Fauna Survey Report

Lake Disappointment

Potash Project

Reward Minerals Ltd

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FINAL

On behalf of:
Reward Minerals Limited
PO Box 1104
NEDLANDS WA 6909
T: (08) 9386 4699
E: admin@rewardminerals.com

Prepared by:
Greg Harewood
Zoologist
PO Box 755
BUNBURY WA 6231
M: 0402 141 197
E: gharewood@iinet.net.au

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Acronyms/Abbreviations:

ALA: Atlas of Living Australia www.ala.org.au

BA: Birdlife Australia (Formerly RAOU, Birds Australia).

BC Bill: Biodiversity Conservation Bill (2015). WA Government.

°C: Degrees Celsius.

CALM: Department of Conservation and Land Management (now DBCA), WA Government.

CAMBA: China Australia Migratory Bird Agreement 1998.

CBD: Central Business District.

DBCA: Department of Biodiversity, Conservation and Attractions (formerly DPaW, DEC, CALM, DoE), WA Government

DBH: Diametre at Breast Height – tree measurement.

DEC: Department of Environment and Conservation (now DBCA), WA Government.

DEH: Department of Environment and Heritage (now DotEE), Australian Government.

DEP: Department of Environment Protection (now DER), WA Government.

DER: Department of Environment Regulation (now DWER), WA Government.

DEWHA: Department of the Environment, Water, Heritage and the Arts (now DotEE), Australian Government

DMP: Department of Mines and Petroleum (formerly DoIR), WA Government.

DoE: Department of Environment (now DER/DBCA), WA Government.

DoP: Department of Planning, WA Government.

DotE: Department of the Environment (now DotEE), Australian Government.

DotEE: Department of the Environment and Energy (formerly SEWPaC, DWEHA, DEH & DotE), Australian Government.

DoIR: Department of Industry and Resources (now DMP), WA Government.

DoW: Department of Water (now DWER), WA Government.

DPaW: Department of Parks and Wildlife (now DBCA), WA Government.

DWER: Department of Water and Environmental Regulation (formed by the amalgamation of OEPA, DoW and DER), WA Government.

EP Act: *Environmental Protection Act 1986*, WA Government.

EPA: Environmental Protection Authority, WA Government.

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999,* Australian Government.

ha: Hectare (10,000 square metres).

IBRA: Interim Biogeographic Regionalisation for Australia.

IUCN: International Union for the Conservation of Nature and Natural Resources – commonly known as the World Conservation Union.

JAMBA: Japan Australia Migratory Bird Agreement 1981.

km: Kilometre.

m: Metre.

mm: Millimetre.

P: Priority - DBCA fauna conservation ranking.

POS: Public Open Space.

RAOU: Royal Australia Ornithologist Union.

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement 2007.

S: Schedule - Western Australian *Wildlife Conservation Act (1950)* Threatened Fauna Category.

SEWPaC: Department of Sustainability, Environment, Water, Population and Communities (now DotEE), Australian Government.

SRE: Short Range Endemic.

SSC: Species Survival Commission, International.

WA: Western Australia.

WAM: Western Australian Museum, WA Government.

WAPC: Western Australian Planning Commission, WA Government.

WC Act: *Wildlife Conservation Act 1950*, WA Government.

SUMMARY

This report details the results of a series of terrestrial fauna surveys carried out as part of Reward Minerals Limited's (Reward) proposed Lake Disappointment Potash (LDP) Project situated in the Little Sandy Desert, approximately 180km south of Telfer and 285km east of Newman, Western Australia (Figures 1 & 2).

The various fauna surveys reported on here have been carried out to provide baseline fauna datasets for areas within and near potential mine and associated infrastructure areas, borefields and along sections of the Willjabu and Talawana Tracks.

The surveys carried out to date have recorded 206 native and seven introduced vertebrate species. The identified native assemblage includes nine species of frog, 59 species of reptiles, 116 species of birds and 22 mammals (includes 10 species of bat). Evidence of 15 species of conservation significance was recorded in or near the defined study area (in addition to two species of local conservation significance), these being:

- Lake Disappointment gecko (*Diplodactylus fulleri*) (P2);
- Unpatterned robust lerista (*Lerista macropisthopus remota*) (P2);
- Lake Disappointment dragon (*Ctenophorus nguyarna*) (local conservation significance);
- Eastern great egret (*Ardea modesta)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Sharp-tailed sandpiper (*Calidris acuminate*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Pectoral sandpiper (*Calidris melanotos*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Red-necked stint (*Calidris ruficollis*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Common greenshank (*Tringa nebularia*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Marsh sandpiper (*Tringa glareola)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Peregrine falcon (*Falco peregrinus*) - S7 (*WC Act*);
- Princess parrot (*Polytelis alexandrae*) - P4 (DBCA Priority Species), Vulnerable (*EPBC Act*);
- Night Parrot (*Pezoporus occidentalis)* – S1 *(WC Act),* Endangered *(EPBC Act);*
- Striated grasswren (sandplain) (*Amytornis striatus striatus*) – P4 (DBCA Priority Species);
- Rainbow bee-eater (*Merops ornatus*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Banded stilt (*Cladorhynchus leucocephalus*) - local conservation significance;

- Northern marsupial mole (*Notoryctes caurinus*) - P4 (DBCA Priority Species);
- Greater bilby (*Macrotis lagotis*) - S3 (*WC Act*), Vulnerable (*EPBC Act*).

One hundred and five individual invertebrate specimens from groups often representing SREs were collected during the fauna and targeted invertebrate surveys carried out. None of the invertebrates collected were confirmed as SREs, however 14 of the species have been classified as potential SREs by invertebrate taxonomists, based primarily on the fact that often other members of the same genus are SREs. All 14 of the potential SREs collected were from sand dune/sand plain habitat which is widespread outside the study area.

An additional 70 samples of invertebrates were collected during the November 2014 invertebrate survey on a section of lake bed. The invertebrate collection contained five species from 27 samples that are considered to be potential SRE's. Two of these species fall within 'traditional' SRE groups: *Lychas* 'lake disappointment' (scorpion) and *Indolpium* 'lake disappointment' (pseudoscorpion). An additional three species were noted as being potential salt lake specialist SRE's: Lepismatidae sp. indet., (silverfish); Lycosidae sp. Indet., (wolf spider), and *Megacephala murchisona*, (tiger beetle).

1. INTRODUCTION

1.1 BACKGROUND

This report details the results of a series of terrestrial fauna surveys carried out as part of Reward Minerals Limited (Reward) Lake Disappointment Potash (LDP) Project situated in the Little Sandy Desert, approximately 180km south of Telfer and 285km east of Newman, Western Australia (Figures 1 & 2).

Exploration work to date by Reward has identified a potential economic resource of potassium sulphate (SOP or "potash") in hypersaline brine contained within the lakebed sediment. To capture the resource, it is envisaged that the brine will be extracted via a series of trenches across the lake and then fed into evaporation ponds, which will be constructed on the playa surface.

The various fauna surveys reported on here were carried out to provide baseline fauna datasets for areas within and near proposed mine and associated infrastructure areas, borefields and along sections of the Willjabu and Talawana Tracks, with a primary focus on identifying any significant impacts on fauna species of conservation significance.

To date the following field surveys and assessments have been carried out:

- Targeted Fauna Survey (October 2012) - Proposed Access Track, Camp Site and Borrow Pit;
- Phase 1 Level 2 Fauna Survey (including targeted surveys) (May 2013) – Lake Disappointment and Willjabu Track;
- Phase 2 Level 2 Fauna Survey (including targeted surveys) (October 2013) - Lake Disappointment and Willjabu Track;
- Marsupial Mole Monitoring Survey (April 2014) – Willjabu Track.
- Phase 3 Level 2 Fauna Survey (including targeted surveys) (October 2016) – Borefield areas and some regional bat surveys (Durba Springs, McKay Range and Desert Queens Baths);
- Phase 4 Level 2 Fauna Survey (including targeted surveys) (March 2017) - Borefield areas and Lake Disappointment;
- Conservation Significant Vertebrate Fauna Assessment (Desktop Review) (February 2017) – Talawana Track; and
- Targeted Fauna Survey (June 2017) – Talawana Track, Willjabu Track and Lake Disappointment.

This report summarises the methods and results of the four phases of Level 2 fauna surveys and of the targeted survey carried out in June 2017. The additional surveys and assessments

are detailed in previous reports (Harewood 2012, 2015 and 2017), although relevant results are taken into consideration here.

It is anticipated that ultimately the survey results will be taken into consideration by State and Federal environmental regulatory authorities when assessing the project. The results have also helped to characterise the level of uncertainty surrounding fauna and habitat values and to define any remaining information gaps."

1.2 STUDY AREA

The fauna surveys (with the exception of some bat surveys) were carried out within a study area which covers about 134,800 ha (of which 70,567ha is covered by Lake Disappointment), the boundary of which is shown in all figures. The study area extends eastwards along the western 220km section of the Talawana Track, then southwards along the Willjabu Track (including adjoining borefield areas) and then over and around the northern and western sections of Lake Disappointment (Figures 1 and 2). The area surveyed fully encompasses the proposed Lake Disappointment project 'development envelope' and the proposed 'disturbance footprint' that would be occupied by project infrastructure.

It should be noted that access to some locations in the Lake Disappointment area was restricted, even for the purpose of non-destructive scientific surveys. These exclusion zones were defined at the request of the traditional owners (the Martu People) where currently no on ground access is permitted to Reward personnel. The exclusion zones include an area around Savory Creek where it enters the Lake, the majority of the eastern and south eastern section of the Lake and a 100m buffer around all islands contained within the boundaries of the Lake. No part of the project's proposed development envelope encroaches on the Aboriginal heritage exclusion zone.

1.3 SURVEY SCOPE

The scopes of the fauna surveys reported on here were to:

- document the vertebrate fauna assemblages within the habitats of the study area using established sampling techniques; and
- identify fauna of conservation significance (particularly state and federally listed threatened, migratory and priority fauna species) present or potentially present within the areas surveyed;

To comply with the scope of works and the likely requirements of environmental regulatory authorities the survey documented in this report was planned and implemented in accordance with:

- EPA (2016a). Statement of Environmental Principles, Factors and Objectives;
- EPA (2016b). Environmental Factor Guideline – Terrestrial Fauna Assessment;
- EPA (2016c). Technical Guidance – Terrestrial Vertebrate Fauna Surveys (replaces EPA (2004). Guidance for the Assessment of Environmental Factors No 56: Terrestrial Surveys for Environmental Impact Assessment, but not yet updated);

- EPA (2016d). Technical Guidance – Sampling Methods for Terrestrial Vertebrate Fauna (replaces EPA & DEC (2010). Technical Guide - Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment, but not yet updated);

- Department of Environment, Water, Heritage and the Arts (DEWHA) (2010a). Survey guidelines for Australia's threatened bats. Guidelines for detecting bats listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory;

- Department of Environment, Water, Heritage and the Arts (DEWHA) (2010b). Survey guidelines for Australia's threatened birds. Guidelines for detecting birds listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory;

- Department of Parks and Wildlife (2017). Interim guideline for preliminary surveys of night parrot (*Pezoporus occidentalis*) in Western Australia. Version 1 May 2017.

- Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) (2011a). Survey guidelines for Australia's threatened mammals. Guidelines for detecting mammals listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999.* Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory;

- Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) (2011b). Survey guidelines for Australia's threatened reptiles. Guidelines for detecting reptiles listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory.

2. METHODS

2.1 FAUNA INVENTORY – LITERATURE REVIEW

2.1.1 Database Searches

Searches of the following databases were undertaken to aid in the compilation of a list of vertebrate fauna potentially occurring within the study area:

- DBCA's NatureMap Database Search (combined data from DBCA, Western Australian Museum, Birds Australia and consultant's reports) (DBCA 2017); and

- DotEE Protected matters search tool (DotEE 2017).

It should be noted that these lists are based on observations from a broader region than the study area and therefore may include species that would only ever occur as vagrants in the

actual study area due to a lack of suitable habitat or the presence of only marginal habitat. The databases also often included very old records and in some cases the species in question have become locally or regionally extinct.

Information from these sources should therefore be taken as indicative only and local knowledge and information needs also to be taken into consideration when determining what actual species may be present within the specific area being investigated.

2.1.2 Previous Fauna Surveys in the Area

Very few fauna surveys, assessments and reviews have been undertaken in nearby areas in the past. The available reports have been used to assist in compiling the potential fauna assemblage for the general area. Those reports referred to included, but were not limited to:

- Actis Environmental and Alexander Holm & Associates (2009). Lake Disappointment Potash Project Environmental Review and Program of Works. Unpublished report for Reward Minerals.
- Bamford, M.J & A.R. (2007). Kintyre Project Area. Fauna observations from site visit, October 2007. Unpublished report for Canning Resources.
- Bamford Consulting Ecologists (2010). Kintyre Project Area Review of Vertebrate Fauna. Unpublished report for Cameco Australia Pty Ltd.
- Bamford Consulting Ecologists (2011). Targeted fauna survey for the proposed Kintyre haul route. Unpublished report for Cameco Australia Pty Ltd.
- Bennelongia Environmental Consultants (2016). Ecological Character of Lake Disappointment. Unpublished report for Reward Minerals. June 2016.
- Bennelongia Environmental Consultants (2017). Aquatic Ecology and Waterbirds at Lake Disappointment: Additional Studies. Unpublished report for Reward Minerals. July 2017 (Draft).
- Blyth, J., A. Burbidge & W. Boles (1997). Report on an expedition to the western desert and eastern Pilbara areas in search of the Night Parrot *Pezoporus occidentalis*. Eclectus. 2:25-30.
- Browne-Cooper, R. & Bamford, M. (2010). Targeted fauna survey for the proposed Kintyre Uranium Mine Project. Unpublished report for Cameco Australia Pty Ltd.
- Davies, S.J.J.F., M. Bamford & M. Bamford (1988). The Night Parrot: a search in the Lake Disappointment area, September 1987. Royal Australasian Ornithologists Union Report (RAOU) Series. 49. Melbourne.
- Hart Simpson and Associates Pty Ltd (1994). Kintyre Project. Fauna studies 1986 to 1992. Unpublished report for Canning Resources.
- Start, A. N. *et al.* (2013). Terrestrial mammals of the south-western Little Sandy Desert, Western Australia Australian Mammalogy, 2013, 35, 54–64.

As with the database searches, some reports consulted refer to species that would not occur in the Lake Disappointment study area due to a lack of suitable habitat (extent and/or quality) and this fact was taken into consideration when compiling the potential fauna species list for the study area. It should also be noted that the NatureMap database is likely to include some records from previous fauna surveys in the area including some of those listed above.

2.1.3 Existing Publications

The following represent the main publications used to identify and refine the potential fauna species list for the study area:

- Anstis, M. (2013). Tadpoles and Frogs of Australia. New Holland Publishers, Sydney.
- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. (2003). The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Victoria.
- Bush, B. and Maryan, B. (2011). Field Guide to Snakes of the Pilbara, Western Australia. WA Museum, Perth.
- Churchill, S. (2008). Australian Bats. Second Edition, Allen & Unwin.
- Cogger, H.G. (2014). Reptiles and Amphibians of Australia. 7th Edition. CSIRO Publishing.
- Johnstone, R.E. and Storr, G.M. (1998). Handbook of Western Australian Birds: Volume 1 – Non-passerines (Emu to Dollarbird). Western Australian Museum, Perth Western Australia.
- Johnstone, R.E. and Storr, G.M. (2004). Handbook of Western Australian Birds: Volume 2 – Passerines (Blue-winged Pitta to Goldfinch). Western Australian Museum, Perth Western Australia.
- Menkhorst, P. and Knight, F. (2011). A Field Guide to the Mammals of Australia. Third Edition, Oxford University Press, Melbourne.
- Pizzey, G & Knight, F. (2012). The Field Guide to the Birds of Australia. 9th Edition. Harper Collins, Sydney.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1983). Lizards of Western Australia II: Dragons and Monitors. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1990). Lizards of Western Australia III: Geckos and Pygopods. WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (1999). Lizards of Western Australia I: Skinks. Revised Edition, WA Museum, Perth.
- Storr, G.M., Smith, L.A. and Johnstone R.E. (2002). Snakes of Western Australia. Revised Edition, WA Museum, Perth.

- Tyler M.J. & Doughty P. (2009). Field Guide to Frogs of Western Australia, Fourth Edition, WA Museum, Perth.
- Van Dyck, S., Gynther, I. & Baker, A. Eds (2013). Field Companion to The Mammals of Australia. Queensland Museum.
- Van Dyck, S. & Strahan, R. Eds (2008). The Mammals of Australia. Third edition. Queensland Museum.
- Wilson, S. and Swan, G. (2013). A Complete Guide to Reptiles of Australia. Third Edition, Reed, New Holland, Sydney.
- Woinarski, J., Burbidge, A. & Harrison, P. (2014). The Action Plan for Australian Mammals 2012. CSIRO Publishing.

2.2 FAUNA INVENTORY - FAUNA SURVEYS

2.2.1 Survey Timing and Weather

Table 1 below shows the daily weather records from the Telfer Aero Weather Station (located approximately 180km north-west of the Project area) during the Level 2 survey periods (when trapping was undertaken) and during the targeted fauna survey.

Because of the distance of the weather station from the actual study area the climate data presented only represents an approximate indication of the prevailing conditions on site at the time of each survey.

It should also be noted that while no rainfall was recorded during the first three survey periods, significant rainfall, well above the monthly average was recorded at Telfer in the month of February 2013, two months prior to the Phase 1 survey. The average for this month is just over 100mm but during February 2013, 300 mm was recorded at Telfer. This appears to have resulted in the significant inundation of sections of Lake Disappointment and nearby freshwater claypans, with many of these areas still containing substantial quantities of water during the May 2013 survey period. This same scenario occurred in January 2017 (when ~382 mm was recorded at Telfer) and resulted in a significant inundation of Lake Disappointment and claypans in the area which was still present during the March 2017 survey period.

The Lake was almost completely dry during the October 2013 and October 2016 survey periods with only small areas of water present in the deepest sections and only a small number of claypans were observed to contain water.

Table 1: Daily Temperatures and Rainfall at the Telfer Aero Weather Station (013030) During Survey Periods (BOM 2017).

Survey	Date	Min (°C)	Max (°C)	Rainfall (mm)
Level 2 Survey Phase 1	1/05/2013	18.0	36.4	0.0
	2/05/2013	16.3	36.1	0.0
	3/05/2013	15.9	35.9	0.0
	4/05/2013	19.5	35.9	0.0
	5/05/2013	20.4	36.2	0.0
	6/05/2013	21.3	35.7	0.0
	7/05/2013	20.7	36.6	0.0
	8/05/2013	20.2	35.5	0.0
	9/05/2013	23.2	30.9	0.0
	10/05/2013	21.7	32.2	0.0
Level 2 Survey Phase 2	16/10/2013	22.5	39.3	0.0
	17/10/2013	21.8	39.7	0.0
	18/10/2013	21.0	41.1	0.0
	19/10/2013	26.7	41.3	0.0
	20/10/2013	26.0	40.7	0.0
	21/10/2013	26.4	33.2	0.0
	22/10/2013	20.1	32.4	0.0
	23/10/2013	20.8	37.3	0.0
	24/10/2013	19.0	38.6	0.0
Level 2 Survey Phase 3	11/10/2016	21.9	36.5	0.0
	12/10/2016	21.4	38.5	0.0
	13/10/2016	22.3	39.7	0.0
	14/10/2016	23.7	39.8	0.0
	15/10/2016	22.1	41.7	0.0
	16/10/2016	23.3	31.1	0.0
	17/10/2016	16.1	30.8	0.0
	18/10/2016	17.1	33.5	0.0
	19/10/2016	22.6	39.2	0.0
Level 2 Survey Phase 4	09/03/2017	22.5	33.7	0.0
	10/03/2017	24.3	34.4	0.8
	11/03/2017	23.3	33.2	11.0
	12/03/2017	25.7	34.3	0.0
	13/03/2017	22.4	34.7	13.2
	14/03/2017	23.9	36.9	0.8
	15/03/2017	27.9	38.8	0.0
	16/03/2017	28.3	39.9	0.0
Targeted Fauna Survey	16/06/2017	13.9	27.9	0.0
	17/06/2017	12.5	27.9	0.0
	18/06/2017	13.5	27.4	0.0
	19/06/2017	11.0	26.6	0.0
	20/06/2017	13.2	27.7	0.0
	21/06/2017	14.0	29.2	0.0
	2206/2017	11.8	30.5	0.0
	23/06/2017	15.0	30.0	0.0
	24/06/2017	18.2	29.7	0.0

2.2.2 Survey Team

The Level 2 trapping surveys were carried out under a "Licence to Take Fauna for Scientific Purposes" issued by the DBCA (Phase 1 - SF 009217, Phase 2 - SF 009514, Phase 3 & 4 – 01-000018-1).

The Phase 1 fauna survey team comprised Greg Harewood, Glen Murray and George Swann. The Phase 2 fauna survey team comprised Greg Harewood, Glen Murray and Michael Brown. Phase 3 was carried out by Greg Harewood and Glen Murray and Phase 4 by Greg Harewood and Mathew Newlands.

The June 2017 targeted survey was carried out by Greg Harewood and George Swann.

Analysis of bat recordings was completed by Mr Bob Bullen (Bat Call WA). Invertebrate identifications were undertaken by Phoenix Environmental Sciences and Alacran Environmental Sciences.

2.2.3 Site Selection

The sampling approach for the Level 2 surveys consisted of a combination of systematic fauna sampling and targeted/opportunistic searches within the range of habitats present within the defined study area.

The systematic component of the fauna survey involved the establishment of eight trap sites (TS 1 to 8) on the edge of Lake Disappointment and along Willjabu Track which were used during Phase 1 and 2 and then another four traps sites (TS 9 to 12) within proposed borefields which were used during Phase 3 and 4 (Table 2 and Figure 3). Sites were selected to provide representative examples of the major vegetation communities and landforms present within the study area, though logistics (i.e. ease of access and travel time) also had to be considered.

Table 2: Trap Sites within the Study Area

Trap Site	Description	Example Image
1	Interdunal flats. Scrub of *Acacia cuthbertsonii* over low scrub of *Eremophila latrobei* and mid-dense hummock grass of *Triodia basedowii.*	

Trap Site	Description	Example Image
2	Riparian salt playa edge. Heath of *Tecticornia* spp.	
3	Dune crest. Open low woodland of *Corymbia opaca* over low scrub *of Acacia ligulata*/*Grevillea juncifolia* and mid-dense hummock grass of *Triodia basedowii.*	
4	Dune crest. Open low woodland of *Corymbia opaca* over low scrub *of Acacia ligulata*/*Grevillea juncifolia* and mid-dense hummock grass of *Triodia basedowii* on sand dunes	
5	Interdunal flats – adjacent to freshwater claypan. Scrub of *Acacia cuthbertsonii* over low scrub of *Eremophila latrobei* and mid-dense hummock grass of *Triodia basedowii* over open herbs of *Glossostigma diandrum*, *Lepidium pholidogynum* and *Stylidium desertorum*.	

Trap Site	Description	Example Image
6	Minor drainage line through a low gypcrete rise near edge of playa. Low scrub of *Acacia ligulata*/*Grevillea juncifolia* over mid-dense hummock grass of *Triodia basedowii*	
7	Interdunal flats. Low scrub of *Acacia ligulata*/*Grevillea juncifolia* over mid-dense hummock grass of *Triodia basedowii*	
8	Interdunal flats. Low scrub *of Acacia ligulata*/*Grevillea juncifolia* and mid-dense hummock grass of *Triodia basedowii*.	
9	Dune crest. Open low woodland of *Corymbia opaca* over low scrub *of Acacia ligulata*/*Grevillea juncifolia* and mid-dense hummock grass of *Triodia basedowii* on sand dunes.	

Trap Site	Description	Example Image
10	Interdunal Swale/Sand Plain. Open low woodland of *Corymbia opaca* over low scrub *of Acacia ligulata*/*Grevillea juncifolia* and mid-dense hummock grass of *Triodia basedowii* on swale/sand plain.	
11	Sandplain. Open low woodland of *Corymbia* spp./ *Hakea lorea* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia* spp. in sandplain.	
12	Creekline. Open low woodland of *Eucalyptus camaldulensis*/ *Corymbia* spp. and Low woodland of *Acacia* spp. over low scrub of *Senna artemisioides* and mixed dwarf scrub in drainage depression in creekline.	

2.2.4 Ground Fauna Survey

To provide information on the abundance and distribution of ground fauna present (i.e. small mammals, reptile and amphibian species), trapping, utilising a combination of cage traps and Elliott traps (to target mammal species), fly wire drift fences with associated pit fall traps (to target small mammals, reptile and amphibian species) and funnel traps (to target larger reptile species) were utilised at each of the main trap sites detailed above.

Each of the 12 trap sites was comprised of 10 trap arrays. Each trap array consisted of a ~7m long, 30 cm high fly wire drift fence with a centrally located pit trap (20L bucket) dug in underneath with one funnel trap located at each end. One Elliott (A) and/or Elliot (B)/cage trap

was also placed in the vicinity of each trap array. Elliot traps were baited with "universal bait" (a mixture of peanut butter, rolled oats and sardines).

Pit traps installed during the Phase 1 survey (TS 1 to 8) were left in place (sealed with a lid and secured with a pile of sand) for re-use during the Phase 2 survey. Pit traps installed during the Phase 3 survey (TS 9 to 12) were left in place (sealed with a lid and secured with a pile of sand) for re-use during the Phase 4 survey.

During Phase 1 and 2 trapping utilised 80 Elliott (A) traps, 16 Elliot (B) or cage traps, 80 (20L) buckets and 160 funnel traps. During Phase 3 and 4 trapping utilised 40 Elliott (A) or (B) traps, 40 (20L) buckets and 80 funnel traps

All traps were left open for seven nights during each phase with the exception of trap site 8 where traps were only open for six nights, during Phase 1. In total 6,902 trap night were completed.

A summary of trap nights carried out during each phase is provided in Table 3 and 4 below. The location of trap sites is shown in Figure 3. Additional details on trap locations (i.e. coordinates, dates open) are provided in Appendix B.

Table 3: Summary of Trap Nights – Phase 1 & 2 (2013)

	Site Number	# Nights for Elliott (A) Traps	# Nights for Elliott (B) or Cage Traps	# Nights for Funnel Traps	# Nights for Bucket Pit Traps	Total # Trap Nights
PHASE 1 MAY 2013	1	70	14	140	70	294
	2	70	14	140	70	294
	3	70	14	140	70	294
	4	70	14	140	70	294
	5	70	14	140	70	294
	6	70	14	140	70	294
	7	70	14	140	70	294
	8	60	12	120	60	252
	Total	**550**	**110**	**1,100**	**550**	**2,310**
PHASE 2 OCTOBER 2013	1	70	14	140	70	294
	2	70	14	140	70	294
	3	70	14	140	70	294
	4	70	14	140	70	294
	5	70	14	140	70	294
	6	70	14	140	70	294
	7	70	14	140	70	294
	8	70	14	140	70	294
	Total	**560**	**112**	**1,120**	**560**	**2,352**
	Grand Total	**1,110**	**222**	**2,220**	**1,110**	**4,662**

Table 4: Summary of Trap Nights – Phase 3 & 4 (2016/17)

	Site Number	# Nights for Elliott (A) Traps	# Nights for Elliott (B) or Cage Traps	# Nights for Funnel Traps	# Nights for Bucket Pit Traps	Total # Trap Nights
PHASE 3 Oct 2016	9	49	21	140	70	280
	10	49	21	140	70	280
	11	49	21	140	70	280
	12	49	21	140	70	280
	Total	**196**	**84**	**560**	**280**	**1,120**
PHASE 4 Mar 2017	9	49	21	140	70	280
	10	49	21	140	70	280
	11	49	21	140	70	280
	12	49	21	140	70	280
	Total	**196**	**84**	**560**	**280**	**1,120**
	Grand Total	**392**	**168**	**1,120**	**560**	**2,240**

2.2.5 Bird Surveys

Sampling of avifauna was carried out using a combination of techniques, including:

- 20 minute unbounded surveys conducted at each of the systematic sampling grids (i.e. Trap Sites 1 to 8) on several occasions;
- Traverses on foot between trap sites and within potential infrastructure areas;
- Bird counts at freshwater wetlands and selected sites in and around Lake Disappointment (supplemented by those carried out by Bennelongia in January 2016 and March 2017);
- Banded Stilt breeding colony survey (supplemented by those carried out by Bennelongia in March 2017). It is understood that DBCA also carried out a survey of breeding waterbirds at Lake Disappointment at this time, though detailed results are not available; and
- Opportunistic observations of avifauna during other survey activities within and around the study area (random during all field surveys).

2.2.6 Acoustic Bat Recordings

A series of bat call surveys have been undertaken in various sections of the entire LDP project area and in some regional locations to date. The surveys have been undertaken at the following locations and dates:

- Phase 1 fauna survey (May 2013): recordings were taken over six nights at six locations along or near the Willjabu Track from McKay Creek to Lake Disappointment (Harewood 2016).

- Phase 2 fauna survey (October 2013): recordings were taken over four nights at four locations along or near the Willjabu Track from McKay Creek to Lake Disappointment (Harewood 2016).

- Phase 3 fauna survey (October 2016): recordings taken at McKay Creek (near the Willjabu Track), McKay Range (just south of Talawana Track) and at two regional locations: Durba Springs (Durba Hills) and Desert Queens Baths (Broadhurst Range – Karlamilyi National Park).

- Talawana Track Botanical Survey (December 2016): recordings were taken over two nights at two locations along the Talawana Track.

- Phase 4 fauna survey (March 2017): recordings were taken over two nights at two locations near McKay Creek/Talawana Track/northern Willjabu Track.

- Targeted fauna survey (June 2017): recordings were taken over 21 nights at five locations along the Talawana Track and at the proposed plant site near Lake Disappointment.

The acoustic bat recordings were undertaken using a Wildlife Acoustics SM2+ Bat Detector set to operate from sunset to sunrise in each instance. The detectors convert ultrasonic echolocation signals produced by bats into audible electronic signals that are then recorded. The recordings were later processed by Bob Bullen (Bat Call WA Pty Ltd) to determine the presence of species specific calls.

2.2.7 Motion Sensing Cameras

Motion sensing cameras were deployed in various numbers during the course of all survey work. Forty one “camera traps” were placed at various locations within the study area during the Phase 1 survey (May 2013) and left in place for about 170 days of operation. These were retrieved during the Phase 2 survey (October 2013) with 15 being re-deployed for about 10 days at this time.

During the Phase 3 fauna survey (October 2016) six camera traps were placed at various locations within the LDP project area and retrieved in March 2013. In December 2016, and additional 26 cameras were placed mainly at various locations along the Talawana Track. These were all retrieved in March 2017 (~90 days operation).

Twelve cameras were also utilised over a 10 day period in June 2017.

The location of cameras is shown in Figure 4 with additional details (i.e. coordinates) provided in Appendix B.

2.2.8 Spotlighting/Head Torching

Nocturnal surveys were carried out at selected trapping sites with the aim of locating nocturnal species that may be difficult to detect using alternative techniques. Vehicle transects were also carried out over five nights (one or two during each phase) along sections Willjabu Track and along the Talawana Track.

2.2.9 Targeted and Opportunistic Surveys

During the course of all the survey work non-systematic opportunistic observations of fauna species were made and recorded. Secondary evidence of fauna such as tracks, diggings and scats were also noted.

At each trapping site microhabitats were actively searched with the aim of locating the more cryptic fauna species (including invertebrates) that may inhabit the site. Searches included but were not limited to investigating burrows, investigating scats, tracks and other traces, turning fallen timber and rocks, opening standing timber crevices, peeling bark and raking leaf litter.

Additional targeted surveys were carried out during the June 2017 nigh parrot survey (see section 2.2.10) for evidence of the great desert skink, the greater bilby and the brush-tailed mulgara. On foot transects were carried out across proposed clearing areas of the Talawana Track and the Processing Plant Site while searching for signs of activity, including burrows, tracks, scats and diggings.

2.2.10 Night Parrot Survey

In June 2017 a targeted survey for the night parrot (*Pezoporus occidentalis*) carried out in accordance with “interim” guidelines issued by DBCA (DPaW 2017) was undertaken. The surveys were undertaken in areas of apparently suitable habitat along the Talawana Track, Willjabu Track, the proposed processing plant site and around the edge of lake Disappointment north of Savory Creek (outside of the exclusion zone).

The survey included:

- passive acoustic surveys;
- listening surveys by experienced observers; and
- targeted and area searches around waterholes/bores while looking for night parrot feathers.

The surveys were carried out in areas of most likely roosting and nesting habitat (e.g. long unburnt spinifex, in particular near areas of healthy stands of samphire, if present) located within the defined study area and any other location in close proximity to proposed development areas or Lake Disappointment).

Passive call detection using automated recording units (ARUs) was undertaken using Wildlife Acoustic SM2+ and SM4 recorders (eight in total). Seven of these units were placed in areas of suitable habitat and left to record for six nights in accordance with DBCA guidelines (DPaW 2017). One “roving” ARU was also deployed and moved to a new location each night. In total 14 sites were surveyed (Figure 5).

Recordings were analysed for night parrot calls by Bob Bullen (Bat Call WA Pty Ltd) and in the case of some recordings also by Nigel Jacket.

The listening surveys were carried out by two personnel (Greg Harewood and George Swan) at wide spaced (several hundred metres) intervals within identified habitat at six locations (Figure 5). The surveys commenced just before sunset and continued until approximately one hour after last light. Both personnel are familiar with WA night parrot calls.

Survey work also included daytime targeted searches at waterholes and area searches for feathers. Camera traps were deployed at water holes/troughs where considered likely to be effective.

Additional details on the location of each passive call detection site and date and times deployed are contained within Appendix B.

2.2.11 Terrestrial Short-Range Endemic/Salt Lake Specialist Invertebrates

Phoenix Environmental Sciences Pty Ltd (PES) undertook a terrestrial short-range endemic (SRE) invertebrate fauna survey for the LDP Project in May 2013 (PES 2014). To assist in this assessment any invertebrates suspected of being SRE's (e.g. millipedes, scorpions, slaters, pseudoscorpions, mygalomorph spiders and snails) collected in traps or during other targeted opportunistic survey work during all phases of the fauna survey were retained and submitted to experts for formal identification and comments.

An additional small scale invertebrate survey was also carried out over the playa itself in November 2014. Thirty 2.5 litre plastic buckets utilised as dry pit traps. The traps were dug into place at approximately 30 metre intervals along the shoreline of Lake Disappointment and out onto the playa. Traps were check each morning and mid-afternoon. Invertebrate specimens of interest were retained (spiders, beetles, scorpions, ants, crickets, earwigs etc.). The invertebrates collected during this survey were submitted to Dr Erich S. Volschenk for formal identification and comments (ScorpionID 2016).

Additional details on the methods employed and the results of some of these assessments (PES 2014, ScorpionID 2016, Alacran 2016, Alacran 2017) are provided in reports held in Appendix G.

2.3 FAUNA CONSERVATION CATEGORIES

The conservation significance of fauna species has been assessed using the following sources:

- *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*). Administered by the Australian Government Department of the Environment and Energy (DotEE);
- *Wildlife Conservation Act 1950 (WC Act).* Administered by the Western Australian Department of Biodiversity Conservation and Attractions (DBCA) (Govt. of WA 2017);
- Red List produced by the Species Survival Commission (SSC) of the World Conservation Union (also known as the IUCN Red List - the acronym derived from its

former name of the International Union for Conservation of Nature and Natural Resources). The Red List has no legislative power in Australia but is used as a framework for State and Commonwealth categories and criteria; and the

- DBCA Priority Fauna list. A non-legislative list maintained by DBCA for management purposes (DBCA 2017).

The *EPBC Act* also requires the compilation of a list of migratory species that are recognised under international treaties including the:

- Japan Australia Migratory Bird Agreement 1981 (JAMBA);
- China Australia Migratory Bird Agreement 1998 (CAMBA);
- Republic of Korea-Australia Migratory Bird Agreement 2007 (ROKAMBA); and
- Bonn Convention 1979 (The Convention on the Conservation of Migratory Species of Wild Animals).

(Note - Species listed under JAMBA are also protected under Schedule 3 of the *WC Act*.)

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as matters of national environmental significance (NES) under the *EPBC Act*.

The conservation status of all vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the Project area has been assessed using the most recent lists published in accordance with the above-mentioned instruments and is indicated as such in the fauna listings of this report. A full listing of conservation codes is provided in Appendix A.

2.4 TAXONOMY AND NOMENCLATURE

Taxonomy and nomenclature for fauna species used in this report is generally taken from the DBCA's WA Fauna Census Database which is assumed to follow Aplin and Smith (2001) for amphibians and reptiles and Johnstone (2001) for birds. Jackson and Groves (2015) has been used for mammals.

Common names are taken from the WAM recognised primary common name listings when specified, though where common names are not provided they have been acquired from other publications. Sources include Cogger (2014), Wilson and Swan (2013), Van Dyck & Strahan (2013), Christidis and Boles (2008), Bush *et al.* (2010), Bush *et al.* (2007), Tyler & Doughty (2009), and Glauret (1961). Not all common names are generally accepted.

2.5 LIKELIHOOD OF OCCURRENCE – FAUNA OF CONSERVATION SIGNIFICANCE

Fauna of conservation significance identified during the literature review as previously being recorded in the general area were assessed and ranked for their likelihood of occurrence within the study area itself if not directly recorded during the survey period.

The rankings and criteria used were:

- Would Not Occur: There is no suitable habitat for the species in the study area and/or there is no documented record of the species in the general area since records have been kept and/or the species is generally accepted as being locally/regionally extinct (supported by a lack of recent records).
    - Locally Extinct: Populations no longer occur within a small part of the species natural range, in this case within 10 or 20km of the study area. Populations do however persist outside of this area.
    - Regionally Extinct: Populations no longer occur in a large part of the species natural range, in this case within the southern forest regions. Populations do however persist outside of this area.
- Unlikely to Occur: The study area is outside of the currently documented distribution for the species in question, or no suitable habitat (type, quality and extent) was identified as being present during the field assessment. Individuals of some species may occur occasionally as vagrants/transients especially if suitable habitat is located nearby but the study area itself would not support individuals or a population the species.
- Possibly Occurs: The study area is within the known distribution of the species in question and habitat of at least marginal quality was identified as being present during the field assessment, supported in some cases by recent records being documented in literature from within or near the study area. In some cases, while a species may be classified as possibly being present at times, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.
- Known to Occur: The species in question was positively identified as being present (for sedentary species) or as using the study area as habitat for some other purpose (for non-sedentary/mobile species) during the field survey. This information may have been obtained by direct observation of individuals or by way of secondary evidence (e.g. foraging debris, tracks and scats). In some cases, while a species may be classified as known to occur, habitat may be marginal (e.g. poor quality, fragmented, limited in extent) and therefore the frequency of occurrence and/or population levels may be low.

2.6 SURVEY LIMITATIONS

The fauna assessment was designed and carried out to conform with a Level 2 survey as defined in EPA Guidance statement No. 56 (EPA 2016c). The assessment has included a desktop analysis aimed at providing a list of expected species and the completion of two phase seasonal survey involving a detailed trapping program, targeted and opportunistic fauna observations, and the use of motion sensing cameras and bat detector recordings.

Fauna species are indicated as potentially present within this report based on there being suitable (quality and extent) habitat within the study area. With respect to trapping, targeted

and opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- seasonal inactivity during field survey;
- species present within micro habitats not surveyed;
- cryptic species able to avoid detection; and
- transient wide-ranging species not present during survey period.

The lack of observational data on some species should therefore not be taken as necessarily indicating that a species is absent from the site.

In recognition of survey limitations a precautionary approach has been adopted for this assessment. Any fauna species that would possibly occur within the study area as identified through ecological databases, publications, discussions with local experts/residents and the habitat knowledge of the Author has been assumed to potentially occur, although not necessarily on a permanent basis or in significant numbers.

The main constraint encountered was access difficulties to locations around Lake Disappointment. No tracks exist to most parts of the playas edge and a helicopter was employed to allow the assessment of the more isolated sections. The implementation of exclusion zones at the request of the traditional owners also meant that some areas (mainly the south eastern section of the Lake, Savory Creek and islands) could not be surveyed to the same degree as other parts, though it should be noted that these areas will not be subject to development in any event.

Fauna survey limitations and constraints are provided in Table 5.

Table 5: Fauna Survey Limitations and Constraints

Potential Constraint	Survey Limitation (Yes/No) Significant Moderate Negligible	Comments on Survey Outcomes
Competency/Experience of the consultant carrying out the survey.	No	Consultant Zoologists that executed the survey have conducted many level 1 and level 2 surveys in WA and can be regarded as suitably qualified.
Scope.	No	The survey carried out was a Level Two survey, comprising of a desktop survey and a series of seasonal and targeted surveys that has included a habitat assessment, trapping program, and opportunistic observations. No constraints encountered.
Proportion of fauna identified, recorded and/or collected.	No	The field surveys recorded about 80% of listed potential vertebrate species considered likely to be present in the area. It should be noted that the potential species list is very likely an over estimation of the species that are actually present on a regular basis.
Sources of information.	Yes, Moderate	The study area has not been subject to detailed surveys in the past and specific fauna values are not well documented.
The proportion of the task achieved and further work.	No	The survey work as planned was completed.
Timing/weather/season/cycle.	No	The Level 2 surveys were carried out to coincide with the recommended survey periods for this bioregion (EPA 2016d).

Potential Constraint	Survey Limitation (Yes/No) Significant Moderate Negligible	Comments on Survey Outcomes
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No	No disturbances of significance occurred.
Intensity (in retrospect, was the intensity adequate).	No	Based on the results achieved, the surveys are considered adequate for a multiphase seasonal survey for the areas investigated.
Completeness (e.g. was relevant area fully surveyed).	Yes, Negligible	Large areas and access restrictions made it difficult to survey the entire study area to same degree, though much of the "study area is outside of any proposed development footprints.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Yes, Moderate	No unresolved problems/uncertainties arose with respect to identifying most of the observed vertebrate fauna species. Some invertebrates present pose identification problems so establishing local and regional significance could be difficult.
Remoteness and/or access problems.	Yes, Negligible	Access to some areas not allowed and/or difficult, though these are all outside of any proposed development footprints.
Availability of contextual (e.g. biogeographic) information on the region.	No	Previous fauna survey data for the wider area is limited though general biogeographic data is available.

3. REGIONAL CONTEXT

3.1 BIOGEOGRAPHIC SETTING

The study area lies within the Keartland Botanical District of the Little Sandy Desert Region in the Eremaean Province of WA. The Keartland Botanical District consists predominantly of shrub steppes of *Acacia* and *Grevillea*, and *Triodia* spp. on dunes and swales. Patches of desert oak and mulga also occur within the area (Beard 1990).

Based on the Interim Biogeographic Regionalisation of Australia (IBRA - Thackway & Cresswell 1995) the Little Sandy Desert Region is further divided into subregions, with the Lake Disappointment Exploration Program located within both the Rudall (LSD1) and Trainor (LSD2) subregions. The Project is situated primarily in the Trainor subregion with a minor portion of the northern study area within the Rudall subregion.

The vegetation of the Rudall subregion is sparse shrub-steppe over *Triodia basedowii* on stony hills, with River Gum communities and bunch grasslands on alluvial deposits in and associated with ranges (Kendrick 2001).

The vegetation of the Trainor subregion is shrub steppe of *acacias*, *Aluta maisonneuvei* and *grevilleas* over *Triodia schinzii* on sandy surfaces. Vegetation also includes sparse shrub-steppe over *Triodia basedowii* on stony hills, with eucalyptus and coolibah communities and bunch grasslands on alluvial deposits and drainage lines associated with ranges (Cowan & Kendrick 2001).

3.2 PHYSICAL ENVIRONMENT

3.2.1 Climate

The climate of both the Rudall and Trainor subregions is characterised as arid with summer rainfall in the Rudall subregion and episodic summer rainfall in the Trainor subregion (Cowan & Kendrick 2001, Kendrick 2001). The Little Sandy Desert bioregion has an arid climate with summer-dominant rainfall. The average rainfall is about 178 mm (DEWHA 2008a). The study area has an annual pan evaporation rate of approximately 3600-4000mm and an average annual evapotranspiration rate of 300mm (BoM 2017).

Rainfall data for the Telfer Aero weather station (#13030) located approximately 180km north-west of the LDP Project area is provided in Figure 6 (BOM 2017).

Annual rainfall for 2013 (first year of field surveys) was above average (363mm) recording a total of 603mm. Rainfall was highest in January and February. In 2016 (second year of survey) rainfall was below average (192mm). In January and February 2017 (prior to third year of survey in March), rainfall levels exceeded the annual average, recording 494.8mm.

3.2.2 Topography, Hydrology and Geology

Beard (1990) describes the topography of the Little Sandy Desert region as a sandplain with numerous low hills and small ranges. The hills and ranges mainly consist of bare rock and shallow stony soils, while the plains consist of red earthy sands. Beard (1990) also describes the underlying geology as a quaternary sandplain with longitudinal dunes that have developed over locally exposed Proterozoic siliceous rocks.

Lake Disappointment is the lowest point in the Little Sandy Desert and is therefore a point of drainage, its catchment area extending 500 km north-south, and 600 km east-west (Beard 2005).

The Lake is a salt rich playa with no outlet which periodically fills or partially fills with water to form a temporary lake with prevailing salinities dependant on water volume. The playa may contain fresh water immediately after substantial rain, but becomes more saline as it dries and is classified as hypersaline but with poikilohaline (highly variable) characteristics.

Lake Disappointment is fed by several ephemeral creeks and by direct precipitation. Savory Creek, one of the most significant drainage channels, enters the lake from the north-west. The creek flow into the playa is impeded by a substantial sand bar which has resulted in the establishment of a narrow but long permanent hypersaline pool leading west out from the playas edge (Lynch 1995).

Examination of air photos indicates that the eastern half of the playa is characterised by a large area of elevated flats with scattered islands (see Figure 2). This area appears to be surrounded by deep, somewhat discontinuous channels where water accumulates preferentially after rain events and these are therefore also the last areas to dry out.

The playa surface consists of poorly consolidated saline lacustrine sediments (clay, silt, sand and gypsum) and while the playa, by definition, lacks surface water for most of the year,

sediments underlying the salt crust are permanently saturated with hypersaline "brine" which forms a shallow water table (Lynch 1995).

3.2.3 Vegetation Mapping

Detailed vegetation mapping of the study area has been undertaken by Botanica Consulting (2017). Fourteen vegetation types were identified within the study area. These vegetation types were located within six different landform types and comprised eight major vegetation groups. The extent of the various mapped vegetation units is shown in Figure 7. A brief description is provided the table below.

Table 6: Landform and Vegetation Communities (Botanica 2017)

Landform	Major Vegetation Group	Floristic Community	Code
Closed Depression	Chenopod Shrublands, Samphire Shrublands and Forblands (MVG22)	Heath of mixed *Tecticornia* spp. on Salt Lake edge	CD-CSSSF1
	Not Vegetated	Salt Lake	CD-SL1
	Other Grasslands, Herblands, Sedgelands and Rushlands (MVG21)	Open mixed herbs in clay-loam depression	*CD-OGHSR1*
Dunefield	Casuarina Forests and Woodlands (MVG 8)	Low forest of *Allocasuarina decaisneana* over open scrub of Acacia/ Grevillea and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales	D-CFW1
	Hummock Grasslands (MVG20)	Open low woodland of *Corymbia opaca* over low scrub of *Acacia/Grevillea* spp. and mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales	D-HG1
		Scrub of *Acacia/Eremophila/Grevillea* spp. over mid-dense hummock grass of *Triodia basedowii* on sand dunes/ swales	D-HG2
Open Depression	Acacia Forests and Woodlands (MVG 6)	Low woodland of *Acacia* spp. over low scrub of *Senna artemisioides* and mixed dwarf scrub in drainage depression	OD-AFW1
	Eucalypt Woodland (MVG 5)	Open low woodland of *Eucalyptus camaldulensis/ Corymbia* spp. over mid-dense hummock grass of *Triodia* spp. in creekline	OD-EW1
	Other Shrublands (MVG 17)	Low woodland of *Hakea lorea/ Melaleuca glomerata* over low heath of *Fimbristylis eremophila* in drainage depression	OD-OS1
Plain	Hummock Grasslands (MVG20)	Open low woodland of *Corymbia* spp./ *Hakea lorea* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia* spp. in sandplain	P-HG1
		Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia bivenosa* and mid-dense hummock grass of *Triodia basedowii* in sandplain	P-HG2

Landform	Major Vegetation Group	Floristic Community	Code
Rocky Hillslope	Acacia Forests and Woodlands (MVG 6)	Scrub of *Acacia* spp. over mixed low scrub and mid-dense hummock grass of *Triodia pungens* on rocky hillslope	RH-AFW1
	Mallee Woodlands and Shrublands (MVG 14)	Open shrub mallee of *Eucalyptus gamophylla/ E. kingsmillii* subsp. *kingsmillii* over low scrub of *Acacia/ Grevillea* spp. and mid-dense hummock grass of *Triodia* spp. on rocky hillslope	RH-MWS1
Rocky Plain	Acacia Forests and Woodlands (MVG 6)	Low woodland of *Acacia* spp. over low scrub of *Eremophila/ Senna* spp. And mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-AFW1
	Hummock Grasslands (MVG20)	Open low woodland of *Corymbia aspera* over low scrub of *Acacia* spp. and mid-dense hummock grass of *Triodia basedowii* on rocky plain	RP-HG1

3.3 CONSERVATION RESERVES IN THE AREA

Lake Disappointment is listed as a Nationally Important Wetland with high conservation and anthropological value (Lynch 1995). The criteria used to justify its inclusion on the Nationally Important Wetlands list are:

- Criterion 1: it is a good example of a wetland type occurring within a biogeographic region in Australia; and
- Criterion 3: it is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

The southern extremity of the study area is located in an area identified in the EPA Red Book for potential, proposed reservation in the future. The Karlamilyi National Park, (formerly Rudall River National Park) is situated directly north of the study area with a small section of the Talawana Track running within its boundary. Karlamilyi National Park is Western Australia's largest national park encompassing more than 1.2 million hectares.

4. SURVEY RESULTS

4.1 FAUNA INVENTORY – LITERATURE REVIEW

A list of expected fauna species likely to occur in the study area was compiled from information obtained during the literature review and is presented in Appendix D. This listing was refined after information gathered during the various site surveys were reviewed. The DBCA NatureMap database search results are summarised in this species listing. The raw database search results from NatureMap (DBCA 2017) and the Protected Matters Search Tool (DotEE 2017) are contained within Appendix C.

Table 7 below provides a summary of the potential fauna species considered most likely to be present in the general area (but not necessarily within the Project Area itself) based on species group and conservation status.

The list of potential fauna takes into consideration that firstly the species in question is not known to be locally extinct and secondly that suitable habitat for each species, as identified during the field work, is present within the study area, though compiling an accurate list has limitations.

Table 7: Summary of Potential Vertebrate Fauna Species (as listed in Appendix D)

Group	Total Number of Potential Species	Potential Number of Specially Protected Species	Potential Number of Migratory Species	Potential Number of Priority Species
Amphibians	10	0	0	0
Reptiles	79[1]	1	0	2
Birds	144	4	11	1
Non-Volant Mammals	23[6]	1	0	2
Volant Mammals (Bats)	11	0	0	0
Total	**267[7]**	**6**	**11**	**5**

Superscript = number of introduced species included in total. Note: Where a species has two classifications only one is tabled i.e. The Curlew Sandpiper (listed here as Migratory) is also classified as a threatened species (Vulnerable). The Princess Parrot is tabled here as a threatened species (Vulnerable) but is also listed as a Priority 4 species.

The specific habitat and microhabitat requirements and ecology of many of the species known to occur in the wider area are often not well understood and/or documented. It can therefore be difficult to exclude species from the potential list based on a lack of a specific habitat or microhabitat within the study area. As a consequence of this limitation the potential fauna list produced is most likely an overestimation of those species that actually utilise the study area for some purpose. Some species may be present in the general area but may only use the study area itself on rare occasions or as vagrants/transients.

4.2 FAUNA INVENTORY – DETAILED FAUNA SURVEY

A summary of the number of species from each vertebrate group identified during all the phases of the fauna survey is provided in Table 8 below. A complete list of the species recorded is detailed in Appendix D. The raw trapping, bat recording, bird surveys, opportunistic and camera trap results are provided in Appendix F.

Table 6: Number of Vertebrate Fauna Species Recorded

Group	Combined Total	Species of Conservation Significance
Amphibians	9	0
Reptiles	59	2
Introduced Reptiles	1	0
Birds	116	11
Native Non-Volant Mammals	12	2
Bats	10	0
Introduced Mammals	6	0
Total	**213**	**15**

Total number of species recorded = the total number of species found to occur in the defined study area, including species found outside of possible impact areas.

The surveys have identified approximately 80% of the predicted species considered likely to be present. Fifteen of the 22 state or federally listed vertebrate fauna species of conservation significance considered likely to frequent the area at times (albeit some rarely) have been observed/recorded. Those observed include four specially protected, seven migratory and four priority vertebrate fauna species.

It should be noted that the Lake Disappointment dragon is not included in this total as it is not listed by any authority as threatened or as a priority species. It can however be regarded as being of local conservation significance given it appears to be confined to riparian samphire habitat around Lake Disappointment. Birds identified as breeding on islands within Lake Disappointment (i.e. primarily the banded stilt) must also be considered as being of local conservation significance despite not having any official classification on state, federal or DBCA listings.

4.2.1 Amphibians

A total of nine species of frog were captured during the field surveys. The highest diversity was found at Trap Site 12 (McKay Creek) where eight species were recorded.

Based on the literature review one other species of frog is considered likely to occur in the general area.

None of the identified or potential amphibian species that may occur in the area are listed as threatened or as DBCA priority species.

4.2.2 Reptiles

A total of 59 species of native reptile were captured and/or observed during the field surveys. One introduced reptile was recorded (the Asian house gecko). Based on the literature review another 20 species are considered likely to occur in the general area.

Two listed species of conservation significance and a species of local conservation significance were recorded, these being:

- Lake Disappointment gecko (*Diplodactylus fulleri*) - P2 (DBCA Priority species);
- Unpatterned robust lerista (*Lerista macropisthopus remota*) - P2 (DBCA Priority species); and
- Lake Disappointment dragon (*Ctenophorus nguyarna*) – local conservation significance.

The Lake Disappointment gecko (*Diplodactylus fulleri*) was captured a total of six times over the Phase 1 and 2 surveys, all at Trap Site 2 on the Lakes edge. As with the Lake Disappointment dragon it appears to have a distribution confined to the samphire habitat bordering the playa (and possibly some islands). Up until the Phase 1 survey in 2013 there were only five other records of the species at Lake Disappointment in the DBCA database.

The location of the combined observations (i.e. this survey and DBCA records) of the Lake Disappointment gecko are shown in Figure 9.

The species is nocturnal and does not make distinctive burrows so it is harder to locate than the Lake Disappointment Dragon, hence the lack of observations in areas outside of the main trapping area, where only day searches were carried out. It is however considered likely to be found almost anywhere around the playa and possibly on islands within the Lake wherever suitable samphire habitat is present.

Twelve unpatterned robust leristas (*Lerista macropisthopus remota*) were captured in total over all phases of the fauna survey. The locations of the captures are shown in Figure 9. There are no other nearby records within the DBCA database and these observations appear to represent a significant range extension for the species eastwards, though it is probably widespread in the general area given the large extent of suitable habitat (i.e. sand dunes/sand plains).

The Lake Disappointment dragon (*Ctenophorus nguyarna*) was observed 18 times during the Phase 1 survey. The species was captured on several occasions at Trap Site 2 and it was also observed (or its characteristic burrows) at various other locations around the shore line within its preferred habitat, samphire. It was recorded an additional 10 times during the Phase 2 survey but with much less frequency at Trap Site 2.

Up until the Phase 1 survey there were only 13 records of the species in the DBCA database. The location of the combined observations (i.e. this survey and DBCA) of the Lake Disappointment dragon are shown in Figure 9. The results suggest it is likely to be found almost anywhere around the Lake and possibly on islands within the playa wherever suitable samphire habitat is present.

The only other reptile species of conservation significance that is considered likely to occur in the general area (though not necessarily within the LDP Project area) is the

- Great desert skink (*Liopholis kintorei)* - S3 *(WC Act),* Vulnerable (*EPBC Act*).

No evidence of this species has been found to date in any of the areas surveyed. There is however a record of a "fresh burrow" on the Talawana Track made during monitoring of plot sites for the Desert Rangelands Project carried out by the Martu people and reported in 2012 by the DBCA (Martu Country Desert Rangelands Project Map - 2013 Fauna and water monitoring Plots - dated August 6, 2012). This observation was made directly adjacent to the Talawana Track about 2.1km west of the Willjabu Track intersection. The current status of this burrow is unknown as it has not been relocated despite a search of the area. The great desert skink lives in family groups and builds distinctive burrow systems with associated scat latrines which make its presence relatively easy to confirm.

The closest DBCA records within NatureMap (DBCA 2017) are from Lake Dora which is situated in the Karlamilyi National Park about ~100km north of the study area at its closest point.

4.2.3 Birds

One hundred and sixteen bird species were observed/recorded in or near the study area during the field survey. Based on the desktop study results another 28 species may occur in the general area.

Eleven listed species of conservation significance (and one species of local conservation significance) have been recorded to date, these being:

- Eastern great egret (*Ardea modesta)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Sharp-tailed sandpiper (*Calidris acuminate*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Pectoral sandpiper (*Calidris melanotos*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Red-necked stint (*Calidris ruficollis*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Common greenshank (*Tringa nebularia*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Marsh sandpiper (*Tringa glareola)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Peregrine falcon (*Falco peregrinus*) - S7 (*WC Act*);
- Princess parrot (Polytelis alexandrae) - P4 (DBCA Priority Species), Vulnerable (*EPBC Act*);
- Night parrot (*Pezoporus occidentalis*) – S1 (*WC Act*), Endangered (*EPBC Act*);
- Striated grasswren (sandplain) (*Amytornis striatus striatus*) - (DBCA Priority Species);
- Rainbow bee-eater (Merops ornatus) - S5 (*WC Act*), Migratory (*EPBC Act*); and
- Banded stilt (*Cladorhynchus leucocephalus*) - local conservation significance.

A single eastern great egret (a common Australia resident waterbird listed as migratory) was recorded in March 2017 on a freshwater claypan by Bennelongia (2017). While this species has some potential to utilise any of the low lying areas in the region (e.g. lakes, claypans,

creeks, dams and roadside ditches) subject to temporary inundation after significant rain events, it would only occur rarely and in very small numbers.

The five migratory waders observed at various times during the course of the surveys the common greenshank, the marsh sandpiper, red-necked stint, the sharp-tailed sandpiper and the pectoral sandpiper have all been recorded in generally in small numbers (<10), though in excess of 350 sharp tailed sandpipers were recorded in 2017 (Bennelongia 2017).

It should be noted that all of the above mentioned migratory waders only breed in the northern hemisphere, and migrate to the southern hemisphere around spring onwards (~September) before returning north in summer/early autumn (~March/April), though a small number of individuals are known to "over winter" in Australia.

The peregrine falcon was not recorded within the actual study area but in the Durba Hills about 15km south west of the southern boundary of Lake Disappointment in 2013. The species potentially breeds in this location given the presence of near vertical rocky cliff faces. Individuals of this species potentially utilise some sections of the actual Project area given they have large home ranges, though it can be expected to occur only very occasionally.

A single flock of four princess parrots were observed flying overhead during the Phase 1 survey in May 2013. Princess parrots are highly nomadic, and its frequency of occurrence within the Project area would be very low and generally only temporary. Most of the study area appears to represent marginal habitat for this species given the lack of large trees required for roosting and nesting.

Calls of a night parrot were recorded on an ARU during the targeted survey carried out in June 2017 at a location along Willjabu Track (see Figure 5). The calls were recorded several times over the course of one night (20 – 21 June 2017) and have been confirmed as being that of a night parrot by Bob Bullen, Nigel Jackett and several members of the Night Parrot Recovery Team (Alan Burbidge and Nick Leseburg). It is not known at this stage if this area represents a roosting, nesting or foraging site for the species. Additional surveys by Reward aimed at determining the status of this site and the presence of the bird in other regional locations are planned.

The area at which the calls were detected is located in an interdunal swale and is characterised by having relatively large, dense spinifex coverage with some areas of chenopods in addition to some claypans, which at the time of the survey were inundated with freshwater.

Striated grasswrens were recorded during the May 2013 survey a few kilometres north of Lake Disappointment near the Willjabu Track. This record is based on unrecorded calls only and is therefore somewhat tentative. It would appear, based on the lack of any other sightings to be at best uncommon in the study area.

The rainbow bee-eater was observed on numerous occasions over several phases of the survey, with all but one sighting being at McKay Creek. The rainbow bee-eater is not a threatened species and can be regarded as common. It may be resident in the area and has been observed breeding in the vicinity of McKay Creek.

Surveys of Lake Disappointment have confirmed the Lake is used by large numbers of banded stilts for breeding when inundated and it has been concluded that it appears to be a significant breeding site for the species at the national level (Bennelongia 2017). Most recently (March 2017) over 100,000 birds were recorded on the Lake, with over 49,000 nests being recorded (Bennelongia 2017). It is understood that DBCA also surveyed Lake Disappointment at around this same time. The Author is not aware of any publicly available report at this stage but an ABC news report (ABC 2017) indicates that DBCA observed an estimated "90,000 banded stilts", which is consistent with Bennelongia's results.

An additional banded stilt breeding colony survey was also carried out by the Author (Greg Harewood) out in March 2017 during the Phase 4 fauna survey and involved the examination of over 200 islands within Lake Disappointment from a helicopter. Fifteen islands were identified as having some degree of banded stilt breeding activity taking place with five having significant breeding colonies. During their independent survey Bennelongia estimated that these five islands contained between 2,000 - 27,000 nests per island (Bennelongia 2017). The location of these colonies, smaller colonies and all the islands examined are shown in Figure 10.

During the May 2013 survey banded stilts were also observed at various locations on Lake Disappointment, sometimes in significant numbers (total of 455 observations, with one count of 157 at one location). Many of the observations were of dead or non-flying juveniles clearly indicating that a breeding event had taken place prior to the survey being undertaken, presumably in response to the flooding which resulted after the significant rainfall event recorded in February of that year.

By the time of the May 2013 survey the water had however dried up to a point where the islands were no longer isolated and the aquatic food source had depleted in at least some areas (presumably due to rising salinities), a consequence of which appeared to be the death of significant numbers of non-flying juveniles.

Subsequent to the 2013 observations, during a flora assessment in July 2015 Botanica Consulting (2015) located evidence of a recent banded stilt breeding event on a small island in the central area of the Lake. Evidence observed was in the form of abandoned nests and eggs and numerous dead individuals (presumably non-flying juveniles) suggesting the breeding event had failed due to drying conditions.

Banded stilts have previously been recorded breeding at or near Lake Disappointment. In August 1971, W.H. Butler recorded both adult and juvenile banded stilt using a claypan 30 km south of Durba Spring on the Canning Stock Route, and others using a claypan 4 km north of Well No. 11. He collected an immature specimen that was thought to have come from a presumed nesting attempt at Lake Disappointment, which had filled in May of that year (Kolichis 1976).

A breeding attempt was also documented in 2004 where numerous dead juveniles and a small number of live individuals were observed in various locations along the Lake shore from Savory Creek northwards (Clarke *et al.* 2004). The exact location at which breeding took place was not identified.

An additional five species of conservation significant species may occur in the study area but to date have not been recorded, these are:

- Grey falcon (*Falco hypoleucos*) - S3 (*WC Act*);
- Caspian tern (*Sterna caspia*) - S S5 (*WC Act*), Migratory (*EPBC Act*);
- Common sandpiper (*Tringa hypoleucos)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Curlew sandpiper (*Calidris ferruginea)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Wood sandpiper (*Tringa glareola)* - S5 (*WC Act*), Migratory (*EPBC Act*); and

This grey falcon may frequent the general area at times but because it is rare and nomadic with a sparse distribution its frequency of occurrence would be very low. The denser woodland bordering McKay Creek represents potential breeding habitat.

The caspian tern and the various migratory waders listed as possibly occurring would, as with those already observed, only occur in small numbers and for short periods after episodic rain events of a magnitude sufficient to supply the required amount of water.

4.2.4 Native Non-Volant Mammals

A total of 12 species of native, non-flying mammals were captured and/or other evidence observed during the field surveys. Based on the literature review another five species are considered potentially present, subject to suitable habitat being present.

Two listed species of conservation significance have been recorded to date, these being:

- Northern marsupial mole (*Notoryctes caurinus*) - P4 (DBCA Priority Species);
- Greater bilby (*Macrotis lagotis*) - S3 (*WC Act*), Vulnerable (*EPBC Act*).

Northern marsupial moles were not directly observed but its distinctive tracks, made when making brief short traverses above ground, were recorded at several locations on dune crests and its underground tunnels were recorded at numerous locations during targeted surveys for the species, which involved digging trenches in dunes.

The presence of this species in the LDP Project area was initially established during the targeted survey of Willjabu Track carried out in October 2012. During this survey two trenches were dug in sand dunes and several backfilled tunnels (“mole holes”) attributed to the northern marsupial mole identified (Harewood 2012). Also as part of an approved Conservation Management Plan (Botanica 2013a) monitoring program, 20 trenches were dug into dunes along the access track in April 2014 and assessed for marsupial mole activity (Harewood 2015). Nineteen of these trenches showed evidence of the northern marsupial mole in the form of backfilled tunnels of various ages. The location of all evidence of marsupial mole activity is shown in Figure 11.

It should be noted that mole holes persist in the sand profile for at least several years and thus accumulate over periods of time and perhaps many decades (Benshemesh 2009) and therefore may not be indicative of any recent mole activity at that specific location.

The greater bilby has only been recorded once within the study area despite substantial survey effort including targeted surveys in specific locations. The single individual recorded was observed crossing the Talawana Track at night time by a Reward employee (Dan Tenardi pers. comms. 2016).

This species has been the subject of targeted surveys within proposed clearing areas along the Talawana Track, along the Willjabu Track prior to its construction (Harewood 2012) and additional searches during the subsequent fauna surveys in the south, with no evidence of its presence being found. The lack of evidence of this species presence strongly suggests it is generally absent or at best uncommon in the area. Nonetheless it must be regarded as a potential species, given the single observation and a small number of other records from nearby areas (Martu Country Desert Rangelands Project Map - 2013 Fauna and water monitoring Plots - dated August 6, 2012).

One undetected species of conservation significance is, based on available information, considered likely to occur in the general area (though not necessarily within the Project area itself), this being

- Brush-tailed mulgara (*Dasycercus blythi)* - P4 (DBCA Priority Species).

This species has been the subject of targeted searches (i.e. trapping, spot surveys, transects, and camera traps) during the various surveys reported on here, with no evidence of its presence being found. At this stage, given the lack of actual observations and the level of survey carried out to date it is not considered likely to occur within the areas investigated, though populations may persist in the wider area.

Two specimens of planigale were also collected during the May 2013 survey. As Lake Disappointment is well outside of the range of any known species of planigale both specimens were submitted to the WAM for formal identification (voucher numbers M61405 and M61406). WAM have indicated that the specimens submitted represent an as yet undescribed species that “occurs all over the Pilbara region” (email Dr Kenny J. Travouillon to Greg Harewood – 8 June 2016).

4.2.5 Bats

In total, ten of the predicted eleven species of bats were recorded during all phases of the survey. One additional bat species is considered as likely to occur. None of the identified or potential bat species are listed as threatened or as DBCA priority species.

The Pilbara leaf-nose bat was recorded during a regional bat survey at Desert Queens Baths, a permanent water hole in rocky ranges making up much of the Karlamilyi National Park (Bullen and Harewood 2016) (50km north of the Talawana Track) but given the lack of preferred habitat it is not considered a potential species in any section of the LDP area.

4.2.6 Introduced Fauna

Seven introduced vertebrate animal species were identified as being present during the field survey, these being the:

- Asian house gecko (*Hemidactylus frenatus*);
- Camel (*Camelus dromedaries*);
- European cattle (*Bos taurus*);
- Cat (*Felis catus*);
- House mouse (*Mus musculus*);
- Rabbit (*Oryctolagus cuniculus*); and
- Red fox (*Vulpes vulpes*).

4.2.7 Terrestrial Short-Range Endemic/Salt Lake Specialist Invertebrates

Twenty eight individual invertebrate specimens were collected during Phase 1 and 2 of the fauna survey (May and October 2013) and submitted to Phoenix Environmental Sciences for identification as part of their independent targeted SRE assessment (during which time they collected an additional 27 species – 55 specimens in total). An additional 50 individual invertebrate specimens were collected during Phase 3 and 4 of the fauna survey (October 2016 and March 2017) and submitted to Alacran Environmental Science for identification.

Specimens collected included scorpions, mygalomorph (trapdoor) spiders, wolf spiders and slaters (isopods). The following is a summary of the combined findings made by Phoenix Environmental Sciences (PES 2014) and Alacran (2016, 2017), the full reports of which are presented in Appendix G.

The 55 individual specimens collected during the targeted SRE assessment and the Phase 1 and 2 surveys represented 14 individually-recognised taxa from six orders, nine families and at least ten genera. Of these, a total of five taxa in four genera from three families and three orders were considered to include potential SRE species or taxa, these being:

Phase 1 & 2

- *Aname* sp. indet. (trapdoor spider, family Nemesiidae);
- *Kwonkan* ‘disappointment’ (trapdoor spider, family Nemesiidae);
- *Urodacus* ‘disappointment’ (scorpion, family Urodacidae);
- *Urodacus* ‘princess pea’ (scorpion, family Urodacidae);
- *Buddelundia* ‘10LD’ (slater, family Armadillidae).

The 50 individual specimens collected during the Phase 3 and 4 surveys represented 13 individually-recognised taxa from three orders, six families and at least seven genera. Of these, a total of 10 taxa in four genera from six families and three orders were considered to include potential SRE species or taxa, these being:

Phase 3 & 4

- *Aganippe* 'LD1' *(*trapdoor spider, family Idiopidae*);*
- *Aganippe* 'LD2' (trapdoor spider, family Idiopidae);
- Synothele (Barychelidae) 'LD1'(trapdoor spider, family Barychelidae);
- *Kwonkan* 'LD1' (trapdoor spider, family Nemesiidae);
- *Lychas* 'telfer'' (scorpion, family Buthidae);
- *Lychas '099'* (scorpion, family Buthidae);
- *Lychas 'multipunctatus complex'* (scorpion, family Buthidae);
- *Lychas 'annulatus complex'* (scorpion, family Buthidae);
- *Urodacus 'yaschenkoi species complex'* (scorpion, family Urodacidae);
- *Buddelundia* '10LD' (slater, family Armadillidae).

Of the 14 potential SREs taxa collected in the field survey, eight are currently known only from the study area; these include four trapdoor spiders (Aganippe 'LD1' & 'LD 2', Synothele 'LD1't and Kwonkan 'LD1'), three scorpions (*Urodacus* 'disappointment' and *Urodacus* 'princess pea', and *Lychas* '099') and the isopod (*Buddelundia* '10LD').

All of the potential SREs collected in the field survey were recorded in sand dune/sand plain habitat which is widespread outside the study area and it would appear highly unlikely that any are restricted to the area of collection. The identification of new potential SRE taxa and new species is expected for a previously unsurveyed area (PES 2014).

An additional 70 samples of invertebrates were collected during the November 2014 invertebrate survey on a section of lake bed. The samples were assessed by ScorpionID against the 'typical' short-range endemic (SRE) taxa, in addition to species with the potential to be salt lake specialists and endemic to Lake Disappointment.

The following is a summary of findings made by ScorpionID (ScorpionID 2016), the full report of which is held in Appendix G.

The invertebrate collection contained five species from 27 samples that are considered to be potential SRE's. Two of these species fall within 'traditional' SRE groups: *Lychas* 'lake disappointment' (scorpion) and *Indolpium* 'lake disappointment' (pseudoscorpion). An additional three species were noted as being potential salt lake specialist SRE's: Lepismatidae sp. indet., (silverfish); Lycosidae sp. Indet., (wolf spider), and *Megacephala murchisona*, (tiger beetle).

The location where potential SREs and salt lake specialists were captured is shown in Figure 12.

5. LIKELIHOOD OF OCCURRENCE - VERTEBRATE FAUNA OF CONSERVATION SIGNIFICANCE

Based on the literature review, current documented distributions, habitat preferences and field survey results, 22 fauna species of conservation significance have been listed as potentially occurring in the general area, though not all will necessarily occur within the study area itself. The species are:

- Unpatterned Robust Lerista *Lerista macropisthopus remota* – P2 (DBCA Priority Species);
- Lake Disappointment Gecko *Diplodactylus fulleri* - P2 (DBCA Priority Species);
- Great Desert Skink *Liopholis kintorei* – S3 (*WC Act*), Vulnerable (*EPBC Act*);
- Peregrine Falcon *Falco peregrinus* – S7 (*WC Act*);
- Grey Falcon *Falco hypoleucos* - S3 (*WC Act*);
- Princess Parrot *Polytelis alexandrae* - P2 (DBCA Priority Species), Vulnerable (*EPBC Act*);
- Night Parrot *Pezoporus occidentalis* - S1 (*WC Act*), Endangered (*EPBC Act*);
- Migratory Shorebirds/Waders (10 species predicted) – S5 (*WC Act*), Migratory (*EPBC Act*);
- Striated Grasswren (sandplain) *Amytornis striatus striatus* - P4 (DBCA Priority Species);
- Rainbow Bee-eater *Merops ornatus* – S5 (*WC Act*), Migratory (*EPBC Act*);
- Brush-tailed Mulgara *Dasycercus blythi* – P4 (DBCA Priority Species);
- Northern Marsupial Mole *Notoryctes caurinus* – P4 (DBCA Priority Species); and
- Greater Bilby *Macrotis lagotis* - S3 (*WC Act*), Vulnerable (*EPBC Act*).

It should be noted that while habitats onsite for one or more of the species listed above are considered possibly suitable, some or all may be marginal in extent/quality and therefore the fauna species considered as possibly occurring may in fact only visit the area for short periods as infrequent vagrants.

A number of other species of conservation significance, while possibly present in the wider area are not listed as potential species due to known localised extinction (and no subsequent recruitment from adjoining areas), lack of suitable habitat and/or because they are accidental vagrants and would under normal circumstances never occur.

A summary of conservation significant species previously recorded in the wider area and reasons for their inclusion or omission from the list of potential species is provided in Table 7 below. Additional details on each species are provided in Appendix E.

Table 7: Likelihood of Occurrence – Fauna Species of Conservation Significance (continues on following pages)

Species	Conservation Status (see Appendix A for codes)			Habitat Present	Likelihood of Occurrence
	EPBC Act	*WC Act*	DBCA Priority		
Lake Disappointment Dragon *Ctenophorus nguyarna*	-	-	-	Yes – areas of samphire around Lake.	Known to occur – recorded during survey.
Lake Disappointment Gecko *Diplodactylus fulleri*	-	-	P2	Yes – areas of samphire around Lake.	Known to occur – recorded during survey.
Unpatterned Robust Lerista *Lerista macropisthopus remota*	-	-	P2	Yes - sand dunes and sand plains.	Known to occur – recorded during survey.
Great Desert Skink *Liopholis kintorei*	Vulnerable	S3	-	Yes - sand plains and sand dunes vegetated with spinifex.	Possible but not recorded to date despite targeted surveys.
Eastern Great Egret *Ardea alba*	Migratory	S5	-	Yes/Marginal – Seasonally flooded claypans.	Possible (one individual recorded on nearby claypans) but would only be present on rare occasions when conditions are suitable.
Cattle Egret *Ardea ibis*	Migratory	S5	-	No/Marginal – Seasonally flooded claypans.	Unlikely to occur.
Peregrine Falcon *Falco peregrinus*	-	S7	-	Yes – Air space over area - foraging habitat only.	Possible - Recorded south of Lake Disappointment at Durba Hills.
Grey Falcon *Falco hypoleucos*	-	S3	-	Yes – Air space over area - foraging habitat only.	Possible but would only occur very rarely.
Migratory Shorebirds	Migratory /Various	S5	-	Yes – wetlands, flooded playa.	Several species recorded, others possibly occur but all would be present only very occasionally as transients after significant rain events.
Oriental Plover *Charadis veredus*	Migratory	S5/Various	-	Yes/Marginal - areas of samphire around Lake.	Unlikely but may occur very occasionally.
Banded Stilt *Cladorhynchus leucocephalus*	-	-	-	Yes – Islands and seasonally flooded sections of the Lake.	Known to breed on islands within Lake Disappointment after seasonal inundation events.
Caspian Tern *Hydroprogne caspia*	Migratory	S5	-	Yes/Marginal – Seasonally flooded sections of the Lake.	Unlikely but may occur very occasionally after significant rain events.
Night Parrot *Pezoporus occidentalis*	Endangered	S1	-	Yes – sandplains with dense spinifex.	Known to occur – recorded during survey.

Species	Conservation Status (see Appendix A for codes)			Habitat Present	Likelihood of Occurrence
	EPBC Act	*WC Act*	DBCA Priority		
Princess Parrot *Polytelis alexandrae*	Vulnerable	-	P4	Yes – low woodlands and scrublands	Known to occur but would only be present occasionally given highly nomadic habits.
Rainbow Bee-eater *Merops ornatus*	Migratory	S5	-	Yes – most terrestrial habitats with roosting options.	Known to occur – recorded during survey.
Barn Swallow *Hirundo rustica*	Migratory	S5	-	Yes - Air space over area - foraging habitat only.	Unlikely and then only on very rare occasions.
Grey Wagtail *Motacilla cinerea*	Migratory	S5	-	No	Unlikely to occur.
Yellow Wagtail *Motacilla flava*	Migratory	S5	-	No	Unlikely to occur.
Striated Grasswren (sandplain) *Amytornis striatus striatus*	-	-	P4	Yes – sand dunes/sandplains	Known to occur (one tentative record).
Brush-tailed Mulgara *Dasycercus blythi*	-	-	P4	Yes - sand plains and sand dunes.	Possible but not recorded to date despite targeted surveys.
Northern Marsupial Mole *Notoryctes caurinus*	-	-	P4	Yes – sand dunes	Known to occur. Recorded during surveys
Greater Bilby *Macrotis lagotis*	Vulnerable	S3	-	Yes - sand plains and sand dunes.	Known to occur (single observation on Talawana track).
Northern Quoll *Dasyurus hallucatus*	Endangered	S3	-	No/Very Marginal	Unlikely to Occur
Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*	Vulnerable	S3	-	No	Would Not Occur.
Ghost Bat *Macroderma gigas*	Vulnerable	S3	-	No	Would Not Occur
Western Pebble-mound Mouse *Pseudomys chapmani*	-	-	P4	No/Marginal	Unlikely to Occur

6. CONCLUSION

The range of fauna surveys within the Lake Disappointment Potash Project area have been undertaken for the purposes of providing baseline data on the fauna assemblages present. The surveys carried out to date have recorded 205 native and seven introduced vertebrate species. The identified native assemblage includes nine species of frog, 59 species of reptiles, 115 species of birds and 22 native mammals (includes 10 species of bat).

Evidence of 15 species of conservation significance was recorded in or near the defined study area (in addition to two species of local conservation significance), these being:

- Lake Disappointment gecko (*Diplodactylus fulleri*) (P2);
- Unpatterned robust lerista (*Lerista macropisthopus remota*) (P2);
- Lake Disappointment dragon (*Ctenophorus nguyarna*) (local conservation significance);
- Eastern great egret (*Ardea modesta)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Sharp-tailed sandpiper (*Calidris acuminate*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Pectoral sandpiper (*Calidris melanotos*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Red-necked stint (*Calidris ruficollis*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Common greenshank (*Tringa nebularia*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Marsh sandpiper (*Tringa glareola)* - S5 (*WC Act*), Migratory (*EPBC Act*);
- Peregrine falcon (*Falco peregrinus*) - S7 (*WC Act*);
- Princess parrot (*Polytelis alexandrae*) - P4 (DBCA Priority Species), Vulnerable (*EPBC Act*);
- Night parrot (*Pezoporus occidentalis)* - S1 (*WC Act*), Endangered (*EPBC Act*);
- Striated grasswren (sandplain) (*Amytornis striatus striatus*) - (DBCA Priority Species);
- Rainbow bee-eater (*Merops ornatus*) - S5 (*WC Act*), Migratory (*EPBC Act*);
- Banded stilt (*Cladorhynchus leucocephalus*) - local conservation significance;
- Northern marsupial mole (*Notoryctes caurinus*) - P4 (DBCA Priority Species);
- Greater bilby (*Macrotis lagotis*) - S3 (*WC Act*), Vulnerable (*EPBC Act*).

One hundred and five individual invertebrate specimens from groups often representing SREs were collected during the fauna and targeted invertebrate surveys carried out. None of the invertebrates collected were confirmed as SREs however 14 of the species have been classified as potential SREs by invertebrate taxonomists, based primarily on the fact that often other members of the same genus are SREs. All 14 of the potential SREs collected were from sand dune/sand plain habitat which is widespread outside the study area.

An additional 70 samples of invertebrates were collected during the November 2014 invertebrate survey on a section of playa. The invertebrate collection contained five species from 27 samples that are considered to be potential SRE's. Two of these species fall within 'traditional' SRE groups: *Lychas* 'lake disappointment' (scorpion) and *Indolpium* 'lake disappointment' (pseudoscorpion). An additional three species were noted as being potential

salt lake specialist SRE's: Lepismatidae sp. indet., (silverfish); Lycosidae sp. Indet., (wolf spider), and *Megacephala murchisona*, (tiger beetle).

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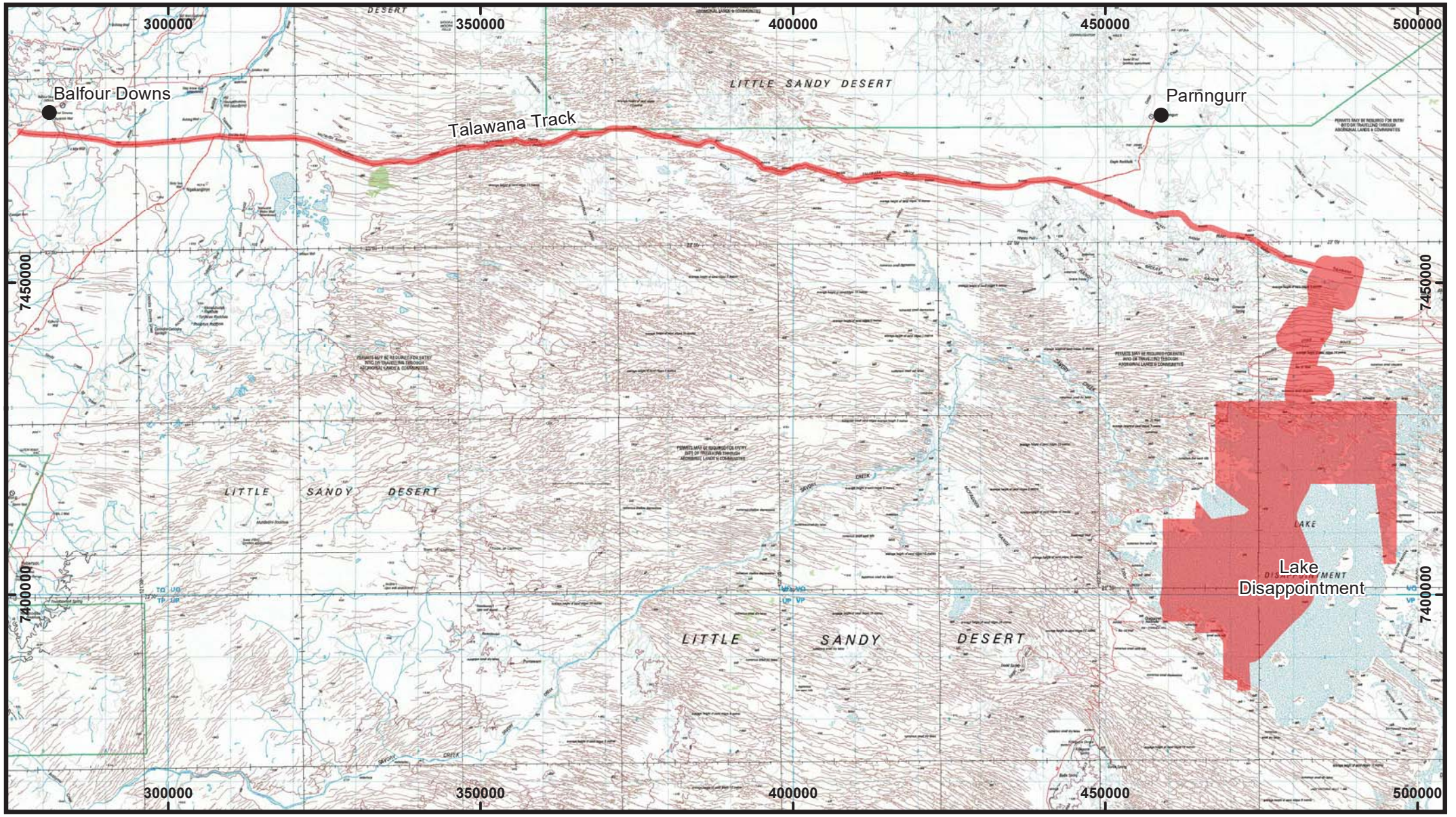
FIGURES



Legend

Study Area

0 10 20 30 40 50

Kilometres

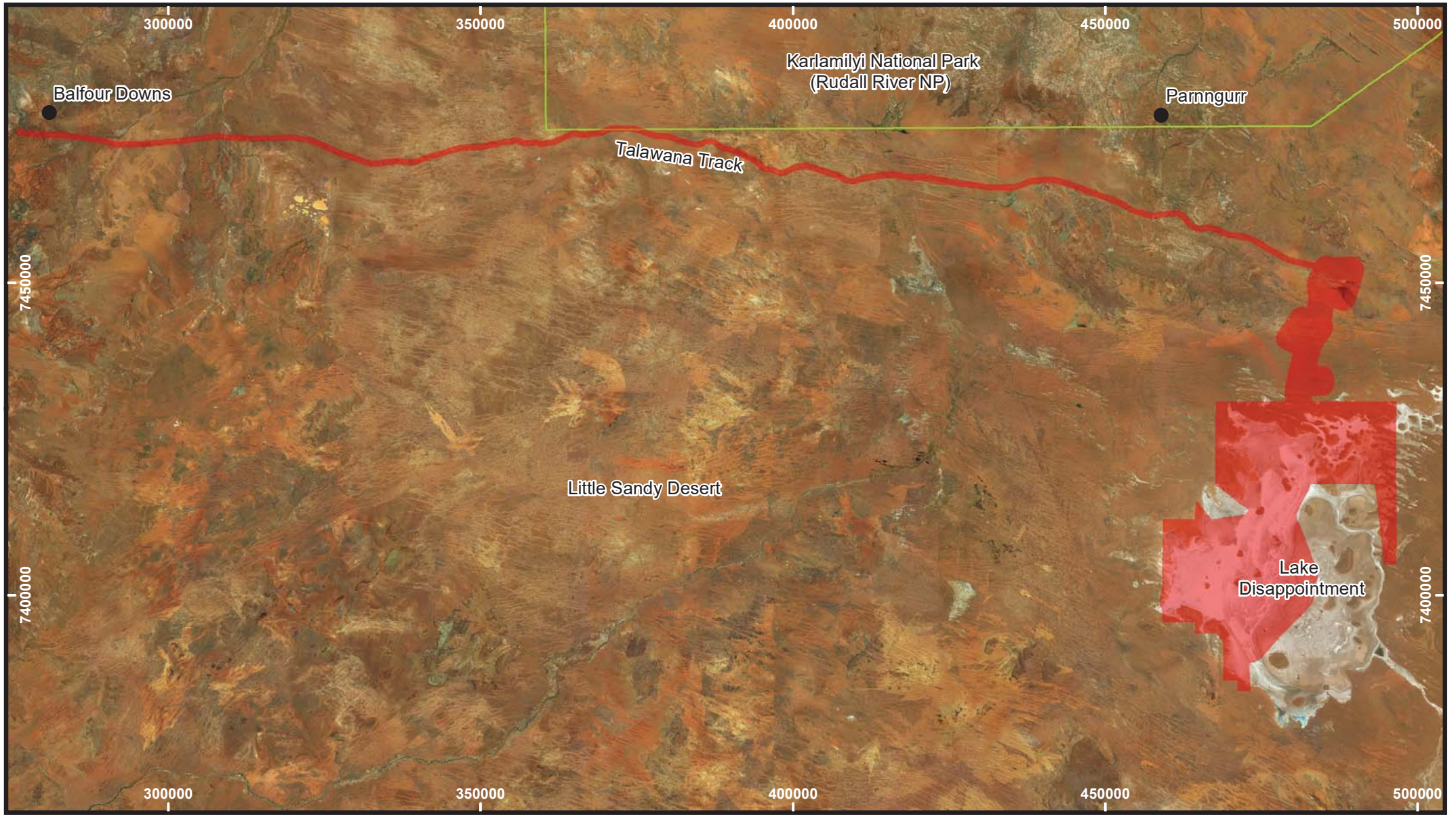
Fauna Survey

Reward Minerals Ltd
Lake Disappointment Potash Project

Study Area and Surrounds

Scale: G Harewood
Date: August 2017
Scale: 1:820,000
Projection/Coordinate System: UTM/MGA Zone 51

Figure: 1



Legend

- Study Area
- National Park Boundary

0 10 20 30 40 50
Kilometres

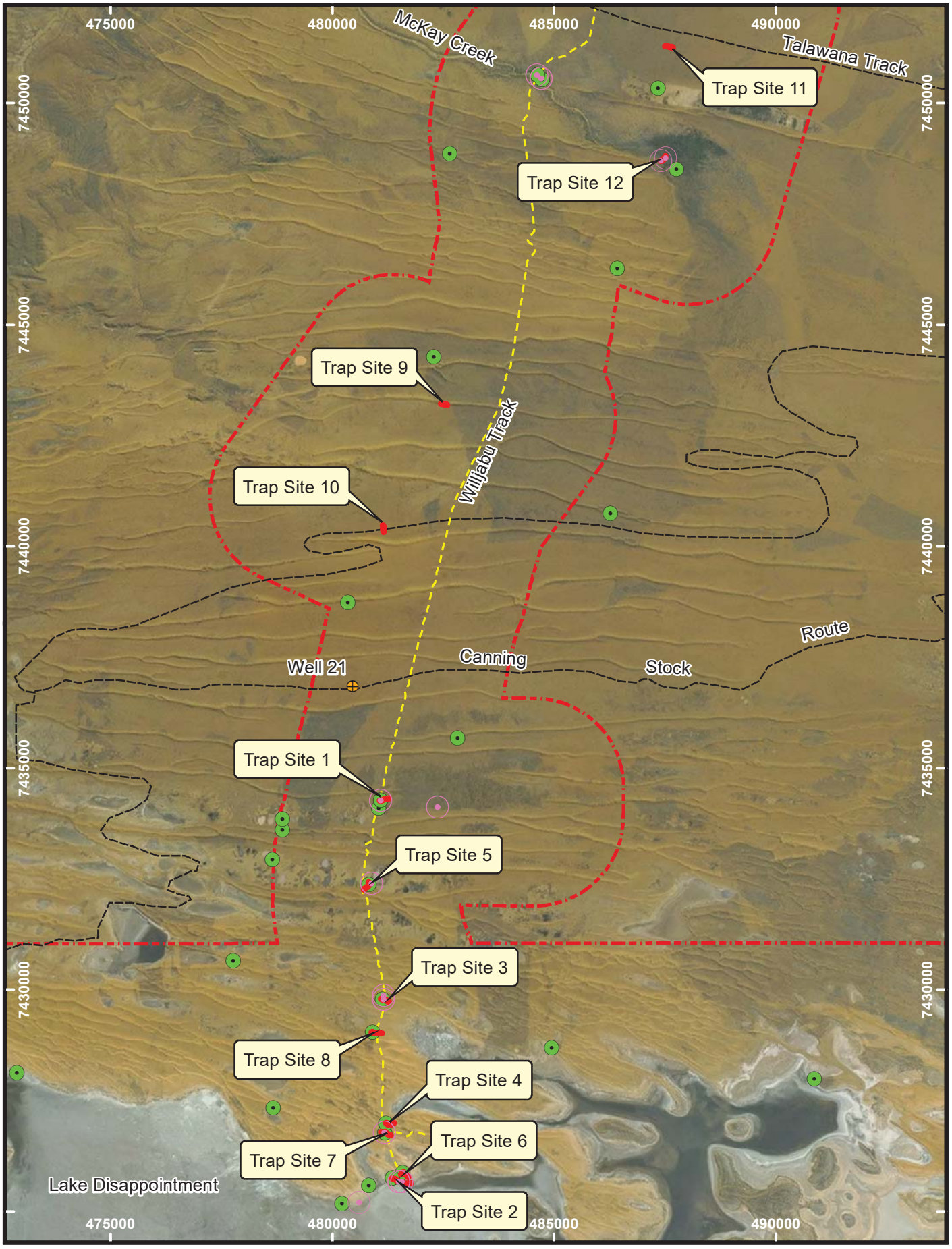
Fauna Survey

Reward Minerals Ltd
Lake Disappointment Potash Project

Study Area Air Photo

Scale: G Harewood
Date: August 2017
Scale: 1:820,000
Projection/Coordinate System: UTM/MGA Zone 51

Figure: 2



Legend

- Study Area
- Pit/Funnel/Elliot Trap Array
- Camera Trap
- Bat Recording Site

N

0 1 2 3 4 5

Kilometres

Fauna Survey

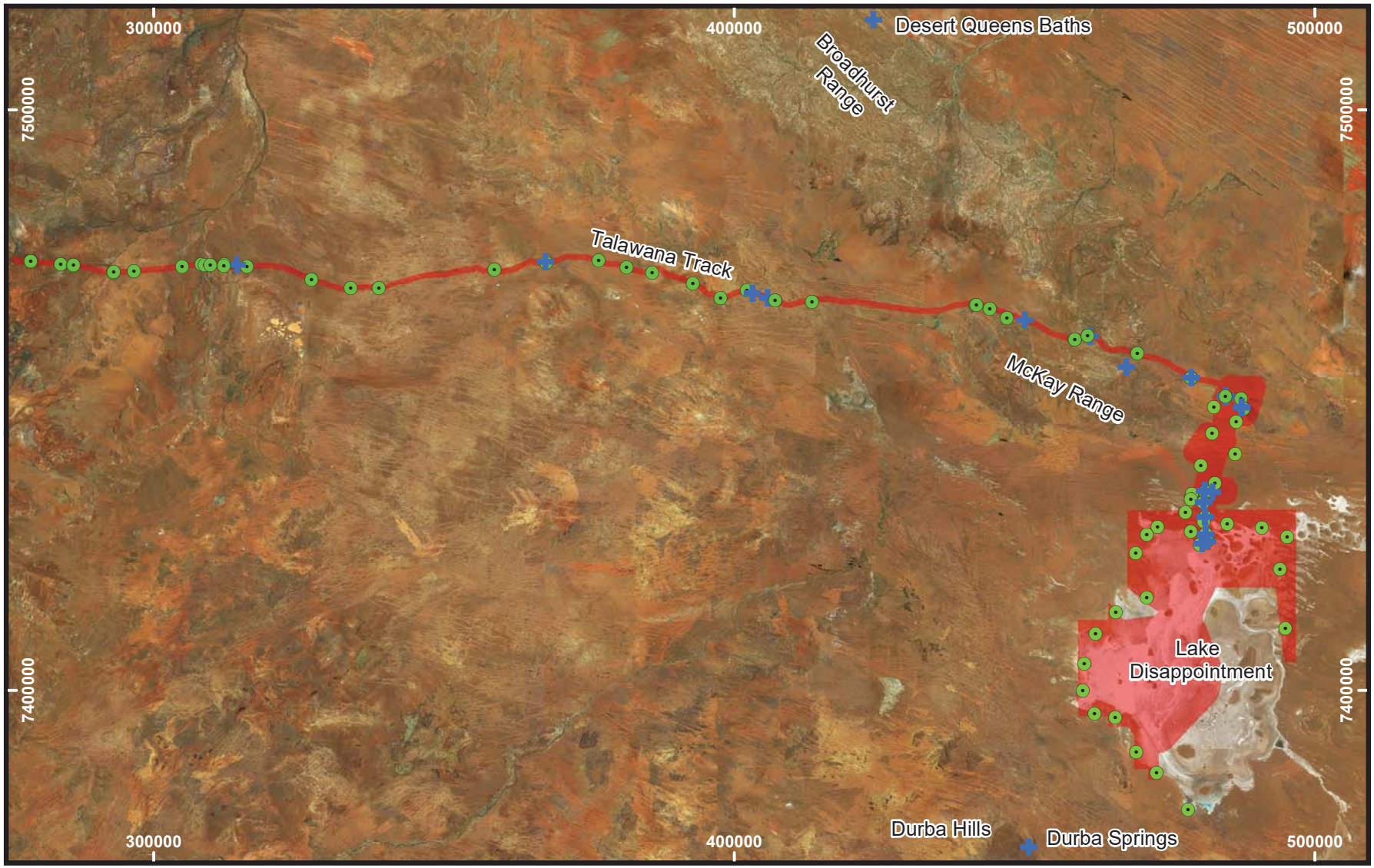
Reward Minerals Ltd
Lake Disappointment Potash Project

Trap, Bat and Camera Sites

(Willjabu Track Area)

Drawn: G Harewood
Date: August 2017
Scale: 1:115,000
Projection/Coordinate System: UTM/MGA Zone 51

Figure: 3



Legend

- Study Area
- Camera Trap Site
- Bat Recording Site

N

0 10 20 30 40 50

Kilometres

Fauna Survey

Reward Minerals Ltd
Lake Disappointment Potash Project

Camera Trap and Bat Recording Locations

Drawn: G Harewood	
Date: August 2017	
Scale: 1:1,000,000	
Projection/Coordinate System: UTM/MGA Zone 51	Figure: 4

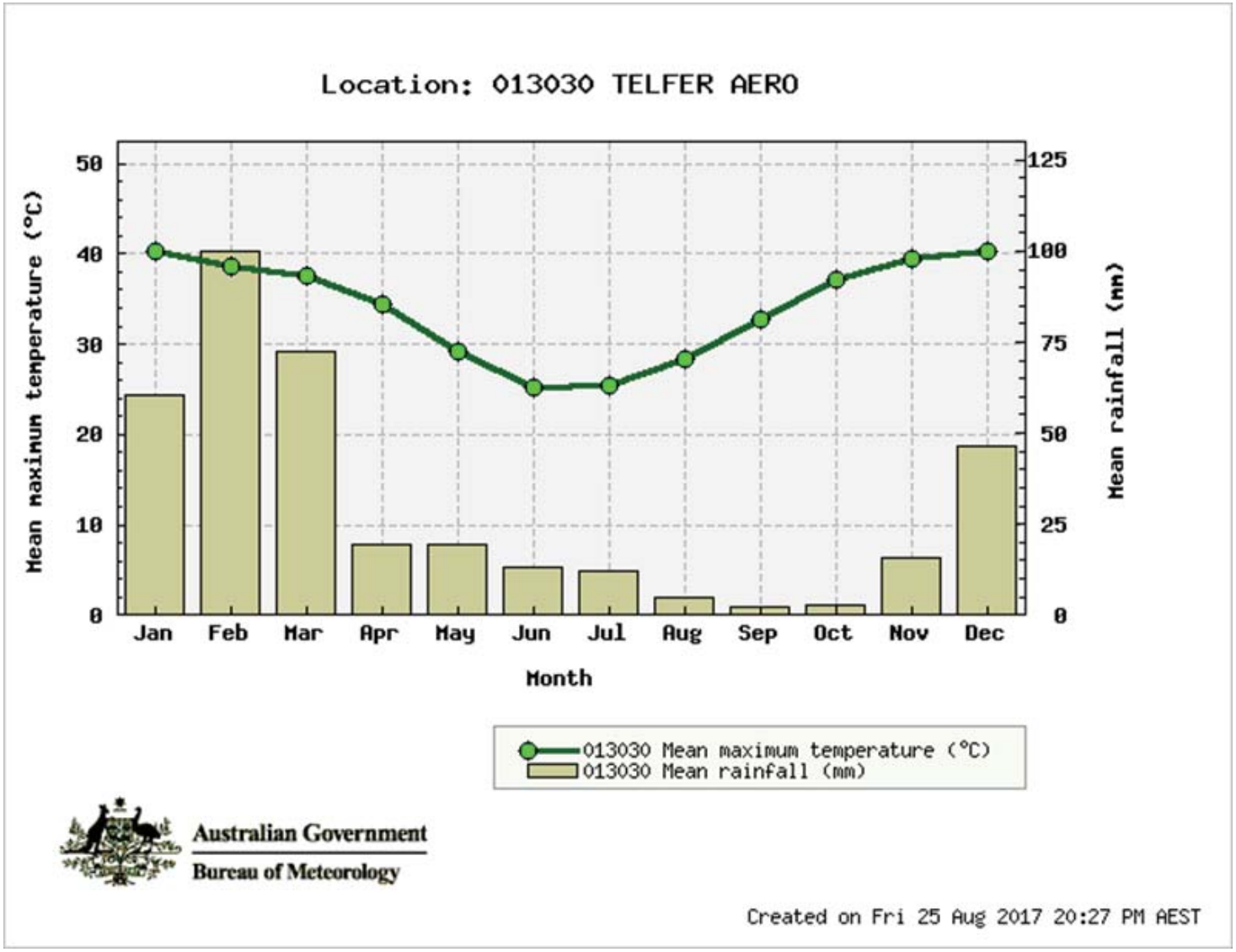
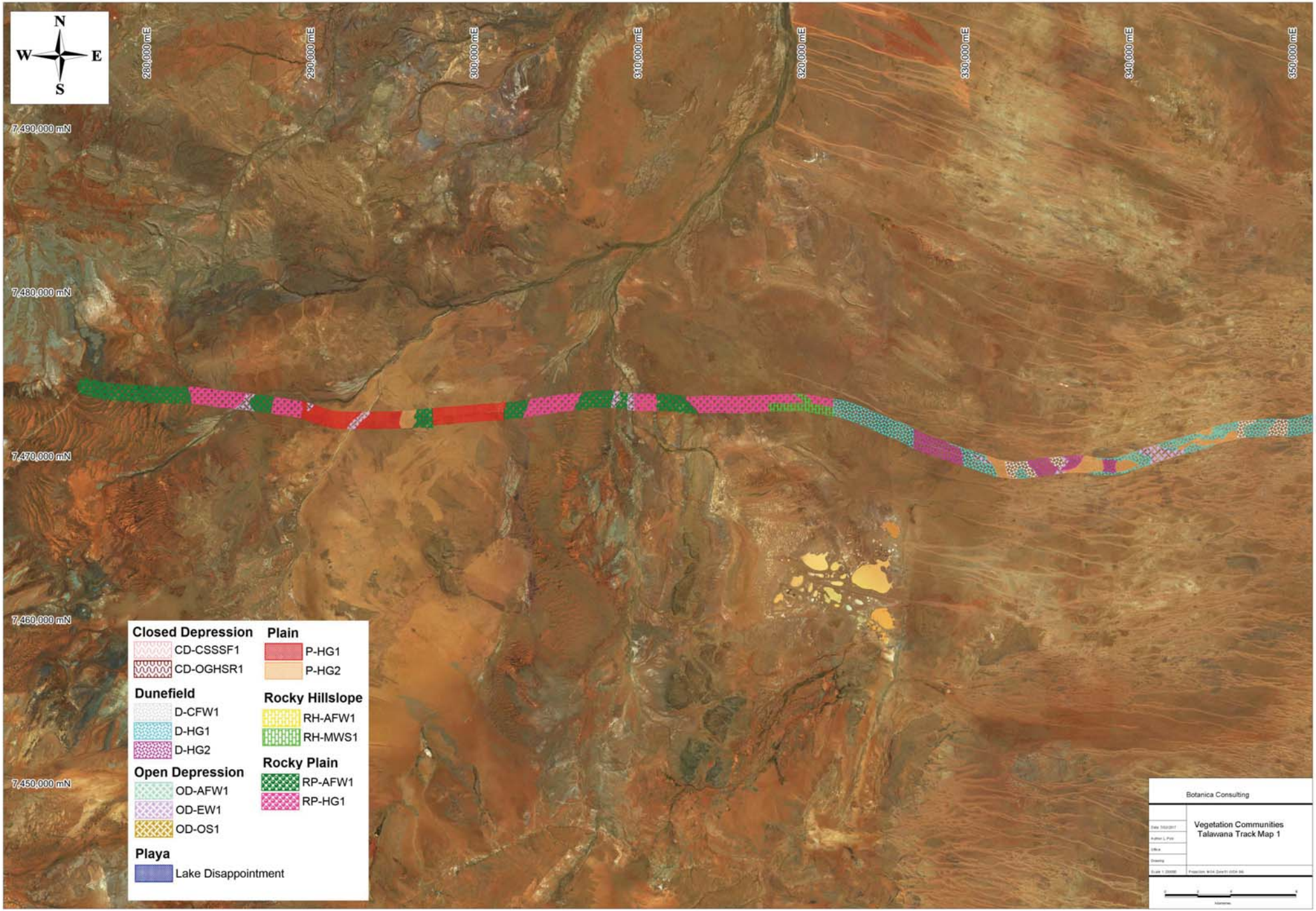


Figure 6: Mean Monthly Rainfall and Maximum and Minimum Temperatures (Telfer Aero Records 1974 – 2017, BoM 2017)


N
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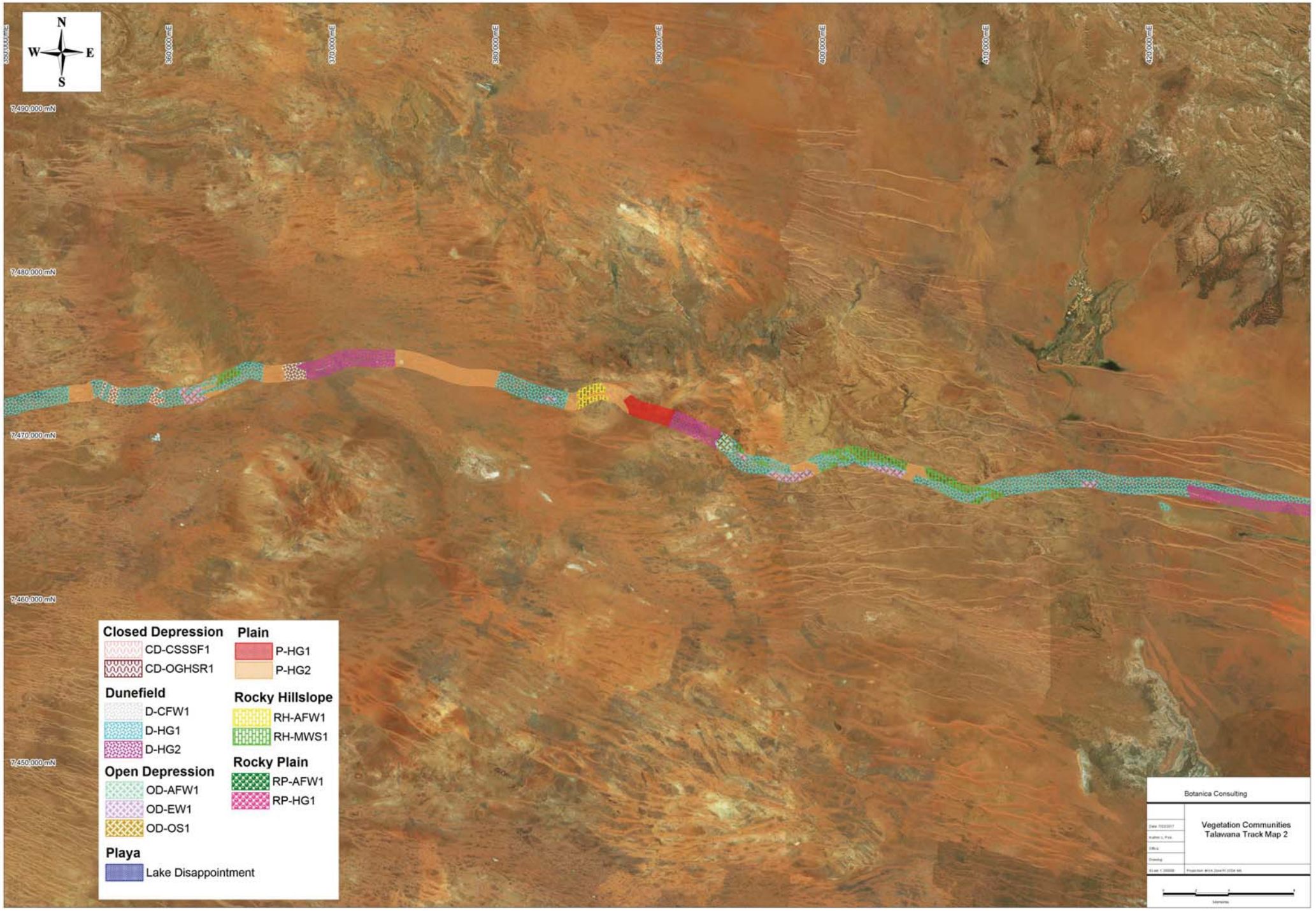
330,000 mE
340,000 mE
350,000 mE
7,490,000 mN
7,480,000 mN
7,470,000 mN
7,460,000 mN
7,450,000 mN
Closed Depression
CD-CSSSF1
CD-OGHSR1
Dunefield
D-CFW1
D-HG1
D-HG2
Open Depression
OD-AFW1
OD-EW1
OD-OS1
Playa
Lake Disappointment
Plain
P-HG1
P-HG2
Rocky Hillslope
RH-AFW1
RH-MWS1
Rocky Plain
RP-AFW1
RP-HG1
Botanica Consulting
Vegetation Communities
Talawana Track Map 1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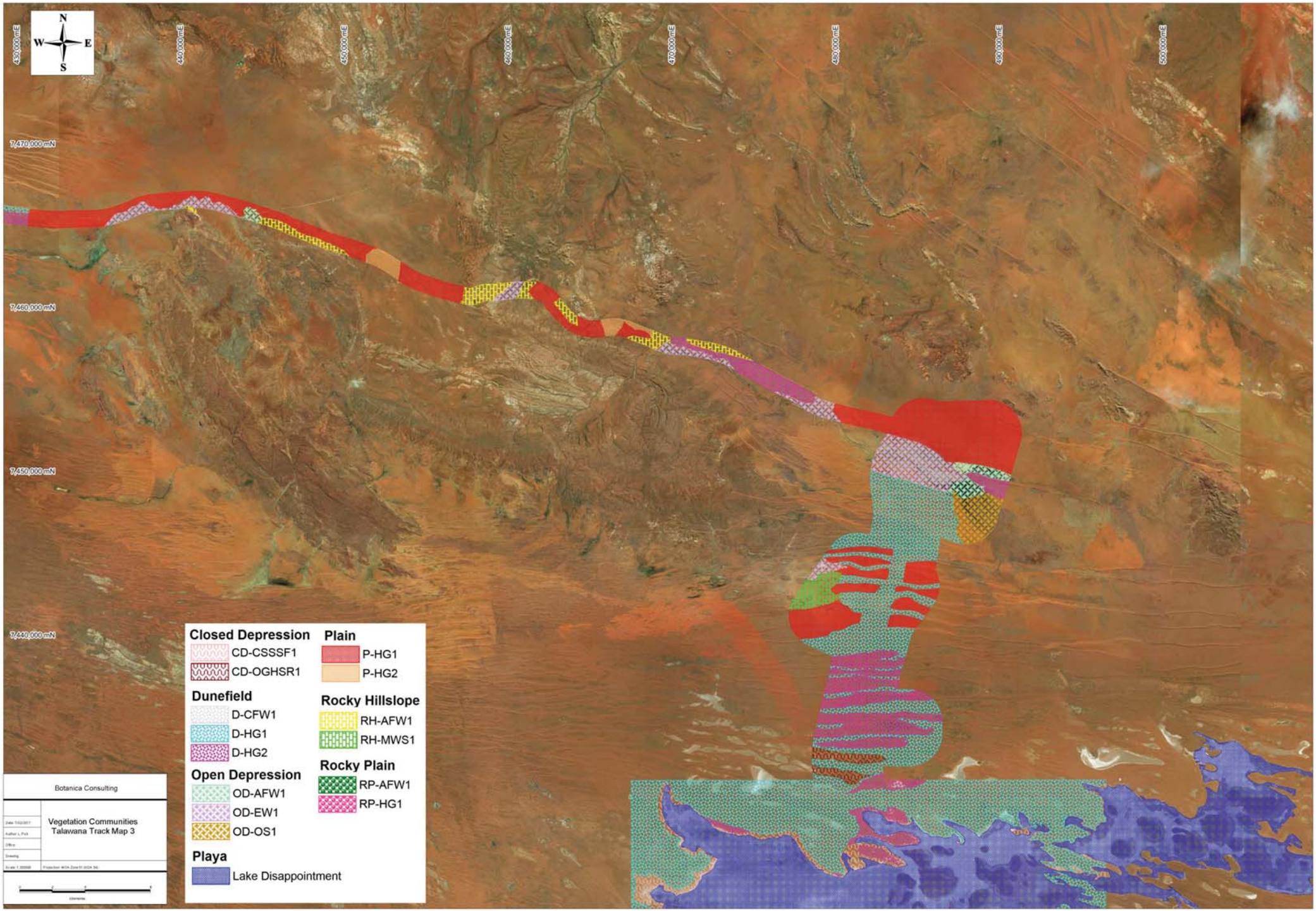
7,450,000 mN
Closed Depression
CD-CSSSF1
CD-OGHSR1
Dunefield
D-CFW1
D-HG1
D-HG2
Open Depression
OD-AFW1
OD-EW1
OD-OS1
Playa
Lake Disappointment
Plain
P-HG1
P-HG2
Rocky Hillslope
RH-AFW1
RH-MWS1
Rocky Plain
RP-AFW1
RP-HG1
Botanica Consulting
Vegetation Communities
Talawana Track Map 2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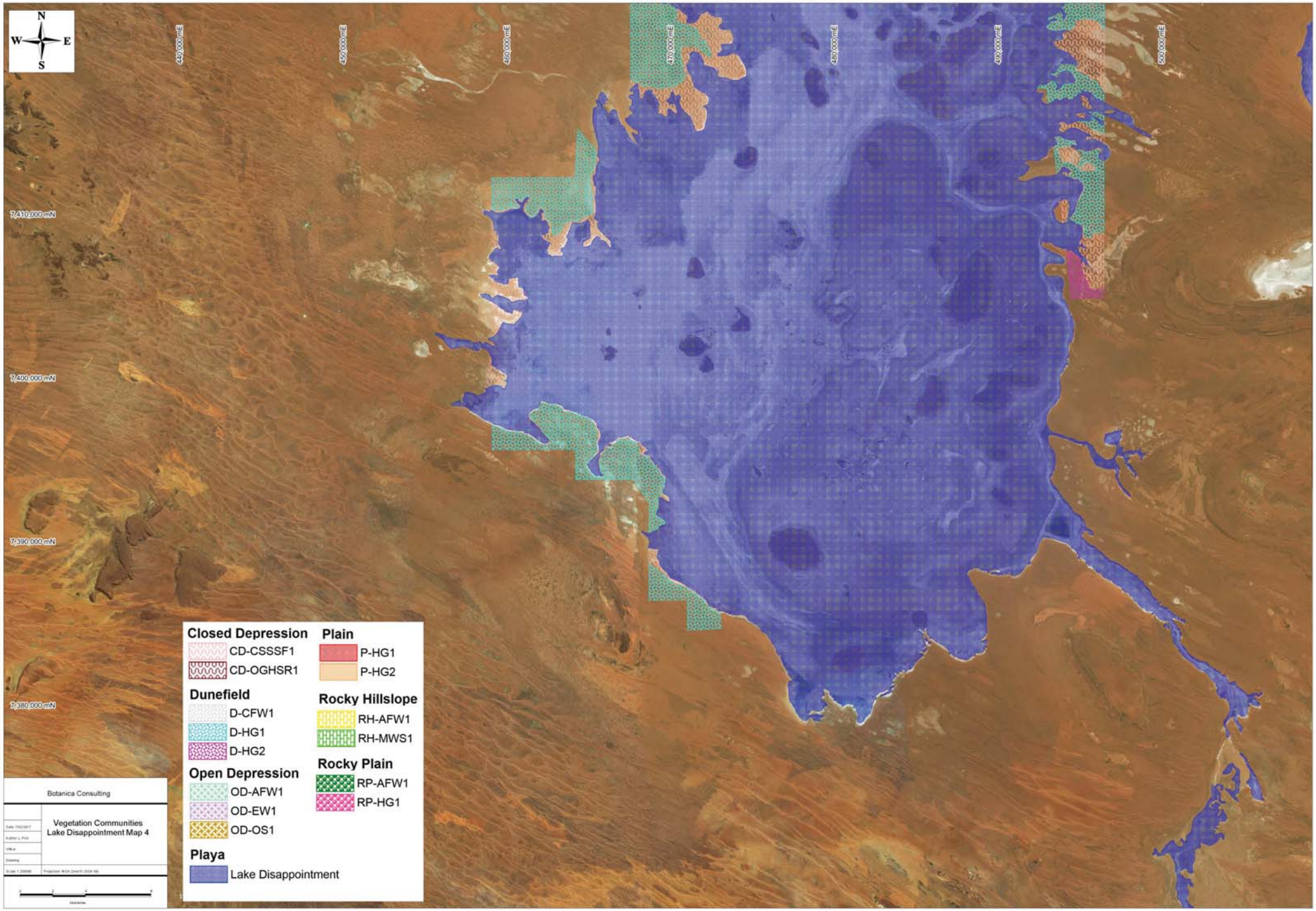
460,000 mE
470,000 mE
480,000 mE
490,000 mE
500,000 mE
7,470,000 mN
7,460,000 mN
7,450,000 mN
7,440,000 mN
Closed Depression
CD-CSSSF1
CD-OGHSR1
Dunefield
D-CFW1
D-HG1
D-HG2
Open Depression
OD-AFW1
OD-EW1
OD-OS1
Playa
Lake Disappointment
Plain
P-HG1
P-HG2
Rocky Hillslope
RH-AFW1
RH-MWS1
Rocky Plain
RP-AFW1
RP-HG1
Botanica Consulting
Vegetation Communities
Talawana Track Map 3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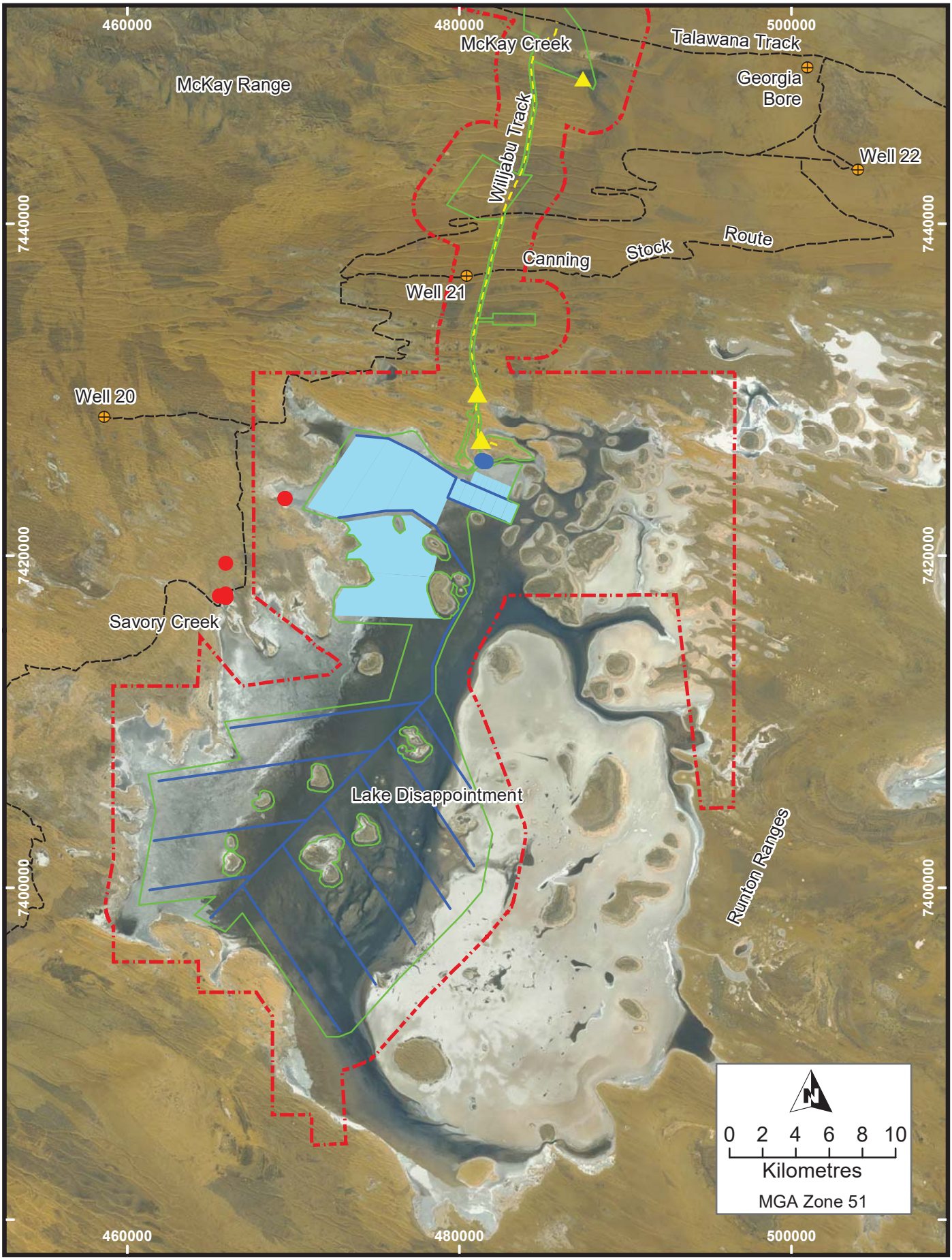
7,400,000 mN
7,390,000 mN
7,380,000 mN
Closed Depression
CD-CSSSF1
CD-OGHSR1
Dunefield
D-CFW1
D-HG1
D-HG2
Open Depression
OD-AFW1
OD-EW1
OD-OS1
Playa
Lake Disappointment
Plain
P-HG1
P-HG2
Rocky Hillslope
RH-AFW1
RH-MWS1
Rocky Plain
RP-AFW1
RP-HG1
Botanica Consulting
Vegetation Communities
Lake Disappointment Map 4



Legend

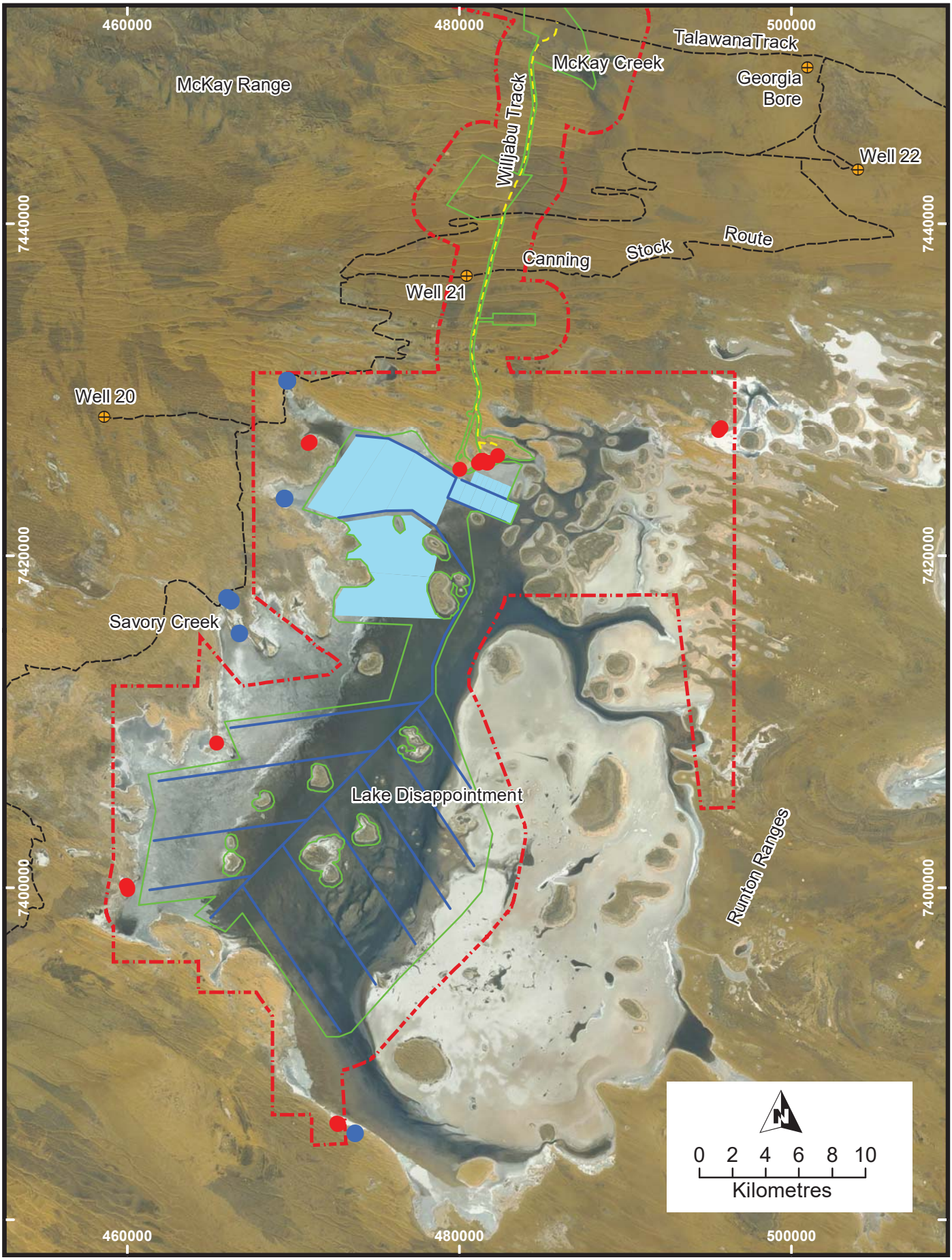
- Study Area
- Development Envelope
- Ponds or Dumps
- Brine or Processing Trench
- Unpatterned Robust Lerista (P2)
- Lake Disappointment Gecko (P2)
- Lake Disappointment Gecko (P2) (Other DBCA Records)

Fauna Survey

Reward Minerals Ltd
Lake Disappointment Potash Project

Reptiles of Conservation Significance - Records

Drawn: G Harewood	
Date: August 2017	
Scale: 1:310,000	
Projection/Coordinate System: UTM/MGA Zone 51	Figure: 8



Legend

- Study Area
- Development Envelope
- Ponds/Dumps
- Brine or Processing Trench
- Fauna Survey Records
- Other Records (DBCA)

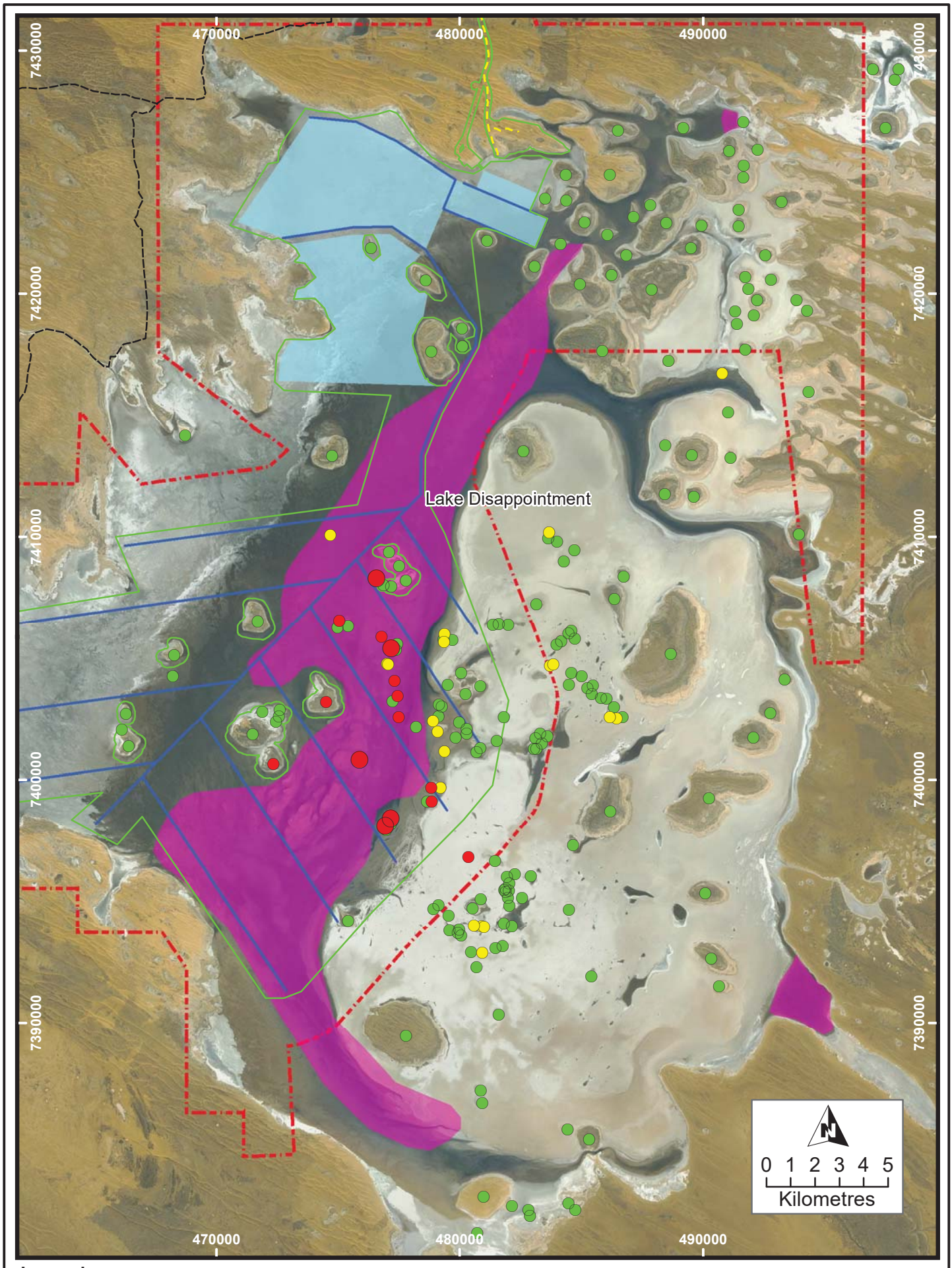
Fauna Survey

Drawn: G Harewood
Date: August 2017
Scale: 1:310,000
Projection/Coordinate System: UTM/MGA Zone 51

Reward Minerals Ltd
Lake Disappointment Potash Project

Lake Disappointment Dragon - Records

Figure: 9



Legend

- Study Area
- Development Envelope
- Ponds/Dumps
- Brine or Processing Trench
- Banded Stilt Creche (Dispersed young) Bennelongia 2017)
- Large Banded Stilt breeding colony (5)
- Small Banded Stilt breeding colony (10)
- Small breeding colony (other waterbirds) (19)
- No waterbird breeding activity evident (187)

Other breeding waterbirds = Mainly Red-necked Avocet, Gull-billed Tern and Grey Teal.

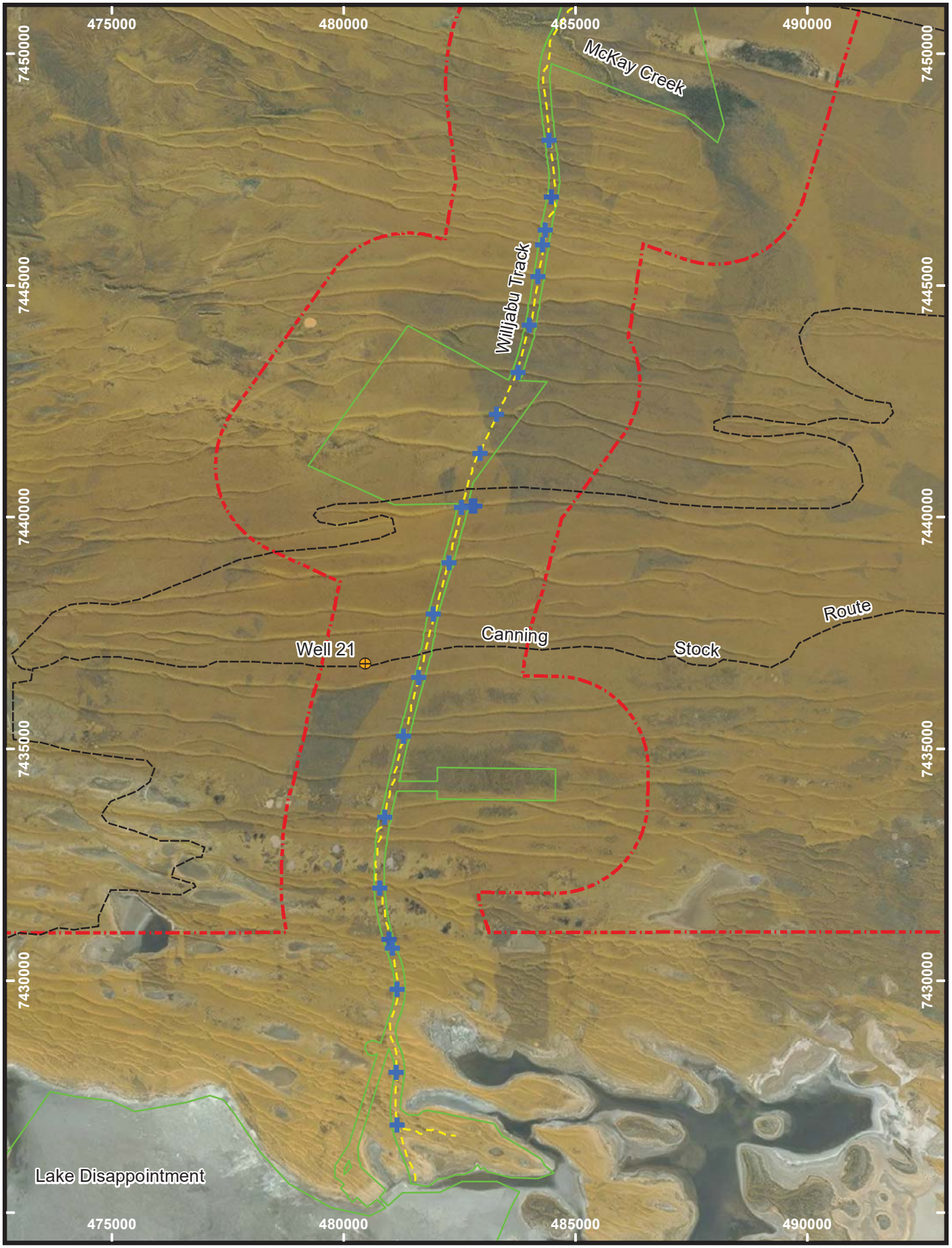
Fauna Survey

Drawn: G Harewood
Date: Sept 2017
Scale: 1:205,000
Projection/Coordinate System: UTM/MGA Zone 51

Reward Minerals Ltd
Lake Disappointment Potash Project

Island Survey Breeding Colonies Waterbirds

Figure: 10



Legend

- Survey Area
- Development Envelope
- Northern Marsupial Mole (P4) (Tunnels/Tracks)

0 1 2 3 4 5
Kilometres

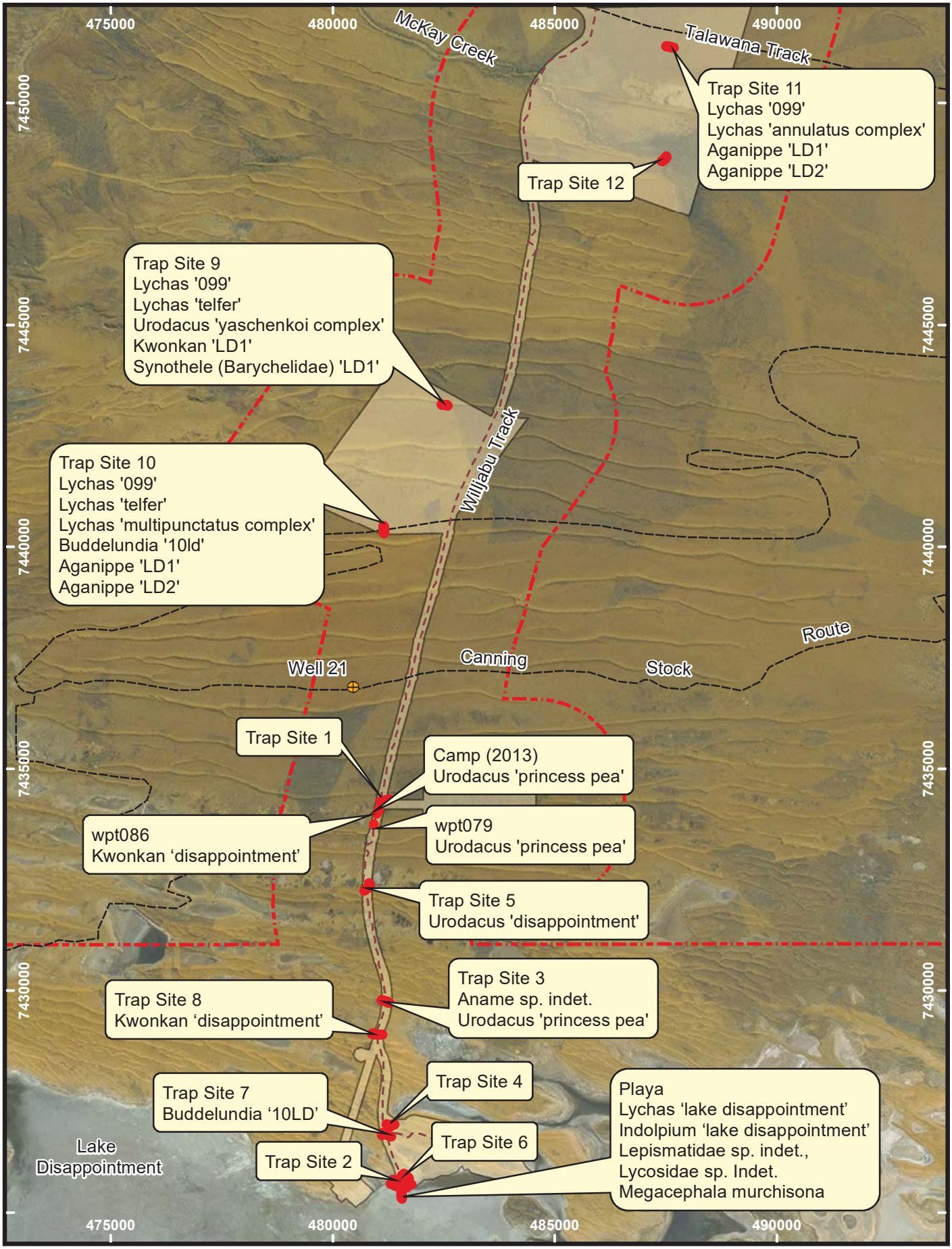
Fauna Survey

Drawn: G Harewood
Date: August 2017
Scale: 1:110,000
Projection/Coordinate System: UTM/MGA Zone 51

Reward Minerals Ltd
Lake Disappointment Potash Project

Northern Marsupial Mole Records

Figure: 11



Legend

- Study Area
- Off Playa Development Envelope
- Trap/Collection Site

N

0 1 2 3 4 5

Kilometres

Fauna Survey

Drawn: G Harewood

Date: Sept 2017

Scale: 1:115,000

Projection/Coordinate System: UTM/MGA Zone 51

Reward Minerals Ltd
Lake Disappointment Potash Project

Potential SRE Invertebrates Records

Figure: 12

APPENDIX A

Conservation Categories

***EPBC Act (1999)* Threatened Fauna Categories**

Threatened fauna may be listed under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) in any one of the following categories:

Category	Code	Description
Extinct	E	There is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	EW	A species (a) is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically Endangered	CE	A species is facing an extremely high risk of extinction in the wild in the immediate future.
*Endangered	EN	A species: (a) is not critically endangered; and (b) is facing a very high risk of extinction in the wild in the near future.
*Vulnerable	VU	A species (a) is not critically endangered or endangered; and (b) is facing a high risk of extinction in the wild in the medium-term future.
Conservation Dependent	CD	A species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered
*Migratory	Migratory	(a) all migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and (c) all native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Marine	Ma	Species in the list established under s248 of the *EPBC Act*

Note: Only species in those categories marked with an asterix are matters of national environmental significance (NES) under the *EPBC Act*.

Wildlife Conservation (Specially Protected Fauna) Notice 2015 Categories

Published as Specially Protected under the *Wildlife Conservation Act 1950*, and listed under Schedules 1 to 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

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.

Category	Code	Description
Schedule 1 Critically Endangered species	CR	Threatened species considered to be facing an extremely high risk of extinction in the wild.
Schedule 2 Endangered species	EN	Threatened species considered to be facing a very high risk of extinction in the wild.
Schedule 3 Vulnerable species	VU	Threatened species considered to be facing a high risk of extinction in the wild.
Schedule 4 Presumed extinct species	EX	Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
Schedule 5 Migratory birds protected under an international agreement	IA	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.
Schedule 6 Fauna that is of special conservation need as conservation dependent fauna	CD	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
Schedule 7 Other specially protected fauna.	OS	Fauna otherwise in need of special protection to ensure their conservation.

Western Australian DPaW Priority Fauna Categories

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna 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.

Category	Code	Description
Priority 1 Poorly Known Species.	P1	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.
Priority 2 Poorly Known Species.	P2	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.
Priority 3 Poorly Known Species.	P3	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.
Priority 4 Rare, Near Threatened and other species in need of monitoring.	P4	(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 do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (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).

IUCN Red List Threatened Species Categories

The *IUCN Red List of Threatened Species*™ is a checklist of taxa that have undergone an extinction risk assessment using the *IUCN Red List Categories and Criteria*.

Categories are summarized below.

Category	Code	Description
Extinct	EX	Taxa for which there is no reasonable doubt that the last individual has died.
Extinct in the Wild	EW	Taxa which is known only to survive in cultivation, in captivity or and as a naturalised population well outside its past range and it has not been recorded in known or expected habitat despite exhaustive survey over a time frame appropriate to its life cycle and form.
Critically Endangered	CR	Taxa facing an extremely high risk of extinction in the wild.
Endangered	EN	Taxa facing a very high risk of extinction in the wild.
Vulnerable	VU	Taxa facing a high risk of extinction in the wild.
Near Threatened	NT	Taxa which has been evaluated but does not qualify for CR, EN or VU now but is close to qualifying or likely to qualify in the near future.
Least Concern	LC	Taxa which has been evaluated but does not qualify for CR, EN, VU, or NT but is likely to qualify for NT in the near future.
Data Deficient	DD	Taxa for which there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.
Not Evaluated	NE	Taxa which has not been evaluated.

A full list of categories and their meanings are available at:

http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria

APPENDIX B

Fauna Trap, Recording and Search Sites – Details

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Greg Harewood on 25/08/2017

Kingdom	Animalia
Current Names Only	Yes
Core Datasets Only	Yes
Method	'By Circle'
Centre	122° 37' 15" E,22° 57' 31" S
Buffer	40km
Group By	Species Group

Species Group	Species	Records
Amphibian	7	657
Bird	92	1073
Invertebrate	2	4
Mammal	24	250
Reptile	56	819
TOTAL	**181**	**2803**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Amphibian					
1.	25374	*Cyclorana longipes (Long-footed Frog)*			
2.	25375	*Cyclorana maini (Sheep Frog)*			
3.	25392	*Litoria rubella (Little Red Tree Frog)*			
4.	25422	*Neobatrachus aquilonius (Northern Burrowing Frog)*			
5.	25427	*Neobatrachus sutor (Shoemaker Frog)*			
6.	25430	*Notaden nichollsi (Desert Spadefoot)*			
7.	25442	*Uperoleia micromeles (Tanami Toadlet)*			
Bird					
8.	24559	*Acanthagenys rufogularis (Spiny-cheeked Honeyeater)*			
9.	24265	*Acanthiza uropygialis (Chestnut-rumped Thornbill)*			
10.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
11.	25536	*Accipiter fasciatus (Brown Goshawk)*			
12.	25544	*Aegotheles cristatus (Australian Owlet-nightjar)*			
13.	25647	*Amytornis striatus (Striated Grasswren)*			
14.	24312	*Anas gracilis (Grey Teal)*			
15.	25670	*Anthus australis (Australian Pipit)*			
16.	24268	*Aphelocephala nigricincta (Banded Whiteface)*			
17.	24285	*Aquila audax (Wedge-tailed Eagle)*			
18.	24340	*Ardea novaehollandiae (White-faced Heron)*			
19.	24341	*Ardea pacifica (White-necked Heron)*			
20.	24610	*Ardeotis australis (Australian Bustard)*			
21.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
22.	24352	*Artamus cinereus subsp. melanops (Black-faced Woodswallow)*			
23.	24356	*Artamus personatus (Masked Woodswallow)*			
24.	24318	*Aythya australis (Hardhead)*			
25.		*Barnardius zonarius*			
26.	25715	*Cacatua roseicapilla (Galah)*			
27.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
28.	24269	*Calamanthus campestris (Rufous Fieldwren)*			
29.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
30.	24564	*Certhionyx variegatus (Pied Honeyeater)*			
31.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
32.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
33.	47909	*Cheramoeca leucosterna (White-backed Swallow)*			
34.	24289	*Circus assimilis (Spotted Harrier)*			
35.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
36.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
37.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
38.	24416	*Corvus bennetti (Little Crow)*			
39.	25593	*Corvus orru (Torresian Crow)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
40.	24671	*Coturnix pectoralis (Stubble Quail)*			
41.	25701	*Coturnix ypsilophora (Brown Quail)*			
42.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
43.	25596	*Cracticus torquatus (Grey Butcherbird)*			
44.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
45.		*Egretta novaehollandiae*			
46.		*Elanus axillaris*			
47.	25540	*Elanus caeruleus (Black-shouldered Kite)*			
48.	24631	*Emblema pictum (Painted Finch)*			
49.		*Eolophus roseicapillus*			
50.	24568	*Epthianura aurifrons (Orange Chat)*			
51.	24570	*Epthianura tricolor (Crimson Chat)*			
52.	24837	*Eremiornis carteri (Spinifex-bird)*			
53.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
54.	25621	*Falco berigora (Brown Falcon)*			
55.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
56.	25623	*Falco longipennis (Australian Hobby)*			
57.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
58.	24476	*Falco subniger (Black Falcon)*			
59.	24401	*Geopelia cuneata (Diamond Dove)*			
60.	24404	*Geophaps plumifera (Spinifex Pigeon)*			
61.	25530	*Gerygone fusca (Western Gerygone)*			
62.	24443	*Grallina cyanoleuca (Magpie-lark)*			
63.	24295	*Haliastur sphenurus (Whistling Kite)*			
64.	24296	*Hamirostra isura (Square-tailed Kite)*			
65.	24297	*Hamirostra melanosternon (Black-breasted Buzzard)*			
66.	25734	*Himantopus himantopus (Black-winged Stilt)*			
67.	24367	*Lalage tricolor (White-winged Triller)*			
68.	25661	*Lichmera indistincta (Brown Honeyeater)*			
69.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
70.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
71.	25652	*Malurus leucopterus (White-winged Fairy-wren)*			
72.	24549	*Malurus leucopterus subsp. leuconotus (White-winged Fairy-wren)*			
73.	24583	*Manorina flavigula (Yellow-throated Miner)*			
74.	47997	*Melanodryas cucullata (Hooded Robin)*			
75.	24736	*Melopsittacus undulatus (Budgerigar)*			
76.	24598	*Merops ornatus (Rainbow Bee-eater)*		IA	
77.	24742	*Nymphicus hollandicus (Cockatiel)*			
78.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
79.	24618	*Oreoica gutturalis (Crested Bellbird)*			
80.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
81.	24627	*Pardalotus rubricatus (Red-browed Pardalote)*			
82.	25682	*Pardalotus striatus (Striated Pardalote)*			
83.	48060	*Petrochelidon ariel (Fairy Martin)*			
84.	24659	*Petroica goodenovii (Red-capped Robin)*			
85.	24409	*Phaps chalcoptera (Common Bronzewing)*			
86.	25703	*Podargus strigoides (Tawny Frogmouth)*			
87.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
88.	24752	*Polytelis alexandrae (Princess Parrot)*		P4	
89.	25706	*Pomatostomus temporalis (Grey-crowned Babbler)*			
90.	24390	*Psophodes occidentalis (Western Wedgebill, Chiming Wedgebill)*			
91.	42344	*Purnella albifrons (White-fronted Honeyeater)*			
92.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
93.	25656	*Stipiturus ruficeps (Rufous-crowned Emu-wren)*			
94.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
95.	30870	*Taeniopygia guttata (Zebra Finch)*			
96.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
97.	42351	*Todiramphus pyrrhopygius (Red-backed Kingfisher)*			
98.	24851	*Turnix velox (Little Button-quail)*			
99.	25762	*Tyto alba (Barn Owl)*			
Invertebrate					
100.		*Argiope protensa*			
101.		*Trichocyclus gnalooma*			
Mammal					
102.	24254	*Camelus dromedarius (Dromedary, Camel)*	Y		
103.	25454	*Canis lupus (Dog, Dingo)*	Y		
104.	24039	*Canis lupus subsp. dingo (Dingo)*	Y		
105.	24181	*Chaerephon jobensis (Greater Northern Freetail-bat, Northern Mastiff Bat)*			
106.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
107.	30903	*Dasycercus blythi (Brush-tailed Mulgara, Ampurta)*		P4	
108.	24091	*Dasykaluta rosamondae (Little Red Kaluta)*			
109.	24041	*Felis catus (Cat)*	Y		
110.	24135	*Macropus robustus subsp. erubescens (Euro, Biggada)*			
111.	24136	*Macropus rufus (Red Kangaroo, Marlu)*			
112.	24223	*Mus musculus (House Mouse)*	Y		
113.	24094	*Ningaui ridei (Wongai Ningaui)*			
114.	24224	*Notomys alexis (Spinifex Hopping-mouse)*			
115.	24147	*Notoryctes caurinus (Northern Marsupial Mole, Kakarratul)*		P4	
116.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
117.	24233	*Pseudomys chapmani (Western Pebble-mound Mouse, Ngadji)*		P4	
118.	24235	*Pseudomys desertor (Desert Mouse)*			
119.	24237	*Pseudomys hermannsburgensis (Sandy Inland Mouse)*			
120.	24174	*Saccolaimus flaviventris (Yellow-bellied Sheath-tailed Bat)*			
121.	24200	*Scotorepens greyii (Little Broad-nosed Bat)*			
122.	24120	*Sminthopsis youngsoni (Lesser Hairy-footed Dunnart)*			
123.	24175	*Taphozous georgianus (Common Sheath-tailed Bat)*			
124.	24205	*Vespadelus finlaysoni (Finlayson's Cave Bat)*			
125.	24040	*Vulpes vulpes (Red Fox)*	Y		
Reptile					
126.	30833	*Amphibolurus longirostris (Long-nosed Dragon)*			
127.	25236	*Aspidites ramsayi (Woma)*			
128.	30893	*Cryptoblepharus buchananii*			
129.	25458	*Ctenophorus caudicinctus (Ring-tailed Dragon)*			
130.	24865	*Ctenophorus caudicinctus subsp. caudicinctus (Ring-tailed Dragon)*			
131.	25459	*Ctenophorus isolepis (Crested Dragon, Military Dragon)*			
132.	24875	*Ctenophorus isolepis subsp. gularis (Central Military Dragon)*			
133.	24876	*Ctenophorus isolepis subsp. isolepis (Crested Dragon, Military Dragon)*			
134.	30898	*Ctenophorus nguyarna (Lake Disappointment Dragon)*			
135.	24882	*Ctenophorus nuchalis (Central Netted Dragon)*			
136.	25461	*Ctenotus brooksi*			
137.	25037	*Ctenotus dux*			
138.	25462	*Ctenotus grandis*			
139.	25045	*Ctenotus helenae*			
140.	25050	*Ctenotus leae*			
141.	25463	*Ctenotus pantherinus (Leopard Ctenotus)*			
142.	25064	*Ctenotus pantherinus subsp. ocellifer (Leopard Ctenotus)*			
143.	25062	*Ctenotus piankai*			
144.	30830	*Delma desmosa*			
145.	25001	*Delma nasuta*			
146.	24926	*Diplodactylus conspicillatus (Fat-tailed Gecko)*			
147.	24928	*Diplodactylus fulleri (Lake Disappointment Ground Gecko)*		P2	
148.	42401	*Diporiphora paraconvergens (Grey-striped Western Desert Dragon)*			
149.	43381	*Eremiascincus pallidus (Western Narrow-banded Skink, Narrow-banded Sand Swimmer)*			
150.	24956	*Gehyra pilbara*			
151.	24957	*Gehyra purpurascens*			
152.	24959	*Gehyra variegata*			
153.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
154.	25125	*Lerista bipes*			
155.	25142	*Lerista ips*			
156.	25150	*Lerista macropisthopus subsp. remota (Unpatterned Robust Slider (central interior WA), skink)*		P2	
157.	25181	*Lerista xanthura*			
158.	25005	*Lialis burtonis*			
159.	30933	*Lucasium stenodactylum*			
160.	25184	*Menetia greyii*			
161.	24904	*Moloch horridus (Thorny Devil)*			
162.	25495	*Morethia ruficauda*			
163.	24966	*Nephrurus laevissimus*			
164.	25497	*Nephrurus levis*			
165.	25499	*Notoscincus ornatus*			
166.	25261	*Pseudechis australis (Mulga Snake)*			
167.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			
168.	25263	*Pseudonaja modesta (Ringed Brown Snake)*			
169.	25009	*Pygopus nigriceps*			
170.	24982	*Rhynchoedura ornata (Western Beaked Gecko)*			
171.	25305	*Simoselaps anomalus (Desert Banded Snake)*			
172.	25517	*Strophurus ciliaris*			
173.	24924	*Strophurus ciliaris subsp. aberrans*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
174.	24927	*Strophurus elderi*			
175.	25202	*Tiliqua multifasciata (Central Blue-tongue)*			
176.	25209	*Varanus acanthurus (Spiny-tailed Monitor)*			
177.	25210	*Varanus brevicauda (Short-tailed Pygmy Monitor)*			
178.	25212	*Varanus eremius (Pygmy Desert Monitor)*			
179.	25215	*Varanus gilleni (Pygmy Mulga Monitor)*			
180.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
181.	25223	*Varanus panoptes subsp. rubidus*			

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.

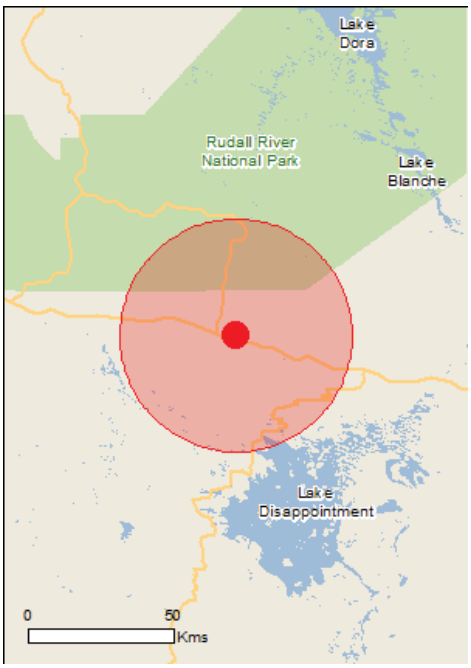
EPBC Act Protected Matters Report

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: 25/08/17 22:10:41



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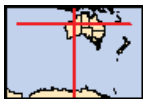

Summary

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:	4
Listed Migratory Species:	7

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:	10
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:	8
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat may occur within area
Mammals		
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat may occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat likely to 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		
Hirundo rustica Barn Swallow [662]		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
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species

Name	Threatened	Type of Presence
		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		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		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
Karlamilyi	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
Mammals		
Camelus dromedarius Dromedary, Camel [7]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur 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		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Lake Disappointment (Savory Creek) System	WA

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.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

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

-22.95862 122.62086

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
-Department of Land and Resource Management, Northern Territory
-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, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-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 D

Vertebrate Fauna Recorded or Potentially in Study Area

Fauna Recorded or Potentially Present

Lake Disappointment

Approximate centroid - 23.269440°S and 122.825120°E

Compiled by G Harewood - October 2017

Recorded = X

Harewood, G. (2017) . Fauna Survey Report - Lake Disappointment Potash Project. Unpublished report for Reward Minerals Ltd. October 2017.

DBCA (2017). NatureMap Database Search. “By Circle” 122°49' 30" E, 23°16' 09" S/ (plus 40km buffer). Accessed 25/08/2017.

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Amphibia				
Myobatrachidae Ground or Burrowing Frogs				
Neobatrachus aquilonius	Northern Burrowing Frog	LC	X	X
Neobatrachus sutor	Shoemaker Frog	LC	X	X
Notaden nichollsi	Desert Spadefoot	LC	X	X
Platypectrum spenceri	Spencer's Burrowing Frog	LC	X	
Uperoleia glandulosa	Glandular Toadlet	LC	X	
Uperoleia micromeles	Tanami Toadlet	LC	X	X
Hylidae Tree or Water-Holding Frogs				
Cyclorana longipes	Long-footed Frog	LC		X
Cyclorana maini	Main's Frog	LC	X	X
Cyclorana platycephala	Water-holding Frog	LC	X	
Litoria rubella	Little Red Tree Frog	LC	X	X

WC Act Status - S1 to S7, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DBCA Priority Status - P1 to P4, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, IUCN Red List Category Definitions LC = Least Concern - see Appendix A and http://www.iucnredlist.org/technical-documents/categories-and-criteria/2001-categories-criteria for others.

Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Reptilia				
Carphodactylidae Knob-tailed Geckos				
Nephrurus laevissimus	Pale Knob-tail Gecko		X	X
Nephrurus levis	Smooth Knob-tail Gecko		X	X
Diplodactylidae Geckoes				
Crenadactylus ocellatus	Clawless Gecko			
Diplodactylus conspicillatus	Fat-tailed Gecko		X	X
Diplodactylus fulleri	Lake Disappointment Gecko	P2	X	X
Lucasium stenodactylum	Box-patterned Gecko		X	X
Rhynchoedura ornata	Western Beaked Gecko		X	X
Strophurus ciliaris	Northern Spiny-tailed Gecko		X	X
Strophurus elderi	Jewelled Gecko		X	X
Strophurus jeanae	Southern Phasmid Gecko			

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Gekkonidae Geckoes				
Gehyra pilbara	Pilbara Dtella			X
Gehyra purpurascens	Purple Arid Dtella		X	X
Gehyra variegata	Variegated Dtella		X	X
Hemidactylus frenatus	Asian House Gecko	Introduced	X	
Heteronotia binoei	Bynoe's Gecko		X	X
Pygopodidae Legless Lizards				
Delma butleri	Unbanded Delma			
Delma desmosa	Desert Delma		X	X
Delma haroldi	Necked-barred Delma		X	
Delma nasuta	Long-nosed Delma		X	X
Lialis burtonis	Burton’s Legless Lizard		X	X
Pygopus nigriceps	Western Hooded Scaly-foot		X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Agamidae Dragon Lizards				
Ctenophorus isolepis	Central Military Dragon		X	X
Ctenophorus nguyarna	Lake Disappointment Dragon		X	X
Ctenophorus nuchalis	Central Netted Dragon		X	X
Diporiphora paraconvergens	Grey-striped Western Desert Dragon		X	X
Gowidon longirostris	Long-nosed Dragon		X	
Moloch horridus	Thorny Devil		X	X
Varanidae Monitor's or Goanna's				
Varanus acanthurus	Spiny-tailed Monitor		X	X
Varanus brevicauda	Short-tailed Pygmy Monitor		X	X
Varanus eremius	Pygmy Desert Monitor		X	X
Varanus giganteus	Perentie		X	
Varanus gilleni	Pygmy Mulga Monitor		X	X
Varanus gouldii	Sand Goanna		X	X
Varanus tristis	Racehorse Goanna			

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Scincidae Skinks				
Carlia triacantha	Desert Rainbow-skink			
Ctenotus ariadnae	Ariadna's Ctenotus		X	
Ctenotus brooksi	Brook's Wedge-snouted Ctenotus		X	X
Ctenotus calurus	Blue-tailed Ctenotus		X	
Ctenotus dux	Narrow-lined Ctenotus		X	X
Ctenotus grandis	Giant Desert Ctenotus		X	X
Ctenotus hanloni	Nimble Ctenotus		X	
Ctenotus helenae	Dusky Ctenotus		X	X
Ctenotus leae	Orange-tailed Finesnout Ctenotus		X	X
Ctenotus leonhardii	Leonhardi's Skink			
Ctenotus nasutus	Long-snouted Ctenotus		X	
Ctenotus pantherinus	Leopard Ctenotus		X	X
Ctenotus piankai	Pianka's Ctenotus		X	X
Ctenotus quattuordecimlineatus	Fourteen-lined Ctenotus		X	
Ctenotus schomburgkii	Barred Wedge-snout Ctenotus		X	

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Cyclodomorphus melanops melanops	Spinifiex Slender Blue-tongue			
Eremiascincus fasciolatus	Narrow-banded Sand Swimmer		X	
Eremiascincus richardsonii	Broad-banded Sand Swimmer			
Lerista bipes	Western Two-toed Slider		X	X
Lerista desertorum	Central Deserts Robust Slider			
Lerista ips	Robust Worm-slider		X	X
Lerista macropisthopus remota	Unpatterned Robust Lerista	P2	X	X
Lerista timida	Shy Slider			
Lerista vermicularis	Slender Duneslider			
Lerista xanthura	Yellow-tailed Plain Slider		X	X
Liopholis inornata	Desert Skink			
Liopholis kintorei	Great Desert Skink	S3 VU VU A1c		
Liopholis striata	Night Skink			
Menetia greyii	Common Dwarf Skink		X	X
Morethia ruficauda	Fire-tailed Skink		X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Notoscincus ornatus	Ornate Snake-eyed Skink		X	X
Proablepharus reginae	Spinifex Snake-eyed Skink			
Tiliqua multifasciata	Desert Blue Tongue Lizard		X	X
Typhlopidae Blind Snakes				
Anilios endoterus	Desert Blind Snake		X	
Anilios grypus	Northern Beaked Blind Snake		X	
Boidae Pythons, Boas				
Aspidites ramsayi	Woma		X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Elapidae Elapid Snakes				
Acanthophis pyrrhus	Desert Death Adder			
Brachyurophis fasciolata	Narrow-banded Shovel-nosed Snake		X	
Demansia shinei	Shine's Whipsnake			
Furina ornata	Moon Snake		X	X
Pseudechis australis	Mulga Snake		X	X
Pseudonaja mengdeni	Gwardar		X	X
Pseudonaja modesta	Ringed Brown Snake		X	X
Simoselaps anomalus	Desert Banded Snake		X	X
Suta fasciata	Rosen's Snake			

Aves

Casuariidae Emus, Cassowarries				
Dromaius novaehollandiae	Emu	LC	X	
Phasianidae Quails, Pheasants				
Coturnix pectoralis	Stubble Quail	LC	X	X
Coturnix ypsilophora	Brown Quail	LC		X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Anatidae Geese, Swans, Ducks				
Anas gracilis	Grey Teal	LC	X	X
Anas rhynchotis	Australasian Shoveler	LC		X
Anas superciliosa	Pacific Black Duck	LC	X	X
Aythya australis	Hardhead	LC	X	X
Chenonetta jubata	Australian Wood Duck	LC	X	X
Cygnus atratus	Black Swan	LC		
Dendrocygna eytoni	Plumed Whistling Duck	LC		
Malacorhynchus membranaceus	Pink-eared Duck	LC	X	X
Stictonetta naevosa	Freckled Duck	LC	X	X
Podicipedidae Grebes				
Poliocephalus poliocephalus	Hoary-headed Grebe	LC	X	X
Tachybaptus novaehollandiae	Australasian Grebe	LC	X	X
Anhingidae Darters				
Anhinga melanogaster	Darter			

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Phalacrocoracidae Cormorants				
Phalacrocorax melanoleucos	Little Pied Cormorant	LC	X	X
Phalacrocorax sulcirostris	Little Black Cormorant	LC		
Phalacrocorax varius	Pied Cormorant	LC		
Pelecanidae Pelicans				
Pelecanus conspicillatus	Australian Pelican	LC		
Ardeidae Herons, Egrets, Bitterns				
Ardea garzetta	Little Egret		X	
Ardea intermedia	Intermediate Egret			
Ardea modesta	Eastern Great Egret	S5 Mig CA JA LC	X	
Ardea novaehollandiae	White-faced Heron	LC	X	X
Ardea pacifica	White-necked Heron	LC	X	X
Nycticorax caledonicus	Nankeen Night Heron	LC	X	
Threskiornithidae Iibises, Spoonbills				
Threskiornis molucca	Australian White Ibis	LC		
Threskiornis spinicollis	Straw-necked Ibis	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Accipitridae Kites, Goshawks, Eagles, Harriers				
Accipiter cirrocephalus	Collared Sparrowhawk	LC		X
Accipiter fasciatus	Brown Goshawk	LC	X	X
Aquila audax	Wedge-tailed Eagle	LC	X	X
Aquila morphnoides	Little Eagle	LC	X	X
Circus approximans	Swamp Harrier	LC	X	X
Elanus caeruleus	Black-shouldered Kite	LC	X	X
Haliastur sphenurus	Whistling Kite	LC	X	X
Hamirostra isura	Square-tailed Kite	LC	X	X
Hamirostra melanosternon	Black-breasted Buzzard	LC	X	X
Milvus migrans	Black Kite	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Falconidae Falcons				
Falco berigora	Brown Falcon	LC	X	X
Falco cenchroides	Australian Kestrel	LC	X	X
Falco hypoleucos	Grey Falcon	S3 VU D1		
Falco longipennis	Australian Hobby	LC	X	X
Falco peregrinus	Peregrine Falcon	S7 LC	X	X
Falco subniger	Black Falcon	LC	X	X
Gruidae Cranes				
Grus rubicunda	Brolga	LC	X	X
Rallidae Rails, Crakes, Swamphens, Coots				
Fulica atra	Eurasian Coot	LC	X	X
Gallinula ventralis	Black-tailed Native-hen	LC	X	X
Otididae Bustards				
Ardeotis australis	Australian Bustard	LC	X	X
Turnicidae Button-quails				
Turnix velox	Little Button-quail	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Scolopacidae Curlews, Sandpipers, Snipes, Godwits				
Calidris acuminata	Sharp-tailed Sandpiper	S5 Mig CA JA RK LC	X	X
Calidris ferruginea	Curlew Sandpiper	S3 VU S5 Mig CR CA JA		
Calidris melanotos	Pectoral Sandpiper	S5 Mig JA RK LC	X	
Calidris ruficollis	Red-necked Stint	S5 Mig CA JA RK LC	X	X
Tringa glareola	Wood Sandpaper	S5 Mig CA JA RK LC		
Tringa hypoleucos	Common Sandpiper	S5 Mig CA JA RK LC		
Tringa nebularia	Common Greenshank	S5 Mig CA JA RK LC	X	X
Tringa stagnatilis	Marsh Sandpiper	S5 Mig CA JA RK LC	X	
Burhinidae Stone Curlews				
Burhinus grallarius	Bush Stone-curlew	LC	X	
Recurvirostridae Stilts, Avocets				
Cladorhynchus leucocephalus	Banded Stilt	LC	X	X
Himantopus himantopus	Black-winged Stilt	LC	X	X
Recurvirostra novaehollandiae	Red-necked Avocet	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Charadriidae Lapwings, Plovers, Dotterels				
Charadrius melanops	Black-fronted Dotterel	LC	X	X
Charadrius ruficapillus	Red-capped Plover	LC	X	X
Erythrogonys cinctus	Red-kneed Dotterel	LC	X	X
Vanellus tricolor	Banded Lapwing	LC	X	X
Laridae Gulls, Terns				
Larus novaehollandiae	Silver Gull	LC	X	
Sterna caspia	Caspian Tern	S5 Mig CA JA LC		
Sterna hybrida	Whiskered Tern	LC	X	
Sterna nilotica	Gull-billed Tern	LC	X	X
Columbidae Pigeons, Doves				
Geopelia cuneata	Diamond Dove	LC	X	X
Geophaps plumifera	Spinifex Pigeon	LC	X	X
Ocyphaps lophotes	Crested Pigeon	LC	X	X
Phaps chalcoptera	Common Bronzewing	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Psittacidae Parrots				
Cacatua roseicapilla	Galah	LC	X	X
Cacatua sanguinea	Little Corella	LC	X	
Melopsittacus undulatus	Budgerigar	LC	X	X
Nymphicus hollandicus	Cockatiel	LC	X	X
Platycercus zonarius	Australian Ringneck	LC	X	
Polytelis alexandrae	Princess Parrot	P4 VU NT	X	X
Cuculidae Parasitic Cuckoos				
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC	X	
Chrysococcyx osculans	Black-eared Cuckoo	LC		
Cuculus pallidus	Pallid Cuckoo	LC	X	
Strigidae Hawk Owls				
Ninox novaeseelandiae	Boobook Owl	LC	X	X
Tytonidae Barn Owls				
Tyto alba	Barn Owl	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Podargidae Frogmouths				
Podargus strigoides	Tawny Frogmouth	LC	X	X
Caprimulgidae Nightjars				
Eurostopodus argus	Spotted Nightjar	LC	X	
Aegothelidae Owlet-nightjars				
Aegotheles cristatus	Australian Owlet-nightjar	LC	X	X
Halcyonidae Tree Kingfishers				
Todiramphus pyrrhopygius	Red-backed Kingfisher	LC	X	X
Meropidae Bee-eaters				
Merops ornatus	Rainbow Bee-eater	S5 Mig JA LC	X	X
Maluridae Fairy Wrens, GrassWrens				
Amytornis striatus	Striated Grasswren	P4	X	X
Malurus lamberti	Variegated Fairy-wren	LC	X	X
Malurus leucopterus	White-winged Fairy-wren	LC	X	X
Stipiturus ruficeps	Rufous-crowned Emu-wren	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces				
Acanthiza apicalis	Broad-tailed Thornbill	LC		
Acanthiza uropygialis	Chestnut-rumped Thornbill	LC	X	X
Aphelocephala nigricincta	Banded Whiteface	LC		X
Calamanthus campestris	Rufous Fieldwren	LC	X	X
Gerygone fusca	Western Gerygone	LC	X	X
Smicrornis brevirostris	Weebill	LC		
Pardalotidae Pardalotes				
Pardalotus rubricatus	Red-browed Pardalote	LC	X	X
Pardalotus striatus	Striated Pardalote	LC		X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Meliphagidae Honeyeaters, Chats				
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	LC	X	X
Certhionyx niger	Black Honeyeater	LC	X	
Certhionyx variegatus	Pied Honeyeater	LC	X	X
Epthianura aurifrons	Orange Chat	LC	X	X
Epthianura tricolor	Crimson Chat	LC	X	X
Lichenostomus keartlandi	Grey-headed Honeyeater	LC	X	
Lichenostomus penicillatus	White-plumed Honeyeater	LC	X	
Lichenostomus virescens	Singing Honeyeater	LC	X	
Lichmera indistincta	Brown Honeyeater	LC	X	X
Manorina flavigula	Yellow-throated Miner	LC	X	X
Phylidonyris albifrons	White-fronted Honeyeater	LC	X	
Petroicidae Australian Robins				
Petroica cucullata	Hooded Robin	LC		
Petroica goodenovii	Red-capped Robin	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Cinclosomatidae Whipbirds, Wedgebills, Quail Thrushes				
Cinclosoma castaneothorax	Chestnut-breasted Quail-thrush	LC		
Psophodes occidentalis	Western Wedgebill	LC		X
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers				
Colluricincla harmonica	Grey Shrike-thrush	LC		X
Oreoica gutturalis	Crested Bellbird	LC	X	X
Pachycephala rufiventris	Rufous Whistler	LC	X	X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo				
Grallina cyanoleuca	Magpie-lark	LC	X	X
Rhipidura fuliginosa	Grey Fantail	LC	X	X
Rhipidura leucophrys	Willie Wagtail	LC	X	X
Campephagidae Cuckoo-shrikes, Trillers				
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	X	X
Lalage tricolor	White-winged Triller	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Artamidae Woodswallows, Butcherbirds, Currawongs				
Artamus cinereus	Black-faced Woodswallow	LC	X	X
Artamus minor	Little Woodswallow	LC		X
Artamus personatus	Masked Woodswallow	LC	X	X
Artamus superciliosus	White-browed Woodswallow	LC	X	
Cracticidae Currawongs, Magpies & Butcherbirds				
Cracticus nigrogularis	Pied Butcherbird	LC		X
Cracticus tibicen	Australian Magpie	LC	X	
Cracticus torquatus	Grey Butcherbird	LC		X
Corvidae Ravens, Crows				
Corvus bennetti	Little Crow	LC	X	X
Corvus orru	Torresian Crow	LC	X	X
Ptilonorhynchidae Bowerbirds				
Ptilonorhynchus guttatus	Western Bowerbird		X	
Motacillidae Old World Pipits, Wagtails				
Anthus australis	Australian Pipit	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Estrilidae Grass Finches & Mannikins				
Emblema pictum	Painted Finch	LC	X	X
Taeniopygia guttata	Zebra Finch	LC	X	X
Dicaeidae Flowerpeckers				
Dicaeum hirundinaceum	Mistletoebird	LC	X	X
Hirundinidae Swallows, Martins				
Cheramoeca leucosternus	White-backed Swallow	LC	X	X
Hirundo ariel	Fairy Martin	LC	X	X
Hirundo nigricans	Tree Martin	LC	X	X
Sylviidae Old World Warblers				
Cincloramphus cruralis	Brown Songlark	LC	X	X
Cincloramphus mathewsi	Rufous Songlark	LC	X	X
Eremiornis carteri	Spinifex-bird	LC	X	X

Mammalia

Thylacomyidae Bilbies				
Macrotis lagotis	Greater Bilby	S3 VU VU C1	X	

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Tachyglossidae Echidnas				
Tachyglossus aculeatus	Echidna	LC		
Dasyuridae Carnivorous Marsupials				
Antechinomys laniger	Kultarr	LC		
Dasycercus blythi	Brush-tailed Mulgara	P4		X
Dasykaluta rosamondae	Little Red Kaluta	LC	X	X
Ningaui ridei	Wongai Ningaui	LC	X	X
Planigale sp.	Planigale (undescribed)	LC	X	X
Pseudantechinus roryi	Rory's Pseudantechinus			
Sminthopsis macroura	Stripe-faced Dunnart	LC	X	X
Sminthopsis ooldea	Ooldea Dunnart	LC		
Sminthopsis youngsoni	Lesser Hairy-footed Dunnart	LC	X	X
Notoryctidae Marsupial Moles				
Notoryctes caurinus	Northern Marsupial Mole	P4 DD	X	X
Macropodidae Kangaroos, Wallabies				
Macropus rufus	Red Kangaroo	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Emballonuridae Sheath-tailed Bats				
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	LC	X	X
Taphozous georgianus	Common Sheathtail-bat	LC	X	X
Taphozous hilli	Hill's Sheathtail-bat	LC	X	
Molossidae Freetail Bats				
Austronomus australis	White-striped Freetailed Bat	LC	X	X
Chaerephon jobensis	Greater Northern Free-tailed Bat	LC	X	X
Ozimops lumsdenae	Northern Free-tailed Bat	LC	X	
Vespertilionidae Ordinary Bats				
Chalinolobus gouldii	Gould's Wattled Bat	LC	X	X
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC	X	X
Scotorepens balstoni	Inland Broad-nosed Bat	LC		
Scotorepens greyii	Little Broad-nosed Bat		X	X
Vespadelus finlaysoni	Finlayson's Cave Bat	LC	X	X

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Class **Family** *Species*	Common Name	Conservation Status	Harewood 2017	DBCA 2017
Muridae Rats, Mice				
Mus musculus	House Mouse	Introduced	X	X
Notomys alexis	Spinifex Hopping-mouse	LC	X	X
Pseudomys desertor	Desert Mouse	LC	X	X
Pseudomys hermannsburgensis	Sandy Inland Mouse	LC	X	X
Canidae Dogs, Foxes				
Canis lupus dingo	Dingo	LC	X	
Vulpes vulpes	Red Fox	Introduced	X	X
Felidae Cats				
Felis catus	Cat	Introduced	X	X
Bovidae Horned Ruminants				
Bos taurus	European Cattle	Introduced	X	
Camelidae Camels				
Camelus dromedarius	Camel	Introduced	X	X
Leporidae Rabbits, Hares				
Oryctolagus cuniculus	Rabbit	Introduced	X	

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APPENDIX E

Conservation Significant Vertebrate Species - Profiles

Lake Disappointment Gecko (*Diplodactylus fulleri*)

Status: The Lake Disappointment gecko is listed as Priority 2 by DBCA.

Regional distribution: Currently only known from Lake Disappointment (Cogger 2014).

Habitat: Low samphire shrubs bordering Lake Disappointment, foraging on bare salt crust between shrubs (Wilson & Swan 2013).

Likely presence in study area: Six individuals of this species were captured during the Phase 1 and 2 surveys at trap site 2 on the Lakes edge. The species is nocturnal and does not make distinctive burrows so it is harder to locate, hence the lack of observations in areas outside of the main trapping area, where only day searches were carried out. It is considered likely to be found almost anywhere around the Lake and possibly on islands within the Lake wherever suitable samphire habitat is present.

Listed as a potential species based on currently available information

Unpatterned Robust Lerista *Lerista macropisthopus remota*

Status: This sub-species of the unpatterned robust lerista is listed as Priority 2 by DBCA.

Regional distribution: Described as the "Robertson Range and Mundiwindi, areas east of Newman" (Storr *et al.* 1999) and the "central interior" (Wilson & Swan 2013).

Habitat: *Acacia* shrublands and woodlands. Forms shelter in loose soil under leaf litter at bases of shrubs (Wilson & Swan 2013).

Likely presence in study area: Twelve individuals of this species have been captured during the various surveys carried out within other sections of the Lake Disappointment project area to date

The nearest other records are from near Jigalong (DBCA 2017) and the Lake Disappointment observations appear to represent a significant range extension for the species eastwards, though it is probably widespread in the general area given the large extent of suitable habitat (i.e. sand dunes/sand plains).

Listed as a potential species based on currently available information

Great Desert Skink *Liopholis kintorei*

Status: This species is listed as Schedule 3 under the *WC Act* and as Vulnerable under the *EPBC Act*.

Regional distribution: The species appears to have occurred in widespread, but connected, populations in the past in the Great Sandy, Gibson, Great Victoria and Tanami Deserts in the

eastern interior of WA and adjacent areas in south-western NT and northwestern SA (Cogger 2014).

The reported distribution (2001 estimate) consists of, but is probably not limited to, seven isolated populations. Three populations occur in WA at Patjarr (< 2500 individuals), near the Kiwirrkura community, including the vicinity of Lake Mackay (< 500 individuals), and in Rudall River NP (unknown population size). Populations also occur in the NT in the Tanami Desert, including Rabbit Flat, Sangster's Bore, The Granites and near Kintore, (< 2250 individuals); in Uluru - Kata Tjuta NP including part of the Yulara borefields (< 500 individuals); and in the Yulara lease lands including part of the Yulara borefields (< 350 individuals). Only one population is known to persist in SA, near Watarru on the Anangu-Pitjantjatjara Lands (< 50 individuals) (McAlpin 2001).

Habitat: Arid sand flats and clay based loamy soils vegetated with spinifex (Wilson and Swan 2013). Found in a variety of desert habitats on sandy, clay and loamy soils (Cogger 2014). Sandplain vegetated by spinifex and scattered shrubs seems to be the habitat type most widely used (McAlphin, 2001). In the Tanami Desert and parts of the Great Sandy Desert they also inhabit paleodrainage lines characterised by giant termite mounds and titree (*Melaleuca* spp.) shrubs.

Likely presence in study area: No evidence of this species has been found within any section of the Lake Disappointment Project area to date despite some targeted surveys (Harewood 2012, Harewood 2016). There is however a record of a fresh burrow on the Talawana Track made during monitoring of plot sites for the Desert Rangelands Project carried out by the Martu people and reported in 2013 (exact date of observation unknown). This record is located directly adjacent to the Talawana Track about 2.1km west of the Willjabu Track intersection. The current status of this burrow is unknown as it has not been relocated.

The closest DBCA records within NatureMap (2017) are from Lake Dora which is situated about ~100km north of the Project area at its closest point.

Given that evidence of this species presence along the Talawana Track has been reported in the past and that habitat in some sections of the study area does appear at least superficially suitable (sand/loam plains) it must be assumed to potentially be present.

Listed as a potential species based on currently available information.

Lake Disappointment Gecko (*Diplodactylus fulleri*)

Status: The Lake Disappointment gecko is listed as Priority 2 by DBCA.

Regional distribution: Currently only known from Lake Disappointment (Cogger 2014).

Habitat: Low samphire shrubs bordering Lake Disappointment, foraging on bare salt crust between shrubs (Wilson & Swan 2013).

Likely presence in study area: Six individuals of this species were captured during the Phase 1 and 2 surveys at trap site 2 on the Lakes edge. The species is nocturnal and does not make distinctive burrows so it is harder to locate, hence the lack of observations in areas outside of the main trapping area, where only day searches were carried out. It is considered likely to be found almost anywhere around the Lake and possibly on islands within the Lake wherever suitable samphire habitat is present.

Listed as a potential species based on currently available information

Lake Disappointment Dragon (*Ctenophorus nguyarna*)

Status: The Lake Disappointment Dragoon is of local conservation significance.

Regional distribution: Currently only known from Lake Disappointment (Cogger 2014).

Habitat: Low samphire shrubs bordering Lake Disappointment, foraging on bare salt crust between shrubs, where it digs shallow burrows (Wilson & Swan 2013).

Likely presence in study area: The Lake Disappointment dragon was observed 18 times during the Phase 1 survey. The species was captured on several occasions at Trap Site 2 and it was also observed (or its characteristic burrows) at various other locations around the Lake shore within its preferred habitat, samphire. It was recorded an additional 10 times during the Phase 2 survey but with much less frequency at Trap Site 2.

The results suggest it is likely to be found almost anywhere around the Lake and possibly on islands within the Lake wherever suitable samphire habitat is present.

Listed as a potential species based on currently available information

Eastern Great Egret *Ardea alba (modesta)*

Status: This species of egret is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The eastern great egret is not a threatened species and can be regarded as common over its main documented range.

Regional distribution: The eastern great egret is common and very widespread in Australia and can occur in any suitable permanent or temporary habitat within most areas (Morcombe 2004). In WA it is however rarely recorded in the arid eastern interior south of Lake Gregory or east of Lake Nabberu (Johnston and Storr 1998).

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe 2004).

Likely presence in study area: Very rarely recorded in this general area. A single individual was recorded by Bennelongia (2017) on a freshwater claypan. While this species has some potential

to utilise any of the low lying areas in the region (e.g. lakes, claypans, creeks, dams and roadside ditches) subject to temporary inundation after significant rain events, it would only occur rarely and in very small numbers.

Listed as a potential species based on currently available information.

Cattle Egret *Ardea ibis*

Status: This species of egret is listed as Schedule 5 under the *WC Act and as* Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The cattle egret is not a threatened species and can be regarded as common over its main documented range.

Regional distribution: Widespread from the Kimberley to coastal south east Australia. Mostly a winter spring migrant to southern areas (Pizzey and Knight 2012). In WA the cattle egret is relatively common in the northern sections of its range but is an irregular visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe 2004).

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe 2004).

Likely presence in study area: Very rarely recorded in this general area. While this species has some potential to utilise low lying areas in the region (e.g. lakes, claypans, creeks, dams and roadside ditches) subject to temporary inundation after significant rain events it is very unlikely to occur under normal circumstances.

Not listed as a potential species based on currently available information.

Banded Stilt (*Cladorhynchus leucocephalus*)

Status: The Banded stilt can be regarded as common over much of its range but is of local conservation significance at Lake Disappointment, given it uses the area for breeding in large numbers when suitable conditions prevail.

Regional distribution: Southern inland and coastal South and Western Australian north to Broome and southern Northern Territory. Dispersive, nomadic and irruptive movements influenced by effect of weather on water levels, salinity and food organism, particularly brine shrimps. (Pizzey and Knight 2012)

Habitat: Shallow salt lakes, saltmarshes, tidal mudflats, commercial salt fields, occasionally flooded claypans and shallow freshwater lakes (Pizzey and Knight 2012).

Likely presence in study area: Known to breed on some sections of the Lake after seasonal inundation events. In 2017 over 100,000 birds were observed on the Lake, with over 49,000 nests being recorded (Bennelongia 2017).

Listed as a potential species based on currently available information

Peregrine Falcon *Falco peregrinus*

Status: This species is listed as Schedule 7 under the *WC Act*.

Regional distribution: Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2004). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey. Also known to utilise the pit walls of decommissioned open cut mines for nesting.

Likely presence in study area: The peregrine falcon has not been recorded within the actual Lake Disappointment project area to date but was observed in the Durba Hills about 15km south west of the southern tip of the Lake during surveys undertaken in 2013 (Harewood 2016). The species potentially breeds in this location given the presence of near vertical rocky cliff lines. There are also DBCA records from the McKay Ranges and Karlamilyi National Park (Rudall River National Park) (DBCA 2017). Individuals of this species may therefore utilise airspace over the Project area as foraging habitat given they have large home ranges, though it can be expected to occur only very occasionally.

Listed as a potential species based on currently available information.

Grey Falcon *Falco hypoleucos*

Status: Listed as Schedule 3 under the *WC Act*.

Regional distribution: Within WA found in the northern half south to about 26°S (Gascoyne, Lake Carnegie and Warburton), casual further south (Johnstone and Storr 1998).

Habitat: Lightly treed plains, gibber deserts, sand ridges, pastoral lands, timbered water courses but seldom in driest deserts (Pizzey & Knight 2012). It has a distribution centred around ephemeral or permanent drainage lines, utilising old nests of other bird species situated in the tallest trees along the river systems (Garnett and Crowley 2000).

Likely presence in study area: This species may frequent the general area but because it is rare and nomadic with a sparse distribution its frequency of occurrence would be very low. The denser woodland bordering McKay Creek represents potential breeding habitat.

Listed as a potential species based on currently available information.

Migratory Shorebirds/Waders

A small number of migratory shorebird species have previously been recorded in the wider area. Not all specific species are discussed in detail.

Status: Migratory shorebirds are listed as such under the *EPBC Act*, the *WC Act* (Schedule 5) and under international agreements to which Australia is a signatory. Some species are also listed as threatened under various state and federal categories, others are not.

Regional Distribution: All species are either widespread summer migrants to Australia or residents. Most migratory shorebirds have a distribution limited to coastal areas. Some do however frequent arid inland areas, typically after significant rainfall events temporarily flood inland salt lakes, claypans and other low lying areas.

Habitat: Varies between species but includes beaches and permanent/temporary wetlands varying from billabongs, swamps, lakes, floodplains, sewerage farms, saltwork ponds, estuaries, lagoons, mudflats sandbars, pastures, airfields, sports fields and lawns.

Likely presence in study area: Salt lakes and claypans represent potential habitat for migratory shorebirds when inundated though this specific area is not recognised as significant to migratory shorebirds and the level of utilisation is likely to be very low (i.e. species diversity and numbers of individuals).

As with other birds which rely on wetlands the presence of suitable habitat (and therefore the birds themselves) in freshwater claypans or on the salt lake itself is totally dependent on unpredictable, episodic rain events of a magnitude sufficient to supply the required amount of water. It should be noted that migratory waders only breed in the northern hemisphere, but migrate to the southern hemisphere during spring and then leave late summer/early autumn.

Several migratory waders are listed as potential species based on available information, though frequency of occurrence would be very low and opportunistic.

Oriental Plover *Charadrius veredus*

Status: The oriental plover is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The oriental plover is not a threatened species and it can be regarded as common over its main documented range.

Regional Distribution: Breeds in Mongolia and Manchuria – regular summer migrant to Australia (September to March) (Pizzey & Knight 2012). Kimberley, north western interior (Lake Gregory) and north west coastal plains (south to tropic); casual or vagrant elsewhere (south to 32°15'S) (Johnstone and Storr 1998).

Habitat: The oriental plover is generally found inland; in open grasslands in arid and semi-arid zones; and less often in estuarine or littoral environments. This species prefers flat inland plains, sparsely vegetated short grass with hard bare ground including claypans, playing fields, lawns and cattle camps. The oriental plover may move to lightly-wooded grasslands with the onset of the wet season (Birdlife Australia 2017).

Likely presence in study area: There are no records of this species within several hundred kilometres of the study area (DBCA 2017). While some habitat appears superficially suitable it is unlikely to be specifically attracted to the area and it is only likely to occur as a casual/vagrant on very rare occasions at best.

Not listed as a potential species based on currently available information.

Princess Parrot *Polytelis alexandrae*

Status: This species is listed as Priority 4 by the DBCA and as Vulnerable under the *EPBC Act*.

Regional Distribution: Rare, highly nomadic (Pizzey & Knight 2012). Found in the eastern deserts north to the Edgar Ranges, west to the Gregory Range, Well 18, Mt Bates, Lake Throssell and Mt Luck and south to Queen Victoria Spring and Carlisle Lakes, casual further north (Fossil Downs, Bohemia Downs) and west (head of Gascoyne, head of the Murchison, Wiluna, Wanjarri, Sandstone, Laverton, Kookynie, Menzies, Kanowna). Also deserts of eastern Australia (Johnstone and Storr 1998).

Habitat: Arid shrubland, particularly mulga, Desert Oak and Spinifex country including trees along watercourses (Simpson and Day 2010). The princess parrot inhabits sand dunes and sand flats supporting open woodlands and shrublands that usually consist of scattered stands of *Eucalyptus* (including *E. gongylocarpa* and mallee species), *Casuarina* or *Allocasuarina* trees and an understorey of shrubs such as *Acacia* (especially *A. aneura*), *Senna, Eremophila, Grevillea, Hakea* and a ground cover dominated by *Triodia* species (DotEE 2017).

Likely presence in study area: Four individuals of this species were observed flying overhead during the May 2013 survey in the vicinity of Lake Disappointment (Harewood 2016). The denser woodland bordering McKay Creek represents potential breeding habitat though it is not known if it is used for this purpose.

Listed as a potential species based on currently available information.

Night Parrot *Pezoporus occidentalis*

Status: This species is listed as Schedule 1 under the *WC Act* and as Endangered under the *EPBC Act*.

Regional Distribution: Historical evidence indicates that night parrots were distributed over much of semi-arid and arid Australia (Garnett and Crowley 2000). Extremely secretive and hard

to flush, in WA, up until recently, there were only three accepted records of night parrots since 1935, all from the Pilbara region (1979, 1980 and 2005; DotEE 2017). There have also been several targeted surveys in WA for the night parrot in the past, including unsuccessful searches in the Lake Disappointment area in 1987 (Davies *et al.* 1988) and others in the Western Desert and East Pilbara areas in Western Australia in 1996 (Blyth *et al.* 1997).

There have however been several recent records (one in March 2017) of the species in the vicinity of Lorna Glen Station/Lake Carnegie (~ 320km south of Lake Disappointment) (Hamilton *et al.* 2017).

Habitat: Preferred habitat is thought to be spinifex grasslands or samphire and chenopod shrublands on claypans, floodplains or the margins of salt lakes, creeks or other water bodies (Johnstone and Storr 1998; Higgins 1999; DotEE 2017). Roosting and nesting sites are consistently reported as being within clumps of dense vegetation, primarily old and large spinifex clumps, but sometimes other vegetation types (Higgins 1999, Murphy 2015).

Likely presence in study area: Calls of a night parrot were recorded on an ARU during the targeted survey carried out in June 2017 at a location along Willjabu Track. It is not known if this area represents a roosting, nesting or foraging site for the species. Additional surveys aimed at determining the status of this site and the presence of the bird in other regional locations are now being undertaken.

Listed as a potential species based on currently available information.

Fork-tailed Swift *Apus pacificus*

Status: The fork-tailed swift is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The fork-tailed swift is not a threatened species and it can be regarded as common over its main documented range.

Regional Distribution: Breeds in the Himalayas, Siberia, Japan and south east Asia (Pizzey and Knight 2012). A summer migrant (Oct-Apr) to Australia (Morcombe 2004). Common in the Kimberley, uncommon to moderately common near north west, west and south west coast, rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2004).

Likely presence in study area: Fork-tailed swifts are potentially a very occasional summer visitor to the study area but they are entirely aerial and largely independent of terrestrial habitats.

Not listed as a potential species given it would only occur very rarely and then only for short periods.

Barn Swallow *Hirundo rustica*

Status: The barn swallow is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The barn swallow is not a threatened species and it can be regarded as common over its main documented range.

Regional Distribution: Widespread in northern hemisphere, winters in southern hemisphere. In Australia occurs from Kimberley to north east and south east Queensland. Vagrant elsewhere.

Habitat: Open country, agricultural land especially near water, rail yards towns and overhead wires (Pizzey and Knight 2012).

Not listed as a potential species given it would only occur very rarely and then only for short periods.

Rainbow Bee-eater *Merops ornatus*

Status: This species is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The rainbow bee-eater is not a threatened species and it can be regarded as common over its main documented range.

Regional Distribution: The rainbow bee-eater is a breeding resident in northern Australia and summer breeding migrant to southern Australia (Pizzey and Knight 2012).

Habitat: Open country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe 2004). Breeds underground in areas of suitable soft soil firm enough to support tunnel building. Nest is a burrow usually dug at a slight angle in flat ground, sometimes into sandy banks or cuttings and often on margins of roads and tracks (Johnstone and Storr 1998).

Likely presence in study area: The rainbow bee-eater has been observed numerous times within the Lake Disappointment project area with most sightings being at or very near McKay Creek. It has also been observed breeding in this area (Harewood 2016). It may be resident in the area all year round.

Listed as a potential species based on currently available information

Striated Grasswren (sandplain) *Amytornis striatus striatus*

Status: This sub-species is listed as Priority 4 by DBCA.

Regional distribution: Found in the eastern deserts between lats.20° and 28°39'S (north to Sahara Track and Well 48 and including much of Great Sandy, Gibson and Great Victoria Deserts), west to Erliston and south to 39 km ENE of Laverton, 27 km S of Neale Junction and

the Serpentine Lakes, with an apparently isolated population between Meekatharra and Wiluna and another near Queen Victoria Spring (Johnstone and Storr 1998). NatureMap shows three nearby specimens, all collected in 1966 east of Georgia Bore on the CSR (DBCA 2017).

Habitat: Mainly spinifex, with or without low shrubs (especially *Thryptomene maisonneuvei*) and herbage, on sandy or loamy plains; also bushy acacias (especially *A. ligulata* and *A. aneura*) on sandridges and interdunes, usually with spinifex (Johnstone and Storr 1998).

Likely presence in study area: Striated grasswrens were recorded during the May 2013 survey a few kilometres north of Lake Disappointment near the Willjabu Track. This record is based on calls only and is therefore somewhat tentative (Harewood 2016).

Listed as a potential species based on currently available information.

Grey Wagtail *Motacilla cinerea*

Status: The grey wagtail is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The grey wagtail is not a threatened species and it can be regarded as common over its main documented range.

Regional distribution: A rarely recorded, accidental vagrant that has on a few occasions been recorded on widely separated parts of the Australian coastline (Pizzey & Knight 2012).

Habitat: In Australia, near running water in disused quarries, sandy, rocky streams in escarpments and rainforest, sewerage ponds, ploughed fields and airfields (Pizzey & Knight 2012).

Likely presence in study area: This species preferred habitat is absent from the study area and under normal circumstances it would not occur.

Not listed as a potential species based on currently available information.

Yellow Wagtail *Motacilla flava*

Status: The yellow wagtail is listed as Schedule 5 under the *WC Act* and as Migratory under the *EPBC Act* including international agreements to which Australia is a signatory. The yellow wagtail is not a threatened species and it can be regarded as common over its main documented range.

Regional distribution: A regular summer migrant to mostly coastal northern Australia, vagrant in southern Australia (Pizzey & Knight 2012).

Habitat: Habitat requirements for the yellow wagtail are highly variable, but typically include open grassy flats near water. Other preferred habitats include open areas with low vegetation such as grasslands, airstrips, pastures, sports fields; damp open areas such as muddy or grassy

edges of wetlands, rivers, irrigated farmland, dams, waterholes and sewage farms. They also sometimes utilise tidal mudflats and edges of mangroves (Pizzey & Knight 2012).

Likely presence in study area: This species preferred habitat is absent from the study area and under normal circumstances it would not occur.

Not listed as a potential species based on currently available information.

Brush-tailed Mulgara *Dasycercus blythi*

Status: Listed as Priority 4 by the DBCA.

Regional distribution: Distributed widely across central and inland Australia broadly bounded by the Tanami Desert in the north, Simpson Desert in the east, Great Victoria Desert in the south and the Carnarvon, Murchison and Pilbara regions in the west (Woinarski *et al.* 2014).

Habitat: The brush-tailed mulgara occurs in a range of vegetation types including hummock grass plains, sand ridges and mulga shrubland on loamy sand, however, the principal habitat is mature hummock grasslands of spinifex, especially *Triodia basedowii* and *T. pungens* where it lives in burrows that it digs on the flats between low sand dunes (Van Dyck & Strahan 2008). The location of brush-tailed mulgara colonies may be influenced by the presence of better watered areas such as paleo-drainage systems or drainage lines in sand plain or sand dune habitats (Masters *et al.* 2003).

Likely presence in study area: No evidence of Mulgara has been found during targeted surveys carried out along a section of the Talawana Track (Harewood 2012) or during subsequent surveys (Harewood 2016, 2017). There are however several records from the Talawana Track and nearby areas (DBCA 2017, Desert Rangelands Project 2013 – DBCA unpublished data) and it must therefore be regarded as a potential species where ever suitable habitat (e.g. sand plains and sand ridges) is present.

Listed as a potential species based on currently available information

Northern Quoll *Dasyurus hallucatus*

Status: The northern quoll is listed as Schedule 3 under the *WC Act* and as Endangered under the *EPBC Act*.

Regional distribution: The northern quoll's former range extended over most of northern Australia particularly in higher rainfall and more rugged areas (Woinarski *et al.* 2014). A 75% reduction in habitat range occurred during the 20th century, so that the species is now restricted to the Pilbara and north Kimberley in Western Australia and a few discrete populations across the Northern Territory and eastern Queensland (Braithwaite and Griffiths 1994). The Pilbara populations may now be largely isolated (How *et al.* 2009).

In Western Australia the northern quoll has been recorded from many areas in the Kimberley, and several areas in the Pilbara, including the lower reaches of the Fortescue River (King 1989); Wittenoom Gorge (in the early 1990s); and banded ironstone ranges north-east of Marble Bar (WA Department of Environment and Conservation unpublished data).

Northern quolls also occur on a number of offshore islands in Western Australia (Adolphus, Augustus, Bigge, Boongaree, Capstan, Dolphin, Hidden, Koolan, Purrungku, Uwins and Wollaston: (Kendrick 2007).

An apparently isolated population of the northern quoll was confirmed within the Throssell and Broadhurst Ranges of the Karlamilyi National Park (Rudall River NP) in 2013. Evidence of the species was recorded from two distinct locations of similar habitat: deep dissected rocky gorges containing caves and permanent waterholes. One individual was photographed by a motion-sensitive camera and several scats were collected, with mitochondrial DNA analysis confirming the identification. At the time these records were a significant range extension (~200 km) and due to habitat restrictions are likely to represent the very eastern extreme of the species' range (Turpin and Bamford 2014).

More recently (2014, 2015 and 2016) DBCA have obtained additional evidence of the species presence in the ranges making up the western half of the park in the form of motion sensing camera pictures, scats and a single live specimen (DBCA 2017, http://www.abc.net.au/news/2016-09-09/).

Habitat: Northern quolls do not have highly specific habitat requirements and they can occur in a variety of habitats across their range. It is however known that important areas for northern quoll, consistent across its range, are the rocky hills, scree slopes and river systems/creek lines which have larger hollow bearing trees. Northern quolls do not need permanent water, but are often found in association with it, probably due to the increase abundance of prey. Other areas surrounding the above mentioned "important" habitats including open spinifex meadows, gibber plains, hill systems and similar landforms that provide foraging habitat and are also necessary for survival (Thompson 2010).

Refuge from fire and predation are critical to the survival of individual Northern Quolls (Thompson 2010). Documented daytime refuge sites ("dens") included burrows, termite mounds, hollow logs, hollow trees, crevices and caves (Menkhorst & Knight 2011).

Likely presence in study area: There are no documented records of the northern quoll occurring south of the ranges making up much of the western most part of the Karlamilyi National Park. While evidence of northern quolls has been found about 30km north of the Talawana Track in a section of the ranges (DBCA 2017) it is considered unlikely that quolls would under normal circumstances venture southwards out of this area given that habitat appears largely unsuitable or at best very marginal for them to utilise on a permanent basis.

Not listed as a potential species based on currently available information.

Northern Marsupial Mole *Notoryctes caurinus*

Status: This species is listed as Priority 4 by DBCA.

Regional distribution: The distribution of the northern marsupial mole is known from scattered records throughout the sandy deserts of inland Australia including the Great Sandy, Little Sandy, Gibson, Tanami, Great Victoria and western Simpson Deserts. Most of these records derive from specimens or traditional information provided by Aboriginal people to collectors (Benshemesh 2003).

Habitat: Very little is known about the habitat requirements of marsupial moles. They are most often recorded in sandy dunes habitats supporting various acacias and other shrubs and often but not always in association with spinifex. Such habitat is widespread in and typical of the sandy deserts. Marsupial moles may also occur in some sandy plains, and might also occupy sandy river flats, especially in areas where aeolian dunes also occur. Marsupial moles are not capable of travelling far across hard ground and continuity of suitable habitat is likely to be important for the occurrence of marsupial moles in an area (Benshemesh & Mann 2009).

Likely presence in study area: Evidence of the northern marsupial mole has been found during all fauna surveys carried out and reported on to date (Harewood 2012, 2015 and 2016). These results suggest that the species is very likely to be widespread and relatively common in dunes systems through the wider area.

Listed as a potential species based on currently available information

Greater Bilby *Macrotis lagotis*

Status: The greater bilby is listed as Schedule 3 under the *WC Ac*t and as Vulnerable under the *EPBC Act*.

Regional distribution: The greater bilby formerly occurred over 70% of arid and semi-arid mainland Australia south of Latitude 18°S. Its range has however declined northwards and the decline is continuing. In WA wild subpopulations are now restricted predominately to the Tanami, Gibson, Little Sandy and Great Sandy Deserts, and parts of the Pilbara with a patchy population near Broome on the Dampier Peninsula (Wornarski *et al.* 2014).

Habitat: Three major vegetation types have been found to support this species: open tussock grassland (both grasses and forbs) growing on uplands and hills; mulga woodland/shrubland (both pure mulga and mixed stands of mulga/witchetty bush) growing on ridges and rises; and hummock grassland growing on sand plains and dunes, drainage systems, salt lake systems and other alluvial areas. Current habitat includes *Acacia* shrublands, spinifex and hummock grassland (Menkhorst and Knight 2011). Mitchell grass and stony downs country if cracking clay, also desert sand plains and dune fields sometimes with spinifex hummock grassland and acacia shrubland (Van Dyck *et al.* 2013).

Likely presence in study area: This species was the subject of a targeted survey along the eastern section of the Talawana Track study area prior to the construction of the Willjabu Track (Harewood 2012) and additional searches during the subsequent fauna surveys in the south, with no evidence of its presence being found (Harewood 2016, 2017).

One individual was however observed crossing the Talawana Track at night time (Dan Tenardi pers. comms. 2016) and there are a small number of records from nearby areas (Desert Rangelands Project 2013 – DBCA unpublished data) and it must therefore be regarded as a potential species, though it would appear, based on the overall records in this general area, to be uncommon at best.

Listed as a potential species based on currently available information.

Pilbara Leaf-nosed Bat *Rhinonicteris aurantius*

Status: The Pilbara leaf-nose bat is listed as Schedule 3 under the *WC Act* and as Vulnerable under the *EPBC Act*.

Regional distribution: The Pilbara leaf-nose bat is found throughout the Pilbara region of WA and further south to Barlee Range in the adjacent Gascoyne region. Available distribution data suggests three geographically defined subpopulations: in the mines of the eastern Pilbara; scattered throughout the Hamersley Range and northern Gascoyne (Wornarski *et al.* 2014). This includes confirmed roosts at Bamboo Creek mine, Copper Hills mine, Klondyke Queen mine, Lalla Rookh mine and one cave in the Barlee Range; and 16 other likely permanent occurrences. Locations are defined as sites that support a colony, such as a cave or mine (Armstrong 2003).

Recently (October 2016) the species has been recorded within the Karlamilyi National Park at Desert Queens Baths (Bullen and Harewood 2016). This represents a range extension of about 100 km east of the previously accepted range for the species and is the first “live” record from the Little Sandy Desert.

Habitat: During the dry season this species roosts in caves and mine adits with stable, warm and humid microclimates. It is thought that forest areas can be used in the wet season if conditions are hot and humid (Churchill 2008).

Likely presence in study area: There are no documented records of the Pilbara leaf-nose bat occurring south of the ranges making up much of the western most part of the Karlamilyi National Park where it has only recently been recorded (Bullen and Harewood 2016) at a location 50km north of the Talawana Track.

Additional bat surveys undertaken in the McKay Ranges, McKay Creek, along the Talawana Track, south along the Willjabu Track and at Durba Springs (Harewood 2016, Harewood unpublished data) have failed to detect the species. The study area also lacks suitable primary

roost habitat for the species (i.e. caves and mine adits). These observations suggest that the species would be unlikely, under normal circumstances, to frequent the study area.

Not listed as a potential species based on currently available information.

Ghost Bat *Macroderma gigas*

Status and Distribution: The ghost bat is listed as Schedule 3 under the *WC Act* and as Vulnerable under the E*PBC Act*.

Regional distribution: Previously distributed across most of inland and northern Australia, this species is now restricted to the north of the continent from the arid Pilbara to rainforests of north Queensland (Churchill 2008, Van Dyck and Strahan 2008). Armstrong and Anstee (2000), in their summary of the geographic distribution of *M. gigas* in the Pilbara, reported that they had been present in the Abydos Plain, Chichester Plateau, Gascoyne Range, George Range, Hamersley Plateau and Oakover Valley.

Habitat: Requires undisturbed caves, rock piles and mine shafts for roosting. They forage for food over a wide range of habitats including arid spinifex hillsides, black soil grasslands, monsoon forest, open savannah woodland, tall open forest, deciduous vine forest and tropical rainforest (Churchill 2008). Its preferred habitat in the Hamersley Range is caves beneath bluffs of low rounded hills composed of Marra Mamba geology and granite rock piles in the eastern Pilbara (Armstrong and Anstee 2000).

Likely presence in study area: The closest most recent documented records of the ghost bat to the study area are from Telfer, ~150km north (dated 2015 – DBCA 2017). Recent (2013 to 2016) bat surveys in the Karlamilyi National Park, McKay Ranges, McKay Creek, along the Talawana Track, south along the Willjabu Track and at Durba Springs have failed to detect the species (Harewood 2016, 2017).

The study area also lacks suitable primary roost habitat for the species (i.e. caves, rock piles and mine shafts). These records and observations suggest that the species would be unlikely, under normal circumstances, to frequent study area.

Not listed as a potential species based on currently available information.

Western Pebble-mound Mouse *Pseudomys chapmani*

Status: This species is listed as Priority 4 by DBCA.

Regional distribution: *P. chapmani* is endemic to WA. Its current range extends from the ranges of the central and southern Pilbara to the ranges of the Little Sandy Desert. Suitable habitat for western pebble-mice is common but patchily distributed in the Pilbara bioregion. The persistence of abandoned mounds in the Gascoyne region, Murchison regions and isolated coastal ranges in the Pilbara indicates considerable decline in range. This decline has been attributed to foxes and exotic herbivores and possibly other factors.

Habitat: Found on stony hillsides with hummock grassland (Menkhorst & Knight 2011) often with a sparse overstorey of eucalypts and scattered shrubs (Van Dyck and Strahan 2008) and often close to narrow bands of *Acacia* dominated scrub along incised drainage lines (Start 2008. The species is well-known for the characteristic pebble-mounds which it constructs over underground burrow systems. These mounds are most common on spurs and lower slopes of rocky hills (Morris & Burbidge, 2008).

Likely presence in study area: Historical records (1980 – individuals, 1994 - mounds) of this species exist for the McKay Range, just south of the Talawana Track (DBCA 2017), these being at the extreme south eastern limit of the species known range in this area. The Talawana Track passes through some low rocky hillsides that extend northwards from the McKay Range and these areas may represent suitable habitat for the species. The current status of the species in this area is however unknown, though no evidence of the species was observed during a survey along the track in these locations in 2012 and 2017 (Harewood 2012, 2017). The species is very likely to be locally extinct however it must be assumed to be present, unless confirmed otherwise.

Listed as a potential species based on currently available information.

APPENDIX F

Raw Vertebrate Trapping & Recording Results

APPENDIX G

Invertebrate Reports – Phoenix/ScorpionID/Alacran

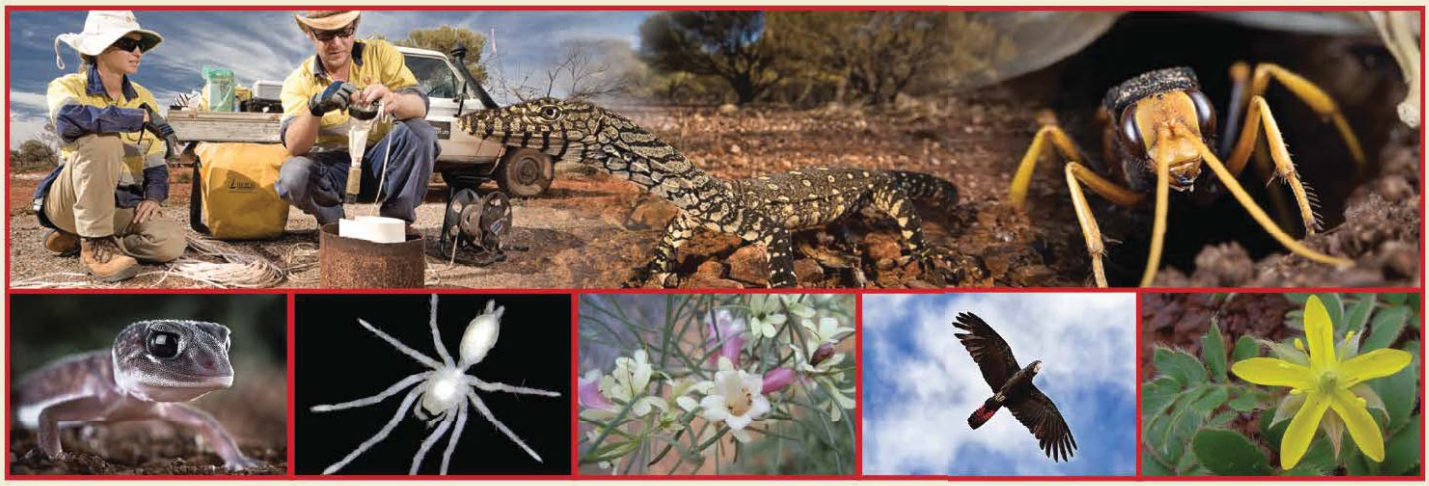
PHOENIX
ENVIRONMENTAL SCIENCES

Short-range endemic invertebrate fauna survey of the Lake Disappointment Potash Project

Prepared for Botanica Consulting, on behalf of Reward Minerals Ltd

September 2014

Final Report



Short-range endemic invertebrate fauna survey of the Lake Disappointment Potash Project

Prepared for Botanica Consulting, on behalf of Reward Minerals Ltd

Final Report

Authors: Nick Dight

Reviewer: Volker Framenau

Date: 306 September 2014

Submitted to: Andrea Williams (Botanica Consulting) and Greg Harewood

Chain of authorship and review			
Name	Task	Version	Date
Nick Dight	Draft for technical review	1.0	23 July 2013
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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: 1023-LD-BOT-SRE

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EXECUTIVE SUMMARY

In March 2013, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Botanica Consulting (Botanica) to undertake a short-range endemic (SRE) invertebrate survey for the Lake Disappointment Potash Project ('the Project') on behalf of Reward Minerals Ltd. This report details the results of the survey for the Project, located 285 km east of Newman. The study area for this survey consists of seven Exploration Licences (E45/2801, E45/2802, E45/2803, and E69/2156, E69/2157, E69/2158, E69/2159), one Miscellaneous License (L45/0302) and one Mining Lease (M45/1227).

A desktop review was conducted prior to the field work, comprising a habitat assessment, database searches and literature review. The aims of the desktop review were to determine the potential conservation significant SRE invertebrate species and SRE habitats in the study area. Short-range endemic fauna are defined as animals that display restricted geographic distributions, nominally less than 10,000 km^2, that may also be disjunct and highly localised.

Field survey methodology consisted of foraging, combined soil/leaf litter sifting and opportunistic trapping of invertebrates from the concurrent vertebrate fauna survey. A total of 15 primary survey sites were sampled in a single field trip in May 2013. These 15 sites consisted of three subsites (labelled A, B and C) which were located within three broad habitat types (playa, samphire riparian vegetation and sand dunes respectively). An additional 14 sites represented opportunistic sample sites within sand dune habitat.

The survey fulfilled the requirements of the Environmental Protection Authority's (EPA) Guidance Statement 56 (*Terrestrial fauna surveys for environmental impact assessment in Western Australia*) and Guidance Statement 20 (*Sampling of short range endemic invertebrate fauna for environmental impact assessment in Western Australia*).

The desktop review recovered one potential SRE (*Aname* sp. indet.) from the study area. The mygalomorph spider genus *Aname* is widely recorded in northern WA; however, the genus was less common in the desktop review area with only three recorded specimens. Many *Aname* appear to have restricted distributions, therefore unidentified specimens are considered to be potential SREs.

The field survey recovered a total of 55 individual specimens within the SRE target groups from the study area, representing 14 individually-recognised taxa from six orders, nine families and at least ten genera. Of these, a total of five taxa in four genera from three families and three orders comprising 18 individuals (33% of total catch) are considered to include potential SREs:

- *Aname* sp. indet. (family Nemesiidae, wishbone trapdoor spiders)
- *Kwonkan* 'disappointment' (family Nemesiidae, wishbone trapdoor spiders)
- *Urodacus* 'disappointment' (family Urodacidae, scorpions)
- *Urodacus '*princess pea' (family Urodacidae, scorpions)
- *Buddelundia* '10LD' (family Armadillidae, slaters).

Of the five SREs collected in the field survey, four are previously unidentified species and three of these are currently known only from the study area. All five SREs collected in the field survey were from sand dune habitat which is widespread outside the study area. No SREs were collected from the lake playa.

The collection of four new SRE taxa was not unexpected for a previously unsurveyed area. The presence of specialist groups on other salt lakes in Western Australia, e.g. specialist spiders, beetles, ants and pseudoscorpions on Lake Lefroy, may indicate potential for a greater diversity of species on Lake Disappointment than was recorded in this study.

Clearing, construction and drawdown caused by dewatering may alter surface water flow and hydrology, which is probably the main threatening process of the Project. In the absence of hydrological and other data critical to conduct EIA, and with a paucity of SRE data from the current survey, it is only possible to say that altered hydrology may have large scale impacts to burrowing groups on the lake surface and habitat dependant groups surrounding Lake Disappointment.

Further survey across a broader area is required to explore the presence of endemic salt lake specialists such as the tiger beetles in the genus *Megacephala* and wolf spiders in the genera *Tetralycosa* and *Hogna*, in habitats that may be affected by drawdown and other threatening processes.

SRE taxa only collected from within the study area (*U.* 'disappointment', *U.* 'princess pea' and *Buddelundia* '10LD') were all from sand dune habitat, where these SREs typically rely on woody outcrops and *Acacia* woodlands. Changes to fire regimes and the introduction of weeds can be a major impact to these habitats, and may alter them in a way that renders them unsuitable for specially-adapted SRE invertebrates.

Based on the widespread distribution of sand dune habitat, the expected impact from habitat clearance and habitat fragmentation from the Project is expected to be low for all taxa collected.

With respect to the conservation of SRE invertebrates and their habitat in relation to the Project the following approach is recommended:

- expand the invertebrate survey onto the playa to address the knowledge gaps in fauna and habitats of this remote lake, considering the anticipated, eventual construction (and associated impacts) of trenches across the whole lake
- obtain detailed hydrological modelling data (particularly, the cone of depression) once completed, and assess impact in context of burrowing and other specialist invertebrates identified in further studies.

Future SRE surveys should:

- be initiated after hydrological modelling is complete and potential impact footprints and scenarios (e.g. drawdown boundaries/timeframes) are known
- collect multi-season data, e.g. two further sampling events in two different seasons to account for seasonality in invertebrate occurrence/life cycles
- consider all potentially-impacted habitats including the poorly accessible playa of the lake (i.e. consider the use of helicopters)
- include regional data points (i.e. Lake Dora, Lake Auld) to provide better context for study area data.

1 INTRODUCTION

In March 2013, Phoenix Environmental Sciences Pty Ltd (Phoenix) was commissioned by Botanica Consulting, on behalf of Reward Minerals Ltd to undertake a short-range endemic (SRE) invertebrate fauna survey for the Lake Disappointment Potash Project ('the Project'). This report describes the SRE survey undertaken in May 2013.

1.1 BACKGROUND

Lake Disappointment is located 285 km east of Newman in the Little Sandy Desert bioregion (Department of the Environment 2014c) of Western Australia (WA) (Figure 1-1). The study area consists of seven Exploration Licences (E45/2801, E45/2802, E45/2803, and E69/2156, E69/2157, E69/2158, E69/2159), one Miscellaneous License (L45/0302) and one Mining Lease (M45/1227) (Figure 1-2). It is situated on Martu land which was granted native title to the Martu people in 2002. The Martu people are the Aboriginal people of the Western Desert region who have exclusive use, occupation, possession and control of the area.

The resource, potassium sulphate, is contained in the lakebed sediment, which varies between three and ten metres in depth, averaging four metres. The proposed method of extraction is via pumping hypersaline solution from bores in the lake and fed into evaporation ponds, which will be constructed within the lake.

A clearing permit has been granted and Program of Works application made for Stage 1 activities (Botanica 2013), including:

- Talawana track upgrade
- site access track construction
- exploration camp construction
- infill drilling.

Environmental Impact Assessments (EIAs) are proposed for the Stage 2 activities (Botanica 2013), including:

- construction of trial ponds (up to seven in total)
- construction of test trenches (up to ten in total)
- construction of regional monitoring bores off the lake (eight)
- investigation into Acid Sulphate Soil potential (no additional ground disturbance required, using Stage 1 infill drilling sites).

The EIA process is incomplete at the time of writing; therefore there is an absence of data, e.g. hydrological modelling that will be required to assess impacts to biota.

Lake Disappointment is one of the largest salt lakes in Western Australia, covering an area of over 1000 km^2. It is the lowest point in the Little Sandy Desert, so is naturally low-lying and a point of drainage, its catchment area extending 500 km north-south, and 600 km east-west (Beard 2005).

The lake is listed as a Nationally Important Wetland with high conservation and anthropological value (Lynch 1995). The criteria for its inclusion on the Nationally Important Wetlands list are:

- Criteria 1: it is a good example of a wetland type occurring within a biogeographic region in Australia.
- Criteria 3: it is a wetland which is important as the habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail.

Lake Disappointment has been proposed as an A Class Reserve for conservation and presence of Aboriginal anthropological sites, with secured rights to be jointly held by the National Parks and Nature Conservation Authority and the WA Museum. The site is listed on the Register of the National Estate (Lynch 1995).

1.2 SCOPE OF WORK AND SURVEY OBJECTIVES

The objective of the survey was to define terrestrial SRE habitats and taxa of the study area, and their known or likely representation outside the study area.

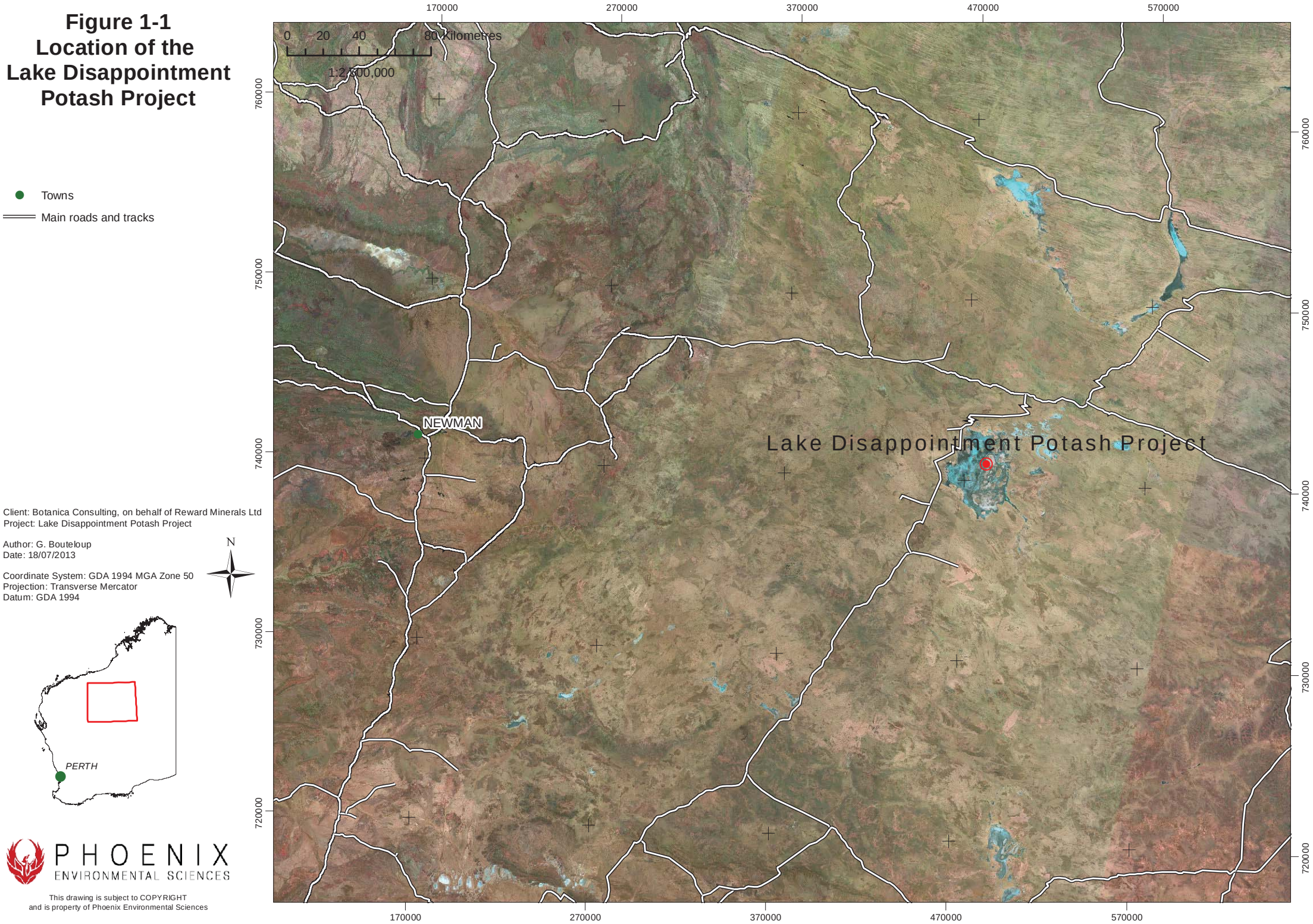
The scope of works undertaken to achieve these objectives was as follows:

- conduct a desktop review of available technical reports and relevant databases to determine the potential SRE species and habitats within the study area
- conduct an SRE field survey in the study area (foraging only)
- undertake data analysis, sample processing and species identifications for samples collected during the field survey
- prepare maps showing potential SRE species records and habitats in the study area
- prepare a technical report outlining survey methods, results, assessment of potential SRE species and habitats, assessment of potential impacts on SRE species from the Project and recommendations for management and mitigation of impacts.

This SRE survey adhered to the principles and practices of the Environmental Protection Authority's (EPA) *Guidance Statement No. 20: Sampling of short-range endemic invertebrate fauna for environmental impact assessment (EIA) in Western Australia* (EPA 2009), which outlines preferred methods for the surveying and assessment of SREs in the context of EIA.

The survey has also been designed in accordance with the EPA *Guidance Statement 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 limitations of the survey with respect to *Guidance Statement 56* (EPA 2004) (see Section 4.10).

Figure 1-1
Location of the Lake Disappointment Potash Project



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Project: Lake Disappointment Potash Project

Author: G. Bouteloup
Date: 18/07/2013

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

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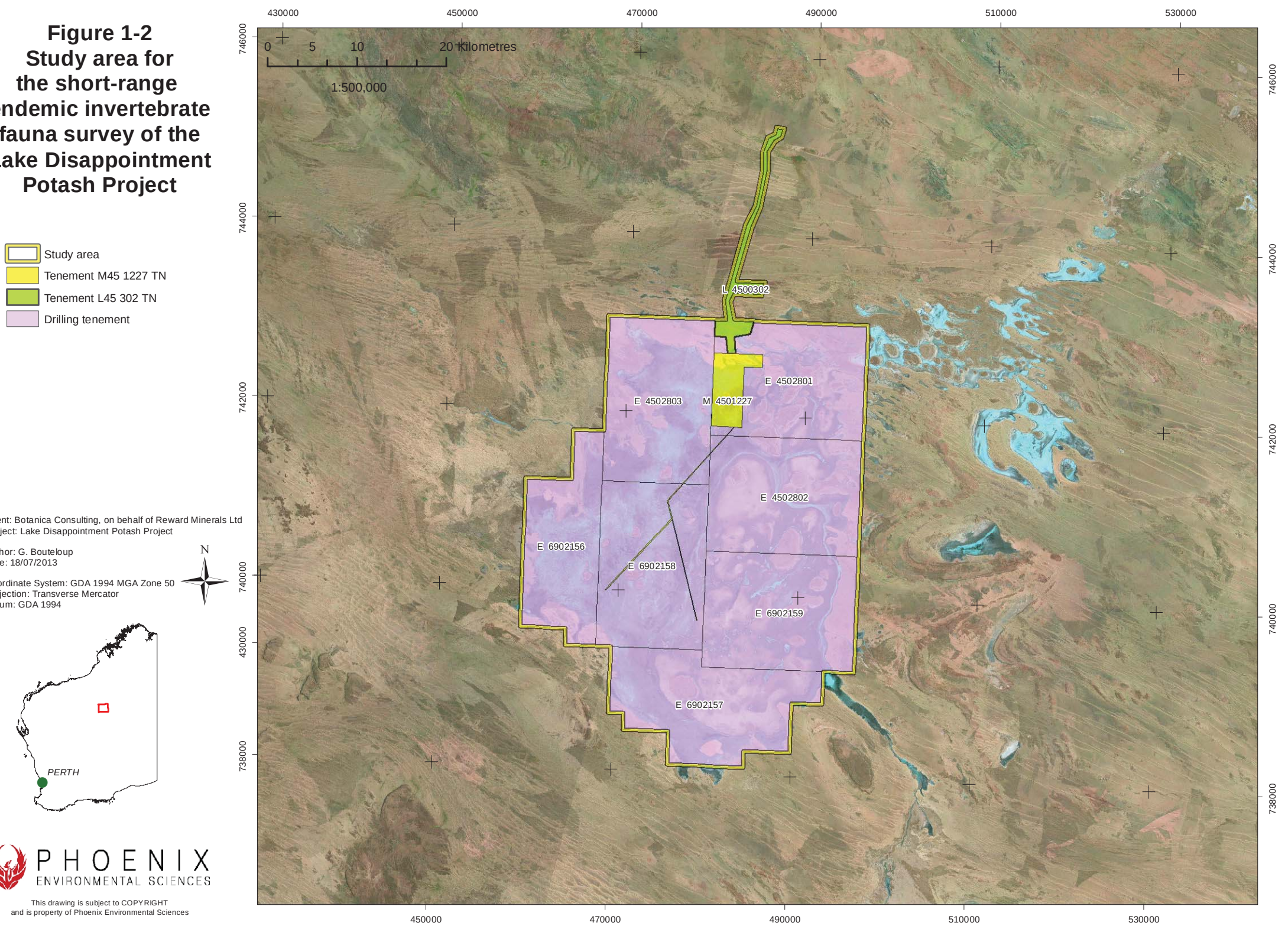
Figure 1-2
Study area for the short-range endemic invertebrate fauna survey of the Lake Disappointment Potash Project



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2 EXISTING ENVIRONMENT

2.1 INTERIM BIOGEOGRAPHIC REGIONALISATION OF AUSTRALIA

The Interim Biogeographic Regionalisation of Australia (IBRA) defines 'bioregions' as large land areas characterised by broad, landscape-scale natural features and environmental processes that influence the functions of entire ecosystems (Department of the Environment 2014c; Thackway & Cresswell 1995). Their purpose is to record and categorise the large-scale geophysical patterns that occur across the Australian continent. The identified patterns in the landscape are linked to fauna and flora assemblages and processes at the ecosystem scale. They are a useful means for simplifying and reporting on more complex patterns of biodiversity (Thackway & Cresswell 1995).

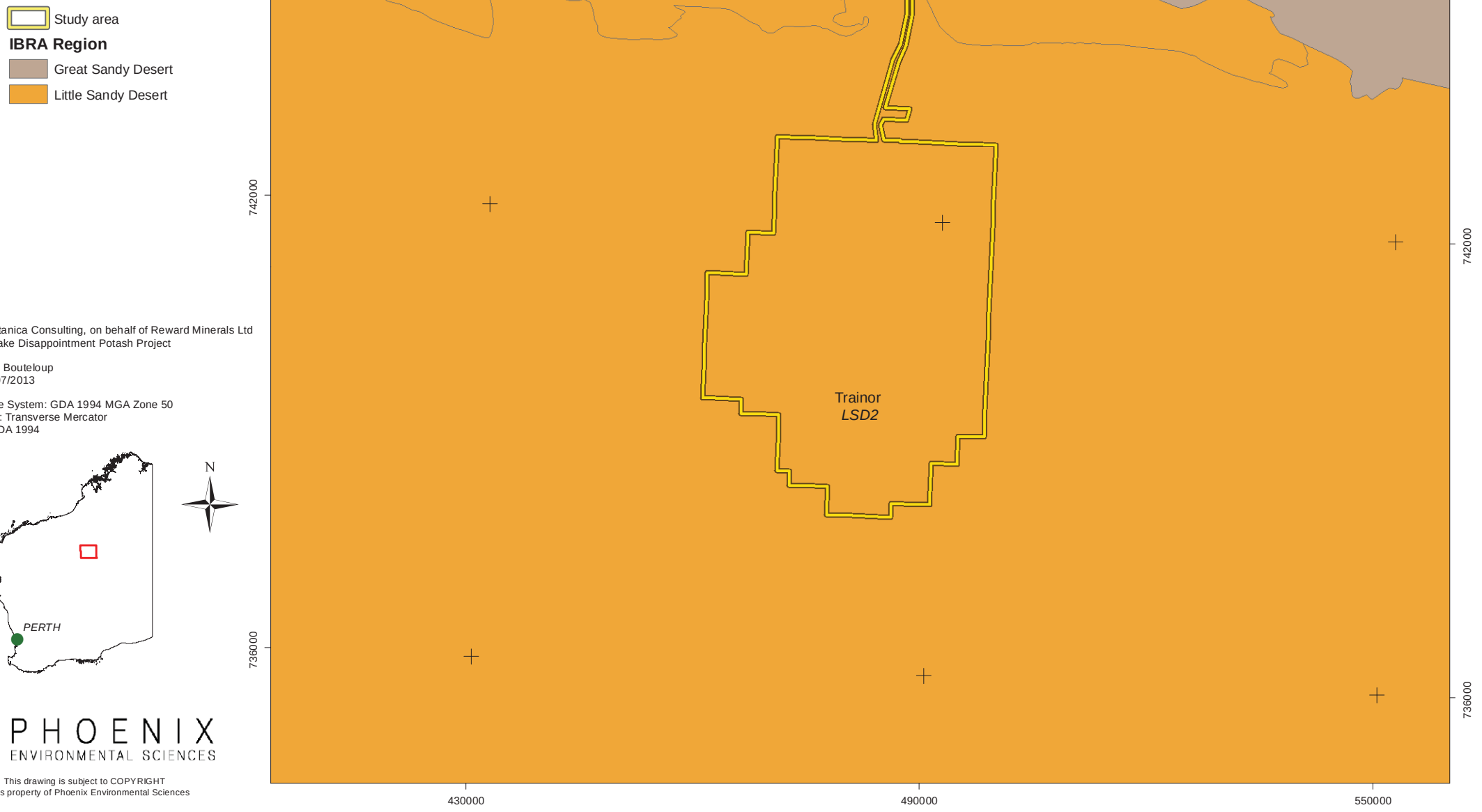
Western Australia contains 26 IBRA bioregions and 53 subregions. By combining information for an IBRA region with information on protected areas within the region and its subregions, the level of protection of Australia's various landscapes can be established. IBRA is therefore a dynamic tool for monitoring progress towards building a comprehensive, adequate and representative reserve system (Department of the Environment 2014c).

The Project falls within the Little Sandy Desert region. The Little Sandy Desert region covers an area of 110,900 km^2 and is divided into two subregions:

- **Rudall** (8.9% of the Little Sandy Desert): sparse shrub-steppe over *Triodia basedowii* on stony hills, with River Red Gum communities and bunch grasslands on alluvial deposits in and associated with ranges (Kendrick 2001)
- **Trainor** (91.1% of the Little Sandy Desert): Shrub steppe of acacias, *Aluta maisonneuvei* and grevilleas over *Triodia schinzii* on sandy surfaces. Sparse shrub-steppe over *Triodia basedowii* on stony hills, with eucalypt and Coolibah communities and bunch grasslands on alluvial deposits and drainage lines associated with ranges (Cowan & Kendrick 2001).

The Project is situated primarily in the Trainor subregion (Figure 2-1) with a minor portion of the northern study area within the Rudall subregion.

Figure 2-1
Location of the Lake Disappointment Potash Project in relation to IBRA regions and subregions



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2.2 CLIMATE AND WEATHER

The Little Sandy Desert bioregion has an arid climate with summer-dominant rainfall. The average rainfall is about 178 mm (DEWHA 2008). Average annual (pan) evaporation in the area is approximately 3,600–4,066 mm per year (Department of Agriculture 2003), which greatly exceeds annual rainfall and consequently contributes to the arid environment.

The nearest Bureau of Meteorology (BOM) weather station is located at Telfer airport (no. 13030, 21.71°S, 122.23°E), approximately 180 km north-west of the Lake Disappointment Potash Project. Telfer airport records the highest maximum mean monthly temperature (40.6°C) in January, the lowest maximum mean annual temperature (10.6°C) in July and an average annual rainfall of 370.7 mm (BOM 2013) (Figure 2-2).

Records during May 2013 from Telfer show above average rainfall (Figure 2-2) compared to historical means. In the same month, mean daily maximum temperatures at Telfer were below average. Mean daily minimum temperatures were above historical means (Figure 2-2).

The climate data suggest that conditions were suitable for SRE surveys. It should be noted however that these conditions are not based on locations nearby the study area and are not indicative of exact conditions on site.

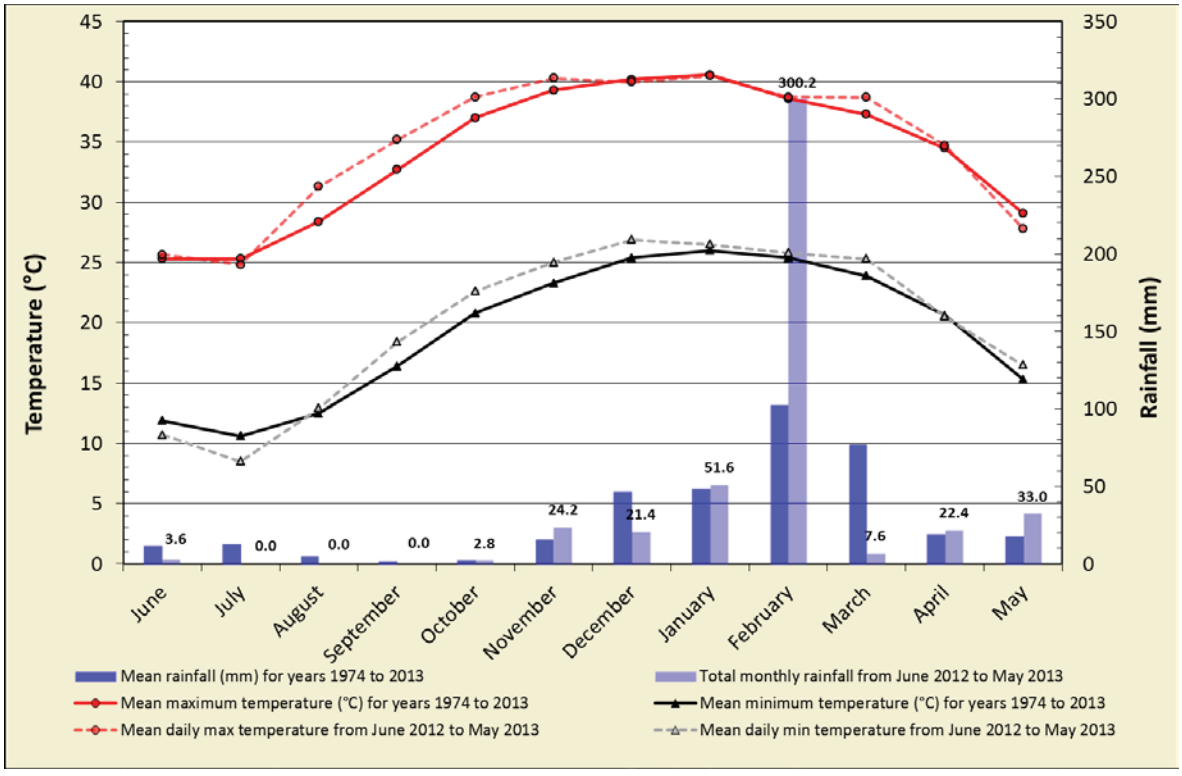


Figure 2-2 **Climate data (average monthly temperatures and rainfall records) and weather (temperature and rainfall preceding survey) for Telfer airport (BOM 2013)**

2.3 LAND USE

Land use of the bioregion is predominantly Aboriginal Native Title. Smaller areas are allocated designated conservation estate (4.6%) and pastoral leases (2%) (DEWHA 2008).

2.3.1 Threatening processes

The restricted ranges of SREs in combination with often very specific habitat preferences make them particularly vulnerable to adverse effects caused by some of the land uses mentioned above (Harvey 2002). The main threatening processes to SRE taxa in Western Australia are:

- **Wildfire and alteration of fire regimes:** Over 18% of the Little Sandy Desert region was burnt in 2000 (DEWHA 2008). *Acacia* woodlands support assemblages of species, including SREs, which do not persist in the spinifex scrublands that are replacing the *Acacia* after the fires of 2000.
- **Habitat alteration through grazing:** Grazing in the Little Sandy Desert does not affect potential SRE habitat as much as in other areas of WA due to a low level of grazing. The use of grazing in the region is approximately 2% and did not change significantly between 1992–2005 (DEWHA 2008).
- **Spread of introduced fauna including unmanaged livestock and feral bees:** Twelve introduced mammals compete with and/or prey on indigenous species in northern regions of WA, including house mice, black rats, feral dogs and cats, red fox, European rabbit, brumbies, feral pigs and camels (see also McKenzie & Burbidge 2002).
- **Spread of weeds**: Buffel grass is common in the Trainor subregion, it's distribution is increasing, probably to the exclusion of native species (Cowan & Kendrick 2001).
- **Habitat destruction through mining and associated infrastructure:** Mining developments are sparse in the region; one project (Kintyre) is present within the area for the desktop review (Figure 2-3).
- **Climate change:** Current predictions suggest that bioregions in North West WA may become warmer with more hot days and fewer cold nights and, may experience lower annual rainfall. Droughts may be more severe and storm events become more common (McKenzie *et al.* 2009). These effects may enhance the effects of other threatening processes, in particular the likelihood of fire and the introduction of more species from the tropics.

2.3.2 Conservation Reserves

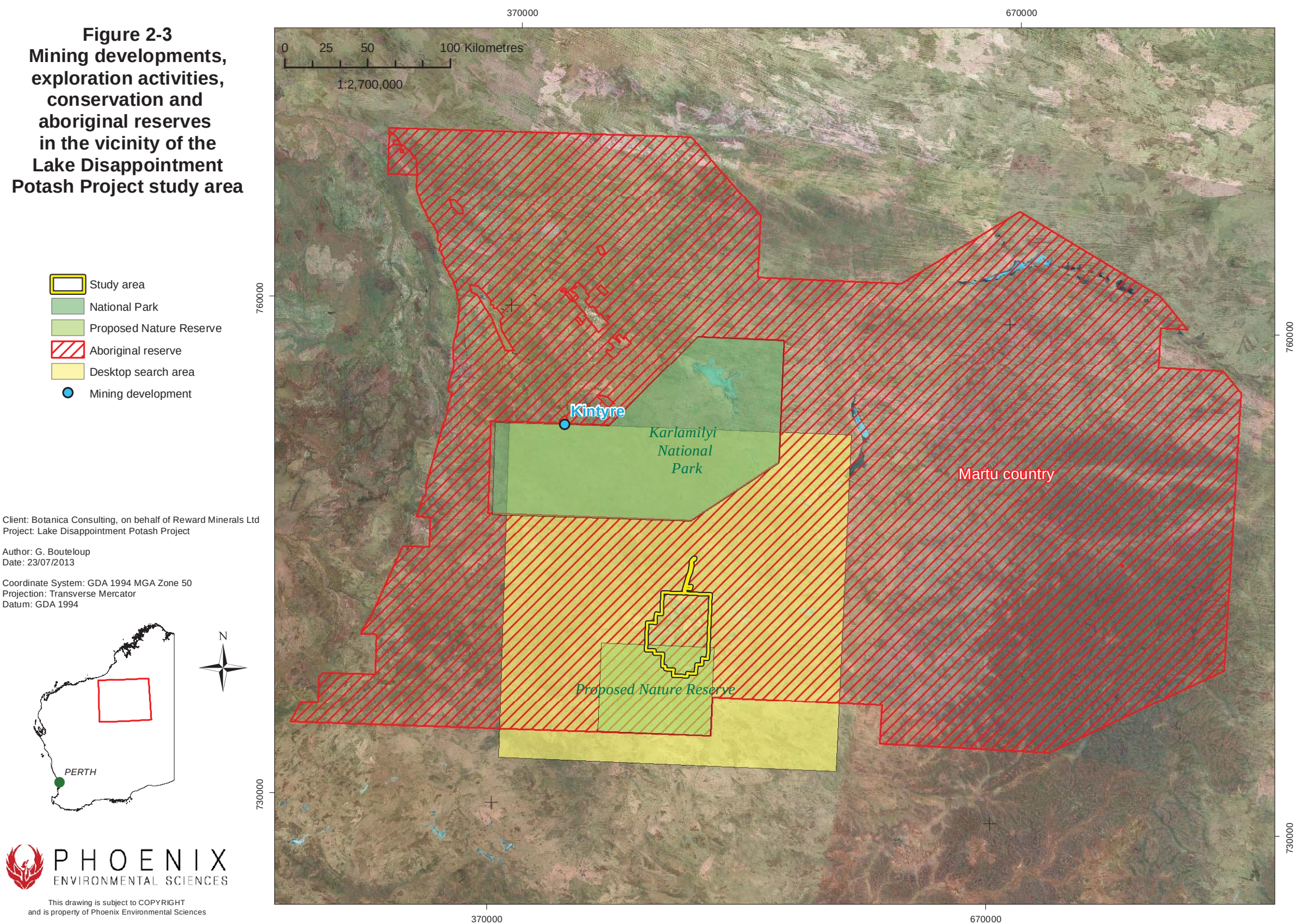
One conservation reserve in the vicinity of the study area is considered to provide biological refugia for fauna, Karlamilyi National Park, formerly Rudall River National Park (Morton *et al.* 1995) (Figure 2-3). Karlamilyi National Park is located approximately 50 km north of Lake Disappointment and is Western Australia's largest national park encompassing more than 1.2 million hectares (DEC 2012). Knowledge of the invertebrate fauna is limited (Cowan & Kendrick 2001; Kendrick 2001).

Lake Disappointment is listed as a Nationally Important Wetland (Environment Australia 2001). The southern region of the Project itself is within an area of 366700 ha proposed as an A-class Nature Reserve (Lynch 1995) (Figure 2-3). To date this proposed reserve has not been approved.

2.3.3 Aboriginal Reserves

The study area lies within the Martu country (Figure 2-3). Granted as Native Title in 2002, the Martu country covers an area of 136,000 km², surrounds the Karlamilyi National Park and includes a portion of the Canning Stock Route (Kormendy 2002).

Figure 2-3
Mining developments, exploration activities, conservation and aboriginal reserves in the vicinity of the Lake Disappointment Potash Project study area



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Datum: GDA 1994

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2.4 BIOLOGICAL CONTEXT

2.4.1 Short-range endemic invertebrates

Short-range endemic fauna 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). The most appropriate analogy is that of an island, where the movement of fauna is restricted by the surrounding marine waters, therefore isolating the fauna from other terrestrial populations. Isolating mechanisms and features such as roads, urban infrastructure, large creek lines and ridges can act to prevent the dispersal and gene flow of the less mobile invertebrate species.

Short-range endemism in terrestrial invertebrates is believed to have evolved through two primary processes (Harvey 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 slaters 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 may have settled in particular isolated habitat types by means of dispersal or phoresy (transport of one organism by another) and evolved in isolation into distinct species. Such habitat islands include rocky outcrops (pseudoscorpions in the genus *Synsphyronus* or spiders in the family Selenopidae are typical examples) or salt lakes (e.g. wolf spiders of the genus *Tetralycosa*). Unlike relictual SREs in mesic habitats, habitat specialist SREs are restricted by environmental parameters other than humidity and are often found in arid environments such as the Pilbara.

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):

- poor powers of dispersal
- confinement to discontinuous habitats
- seasonality, i.e. only active in cooler or wetter months
- slow growth
- low levels of fecundity.

In the Little Sandy Desert, the current knowledge of invertebrate species is relatively poor and the rarity of collections from certain areas makes it difficult to assess the distribution and likely occurrence of SRE species (Cowan & Kendrick 2001; Kendrick 2001). Habitats such as mountains containing gullies/gorges and south-facing slopes (principally within the Karlamilyi National Park), salt lakes, wetlands and rivers often include unique habitat attributes set amongst a relatively homogeneous surrounding landscape. These unique, isolated microhabitats often harbour SRE taxa. Potential SRE taxa of the Little Sandy Desert include the following groups that represent the target invertebrates of this survey (EPA 2009):

- spiders and relatives (Arachnida)
    - spiders (Araneae), in particular trapdoor spiders (Mygalomorphae) and selected modern spiders (Araneomorphae) (here mainly salt flat endemic wolf spiders, family Lycosidae)
    - harvestmen (Opiliones)
    - false scorpions (Pseudoscorpiones)
    - true scorpions (Scorpiones)
- 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)
- earth worms (Oligochaeta).

Epigaeic (ground-dwelling), often wingless beetles are not typically targeted as SRE invertebrates (EPA 2009). However, in the Pilbara for example, they have recently been proposed to contain a substantial proportion of range restricted species (Guthrie *et al.* 2010). Given the known habitat association with flightless beetles and salt lakes (McCairns *et al.* 1997), these groups were also targeted in this survey.

2.4.2 Categories of short-range endemism

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' – attributed to W. Cowper, 1731–1800).
- **Lack of taxonomic resolution**: Many potential SRE taxa (based on habitat constraints, 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 increasingly being employed to overcome these identification problems.

Currently, there is no accepted system to determine the likelihood that a species is an SRE, although the WA Museum has recently developed a categorisation that includes one category of uncertain SREs ('potential') (Western Australian Museum 2013). In contrast, Phoenix employs a system that includes two categories of uncertain SREs ('likely' and 'potential') that allows setting conservation priorities within a project (Table 2-1). These categories are dynamic and can change with every single survey as knowledge of SRE status is updated. For example, the millipede *Austrostrophus stictopygus*

Hoffman, 2003 (order Spirobolida) has been shown widespread in the Pilbara based on material collected as part of environmental assessment studies following its initial description from few localities (Harvey *et al.* 2011; Hoffman 2003).

Life stages of species that cannot be identified at the species level, e.g. some females and juveniles, are 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 a few of the 140+ known species in this genus are currently considered SREs (Wojcieszek *et al.* 2011).

Although the different categories of 'SRE-likelihood' may help to set conservation priorities, SRE taxa of all categories should be assessed on their merit, in order to determine appropriate conservation measures that 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*" (EPA 2002).

Table 2-1 Short-range endemic categories reflecting survey, taxonomic and identification uncertainties

SRE category	Criteria	Typical representative
Confirmed	Confirmed or almost certainly SRE; taxonomy of the group is well known (but not necessarily published); group is well represented in collections, in particular from the region in question; high levels of endemism exists in documented species; inference is often possible from immature specimens	*Antichiropus* millipedes (Paradoxosomatidae); scorpions in the genus *Aops* (Urodacidae)
Likely	Taxonomically poorly resolved group; unusual morphology for the group (e.g. some form of troglomorphism); often singleton in survey and few, if any, regional records	Opiliones in the genus *Dampetrus*; some pseudoscorpions (*Synsphyronus*) and slaters (Philosciidae); araneomorph spiders in the genus *Karaops* (Selenopidae)
Potential	Taxonomically poorly resolved group; often common in certain microhabitats in SRE surveys (i.e. litter dwellers), but no other regional records; congeners (= species in the same genus) often widespread	Mygalomorph spiders (*Aname, Conothele, Missulena, Synothele*), centipedes (Cryptopidae: *Cryptops*; Geophilomorpha: *Sepedonophilus, Mecistocephalus*)
Widespread	Taxonomically well resolved (but often not published) and demonstrated wide distribution (i.e. > 10,000 km2).	

2.4.3 Terrestrial invertebrates of salt lakes in Western Australia

The interior of mid and south-western Australia contains a vast area of ephemeral salt lakes. These were formed by the fragmentation of paleodrainage basins that existed prior to the aridification of the continent starting in the Miocene (van de Graaff *et al.* 1977). Proposed ancient basins remained well preserved because of tectonic stability and slow erosion and sedimentation (van de Graaff *et al.* 1977).

Salt lakes host a diverse array of fauna and flora, despite representing one of the most hostile ecosystems on earth due to high incident daily temperatures and high salt concentrations in the soil and the ephemeral water body of the lake. Colonial waterbird concentrations on freshly filled playas can number hundreds of thousands (Johnstone & Storr 1998) and is based on a significant short-term productivity of the lake. Primary production of salt lakes is generally based on microbial mats of cyanobacteria and diatoms (Bauld 1981). A productive lake may have a limited range of halobiontic crustaceans, typically one species of brine shrimp (*Parartemia*), ostracods and copepods (Curtin University of Technology 1999). Shield shrimps (*Triops australiensis*) and molluscs, e.g. in the genus *Coxiella* (Pomatiopsidae) (e.g. Davis 1979), may also contribute to the aquatic food chain.

Fauna surveys of salt lakes in Western Australia have traditionally focused on the aquatic biota and these studies show some degree of endemicity (Pinder *et al.* 2002). Since 1998, studies of salt lakes in Western Australia have demonstrated clear links between water quality and the composition of benthic microbial communities (M. White pers. comm.) However, comparatively little is known about the terrestrial invertebrate fauna associated with saline lakes in Western Australia (Durrant & Guthrie 2004). Whilst salt lakes have a characteristically zoned shoreline vegetation (Lyons *et al.* 2004), highest endemicity is to be expected on the lake playa itself. The mostly dry surface of the salt lake represents isolated habitat that requires very specific adaptions for survival.

In Western Australia, Lake Lefroy belongs to one of the better studied systems due to environmental impact assessments for continued mining in and around the lake (EPA 2000; SIGM 2012). Hudson (1995) identified 14 possible salt lake specialist terrestrial invertebrates that consistently inhabit the playa of Lake Lefroy and surrounding lakes. These included five species of spiders, three of which were wolf spiders (Lycosidae: *Tetralycosa*, *Hogna*[1]), five species of beetles, four of which were tiger beetles (Carabidae: Cicindelinae: *Ravicindela*[1], *Megacephala*), ants (Formicidae), a cricket (Gryllidae: possibly *Apterogryllus*), and an earwig (Labiduridae: *Labidura*). Subsequently, a rove beetle (Staphylinidae), an ant (*Iridomyrmex*), a pseudoscorpion (Olpiidae: *Austrohorus*) and two additional spider species (in the families Amaurobiidae and Theridiidae) were identified as potential specialists from the lake surface of Lake Lefroy (Curtin University of Technology 1999).

Wolf spiders, tiger beetles, crickets, ants, and earwigs appear to be the typical invertebrate assemblage of playas in Western Australia. On the saline playas, these groups are burrowing specialists that generally forage at night, often positioning themselves close to the water table enabling them to survive an otherwise inhospitable environment. Similar assemblages are found in South Australia although they may differ at the genus or species level. For example, the most common species of *Tetralycosa* wolf spiders in South Australia is *Tetralycosa eyrei* (Hudson & Adams 1996). In addition, South Australian salt lakes harbour a specialised scorpion (*Australobuthus xerolimniorum*) (Hudson 1997) and a diverse fauna of flightless carabid beetles in the subfamily Pogoninae (Baehr & Hudson 2001).

Two different genera of wolf spiders have specialised on saline playas, *Hogna* and *Tetralycosa* (see also Hudson & Adams 1996). Whereas salt lake *Hogna* are limited to a single species that is

[1] Taxonomy updated from original report.

widespread in WA, *Hogna salifodina* (McKay 1976), *Tetralycosa* is much more speciose. Twelve species are currently known in the genus of which at least eight are saline playa specialists and an additional three are known from samphire vegetation often near salt lakes (Framenau & Hudson, unpublished data). Endemicity appears comparatively high, for example there are two endemic species of *Tetralycosa* known from Lake Moore and a salt lake north of Yindi Station (Framenau & Hudson, unpublished data). Similarly, salt lake populations of tiger beetles in the genus *Ravicindela* show moderate levels of vicariant speciation and endemicity in WA (Kamoun & Hogenhout 1996; Pons *et al.* 2006). The pseudoscorpion *Austrohorus* from Lake Lefroy has so far not been collected elsewhere and may represent an endemic of the lake playa (Dalcon 2013). In contrast, some saline playa specialists appear to disperse well and are widespread, such as the wolf spider *Tetralycosa alteripa* which occurs on salt lakes in WA and into South Australia (Hudson 1997) or species in the tiger beetle genus *Megacephala* (McCairns *et al.* 1997).

2.5 RELEVANT LEGISLATION

2.5.1 Commonwealth

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), actions that have, or are likely to have, a significant impact on a matter of national environmental significance (NES) require approval from the Australian Government Minister for the Environment, Water, Heritage and the Arts (the Minister). The EPBC Act provides for the listing of nationally threatened native species as matters of NES.

Fauna species of national conservation significance may be classified as 'critically endangered', 'endangered', 'vulnerable' or 'conservation dependent' Few invertebrate taxa from WA are listed as matters of NES and those that are mostly include species that have experienced significant range contractions and populations declines due to habitat loss, for example the Margaret River Marron (*Cherax tenuimanus*) (Critically Endangered) and the Shield-backed Trapdoor Spider (*Idiosoma nigrum*) (Vulnerable) (Department of the Environment 2014b) .

2.5.2 State

Native species in Western Australia which are under identifiable threat of extinction are protected under the Western Australian *Wildlife Conservation Act 1950* (WC Act). Under the WC Act, the *Wildlife Conservation (Specially Protected Fauna) Notice 2013* (Western Australian Government 2013) recognises four classifications of rare and endangered fauna:

- **Schedule 1:** Fauna that is rare or is likely to become extinct
- **Schedule 2:** Fauna presumed to be extinct
- **Schedule 3:** Migratory birds protected under an international agreement
- **Schedule 4:** Other specially protected fauna.

In addition, the Department of Parks and Wildlife (DPaW), formerly Department of Environment and Conservation (DEC) produces a list of Priority species (last update: September 2013) (DPaW 2013) that have not been assigned statutory protection under the WC Act. Species on this list are considered to be of conservation priority because there is insufficient information to assess their conservation status or they are considered to be rare but not threatened and are in need of monitoring. The DER Priority Fauna List categories are:

- **Priority 1:** Taxa with few, poorly known populations on threatened lands
- **Priority 2:** Taxa with few, poorly known populations on conservation lands
- **Priority 3:** Taxa with several, poorly known populations, some on conservation lands

- **Priority 4:** Taxa in need of monitoring – considered not currently threatened but could be if present circumstances change
- **Priority 5:** Taxa in need of monitoring – considered not currently threatened but subject to a conservation program, the cessation of which could result in the species becoming threatened.

Few SRE invertebrate taxa are listed under the WC Act and while there are several invertebrate species on DPaW's Priority list (some of which are SRE taxa), these lists cannot be relied on as a complete guide to conservation significant invertebrate taxa within a particular location.

The most up-to-date listings of invertebrates and their distribution is available through database searches of the WA Museum invertebrate databases, including the Arachnology/Myriapodology database of the Department of Terrestrial Zoology and the Mollusca and Crustacea databases of the Department of Aquatic Zoology.

3 METHODS

3.1 DESKTOP REVIEW

The nominal maximum range of short-range endemism, i.e. 100 km x 100 km (Harvey 2002) was used to determine if any SRE taxa have previously been recorded in the study area or its vicinity. Therefore, the search grid extended approximately 100 km from the centre of the study area. Where the search criteria were too large for databases to accept (i.e. NatureMap) multiple searches were conducted to cover this area. The following database searches were requested or undertaken to determine if any SRE taxa have previously been recorded in the study area or its vicinity:

- WA Museum Arachnology and Myriapodology database, WA Museum Mollusca database and WA Museum Crustacea database (NW corner 121°44.976'E, 22°19.968'S and SE corner 123°45.072'E, 24°9.696'S)
- EPBC Act Protected Matters database (NW corner 121.7496°E, 22.3328°S and SE corner 123.7512°E, 24.1616°S)
- DER/WA Museum NatureMap database (NW corner 122°4'31.998", 22°37'13.998" and SE corner 123°25'09"E, 23°53'4.002"S).

In the area targeted by the desktop review, there was one mining development for which SRE invertebrate surveys were conducted, the Kintyre Uranium Project (ENVIRON 2010) located approximately 128 km NW of the study area (Figure 2-3). Despite the low volume of data from resource exploration, distribution information of the invertebrates that have been recorded through research collections is available through the WA Museum database and was accessed for this desktop review.

3.2 HABITAT ASSESSMENT AND SITE SELECTION

Three broad habitat types that potentially harbour SRE invertebrates were identified in the study area, namely:

- Saline playa (PLA): uniform, exposed lake surface devoid of vegetation with extensive salt crust (sodium chloride) and crystal formations. Soil beneath surface consists of soft moist sand.
- Samphire riparian vegetation (SPH): low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.
- Sand dunes (SAN): spinifex dominated sand dunes surrounding the lake. Sparse outcrops of Gypsum on loose sandy surface.

Fifteen primary survey sites were surveyed, each of these sites consisted of three subordinate (sub) sites, one within each of the broad habitats (PLA, SPH and SAN labelled A, B and C respectively) (Table 3-1; Figure 3-1). Invertebrate collections from 14 secondary sites from the concurrent vertebrate fauna survey were also utilised. Site descriptions for the 15 primary SRE sites detailing geography, vegetation, soil, rockiness, litter, disturbance and site photographs are provided (Appendix 1).

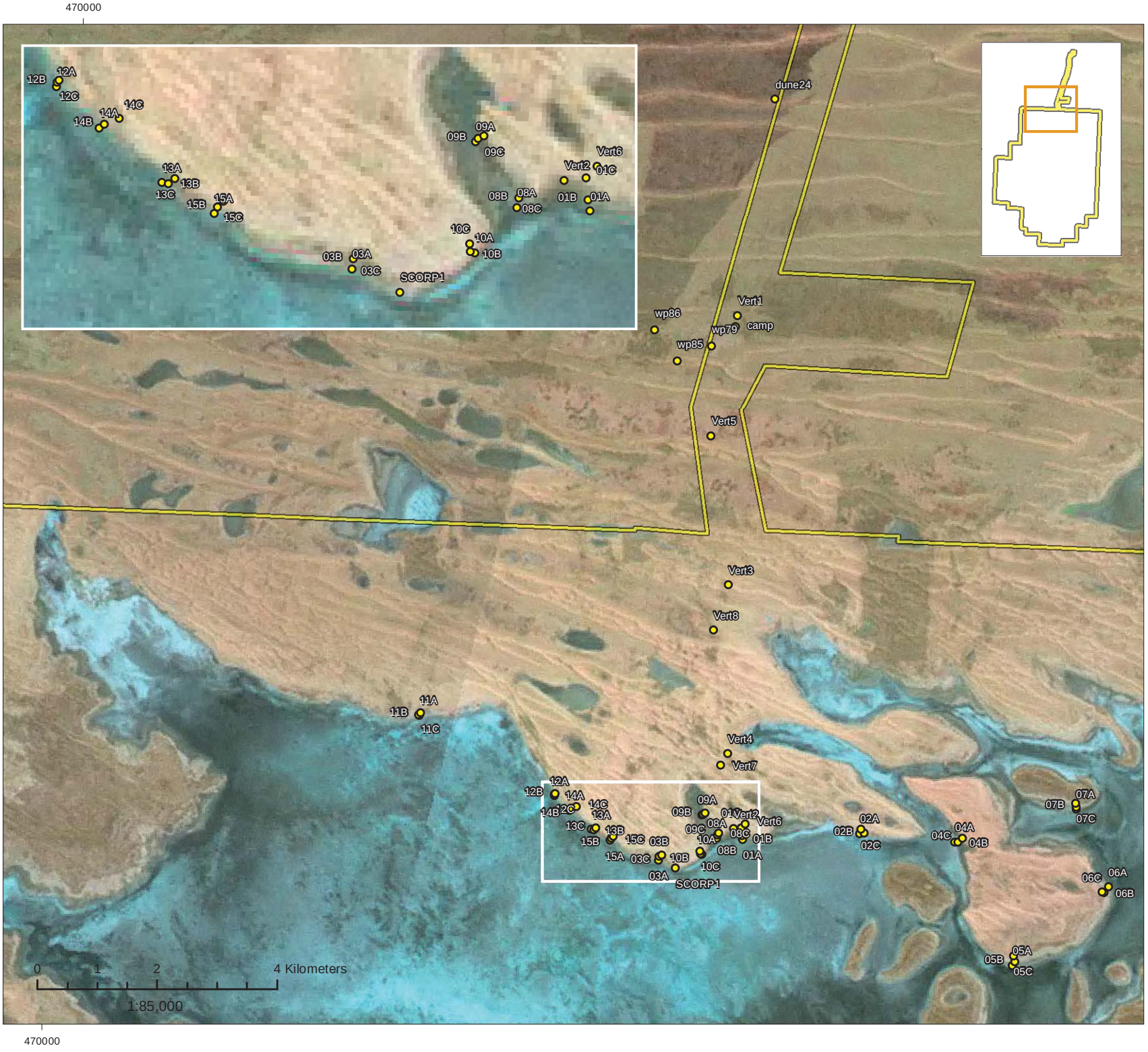
Table 3-1 Sampling sites and survey effort for the short-range endemic invertebrate survey of the Lake Disappointment Potash Project

Site	Sub site	Habitat type[a]	Easting (51K)	Northing (51K)	Collecting techniques[b]	Foraging time (mins)	Litter sifts (No.)	Dry pitfall traps
01	A	PLA	481515	7425569	FO	20	0	0
	B	SPH	481501	7425633	FO	20	0	0
	C	SAN	481484	7425763	FO, LS	20	3	0
02	A	PLA	483456	7425746	FO	20	0	0
	B	SPH	483536	7425756	FO	20	0	0
	C	SAN	483477	7425822	FO, LS	20	3	0
03	A	PLA	480135	7425170	FO	20	0	0
	B	SPH	480139	7425230	FO	20	0	0
	C	SAN	480182	7425254	FO, LS	20	3	0
04	A	PLA	485046	7425673	FO	20	0	0
	B	SPH	485094	7425670	FO	20	0	0
	C	SAN	485167	7425741	FO, LS	20	3	0
05	A	PLA	486081	7423660	FO	20	0	0
	B	SPH	486127	7423721	FO	20	0	0
	C	SAN	486100	7423824	FO, LS	20	3	0
06	A	PLA	487624	7425033	FO	20	0	0
	B	SPH	487554	7424935	FO	20	0	0
	C	SAN	487522	7424944	FO, LS	20	3	0
07	A	PLA	487034	7426307	FO	20	0	0
	B	SPH	487035	7426334	FO	20	0	0
	C	SAN	487029	7426404	FO, LS	20	3	0
08	A	PLA	481085	7425571	FO	20	0	0
	B	SPH	481095	7425627	FO	20	0	0
	C	SAN	481113	7425657	FO, LS	20	3	0
09	A	PLA	480828	7425948	FO	20	0	0
	B	SPH	480840	7425965	FO	20	0	0
	C	SAN	480876	7425983	FO, LS	20	3	0
10	A	PLA	480849	7425295	FO	20	0	0
	B	SPH	480824	7425302	FO	20	0	0
	C	SAN	480819	7425348	FO, LS	20	3	0
11	A	PLA	476055	7427411	FO	20	0	0
	B	SPH	476052	7427419	FO	20	0	0
	C	SAN	476083	7427448	FO, LS	20	3	0
12	A	PLA	478359	7426168	FO	20	0	0
	B	SPH	478361	7426196	FO	20	0	0

Site	Sub site	Habitat type[a]	Easting (51K)	Northing (51K)	Collecting techniques[b]	Foraging time (mins)	Litter sifts (No.)	Dry pitfall traps
	C	SAN	478371	7426204	FO, LS	20	3	0
13	A	PLA	478999	7425631	FO	20	0	0
	B	SPH	479039	7425628	FO	20	0	0
	C	SAN	479074	7425658	FO, LS	20	3	0
14	A	PLA	478620	7425937	FO	20	0	0
	B	SPH	478646	7425960	FO	20	0	0
	C	SAN	478732	7425997	FO, LS	20	3	0
15	A	PLA	479312	7425463	FO	20	0	0
	B	SPH	479330	7425502	FO	20	0	0
	C	SAN	479363	7425538	FO, LS	20	3	0
Vert1	-	SAN	481072	7434270	dPT	-	-	10
Vert2	-	SAN	481357	7425743	dPT	-	-	10
Vert3	-	SAN	481100	7429788	dPT	-	-	10
Vert4	-	SAN	481206	7426984	dPT	-	-	10
Vert5	-	SAN	480715	7432252	dPT	-	-	10
Vert6	-	SAN	481546	7425833	dPT	-	-	10
Vert7	-	SAN	481099	7426787	dPT	-	-	10
Vert8	-	SAN	480885	7429026	dPT	-	-	10
camp	-	SAN	481046	7434082	OP	-	-	-
Scorp1	-	PLA	480422	7425045	OP	-	-	-
Dune24	-	SAN	481548	7437889	OP	-	-	-
Wp79	-	SAN	480664	7433748	OP	-	-	-
Wp85	-	SAN	480102	7433478	OP	-	-	-
Wp86	-	SAN	479706	7433979	OP	-	-	-
Total						**900**	**45**	**80**

[a] – PLA – Saline playa; SPH – Samphire riparian vegetation; SAN – Sand dunes; [b] –FO – foraging; LS – litter and soil sieve; dPT – dry pitfall trap; OP – opportunistic sampling.

Figure 3-1
Collection sites for the short-range endemic survey of the Lake Disappointment Potash Project study area



Study area

Survey sites

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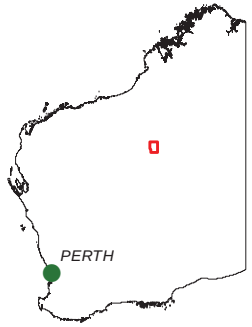
Project: Lake Disappointment Potash Project

Author: G. Bouteloup
Date: 22/07/2013

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

N



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3.3 FIELD METHODS

The field survey was conducted in a single field trip from 2–6 May 2013. The collecting methods consisted of three proven, industry-recognised sampling techniques to target SRE taxa: active searches (foraging), sieving of combined leaf litter and soil samples and dry pitfall trapping (see Figure 3-1 for total survey effort).

3.3.1 Hand foraging

Hand foraging incorporated the systematic inspection of logs, larger plant debris, the underside of bark of larger trees and the underside of rocks. Methodical searches were conducted amongst the leaf litter of shade-bearing tall shrubs and trees and spinifex bases were inspected thoroughly. Rocks and rock crevices were inspected, particularly for pseudoscorpions.

A standardised approach was undertaken at 15 sites, whereby each site was sampled for a minimum of 1 person hour; a 20 min search was conducted at each of the three sub sites (Figure 3-1). Spider burrows identified during the searches were excavated if they were considered to be inhabited. Excavation involved removing soil from around the burrow to carefully expose the burrow chamber and remove the spider. Opportunistic hand foraging occurred at a further six sites (Figure 3-1); these records represent chance collections during the survey duration.

3.3.2 Litter/soil sieving

At least three combined litter/soil sifts were undertaken at 15 sites, these were conducted in sand dune habitat (sub site C) where leaf litter was available. The collection of leaf litter samples were standardised volumetrically by the diameter and height (310 mm x 50 mm = 1.55 L) of the sieves which were completely filled with compressed litter and the upper layers of underlying soil. Samples were sieved through three stages of decreasing mesh size over a round tray and invertebrates were picked from the sieves and tray with forceps or an aspirator.

These samples particularly targeted small spiders (Araneomorphae), pseudoscorpions, buthid scorpions, millipedes, centipedes (in particular Geophilomorpha and Cryptopidae), smaller species of molluscs (e.g. Pupillidae) and slaters.

In situ collecting and sieving was preferred over transporting litter samples to the laboratory. Small invertebrates are best detected when moving and transport to the laboratory can kill a large proportion of the catch. In addition, if litter sieves in the field contain groups of interest, more extensive searches can be conducted, providing greater flexibility in the sampling protocol. Specimens of the target taxa were immediately fixed in absolute ethanol to preserve tissue for future molecular analyses.

3.3.3 Dry pitfall trapping

Eight dry pitfall trapping sites established during a concurrent vertebrate survey by Greg Harewood were made available for this survey. Ten nine-litre buckets were exposed at each of the sites. Invertebrate specimens cleared daily from traps were provided to Phoenix for inclusion in the SRE survey results.

3.4 TAXONOMY AND NOMENCLATURE

3.4.1 Morphological species identification

Phoenix has considerable in-house expertise in the identification of SRE target groups. Senior staff involved in the identification are also Research Associates with a longstanding taxonomic research history at the WA Museum (Table 3-2).

In all cases, identifications relied on direct comparison with reference material from the WA Museum. WA Museum staff were engaged to identify groups in which Phoenix does not have the appropriate expertise (e.g. some pseudoscorpions and all snails). The reliance on the WA Museum reference collections provides the important regional context in the assessment of short-range endemism for unpublished taxa.

Most material collected during the SRE survey, in particular SRE species, has been lodged with the WA Museum, the exception being some representative specimens that remained in the Phoenix reference collection.

Table 3-2 Taxonomic specialists that identified the short-range endemic invertebrates from the survey

Personnel	Taxonomic group/s
Dr Volker W. Framenau[1, 2]	Araneae (Mygalomorphae, Araneomorphae)
Dr Erich S. Volschenk[1, 2]	Scorpiones, Pseudoscorpiones
Dr Simon Judd[1]	Isopoda
Ms Anna Leung[1]	Pseudoscorpiones, Chilopoda (Geophilomorpha)
Dr Mark Harvey[3]	Pseudoscorpiones
Mr Corey Whisson[3]	Mollusca
Nadine Guthrie[4]	Coleoptera

[1]Phoenix Environmental Sciences; [2]Research Associate WA Museum; [3]WA Museum; [4]Department of Parks and Wildlife.

3.4.2 Nomenclature

The nomenclature of described invertebrates and higher taxa follows a number of taxon-specific references, most of which are available online (Table 3-3). However, many SRE invertebrate species are currently unnamed and morphospecies designations listed in this report are adopted from the nomenclatural systems developed by the respective taxonomic authorities. Reference collections generally reside with WA Museum and morphospecies designations generally follow listings developed by the WA Museum (Table 3-3) as expected by the EPA (EPA 2004).

Taxonomic authors for described species are listed (Appendix 2; Appendix 3).

Table 3-3 Nomenclatural references, morphospecies designations and reference collections

Taxonomic group	Taxonomic reference for described species and higher taxa	Morphospecies designation and reference collection
Araneae (Araneomorphae)	World Spider Catalog (2014)	Reference collection at WAM
Araneae (Mygalomorphae)	World Spider Catalog (2014)	"MYG"- morphospecies designation developed by V.W. Framenau (WAM, Phoenix), reference collection at WAM
Pseudoscorpiones	Harvey (2011)	"PSE"-morphospecies designation developed by M. Harvey (WAM), reference collection at WAM
Scorpiones	Rein (2011), Fet *et al.* (2000), Glauert (1925), Koch, (1977), Kovařík (1997; 2002), Volschenk and Prendini (2008), Volschenk *et al.* (2000) Volschenk *et al.* (2012)	Morphospecies designation developed by E.S. Volschenk (WAM, Phoenix), reference collection at WAM
Chilopoda (Geophilomorpha, Cryptopidae only)	Colloff *et al.* (2005), Minelli *et al.* (2006 onwards)	Taxonomically poorly studied groups, no reference collection available
Isopoda	Schmalfuss (2003); Schmidt and Leistikow (2004); Schotte *et al.* (2008)	Morphospecies designation developed by S. Judd (Phoenix), reference collection at WAM
Coleoptera	McCairns *et al.* (1997)	Reference collection at WAM
Eupulmonata[a]	Stanisic *et al.* (2010), Whisson & Kirkendale (2014), C. Whisson (Collection Manager: Non-Marine Aquatics, WA Museum, Department of Aquatic Zoology, pers. comm.,)	Morphospecies designations developed by C. Whisson and S. Slack-Smith (WAM), reference collection at WAM

[a] – For practical purposes, Eupulmonata is here considered an order (Department of the Environment 2014a); however, it is acknowledged that Bouchet *et al.* (2005) consider it a rank-free clade.

3.5 STATISTICAL ANALYSES

A minimum of 20 specimens collected is considered the lowest number to provide reliable statistical results for species accumulation curves (Gotelli & Colwell 2001). Therefore, species accumulation analyses were not conducted for any of the groups collected.

3.6 SURVEY PERSONNEL

The personnel involved in the survey are presented (Table 3-4).

Table 3-4 Project team for the Lake Disappointment invertebrate fauna survey

Name	Qualifications	Role/s
Dr Volker W. Framenau	M.Sc. (Cons. Biol.), Ph.D. (Zool.)	Project Manager, taxonomy, report writing
Nicholas Dight	B. Sc. (Biol.)	Project Manager, field surveys, taxonomy, report writing, GIS
Anna Leung	B.Sc. (Env. Sci.) (Hons)	Field surveys, taxonomy
Guillaume Bouteloup	Advanced Diploma (Land Cons. Mgmt)	GIS
Melanie White	B.Sc. (Biol.) (Hons)	Report review

4 RESULTS

4.1 DESKTOP REVIEW

One SRE invertebrate was identified from the study area through the desktop review, the trapdoor spider *Aname* sp. indet. (Nemesiidae) (Table 4-1). The genus *Aname* is widely recorded in northern WA, however only three records were recovered from the desktop review (Figure 4-1). The genus contains some SREs in addition to many widespread species; therefore unidentified taxa are considered potential SREs. Detailed taxonomic and distribution assessments for these *Aname* are provided in sections 4.4.1.1.

Three potential SRE invertebrate taxa records from two orders, three families and three genera were identified through the desktop review outside the study area, but within a range of approximately 100 km around the study area which may therefore include SREs from the study area (Table 4-1; Figure 4-1; Appendix 2).

Aname sp. indet. represents a higher taxonomic rank; therefore species-level comparison with material from the survey may not be possible on the basis of morphology ("sp. indet."). *Lychas mjobergi* Kraepelin, 1916 is the only formally described species recovered from the desktop review. *Urodacus* 'armatus' designates members of a species-complex associated with *Urodacus armatus* Pocock, 1888 (E. Volschenk, unpublished data).

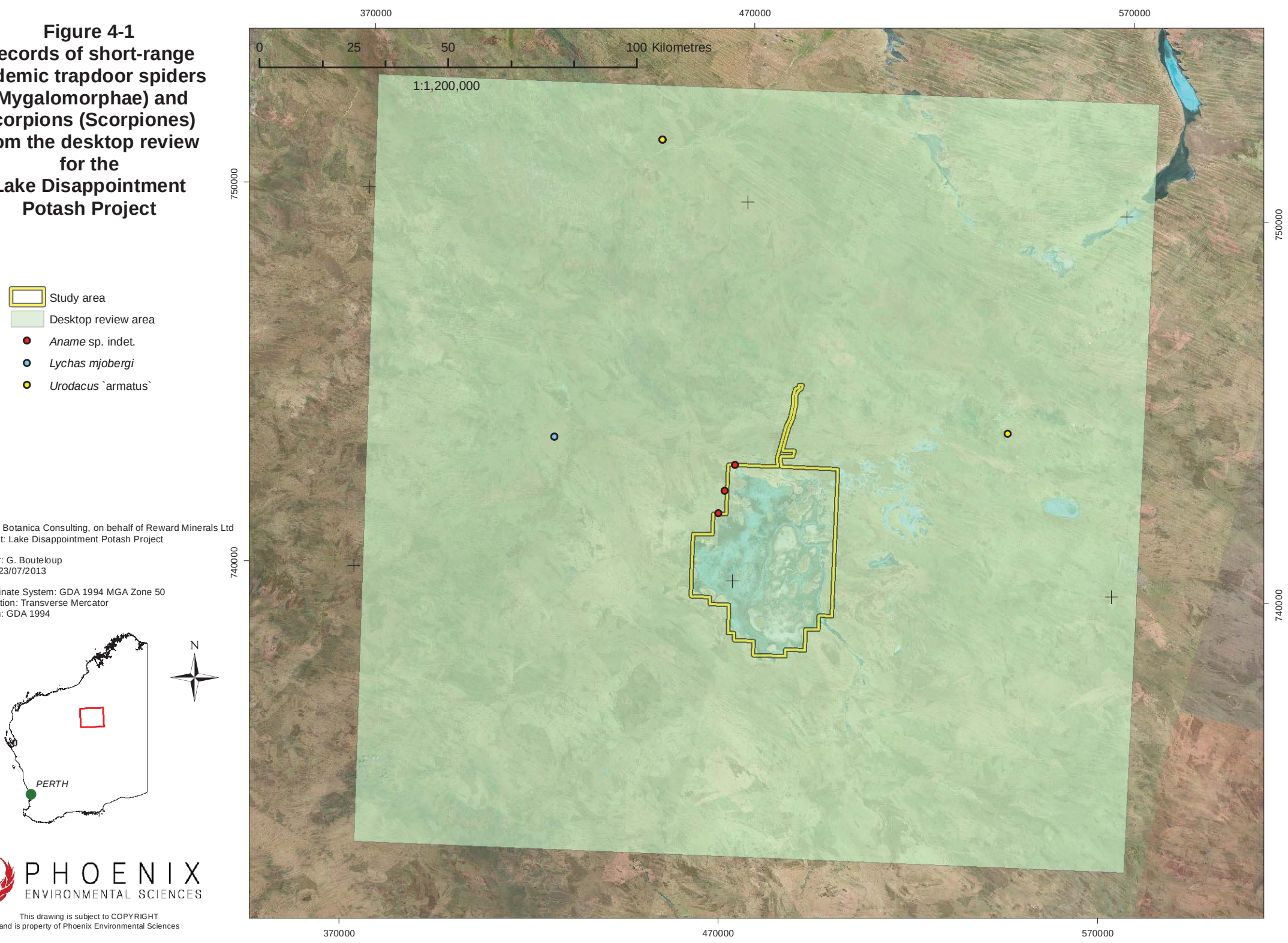
Searches of the EPBC database did not reveal any conservation significant SRE invertebrates from the area of the desktop review. The WA Museum database for crustaceans did not include any terrestrial species, but was limited to subterranean forms.

Table 4-1 Short-range endemic invertebrates identified through the desktop review for the Lake Disappointment Potash Project

Family	Genus and species	Locality	SRE category[a]	Recorded location	Source
Order Araneae (spiders)					
Infraorder Araneomorphae (modern spiders)					
Nemesiidae	*Aname* sp. indet.	Canning Stock Route, Savoury Creek, NW tip of Lake Disappointment	Potential	Study area, regional area	WA Museum
Order Scorpiones (scorpions)					
Buthidae	*Lychas mjobergi*	Savoury Creek	Potential	Study area	WA Museum, NatureMap
Urodacidae	*Urodacus* 'armatus'	Rudall River, Talawana Track	Potential	Study area	WA Museum

[a] – see section 2.4.2 for explanation of SRE categories.

Figure 4-1
Records of short-range endemic trapdoor spiders (Mygalomorphae) and scorpions (Scorpiones) from the desktop review for the Lake Disappointment Potash Project



Client: Botanica Consulting, on behalf of Reward Minerals Ltd
Project: Lake Disappointment Potash Project

Author: G. Bouteloup
Date: 23/07/2013

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

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4.2 FIELD SURVEY

A total of 55 individual specimens in the SRE target groups (see 2.4.2) were collected from the study area, representing 14 individually-recognised taxa from six orders, nine families and at least ten genera (Appendix 3). Twenty specimens were collected from primary survey foraging sites, nine from opportunistic collecting sites and 28 from incidental collections from dry pitfall traps (Appendix 3).

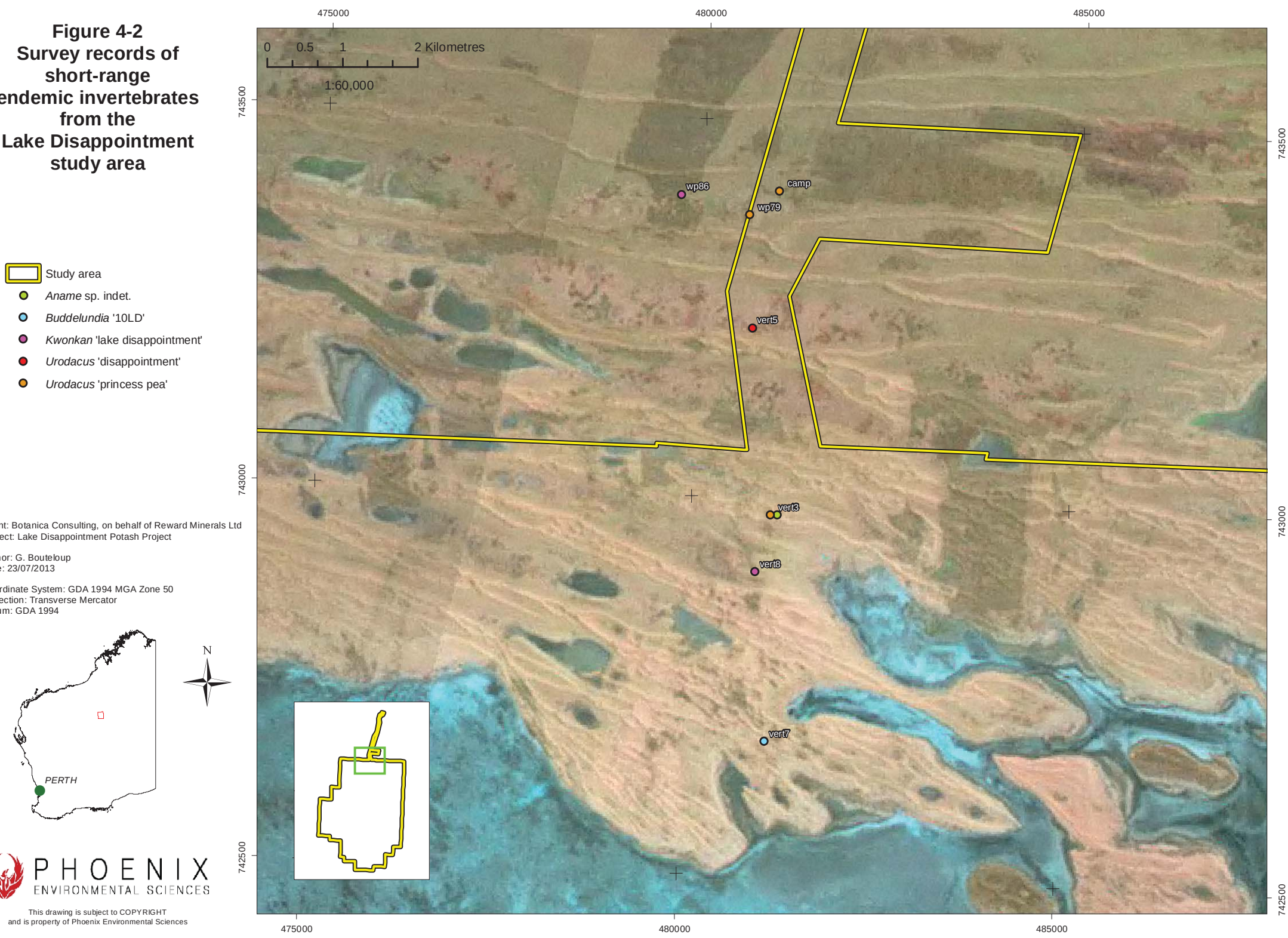
Five taxa in four genera from three families and three orders comprising 18 individuals (33% of total catch) are considered to include species from the "potential" SRE category (Table 4-2; Figure 4-2):

Detailed assessments of taxonomy and distributions for all SREs collected in the study area are provided (sections 4.3 to 4.8).

Table 4-2 Short-range endemic invertebrate taxa recorded during the survey of the Lake Disappointment Potash Project study area

Family	Genus and species	SRE status	Sites	No. of specimens	Habitat
Order Araneae (spiders)					
Infraorder Mygalomorphae (trapdoor spiders)					
Nemesiidae	*Aname* sp. indet.	Potential	Vert3	1	Sand dunes
Nemesiidae	*Kwonkan* 'disappointment'	Potential	Vert8, Wp86	2	Sand dunes
Order Scorpiones (scorpions)					
Urodacidae	*Urodacus* 'disappointment'	Potential	Vert5	1	Sand dunes
Urodacidae	*Urodacus* 'princess pea'	Potential	Camp, Vert3, Wp79	3	Sand dunes
Order Isopoda (slaters)					
Armadillidae	*Buddelundia* '10LD'	Potential	Vert7	11	Sand dunes

Figure 4-2
Survey records of short-range endemic invertebrates from the Lake Disappointment study area



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4.3 ARANEAE – ARANEOMORPHAE (MODERN SPIDERS)

The Araneae (spiders) are characterised by a number of unique characters, including abdominal appendages modified as spinnerets, silk glands and associated spigots, cheliceral venom glands and male pedipalp tarsi modified as secondary genitalia from sperm transfer (Coddington & Levi 1991). Spiders are one of the largest and most diverse orders of arachnids with more than 44,000 described species worldwide (World Spider Catalog 2014), and approximately 3,600 species named from Australia (Framenau 2014; Framenau *et al.* in press).

In contrast to the Mygalomorphae (trapdoor spiders, see section 4.4), Araneomorphae (modern spiders) are rarely targeted in SRE surveys. Araneomorphae often disperse very well, for example by wind-drift on gossamer threads ('ballooning') (e.g. Bell *et al.* 2005), and many species are widely distributed across the Australian landscape (Harvey 2002).

No SRE araneomorph spiders were recorded from study area in the desktop review.

Four specimens of wolf spiders (family Lycosidae) were collected in the study area (Table 4-3). All were juvenile and it was not possible to identify these at the species level. However, somatic morphology did not resemble that of known salt lake endemics such as the genera *Tetralycosa* and *Hogna* (see section 2.4.3) and they are here not considered SREs.

Table 4-3 Modern spiders (Araneae: Araneomorphae) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon	Site		Total
	Vert2	Vert6	
Lycosidae			
Lycosidae sp. indet.	3	1	**4**
Total	**3**	**1**	**4**

4.4 ARANEAE – MYGALOMORPHAE (TRAPDOOR SPIDERS)

Trapdoor spiders represent one of the focal groups in surveys of SRE taxa (Harvey 2002). A number of mygalomorph spiders, e.g. *Idiosoma nigrum*, *Kwonkan eboracum* and *Moggridgea tingle* are listed on Schedule 1 of the *Wildlife Conservation (Specially Protected Fauna) Notice 2013 (Western Australian Government 2013)*. The Western Australian mygalomorph fauna is vast and many families and genera remain taxonomically poorly known (e.g. Barychelidae: *Idiommata*; Idiopidae: *Aganippe*; Nemesiidae: *Aname*, *Chenistonia*, *Kwonkan*).

Unidentified nemesiid spiders in the genus *Aname* (*Aname* sp. indet.) were the only SRE mygalomorph spiders recorded from the study area in the desktop review; these were recorded from two locations (Figure 4-1; Figure 4-2).

Three specimens of mygalomorph spiders representing at least two species were collected in the study area (Table 4-4; Figure 4-2). Both of these are considered potential SREs.

Table 4-4 Trapdoor spiders (Araneae: Mygalomorphae) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon[a]	Site			Total
	Vert3	Vert8	Wp86	
Nemesiidae				
Aname sp. indet.	1			1
Kwonkan sp. indet.		1	1	2
Totals	**1**	**1**	**1**	**3**

[a] – species categorised as potential SREs are shaded in green.

4.4.1 Family Nemesiidae (wishbone trapdoor spider)

Members of the mygalomorph spider family Nemesiidae are represented in Western Australia by several genera, including *Aname*, *Chenistonia*, *Yilgarnia*, *Stanwellia*, *Teyl*, *Swolnpes* and *Kwonkan* (Main & Framenau 2009). They usually dig burrows in the soil, and do not cover their burrow entrances with lids.

4.4.1.1 Genus *Aname*

The genus *Aname* currently includes 37 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 Biological 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 two studies from northern Australia, including the Pilbara (Harvey *et al.* 2012; Raven 1985). Therefore, unidentifiable specimens are considered potential SREs.

***Aname* sp. indet.**

A single specimen of *Aname* was collected from sand dune habitat (Table 4-2). The specimen was juvenile and could not be identified to species. Three other records of *Aname* were also recovered in the desktop review, one of which is within the study area, but it is not possible to associate the juvenile from this survey with these records based on morphology alone.

4.4.1.2 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 2013* (Western Australian Government 2013). *Kwonkan* includes those nemesiid spiders that have spines on their pedal tarsi although this simple concept ignores much more informative genitalic characters.

***Kwonkan* 'disappointment'**

Two specimens of *Kwonkan* were collected from sand dune habitat (Table 4-2), one specimen within the study area and one specimen outside. Both specimens possess the identifying pedal tarsal spines of the genus *Kwonkan*, however the spinal arrangement is unlike that of the type specimen and further taxonomic studies into the genus are required to confirm *Kwonkan* 'disappointment' as true *Kwonkan*. The specimen may represent a yet undescribed nemesiid genus These records currently represent the only records of specimens with this peculiar setal arrangement of the tarsi and therefore *Kwonkan* 'disappointment' is considered a potential SRE.

4.5 PSEUDOSCORPIONES (FALSE SCORPIONS OR PSEUDOSCORPIONS)

The Western Australian pseudoscorpion fauna is fairly diverse with representatives of 17 different families (Harvey 2011). 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 (Harvey 1992).

No SRE pseudoscorpions were recorded from the study area in the desktop review.

Four pseudoscorpion specimens from at least two species in two genera and families were collected in the study area (Table 4-5). None of these are considered potential/likely/confirmed SREs. For example, *Synsphyronus callus* Hoff, 1947 is known from areas of the north-west and is also widespread in south-west coastal regions of WA (Harvey 1987). Genera in the Olpiidae, such as *Beierolpium*, belong to the most frequently collected pseudoscorpions in the north-west of Western Australia and their terrestrial representatives are generally not believed to contain many, if any, SREs (M. Harvey 2012, pers. comm.).

Table 4-5 Pseudoscorpions (Pseudoscorpiones) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon	Site				Total
	7C	12C	14C	15C	
Garypidae					
Synsphyronus callus	1				**1**
Olpiidae					
Beierolpium '8/2'			1		**1**
Beierolpium sp. indet.		1		1	**2**
Total	**1**	**1**	**1**	**1**	**4**

4.6 SCORPIONES (SCORPIONS)

Scorpions are characterised by the presence of chelate pedipalps, pectines and an elongate metasoma furnished with a sting. Scorpions are important components of arid ecosystems because their levels of diversity and abundance contribute significantly to the biomass of animal assemblages and they are important predators and prey for other species (Volschenk *et al.* 2010).

No SRE scorpions were recorded from the study area in the desktop review.

A total of 17 specimens of scorpions representing at least five species in two genera and two families were collected in the survey (Table 4-6). Two species (*Urodacus* 'disappointment' and *Urodacus* 'princess pea') are considered potential SREs.

Table 4-6 Scorpions (Scorpiones) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon[a]	Site										Total
	11A	Camp	Dune24	Scorp1	Vert3	Vert4	Vert5	Vert7	Wp79	Wp85	
Buthidae											
Lychas 'adonis'		1									**1**
Lychas 'telfer'					2	3		1			**6**
Urodacidae											
Urodacus 'disappointment'							1				**1**
Urodacus 'princess pea'		1			1				1		**3**
Urodacus yaschenkoi	3		1	1						1	**6**
Total	**3**	**2**	**1**	**1**	**4**	**3**	**1**	**1**	**1**	**1**	**17**

[a] – species categorised as potential SREs are shaded in green.

4.6.1 Family Urodacidae

The family Urodacidae is endemic to Australia (Fet 2000; Prendini 2000; Prendini & Wheeler 2005; Volschenk *et al.* 2000) where it is represented by the genera *Urodacus* Peters, 1861 and *Aops* Volschenk and Prendini, 2008.

4.6.1.1 Genus *Urodacus*

Urodacus was considered a member of the family Scorpionoidea for many years, but in a revision of the superfamily Scorpionoidea, Prendini (2000) placed *Urodacus* in its own family. Unlike the species designations for Buthidae, Koch's (1977) species of *Urodacus* have been mostly supported by subsequent authors (Harvey & Volschenk 2002; Volschenk & Prendini 2008; Volschenk *et al.* 2000). The biggest issue confronting *Urodacus* taxonomy is the number of undescribed species being uncovered through current revisionary work (E. S. Volschenk, unpublished data). Currently 23 species of *Urodacus* are described; however, this may represent as little as 20% of the real diversity of this genus in Australia. *Urodacus* appears to be 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. During a large-scale survey of the Pilbara fauna, Volschenk *et al*. (2010) recorded nine undescribed species and only one formerly describes species was reported in the study.

***Urodacus* 'disappointment'**

A single specimen of *Urodacus* 'disappointment' was collected from the survey in sand dune habitat. This record represents the only known location of a previously unidentified species of *Urodacus*. Based on current knowledge of *Urodacus* 'disappointment' it is a potential SRE.

***Urodacus* 'princess pea'**

Three specimens of *Urodacus* 'princess pea' were collected from the survey in areas of sand dune habitat. These specimens represent the only known location of a previously unidentified species of *Urodacus*. Based on current knowledge of *Urodacus* 'princess pea' it is a potential SRE.

4.7 COLEOPTERA (BEETLES)

Beetles (Coleoptera) are holometabolic insects that are characterised by sclerotised forewings (elytra) and the presence of chewing mandibles. They currently represent the largest insect order with more than 300,000 described species of Coleoptera worldwide; the Australian beetle fauna consists of almost 23,000 described species in 121 families and 3,265 genera (Austin *et al.* 2004; Naumann 2000; Yeates *et al.* 2003). Beetles in general are generally not targeted as typical SREs as most species are widely distributed, however a number of carabid beetles are known to be restricted to salt lake environments (Kamoun & Hogenhout 1996; McCairns *et al.* 1997).

Six specimens of tiger beetles (family Carabidae, subfamily Cicindelinae) in the genus *Megacephala* were collected during the survey. Species identification of three females is difficult based on available morphological features, one of these could represent either *M. oleadorsa* or *M. canninga* and the other two specimens may represent *M. murchisona*. Three specimens collected from the lake surface were in poor condition and could also not be identified to species level. All three of the potential *Megacephala* species are widespread in WA, *M. murchisona* is the only taxon not known to be associated with salt lakes (McCairns *et al.* 1997). Based on the wide distribution of these species, none are considered SREs.

Table 4-7 Beetles (Coleoptera) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon	Site			Total
	03A	13A	Vert2	
Carabidae				
Megacephala sp. indet.	2	1	2	**6**
Totals	**2**	**1**	**2**	**6**

4.8 ISOPODA (SLATERS)

Almost 200 described species of Oniscidea, a suborder of the Isopoda containing the supralittoral, terrestrial and secondarily aquatic slaters (or woodlice), have been recorded from Australia (Department of the Environment 2011). The WA fauna is comparatively poorly known with many undescribed species (Judd & Horwitz 2003). Slaters are an ideal biological model for faunistic and biogeographical studies, due to their reduced dispersal ability and narrow habitat preferences (Taiti & Argano 2009). Consequently, they belong to one of the target groups of SRE surveys (EPA 2009; Harvey 2002).

No SRE slaters were recovered from the study area by the desktop review. During the field survey, a total of 11 specimens of slaters were collected in the study area, representing a single species (Table 4-8). Most species of the genus *Buddelundia* are widespread in the Pilbara region and beyond, however the genus does contain new species for which the distribution is unknown (S. Judd, unpublished data).

Table 4-8 Slaters (Isopoda) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon[a]	Site	Total
	Vert7	
Armadillidae		
Buddelundia '10LD'	11	**11**
Totals	**11**	**11**

[a] – species categorised as potential SREs are shaded in green.

4.8.1 Family Armadillidae (pill bugs)

Armadillidae typically have a convex dorsal surface and the animal can roll up into a ball. Most species of the Armadillidae are found in the southern hemisphere and mainly occur in the tropical and subtropical zone (Lewis 1998), although the genus *Buddelundia* is also widespread in south-western WA. The family is diverse in Australia, currently 24 genera are described; many species live in litter or under wood and stones in forest or woodland or near the coast (Green *et al.* 2010). The armadillid genus *Buddelundia* is endemic to Australia (Lewis 1998).

4.8.1.1 Genus *Buddelundia*

Members of the genus *Buddelundia* belong to the most common terrestrial isopods in WA and the genus was well represented in the material. The genus is currently under taxonomic revision by S. Judd (Phoenix). Only a few species of *Buddelundia* have a very wide distribution, and many represent SREs.

***Buddelundia* '10LD'**

Eleven specimens of *Buddelundia* '10LD' were collected from a single site within sand dunes. *Buddelundia* '10' is a species complex represented by many specimens from recent collections from central to northern WA. Within this complex, *Buddelundia* '10LD' is currently the only known record of this complex from this area, and as such considered a potential SRE.

4.9 EUPULMONATA (SNAILS)

Molluscs are one of the most diverse groups of invertebrates and the Australian fauna is characterised by a high degree of endemism (Beesley *et al.* 1998). Lands snails (Eupulmonata) belong to the target groups for SRE surveys due to their limited dispersal capabilities, in combination with often strict dependencies on particular soils (EPA 2009; Harvey 2002). These characteristics have also resulted in a significant global decline of non-marine molluscs (Lydeard *et al.* 2004).

No SRE snails were recovered from the study area in the desktop review.

A total of three specimens of snails representing a single species in the family Pupillidae were collected in the study area (Table 4-9). *Pupoides adelaidae* (Adams & Angas, 1864) is well described and documented to have wide ranges from the Western Plateau through South Australia to Victoria (Smith 1992).

Table 4-9 Snails (Eupulmonata) collected during the short-range endemic survey of the Lake Disappointment Potash Project study area, by site

Taxon	Site			Total
	6C	11C	15C	
Pupoides adelaidae	2	6	2	**10**
Totals	**2**	**6**	**2**	**10**

4.10 SURVEY LIMITATIONS

Of the possible limitations identified by *Guidance Statement 56* (EPA 2004), the remoteness of the Project and associated access restrictions was a major limiting factor.

Access around the study area via roads was limited to the western side of Lake Disappointment and the established roads were not trafficable during the time of the survey. Additionally, attempts to traverse the study area via amphibious vehicle did not allow access to the expected extent, due to damage sustained to the vehicle from the abrasive action of the lake surface. As a result, the study area was not completely surveyed and SRE assessment was limited to its northern edge.

5 DISCUSSION

Lake Disappointment is listed as a Nationally Important Wetland with high conservation and anthropological value, proposed as an A Class Reserve for conservation and Aboriginal anthropological sites (Lynch 1995).

The Lake's conservation value partly relates to the provision of important refugia for taxa at critical stages of their life cycle, e.g. freshwater aquatic invertebrates in sporadic wet conditions that feed migratory waterbirds. This potentially includes unique terrestrial invertebrates with specialist traits for surviving the mostly-dry but ephemerally wet conditions.

The objective of the study conducted by Phoenix in May 2103 was to define terrestrial SRE taxa and habitats of the study area, and comment on their known or likely representation outside the study area via desktop and field survey data.

With adequate data, it may be possible to comment on potential impacts of the Project on SRE fauna and habitats, and appropriate management and mitigation strategies.

5.1 SHORT-RANGE ENDEMIC INVERTEBRATE ASSEMBLAGE

The present study represents the first known SRE fauna assessment of the lake. However, one potential SRE invertebrate, the trapdoor spider *Aname* sp. indet. (family Nemesiidae) had been previously recorded from the study area, and three potential SRE invertebrate taxa were had been collected within the area of the desktop review, i.e. within approximately 100 km distance to the study area.

The collection of four new SRE taxa (currently known only from this survey) is expected for a previously-unsurveyed area. This result warrants further study to better understand their local distribution and abundance and therefore, make more-definitive comment on potential impacts.

Two of the four new species belong to the diverse scorpion genus *Urodacus*; a third belongs to the isopod genus *Buddelundia*, in which many of the identified species appear to have restricted distributions. Both genera are currently being taxonomically revised by Phoenix staff presenting an opportunity to more-clearly define SRE status.

The presence of specialist groups on other salt lakes in Western Australia, e.g. specialist spiders, beetles, ants and pseudoscorpions on Lake Lefroy, may indicate potential for a greater diversity of species on Lake Disappointment than was recorded in this study. For example, Hudson (1995) identified 14 possible salt lake specialist invertebrates that consistently inhabit the playa of Lake Lefroy and surrounding lakes.

5.2 SHORT-RANGE ENDEMIC INVERTEBRATE HABITATS

Three main habitat types were identified during the survey around Lake Disappointment, the saline playa of the lake, riparian samphire vegetation and sand dunes surrounding the riparian habitat. Lack of access tracks and poor trafficability of the playa of Lake Disappointment within the study area were major limitations to the survey. In the May 2013 survey, all taxa were collected from the 'sand dune habitat' only, but there is a distinct possibility that salt lake specialist SRE invertebrates are present within other habitats in the study area.

It can be reasonably assumed that much of the habitat in and surrounding the study area is homogenous, however habitat associated with island vegetation central to the study area or the freshwater flow into the Lake Disappointment, particularly Savoury Creek, is likely to provide

different habitat attributes than the areas sampled in this survey (e.g. as noted in Lake Carey, M. White pers. comm.).

5.3 ASSESSMENT OF POTENTIAL IMPACTS TO SHORT-RANGE ENDEMIC INVERTEBRATES

In assessing development proposals, the EPA aims to ensure that proposals do not potentially threaten the viability of, or lead to the extinction of any SRE species (EPA 2009) by:

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

Accordingly, the main aims of this assessment were to:

- determine whether any SRE taxa may be restricted solely to the study area of the Project and therefore be at risk of extinction from the Project
- determine whether adequate habitat exists outside the study area for SRE species recorded within the study area
- assess potential impacts from threatening processes of the Project for SRE species recorded within the study area.

It is challenging to address the aims of this assessment for the Project, because:

- SRE records were low in the current survey (e.g. single records of new taxa)
- the lake and region are poorly surveyed, so there is little contextual/comparative data
- EIA is only partly completed for the Project; data that is essential for impact assessment to SRE, e.g. hydrological modelling, is currently unavailable.

In terms of the potential impacts on SRE invertebrates, *Guidance Statement 20* (EPA 2009) identifies five key threatening processes, including:

- changes to surface hydrology
- changes to fire regimes
- introduction and/or spread of weeds and soil pathogens
- clearing of native vegetation (habitat removal)
- fragmentation and subdivision of habitats.

The Project currently comprises of two stages of activity, Stage 1 and Stage 2. The activities with potential to impact SRE invertebrates include the extent of Stage 1 (excluding the upgrade of the Talawana track) in ML L45/0302 and construction of trial ponds (up to seven) and test trenches (up to ten) (Botanica 2013).

Clearing, construction and drawdown caused by dewatering may alter surface water flow and hydrology, which is probably the main threatening process of the Project. In the absence of hydrological and other data critical to conduct EIA, and with a paucity of SRE data from the current survey, it is only possible to say that altered hydrology may have large scale impacts to burrowing groups on the lake surface and habitat dependant groups surrounding Lake Disappointment (EPA 2000; SIGM 2012).

Further survey across a broader area is required to rule out or confirm the presence of endemic salt lake specialists such as the tiger beetles *Megacephala* and wolf spiders *Tetralycosa* and *Hogna*, in habitats that may be affected by drawdown and other threatening processes.

Short-range endemic invertebrate taxa only collected from within the study area (*U.* 'disappointment', *U.* 'princess pea' and *Buddelundia* '10LD') were all from sand dune habitat, where these SREs typically rely on woody outcrops and *Acacia* woodlands. Changes to fire regimes and the introduction of weeds can be a major impact to these habitats, and may alter them in a way that renders them unsuitable for specially-adapted SRE invertebrates.

The level of habitat clearance from the Project as defined by the activities of Stage 1 and 2 is limited, which indicates a low risk to SREs of the study area.

The potential of habitats becoming fragmented as a result of the Project is also expected to be low based on the widespread availability of habitat outside the study area.

5.4 RECOMMENDATIONS

Protection of habitat is central to conservation strategies for SRE invertebrates. Protecting SRE habitat has the added benefit of protecting broader species assemblages and helping to maintain whole of ecosystem functions. This concept is equally relevant at the operational stage. The initial focus at this early stage of project design should be on avoiding or minimising impacts to important habitat as much as possible.

Given the significance of the lake at the bioregional scale, the potential for a greater range of playa specialists to be present and a current lack of hydrological data, the main recommendation for the Project is to complete further sampling in order to gain a more comprehensive understanding of the invertebrate community on and around Lake Disappointment.

The following approach is recommended:

- expand the invertebrate survey onto the playa to address the knowledge gaps in fauna and habitats of this remote lake, considering the anticipated, eventual construction (and associated impacts) of trenches across the whole lake
- obtain detailed hydrological modelling data (particularly, the cone of depression) once completed, and assess impact in context of burrowing and other specialist invertebrates identified in further studies.

Future SRE surveys should:

- be initiated after hydrological modelling is complete and potential impact footprints and scenarios (e.g. drawdown boundaries/timeframes) are known
- collect multi-season data, e.g. two further sampling events in two different seasons to account for seasonality in invertebrate occurrence/life cycles
- consider all potentially-impacted habitats including the poorly accessible playa of the lake (i.e. consider the use of helicopters)
- include regional data points (i.e. Lake Dora, Lake Auld) to provide better context for study area data.

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Appendix 1 Site descriptions of primary survey sites

Site number	01A
Site type	Foraging
Easting (WGS84)	481515
Northing (WGS84)	7425569
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**01B**
Site type	Foraging
Easting (WGS84)	481501
Northing (WGS84)	7425633
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**01C**
Site type	Foraging
Easting (WGS84)	481484
Northing (WGS84)	7425763
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**02A**
Site type	Foraging
Easting (WGS84)	483456
Northing (WGS84)	7425746
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**02B**
Site type	Foraging
Easting (WGS84)	483536
Northing (WGS84)	7425756
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**02C**
Site type	Foraging
Easting (WGS84)	483477
Northing (WGS84)	7425822
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**03A**
Site type	Foraging
Easting (WGS84)	480135
Northing (WGS84)	7425170
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**03B**
Site type	Foraging
Easting (WGS84)	480139
Northing (WGS84)	7425230
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**03C**
Site type	Foraging
Easting (WGS84)	480182
Northing (WGS84)	7425254
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**04A**
Site type	Foraging
Easting (WGS84)	485046
Northing (WGS84)	7425673
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**04B**
Site type	Foraging
Easting (WGS84)	485094
Northing (WGS84)	7425670
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**04C**
Site type	Foraging
Easting (WGS84)	485167
Northing (WGS84)	7425741
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**05A**
Site type	Foraging
Easting (WGS84)	486081
Northing (WGS84)	7423660
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**05B**
Site type	Foraging
Easting (WGS84)	486127
Northing (WGS84)	7423721
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**05C**
Site type	Foraging
Easting (WGS84)	486100
Northing (WGS84)	7423824
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**06A**
Site type	Foraging
Easting (WGS84)	487624
Northing (WGS84)	7425033
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**06B**
Site type	Foraging
Easting (WGS84)	487554
Northing (WGS84)	7424935
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**06C**
Site type	Foraging
Easting (WGS84)	487522
Northing (WGS84)	7424944
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**07A**
Site type	Foraging
Easting (WGS84)	487034
Northing (WGS84)	7426307
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**07B**
Site type	Foraging
Easting (WGS84)	487035
Northing (WGS84)	7426334
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**07C**
Site type	Foraging
Easting (WGS84)	487029
Northing (WGS84)	7426404
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**08A**
Site type	Foraging
Easting (WGS84)	481085
Northing (WGS84)	7425571
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**08B**
Site type	Foraging
Easting (WGS84)	481095
Northing (WGS84)	7425627
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**08C**
Site type	Foraging
Easting (WGS84)	481113
Northing (WGS84)	7425657
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**09A**
Site type	Foraging
Easting (WGS84)	480828
Northing (WGS84)	7425948
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**09B**
Site type	Foraging
Easting (WGS84)	480840
Northing (WGS84)	7425965
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**09C**
Site type	Foraging
Easting (WGS84)	480876
Northing (WGS84)	7425983
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**10A**
Site type	Foraging
Easting (WGS84)	480849
Northing (WGS84)	7425295
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**10B**
Site type	Foraging
Easting (WGS84)	480824
Northing (WGS84)	7425302
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**10C**
Site type	Foraging
Easting (WGS84)	480819
Northing (WGS84)	7425348
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**11A**
Site type	Foraging
Easting (WGS84)	476055
Northing (WGS84)	7427411
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**11B**
Site type	Foraging
Easting (WGS84)	476052
Northing (WGS84)	7427419
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**11C**
Site type	Foraging
Easting (WGS84)	476083
Northing (WGS84)	7427448
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**12A**
Site type	Foraging
Easting (WGS84)	478359
Northing (WGS84)	7426168
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**12B**
Site type	Foraging
Easting (WGS84)	478361
Northing (WGS84)	7426196
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**12C**
Site type	Foraging
Easting (WGS84)	478371
Northing (WGS84)	7426204
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**13A**
Site type	Foraging
Easting (WGS84)	478999
Northing (WGS84)	7425631
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**13B**
Site type	Foraging
Easting (WGS84)	479039
Northing (WGS84)	7425628
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**13C**
Site type	Foraging
Easting (WGS84)	479074
Northing (WGS84)	7425658
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Allocasuarina*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
A small copse of *Allocasuarina* on sand dunes dominated by spinifex surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**14A**
Site type	Foraging
Easting (WGS84)	478620
Northing (WGS84)	7425937
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**14B**
Site type	Foraging
Easting (WGS84)	478646
Northing (WGS84)	7425960
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**14C**
Site type	Foraging
Easting (WGS84)	478732
Northing (WGS84)	7425997
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Allocasuarina*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
A small copse of *Allocasuarina* on sand dunes dominated by spinifex surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Site number	**15A**
Site type	Foraging
Easting (WGS84)	479312
Northing (WGS84)	7425463
Zone	51K
Habitat type	Playa
Dominant vegetation	None
Dominant grass	None
Slope	Negligible
Soil texture	Sandy-clay
Soil colour	Red-brown
Surface	Surface crust
Rock cover	None
Leaf litter distribution	None
Leaf litter depth	n/a
Dead wood	None
Disturbance details	Camel tracks
Fire history	None
Fire intensity	n/a

Description:
Uniform exposed lake surface devoid of vegetation with extensive salt crust and crystal formations. Soil beneath surface consists of soft moist sand.

Site number	**15B**
Site type	Foraging
Easting (WGS84)	479330
Northing (WGS84)	7425502
Zone	51K
Habitat type	Samphire riparian vegetation
Dominant vegetation	Samphire
Dominant grass	None
Slope	Negligible
Soil texture	Sandy clay
Soil colour	Red-brown
Surface	Surface plates; deeply cracked
Rock cover	None
Leaf litter distribution	Sparse
Leaf litter depth	<1 cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Low exposed and widespread Samphire community on the edge of the lake. Salt crust continues from the lake surface with extensive surface cracking. Surface texture is much more variable than the lake surface.

Site number	**15C**
Site type	Foraging
Easting (WGS84)	479363
Northing (WGS84)	7425538
Zone	51K
Habitat type	Sand dune
Dominant vegetation	*Acacia*
Dominant grass	Spinifex
Slope	Moderate, south
Soil texture	Sand
Soil colour	Orange
Surface	Loose soil
Rock cover	Gypsum, 5–30 %
Leaf litter distribution	Sparse
Leaf litter depth	< 1cm
Dead wood	Sparse
Disturbance details	Camel tracks
Fire history	10-15 years
Fire intensity	Low

Description:
Acacia and spinifex dominated sand dunes surrounding Lake Disappointment. Sparse outcrops of Gypsum on loose sandy surface.

Appendix 2 Short-range endemic invertebrates identified in the desktop review

WAM reg. no. (or other data source)	Family	Genus and species	Location (as provided by data source)	Latitude (WGS84, 51K)	Longitude (WGS84, 51K)
Order Araneae (spiders)					
Infraorder Mygalomorphae (trapdoor spiders)					
T62812	Nemesiidae	*Aname* sp. indet.	NW. tip of Lake Disappointment	469411	7430534
T85867	Nemesiidae	*Aname* sp. indet.	Lake Disappointment, Savory Creek mouth	465554	7417550
T62611	Nemesiidae	*Aname* sp. indet.	Canning Stock Route, near Lake Disappointment	466971	7423642
Order Scorpiones (scorpions)					
T17131	Buthidae	*Lychas mjobergi* Kraepelin, 1916	560 km S. of Broome	421502	7435982
T17132	Buthidae	*Lychas mjobergi* Kraepelin, 1916	560 km S. of Broome	421502	7435982
T9907	Urodacidae	*Urodacus* `armatus`	Rudall River Camp	446811	7515434
T9908	Urodacidae	*Urodacus* `armatus`	Rudall River Camp	446811	7515434
T9909	Urodacidae	*Urodacus* `armatus`	Rudall River Camp	446811	7515434
T87991	Urodacidae	*Urodacus* `armatus`	Talawana Track, 21 km E, of Well [no.] 24	540952	7441668
T9918	Urodacidae	*Urodacus* `armatus`	Rudall River Camp 4	446811	7515434

Appendix 3 Specimens of short-range endemic target taxa collected during survey

Higher taxon	Genus and species	Sites																										Total
		01A	01B	01C	02A	02B	02C	03A	03B	03C	04A	04B	04C	05A	05B	05C	06A	06B	06C	07A	07B	07C	08A	08B	08C	09A	09B	09C	
Order Araneae (spiders)																													
Infraorder Araneomorphae (modern spiders)																													
Lycosidae	Lycosidae sp. indet.																												**0**
Infraorder Mygalomorphae (trapdoor spiders)																													
Nemesiidae	*Aname* sp. indet.																												**0**
Nemesiidae	*Kwonkan* 'disappointment																												**0**
Order Pseudoscorpiones (pseudoscorpions)																													
Garypidae	*Synsphyronus callus* Hoff, 1947																					1							**0**
Olpiidae	*Beierolpium* '8/2'																												**1**
Olpiidae	*Beierolpium* sp. indet.																												**0**
Order Scorpiones (scorpions)																													
Buthidae	*Lychas* 'adonis'																												**0**
Buthidae	*Lychas* 'telfer'																												**0**
Urodacidae	*Urodacus* 'disappointment'																												**0**
Urodacidae	*Urodacus* 'princess pea'																												**0**
Urodacidae	*Urodacus yaschenkoi* (Birula, 1903)																												**0**
Order Coleoptera (beetles)																													
Carabidae	*Megacephala* sp. indet.							2																					**2**
Order Isopoda (slaters)																													
Armadillidae	*Buddelundia* '10LD'																												**0**
Order Eupulmonata (snails)																													
Pupillidae	*Pupoides adelaidae* (Adams & Angas, 1864)																		2										**2**
Total		-	-	-	-	-	-	**2**	-	-	-	-	-	-	-	-	-	-	**2**	-	-	**1**	-	-	-	-	-	-	**5**

Higher taxon	Genus and species	Sites																											Total
		10A	10B	10C	11A	11B	11C	12A	12B	12C	13A	13B	13C	14A	14B	14C	15A	15B	15C	Camp	Dune24	Scorp1	Vert1	Vert2	Vert3	Vert4	Vert5	Vert6	
Order Araneae (spiders)																													
Infraorder Araneomorphae (modern spiders)																													
Lycosidae	Lycosidae sp. indet.																							3				1	**4**
Infraorder Mygalomorphae (trapdoor spiders)																													
Nemesiidae	*Aname* sp. indet.																								1				**1**
Nemesiidae	*Kwonkan* 'disappointment'																												**0**
Order Pseudoscorpiones (pseudoscorpions)																													
Garypidae	*Synsphyronus callus* Hoff, 1947																												**0**
Olpiidae	*Beierolpium* '8/2'															1													**1**
Olpiidae	*Beierolpium* sp. indet.									1									1										**2**
Order Scorpiones (scorpions)																													
Buthidae	*Lychas* 'adonis'																			1									**1**
Buthidae	*Lychas* 'telfer'																								2	3			**5**
Urodacidae	*Urodacus* 'disappointment'																										1		**1**
Urodacidae	*Urodacus* 'princess pea'																			1					1				**2**
Urodacidae	*Urodacus yaschenkoi* (Birula, 1903)				3																1	1							**5**
Order Coleoptera (beetles)																													
Carabidae	*Megacephala* sp. indet.										1													3					**4**
Order Isopoda (slaters)																													
Armadillidae	*Buddelundia* '10LD'																												**0**
Order Eupulmonata (snails)																													
Pupillidae	*Pupoides adelaidae* (Adams & Angas, 1864)						6												2										**8**
Total		**-**	**-**	**-**	**3**	**-**	**6**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**3**	**2**	**1**	**1**	**-**	**6**	**4**	**3**	**1**	**1**	**34**

Higher taxon	Genus and species	Sites					Total
		Vert7	Vert8	Wp79	Wp85	Wp86	
Order Araneae (spiders)							
Infraorder Araneomorphae (modern spiders)							
Lycosidae	Lycosidae sp. indet.						**0**
Infraorder Mygalomorphae (trapdoor spiders)							
Nemesiidae	*Aname* sp. indet.						**0**
Nemesiidae	*Kwonkan* 'disappointment'		1			1	**2**
Order Pseudoscorpiones (pseudoscorpions)							
Garypidae	*Synsphyronus callus* Hoff, 1947						**0**
Olpiidae	*Beierolpium* '8/2'						**0**
Olpiidae	*Beierolpium* sp. indet.						**0**
Order Scorpiones (scorpions)							
Buthidae	*Lychas* 'adonis'						**0**
Buthidae	*Lychas* 'telfer'	1					**1**
Urodacidae	*Urodacus* 'disappointment'						**0**
Urodacidae	*Urodacus* 'princess pea'			1			**1**
Urodacidae	*Urodacus yaschenkoi* (Birula, 1903)				1		**1**
Order Coleoptera (beetles)							
Carabidae	*Megacephala* sp. indet.						**0**
Order Isopoda (slaters)							
Armadillidae	*Buddelundia* '10LD'	11					**11**
Order Eupulmonata (snails)							
Pupillidae	*Pupoides adelaidae* (Adams & Angas, 1864)						**0**
Total		**12**	**1**	**1**	**1**	**1**	**16**

a – species categorised as potential SREs are shaded green.

ScorpionID

ABN: 33577027061
Phone: 0457111317
email: evolsche@gmail.com

TAXONOMY AND SHORT-RANGE ENDEMIC ASSESSMENT OF INVERTEBRATES FROM LAKE DISAPPOINTMENT

Prepared for Greg Harewood

The contents of 70 samples of invertebrates from Lake Disappointment were identified and assessed for short-range endemism. The samples were assessed against the 'typical' short-range endemic (SRE) taxa, in addition to species with the potential to be salt lake specialists and endemic to Lake Disappointment. Five species were identified as potential SRE's: *Lychas* 'lake disappointment', six samples; *Indolpium* 'lake disappointment', three samples; *Lycosidae* sp. indet., six samples; Lepispatidae sp. indet., six samples; and *Megacephala murchisona*, 10 samples. The latter three species are not typically considered to be potential SRE's; however, they are noted in this instance because they may represent salt-lake specialists and in the instance of the lycosid and lepismatid samples, the specimens could not be identified more accurately owing to their immaturity and or physical damage. *Megacephala murchisona* a tiger beetle, is previously only known from the Murchison region of WA. It is possible that the species from Lake Disappointment is a different 'cryptic species' and this can only be assessed using genomic methods.

Taxonomic identifications were not resolved to species level for families or orders that are not known to contain SRE's and have well developed dispersal capabilities. These families comprised 31 samples of Formicidae (ants), nine samples representing Coleoptera (beetles) from families (Melyridae, Scarabaeidae and Tenebrionidae) and three samples representing Theridiidae (theridiid spiders).

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SCOPE OF WORK

In December, 2015, Greg Harewood submitted a collection of 70 invertebrate samples from Lake Disappointment for taxonomic identification and short-range endemic assessment.

BACKGROUND AND METHODS

All specimens were identified to at least family level where possible. Only species belonging to families known to contain SRE's or salt lake specialists were identified below the level of family. The methods used to make species identifications and assess SRE categories closely follow those used by the WAM (W.A. Museum). McCairns *et al.* (1997) was used to identify *Megacephala* species. A more detailed description of the methods and principals used to assess SRE categories are detailed in Appendix 1.

In addition to following the SRE assessments adopted by the WAM, the potential for salt lake specialists was also considered. Hudson and Adams (1996) demonstrated that in South Australia, salt lakes may support locally endemic species. In many instances, salt lake species are characterised by the presence of the following characteristics, relative to non-salt lake relatives: pale body colouration, elongation of appendages, reduction or loss of wings and enlarged eyes (Volschenk unpublished data). The presence of these features was included in the assessment of these species.

RESULTS

Species belonging to the families Theridiidae (tangle-web spiders), Formicidae (ants), Scarabaeidae (scarab beetles) , Melyridae (soft-wing flower beetles) and Tenebrionidae (Darkling beetles) were considered to be 'widespread' and constituted the majority of samples (43) but are not known to contain SRE's or possess features indicative of salt lake specialists.

The collection contained five species from 27 samples that are considered to be potential SRE's. Two of these species fall within 'traditional' SRE groups: *Lychas* 'lake disappointment' (scorpion) and *Indolpium* 'lake disappointment' (pseudoscorpion). An additional three species were noted as being potential salt lake specialist SRE's: Lepismatidae sp. indet., silverfish; Lycosidae sp. Indet., wolf spiders, and *Megacephala murchisona*, a tiger beetle. (Table 1). The complete record of the specimens identified is presented in Appendix 2

Table 1. List of species present with assigned SRE categories.

Order	Family	Species	SRE category
Araneae	Lycosidae	Lycosidae sp. indet.	potential SRE
Pseudoscorpiones	Olpiidae	*Indolpium* 'lake disappointment'	potential SRE
Scorpiones	Buthidae	*Lychas* 'lake disappointment'	potential SRE
Coleoptera	Carabidae	*Megacephala murchisona*	potential SRE
Thysanura	Lepismatidae	Lepismatidae sp. indet	potential SRE

DISCUSSION

Five potential SRE species were present in this collection. A brief discussion on these species and justification for these rankings is given below.

***Lychas* 'lake disappointment'** represents a new species and is only known from the specimens in this collection. This species is considered to be a potential SRE owing to its close relationship to the *Lychas* 'annulatus complex' which is known to contain SRE species (unpublished data). The absence of this species from previous surveys of the Great Sandy Desert is further evidence that it is could be an SRE.

***Indolpium* 'lake disappointment'** was represented by three specimens. This species is more slender than the Pilbara morphospecies, and is therefore considered to be a different species. *Indolpium* is poorly resolved and the taxonomy of the Western Australian Fauna is largely unworkable. This species is considered a potential because it appears to be a new species and only recorded from the present collection

Lycosidae sp. indet. was represented by two juvenile specimens. At least three described species in this family are known to live only on the surface of salt lakes. Hudson and Adams (Hudson and Adams 1996) also demonstrated the presence of several cryptic species endemic to South Australia's salt lakes.

Lepismatidae sp. indet. was represented by six samples. All of the specimens were badly damaged precluding greater taxonomic resolution. The small size of this species and its apparent pale colouration may indicate that it is a salt lake specialist. It should also be noted that in most lepismatid silverfish, most of the body markings are comprised of pigmented scale setae that are easily dislodged during capture and preservation, thus making them appear very pale. Freshly collected and undamaged adult samples of this species need to be examined in order to make more resolved assessment salt lake association. The absence of detailed phylogeographic information for WA Lepismatidae necessitates the use of genomic methods such as DNA Barcoding (Hebert *et al.* 2003a; Hebert *et al.* 2003b) in order to verify the species boundaries with this species and those from nearly localities or elsewhere in WA.

Megacephala murchisona was represented in 10 samples. Species level identifications were made using McCairns *et al.* (1997); however, In that revision, specimens of this species were only noted from the "Murchison District". Lake Disappointment is located ~650 km NE of the nearest Murchison record and this may be sufficient to restrict gene flow between the Murchison and Great Sandy Desert as noted for salt lake specialist spiders in South Australia (Hudson and Adams 1996). The presence of locally endemic cryptic species cannot be discounted. The absence of detailed phylogeographic information for *Megacephala* in WA necessitates the use of genomic methods such as DNA Barcoding (Hebert *et al.* 2003a; Hebert *et al.* 2003b) in order to verify the species boundaries with this species and those from nearly localities or elsewhere in WA.

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Appendix 1. Background and Methods

SHORT-RANGE ENDEMISM

Short-range endemics are organisms with small geographic distributions (Harvey 2002; Ponder and Colgan 2002), nominally less than 10,000 km^2 (Harvey 2002). These organisms are typically characterised by one or more of the following characteristics:

- limited dispersal capabilities,
- seasonal activity (cooler or wetter periods),
- slow growth, and
- low levels of fecundity.

Isolating mechanisms are typically inhospitable habitat such as rivers, rocky ridges or plains that act to prevent dispersal (gene flow) between populations. Two types of short-range endemism have been recognised: Relictual Endemism and Habitat Specialist Endemism (Harvey 2002; Ponder and Colgan 2002).

Relictual SREs result when speciation occurs following the fragmentation of continuous habitat into two or more refugia. In Australia, the primary driver of this over the last 65 million years has been aridification, which acted to isolate formerly widespread species living in mesic forests to small patches of mesic refugia. Relictual SREs include scorpions in the genus *Aops* (Volschenk and Prendini 2008), pseudoscorpions in the genera *Tyrannochthonius* (Edward and Harvey 2008; Harvey 1991), *Indohya* (Harvey 1993b; Harvey and Volschenk 2007) and *Idioblothrus* (Harvey 1993a; Harvey and Leng 2008; Muchmore 1982) and millipedes in the genus *Antichiropus* (Car and Harvey 2014; Car *et al.* 2013b). Troglobites are thought to be extreme examples of relictual SREs; most troglobites from the Pilbara have surface dwelling relatives living in the more mesic forests of northern Australia (Harvey 2002; Ponder and Colgan 2002).

Habitat specialist SREs are species that have adapted to very specific environment types, including those found in arid environments (e.g. rocky outcrops or isolated dune systems). Such habitats are often relatively young (<10 million years) and therefore are not refugial. Examples of habitat specialist SREs include spiders in the family Selenopidae and pseudoscorpions in the genera *Synsphyronus* (Harvey 2011, 2012) and *Feaella* (Harvey 1989; Harvey and Volschenk 2007).

DEFINING SHORT-RANGE ENDEMISM

Assessment of short-range endemism can be challenging when data for evaluation are absent or limited. Limitations may include any of the following:

- **Poor survey coverage,** e.g. the fauna of an area has not been sampled extensively enough to enable assessment of species distributions. The absence of a species from survey records may not mean that it is absent from the area.
- **Poor taxonomic resolution,** e.g. a species has not been subject to systematic investigation, and/or the identity is either difficult or impossible to determine. Good taxonomic resolution does not necessarily need to be in the form of published revisions, as it can be facilitated by any of the following:
  - a researcher actively working on the group who can authorise identifications,
  - a publically accessible reference collection, and/or;
  - assessment of species boundaries using genomic methods such as DNA barcoding (Hebert *et al.* 2003a; Hebert *et al.* 2003b).
- **Identification issues**, e.g. surveys sampled life stages of potential SREs that are impossible to identify on the basis of morphological characters. Examples of relevant taxa include juvenile or female millipedes, mygalomorph spiders and *Urodacus* scorpions. Genomic methods have great potential to overcome this type of limitation.

There are no published systems for assessing the SRE potential for a species. Given this, ScorpionID employs the three categories used by the WA Museum to assess SRE-status of invertebrates (Western Australian Museum 2013):

- **Confirmed SRE:** This category applies when the identity of the taxon is unambiguous and its distribution is less than 10 000km^2 based on publically available vouchered records. Supporting data can be either genomic (from DNA sequences) or morphological, ideally both.
- **Potential SRE:** This category applies to situations where there are knowledge gaps for the taxon. The following sub-categories further elucidate this status:
  - **Data Deficiency:** This category covers taxa for which there is insufficient data available to determine SRE status. Factors that fall under this category include:
    - insufficient geographic information,
    - insufficient taxonomic information, and/or
    - inappropriate life stages prevent identification to species level.
  - **Habitat Indicators:** This category employs habitat characteristics to evaluate SRE status when particular habitats are known to support SRE taxa. For example, many species sampled from subterranean habitats are known to be range restricted; a new species discovered from such habitat therefore has greater potential to be range restricted (i.e. a SRE) than widespread.
  - **Morphological Evidence:** This category uses one or more morphological characters that are characteristic of SRE taxa inhabiting restricted environments, e.g. the specialised morphological features of animals adapted to subterranean habitats, including body markings that are absent or significantly paler than surface dwelling relatives, eyes that are absent or significantly reduced, and/or longer appendages (legs and antennae) than surface relatives.
  - **Unpublished Research & Expertise:** This category relies on unpublished research or expertise to develop SRE status.

  These categories of categories of potential SRE may be helpful in developing conservation priorities, however, each taxon should be assessed on its merit and in accordance with the *Precautionary Principle* (EPA 2002):

  > "*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*" (EPA 2002).

- **Widespread (not an SRE)**: This category applies when vouchered evidence demonstrates a distribution greater than 10,000 km^2.

TAXONOMY

The taxonomic nomenclature of invertebrates follows the references detailed in **Error! Reference source not found.**. Morphospecies designations follow the parataxonomy of the scientist(s) working on the group; these informal names are written between single quotation marks rather than being italicised as they are not valid under the International Code of Zoological Nomenclature (1999).

Table 2. The following 'general' references and collections were used to assist with morphospecies designations

Order	Taxonomic reference	Morphospecies and reference collection
Araneae	(Framenau *et al.* 2014; Raven *et al.* 2002; World Spider Catalog 2014)	Reference collection and morphospecies codes of the WA Museum.
Pseudoscorpiones	(Harvey 1992; Harvey 2012, 2013; Murienne *et al.* 2008)	Reference collection and morphospecies codes of the WA Museum
Scorpiones	(Fet *et al.* 2000; Glauert 1925a, b; Kovařík 1997; Volschenk *et al.* 2010; Volschenk and Prendini 2008; Volschenk *et al.* 2000)	Reference collection at the WA Museum. Morphospecies designation by E.S. Volschenk
Isopoda	(Schmalfuss 2003; Schmidt and Leistikow 2004; Schotte *et al.* 2008)	Reference collection at the WA Museum. Morphospecies designation by Dr Simon Judd.
Chilopoda	(Colloff *et al.* 2005; Lewis 1981)	Reference collection and morphospecies codes of the WA Museum
Diplopoda	(Car and Harvey 2013, 2014; Car *et al.* 2013a; Car *et al.* 2013b; Edward and Harvey 2010; Sierwald 2006)	Reference collection and morphospecies codes of the WA Museum
Insecta	(CSIRO 1991)	Reference collection of the WA Museum. Morphospecies designation by E.S. Volschenk

Phylogenetic Species Concept (Cracraft 1983) is used for delineating morphospecies:

> "A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent."

IDENTIFICATION

Unless otherwise stated, species identifications were carried out by the author. The references used for species determination are summarised in Table 2.

SPECIMEN LODGEMENT

In accordance with EPA Guidance Statement 20 (2009), specimens submitted to ScorpionID for taxonomic identification will be offered to the WA Museum for inclusion in the state's specimen collection.

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Appendix 2. List of specimens identified from Lake Disappointment samples

Reference Code	Order	Species	Site code	Latitude (South)	Longitude (East)	Males	Females	Juveniles	Total
LD005	Araneae	Lycosidae sp. indet.	TS 07	23°16'44	122°49'09		1		1
LD057	Araneae	Lycosidae sp. indet.	TS 10	23°16'44	122°49'06			1	1
LD062	Araneae	Theridiidae sp. indet	TS 21	23°16'48	122°49'10	1			1
LD009	Araneae	Theridiidae sp. indet	TS 26	23°16'51	122°49'11		1		1
LD020	Araneae	Theridiidae sp. indet	TS 21	23°16'48	122°49'10	1			1
LD070	Pseudoscorpiones	*Indolpium* 'lake disappointment'	TS 26	23°16'51	122°49'11			1	1
LD008	Pseudoscorpiones	*Indolpium* 'lake disappointment'	TS 12	23°16'43	122°49'04			1	1
LD054	Pseudoscorpiones	*Indolpium* 'lake disappointment'	TS 05	23°16'43	122°49'11	1			1
LD012	Scorpiones	*Lychas* 'lake disappointment'	TS 03	23°16'48	122°49'13			1	1
LD052	Scorpiones	*Lychas* 'lake disappointment'	TS 03	23°16'48	122°49'13			1	1
LD001	Scorpiones	*Lychas* 'lake disappointment'	TS 22	23°16'48	122°49'10	1			1
LD037	Scorpiones	*Lychas* 'lake disappointment'	TS 03	23°16'48	122°49'13			1	1
LD065	Scorpiones	*Lychas* 'lake disappointment'	TS 05	23°16'43	122°49'11		1		1
LD004	Scorpiones	*Lychas* 'lake disappointment'	TS 12	23°16'43	122°49'04			1	1
LD014	Coleoptera	*Megacephala murchisona*	TS 05	23°16'43	122°49'11		1		1
LD011	Coleoptera	*Megacephala murchisona*	TS 03	23°16'48	122°49'13		1		1
LD035	Coleoptera	*Megacephala murchisona*	TS 28	23°16'52	122°49'11				1
LD016	Coleoptera	*Megacephala murchisona*	TS 07	23°16'44	122°49'09	1			1
LD042	Coleoptera	*Megacephala murchisona*	TS 10	23°16'44	122°49'06	1			1
LD022	Coleoptera	*Megacephala murchisona*	TS 14	23°16'42	122°49'03	1			1
LD029	Coleoptera	*Megacephala murchisona*	TS 05	23°16'43	122°49'11	1			1
LD047	Coleoptera	*Megacephala murchisona*	TS 27	23°16'51	122°49'11	1			1
LD040	Coleoptera	*Megacephala murchisona*	TS 06	23°16'44	122°49'10		1		1

Reference Code	Order	Species	Site code	Latitude (South)	Longitude (East)	Males	Females	Juveniles	Total
LD017	Coleoptera	*Megacephala murchisona*	TS 08	23°16'44	122°49'08	1			1
LD048	Coleoptera	Melyridae sp. indet.	TS 25	23°16'50	122°49'11			1	1
LD002	Coleoptera	Melyridae sp. indet.	TS 22	23°16'48	122°49'10			2	2
LD046	Coleoptera	Melyridae sp. indet.	TS 29	23°16'53	122°49'11			2	2
LD010	Coleoptera	Melyridae sp. indet.	TS 23	23°16'49	122°49'10				1
LD003	Coleoptera	Melyridae sp. indet.	TS 20	23°16'47	122°49'10			2	2
LD061	Coleoptera	Melyridae sp. indet.	TS 23	23°16'49	122°49'10			1	1
LD069	Coleoptera	Melyridae sp. indet.	TS 30	23°16'53	122°49'11			2	2
LD049	Coleoptera	Scarabaeidae sp. indet.	TS 17	23°16'45	122°49'10	1			1
LD060	Coleoptera	Tenebrionidae sp. indet.	TS 15	23°16'42	122°49'02	1			1
LD015	Hymenoptera	Formicidae sp. indet.	TS 05	23°16'43	122°49'11		1		1
LD038	Hymenoptera	Formicidae sp. indet.	TS 04	23°16'44	122°49'12		1		1
LD041	Hymenoptera	Formicidae sp. indet.	TS 08	23°16'44	122°49'08		1		1
LD051	Hymenoptera	Formicidae sp. indet.	TS 02	23°16'44	122°49'14		1		1
LD027	Hymenoptera	Formicidae sp. indet.	TS 03	23°16'48	122°49'13		1		1
LD050	Hymenoptera	Formicidae sp. indet.	TS 01	23°16'45	122°49'15		1		1
LD044	Hymenoptera	Formicidae sp. indet.	TS 12	23°16'43	122°49'04		1		1
LD045	Hymenoptera	Formicidae sp. indet.	TS 13	23°16'43	122°49'04		1		1
LD025	Hymenoptera	Formicidae sp. indet.	TS 09	23°16'44	122°49'07		1		1
LD024	Hymenoptera	Formicidae sp. indet.	TS 10	23°16'44	122°49'06		2		2
LD032	Hymenoptera	Formicidae sp. indet.	TS 08	23°16'44	122°49'08		1		1
LD071	Hymenoptera	Formicidae sp. indet.	TS 15	23°16'42	122°49'02		1		1
LD026	Hymenoptera	Formicidae sp. indet.	TS 02	23°16'44	122°49'14		1		1
LD036	Hymenoptera	Formicidae sp. indet.	TS 01	23°16'45	122°49'15		1		1
LD053	Hymenoptera	Formicidae sp. indet.	TS 05	23°16'43	122°49'11		1		1
LD019	Hymenoptera	Formicidae sp. indet.	TS 13	23°16'43	122°49'04		1		1
LD056	Hymenoptera	Formicidae sp. indet.	TS 02	23°16'44	122°49'14		1		1

Reference Code	Order	Species	Site code	Latitude (South)	Longitude (East)	Males	Females	Juveniles	Total
LD064	Hymenoptera	Formicidae sp. indet.	TS 04	23°16'44	122°49'12		1		1
LD059	Hymenoptera	Formicidae sp. indet.	TS 13	23°16'43	122°49'04		1		1
LD030	Hymenoptera	Formicidae sp. indet.	TS 05	23°16'43	122°49'11		1		1
LD066	Hymenoptera	Formicidae sp. indet.	TS 06	23°16'44	122°49'10		1		1
LD067	Hymenoptera	Formicidae sp. indet.	TS 09	23°16'44	122°49'07		1		1
LD068	Hymenoptera	Formicidae sp. indet.	TS 15	23°16'42	122°49'02		1		1
LD007	Hymenoptera	Formicidae sp. indet.	TS 10	23°16'44	122°49'06		1		3
LD006	Hymenoptera	Formicidae sp. indet.	TS 02	23°16'44	122°49'14		1		1
LD063	Hymenoptera	Formicidae sp. indet.	TS 12	23°16'43	122°49'04		1		1
LD043	Hymenoptera	Formicidae sp. indet.	TS 11	23°16'44	122°49'06		1		1
LD033	Hymenoptera	Formicidae sp. indet.	TS 11	23°16'44	122°49'06		1		1
LD034	Hymenoptera	Formicidae sp. indet.	TS 15	23°16'42	122°49'02		1		2
LD031	Hymenoptera	Formicidae sp. indet.	TS 06	23°16'44	122°49'10		1		1
LD058	Hymenoptera	Formicidae sp. indet.	TS 11	23°16'44	122°49'06		1		1
LD021	Thysanura	Lepismatidae sp. indet.	TS 15	23°16'42	122°49'02			2	2
LD028	Thysanura	Lepismatidae sp. indet.	TS 04	23°16'44	122°49'12			1	1
LD039	Thysanura	Lepismatidae sp. indet.	TS 05	23°16'43	122°49'11			1	1
LD018	Thysanura	Lepismatidae sp. indet.	TS 08	23°16'44	122°49'08			1	1
LD055	Thysanura	Lepismatidae sp. indet.	TS 12	23°16'43	122°49'04			1	1
LD013	Thysanura	Lepismatidae sp. indet.	TS 02	23°16'44	122°49'14			1	1

Alacran Environmental Science

ABN: 33577027061
Phone: 0457111317
email: erich@alacranenvironmental.com

TAXONOMY AND SHORT-RANGE ENDEMIC ASSESSMENT OF INVERTEBRATES FROM LAKE DISAPPOINTMENT

Prepared for Zootopia Environmental Services

Invertebrates from Lake Disappointment were identified to species and assessed for short-range endemism. The collection comprised 12 samples containing scorpions and one Isopod sample. Four scorpion species *Lychas* '099', *Lychas* 'multipunctatus complex', *Lychas* 'annulatus complex' and *Lychas* 'telfer' and the Isopod *Buddelundia* '10ld' are potential SRE's.

Author:	Dr Erich S. Volschenk
Date:	Thursday, 22 December 2016
Submitted to	Greg Harewood
Report ID:	1628
Version	1

SCOPE OF WORK

In November 2016, Zootopia Environmental Services submitted a collection of 13 samples (12 scorpion samples and one isopod sample) from Lake Disappointment. The following services were requested:

- taxonomic identifications of samples;
- SRE assessment of these species; and
- Labelling and lodgement of these samples in the WAM (Western Australian Museum) Arachnology collection.

BACKGROUND AND METHODS

The methods used to make species identifications and assess SRE categories closely follow those used by the WAM. A more detailed description of the methods and principals used to assess SRE categories are detailed in Appendix 1.

RESULTS

The collection contained five scorpion species and one isopod species. One species of scorpion is widespread with the remaining scorpions and isopod being potential SRE's. The species present and their corresponding SRE categories are summarised in Table 1.

Table 1. List of species present with assigned SRE categories.

Order	Family	Species	SRE category
Scorpiones	Buthidae	*Lychas* '099'	Potential
		Lychas 'adonis'	Widespread
		Lychas 'multipunctatus complex'	Potential
		Lychas 'annulatus complex'	Potential
		Lychas 'telfer'	Potential
Isopoda	Armadilidae	*Buddelundia* '10ld'	Potential

The complete record of the specimens identified is presented in Appendix 2

DISCUSSION

Five potential SRE species, four scorpions and one Isopod, and one widespread scorpion species were present in this collection. These species and the justification for these rankings is given below:

- ***Lychas* 'adonis'** is a widespread species occurring from the WA Goldfields eastwards through South Australia and central Victoria and South Western NSW.

- ***Lychas* '099'** represents a new species and is only known from the specimens in this collection. This species is a potential SRE owing to lacking information about its distribution.

- ***Lychas* 'telfer'** has been previously recorded from near Telfer, ca 170 km WNW from the specimens present in this collection. The specimens in this collection represent the second recorded locality for this species. While the locality records for this species span a distance greater than the usual SRE threshold (100km) this species may still represent a potential SRE owing to its likely specialised habitat requirements and the absence of information about its occurrence in the area between these localities.
  This species is distinctive in having very long tarsal claws a feature only seen in scorpions specialised for living on soft and unconsolidated sand (Polis 1990). This species may be restricted to this habitat type.

- ***Lychas* 'multipunctatus complex' and *Lychas* 'annulatus complex'** are representatives of species complexes, groups of more than one species for which the boundaries between different species is unclear and under investigation using DNA sequencing methods. Both species complexes are widespread in WA. These specimens are therefore considered to be a potential SRE's and genetic investigations are necessary to better understand their relationships with the other species within their respective group.

- ***Buddelundia* '10ld'** is only known from the vicinity of Lake Disappointment. The specimens in this collection represent the second locality record and they were first recorded at 23°16'00"S 122°48'57"E. This species is considered a potential SRE owing to its restricted range and limited number of records.

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APPENDIX 2. LIST OF SPECIMENS IDENTIFIED FROM LAKE DISAPPOINTMENT

Site code	Client Registration Code	Species	Latitude (South)	Longitude (East)	Males	Females	Juveniles	Total
TS 2	LD 205	*Lychas* '099'	23°08'43	122°48'57	1			1
TS 2	LD 205	*Lychas* '099'	23°08'43	122°48'57	1			1
TS 2	LD 205	*Lychas* '099'	23°08'43	122°48'57	1			1
TS 2	LD 201	*Lychas* 'adonis'	23°08'43	122°48'57	1			1
TS 2	LD 205	*Lychas* 'adonis'	23°08'43	122°48'57	1			1
TS 2	LD 205	*Lychas* 'adonis'	23°08'43	122°48'57	1			1
TS 3	LD 204	*Lychas* 'annulatus complex'	23°03'49	122°52'43			1	1
TS 2	LD 200	*Lychas* 'multipunctatus complex'	23°08'43	122°48'57	1			1
TS 2	LD 205	*Lychas* 'multipunctatus complex'	23°08'43	122°48'57				1
TS 2	LD 205	*Lychas* 'multipunctatus complex'	23°08'43	122°48'57		1		1
TS 1	LD 202	*Lychas* 'telfer'	23°07'12	122°49'46	1			1
TS 1	LD 203	*Lychas* 'telfer'	23°07'12	122°49'46		1		1
TS 2	LD 206	*Buddelundia* '10ld'	23°08'43	122°48'57	5	1		6

Alacran Environmental Science

Report No. 1705

Identification and short-range endemic assessment of invertebrates from Lake Disappointment

Prepared for

Zootopia

Kwonkan 'LD1'

ABN: 33577027061

Phone: 0457111317

email: erich@alacranenvironmental.com

Identification and short-range endemic assessment of invertebrates from Lake Disappointment

Report No. 1705 | Version 1 | Prepared by Erich Volschenk | Submitted to Greg Harewood | 15 May 2017

EXECUTIVE SUMMARY

In March 2017 Zootopia requested taxonomic identification and SRE assessment of a collection of scorpions and spiders from the northern area of Lake Disappointment. The collection included five morphospecies of trapdoor spiders from three families: Idiopidae, *Aganippe* 'LD1' and *Aganippe* 'LD2'; Barychelidae, *Synothele meadhunteri* and *Synothele* 'LD1'; and Nemesiidae, *Kwonkan* 'LD1'. One of these species is widespread (*Synothele meadhunteri*) and the remaining four trapdoor spider species are potential SREs. None of these trapdoor spiders had been previously recorded from surveys around Lake Disappointment.

Three scorpion species were identified from this collection from two families: Buthidae, *Lychas* '099' and *Lychas* 'telfer', and Urodacidae, *Urodacus* 'yaschenkoi complex' and *Urodacus hoplurus*. Except for *Urodacus hoplurus*, which is widespread, these scorpion species are potential SREs. Previous surveys at Lake Disappointment recorded all but one of the scorpion species in the present collection; the exception being *Urodacus hoplurus*.

***Alacran* Environmental Science**

Address	32 Amalfi Way, Canning Vale 6155 Western Australia, AUSTRALIA
Email	erich@alacranenvironmental.com
Phone	+61 (0) 457 111 317

SCOPE

In March 2017, Zootopia requested identification and SRE assessment of a collection of 38 invertebrate samples obtained from dry pitfall traps at Lake Disappointment. The sample identifications are presented below.

BACKGROUND AND METHODS

The methods used to make species identifications and assess SRE categories closely follow those used by the WA Museum. A more detailed description of the methods and principals used to assess SRE categories are detailed in Appendix 1.

RESULTS

One spider was excluded from this assessment as it represents a family (Zodariidae) not known to contain SRE species. The collection contained 18 specimens of trapdoor spiders (Mygalomorphae) representing five morphospecies from three families. A single named trapdoor spider species, *Synothele meadhunteri*, was present, with the remaining four species undescribed. The collection also contained 19 scorpions, represented by one described species (*Urodacus hoplurus*) and three undescribed species. These taxa and their corresponding SRE categories are summarised in Table 1. The complete record of the samples identified is presented in Appendix 2.

Table 1. List of species present in this collection with assigned SRE categories.

Order	Family	Species	SRE category	Sample Count	Individual Count
Araneae (Mygalomorphae)	Idiopidae	*Aganippe* 'LD1'	Potential	11	11
	Idiopidae	*Aganippe* 'LD2'	Potential	3	3
	Barychelidae	*Synothele* 'LD1'	Potential	1	1
	Barychelidae	*Synothele meadhunteri*	Widespread	2	2
	Nemesiidae	*Kwonkan* 'LD1'	Potential	1	1
Scorpiones	Buthidae	*Lychas* 'telfer'	Potential	4	4
	Buthidae	*Lychas* '099'	Potential	8	9
	Urodacidae	*Urodacus hoplurus*	Widespread	3	3
	Urodacidae	*Urodacus* 'yaschenkoi species complex'	Potential	4	4
			Totals	**37**	**38**

DISCUSSION

Species delineation and SRE justification for each taxon are discussed below.

ARACHNIDA

Araneae, Mygalomorphae (Trapdoor spiders)

Trapdoor spiders are known to contain numerous SRE species and nearly all of the families present in Western Australia contain representatives with confirmed or potential short-range distributions (Castalanelli et al. 2014; Harvey et al. 2012; Rix et al. 2017). Species identification of trapdoor spiders is heavily based on

characteristics of adult male palps and identification of most species is impossible from, juveniles and females. It is however possible to determine the identity of females and juveniles in most families using DNA Bar-coding methods (Castalanelli *et al.* 2014; Hebert *et al.* 2003a; Hebert *et al.* 2003b).

Barychelidae (Brush-footed Trapdoor Spiders)

The brush-footed spiders are poorly known in Western Australia, where the family is represented by the genera *Aurecocrypta*, *Idiomata*, *Moruga, Mundjelia* and *Synothele* (Raven 1994). Both species identified in this collection represent species of the genus *Synothele* (Raven 1994). In Western Australia, most species of *Synothele* are only known from one or two specimens with small distribution ranges (Raven 1994). For this reason, most *Synothele* morphospecies are potential SREs.

Synothele meadhunteri

This species represents the only named species of trapdoor spider in this collection. It is a very **widespread** species with the holotype from Queen Victoria Springs in Western Australia and the paratype from Roxby Downs in South Australia (Raven 1994). Additional specimens of this species have been recorded from Albion Downs in the Northern Goldfields, and in the Pilbara ~72 km NW of Newman (WA Museum records).

***Synothelae* 'LD1'**

No matches could be found among the WA Museum *Synothele* morphospecies for the second species in this collection, which is here referred to as *Synothele* 'LD1'. *Synothele* 'LD1' is a **potential SRE** owing to the absence of near matches with *Synothele* species and morphospecies in the WA Museum voucher collection.

No other records of Barychellidae could be found from previous surveys from Lake Disappointment (Phoenix 2014) or from a database search (WA Museum) of the area.

Idiopidae (True Trapdoor Spiders)

The Australian Idiopidae are currently under revision and the status of several genera are about to be revised considerably (Rix *et al.* 2017 (in press)). One of the major outcomes of that research will be the synonymy of the genus *Aganippe* with *Idiosoma*. Since the formal name change has not occurred yet, the name *Aganippe* is used here, but the name change to *Idiosoma* is imminent and will affect both species in this collection. The genus *Aganippe* contains numerous undescribed species many of which are SREs while some are widespread.

***Aganippe* 'LD1' and *Aganippe* 'LD2'**

Two species of *Aganippe* were identified based on the adult male palp morphology. Comparison of these specimens with WA Museum vouchers was impossible owing to the entire collection of adult males currently being on loan to researchers in Qld. In the absence of these specimens, plates of diagnostic characters of the two morphospecies were presented to Dr M. Rix (currently revising the family Idiopidae) for examination and comment. Neither of these species could be attributed to any of the morphospecies currently recognised (M. Rix Pers. Comm. 2017). Both species are **potential SREs**.

No other records of Idiopidae could be found from previous surveys from Lake Disappointment (Phoenix 2014) or from a database search of the area (WA Museum).

Nemesiidae (Wish-bone Trapdoor Spiders)

In Western Australia, the family Nemisiidae is represented by the genera *Aname*, *Chenistonia*, *Kwonkan*, *Stanwellia*, *Swolnpes*, *Teyl* and *Yilgarnia*. Numerous undescribed species are known from Western Australia with both large and small distributions (Durrant *et al.* 2010; Main *et al.* 2000; Raven 1981, 1985)

***Kwonkan* 'LD1'**

The genus *Kwonkan* is represented by six species all of which are endemic to Western Australia (Main 1977, 1983). The boundaries between *Kwonkan* and *Yilgarnia*, containing two described species, are also uncertain with intermediate forms known from the Pilbara region (Durrant *et al.* 2010).

A single male specimen of this species was present in the collection. Phoenix (2014) recorded one species in this genus, *Kwonkan* 'disappointment'. That identification was based on an unusual arrangement of spine setae on the pedal tarsi, despite the absence of adult males. The specimen in the present collection was compared with the two specimens of *Kwonkan* 'disappointment'; however, comparison was difficult owing to the immature state of both of those specimens. *Kwonkan* 'LD1' appears to be a different species. *Kwonkan* 'LD1' also couldn't be matched with any of the *Kwonkan* vouchers in the WA Museum, therefore it is a **potential SRE**.

A previous desktop assessment of the area identified a single record from this family: *Aname* sp. indet. and which was assigned as a potential SRE (Phoenix 2014).

Scorpiones (Scorpions)

Four scorpion families are known from Western Australia. Short-range endemic species are known from Buthidae, Urodacidae and Hormuridae. Research currently being undertaken at the WA Museum (Harvey 2014; Volschenk 2008; Volschenk *et al.* 2010; Volschenk *et al.* 2012; Volschenk *et al.* 2000) has identified numerous undescribed species. As little as 15% of the scorpion fauna of WA appears to be described. Species delineation in scorpions varies in complexity: species from the family Buthidae can be identified from all but 1st and 2nd instars; however, species identification of Bothriuridae, Urodacidae and Hormuridae is often heavily dependent on characteristics only present in adult males. The families Buthidae and Urodacidae also contain several species complexes containing cryptic species, which can only be currently identified using DNA barcoding methods.

Buthidae (Narrow handed scorpions)

In Western Australia, the family Buthidae is currently represented by three genera, *Lychas*, *Isometroides* and *Isometrus*. Representatives of *Lychas* are frequently collected in surveys of WA and current investigations on the genus *Lychas* (WA Museum) indicates the presence of several species complexes, some of which appear to contain SREs.

***Lychas* '099'**

Nine samples of this species were present in this collection. The species is only known from samples in this collection and from a previous collection from Lake Disappointment (Alacran 2016). *Lychas* '099' is therefore considered to be a **potential SRE**.

Alacran (2016) identified a single juvenile specimen of *Lychas* 'annulatus complex'. The assessment of that specimen was reviewed with the addition of new material of *Lychas* '099' from this collection and it is now considered to be a juvenile *Lychas* '099'.

***Lychas* 'telfer'**

This species was represented by four samples in this collection. This species was also present in previous surveys from Lake Disappointment (Alacran 2016; Phoenix 2014). As its morphospecies name implies, the first records of this species were near Telfer, approximately ~170 km north of the present survey location. This species was considered 'widesread' by Phoenix (2014); however, after further examination of its distribution and specialised morphology, Alacran (2016) considered this species to be a **potential SRE**, a position maintained here also.

Urodacidae (Burrowing scorpions)

Urodacus hoplurus

Three specimens of *Urodacus hoplurus* were present in this collection, two adult males and a single subadult male. This species appears to be widespread across arid parts of Australia (Volschenk, unpublished data).

***Urodacus* 'yaschenkoi complex'**

Four adult male specimens of this species were present in this collection. Representatives of this group are all characterised by a general morphological description for *Urodacus yaschenkoi* as described by Koch (1977); however, research on this group (Volschenk, unpublished data) indicates the presence of at least four distinct species. While under revision, all species diagnosed as *Urodacus yaschenkoi* are considered part of a species complex and unassessed representatives, as well as northern populations, are considered potential short-range endemics.

The specimens present in this collection are all significantly paler and more granular than any of the other representatives of this group. They are therefore considered to be **potential SRE's**. Phoenix (2014) also reported this species and considered it to be widespread, a position no longer supported by current research on this group (Volschenk, unpublished data).

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APPENDIX 1. BACKGROUND AND METHODS

SHORT-RANGE ENDEMISM

Short-range endemics are organisms with small geographic distributions (Harvey 2002; Ponder and Colgan 2002), nominally less than 10,000 km^2 (Harvey 2002). These organisms are typically characterised by one or more of the following characteristics:

- limited dispersal capabilities,
- seasonal activity (cooler or wetter periods),
- slow growth, and
- low levels of fecundity.

Isolating mechanisms are typically inhospitable habitat such as rivers, rocky ridges or plains that act to prevent dispersal (gene flow) between populations. Two types of short-range endemism have been recognised: Relictual Endemism and Habitat Specialist Endemism (Harvey 2002; Ponder and Colgan 2002).

Relictual SREs result when speciation occurs following the fragmentation of continuous habitat into two or more refugia. In Australia, the primary driver of this over the last 65 million years has been aridification, which acted to isolate formerly widespread species living in mesic forests to small patches of mesic refugia. Relictual SREs include scorpions in the genus *Aops* (Volschenk and Prendini 2008), pseudoscorpions in the genera *Tyrannochthonius* (Edward and Harvey 2008; Harvey 1991), *Indohya* (Harvey 1993b; Harvey and Volschenk 2007) and *Idioblothrus* (Harvey 1993a; Harvey and Leng 2008; Muchmore 1982) and millipedes in the genus *Antichiropus* (Car and Harvey 2014; Car *et al.* 2013b). Troglobites (obligate subterranean species) are thought to be extreme examples of relictual SREs; most troglobites from the Pilbara have surface dwelling relatives living in the more mesic forests of northern Australia (Harvey 2002; Ponder and Colgan 2002).

Habitat specialist SREs are species that have adapted to very specific environment types, including those found in arid environments (e.g. rocky outcrops or isolated dune systems). Such habitats are often relatively young (<10 million years) and therefore are not refugial. Examples of habitat specialist SREs include spiders in the family Selenopidae and pseudoscorpions in the genera *Synsphyronus* (Harvey 2011, 2012) and *Feaella* (Harvey 1989; Harvey and Volschenk 2007), and scorpions in the genera *Lychas* and *Urodacus*.

DEFINING SHORT-RANGE ENDEMISM

Assessment of short-range endemism can be challenging when data for evaluation are absent or limited. Limitations may include any of the following:

- **Poor survey coverage,** e.g. the fauna of an area has not been sampled extensively enough to enable assessment of species distributions. The absence of a species from survey records may not mean that it is absent from the area.
- **Poor taxonomic resolution,** e.g. a species has not been subject to systematic investigation, and/or the identity is either difficult or impossible to determine. Good taxonomic resolution does not necessarily need to be in the form of published revisions, as it can be facilitated by any of the following:
  - a researcher actively working on the group who can authorise identifications,
  - a publicly accessible reference collection, and/or;
  - assessment of species boundaries using genomic methods such as DNA barcoding (Hebert et al. 2003a; Hebert et al. 2003b).
- **Identification issues**, e.g. surveys sampled life stages of potential SREs that are impossible to identify based on morphological characters. Examples of relevant taxa include juvenile or female millipedes,

mygalomorph spiders and *Urodacus* scorpions. Genomic methods have great potential to overcome this type of limitation.

There are no published systems for assessing the SRE potential for a species. Given this, I employ a three-category system used by the WA Museum to assess SRE-status of invertebrates:

- **Confirmed SRE:** This category applies when the identity of the taxon is unambiguous and its distribution is less than 10 000km^2 based on publicly available vouchered records. Supporting data can be either genomic (from DNA sequences) or morphological, ideally both.
- **Potential SRE:** This category applies to situations where there are knowledge gaps for the taxon. The following sub-categories further elucidate this status:
    - **Data Deficiency:** This category covers taxa for which there is insufficient data available to determine SRE status. Factors that fall under this category include:
        - insufficient geographic information,
        - insufficient taxonomic information, and/or
        - inappropriate life stages prevent identification to species level.
    - **Habitat Indicators:** This category employs habitat characteristics to evaluate SRE status when habitats are known to support SRE taxa. For example, many species sampled from subterranean habitats are known to be range restricted; a new species discovered from such habitat therefore has greater potential to be range restricted (i.e. a SRE) than widespread.
    - **Morphological Evidence:** This category uses one or more morphological characters that are characteristic of SRE taxa inhabiting restricted environments, e.g. the specialised morphological features of animals adapted to subterranean habitats, including body markings that are absent or significantly paler than surface dwelling relatives, eyes that are absent or significantly reduced, and/or longer appendages (legs and antennae) than surface relatives.
    - **Unpublished Research & Expertise:** This category relies on unpublished research or expertise to develop SRE status.

  These categories of categories of potential SRE may be helpful in developing conservation priorities, however, each taxon should be assessed on its merit and in accordance with the *Precautionary Principle* (EPA 2002):

  > "*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*".

- **Widespread (not an SRE)**: This category applies when vouchered evidence demonstrates a distribution greater than 10,000 km^2.

TAXONOMY

The taxonomic nomenclature of invertebrates follows the references detailed in Table 1. Morphospecies designations follow the parataxonomy of the scientist(s) working on the group; these informal names are written between single quotation marks rather than being italicised as they are not valid under the International Code of Zoological Nomenclature (1999).

The Phylogenetic Species Concept (Cracraft 1983) is used for delineating morphospecies:

> "A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent."

IDENTIFICATION

Unless otherwise stated, species identifications were carried out by the author. The references used for species determination are summarised in Table 1. Unpublished morphospecies were compare directly with vouchers at the WA Museum.

Table 1. The following 'general' references and collections were used to assist with morphospecies designations

Order	Taxonomic reference	Morphospecies and reference collection
Araneae	(Raven et al. 2002; World Spider Catalog 2014)	Reference collection and morphospecies codes of the WA
Pseudoscorpiones	(Harvey 1992; Harvey 2012, 2013; Murienne et al. 2008)	Reference collection and morphospecies codes of the WA
Scorpiones	(Acosta 1990; Fet *et al.* 2000; Glauert 1925a, b; Kovařík 1997; Monod *et al.* 2013; Volschenk *et al.* 2010; Volschenk and Prendini 2008; Volschenk *et al.* 2000)	Reference collection at the WA Museum. Morphospecies designation by E.S. Volschenk.
Isopoda	(Schmalfuss 2003; Schmidt and Leistikow 2004; Schotte et al. 2008)	Reference collection at the WA Museum. Morphospecies designation by Dr Simon Judd.
Chilopoda	(Colloff et al. 2005; Lewis 1981)	Reference collection and morphospecies codes of the WA
Diplopoda	(Car and Harvey 2013, 2014; Car et al. 2013a; Car et al. 2013b; Edward and Harvey 2010; Sierwald 2006)	Reference collection and morphospecies codes of the WA Museum.
Insecta	(CSIRO 1991)	Reference collection within the WA Museum. Morphospecies designation by E.S. Volschenk or as otherwise noted.

SPECIMEN LODGEMENT

In accordance with EPA Guidance Statement 20 (2009), specimens submitted to Alacran Environmental Science for taxonomic identification will be offered to the WA Museum for inclusion in their biological collections.

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CLIENT REG.	ORDER	FAMILY	SPECIES	Site Code	LATITUDE	LONGITUDE	TOTAL
LD215	Araneae	Barychelidae	*Barychelidae* 'LD1'	TS 1	23°07'12	122°49'46	1
LD210	Araneae	Barychelidae	*Synothele meadhunteri*	TS 1	23°07'12	122°49'46	1
LD209	Araneae	Barychelidae	*Synothele meadhunteri*	TS 1	23°07'12	122°49'46	1
LD212	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 2	23°03'49	122°52'43	1
LD214	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 2	23°08'43	122°48'57	1
LD232	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 2	23°08'43	122°48'57	1
LD221	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD230	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 2	23°08'43	122°48'57	1
LD217	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD219	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD208	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD220	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD223	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 3	23°02'49	122°52'44	1
LD227	Araneae	Idiopidae	*Aganippe* 'LD1'	TS 2	23°08'43	122°48'57	1
LD213	Araneae	Idiopidae	*Aganippe* 'LD2'	TS 2	23°08'43	122°48'57	1
LD218	Araneae	Idiopidae	*Aganippe* 'LD2'	TS 3	23°02'49	122°52'44	1
LD222	Araneae	Idiopidae	*Aganippe* 'LD2'	TS 2	23°08'43	122°48'57	1
LD216	Araneae	Nemesiidae	*Kwonkan* 'LD1'	TS 1	23°07'12	122°49'46	1
LD236	Araneae	Zodariidae	Zodariidae sp. indet.	TS 3	23°02'49	122°52'44	1
LD235	Scorpiones	Buthidae	*Lychas* '099'	TS 3	23°02'49	122°52'44	1
LD235	Scorpiones	Buthidae	*Lychas* '099'	TS 3	23°02'49	122°52'44	1
LD235	Scorpiones	Buthidae	*Lychas* '099'	TS 3	23°02'49	122°52'44	1
LD237b	Scorpiones	Buthidae	*Lychas* '099'	TS 2	23°08'43	122°48'57	1
LD237c	Scorpiones	Buthidae	*Lychas* '099'	TS 2	23°08'43	122°48'57	1

CLIENT REG.	ORDER	FAMILY	SPECIES	Site Code	LATITUDE	LONGITUDE	TOTAL
LD233	Scorpiones	Buthidae	*Lychas* '099'	TS 1	23°07'12	122°49'46	1
LD237	Scorpiones	Buthidae	*Lychas* '099'	TS 2	23°08'43	122°48'57	1
LD235	Scorpiones	Buthidae	*Lychas* '099'	TS 3	23°02'49	122°52'44	1
LD226	Scorpiones	Buthidae	*Lychas* 'telfer'	TS 1	23°07'12	122°49'46	1
LD231	Scorpiones	Buthidae	*Lychas* 'telfer'	TS 2	23°08'43	122°48'57	1
LD226	Scorpiones	Buthidae	*Lychas* 'telfer'	TS 1	23°07'12	122°49'46	1
LD211	Scorpiones	Buthidae	*Lychas* 'telfer'	TS 1	23°07'12	122°49'46	1
LD234	Scorpiones	Urodacidae	*Urodacus hoplurus*	TS 2	23°08'43	122°48'57	1
LD238	Scorpiones	Urodacidae	*Urodacus hoplurus*	TS 1	23°07'12	122°49'46	1
LD228	Scorpiones	Urodacidae	*Urodacus hoplurus*	TS 2	23°08'43	122°48'57	1
LD224	Scorpiones	Urodacidae	*Urodacus* 'yaschenkoi complex'	TS 1	23°07'12	122°49'46	1
LD229b	Scorpiones	Urodacidae	*Urodacus* 'yaschenkoi complex'	TS 1	23°07'12	122°49'46	1
LD229a	Scorpiones	Urodacidae	*Urodacus* 'yaschenkoi complex'	TS 1	23°07'12	122°49'46	1
LD225	Scorpiones	Urodacidae	*Urodacus* 'yaschenkoi complex'	TS 1	23°07'12	122°49'46	1

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The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

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