eupulmonata, Gastropoda)
- earth worms (Oligochaeta).

Whilst other invertebrate groups have recently been proposed to contain a substantial proportion of range-restricted species, e.g. epigaeic (ground-dwelling), often wingless beetles in the Pilbara (Guthrie *et al.* 2010), these are currently not targeted in SRE invertebrate surveys (EPA 2009).

2.1.2 Categories of short-range endemism

There is currently no accepted system in place to define the varying probabilities of a species to be an SRE. The uncertainty in categorising a specimen as SRE originates in a number of factors including:

- **Poor regional survey density** (sometimes taxon-specific): A regional fauna is simply not known well enough to assess the distribution of species. This factor also considers the fact that, simply because a species has not been found regionally, does not mean it is really absent; this confirmation ('negative proof') is almost impossible to obtain ("absence of proof is not proof of absence").
- **Lack of taxonomic resolution**: many potential SRE taxa (based on preferences for typical SRE habitats, SRE status of closely related species, or morphological peculiarities such as troglomorphism) have never been taxonomically treated and identification to species level is very difficult or impossible as species-specific character systems have not been defined. Good taxonomic resolution does not necessarily require a published revision, but generally requires a taxonomist to be actively working on this group or a well-established, preferably publicly available, reference collection (i.e. museum collection).
- **Problems of identification**: SRE surveys often recover life stages of potential SRE taxa that cannot be confidently identified based on morphological characters, even if revisions exist. These include, for example, juvenile or female millipedes, mygalomorph spiders and scorpions. Molecular techniques are increasing being employed to overcome these identification problems.

Considering these factors of uncertainty, Phoenix currently employs a simple three-tier system to categorise the different probabilities of short-range endemism: confirmed, likely or potential SRE (Table 2-1). These categories are dynamic and can change with every survey.

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are here assessed based on the knowledge of the higher taxon they belong to, i.e. family or genus. For example, all juvenile or female *Antichiropus* millipedes would be classified as 'confirmed SRE' as all but two of the known species in this genus are considered SREs (Wojcieszek *et al.* 2011).

The different categories of 'SRE-likelihood' may help to set conservation priorities; however, SRE taxa of all categories should be considered to determine appropriate conservation measures in order to adhere to the Precautionary Principle within Environmental Impact Assessments. That is, "*where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental degradation*" (e. g. EPA 2002) .

Table 2-1 Phoenix SRE categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
(Confirmed) SRE	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group well represented in collections, in particular from the region in question; high levels of endemism in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes and araneomorph spiders in the genus *Karaops* (Selenopidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (i.e. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones, some pseudoscorpions and slaters, many mygalomorph spiders
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners often widespread	Cryptopidae, Geophilida

2.2 IDENTIFICATION AND PERSONNEL

All spiders were examined in 70% or 100% ethanol under Leica M205A and M80 stereomicroscopes.

The method of identification for each taxon, i.e. by taxonomic literature or comparison with type or other reference material, is indicated in the taxonomic part of this report. Phoenix personnel involved in the identification are listed in Table 2-2.

Table 2-2 Phoenix personnel involved in identification

Taxonomic group	Title	Qualification
Dr Volker Framenau	Manager, Terrestrial Invertebrates	One of Australia's leading arachnologists with taxonomic expertise in major araneomorph and mygalomorph spiders; established the WAM mygalomorph reference collection
Kate Penwarden	Zoologist	B.Sc. (Honours) (Zool., Cons. Biol.)

2.3 TAXONOMY AND NOMENCLATURE

The taxonomic nomenclature of spiders treated here follows Platnick (Platnick 2011).

Morphospecies designations of undescribed species are generally adopted from the systems of the scientist(s) working on the group. For mygalomorph spiders, the Western Australian Museum has established a morphological reference collection of males that aids in the identification of spiders. Morphospecies are numbered consecutively with the prefix "MYG", e.g. *Aname* 'MYG001' (Nemesiidae).

2.4 SPECIMEN DEPOSITORY

The EPA guidance statement No. 20 ('*Sampling of short-range invertebrate fauna for environmental impact assessment in Western Australia*') (EPA 2009) recommends that all specimens representing SRE target groups are lodged with the WAM to enhance the knowledge of the distribution of putatively rare species. Phoenix adheres to this recommendation and all of the survey specimens were returned to the Arachnology Department of the Western Australian Museum.

3 RESULTS

3.1 SUMMARY

The mygalomorph spiders identified belong to at least 14 morphospecies in 12 genera and seven families (Table 3-1, Appendix 1). One species, *Aname* 'MYG235' (Nemesiidae), is considered a likely SRE, five taxa represent potential SREs and eight species are not considered SREs.

Three araneomorph spiders were delivered for identification, including *Meedo yarragin* Platnick, 2002 and an unidentified male in the family Zodariidae (Appendix 1). None of these are SREs (e.g. Platnick 2002).

Table 3-1 SRE-status of mygalomorph spiders from Yakabindie

Taxon	SRE status	Remarks
Actinopodidae		
Missulena sp. indet. (juv.)	not SRE	only known from some widespread morphospecies in the area (WA Museum database)
Barychelidae		
Mandjelia 'MYG035'	not SRE	widespread in central WA
Synothele meadhunteri Raven, 1994	not SRE	widespread in central WA
Ctenizidae		
Conothele sp. indet.	potential SRE	genus with high diversity in some regions of WA; males required for accurate identification
Dipluridae		
Cethegus sp. indet.	potential SRE	genus with deep genetic divergence between populations suggesting limited dispersal potential; males required for accurate identification
Idiopidae		
Aganippe sp. indet.	potential SRE	many known morphospecies of *Aganippe* widespread, but some range-restricted (WA Museum database); males required for accurate identification

(continued next page)

(Table 3-1 continued)

Taxon	SRE status	Remarks
Anidiops sp. indet.	potential SRE	many known morphospecies of *Anidiops* widespread, but some range-restricted (WA Museum database); males required for accurate identification
Gaius sp. indet.	not SRE	known morphospecies of *Gaius* widespread (WA Museum database); males required for accurate identification
Idiopidae sp. indet.		either *Anidiops* or *Gaius*, similar ratings as above apply
Nemesiidae		
Aname 'MYG173'	not SRE	also known from Lake Way and Lake Maitland
Aname 'MYG177'	not SRE	also known from Lake Way
Aname 'MYG235'	likely SRE	Belongs to a distinct group of small *Aname*, all known from only single locality
Aname sp. indet.		males required for accurate identification
Kwonkan 'MYG175'	not SRE	more recently recorded as far south as Leinster and Koolyanobbing
Kwonkan sp. indet.		possibly conspecific with *Kwonkan* 'MYG175'; same rating applies
Yilgarnia sp. indet.	potential SRE	genus previously not known from the area; males required for accurate identification
Theraphosidae		
Selenotholus foelschei Hogg, 1902	not SRE	widespread throughout WA (WA Museum database)

3.2 MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of short-range endemic taxa (EPA 2009; Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum* Main, 1952, *Kwonkan eboracum* Main, 1983, and *Moggridgea tingle* Main, 1991, 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 (Western Australian Government 2010).

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*).

3.2.1 Family 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.

3.2.1.1 Genus *Missulena*

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). 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 WA Museum 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), however this may only happen over a few metres thus limiting long-distance dispersal (R. J Raven, personal communication).

***Missulena* sp. indet. (juv.)**

A single juvenile *Missulena* was collected at Yakabindie (Appendix 1) and species identification is not possible. However, a number of common and more or less widespread species have been found around the survey area, e.g. *Missulena* 'MYG48' and *Missulena* 'MYG049' (WA Museum database). The juvenile *Missulena* is therefore not considered to represent an SRE although it is recommended to collect a male to confirm its identity and distribution.

3.2.2 Family Barychelidae (Brush-footed Trapdoor Spiders)

Barychelid spiders, commonly called Brush-footed Trapdoor Spiders, are small to fairly large in size with well-developed claw tufts and short terminal segment of the posterior lateral spinnerets (Raven 1994). 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 60 cm deep and often lack the firm thick door of the Ctenizidae or the extensive webs of Dipluridae.

3.2.2.1 Genus *Mandjelia*

The genus *Mandjelia* differs from most other genera of the Barychelidae by the large (i.e. > 30) number of maxillary cuspules. Twenty-two species are currently described from Australia, most of them from the eastern states (Raven 1994). Two described species are known from WA, *M. humphreysi* Raven & Churchill, 1994 from the Goldfields region and *M. madura* Raven & Churchill, 1994 from the south-east coast (Raven 1994).

***Mandjelia* 'MYG035'**

Mandjelia 'MYG035' is fairly widespread in central WA and can be found from Lorna Glen Station in the north to Laverton in the south. The species has also been found at Lake Way and Albion Downs (WA Museum database). It is not an SRE.

3.2.2.2 Genus *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) with most species known only from very limited ranges (Raven 1994).

***Synothele meadhunteri* Raven, 1994**

Following its description, *S. meadhunteri* has been shown to be widespread throughout central WA (WA Museum database). It is not an SRE.

3.2.3 Family Ctenizidae (Cork-lid Trapdoor Spiders)

The Ctenizidae are represented in Australia by a single genus, *Conothele*. Spiders in this genus can be identified by a distinct dorsal depression in the tibia of the third leg (Raven 1985c).

3.2.3.1 Genus *Conothele*

Members of the genus *Conothele* are found across much of arid and semi-arid Western Australia. The burrows are usually difficult to find as they are sealed with a tight-fitting lid. At least one species is arboreal, living in burrows constructed on the side of tree holes (Main 1985). As in the genus *Missulena*, juvenile *Conothele* are believed to disperse via ballooning (Main 1957b, 1976) limiting their predisposition as short-range endemics.

The taxonomic status of the Western Australian fauna is uncertain, with the entire fauna representing unnamed species. The precise distributions of each species are unknown, and much taxonomic work at the species level is required before the status of individual populations can be ascertained. With seven morphospecies, the WAM/DEC Carnarvon survey recovered a surprisingly high diversity within the genus (Main *et al.* 2000). In contrast, the DEC Pilbara survey found only a single widespread species (Durrant *et al.* 2010).

***Conothele* sp. indet. (♀♀, juv.)**

The material from Yakabindie only contained females and juveniles which could not be identified to species level (Appendix 1). Taking the apparent regional diversity of the genus into account as reported from the Carnarvon Basin (Main *et al.* 2000), the Conothele specimens are here considered to be potential SREs.

3.2.4 Family Dipluridae (Curtain-web Spiders)

Six genera of the Dipluridae are currently known from Australia, including *Australothele*, *Caledothele*, *Carrai*, *Cethegus*, *Masteria* and *Namirea*, of which only *Cethegus* is found in Western Australia (Raven 1984, 1985a). Diplurids are known as Curtain-web Spiders due to the shape of their webs, which consist of numerous strands of silk hanging across the entrance of their burrows.

3.2.4.1 Genus *Cethegus*

The genus *Cethegus* currently includes 11 named species in Australia, including two, *C. fugax* (Simon, 1908) and *C. ischnotheloides* Raven, 1985, from Western Australia (Ecologia 2009; Main 1960; Raven 1984). A number of undescribed species from many different regions of the state are known from the collection of the Western Australian Museum. The status and distribution of these species are not well understood and detailed taxonomic work is needed to understand the Western Australian fauna. A recent molecular study on species in the *C. fugax*-complex from the Murchison region of WA discovered these spiders to be different to the nominal species *C. fugax* from the Jarrah forests around Perth and showed high intra-specific genetic divergence between subpopulation of different mountain ranges within the region, possibly caused by limited dispersal capabilities (Ecologia 2009). Most species from WA appear to belong to the *C. fugax*-complex which is characterised by dark patches on the booklung covers a long, curved embolus of the male pedipalp (Raven 1984).

The nest of *Cethegus* includes vertical, curtain ‐ like strands of silk with adherent soil. At the centre of the nest are two or three funnel ‐ like tubes that join into a common tube leading into a shallow burrow. Radiating from the main web are catching strands which entrap both crawling and flying insects. The nests may be up to thirty centimetres in height and width and they are generally supported against stems of trees or shrubs, tussocks of grass, logs or irregularities in soil such as banks or rocks. Mating and reproduction appears to depend on prevailing seasonal conditions in relation to region or location. Emergent spiderlings may be aerially dispersed over short distances (i.e. several meters) (Main 1995).

***Cethegus* sp. indet. (♀♀, juv.)**

The *Cethegus* specimens from Yakabindie could not be identified to species level but belong to the *Cethegus-fugax* group. Taking the distribution pattern of this group into account (see above), the specimens are here considered potential SREs.

3.2.5 Family Idiopidae (True Trapdoor Spiders)

The mygalomorph spider family Idiopidae includes a number of genera in Western Australia, including *Anidiops*, *Gaius* (currently listed as junior synonym of Anidiops), *Euoplos*, *Blakistonia*, *Cataxia*, *Eucyrtops*, *Idiosoma* and *Misgolas* (Main 1985; Raven & Wishart 2005). They comprise the 'typical' trap door spiders, i.e. those species that usually close the burrow with a hinged door. Spiders of this family are abundant, in particular in relatively stable habitats in temperate to tropical regions (Main 1985).

3.2.5.1 Genus *Aganippe*

The idiopid genus *Aganippe* is common throughout Western Australia. Fourteen species are described from Australia and many new species await description (Main 1985). The genus differs from all other genera in the family Idiopidae by the presence of abdominal sigillae and the presence of two processes on the male pedipalp tibia (Main 1985).

***Aganippe* sp. indet. (♀♀, juv.)**

The *Aganippe* specimens from Yakabindie are female and juvenile and could not be identified to species level (Appendix 1). Western Australian *Aganippe* include both widespread and range-restricted species and the specimens from this survey are therefore considered potential SREs.

3.2.5.2 Genus *Anidiops*

Currently two species of *Anidiops* are described from Western Australia, *A. manstridgei* and *A. villosus* (Main 1985). Pedipalp morphology of both species suggests these to belong to different genera and although not published in the scientific literature, the latter species is often reported as representing a different genus, *Gaius* (see below). *Anidiops* and *Gaius* females can be separated mainly by size with *Gaius* specimens being considerably larger. Spiders in both genera construct leave decorated burrows with a trapdoor. The burrow also includes a 'sock', i.e. the lower section of silk lining has a collar-like structure that the spider can retract to provide a false bottom, presumably serving as anti-predatory mechanism (Main 1985).

A number of undescribed species of *Anidiops* are known from the collection of the WA Museum including some widespread species and some with restricted ranges.

***Anidiops* sp. indet. (♀♀, juv.)**

The females and juveniles from Yakabindie (Appendix 1) cannot be identified to species level, but based on the known distribution of *Anidiops* species, they are here considered potential SREs.

3.2.5.3 Genus *Gaius*

The genus *Gaius* (family Idiopidae) is well represented throughout WA and into the Pilbara region based on WA Museum records. All species have a fairly wide distribution (Framenau *et al.* 2008; Main 1957a, 1978; Schmidt 2007).

***Gaius* sp. indet. (♀♀, juv.)**

No male *Gaius* were found at Yakabindie to allow for accurate species identification. Based on the distribution of known morphospecies within the genus, the females and juveniles from Yakabindie (Appendix 1) are not considered SREs.

3.2.6 Family Nemesiidae (Wishbone Spiders

3.2.6.1 Genus *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 Pilbara survey (Durrant *et al.* 2010) resulted in a similar number as found during the Carnarvon Basin survey (13 species) (Main *et al.* 2000). Many *Aname* species appear to have restricted distributions as shown by a review of species from northern Australia (Raven 1985b).

***Aname* 'MYG173'**

Aname 'MYG173' is a species with remarkable colour variation for the genus, but conservative genital morphology. The species has previously been found at Lake Way and Lake Maitland and is therefore not considered an SRE.

***Aname* 'MYG177'**

Aname 'MYG177' belongs to the *Aname* 'MYG001'-group which is characterised by an overall light colouration and dark-reddish cephalic area in males. *Aname* 'MYG177' was the most commonly collected spider of the Yakabindie survey (Appendix 1). The species has previously been found at Lake Way and is therefore not considered an SRE.

***Aname* 'MYG235'**

Aname 'MYG235' belongs to a distinct group of small *Aname* with a group of stout setae on the retrolateral side of the male tibia. A generic review of the genus *Aname* may show these to represent a different, undescribed genus. Currently, three other species are known in this group, all from very restricted ranges, *Aname* 'MYG098' (Hamersley region), *Aname* 'MYG170' (Yeelirrie) and *Aname* 'MYG209' (Port Hedland). *Aname* 'MYG235' distinctly differs from all these species by unusually short setae and spines on body and legs and details in genital morphology.

Taking the limited ranges of all species of this group into account, *Aname* 'MYG235' is considered a likely SRE.

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

It is not possible to identify the six very small juveniles from the survey (Appendix 1) to species level, but they most likely belong to one of the species listed above.

3.2.6.2 Genus *Kwonkan*

The genus *Kwonkan* is restricted to Western Australia and currently includes six named species (Main 1977; Main 1983). 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) (Western Australian Government 2010). *Kwonkan* includes those nemesiid spiders that have spines on their pedal tarsi.

***Kwonkan* 'MYG175'**

Kwonkan 'MYG175' has initially been considered a potential SRE (Framenau & Harvey 2010), but has since been found widespread in central WA (WA Museum database). It is not an SRE.

The juveniles of *Kwonkan* found during the survey at Yakabindie (Appendix 1) may also belong to this species.

3.2.6.3 Genus *Yilgarnia*

The genus *Yilgarnia* is currently known from two described species in Western Australia (Main 2008), but many more undescribed species are known from collections. Generic boundaries between *Yilgarnia* and *Kwonkan* remain uncertain as some species have the characteristics of both genera, i.e. cuspules on the coxae of the third and fourth leg (*Yilgarnia*) and tarsal spines (*Kwonkan*). This intermittent group was listed as "*Kwonkan/Yilgarnia*" in the WAM/DEC Carnarvon survey, where three species were recovered at a variety of sites (Main *et al.* 2000).

***Yilgarnia* sp. indet. (juv.)**

It is impossible to identify the *Yilgarnia* specimens from this survey as they are immature (Appendix 1). The genus has not been collected in the area around Yakabindie despite intensive surveys at Lake Way and Lake Maitland. Therefore, the specimens are here considered a potential SRE.

3.2.7 Family Theraphosidae (Tarantulas)

The Theraphosidae share with the Barychelidae the presence of claw-tufts, but differ in their much longer spinnerets, the presence of a distinct lobe on the anterior maxillae and generally much larger size (Raven 1985c). They belong to the largest spiders of Australia and are frequently collected to be sold in the pet trade (Raven 2005).

Currently, four genera of Theraphosidae are described from throughout Australia (except Tasmania), *Coremiocnemis* (one species), *Selenocosmia* (four species), *Selenotholus* (one species) and *Selenotypus* (one species) (Platnick 2011), although all Australian *Selenocosmia* appear to be misplaced in this genus (R. J. Raven personal communication, email 12 March 2009). A further genus, *Phlogiellus*, is also believed to occur here, but no species has been formerly described (Raven 2005). Whilst a family revision has not been published recently, the taxonomy is fairly well resolved due to ongoing research by R. J. Raven (Queensland Museum).

3.2.7.1 Genus *Selenotholus*

Selenotholus differs from all other Australian genera of Theraphosidae by the equal length of the first and fourth leg; the first leg is longer than the fourth in *Phlogiellus* and *Coremiocnemis*. The genus can be found throughout the tropical and arid zones of the country.

***Selenotholus foelschei* Hogg, 1902**

Selenotholus foelschei is currently the only described species of *Selenotholus* and is common throughout northern and central WA. It was originally described from the Northern Territory. It is not an SRE.

4 References

Colloff, M. J., Hastings, A. M., Spier, F. & Devonshire, J. 2005. *Centipedes of Australia*. CSIRO Entomology and Australian Biological Resources Study, Canberra. Available at: http://www.ento.csiro.au/biology/centipedes/centipedeKey.html (accessed 23 March 2011).

Durrant, B. J., Harvey, M. S., Framenau, V. W., Ott, R. & Waldock, J. M. 2010. Patterns in the composition of ground-dwelling spider communities in the Pilbara bioregion, Western Australia. *Records of the Western Australian Museum, Supplement* **78**: 185–204.

Ecologia. 2009. Genetic study of the Curtain-web spider Cethegus sp. from the C. fugas [sic] complex.

EPA. 2002. *Position statement no. 3. Terrestrial biological surveys as an element of biodiversity protection*. Environmental Protection Authority, Perth, WA.

EPA. 2009. *Guidance for the assessment of environmental factors (in accordance with the Environmental Protection Act 1986). Sampling of short range invertebrate fauna for environmental impact assessment in Western Australia. No. 20*. Environmental Protection Authority, Perth, WA.

Faulder, R. J. 1995a. *Systematics and biogeography of the spider genus Missulena Walckenaer*. M.Sc. thesis. Department of Crop Sciences, Faculty of Agriculture, University of Sydney, Sydney, NSW.

Faulder, R. J. 1995b. Two new species of the Australian spider genus *Missulena* Walckenaer (Aranenae: Actinopodidae). *Records of the Western Australian Museum, Supplement* **52**: 73–78.

Framenau, V. W. & Harvey, M. S. 2010. *The Short-Range Endemic Invertebrate Fauna of Lake Way and Lake Maitland, Western Australia (2007 & 2010)*. Western Australian Museum, Welshpool, WA. Unpublished report prepared for *Outback Ecology*.

Framenau, V. W., Moir, M. L. & Harvey, M. S. 2008. *Terrestrial invertebrates of the South Coast NRM Region of Western Australia: short-range endemics in Gondwanan relictual habitats*. Western Australian Museum, Welshpool, WA. Unpublished report prepared for South Coast NRM.

Guthrie, N. A., Weir, T. & Will, K. 2010. Localised and regional patterns in ground-dwelling beetle assemblages in a semi-tropical arid zone environment. *Records of the Western Australian Museum, Supplement* **78**: 169–184.

Harvey, M. S. 2002. Short-range endemism among the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* **16**: 555–570.

Harvey, M. S., Berry, O., Edward, K. L. & Humphreys, G. 2008. Molecular and morphological systematics of hypogean schizomids (Schizomida: Hubbardiidae) in semiarid Australia. *Invertebrate Systematics* **22**: 167–194.

Harvey, M. S., Rix, M. G., Framenau, V. W., Hamilton, Z. R., Johnson, M. S., Teale, R. J., Humpherys, G. & Humphreys, W. F. 2011. Protecting the innocent: studying short-range endemic taxa enhances conservation outcomes. *Invertebate Sytematics* **25**: 1–10.

Koch, L. E. 1982. Taxonomy of the centipede *Scolopendra laeta* Haase (Chilopoda: Scolopendridae) in Australia. *Zoological Journal of the Linnean Society* **76**: 125–140.

Koch, L. E. 1983a. Morphological characters of Australian scolopendrid centipedes, and the taxonomy and distribution of *Scolopendra morsitans* L. (Chilopoda: Scolopendridae: Scolopendrinae). *Australian Journal of Zoology* **31**: 79–91.

Koch, L. E. 1983b. Revision of the Australian centipedes of the genus *Cormocephalus* Newport (Chilopoda: Scolopendridae: Scolopendrinae). *Australian Journal of Zoology* **31**: 799–833.

Koch, L. E. 1983c. A taxonomic study of the centipede genus *Ethmostigmus* Pocock (Chilopoda: Scolopendridae: Otostigminae) in Australia. *Australian Journal of Zoology* **31**: 835–849.

Main, B. Y. 1956. Observations on the burrow and natural history of the trapdoor spider *Missulena* (Ctenizidae). *The Western Australian Naturalist* **5**: 73–80.

Main, B. Y. 1957a. Biology of aganippine trapdoor spiders (Mygalomorphae: Ctenizidae). *Australian Journal of Zoology* **5**: 402–473.

Main, B. Y. 1957b. Occurrence of the trap-door spider *Conothele malayana* (Doleschall) in Australia (Mygalomorphae: Ctenizidae). *Western Australian Naturalist* **5**: 209–216.

Main, B. Y. 1960. The genus *Cethegus* Thorell (Mygalomorphae: Macrothelinae). *Journal of the Royal Society of Western Australia* **43**: 30–34.

Main, B. Y. 1976. Spiders *The Australian Naturalist Library*. William Collins, Sydney, pp. 296.

Main, B. Y. 1977. Spiders *The natural history of the Wongan Hills. Handbook No.11.* West Australian Naturalist Club, Perth, pp. 100–107.

Main, B. Y. 1978. Biology of the arid-adapted Australian trapdoor spider *Anidiops villosus* (Rainbow). *Bulletin of the British Arachnological Society* **4**: 161–175.

Main, B. Y. 1983. Further studies on the systematics of Australian Diplurinae (Chelicerata: Mygalomorphae: Dipluridae): two new genera from southwestern Australia. *Journal of Natural History* **17**: 923–949.

Main, B. Y. 1985. Further studies on the systematics of ctenizid trapdoor spiders: a review of the Australian genera (Araneae: Mygalomorphae: Ctenizidae). *Australian Journal of Zoology, Supplement Series* **108**: 1–84.

Main, B. Y. 1995. Survival of trapdoor spiders during and after fire. *CALMScience Supplement* **4**: 407–216.

Main, B. Y. 2008. A new species of the mygalomorph spider genus *Yilgarnia* from the Western Australian wheatbelt (Araneae: Nemesiidae). *Records of the Western Australian Museum* **24**: 321–324.

Main, B. Y., Sampey, A. & West, P. L. J. 2000. Mygalomorph spiders of the southern Carnarvon basin, Western Australia. *Records of the Western Australian Museum, Supplement* **61**: 281–293.

Platnick, N. I. 2002. A revision of the Australasian ground spiders of the families Ammoxenidae, Cithaeronidae, Gallieniellidae, and Trochanteriidae (Araneae: Gnaphosoidea). *Bulletin of the American Museum of Natural History* **271**: 1–243.

Platnick, N. I. 2011. *The world spider catalog, version 12.0*. American Museum of Natural History, New York. Available at: http://research.amnh.org/iz/spiders/catalog/INTRO2.html (accessed 1 August 2011).

Ponder, W. F. & Colgan, D. J. 2002. What makes a narrow-range taxon? Insights from Australian freshwater snails. *Invertebrate Systematics* **16**: 571–582.

Raven, R. J. 1981. A review of the Australian genera of the mygalomorph spider subfamily Diplurinae (Dipluridae: Chelicerata). *Australian Journal of Zoology* **29**: 321–363.

Raven, R. J. 1984. Systematics of the Australian curtain-web spiders (Ischnothelinae: Dipluridae: Chelicerata). *Australian Journal of Zoology, Supplement Series* **93**: 1–102.

Raven, R. J. 1985a. A new and interesting species of *Cethegus* (Ischnothelinae: Dipluridae) from South Australia. *Records of the South Australian Museum* **19**: 15–17.

Raven, R. J. 1985b. A revision of the *Aname pallida* species-group in northern Australia (Anaminae: Nemesiidae: Araneae). *Australian Journal of Zoology* **33**: 377–409.

Raven, R. J. 1985c. The spider infraorder Mygalomorphae (Araneae): cladistics and systematics. *Bulletin of the American Museum of Natural History* **182**: 1–180.

Raven, R. J. 1994. Mygalomorph spiders of the Barychelidae in Australia and the western Pacific. *Memoirs of the Queensland Museum* **35**: 291–706.

Raven, R. J. 2005. A new tarantula species from northern Australia (Araneae, Theraphosidae). *Zootaxa* **1004**: 15–28.

Raven, R. J. & Wishart, G. 2005. The trapdoor spider *Arbanitis* L. Koch (Idiopidae: Mygalomorphae) in Australia. *Memoirs of the Queensland Museum* **51**: 531–557.

Schmidt, T. 2007. *Geographic and spatial structuring of genetic variation in trapdoor spiders (Idiopidae) of the Western Australian Goldfields*. B.Sc. (Honours) thesis. School of Animal Biology, Universtity of Western Australia, Nedlands, WA.

Western Australian Government. 2010. *Wildlife Conservation Act 1950, Wildlife Conservation (Specially Protected Fauna) Notice 2010(2)*. Pp. 4031–4039. Western Australian Government Gazette.

Wojcieszek, J. M., Harvey, M. S. & Rix, M. G. 2011. Optimised captive husbandry conditions for the Western Australian 'Marri Millipede' *Antichiropus variabilis* (Diplopoda: Polydesmida: Paradoxosomatidae), with notes on natural history and tissue preservation techniques. *Records of the Western Australian Museum* **26**: 87–93.

APPENDIX 1 IDENTIFICATION OF SPIDERS (ARANEAE) FROM YAKABINDIE

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
Araneomorphae									
112436	Site 22-503	Gallieniellidae	*Meedo yarragin*	27°26'49.2"S	120°34'24.3"E		1		
112433	Site 26-742	Gallieniellidae	*Meedo yarragin*	27°19'28"S	120°40'18.1"E		1		
112392	Site 10-472	Zodariidae	Zodariidae sp. indet.	27°25'0.7"S	120°35'35.4"E	1			
Mygalomorphae									
114045	Site 17-695	Actinopodidae	*Missulena* sp. indet.	27°28'34.3"S	120°35'53.7"E			1	
114044	Site 16-644	Barychelidae	*Mandjelia* 'MYG035'	27°28'9.5"S	120°34'51.1"E	1			
112394	Site 1-666	Barychelidae	*Mandjelia* 'MYG035'	27°25'36.3"S	120°34'22.5"E			2	
112428	Site 19-766	Barychelidae	*Mandjelia* 'MYG035'	27°24'44.4"S	120°35'18.7"E			1	
112389	Site 20-096	Barychelidae	*Mandjelia* 'MYG035'	27°27'24.7"S	120°35'28"E		1		
112434	Site 21-307	Barychelidae	*Mandjelia* 'MYG035'	27°27'47.3"S	120°35'38.5"E			1	
112358	Site 21-630	Barychelidae	*Mandjelia* 'MYG035'	27°27'47.3"S	120°35'38.5"E	1			
112431	Site 25-361	Barychelidae	*Mandjelia* 'MYG035'	27°17'46.2"S	120°41'5.7"E				
112362	Site 3-017	Barychelidae	*Mandjelia* 'MYG035'	27°25'18.8"S	120°34'37.2"E		1		
112437	Site 3-450	Barychelidae	*Mandjelia* 'MYG035'	27°25'18.8"S	120°34'37.2"E			1	
112374	Site 3-523	Barychelidae	*Mandjelia* 'MYG035'	27°25'18.8"S	120°34'37.2"E	1			
112414	Site 5-046	Barychelidae	*Mandjelia* 'MYG035'	27°26'37.6"S	120°35'22.3"E			1	
112468	Site 12-062	Barychelidae	*Synothele meadhunteri*	27°25'53.2"S	120°35'53.6"E			1	
112441	Site 18-382	Barychelidae	*Synothele meadhunteri*	27°28'50.1"S	120°37'14.8"E			1	
112469	Site 21-634	Barychelidae	*Synothele meadhunteri*	27°27'47.3"S	120°35'38.5"E	1			

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
112378	Site 12-065	Ctenizidae	*Conothele* sp. indet.	27°25'53.2"S	120°35'53.6"E		1		with eggsac
114041	Site 12-067	Ctenizidae	*Conothele* sp. indet.	27°25'53.2"S	120°35'53.6"E			1	
112361	Site 15-074	Ctenizidae	*Conothele* sp. indet.	27°25'29.8"S	120°36'26.1"E		1		
112453	Site 3-019	Ctenizidae	*Conothele* sp. indet.	27°25'18.8"S	120°34'37.2"E		1		
112446	Target 18-170	Dipluridae	*Cethegus* sp. indet.	27°25'52.2"S	120°40'16.3"E		1		
112407	Target 4-147	Dipluridae	*Cethegus* sp. indet.	26°58'25.3"S	120°37'30.5"E			1	
112409	Target 6-148	Dipluridae	*Cethegus* sp. indet.	26°58'49.8"S	120°40'59.8"E			1	
112463	Target 6-149	Dipluridae	*Cethegus* sp. indet.	26°58'49.8"S	120°40'59.8"E		1		
112464	Site 1-014	Idiopidae	*Aganippe* sp. indet.	27°25'36.3"S	120°34'22.5"E		1		
112366	Site 12-188	Idiopidae	*Aganippe* sp. indet.	27°25'53.2"S	120°35'53.6"E		1		not in original list
112399	Site 17-080	Idiopidae	*Aganippe* sp. indet.	27°28'34.3"S	120°35'53.7"E		1		
112427	Site 17-081	Idiopidae	*Aganippe* sp. indet.	27°28'34.3"S	120°35'53.7"E		1	6	
114038	Site 19-090	Idiopidae	*Aganippe* sp. indet.	27°24'44.4"S	120°35'18.7"E		1	21	
112376	Site 21-136	Idiopidae	*Aganippe* sp. indet.	27°27'47.3"S	120°36'38.5"E		1		not in original list
112360	Site 3-020	Idiopidae	*Aganippe* sp. indet.	27°25'18.8"S	120°34'37.2"E		1		
112451	Site 7-048	Idiopidae	*Aganippe* sp. indet.	27°27'15.1"S	120°36'20.3"E			1	
112382	Target 1-142	Idiopidae	*Aganippe* sp. indet.	26°59'58.9"S	120°33'46"E		1		
112379	Site 25-111	Idiopidae	*Anidiops* sp. indet.	27°17'46.2"S	120°41'5.7"E		1		
112462	Site 30-133	Idiopidae	*Anidiops* sp. indet.	27°26'25.3"S	120°41'25.9"E		1		
112365	Target 2-145	Idiopidae	*Anidiops* sp. indet.	26°57'22.7"S	120°31'41.9"E		1		
112402	Site 14-070	Idiopidae	*Gaius* sp. indet.	27°26'15.6"S	120°36'35.4"E		1		
112459	Site 18-083	Idiopidae	*Gaius* sp. indet.	27°28'50.1"S	120°37'14.8"E		1		

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
112375	Site 20-099	Idiopidae	*Gaius* sp. indet.	27°27'24.7"S	120°35'28"E			1	
112421	Site 24-103	Idiopidae	*Gaius* sp. indet.	27°17'57.8"S	120°36'6.3"E		1		
114042	Site 25-110	Idiopidae	*Gaius* sp. indet.	27°17'46.2"S	120°41'5.7"E		1	13	
112370	Target 8-150	Idiopidae	*Gaius* sp. indet.	26°59'36.1"S	120°37'9.4"E		1		
112412	Site 12-063	Idiopidae	*Idiopidae* sp. indet.	27°25'53.2"S	120°35'53.6"E			1	
112425	Site 17-079	Idiopidae	*Idiopidae* sp. indet.	27°28'34.3"S	120°35'53.7"E			1	
112385	Site 17-771	Idiopidae	*Idiopidae* sp. indet.	27°28'34.3"S	120°35'53.7"E			1	
112449	Site 19-092	Idiopidae	*Idiopidae* sp. indet.	27°24'44.4"S	120°35'18.7"E			2	
112367	Site 2-002	Idiopidae	*Idiopidae* sp. indet.	27°25'27.5"S	120°34'53.3"E			1	
112422	Site 28-121	Idiopidae	*Idiopidae* sp. indet.	27°21'40.8"S	120°40'59"E			1	
112373	Site 28-127	Idiopidae	*Idiopidae* sp. indet.	27°21'40.8"S	120°40'59"E			1	
112415	Site 30-132	Idiopidae	*Idiopidae* sp. indet.	27°26'25.3"S	120°41'25.9"E			1	
112448	Site 8-051	Idiopidae	*Idiopidae* sp. indet.	27°26'59.2"S	120°36'16"E			1	
114043	Target 9-156	Idiopidae	*Idiopidae* sp. indet.	27°17'20.24"S	120°34'28.35"E			1	
112458	Site 14-398	Nemesiidae	*Aname* 'MYG173'	27°26'15.6"S	120°36'35.4"E	1			
112384	Site 14-442	Nemesiidae	*Aname* 'MYG173'	27°26'15.6"S	120°36'35.4"E	1			
112450	Site 10-059	Nemesiidae	*Aname* 'MYG177'	27°25'0.7"S	120°35'35.4"E		1		
112447	Site 10-060	Nemesiidae	*Aname* 'MYG177'	27°25'0.7"S	120°35'35.4"E		1		
112454	Site 10-061	Nemesiidae	*Aname* 'MYG177'	27°25'0.7"S	120°35'35.4"E		1		
112395	Site 10-472	Nemesiidae	*Aname* 'MYG177'	27°25'0.7"S	120°35'35.4"E	1			
114039	Site 14-071	Nemesiidae	*Aname* 'MYG177'	27°26'15.6"S	120°36'35.4"E		1		
112403	Site 15-075	Nemesiidae	*Aname* 'MYG177'	27°25'29.8"S	120°36'26.1"E		1		
112455	Site 18-084	Nemesiidae	*Aname* 'MYG177'	27°28'50.1"S	120°37'14.8"E		1		

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
112457	Site 18-085	Nemesiidae	*Aname* 'MYG177'	27°28'50.1"S	120°37'14.8"E		1		
112398	Site 18-511	Nemesiidae	*Aname* 'MYG177'	27°28'50.1"S	120°37'14.8"E	1			
112456	Site 19-088	Nemesiidae	*Aname* 'MYG177'	27°24'44.4"S	120°35'18.7"E		1		
112359	Site 19-093	Nemesiidae	*Aname* 'MYG177'	27°24'44.4"S	120°35'18.7"E		1		
114040	Site 22-676	Nemesiidae	*Aname* 'MYG177'	27°26'49.2"S	120°34'24.3"E	1			
112380	Site 23-102	Nemesiidae	*Aname* 'MYG177'	27°19'19.8"S	120°38'4.7"E	1			
112424	Site 25-112	Nemesiidae	*Aname* 'MYG177'	27°17'46.2"S	120°41'5.7"E		1		
112411	Site 26-115	Nemesiidae	*Aname* 'MYG177'	27°19'28"S	120°40'18.1"E		1		
112442	Site 27-116	Nemesiidae	*Aname* 'MYG177'	27°28'30.1"S	120°41'24.8"E		1		
112408	Site 27-119	Nemesiidae	*Aname* 'MYG177'	27°28'30.1"S	120°41'24.8"E		1		
112405	Site 28-122	Nemesiidae	*Aname* 'MYG177'	27°21'40.8"S	120°40'59"E		1		
112364	Site 28-123	Nemesiidae	*Aname* 'MYG177'	27°21'40.8"S	120°40'59"E		1		
112418	Site 28-124	Nemesiidae	*Aname* 'MYG177'	27°21'40.8"S	120°40'59"E		1		
112420	Site 29-128	Nemesiidae	*Aname* 'MYG177'	27°21'3.4"S	120°37'57.9"E		1		
112444	Site 29-129	Nemesiidae	*Aname* 'MYG177'	27°21'3.4"S	120°37'57.9"E		1		
112465	Site 29-130	Nemesiidae	*Aname* 'MYG177'	27°21'3.4"S	120°37'57.9"E	1			
112443	Site 29-131	Nemesiidae	*Aname* 'MYG177'	27°21'3.4"S	120°37'57.9"E		1		
112413	Site 30-134	Nemesiidae	*Aname* 'MYG177'	27°26'25.3"S	120°41'25.9"E	1			
112416	Site 30-135	Nemesiidae	*Aname* 'MYG177'	27°26'25.3"S	120°41'25.9"E		1		
112381	Site 4-033	Nemesiidae	*Aname* 'MYG177'	27°25'45.2"S	120°34'18.3"E	1			
112446	Site 4-034	Nemesiidae	*Aname* 'MYG177'	27°25'45.2"S	120°34'18.3"E		1		
112452	Site 7-049	Nemesiidae	*Aname* 'MYG177'	27°27'15.1"S	120°36'20.3"E		1		
112404	Site 7-050	Nemesiidae	*Aname* 'MYG177'	27°27'15.1"S	120°36'20.3"E		1		

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
112363	Site 9-056	Nemesiidae	*Aname* 'MYG177'	27°26'35.7"S	120°36'2.7"E	1			
112410	Target 1-139	Nemesiidae	*Aname* 'MYG177'	26°59'58.9"S	120°33'46"E		1		
112417	Target 1-140	Nemesiidae	*Aname* 'MYG177'	26°59'58.9"S	120°33'46"E		1		
112419	Target 1-141	Nemesiidae	*Aname* 'MYG177'	26°59'58.9"S	120°33'46"E		1		
112393	Target 12-157	Nemesiidae	*Aname* 'MYG177'	27°20'27.1"S	120°35'22.6"E		1		
112387	Target 12-158	Nemesiidae	*Aname* 'MYG177'	27°20'27.1"S	120°35'22.6"E		1		
112432	Target 12-159	Nemesiidae	*Aname* 'MYG177'	27°20'27.1"S	120°35'22.6"E		1		not in original list
112423	Target 2-143	Nemesiidae	*Aname* 'MYG177'	26°57'22.7"S	120°31'41.9"E		1		
112440	Target 2-144	Nemesiidae	*Aname* 'MYG177'	26°57'22.7"S	120°31'41.9"E		1		
112406	Target 4-146	Nemesiidae	*Aname* 'MYG177'	26°58'25.3"S	120°37'30.5"E		1		
112391	Target 9-152	Nemesiidae	*Aname* 'MYG177'	27°17'20.24"S	120°34'28.35"E		1		
112386	Target 9-153	Nemesiidae	*Aname* 'MYG177'	27°17'20.24"S	120°34'28.35"E		1		
112388	Target 9-154	Nemesiidae	*Aname* 'MYG177'	27°17'20.24"S	120°34'28.35"E		1		
112390	Target 9-155	Nemesiidae	*Aname* 'MYG177'	27°17'20.24"S	120°34'28.35"E		1		
112397	Site 16-776	Nemesiidae	*Aname* 'MYG235'	27°28'9.5"S	120°34'51.1"E	1			
112401	Site 15-073	Nemesiidae	*Aname* sp. indet.	27°25'29.8"S	120°36'26.1"E			1	
112430	Site 1-513	Nemesiidae	*Aname* sp. indet.	27°25'36.3"S	120°34'22.5"E			1	
112369	Site 15-192	Nemesiidae	*Aname* sp. indet.	27°25'29.8"S	120°36'26.1"E			1	
112396	Site 19-803	Nemesiidae	*Aname* sp. indet.	27°24'44.4"S	120°35'18.7"E			1	
112429	Site 2-568	Nemesiidae	*Aname* sp. indet.	27°25'27.5"S	120°34'53.3"E			1	
112371	Site 30-589	Nemesiidae	*Aname* sp. indet.	27°26'25.3"S	120°41'25.9"E			1	

WAM registration (T-number)	Field number	Family	Genus and species	Latitude	Longitude	♂♂	♀♀	juv.	Remarks
112426	Site 24-359	Nemesiidae	*Kwonkan* 'MYG175'	27°17'57.8"S	120°36'6.3"E	1			
112377	Site 24-453	Nemesiidae	*Kwonkan* 'MYG175'	27°17'57.8"S	120°36'6.3"E	1			
112439	Site 18-382	Nemesiidae	*Kwonkan* sp. indet.	27°28'50.1"S	120°37'14.8"E			1	
112438	Site 26-742	Nemesiidae	*Kwonkan* sp. indet.	27°19'28"S	120°40'18.1"E			1	
112368	Site 5-587	Nemesiidae	*Kwonkan* sp. indet.	27°26'37.6"S	120°35'22.3"E			1	
112435	Site 6-452	Nemesiidae	*Kwonkan* sp. indet.	27°26'56.2"S	120°35'12.8"E	1			
112400	Site 13-066	Nemesiidae	*Yilgarnia* sp. indet.	27°26'0"S	120°35'23.8"E			1	
112470	Site 1-666	Nemesiidae	*Yilgarnia* sp. indet.	27°25'36.3"S	120°34'22.5"E			1	
112445	Target 20-171	Nemesiidae	*Yilgarnia* sp. indet.	27°17'27"S	120°41'11"E			1	
112467	Site 27-117	Theraphosidae	*Selenotholus foelschei*	27°28'30.1"S	120°41'24.8"E			1	
112372	Site 3-018	Theraphosidae	*Selenotholus foelschei*	27°25'18.8"S	120°34'37.2"E			1	
112383	Site 4-045	Theraphosidae	*Selenotholus foelschei*	27°25'45.2"S	120°34'18.3"E			1	

Appendix C Phylogenetic Tree For All Specimens Of Idiopidae

Helix
Molecular
Solutions

School of Animal Biology The University of Western Australia
Hackett Entrance No. 4 Hackett Drive Crawley WA 6009

PO Box 155
Leederville WA 6903

t: (08) 6488 4509 | f: (08) 6488 1029 | abn: 32 133 230 243 | w: www.helixsolutions.com.au

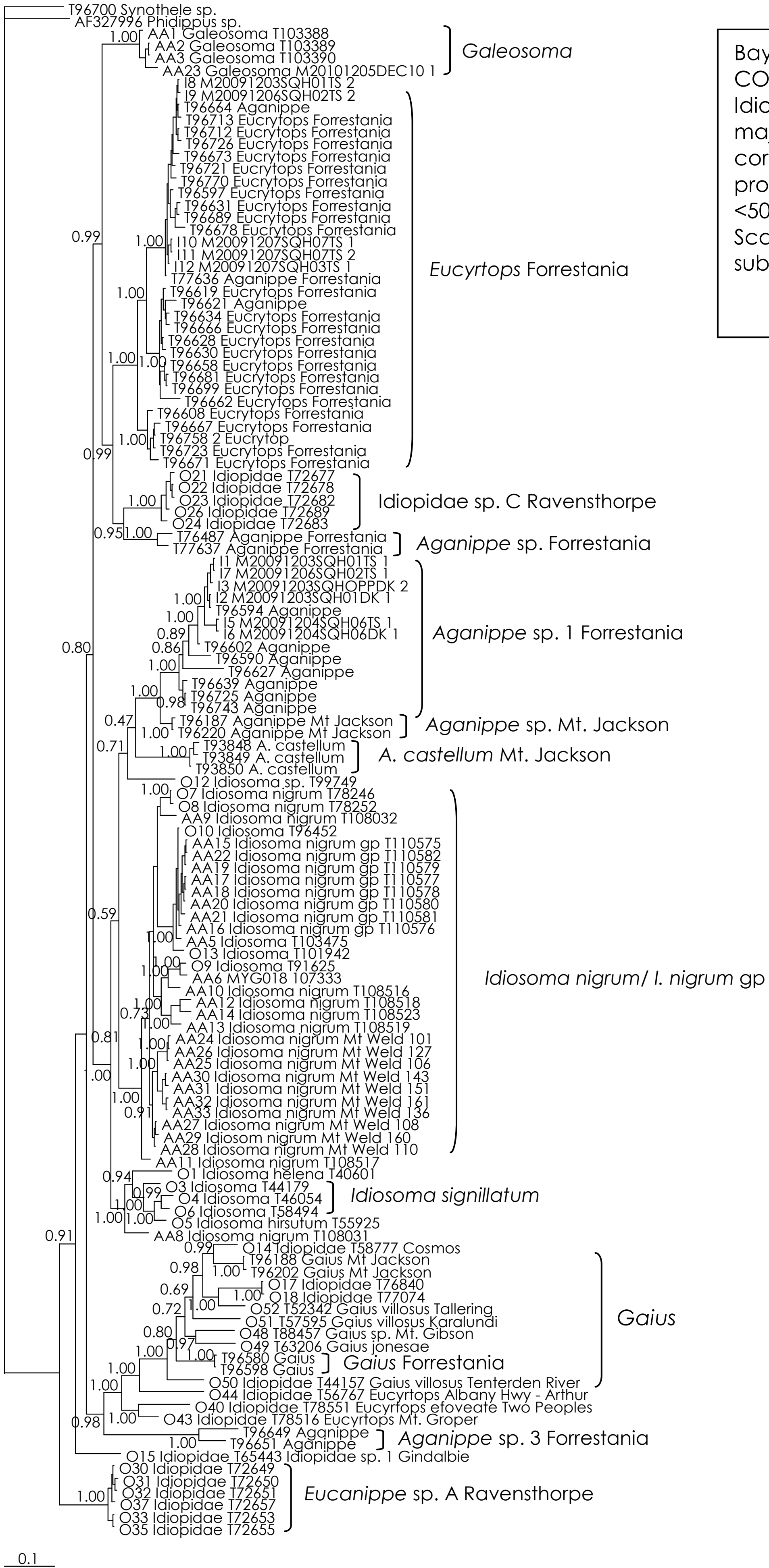
11 April 2011

Re. Phylogenetic tree for all specimens of Idiopidae

Dear Roy and Mark,

Following is the tree generated in MrBayes for all specimens of Idiopidae sequenced to date. The analysis places the specimens of *Idiosoma nigrum* and *I. nigrum* gp. into a single well-supported clade that is characterised by short branch lengths. The *I. nigrum* clade forms a poorly-supported clade with several species of *Aganippe*, to the exclusion of the remaining species of *Idiosoma*. Two genera (*Aganippe*, *Eucyrtops*) appear to be polyphyletic. These features, which contradict the morphology, suggest that the resolution is poor. This is likely attributed to the fact that the number of base-pairs used in the analysis is small compared to the number of haplotypes, and while posterior probabilities are generally high for most major nodes, a more robust resolution of the phylogenetic relationships would likely be attained by including additional genes in the analysis.

Cheers,
Terrie



Bayesian analysis of COI haplotypes of Idiopidae. Numbers on major nodes correspond to posterior probabilities; values <50% are not shown. Scale bar= number of substitutions per site.

Appendix D Yakabindie Scorpion Identification Report

ScorpionID

4 / 76 Royal St, Tuart Hill, WA, 6060 | Ph: 0457 11 13 17 | email: evolschen@gmail.com

Yakabindie Scorpion Identification Report

Report ID: OE-YA-201107
Prepared for: Outback Ecology
By Dr Erich S. Volschenk
Monday, 5 September 2011

Outback Ecology is undertaking a short-range endemic survey at Yakabindie, and has requested:
- Taxonomic identifications of scorpion from the survey;
- SRE assessment of the species represented in the collection, and;
- Lodgement of these specimens in the Western Australian Museum Arachnology Collection

The collection is comprised of 195 samples.

One species present is flagged as a potential SRE: *Urodacus* cf 'gibson 5'

FAMILY: Buthidae

The family Buthidae is the most diverse and wide spread of all scorpion families (Fet & Lowe 2000). In Australia, Buthidae is represented by the genera *Australobuthus* Locket; *Isometrus* Ehrenberg; *Isometroides* Keyserling , *Lychas* C.L. Koch, and *Hemilychas* Hirst. In Western Australia, only the *Isometrus*, *Isometroides* and *Lychas*, have been recorded. The taxonomy of the constituent species of *Isometrus*, *Isometroides* and *Lychas* is very problematic and each genus contains numerous undescribed species, most notably in the genus *Lychas* (Volschenk unpublished data). Most Authors refer to LE Koch (1977) for keys and identification. That revision represents an important study of the Australian scorpions; however, several taxonomic decisions made by LE Koch (1977) have been rejected by subsequent authors and the taxonomy in that publication is not up to date. Most Australian buthid species appear to have wide distributions; however, a few taxa have confirmed SRE distributions (Volschenk unpublished data).

GENUS: *Isometroides*

The taxonomy of the species in this genus is extremely poorly known. Only two species are presently recognised; however, many undescribed species are known. *Isometroides* scorpions are ground dwelling scorpions and are the only scorpion species known to be a predatory specialist. Main (Main) described the association of this species with burrowing spiders and numerous records have followed of this species preying on, and being found in trapdoor spider (Mygalorphae and Lycosidae) burrows (Volschenk Pers. Obs.). Species in this genus never appear to be abundant in pitfall trapping samples; the ground disturbance near the entrance top of the pitfall trap may deter them. While their taxonomy is poorly resolved, most morphospecies appear to have fairly wide distributions; however this may change with further work on their systematics.

Species: *Isometroides* sp. indet.

SRE STATUS
Isometroides sp. indet. is unlikely to be an SRE.

TAXONOMIC RESOLUTION
Isometroides sp. indet. specimen/s could not be identified owing to incorrect sex and/or life history stage.

DISTRIBUTION
Isometroides sp. indet. cannot be defined as this is not a clear species. See comments for the genus.

RECOMENDATIONS
Isometroides sp. indet. management is impossible since it is not clear which species this is.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105808	Site 7-354			1		Volschenk E.S.
T105823	Site 19-086		1			Volschenk E.S.

Number of samples: 2

==

GENUS: *Lychas*

The genus *Lychas* is widespread across the Australian mainland. The taxonomy of this genus is problematic, with numerous undescribed species known in Australia (Volschenk *et al.* 2010). The situation is further complicated with the genus being also represented in Africa, India and eastern Asia (Fet & Lowe 2000). All of the Australian species are endemic and are currently under revision by ES Volschenk. Most species of *Lychas* appear to have wide distributions; however, a small number of species are known to be SRE's.

Species: *Lychas* 'adonis'

SRE STATUS
Lychas 'adonis' is not an SRE.

TAXONOMIC RESOLUTION
Lychas 'adonis' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Lychas 'adonis' has wide distribution across arid Australia. Its distribution is Eyrean, where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. This species has been recorded from Victoria, South Australia and Western Australia. This species appears to prefer sandy spinifex dominated habitats.

RECOMENDATIONS
Lychas 'adonis' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T114062	Site 14-489			1		Volschenk E.S.
T105658	Site 24-454	1		2		Volschenk E.S.
T114064	Site 27-344	1		1		Volschenk E.S.
T105795	Site 14-401	2		1		Volschenk E.S.
T114099	Site 28-285			1		Volschenk E.S.
T114063	Site 28-792			1		Volschenk E.S.
T114065	Site 26-231	1				Volschenk E.S.
T114059	Site 15-214	1				Volschenk E.S.
T105657	Site 24-505			1		Volschenk E.S.
T114061	Site 24-347			1		Volschenk E.S.

Number of samples: 10

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Species: *Lychas* annulatus

SRE STATUS
Lychas annulatus is not an SRE.

TAXONOMIC RESOLUTION
Lychas annulatus is highly variable and is likely to represent a species complex.

DISTRIBUTION
Lychas annulatus has wide distribution across arid Australia. Its distribution is Eyrean, where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. This species has been recorded from Victoria, South Australia and Western Australia. This species appears to prefer sandy spinifex dominated habitats.

RECOMENDATIONS
Lychas annulatus is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105678	Site 9-682			1		Volschenk E.S.
T105676	Site 7-662			1		Volschenk E.S.
T105677	Site 16-658			2		Volschenk E.S.
T105675	Site 30-689			2		Volschenk E.S.
T105674	Site 16-778		1			Volschenk E.S.
T105673	Site 5-702			1		Volschenk E.S.

Number of samples: 6

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Species: *Lychas jonesae*

SRE STATUS

Lychas jonesae is not an SRE.

TAXONOMIC RESOLUTION

Lychas jonesae is a well-defined and clearly recognised species.

DISTRIBUTION

Lychas jonesae has a wide distribution across arid Australia. Its distribution is Eyrean, where it inhabits various habitats including sparse Mallee forests on sand to Spinifex covered dunes. This species has been recorded from Victoria, South Australia and Western Australia.

RECOMENDATIONS

Lychas jonesae is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T114080	Site 29-551			1		Volschenk E.S.
T105842	Site 2-569			1		Volschenk E.S.
T105664	Site 3-521		1			Volschenk E.S.
T105707	Site 27-758			2		Volschenk E.S.
T114060	Site 27-697	1				Volschenk E.S.
T114074	Site 5-588	1				Volschenk E.S.
T105840	Site 10-706			1		Volschenk E.S.
T105660	Site 5-768	1	1			Volschenk E.S.
T105717	Site 22-321			1		Volschenk E.S.
T114079	Site 4-653	1				Volschenk E.S.
T114084	Site 7-480			1		Volschenk E.S.
T105723	Site 5-402		1			Volschenk E.S.
T105838	Site 4-211	1				Volschenk E.S.
T114075	Site 23-494			1		Volschenk E.S.
T105725	Site 8-395	1	1	3		Volschenk E.S.
T114088	Site 27-423			1		Volschenk E.S.
T105848	Site 29-440			3		Volschenk E.S.
T105720	Site 28-735			2		Volschenk E.S.
T114077	Site 9-410	1				Volschenk E.S.
T105712	Site 29-304			2		Volschenk E.S.
T105668	Site 28-672		1			Volschenk E.S.
T114078	Site 7-329			1		Volschenk E.S.
T114093	Site 9-421		1	1		Volschenk E.S.
T105714	Site 21-378			2		Volschenk E.S.

T105670	Site 9-781		1	1		Volschenk E.S.
T105845	Site 10-279		1			Volschenk E.S.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105671	Site 8-373			2		Volschenk E.S.
T114085	Site 22-561			1		Volschenk E.S.
T105663	Site 22-501			2		Volschenk E.S.
T105706	Site 3-316			3		Volschenk E.S.
T114092	Site 3-445			2		Volschenk E.S.
T105661	Site 5-783	2				Volschenk E.S.
T105665	Site 21-747			1		Volschenk E.S.
T114058	Site 8-534		1	1		Volschenk E.S.
T105837	Site 21-358	1	1	2		Volschenk E.S.
T105839	Site 28-294	1				Volschenk E.S.
T105718	Site 19-310			1		Volschenk E.S.
T105844	Site 25-223	1				Volschenk E.S.
T105716	Site 11-657			1		Volschenk E.S.
T105715	Site 25-303		1	3		Volschenk E.S.
T105841	Site 11-281			1		Volschenk E.S.
T114089	Site 30-553	1				Volschenk E.S.
T105849	Site 13-694		1			Volschenk E.S.
T114097	Site 7-592			1		Volschenk E.S.
T114071	Site 19-621			1		Volschenk E.S.
T105722	Site 27-397			3		Volschenk E.S.
T105713	Site 11-763			1		Volschenk E.S.
T105667	Site 19-518		1			Volschenk E.S.
T114072	Site 11-715			1		Volschenk E.S.
T114098	Site 19-255			1		Volschenk E.S.
T114094	Site 16-432			1		Volschenk E.S.
T105662	site 8-308		1			Volschenk E.S.
T114100	Site 18-610	1				Volschenk E.S.
T105666	Site 18-509	1				Volschenk E.S.
T105721	Site 18-384			1		Volschenk E.S.
T105711	Site 17-773			1		Volschenk E.S.
T114081	Site 17-418		1	1		Volschenk E.S.
T105708	Site 2-750		1	2		Volschenk E.S.
T105672	Site 19-529	2		1		Volschenk E.S.
T114087	Site 7-354			2		Volschenk E.S.
T114095	Site 12-690			3		Volschenk E.S.
T114076	Site 6-254			1		Volschenk E.S.
T105724	Site 6-434			1		Volschenk E.S.
T105659	Site 7-483			1		Volschenk E.S.
T105709	Site 13-371			2		Volschenk E.S.
T114083	Site 8-390			1		Volschenk E.S.
T114082	Site 13-785		1	1		Volschenk E.S.
T114096	Site 14-408			1		Volschenk E.S.
T114070	Site 6-451			2		Volschenk E.S.
T105669	Site 6-745			1		Volschenk E.S.
T105719	Site 19-799			1		Volschenk E.S.

Number of samples: 71

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Species: *Lychas* 'splendens'

SRE STATUS
Lychas 'splendens' is not an SRE.

TAXONOMIC RESOLUTION
Lychas 'splendens' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Lychas 'splendens' is relatively widespread and is distributed throughout the Wheat Belt and Goldfields of WA.

RECOMENDATIONS
Lychas 'splendens' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105679	site 8-308		1			Volschenk E.S.
T114069	Site 1-016		1			Volschenk E.S.
T114066	Site 12-541		1			Volschenk E.S.
T114067	Site 10-475			1		Volschenk E.S.
T114068	Target 13-161			1		Volschenk E.S.
T105682	Site 19-761	1				Volschenk E.S.
T105710	Site 12-800	1				Volschenk E.S.
T105681	Site 12-700		1			Volschenk E.S.
T105680	Site 3-668		1			Volschenk E.S.
T105683	Site 2-664	1				Volschenk E.S.

Number of samples: 10

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FAMILY: Urodacidae

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini 2003) where it is represented by the genera *Urodacus* Peters, 1861 and *Aops* Volschenk and Prendini, 2008 .

GENUS: *Urodacus*

Urodacus has been considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea Latreille, Prendini (Prendini) placed *Urodacus* in its own family. Unlike the species designations for Buthidae, LE Koch's (Koch) species' of *Urodacus* have been mostly supported by subsequent authors {Volschenk, 2000 #4517; Harvey, 2002 #9333; (Volschenk 2008). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (Volschenk unpublished data). Currently 22 species of *Urodacus* are described; however, this may represent only 15-20% of the real diversity of this genus in Australia. *Urodacus* is most diverse in Western Australia and few species are recorded east of the Great Dividing Range in eastern Australia. *Urodacus* contains both widespread and SRE species.

Species: *Urodacus* 'gibson 1'

SRE STATUS
Urodacus 'gibson 1' is not an SRE.

TAXONOMIC RESOLUTION
Urodacus 'gibson 1' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Urodacus 'gibson 1' is known from several specimens collected from the Western and Eastern Murchison bioregions. While represented by relatively few specimens their distribution spans 300km.

RECOMENDATIONS
Urodacus 'gibson 1' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105744	Site 28-789		1			Volschenk E.S.
T105738	Site 26-739	1				Volschenk E.S.
T105747	Site 26-725	1				Volschenk E.S.
T105743	Site 26-740	1				Volschenk E.S.
T105739	Site 30-688	1				Volschenk E.S.
T105745	Site 26-749	1				Volschenk E.S.
T105749	Site 26-723	1				Volschenk E.S.
T105748	Site 26-722	1				Volschenk E.S.
T105727	Site 26-724	1				Volschenk E.S.
T105746	Site 25-367	1				Volschenk E.S.
T105735	Site 26-721	1				Volschenk E.S.
T105731	Site 12-532	1				Volschenk E.S.
T105726	Site 25-647	1				Volschenk E.S.
T105733	Site 25-324	1				Volschenk E.S.
T105730	Site 25-364	1				Volschenk E.S.
T105740	Site 26-114			1		Volschenk E.S.
T105737	Site 26-247	1				Volschenk E.S.
T105732	Site 29-573	1				Volschenk E.S.
T105728	Site 26-684	1				Volschenk E.S.
T105729	Site 26-720	1				Volschenk E.S.
T105750	Site 9-419	1				Volschenk E.S.
T105741	Site 9-646	1				Volschenk E.S.
T105742	Site 10-058	1				Volschenk E.S.
T105736	Site 26-253	1				Volschenk E.S.

Number of samples: 24

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Species: *Urodacus* cf 'gibson 5'

SRE STATUS
Urodacus cf 'gibson 5' is a potential SRE.

TAXONOMIC RESOLUTION
Urodacus cf 'gibson 5' appears morphologically similar to *U*. 'gibson5' and may represent a range extension of that species; but, may also represent a new species. Additional comparisons between specimens from each population are necessary in order to determine the relationships between these two potential species.

DISTRIBUTION
Urodacus 'gibson 5' is only known from Mount Gibson area, Avon Wheatbelt bioregion of WA, where *U.* cf 'gibson 5' is known only from a restricted population in the Eastern Murchison bioregion. The two populations are separate from each other by approximately 400 km.

RECOMENDATIONS
Urodacus cf 'gibson 5' should be managed as an SRE until more is known about its relationship with *U.* 'gibson 5'. A genomic comparison between specimens from each population may be the most cost efficient way to determine this without spending large amounts of time comparing morphology.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105832	Target 10-167	1				Volschenk E.S.
T105810	Site 8-054	1				Volschenk E.S.
T105767	Site 8-053	1				Volschenk E.S.
T105751	Site 8-052		1			Volschenk E.S.
T105797	Site 8-572	3				Volschenk E.S.
T105836	Site 8-391	1				Volschenk E.S.
T105765	Site 8-649	1				Volschenk E.S.
T105762	Site 4-043	1				Volschenk E.S.
T105809	Target 14-162	1				Volschenk E.S.
T105812	Target 14-163	1				Volschenk E.S.
T105758	Site 10-057		1			Volschenk E.S.
T105826	Site 8-560	1				Volschenk E.S.
T105794	Site 10-243	1				Volschenk E.S.
T105766	Site 8-640	1				Volschenk E.S.
T105831	Site 1-512	1				Volschenk E.S.
T105786	Site 20-097	1				Volschenk E.S.
T105792	Site 4-211	1				Volschenk E.S.
T105846	Site 2-204			1		Volschenk E.S.
T105829	Site 20-280	2				Volschenk E.S.
T105793	Site 20-248	1				Volschenk E.S.
T105828	Site 20-218	1				Volschenk E.S.
T114090	Site 20-100			1		Volschenk E.S.
T105755	Site 24-107			1		Volschenk E.S.
T105834	Site 2-478	1				Volschenk E.S.
T105805	Site 1-331	2				Volschenk E.S.
T105830	Site 22-496	1				Volschenk E.S.
T105759	Site 16-076	1				Volschenk E.S.
T114073	Site 22-138			1		Volschenk E.S.
T105824	Site 20-098	1				Volschenk E.S.
T105827	Site 16-613	1				Volschenk E.S.
T105790	Site 19-087		1			Volschenk E.S.
T105798	Site 19-797	1				Volschenk E.S.
T105782	Site 19-601	1				Volschenk E.S.
T105760	Site 19-530	1				Volschenk E.S.
T105785	Site 19-465	1				Volschenk E.S.
T105756	Site 19-089	1				Volschenk E.S.
T105783	Site 16-490	1				Volschenk E.S.
T105781	Site 16-775	1				Volschenk E.S.
T105784	Site 1-635	2	1	1		Volschenk E.S.
T105821	Site 22-600	1				Volschenk E.S.
T105763	Site 24-105		1			Volschenk E.S.
T105835	Site 19-091	1				Volschenk E.S.
T105761	Site 22-137	1				Volschenk E.S.
T105796	Site 4-044	1				Volschenk E.S.
T105833	Site 20-603	2				Volschenk E.S.
T105780	Site 22-562	1				Volschenk E.S.
T105764	Site 29-648	1				Volschenk E.S.

Number of samples: 47

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Species: *Urodacus* 'laverton 2'

SRE STATUS
Urodacus 'laverton 2' is not an SRE

TAXONOMIC RESOLUTION
Urodacus 'laverton 2' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Urodacus 'laverton 2' is known from a number of samples collected from the Eastern Murchison bioregion of WA.

RECOMENDATIONS
Urodacus 'laverton 2' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105802	Site 29-436	1				Volschenk E.S.
T105801	Site 29-527	1				Volschenk E.S.
T105818	Site 24-106			1		Volschenk E.S.
T105800	Site 29-525		1			Volschenk E.S.
T105814	Site 28-790	1				Volschenk E.S.
T105799	Site 28-737		1			Volschenk E.S.

Number of samples: 6

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Species: *Urodacus* 'laverton 5'

SRE STATUS
Urodacus 'laverton 5' is not an SRE

TAXONOMIC RESOLUTION
Urodacus 'laverton 5' is a well-defined and clearly recognised morphospecies.

DISTRIBUTION
Urodacus 'laverton 5' is known from a number of samples collected from the Eastern Murchison bioregion of WA.

RECOMENDATIONS
Urodacus 'laverton 5' is not an SRE and no management is recommended.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105776	Site 29-566		1			Volschenk E.S.
T105774	Site 29-850	1				Volschenk E.S.
T105753	Site 28-506	1				Volschenk E.S.
T105777	Site 27-118			1		Volschenk E.S.
T105772	Site 28-237	1				Volschenk E.S.
T105752	Site 28-226	1				Volschenk E.S.
T105775	Site 30-564	1				Volschenk E.S.
T105734	Site 1-457	1				Volschenk E.S.
T105757	Site 29-550	1				Volschenk E.S.
T105769	Site 29-526	1				Volschenk E.S.
T105847	Site 25-113			1		Volschenk E.S.
T105770	Site 25-363	1				Volschenk E.S.
T105754	Site 25-366	1				Volschenk E.S.

WAM Rego.	Client Rego.	♂	♀	Juv.	Notes	Identified by
T105773	Site 25-368	1				Volschenk E.S.
T105768	Site 10-471	1				Volschenk E.S.
T105778	Site 29-425	1				Volschenk E.S.
T105843	Site 24-104			1		Volschenk E.S.
T114091	Target 8-151			1		Volschenk E.S.
T105771	Site 29-449	1				Volschenk E.S.

Number of samples: 19

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Fet, V. 2000. Family Scorpionidae Latreille, 1802. *In:* Fet, V., Sissom, W. D., Lowe, G. & Braunwalder, M. E. (eds) *Catalogue of the scorpions of the world (1758-1998)*. New York Entomological Society, New York, pp. 428-486.

Fet, V. & Lowe, G. 2000. Family Buthidae C.L. Koch, 1837. *In:* Fet, V., Sissom, W. D., Lowe, G. & Braunwalder, M. E. (eds) *Catalogue of the scorpions of the world (1758-1998)*. New York Entomological Society, New York, pp. 54-286.

Hemprich, F. W. & Ehrenberg, C. G. 1828. Arachnoidae. Plates I and II. *Symbolae Pcychae seu Icones et Descriptiones Animalium Evertebratum sepositis Insectis quae ex itinere per Africam borealem et Asiam occidentalum. Friderici Guilelmi Hemprich et Christiani Godofredi Ehrenberg, studio naovae aut illustratea redierunt. Percensuit edidit Dr. C. G. Ehrenberg. Decas 1*. Berolini ex officina Academica, venditur a mittlero: index and plates.

Hirst, S. 1911. Descriptions of new scorpions. *Annals and Magazine of Natural History* **(8) 8**: 462-473.

Keyserling, E. 1885. Die Arachniden Australiens. *In:* Koch, L. & Keyserling, E. (eds) *Die Arachniden Australiens nach der Natur beschrieben und abgebildet*. Bauer & Raspe, Nürnberg, pp. 1-48.

Koch, C. L. 1845. *Die Arachniden. Getreu nach der Natur Abgebildet und Beschrieben.* C.H. Zeh'schen, Nürnberg.

Koch, L. E. 1977. The taxonomy, geographic distribution and evolutionary radiation of Australo-Papuan scorpions. *Records of the Western Australian Museum* **5**: 83-367.

Locket, N. A. 1990. A new genus and species of scorpion from South Australia (Buthidae: Buthinae). *Transactions of the Royal Society of South Australia* **114**: 67-80.

Main, B. Y. 1956. Taxonomy and biology of the genus *Isometroides* Keyserling (Scorpionida). *Australian Journal of Zoology* **4**: 158-164.

Peters, M. B. 1861. Ûeber eine neue Eintheilung der Scorpione und uber die von ihm in Mosambique gesammelten Arten von Scorpionen, aus welchem hier ein Auszug mit getheilt wird. *Monastberichte der Königlichen Preussischen Akademie der Wissenschaften zu Berlin* **1861**: 507-516.

Prendini, L. 2000. Phylogeny and classification of the superfamily Scorpionoidea Latreille 1802 (Chelicerata, Scorpiones): An exemplar approach. *Cladistics* **16**: 1-78.

Prendini, L. 2003. Systematics and biogeography of the family Scorpionidae (Chelicerata: Scorpiones), with a discussion on phylogenetic methods. *Invertebrate Systematics* **17**: 185-259.

Volschenk, E. S., Burbidge, A. H., Durrant, B. J. & Harvey, M. S. 2010. Spatial distribution patterns of scorpions (Scorpiones) in the arid Pilbara region of Western Australia. *Records of the Western Australian Museum, Supplement* **78**: 271–284.

Volschenk, E. S., Prendini, L. 2008. Aops oncodactylus, gen. et sp. nov., the first troglobitic urodacid (Urodacidae: Scorpiones), with a re-assessment of cavernicolous, troglobitic and troglomorphic scorpions. *Invertebrate Systematics* **22**: 235-257.

Appendix E Pseudoscorpions (Arachnida) and Millipedes (Diplopoda) from Yakabindie, Western Australia

Pseudoscorpions (Arachnida) and Millipedes (Diplopoda) from the Yakabindie, Western Australia

Report to *Outback Ecology*

18 November 2011

Mark S. Harvey, Catherine A. Car & Mieke A. Burger

Department of Terrestrial Zoology, Western Australian Museum,

Locked Bag 49, Welshpool DC, Western Australia 6986, Australia

Summary

The samples submitted to the Western Australian Museum on the 30th June 2011 (accession no. A7071) from Yakabindie included millipedes from the family Paradoxosomatidae; and pseudoscorpions from the families Atemnidae (*Oratemnus*), Cheiridiidae (`*PSEAAB*`), Chernetidae (`*PSEAAC*` and *Sundochernes*), Chthoniidae (*Austrochthonius*), Garypidae (*Synsphyronus*), and Olpiidae (*Austrohorus*, *Beierolpium, Indolpium, Linnaeolpium,* and `Genus 7/4`). Most of the pseudoscorpion genera need taxonomic revision and it is therefore difficult to determine if these samples represent short range endemics.

Putative short range endemics:

- ***Antichiropus* `sp. nov. Yakabindie` (Paradoxosomatidae):** This species has only been recorded from this survey from a very small area. As *Antichiropus* species are often have limited distributions, it is highly likely that this species is a short-range endemic.
- ***Synsphyronus* `sp. PSE023` (Garypidae):** This is the first record of this species. It may represent a short-range endemic as some species of *Synsphyronus* are, however more sampling would help determine this species' range.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to alteration proved daunting and were largely ignored as being too diverse and too difficult to comprehend to satisfy the rapid turn-around needed for environmental surveys.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002), and series of major groups were nominated as having a very high proportion of individual species that satisfied a certain set of criteria. The main criterion nominated for inclusion as a Short-Range Endemic (SRE) was that the species had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of ecological and life-history traits, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Terrestrial invertebrates (millipedes and pseudoscorpions) that were collected by *Outback Ecology* from Yakabindie, north of Leinster, were submitted to the Western Australian Museum on 30th June 2011. The millipedes and pseudoscorpions were examined at the WAM museum using Leica dissecting microscopes (MZ6, MZ16).

DIPLOPODA

Order Polydesmida
Family Paradoxosomatidae

Genus *Antichiropus*

The genus *Antichiropus* is the most abundant and diverse millipede group in Western Australia. This genus was first named in 1911 for seven species (Attems 1911), and additional species were added by Jeekel (1982) and Shear (Shear 1992). As the result of large field surveys and taxonomic work at the Western Australian Museum, the genus is now known to consist of over 110 species, ranging as far north as the Pilbara, and extending onto the Nullarbor Plain and the Eyre Peninsula in South Australia (figure below). With the exception of *Antichiropus variabilis*, which inhabits the jarrah 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 kilometres (Harvey, Sampey et al. 2000; Harvey 2002).

Although the vast majority of *Antichiropus* species currently lack formal taxonomic descriptions and scientific names, MSH has spent the past decade comparing different species of the genus and assigning temporary codes to each of the species. The distinction between species 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 *Antichiropus* species is different, making the identification of individual species a relatively simple task. These 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.

***Antichiropus* 'sp. nov. Yackabindie'**

Antichiropus `sp. nov. Yakabindie` is only known from the small number specimens recovered during this survey (Appendix 1) and is therefore considered a short-range endemic species.

ARACHNIDA

Order Pseudoscorpiones

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families. They are found in a variety of biotopes, but can be most commonly collected from the bark of trees, from the underside of rocks, or from leaf litter habitats. The material from this survey included 439 individuals from six families: Atemnidae, Cheiridiidae, Chernetidae, Chthoniidae, Garypidae, and Olpiidae (Appendix 1).

Family Atemnidae

***Oratemnus sp.* (family Atemnidae)**

Seven specimens of *Oratemnus* sp. were collected during the survey (Appendix 1). Atemnids are frequently found under bark of trees in Western Australia, but the systematics of the group, particularly of the genus *Oratemnus*, is uncertain and the taxonomy of most individual species unclear. However, based upon current evidence, it seems that most species will eventually be found to be widely distributed. For this reason, we do not believe that these specimens represent a short-range endemic species.

Family Cheiridiidae

Genus `*PSEAAB*`

One male and three females of an unidentified cheiridiid were collected during the survey (Appendix 1). The systematic status of the many populations of Cheiridiidae is currently unknown but it is very unlikely that any represent short-range endemic species.

Family Chernetidae

Some of the juvenile pseudoscorpions from the family Chernetidae collected during this survey were not identifiable beyond family level. These are indicated as `Genus indet.` `sp. juv.` in Appendix 1.

`PSEAAC` `sp. PSE022` (family Chernetidae)

Chernetidae are the most diverse of all pseudoscorpion families with 113 named genera and 652 named species worldwide. The Australian fauna is quite extensive, with 37 described species (Harvey 2011). Two females were collected from this undescribed genus/species. It is unlikely that they represent short-range endemic species as most chernetids tend to have relatively wide distributions.

***Sundochernes* `sp. PSE020` (family Chernetidae)**

There are two other named species of *Sundochernes* in Western Australia, *S. dubius* from Augusta, and *S. australiensis* from Denmark (Harvey and Volschenk 2007). The specimens from this survey are unlike the descriptions of these two species and are given the species code PSE020. Again, it is unlikely that these specimens represent short-range endemic species as most chernetids tend to have relatively wide distributions.

Family Chthoniidae

***Austrochthonius* `spp. nov.` (family Chthoniidae)**

Twelve specimens of new species of *Austrochthonius* were collected during the survey (Appendix 1). Species of *Austrochthonius* occur in leaf litter and soil environments throughout much of Western Australia, as well as subterranean ecosystems in Cape Range and near Busselton (Harvey 1991; Harvey and Mould 2006). The taxonomy of the Western Australian representatives is not resolved but there are clearly several species represented in the collections of the Western Australian Museum. Most species appear to be widespread and the specimens collected during this project are not believed to represent a short-range endemic species.

Family Garypidae

***Synsphyronus* `sp. PSE023` (family Garypidae)**

One female and possibly one juvenile of a new species of *Synsphyronus* were collected during the survey. Many species of *Synsphyronus* may represent short-range endemic species (Harvey 1987), but these species are generally found in ground habitats such as under rocks; the tree-dwelling species tend to be much more widely distributed, and are not short-range endemics.

Family Olpiidae

Austrohorus spp. (family Olpiidae)

There were 31 specimens of *Austrohorus* collected during the survey (Appendix 1). Extremely similar specimens have been collected from other regions of Western Australia, but there was some obvious morphological variation between some of the samples within this genus which could possibly represent more than one species. More taxonomic investigation is required to determine the number of species represented and their distributions.

Beierolpium spp. (family Olpiidae)

Eighty-seven specimens of *Beierolpium* were collected during this project (Appendix 1). The systematic status of members of this genus has not been fully assessed. At present it is not possible to firmly establish the identity of these species until a complete systematic revision of the Western Australian members of *Beierolpium* is undertaken. The \`sp. 8/2\`, \`sp. 8/3\` and \`sp. 8/4\` species representation refers to the number of trichobothria (sensory hairs) on the fixed and movable chelal fingers in the adults, which is a feature that is likely to coincide at least partly with species distinction. It is possible that these specimens represent short-range endemic species, but a full taxonomic revision of the genus *Beierolpium* in Western Australia is necessary to confirm their status.

Indolpium (family Olpiidae)

Two hundred and forty specimens of *Indolpium* were collected during the survey (Appendix 1). Extremely similar specimens have been collected from other regions of Western Australia. There was some obvious morphological variation between some of the samples within this genus which could possibly represent more than one species. More taxonomic investigation is required to determine the number of species represented, but based on our current levels of knowledge; it is unlikely that these specimens represent short-range endemic species.

Linnaeolpium (family Olpiidae)

Five specimens of this pseudoscorpion genus were collected during the survey (Appendix 1). This genus was recently described for a single troglobitic species (*L. linnaei*) from the Robe River Valley, Pilbara (Harvey and Leng 2008). The species from this survey represents a different species, and while it may eventually be found to represent a short-range endemic species, at present we have insufficient information to establish its status.

Genus `*7/4*` (family Olpiidae)

Twenty-two specimens of `Genus 7/4` were collected during this survey (Appendix 1). Based on our current levels of knowledge, it is not possible to state whether this species is a short-range endemic species.

REFERENCES

Attems, C. G. (1911). Myriopoda exkl. Scolopendridae. Die Fauna Südwest-Australiens. W. Michaelsen and R. Hartmeyer. Jena, Gustav Fischer. **3:** 147-204.

Chapman, A. D. (2009). Numbers of Living Species in Australia and the World. 2nd Edition. Toowoomba, Australian Biodiversity Information Services**:** 84 pp.

EPA (2009). Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986). Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia. No. 20. Perth**:** 31 pp.

Framenau, V. W., M. L. Moir, et al. (2008). Terrestrial Invertebrates of the South Coast NRM Region of Western Australia: Short-range Endemics in Gondwanan Relictual Habitats. Report to South Coast NRM. Welshpool, Western Australian Museum**:** 184pp.

Harvey, M. S. (1987). "A revision of the genus *Synsphyronus* Chamberlin (Garypidae: Pseudoscorpionida: Arachnida)." Australian Journal of Zoology, Supplementary Series **126**: 1-99.

Harvey, M. S. (1991). "The cavernicolous pseudoscorpions (Chelicerata: Pseudoscorpionida) of Cape Range, Western Australia." Records of the Western Australian Museum **15**: 487-502.

Harvey, M. S. (2002). "Short-range endemism among the Australian fauna: some examples from non-marine environments." Invertebrate Systematics **16**: 555-570.

Harvey, M. S. (2011). "Pseudoscorpions of the World, version 2.0. Western Australian Museum, Perth." from http://www.museum.wa.gov.au/catalogues/pseudoscorpions.

Harvey, M. S. and M. C. Leng (2008). "The first troglomorphic pseudoscorpion of the family Olpiidae (Pseudoscorpiones), with remarks on the composition of the family." Records of the Western Australian Museum **24**: 387-394.

Harvey, M. S. and L. G. Mould (2006). "A new troglomorphic species of *Austrochthonius* (Pseudoscorpiones: Chthoniidae) from Australia, with remarks on *Chthonius caecus*." Records of the Western Australian Museum **23**: 205-211.

Harvey, M. S., A. Sampey, et al. (2000). "The Chilopoda and Diplopoda of the southern Carnarvon Basin, Western Australia." Records of the Western Australian Museum **61**: 323-333.

Harvey, M. S. and E. S. Volschenk (2007). "A review of some Australasian Chernetidae: *Sundochernes*, *Troglochernes* and a new genus (Pseudoscorpiones)." Journal of Arachnology **35**: 238-277.

Jeekel, C. A. W. (1982). "Millipedes from Australia, 1: Antichiropodini from South Australia (Diplopoda, Polydesmida, Paradoxosomatidae)." Bulletin Zoologisch Museum, Universiteit van Amsterdam **8**(14): 121-132.

Shear, W. A. (1992). "A new genus and two new species of millipedes from the Cape Range, Western Australia (Diplopoda, Polydesmida, Paradoxosomatidae)." Records of the Western Australian Museum **15**: 777-784.

Yeates, D. K., M. S. Harvey, et al. (2004). "New estimates for terrestrial arthropod species-richness in Australia." Records of the South Australian Museum, Monograph Series **7**: 231-241.

Appendix 1. Specimen data for millipedes and pseudoscorpions collected from Yakabindie

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
113403	Site 13-430	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`00.0"S	120°35`23.8"E				1
113832	Site 10-217	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°25`00.7"S	120°35`35.4"E		1		1
113833	Site 10-224	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°25`00.7"S	120°35`35.4"E				1
113834	Site 10-474	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`00.7"S	120°35`35.4"E				2
113835	Site 10-476	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`00.7"S	120°35`35.4"E				6
113836	Site 10-705	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`00.7"S	120°35`35.4"E				1
113837	Site 10-718	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`00.7"S	120°35`35.4"E				1
113838	Site 10-788	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`00.7"S	120°35`35.4"E			1	1
113839	Site 11-271	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`00.2"S	120°35`47.5"E				1
113840	Site 11-584	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.2"S	120°35`47.5"E			1	1
113841	Site 11-769	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.2"S	120°35`47.5"E				10
113842	Site 1-177	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`36.3"S	120°34`22.5"E	2	2	4	8
113843	Site 12-376	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`53.2"S	120°35`53.6"E	2			2
113844	Site 12-466	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`53.2"S	120°35`53.6"E				3
113845	Site 12-536	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`53.2"S	120°35`53.6"E	1		1	2
113846	Site 12-687	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`53.2"S	120°35`53.6"E	1	1		2
113847	Site 13-246	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`00.0"S	120°35`23.8"E				1
113848	Site 13-286	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.0"S	120°35`23.8"E				1
113849	Site 13-299	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°26`00.0"S	120°35`23.8"E	1			1
113850	Site 13-415	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`00.0"S	120°35`23.8"E				1
113851	Site 1-345	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`36.3"S	120°34`22.5"E	1			1
113852	Site 13-583	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.0"S	120°35`23.8"E				1
113853	Site 13-680	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.0"S	120°35`23.8"E				5
113854	Site 13-786	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.0"S	120°35`23.8"E			1	1
113855	Site 14-212	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`15.6"S	120°36`35.4"E				1
113856	Site 14-319	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`15.6"S	120°36`35.4"E				1
113857	Site 14-400	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`15.6"S	120°36`35.4"E		1	1	2
113858	Site 14-441	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`15.6"S	120°36`35.4"E				5

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
113859	Site 14-485	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`15.6"S	120°36`35.4"E				1
113860	Site 1-459	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus indet.`*	`sp. juv.`	27°25`36.3"S	120°34`22.5"E			1	1
113861	Site 1-515	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`36.3"S	120°34`22.5"E			1	1
113862	Site 15-275	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°25`29.8"S	120°36`26.1"E				1
113863	Site 15-325	Arachnida	Psuedoscorpiones	Olpiidae	*Linnaeolpium*		27°25`29.8"S	120°36`26.1"E		1		1
113864	Site 15-638	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`29.8"S	120°36`26.1"E				1
113865	Site 15-650	Arachnida	Psuedoscorpiones	Garypidae	*Synsphyronus*	`PSE023`	27°25`29.8"S	120°36`26.1"E		1		1
113866	Site 16-077	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`09.5"S	120°34`51.1"E				2
113867	Site 16-183	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°28`09.5"S	120°34`51.1"E		1		1
113868	Site 16-491	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`09.5"S	120°34`51.1"E				1
113869	Site 10-473	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`00.7"S	120°35`35.4"E	3	1		4
113870	Site 16-619	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°28`09.5"S	120°34`51.1"E		1		1
113871	Site 16-643	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°28`09.5"S	120°34`51.1"E				1
113872	Site 16-659	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°28`09.5"S	120°34`51.1"E				2
113873	Site 17-082	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`34.3"S	120°35`53.7"E				2
113874	Site 17-413	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`34.3"S	120°35`53.7"E		1		1
113875	Site 17-417	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`34.3"S	120°35`53.7"E				4
113876	Site 17-616	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`34.3"S	120°35`53.7"E		1		1
113877	Site 17-774	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`34.3"S	120°35`53.7"E				5
113878	Site 18-229	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`50.1"S	120°37`14.8"E				1
113879	Site 18-272	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`50.1"S	120°37`14.8"E				1
113880	Site 13-429	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°26`00.0"S	120°35`23.8"E	1		1	1
113881	Site 18-314	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`50.1"S	120°37`14.8"E				1
113882	Site 18-383	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`50.1"S	120°37`14.8"E				3
113883	Site 18-426	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`50.1"S	120°37`14.8"E				1
113884	Site 19-180	Arachnida	Psuedoscorpiones	Chernetidae	*`Genus indet.`*	`sp. juv.`	27°24`44.4"S	120°35`18.7"E				5
113885	Site 19-608	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°24`44.4"S	120°35`18.7"E				1
113886	Site 19-652	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°24`44.4"S	120°35`18.7"E	1			1
113887	Site 19-752	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°24`44.4"S	120°35`18.7"E				1
113888	Site 19-782	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°24`44.4"S	120°35`18.7"E				1
113889	Site 19-796	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°24`44.4"S	120°35`18.7"E			1	1

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
113890	Site 19-95	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°24`44.4"S	120°35`18.7"E				1
113891	Site 2-001	Arachnida	Psuedoscorpiones	Chernetidae	*`PSEAAC`*	`PSE022`	27°25`27.5"S	120°34`53.3"E		1		1
113892	Site 20-463	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus indet.`*	`sp. juv.`	27°27`24.7"S	120°35`28.0"E			1	1
113893	Site 21-309	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`47.3"S	120°35`38.5"E				1
113894	Site 19-607	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°24`44.4"S	120°35`18.7"E				2
113895	Site 21-362	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`47.3"S	120°35`38.5"E				3
113896	Site 21-553	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. 8`	27°27`47.3"S	120°35`38.5"E	1	3		4
113897	Site 21-631	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°27`47.3"S	120°35`38.5"E	1	2		3
113898	Site 21-633	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°27`47.3"S	120°35`38.5"E	1	1	1	3
113899	Site 2-178	Arachnida	Psuedoscorpiones	Chernetidae	*`PSEAAC`*	`PSE022`	27°25`27.5"S	120°34`53.3"E		1		1
113900	Site 2-203	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°25`27.5"S	120°34`53.3"E				1
113901	Site 22-181	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus indet.`*	`sp. juv.`	27°26`49.2"S	120°34`24.3"E			1	1
113902	Site 22-320	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`49.2"S	120°34`24.3"E				1
113903	Site 22-497	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`49.2"S	120°34`24.3"E				2
113904	Site 22-502	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°26`49.2"S	120°34`24.3"E			1	1
113905	Site 22-577	Arachnida	Psuedoscorpiones	Atemnidae	*Oratemnus*		27°26`49.2"S	120°34`24.3"E				1
113906	Site 22-606	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°26`49.2"S	120°34`24.3"E		1		1
113907	Site 22-677	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`49.2"S	120°34`24.3"E				1
113908	Site 23-101	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`19.8"S	120°38`04.7"E				1
113909	Site 2-327	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°25`27.5"S	120°34`53.3"E			1	1
113910	Site 23-356	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`19.8"S	120°38`04.7"E				5
113911	Site 23-407	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`19.8"S	120°38`04.7"E				4
113912	Site 23-493	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`19.8"S	120°38`04.7"E				2
113913	Site 23-498	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`19.8"S	120°38`04.7"E				4
113914	Site 23-552	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°19`19.8"S	120°38`04.7"E		1		1
113915	Site 23-576	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°19`19.8"S	120°38`04.7"E	1			1
113916	Site 2-416	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`27.5"S	120°34`53.3"E				1
113917	Site 24-184	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°17`57.8"S	120°36`06.3"E			1	1
113918	Site 24-360	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°17`57.8"S	120°36`06.3"E				3
113919	Site 24-455	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°17`57.8"S	120°36`06.3"E				9
113920	Site 24-624	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°17`57.8"S	120°36`06.3"E			1	1

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113921	Site 24-625	Arachnida	Psuedoscorpiones	Cheiridiidae	*`PSEAAB`*		27°17`57.8"S	120°36`06.3"E	1	1		2
113922	Site 24-628	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°17`57.8"S	120°36`06.3"E			1	1
113923	Site 24-691	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°17`57.8"S	120°36`06.3"E				3
113924	Site 25-108	Arachnida	Psuedoscorpiones	Atemnidae	*Oratemnus*		27°17`46.2"S	120°41`05.7"E				1
113925	Site 25-182	Arachnida	Psuedoscorpiones	Atemnidae	*Oratemnus*		27°17`46.2"S	120°41`05.7"E				4
113926	Site 25-317	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°17`46.2"S	120°41`05.7"E				1
113927	Site 25-365	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°17`46.2"S	120°41`05.7"E				3
113928	Site 25-596	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°17`46.2"S	120°41`05.7"E				1
113929	Site 26-232	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°19`28.0"S	120°40`18.1"E				1
113930	Site 26-245	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°19`28.0"S	120°40`18.1"E				1
113931	Site 2-665	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/2`	27°25`27.5"S	120°34`53.3"E		1		1
113932	Site 26-673	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`28.0"S	120°40`18.1"E			1	1
113933	Site 26-712	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°19`28.0"S	120°40`18.1"E				2
113934	Site 19-755	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°24`44.4"S	120°35`18.7"E	3	2	9	14
113935	Site 27-265	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`30.1"S	120°41`24.8"E		1		1
113936	Site 27-333	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`30.1"S	120°41`24.8"E	2			2
113937	Site 27-340	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`30.1"S	120°41`24.8"E				2
113938	Site 27-380	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`30.1"S	120°41`24.8"E				4
113939	Site 27-396	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°28`30.1"S	120°41`24.8"E			1	1
113940	Site 27-574	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`30.1"S	120°41`24.8"E				1
113941	Site 27-698	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`30.1"S	120°41`24.8"E				2
113942	Site 27-713	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°28`30.1"S	120°41`24.8"E				1
113943	Site 27-757	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°28`30.1"S	120°41`24.8"E				2
113944	Site 28-240	Arachnida	Psuedoscorpiones	Atemnidae	*Oratemnus*		27°21`40.8"S	120°40`59.0"E			1	1
113945	Site 28-277	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°21`40.8"S	120°40`59.0"E				1
113946	Site 28-293	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°21`40.8"S	120°40`59.0"E	2	1		3
113947	Site 28-460	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°21`40.8"S	120°40`59.0"E				2
113948	Site 28-671	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°21`40.8"S	120°40`59.0"E				7
113949	Site 28-732	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°21`40.8"S	120°40`59.0"E			1	1
113950	Site 28-791	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°21`40.8"S	120°40`59.0"E				1
113951	Site 29-301	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°21`03.4"S	120°37`57.9"E				2

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113952	Site 29-539	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°21`03.4"S	120°37`57.9"E		1		1
113953	Site 29-637	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°21`03.4"S	120°37`57.9"E				1
113954	Site 30-545	Arachnida	Psuedoscorpiones	Cheiridiidae	*`PSEAAB`*		27°26`25.3"S	120°41`25.9"E		1		1
113955	Site 19-793	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°24`44.4"S	120°35`18.7"E	3			3
113956	Site 30-598	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`25.3"S	120°41`25.9"E		1		1
113957	Site 3-199	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`18.8"S	120°34`37.2"E				1
113958	Site 3-206	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`18.8"S	120°34`37.2"E				1
113959	Site 3-208	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°25`18.8"S	120°34`37.2"E				3
113960	Site 3-313	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°25`18.8"S	120°34`37.2"E				1
113961	Site 4-655	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°25`45.2"S	120°34`18.3"E	1			1
113962	Site 5-266	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`37.6"S	120°35`22.3"E				1
113963	Site 5-404	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`37.6"S	120°35`22.3"E	1		1	2
113964	Site 5-703	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°26`37.6"S	120°35`22.3"E				1
113965	Site 5-710	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°26`37.6"S	120°35`22.3"E				7
113966	Site 5-760	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`37.6"S	120°35`22.3"E				17
113967	Site 6-047	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`56.2"S	120°35`12.8"E				1
113968	Site 6-256	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`56.2"S	120°35`12.8"E				1
113969	Site 6-258	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°26`56.2"S	120°35`12.8"E				1
113970	Site 6-388	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°26`56.2"S	120°35`12.8"E			2	2
113971	Site 6-433	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`56.2"S	120°35`12.8"E				15
113972	Site 6-446	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`56.2"S	120°35`12.8"E				8
113973	Site 6-487	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`56.2"S	120°35`12.8"E				13
113974	Site 6-582	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`56.2"S	120°35`12.8"E				6
113975	Site 6-741	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°26`56.2"S	120°35`12.8"E				1
113976	Site 7-305	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`15.1"S	120°36`20.3"E				10
113977	Site 7-482	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`15.1"S	120°36`20.3"E				2
113978	Site 7-484	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°27`15.1"S	120°36`20.3"E				3
113979	Site 7-556	Arachnida	Psuedoscorpiones	Olpiidae	*Linnaeolpium*		27°27`15.1"S	120°36`20.3"E				1
113980	Site 7-595	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°27`15.1"S	120°36`20.3"E				2
113981	Site 7-661	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`15.1"S	120°36`20.3"E				2
113982	Site 8-372	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`59.2"S	120°36`16.0"E				4

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
113983	Site 8-394	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`59.2"S	120°36`16.0"E	1			1
113984	Site 8-538	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`59.2"S	120°36`16.0"E		1		1
113985	Site 8-558	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`59.2"S	120°36`16.0"E				2
113986	Site 8-641	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`59.2"S	120°36`16.0"E	1		1	2
113987	Site 9-055	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`35.7"S	120°36`02.7"E				1
113988	Site 9-295	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`35.7"S	120°36`02.7"E				1
113989	Site 9-385	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`35.7"S	120°36`02.7"E				5
113990	Site 9-411	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`35.7"S	120°36`02.7"E				11
113991	Site 9-420	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`35.7"S	120°36`02.7"E				10
113992	Site 9-683	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`35.7"S	120°36`02.7"E				10
113993	Site 9-779	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`35.7"S	120°36`02.7"E	1			1
114635	Target 10-166	Arachnida	Psuedoscorpiones	Olpiidae	*Linnaeolpium*		27°26`46.3"S	120°35`15.3"E				1
114636	Target 13-160	Arachnida	Psuedoscorpiones	Chernetidae	*`Genus indet.`*	`sp. juv.`	27°21`40.0"S	120°35`16.3"E			1	1
114637	Target 14-164	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°25`52.2"S	120°34`39.1"E				1
114638	Target 15-168	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°26`50.0"S	120°34`11.3"E			1	1
114639	Target 15-259	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`50.0"S	120°34`11.3"E		1		1
114640	Site 19-802	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°24`44.4"S	120°35`18.7"E		1		1
114641	Site 3-302	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`18.8"S	120°34`37.2"E	2			2
114642	Site 3-431	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`18.8"S	120°34`37.2"E	1			1
114643	Site 3-448	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`18.8"S	120°34`37.2"E	2			2
114644	Site 3-522	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`18.8"S	120°34`37.2"E	2	1		3
114645	Site 3-670	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`18.8"S	120°34`37.2"E	1			1
114646	Site 4-734	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	`sp. nov. Yakabindie`	27°25`45.2"S	120°34`18.3"E	2			2
118827	Site 21-323	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°27`47.3"S	120°35`38.5"E				1
118828	Site 13-430	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°26`00.0"S	120°35`23.8"E				1
118829	Site 13-430	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`00.0"S	120°35`23.8"E				1
118830	Site 13-415	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`00.0"S	120°35`23.8"E				1
118831	Site 10-217	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/4 small`	27°25`00.7"S	120°35`35.4"E	1			1

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	JUV.	TOTAL
118832	Site 12-687	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`53.2"S	120°35`53.6"E	2	1		3
118833	Site 14-485	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`15.6"S	120°36`35.4"E				1
118834	Site 15-650	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°25`29.8"S	120°36`26.1"E			1	1
118835	Site 16-659	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`09.5"S	120°34`51.1"E				2
118836	Site 17-616	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°28`34.3"S	120°35`53.7"E	1			1
118837	Site 18-383	Arachnida	Psuedoscorpiones	Olpiidae	*Linnaeolpium*		27°28`50.1"S	120°37`14.8"E				1
118838	Site 19-752	Arachnida	Psuedoscorpiones	Chernetidae	*`Genus indet.`*	`sp. juv.`	27°24`44.4"S	120°35`18.7"E			1	1
118839	Site 21-309	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°27`47.3"S	120°35`38.5"E			3	3
118840	Site 21-362	Arachnida	Psuedoscorpiones	Olpiidae	*Linnaeolpium*		27°27`47.3"S	120°35`38.5"E				1
118841	Site 23-407	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°19`19.8"S	120°38`04.7"E			1	1
118842	Site 23-498	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°19`19.8"S	120°38`04.7"E	1			1
118843	Site 23-552	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°19`19.8"S	120°38`04.7"E			1	1
118844	Site 23-576	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°19`19.8"S	120°38`04.7"E		1		1
118845	Site 2-416	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°25`27.5"S	120°34`53.3"E				1
118846	Site 27-265	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`30.1"S	120°41`24.8"E	2	2		4
118847	Site 27-333	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°28`30.1"S	120°41`24.8"E		1		1
118848	Site 27-333	Arachnida	Psuedoscorpiones	Cheiridiidae	*`PSEAAB`*		27°28`30.1"S	120°41`24.8"E		1		1
118849	Site 28-240	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. 8/3`	27°21`40.8"S	120°40`59.0"E	1	1		2
118850	Site 28-293	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°21`40.8"S	120°40`59.0"E				1
118851	Site 28-460	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°21`40.8"S	120°40`59.0"E				1
118852	Site 3-199	Arachnida	Psuedoscorpiones	Chthoniidae	*Austrochthonius*	`sp. nov. Pilbara`	27°25`18.8"S	120°34`37.2"E	1	1		1
118853	Site 3-199	Arachnida	Psuedoscorpiones	Chernetidae	*Sundochernes*	`PSE020`	27°25`18.8"S	120°34`37.2"E		1		1
118854	Site 3-313	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°25`18.8"S	120°34`37.2"E			1	1
118855	Site 5-404	Arachnida	Psuedoscorpiones	Garypidae	*Synsphyronus*	`sp. juv.`	27°26`37.6"S	120°35`22.3"E			1	1
118856	Site 6-047	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`56.2"S	120°35`12.8"E				7
118857	Site 6-256	Arachnida	Psuedoscorpiones	Olpiidae	*Indolpium*		27°26`56.2"S	120°35`12.8"E				1
118858	Site 7-661	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°27`15.1"S	120°36`20.3"E				1
118859	Site 8-641	Arachnida	Psuedoscorpiones	Olpiidae	*`Genus 7/4`*		27°26`59.2"S	120°36`16.0"E			1	1
118860	Target 10-166	Arachnida	Psuedoscorpiones	Olpiidae	*Austrohorus*		27°26`46.3"S	120°35`15.3"E			1	1
118861	Site 1-345	Arachnida	Psuedoscorpiones	Olpiidae	*Beierolpium*	`sp. juv.`	27°25`36.3"S	120°34`22.5"E				3

Appendix F Diplopods from Yakabindie, Western Australia

Diplopods from Yakabindie, Western Australia

Report to *Outback Ecology*

16 April 2012

Catherine A. Car & Mark S. Harvey

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

Summary

The samples submitted to the Western Australian Museum on the 10th February and 13th April 2012 included two millipedes from the genus *Antichiropus,* from two undescribed species. This is the first record of *Antichiropus* `DIP002`. The second species is *A.* `DIP003` (formerly known as *Antichiropus* sp. `Yakabindie`) which has a current known distribution of less than 7 km^2. Both of these species are considered a short-range endemic species and of conservation concern.

Short-Range Endemism

The terrestrial invertebrate fauna of inland Australia contains a plethora of species, and just the arthropods were recently estimated to consist of more than 250,000 species (Yeates, Harvey et al. 2004; Chapman 2009). The vast majority of these are found within the Insecta and Arachnida, although significant numbers of millipedes are to be expected. For many years, the prospect of including invertebrates in assessments of biological systems subject to modification proved daunting because of the large numbers of unknown species. These animals were largely ignored, as they were too diverse and their taxonomy too little known for them to be considered in environmental surveys that require a rapid turn-around time.

In a recent publication, the issue of Short-Range Endemism in the Australian invertebrate fauna was examined (Harvey 2002),. Species that could be defined as Short-Range Endemics (SRE) were those that had a naturally small range of less than 10,000 km^2. Harvey (2002) found that those species possessed a series of distinct ecological and life-history traits that contributed to their limited distributions, including:

- poor powers of dispersal;
- confinement to discontinuous habitats;
- usually highly seasonal, only active during cooler, wetter periods; and
- low levels of fecundity.

A number of major invertebrate groups have a high proportion of individual species that show these traits and can be considered SRE's. The Western Australian fauna contains a number of SRE taxa, including millipedes, land snails, trap-door spiders, some pseudoscorpions, slaters, and onychophorans and these represent focal groups in Environmental Impact Assessment studies in the state (EPA 2009). The south coast region is relatively well known compared with other regions of the state (Framenau, Moir et al. 2008), but there are many poorly known species and gaps in our understanding of the distributions of many species.

Methods

Two millipedes collected by *Outback Ecology* from Yakabindie was submitted to the Western Australian Museum on 10th February and 13th April 2012. The specimens were examined at the WA museum using Leica dissecting microscopes (MZ6).

DIPLOPODA

ORDER POLYDESMIDA (FLAT BACKED MILLIPEDES)
Family Paradoxosomatidae

Genus *Antichiropus*

The genus *Antichiropus* is the most abundant and diverse millipede group in WA. This genus was first named in 1911 for seven species (Attems 1911), and additional species were added by Jeekel (1982) and Shear (1992). As the result of large field surveys and taxonomic work at the WA Museum, the genus is now known to consist of over 130 species, ranging as far north as the Pilbara, and extending onto the Nullarbor Plain and the Eyre Peninsula in South Australia. With the exception of *Antichiropus variabilis* Attems,1911, which inhabits the jarrah forests of south-western WA, and *Antichiropus* 'PM1' from the northern Wheatbelt and the Geraldton sandplain, most species of the genus are known to be SREs, and many are known from only a few hundred square kilometres (Harvey, Sampey et al. 2000; Harvey 2002).

Although the vast majority of *Antichiropus* species currently lack formal taxonomic descriptions and scientific names, Dr Mark Harvey has spent the past decade comparing different species of the genus and assigning temporary codes to each of the species. The distinction between species 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 *Antichiropus* species is different, making the identification of individual species a relatively simple task. These 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.

Antichiropus `DIP002`

A single male *Antichiropus* was submitted from this survey (Appendix 1). The specimen was the first record of this species and would be considered a short-range endemic species.

***Antichiropus* `DIP003` (formerly *Antichiropus* sp. `Yakabindie`)**

A single male *Antichiropus* was submitted from this survey (Appendix 1). The specimen was identified as being *Antichiropus* `DIP003`, a species only sampled from a previous survey done by Outback Ecology early in 2011 (Harvey, Car et al. 2011) where 20 males, 5 females, and 10 juveniles of this species were collected from less than a 7 km^2 area (see Figure 1). Our knowledge of the known distribution of most *Antichiropus* species, indicates most strongly that *Antichiropus* `DIP003` (`Yakabindie`) is a short-range endemic species.

Figure 1. Current geographic distribution of *Antichiropus* `DIP003`. Numbers indicate WAM registration numbers.

REFERENCES

Attems, C. G. (1911). Myriopoda exkl. Scolopendridae. Die Fauna Südwest-Australiens. W. Michaelsen and R. Hartmeyer. Jena, Gustav Fischer. **3:** 147-204.

Chapman, A. D. (2009). Numbers of Living Species in Australia and the World. 2nd Edition. Toowoomba, Australian Biodiversity Information Services: 84 pp.

EPA (2009). Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986). Sampling of Short Range Invertebrate Fauna for Environmental Impact Assessment in Western Australia. No. 20. Perth: 31 pp.

Framenau, V. W., M. L. Moir, et al. (2008). Terrestrial Invertebrates of the South Coast NRM Region of Western Australia: Short-range Endemics in Gondwanan Relictual Habitats. Report to South Coast NRM. Welshpool, Western Australian Museum: 184pp.

Harvey, M. S. (2002). "Short-range endemism among the Australian fauna: some examples from non-marine environments." Invertebrate Systematics **16**: 555-570.

Harvey, M. S., C. A. Car, et al. (2011). WAM192: Pseudoscorpions (Arachnida) and millipedes (Diplopoda) from Yakabindie, Western Australia. Welshpool, Western Australian Museum**:** 16 pp.

Harvey, M. S., A. Sampey, et al. (2000). "The Chilopoda and Diplopoda of the southern Carnarvon Basin, Western Australia." Records of the Western Australian Museum **61**: 323-333.

Jeekel, C. A. W. (1982). "Millipedes from Australia, 1: Antichiropodini from South Australia (Diplopoda, Polydesmida, Paradoxosomatidae)." Bulletin Zoologisch Museum, Universiteit van Amsterdam **8**(14): 121-132.

Shear, W. A. (1992). "A new genus and two new species of millipedes from the Cape Range, Western Australia (Diplopoda, Polydesmida, Paradoxosomatidae)." Records of the Western Australian Museum **15**: 777-784.

Yeates, D. K., M. S. Harvey, et al. (2004). "New estimates for terrestrial arthropod species-richness in Australia." Records of the South Australian Museum, Monograph Series **7**: 231-241.

Appendix 1. Specimen data for diplopods collected from Yakabindie

REGNO	FLDNO	CLASS	ORDER	FAMILY	GENUS	SPECIES	LATITUDE	LONGITUDE	M	F	Juv.	TOTAL
120381	Site 1 – 5	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	\`DIP002\`	27°24\`44.6"S	120°35\`19.7"E	1			1
122645	Site 5-4	Diplopoda	Polydesmida	Paradoxosomatidae	*Antichiropus*	\`DIP003\`	27°24\`44.6"S	120°35\`19.7"E	1			1

Appendix G Terrestrial Isopod Identification from Yakabindie, WA

Dr Simon Judd
34 Shardlow Loop
Carine
Western Australia. 6020.
simon_judd@iprimus.com.au
Tel: 0429 020 042

MWH Global
41 Bishop Street
Jolimont
Western Australia. 6014.

Attn: Paul Bolton

17th June 2016

Re: Terrestrial Isopod Identification for Yakabindie Project.

This project has contributed significantly to the knowledge of the terrestrial isopod fauna of the region in question. The only material suitable for comparison and determination of distributions of the taxa comes from the Lake Maitland and Yeelirrie area. Examination of the material collected by this survey has shown the area to have a unique suite of terrestrial isopods. The terrestrial isopod fauna is fundamentally different to the south-west, the Goldfields and the Pilbara regions. The fauna is also significant because of the lack of dominance of the genus *Buddelundia* among the specimens collected. *Buddelundia* normally account for more than 80% of samples from the arid regions of Western Australia (Judd & Taiti, 2011). The specimens are well represented by at least three other genera of the family Armadillidae. The morphospecies collected have morphological affinities with the wetter parts south-west of Western Australia.

This report is accompanied by a datasheet. The material has been registered with the Western Australian Museum (WAM) and the registration numbers are given in the column headed "REGNO". The datasheet is condensed version of the original dataset. The survey was extensive and yielded a lot of isopods. Specimens of the same taxon collected at the same site, on the same day and by the same method, have been grouped in the datasheet. The datasheet therefore shows only a single record for each taxon at each site. This significantly reduces the amount of vials that have to be deposited at the WAM.

The bulk of the specimens belonged to the family Armadillidae. The taxonomy of the Australian Armadillidae is confused and in need of revision. The genera mentioned here reflect the current state of taxonomy and are useful only in the sense that they allow for comparison to the terrestrial isopods found elsewhere in Australia or in previous reports. A brief summary of the taxa and an assessment of their SRE status are given below. Nine taxa were determined and all are considered to be potential or likely SRE species.

Family ARMADILLIDAE

***Budddelundia* 96**

This morphospecies has been collected from the Yeelirrie and Yakabindie area. Its wider distribution is unknown and it should be considered a potential SRE species.

***Budddelundia* 45**

This morphospecies was collected at only 3 sites (Site14, 15 and 29) and is only known from this survey. It is typical of arid-zone *Buddelundia* and may possibly be distributed more widely outside of the project area. It should be considered a potential SRE species.

***Cubaris* yeelirrie1**

This was the most common morphospecies collected and there were about 200 specimens present. What appears to be the same morphospecies is also found at Lake Maitland and Yeelirrie, but further work beyond the scope of this report is required to establish this. These locations are nearby and it is likely that this species has a restricted distribution. It should be considered a potential SRE species.

***Cubaris* yeelirrie2**

This morphospecies was represented by only a few specimens and, like *Buddelundia* 45, these were found at only three sites (Site 14, 27 & 29.). With limited material I can't be certain that there were any fully mature specimens present but the largest specimens present were definitely a different morphospecies from the one above. I have a single specimen of a similar morphospecies that occurs about 150 km to the south of the project area and there is nothing to suggest that the species is more widely distributed outside the project area. There are many similar morphospecies occurring throughout southern WA and many of these are likely SRE species. This should be considered a potential SRE species.

***Pseudodiploexochus* yakabindie**

There are many species undescribed of *Pseudodiploexochus* in the south-west of Western Australia and nearly almost all of these are SRE species. The genus is more commonly found in higher rainfall areas which suggests that *Pseudodiploexochus* yakabindie is a moisture-dependant relictual taxon. I have a single specimen from Yeelirrie which is possibly the same morphospecies, but more material of the latter is needed for comparison. These two locations are about 100 km apart and, therefore, this species is a likely SRE.

Armadillidae yakabindie a

This is very small morphospecies that also possibly occurs at Yeelirrie and Lake Maitland. There are many similar morphospecies throughout WA. These are very small animals and widely distributed, but because of the infrequent collection and cryptic nature, all have potential to be SRE species. The distribution of this taxon is possibly similar to *Cubaris yeelirrie1.* In previous reports isopods of this type have been referred to as "*Spherillo*". This is a potential SRE species.

Armadillidae yakabindie b

This is a very unusual species of Armadillidae. I have only seen two other species with morphologically similar characters, one was collected in the higher rainfall part of the jarrah forest and the other in the Goldfields region. This morphospecies looks superficially very similar to some *Buddelundia*. This is a likely SRE species.

Armadillidae sp. indet.

These species have not been determined because they could not be located at the time of writing. They are of the "*Spherillo*" habit and are likely to belong to Armadillidae yakabindie a. They should be considered potential SRE species and will be determined when they are located.

Family PHILOSCIIDAE

The taxonomy of the Philosciidae is very poorly known in WA. Philosciids are very rarely collected outside of the wetter south-west region and in such areas all considered to be potential SRE species.

Family PLATYARTHRIDAE

***Trichorhina* sp. indet.**

There is one described species of *Trichorhina* from WA and many worldwide. There are many undescribed species in WA. They are very small, occupy cryptic habitats and are widely distributed. They are never regularly collected and in this study they were found at only four sites . Many of the *Trichorhina* are now part of the Trichorhinidae but the WA species have not been included in a formal revision. This is an ancient group and therefore this taxon constitutes one or more potential SRE species.

REFERENCE

Judd, S. & Taiti S. (2011). *Preliminary taxonomy and biogeography of the subfamily Buddelundiinae Vandel (Armadillidae) in Western Australia*. In: Zidar, P. & Štrus, J. (Eds.) Proceedings of the 8th International Symposium of Terrestrial Isopod Biology ISTIB 2011. Ljubljana: pp. 33–34.

Appendix H Land Snails from the area of Yakabindie, 50km North of Leinster, Western Australia

Report to ***Outback Ecology***

Land Snails from the area of Yakabindie, 50km north of Leinster, Western Australia

collected by *Outback Ecology* in January 2011

Corey Whisson

July 2011

Department of Aquatic Zoology (Molluscs), Western Australian Museum

Locked Bag 49, Welshpool DC, Western Australia 6986

Background

Seventeen lots of land snail specimens were collected by the environmental consultancy *Outback Ecology* in January 2011 during a faunal survey of the Yakabindie area, approximately 50km north of Leinster. These specimens were presented to the Mollusc Section of the Western Australian Museum for identification and comment on the 30th June, 2011 (Accession No. A7072).

Specimen data, giving the site numbers, habitat data, co-ordinates and the collecting methods employed were provided with the specimens (Appendix A). No information was provided on the habitat of the sampling sites, or on the spatial relationship of these sample sites to the tenement boundaries.

Procedures

The land snail specimens received from *Outback Ecology* were examined under a *Leica* MZ95 dissecting microscope. They were then compared with dry and preserved specimens in the Molluscan Collections of the Western Australian Museum and with descriptions and figures in relevant publications.

As we have limited material from the Yakabindie area, all survey specimens have been registered and deposited into the Western Australian Museum's Mollusc Collection.

Results

The land snails collected during this survey belong to the terrestrial pulmonate family Pupillidae (Table 1).

All of the species identified from this survey are considered to form part of the indigenous Western Australian fauna.

Table 1. Land snail identifications from *Outback Ecology's* survey of the Yakabindie area during January 2011.

Station	Family	Genus	Species	Reg. No. (WAM S)	No. Specimens
2-187	Pupillidae	*Gastrocopta*	cf. *larapinta*	65909	1 dead-taken
2-187	Pupillidae	*Pupoides*	*myoporinae*	65910	1 dead-taken
2-179	Pupillidae	*Gastrocopta*	cf. *larapinta*	65911	2 dead-taken
2-191	Pupillidae	*Pupoides*	*adelaidae*	65912	1 dead-taken
2-191	Pupillidae	*Gastrocopta*	cf. *larapinta*	65913	1 dead-taken
2-175	Pupillidae	*Gastrocopta*	cf. *larapinta*	65914	1 dead-taken
2-175	Pupillidae	*Gastrocopta*	*bannertonensis*	65915	2 dead-taken
19-094	Pupillidae	*Gastrocopta*	cf. *larapinta*	65916	1 dead-taken
16-176	Pupillidae	*Pupoides*	*adelaidae*	65917	6 dead-taken
16-176	Pupillidae	*Pupoides*	*myoporinae*	65918	3 dead-taken
16-176	Pupillidae	*Gastrocopta*	*bannertonensis*	65919	3 dead-taken
2-003	Pupillidae	*Pupoides*	*adelaidae*	65920	1 dead-taken
2-003	Pupillidae	*Pupoides*	*myoporinae*	65921	3 dead-taken
1-173	Pupillidae	*Pupoides*	cf. *adelaidae*	65922	1 dead-taken
16-078	Pupillidae	*Pupoides*	*adelaidae*	65923	4 dead-taken
16-078	Pupillidae	*Pupoides*	*myoporinae*	65924	2 dead-taken
20-174	Pupillidae	Pupoides	*adelaidae*	65925	1 dead-taken

Family Pupillidae

The distributional range of the family Pupillidae is almost worldwide. However the pupillid fauna of Western Australia has been poorly collected except along the main roads of the more coastal areas of the State and along the main inland roads. As most of those collected specimens were dead-taken, it has been difficult to distinguish congeneric species, because of their generally conservative shell characters.

Sub-family Pupillinae

Pupoides adelaidae (Adams & Angas, 1864)

The specimens collected during this survey most closely resemble the relatively large (height 4.38-6.8mm) dextral pupillid species *Pupoides adelaidae* (Adams & Angas, 1864). That species has a wide geographic distribution that is considered to extend from New South Wales and north-western Victoria, across southern South Australia into the wheatbelt areas of Western Australia and as far to the north-west as Morawa (Solem 1986, Solem 1991). It may possibly also extend from Shark Bay north to North West Cape on the west coast of Western Australia (Solem 1986).

Pupoides myoporinae (Tate, 1880)

The specimens collected during this survey most closely resemble the medium-sized (height 4.18-5.29mm) sinistral pupillid species *Pupoides myoporinae* (Tate, 1880). That species has a wide but apparently-disjunct distribution across most of southern Australia, with known populations extending westwards from Yalata in South Australia to Hines Hill in Western Australia, and with a more restricted eastern range from the Eyre Peninsula to Bannerton in Victoria (Solem 1986, Solem 1991).

Subfamily *Gastrocoptinae*

Gastrocopta cf. *larapinta* (Tate, 1896)

Gastrocopta larapinta is a minute dextrally-coiled species that has a wide but apparently-patchy distribution in central Australia (southern part of the Northern Territory), with a few records from the north-western region of Queensland and along its eastern coasts. There is a single published record of this species from the Oscar Range, located in the southern part of the Kimberley region of Western Australia (Pokryszko 1996).

Recently-collected specimens housed in the Mollusc Collections of the Western Australian Museum indicate that this species is widespread throughout the Pilbara region with an isolated occurrence at Lake Way to the south.

Because the Yakabindie specimens would indicate a small range extension southward for *G. larapinta*, and because there are slight differences in shell morphology, the specimens have only been tentatively identified as belonging to that species.

Subfamily *Gastrocoptinae*

Gastrocopta bannertonensis (Gabriel, 1930)

The specimens collected during this survey exhibit shell characters most consistent with those of the tiny dextral species *Gastrocopta bannertonensis* (Gabriel, 1930). This species has a wide geographic distribution in southern Australia, having been recorded from the southern regions of

Western Australia; South Australia and New South Wales. There is also an isolated record of its presence in an area to the north-west of Alice Springs in the Northern Territory (Pokryszko 1996).

Remarks

All of the species collected during this survey have, or are likely to have, wide distributional ranges.

References

Adams, A. and Angas, G.F., 1864, Descriptions of new species of shells, chiefly from Australia in the collection of Mr Angas. *Proc. Zool. Soc. Lond*. **1864**: 35-40.

Gabriel, C.J. 1930. Catalogue of the land shells of Victoria. *Proceedings of the Royal Society of Victoria* ns **43**: 62–88

Pokryszko, B.M. 1996, The Gastrocoptinae of Australia (Gastropoda: Pulmonata: Pupilloidea): systematics, distribution and origin. *Invertebrate Taxonomy* **10**: 1085-1150.

Solem, A., 1986, Pupilloid land snails from the south and mid-west coasts of Australia. *J. Malac. Soc. Aust*. **7**(3-4): 95-124

Solem, A. 1991. Distribution and diversity patterns of Australian pupilloid land snails (Mollusca: Pulmonata: Pupillidae, s.l.). *Veliger* **34**(3): 233–252

Tate, R. 1880, Descriptions of some new species of South Australia pulmonifera. *Transactions of the Royal Society of South Australia* **3**: 102–104.

Tate, R. 1896. Mollusca. pp. 181–226 *in* Spencer, W.B. (ed.). *Report on the Work of the Horn Scientific Expedition to Central Australia. Pt 2 Zoology*. London & Melbourne : Melville, Mullen & Slade.

Appendix A. Locality data from *Outback Ecology's* survey of the Yakabindie area during January 2011.

Station	Latitude	Longitude	Survey Date	Collector	Collecting Method	Habitat
2-187	27°25`27.5"S	120°34`53.3"E	10/01/2011	Rakimov, A.	Sieved soil	Drainage Line
2-179	27°25`27.5"S	120°34`53.3"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage Line
2-191	27°25`27.5"S	120°34`53.3"E	10/01/2011	Rakimov, A.	Sieved soil	Drainage Line
2-175	27°25`27.5"S	120°34`53.3"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage Line
19-094	27°24`44.4"S	120°35`18.7"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage Line
16-176	27°28`09.5"S	120°34`51.1"E	10/01/2011	Rakimov, A.	Leaf litter	Mulga on sand
2-003	27°25`27.5"S	120°34`53.3"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage line
1-173	27°25`36.3"S	120°34`22.5"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage line
16-078	27°28`09.5"S	120°34`51.1"E	10/01/2011	Rakimov, A.	Leaf litter	Mulga on sand
20-174	27°27`24.7"S	120°35`28.0"E	10/01/2011	Rakimov, A.	Leaf litter	Drainage Line

Biota Environmental Sciences

Biota (n): The living creatures of an area; the flora and fauna together

19 October 2016

Kylie McKay
Environmental Specialist
Nickel West
Via email

Dear Kylie

Black-flanked Rock Wallaby – Indicative Habitat

Background

Black-flanked Rock Wallaby populations are presumed to be locally extinct throughout much of their former range (Woinarski et al 2014), including that part of central Western Australia adjacent to the proposed Yakabindie Nickel Project. A sighting of two wallabies on the Barr Smith Range at a site 25 km to the north-west of the proposed Yakabindie mine area by Geoff Cockerton in 2006 (pers. comm. 2006) (see Figure 1) prompted further investigation by Biota staff (on-site at the time) who collected numerous rock wallaby scats and lodged them with the WA Museum (see Biota 2016 and reference therein). The site was later visited by Dr. David Pearson of DPaW who also confirmed the scats to belong to rock wallabies. In 2010, Dr. Mike Bamford (consultant) independently visited the location and collected scats, which were identified as rock wallaby scats (Bamford 2011). In 2015, Dr. Bamford again visited the cave to collect more scats this time for molecular analyses, with the subsequent result indicating that they most likely belonged to *Petrogale lateralis lateralis* (Bamford 2015). A recent discovery of an extant population of *P. lateralis* at Kalbarri National Park indicates that small populations can go overlooked even at localities that are relatively frequently visited.

The current conservation status of the Black-flanked Rock Wallaby in Western Australia is Endangered (Schedule 2) with the species is considered to be facing a very high risk of extinction in the wild. Federally, the species is listed as Vulnerable.

An extension of the breakaway landform of the Barr Smith Range (Figure 1 and Plates 1 and 2) intersects an indicative haul road route associated with the proposed Yakabindie Nickel Project. Based on the relatively recent records of rock wallabies (from the location 25 km to the north-west of the proposed mine area), BHP Billiton commissioned Biota Environmental Science to undertake an indicative habitat mapping exercise within the broader locality surrounding the Yakabindie Nickel Project.

Level 1 228 Carr Place Leederville WA 6007 | PO Box 155 Leederville WA 6903 | T: (08) 9328 1900 | F: (08) 9328 6138
E: biota@biota.net.au | W: www.biota.net.au

Plate 1. Breakaway habitat from the Yakabindie Project study area showing free face (photo by Geoff Cockerton).

Plate 2. Breakaway habitat from the Yakabindie Project study area (Photo by Geoff Cockerton)

Mapping Exercise

The current study area (i.e. extent of mapping) buffers the Yakabindie Nickel Project boundary by 25 km and extends 25 km to the north of the 2006 sighting (at 120°27'0.54"E, 27°14'27.81"S) (Figure 1). The primary rock-wallaby habitat in this buffered area comprises the breakaway landform associated with the Barr Smith Range. Mapping of this potential habitat was achieved by viewing available Google Earth (https://www.google.com/earth/) imagery and whilst it indicates a largely contiguous length of breakaway, not all of this habitat is suitable for rock wallabies. Rather, only those sections with caves or sufficiently deep and protected overhangs are likely to represent core habitat.

The linear extent of mapped breakaway within the study area is approximately 65 km in length and represents a combined area of approximately 30 km^2. Regionally, Hall and Milewski (1994) described breakaways as common throughout the Sandstone-Sir Samuel area, comprising weathered granite faces punctuated by shallow caves and overhangs.

Within the Yakabindie Project study area, vegetation below the eroding face of the breakaway formation is typically mapped as Breakaway Chenopod Plains (Cockerton 2016). Above the eroding face, vegetation varies depending on the soil characteristics.

Plate 2. Breakaway Chenopod Shrublands.

The current status of the Black-flanked Rock Wallaby in the study area and the Yakabindie Nickel Project area is unknown.

References

Bamford Consulting Ecologists (2011). Vertebrate Fauna Assessment Yeelirrie Project. Baseline Report. Unpublished report for URS Australia Pty Ltd.

Bamford Consulting Ecologists (2015). Yeelirrie Terrestrial Vertebrate Fauna Report. An unpublished report for Cameco Australia Pty Ltd.

Biota (2016). Yakabindie Section 18 Fauna Assemblage and Habitats Review. Unpublished report prepared for BHP Billiton.

Hall and Milewski (1994). In: *The Biological Survey of the Eastern Goldfields of Western Australia. Part 10: Sandstone – Sir Samuel and Laverton – Leonora Study Areas.* (eds: Hall N.J. McKenzie N.L. and Keighery G.J.). Western Australian Museum, Perth Western Australia.

Woinarski J. C. Z., Burbidge A. A. & Harrison P. (2014). The action plan for Australian mammals 2012. CSIRO Publishing, Melbourne. Ecological Society of Australia.