Survey for Aquatic Macroinvertebrates and SRE Fauna for the Lake Mackay SOP Project, Western Australia

Report by Invertebrate Solutions for Agrimin Ltd on behalf of 360 Environmental Pty Ltd

September 2017

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Frontispiece: The scorpion *Urodacus yaschenkoi* from the southern shore of Lake Mackay.

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Executive Summary

Agrimin Limited (Agrimin) is developing its Lake Mackay Sulphate of Potash (SOP) Project and requires a number of baseline biological assessments to be carried out. The SOP Project covers ninetenements covering the majority of Lake Mackay over a total area of 2,560 square kilometres. Lake Mackay is a seasonally inundated salt lake located on the Western Australia (WA) – Northern Territory (NT) border, with most of the lake located within WA. The Project is situated entirely within WA but is accessed from Alice Springs in the NT, 540 km to the south-east.

Invertebrate Solutions has been requested by 360 Environmental Pty Ltd (360 Environmental) to undertake a desktop assessment and field survey for short range endemic (SRE) invertebrates and aquatic macroinvertebrates for the Lake MacKay SOP Project.

Invertebrate Solutions completed a SRE survey at the Lake Mackay SOP Project area in May 2017. This comprised 10 sites on both the mainland and offshore islands. Sites 1 – 6 were surveyed in conjunction with the vertebrate fauna trapping program and used the pitfall traps for collecting potential SRE invertebrates, along with litter sifting and hand searching of appropriate microhabitats. Sites 7 – 10 consisted of litter sifting and hand searching only for potential SRE invertebrates for 1 human hour per site.

An aquatic macroinvertebrate survey was undertaken by Dr Colin Trainor (Trainor Ecological Solutions) and Gerry Bradley (Agrimin) using timed active sweep netting of aquatic habitats in the main Lake Mackay area as well as three surrounding claypans to the south of the lake in April 2017. Sampling consisted of walking sweep net samples using a 250 µm dip net.

The SRE field survey recorded 11 taxa of invertebrates from three classes, seven orders and eight families that have the potential to contain SRE taxa. The SRE survey recorded seven potential SRE invertebrate species from the Lake Mackay SOP Project area. There were no ‘Confirmed’ or ‘Likely’ SRE species recorded during the survey. The majority of the species determined to be "Possible" SRE taxa is due to incomplete taxonomy and unknown species distributions. Almost all the possible SRE species were found at multiple locations during the survey indicating that their distributions are wider than the current survey could determine. Only a single species, *Buddelundia* sp IS01, was found solely on the lake islands which indicates that, in general, the offshore islands are simply more depauperate communities of the normal mainland fauna, however, further surveys in multiple seasons would be required to support this assertion.

The aquatic macroinvertebrate sampling undertaken in April 2017 recorded no invertebrates within Lake Mackay. Three of the nine samples were collected in claypans to the south of Lake Mackay and these samples recorded eight taxa of aquatic macroinvertebrates from four classes, six orders and six families. All the species recorded during the aquatic macroinvertebrate survey are widespread and common throughout the Australian arid zone and, although most records are new for Lake Mackay, they represent an infilling of distributional records rather than range extensions. The water quality data show that Lake Mackay is hypersaline and the ephemeral claypans in the surrounding region are fresh to brackish and provide excellent habitat for aquatic macroinvertebrates.

The SRE and aquatic macroinvertebrate survey at the Lake Mackay SOP Project undertaken in April and May 2017 recorded a diverse range of invertebrate species, many of which are new records for

the Lake Mackay region. This is primarily due to the lack of previous collecting in the area, rather than the region containing a unique species assemblage any different from other parts of the central arid region of Australia.

The development of the Lake Mackay SOP Project is not anticipated to significantly impact adversely on any species recorded in these surveys. When the specific Project footprint and location of infrastructure areas is finalised, these conclusions should be revisited to ensure they remain valid, however, due to the expected limited extent of any processing and infrastructure areas, the current assessment is not expected to alter.

The following recommendations are made with regard to the potential development of the Lake Mackay SOP Project area:

- No further surveys for terrestrial SRE invertebrates are required to meet the EPA Technical guidance, sampling of short range endemic invertebrate fauna (EPA 2016); and
- No further aquatic macroinvertebrate surveys are required.

1. Introduction

Agrimin Limited (Agrimin) is developing its Lake Mackay Sulphate of Potash (SOP) Project and requires a number of baseline biological assessments to be carried out. The SOP Project covers nine tenements covering the majority of Lake Mackay over a total area of 2,560 square kilometres. Lake Mackay is a seasonally inundated salt lake located on the Western Australia (WA) – Northern Territory (NT) border, with most of the lake located within WA. The Project is situated entirely within WA but is accessed from Alice Springs in the NT, 540 km to the south-east.

Invertebrate Solutions has been requested by 360 Environmental Pty Ltd (360 Environmental) to undertake a desktop assessment and field survey for short range endemic (SRE) invertebrates and aquatic macroinvertebrates for the Lake MacKay SOP Project.

1.1 Purpose of this report

360 Environmental requested Invertebrate Solutions to undertake the following scope of works for the Lake Mackay SOP Project area, Western Australia:

- Carry out a desktop review to inform the survey planning and report preparation, including identification of all SRE species likely to occur within the Project area;
- Undertake a SRE invertebrate survey to identify significant species and habitat in accordance with EPA Technical Guidance Sampling of short range endemic invertebrate fauna (EPA 2016);
- Walking sweep net (250µm) transect samples of 10 sample aquatic macroinvertebrate sites:
    - Transects will attempt to target all habitats present at each site;
    - To be conducted over 2 minutes;
    - Samples to be stored in 95% ethanol; and
    - Site descriptions and locations recorded.
- Water quality parameters measured:
    - Temperature (^{o}C);
    - pH;
    - salinity (ppm);
    - dissolved oxygen (mg/L and % saturation); and
    - conductivity (µs/cm).
- Identify 10 samples of aquatic macroinvertebrates from sweep nets to the lowest practical taxonomic level;
- Undertake the field based survey for SRE invertebrates within the Project area;
- Identify to the lowest practical taxonomic unit all potential SRE specimens recorded during the field survey;
- Provide a comprehensive table of all SRE species likely to occur within the Project area and the particular habitats they are likely to occur in;

- Provide recommendations and any suggested requirements for further work to comply with relevant legislation;
- Provide recommendations to minimise potential impacts and any suggested requirements for further work to comply with relevant legislation; and
- Provide a written report containing the above items.

1.2 Project area

The Project covers nine tenements covering the majority of Lake Mackay over a total area of 2,560 square kilometres. Lake Mackay is a seasonally inundated salt lake located on the Western Australia (WA) – Northern Territory (NT) border, with most of the lake located within WA. The Project is situated entirely within WA but is accessed from Alice Springs in the NT, 540 km to the south-east and is shown in Figure 1.

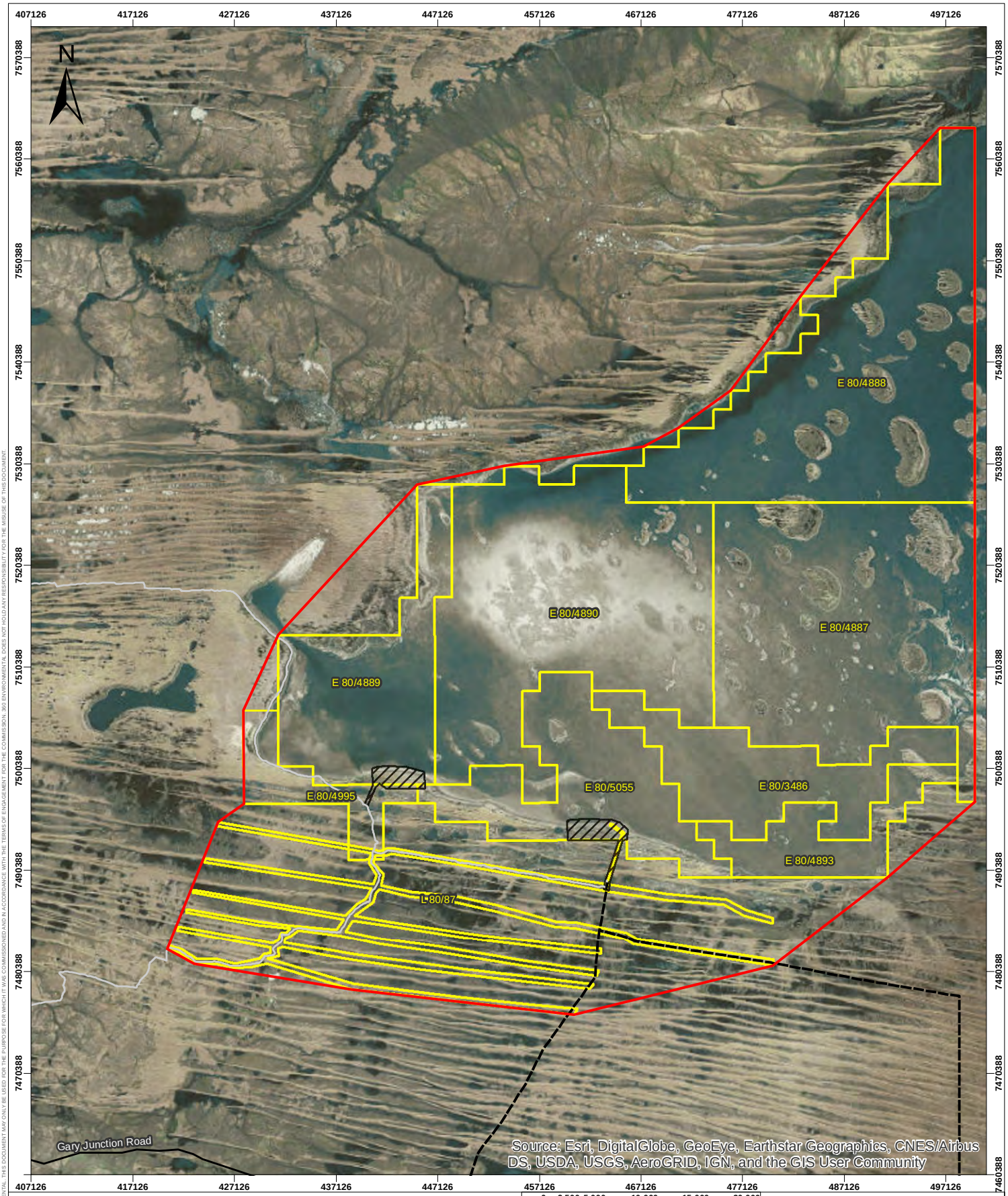
1.3 Survey Effort and Timing

Invertebrate Solutions completed a SRE survey at the Lake Mackay SOP Project area in May 2017. This comprised 10 sites on both the mainland and offshore islands, with the locations shown in Table 1. Sites 1 – 6 were undertaken in conjunction with the vertebrate fauna trapping program and used the pitfall traps for collecting potential SRE invertebrates, along with litter sifting and hand searching of appropriate microhabitats. The survey effort for pitfall trapping nights was calculated as one pitfall trap open for one night multiplied by the number of pitfalls at a site for a total of 300 pitfall trap nights for the survey. Sites 7 – 10 consisted of litter sifting and hand searching only for potential SRE invertebrates for 1 human hour per site. These active search methods were also used at sites 1 – 6.

Table 1 Locations sampled for SRE invertebrates

Sample ID	Easting	Northing	Habitat	Pitfall Trapping Nights	Pitfall Trap Date(s) Sampled	Sieving and Litter Collection
SRE1	481797	7525583	Island	60	10-16 May 2017	13 May 2017
SRE2	484291	7519290	Island	60	10-16 May 2017	13 May 2017
SRE3	464210	7493493	Sand dune	60	10-16 May 2017	14 May 2017
SRE4	477770	7487347	Near freshwater lake	60	11-17 May 2017	15 May 2017
SRE5	464687	7491478	Sand dune	60	11-17 May 2017	15 May 2017
SRE6	442307	7499962	Sand dune	60	12-18 May 2017	14 May 2017
SRE7	451014	7502291	Island	No	-	16 May 2017
SRE8	447315	7501624	Island	No	-	16 May 2017
SRE 9	435754	7499668	Lake shore	No	-	17 May 2017
SRE 10	438621	7497742	Sand dune	No	-	17 May 2017

An aquatic macroinvertebrate survey was undertaken in the main Lake Mackay area as well as some surrounding claypans to the south of the lake in April 2017 A total of nine samples were collected, including three from claypans (Table 2).



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Legend

- Study Area
- Tenements
- Proposed Infrastructure Boundaries
- Existing Road
- Existing Track
- Proposed Track

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- LOCALITY MAP SOURCED FROM LANDGATE 2006
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2017
(© Western Australian Land Information Authority 2017)

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Meters
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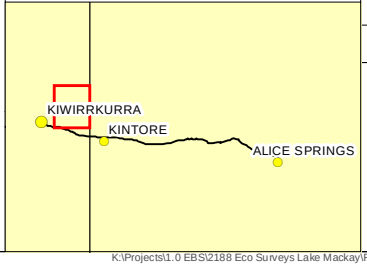
- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



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PROJECT ID	DATE
2188	30/08/2017

HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 52

CREATED	CHECKED	APPROVED	REVISION
EW	SS	SS	0

Survey for Aquatic Macroinvertebrates and SRE Fauna for the Lake Mackay SOP Project

Figure 1
Survey Area

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Legend

- Study Area
- Proposed Infrastructure Boundaries
- Existing Road
- Existing Track
- Proposed Track

Sampling locations

- Aquatic Macro-Invertebrates
- Short Range Endemic Invertebrates

Powered By SLIP ENABLER

- LOCALITY MAP SOURCED FROM LANDGATE 2006
- AERIAL PHOTOGRAPHY SOURCED LANDGATE 2017
(© Western Australian Land Information Authority 2017)

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Meters
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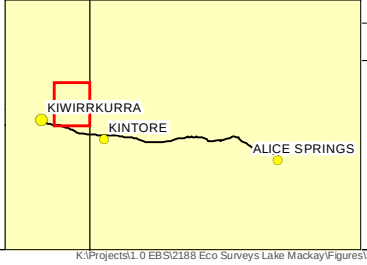
LOCALITY MAP



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Survey for Aquatic Macroinvertebrates and SRE Fauna for the Lake Mackay SOP Project

Figure 2
Sampling Locations

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Table 2 Sites sampled for aquatic macroinvertebrates

Sample ID	Easting	Northing	Habitat	Date Sampled
AM1	490391	7492584	Lake Mackay salt lake	14-Apr-17
AM2	485598	7494480	Lake Mackay salt lake	14-Apr-17
AM3	485329	7516039	Lake Mackay salt lake	15-Apr-17
AM4	494604	7507954	Lake Mackay salt lake	15-Apr-17
AM5	484254	7512142	Lake Mackay salt lake	16-Apr-17
AM6	482252	7511603	Lake Mackay salt lake	16-Apr-17
AM7	459903	7492753	4 ha Claypan (freshwater)	17-Apr-17
AM8	460774	7494177	0.1 ha Claypan (freshwater)	17-Apr-17
AM9	441755	7496647	20 ha Claypan (freshwater)	17-Apr-17

A map showing the locations of the SRE and aquatic macroinvertebrate sampling sites is shown in Figure 2.

1.4 Introduction to SRE fauna

Short range endemic (SRE) invertebrates are species with restricted distributions. The isolation of invertebrates in specific habitats or bioregions leads to endemism at various spatial scales. The vast majority of invertebrates are capable of dispersing substantial distances at some phase of their life cycle. Some groups, however, are susceptible to short-range endemism which describes endemic species with restricted ranges, arbitrarily defined in Western Australia as less than 10,000 km^2 (100 km x 100 km) (Harvey, 2002). Taxa that have been more commonly found to contain SRE representatives include:

- Onychophorans (velvet worms);
- Crustaceans (Isopoda);
- Arachnids (mygalomorph spiders, pseudoscorpions, opiliones, scorpions, schizomids);
- Myriapods (millipedes and centipedes);
- Molluscs (land snails); and
- Insects (hemipterans, grasshoppers, butterflies).

SRE invertebrate fauna taxa are generally found in sheltered, relatively mesic environments such as isolated habitats (e.g. boulder piles, isolated hills, dense patches of vegetation, gullies) and can include microhabitats within these environments such as deep leaf litter accumulation, large logs, under bark, cave areas and springs and permanent water bodies.

Many processes contribute to taxa being susceptible to short range endemism. Generally, these factors are related to the isolation of a species which can include the ability and opportunity to disperse, life history, physiology, habitat requirements, and habitat availability. Taxa that exhibit short range endemism generally exhibit poor dispersal, low growth rates, low fecundity and reliance on habitat types that are discontinuous (Harvey, 2002). Taxa that reside within easily isolated habitats surrounded by physical barriers such as islands, mountains, aquifers, lakes and caves are also more susceptible to becoming SRE species often including additional taxa not otherwise generally forming SREs.

Taxa that exhibit short range endemism are particularly vulnerable to disturbance, either natural or anthropogenic, as they are reliant upon specialised and often restricted habitats (often moist) (Framenau, *et al*., 2008). Short range endemic taxa are unable to disperse to *refugia* when their habitats are threatened or destroyed, thus making them a priority for conservation efforts.

1.5 Conservation Legislation and Guidance Statements

Terrestrial SRE species are protected under state legislation via the Wildlife Conservation (WC) Act (1950), the Environmental Protection Act (1986) and federally under the Environment Protection and Biodiversity Conservation (EPBC) Act (1999). The assessment of SRE fauna for environmental impact assessment (EIA) is undertaken in Western Australia with regard to the Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA 2016).

At the state level, the WC Act provides a list of species that have special protection as species listed under the Wildlife Conservation (Specially Protected Fauna) Notice 2015 (DPaW 2015). This notice is updated periodically by the Department of Biodiversity, Conservation and Attractions (DBCA) (formerly Department of Parks and Wildlife, DPaW) and the current list (December 2016) includes numerous subterranean species, mainly from the Cape Range and Pilbara regions including crustaceans, arachnids and myriapods that are considered to be "rare or likely to become extinct, as critically endangered fauna, or are declared to be fauna that is in need of special protection" (DPaW 2016). In addition to the specially protected fauna, DBCA also maintains a list of Priority fauna that are considered to be of conservation significance but do not meet the criteria for formal listing under the WC Act as Scheduled species. The Priority fauna list is irregularly updated by DBCA and, although it offers no formal legislative protection, these species are generally considered in the EIA process.

There is no current ability for the state government of Western Australia to formally list Threatened or Priority Ecological Communities (TECs/PECs), however, a list of such communities is maintained by DBCA and overseen by the Minister for the Environment. Several subterranean ecological communities are recognised as Threatened including the Bundera Cenote Anchialine community on Cape Range, Cameron's Cave near the townsite of Exmouth on Cape Range, stygal root mat communities in both the Yanchep and Margaret River regions and stygobionts in the Ethel Gorge aquifer in the Pilbara. Communities that are not considered by DBCA to be threatened but may be vulnerable to future impacts are classed as PECs and include numerous calcrete aquifers in the Yilgarn region where each calcrete has been shown to contain an endemic stygal community.

The WC Act is expected to be imminently replaced by the new Biodiversity Conservation Act that has yet to be enacted into law. This new act has been passed by the lower house of the State parliament and will be capable of protecting both species and ecological communities under legislation.

The federal EPBC Act protects both species and ecological communities. The most relevant listing for SRE fauna is the mygalomorph spider *Idiosoma nigrum* that occurs in the Wheatbelt region and is listed as Vulnerable.

1.6 Survey Staff Qualifications

Field sampling for invertebrates was undertaken by experienced ecologists and comprised of:

- Dr Timothy Moulds *BSc (Hons) Geol., PhD. Invert. Ecol.* (Invertebrate Solutions)
- Dr Ron Firth *BSc (Hons)., PhD. Ecol.* (360 Environmental)
- Laura Stevens *BSc (Hons)* (360 Environmental)
- Dr Colin Trainor *BSc, MSc, PhD*. (Trainor Ecological Solutions)
- Gerry Bradley *BSc (Hons) Zool.* (Agrimin Sustainability Manager)

The aquatic macroinvertebrate sampling was undertaken by Dr Colin Trainor and Gerry Bradley. Sampling for SRE invertebrates was undertaken by Dr Tim Moulds, Dr Ron Firth, Laura Stevens and Gerry Bradley. Invertebrate extraction, sorting and identification was completed by Dr Timothy Moulds. Survey work was undertaken under the collection licences issued by the Department of Parks and Wildlife:

- 08-000591-1; Licensee Dr Ron Firth (360 Environmental); Valid from 8-22/05/2017.

1.7 Report Limitations and Exclusions

This study was limited to the written scope provided to the client by Invertebrate Solutions (15th March 2017) and in Section 1.1. This study was limited to the extent of information made available to Invertebrate Solutions at the time of undertaking the work. Information not made available to this study, or which subsequently becomes available may alter the conclusions made herein. Assessment of potential impacts to aquatic macroinvertebrates and SRE fauna was based on proposed development plans provided by the client.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. Invertebrate Solutions has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by Invertebrate Solutions described in this report (this section and throughout this report). Invertebrate Solutions disclaims liability arising from any of the assumptions being incorrect.

Invertebrate Solutions has prepared this report on the basis of information provided by 360 Environmental for Agrimin Ltd and others (including Government authorities), which Invertebrate Solutions has not independently verified or checked beyond the agreed scope of work. Invertebrate Solutions does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Site conditions may change after the date of this report. Invertebrate Solutions does not accept responsibility arising from, or in connection with, any change to the site conditions. Invertebrate Solutions is also not responsible for updating this report if the site conditions change.

Species were identified to the lowest practical taxonomic level, taking into consideration that the taxonomic framework of many invertebrate groups is incomplete and often in need of substantial revision to enable accurate identification. Short Range Endemic status was assigned using the available information from the WAM database and discussion with appropriate taxonomic authorities for various invertebrate groups. Insufficient information exists for many invertebrate

species due to specimens being juvenile, the wrong sex to allow identification, damaged, or inadequate taxonomic frameworks, precluding the assignment of SRE status.

Field surveys for SRE invertebrates require multiple seasonal surveys to fully record all species that may be present in an area, and in varying weather conditions. The current survey was undertaken during a single season and additional surveys at different times of the year may record additional species.

2. Methods

Invertebrate Solutions undertook the following tasks for the SRE and aquatic macroinvertebrate survey of the Lake Mackay SOP Project area:

- SRE desktop assessment based upon Western Australian Museum Records;
- SRE survey of the Project Area (10 sites – 1 hour active searching and litter samples, 6 sites dry pitfall trapping in conjunction with the vertebrate fauna survey); and
- Aquatic macroinvertebrate sampling of 9 sites (undertaken by Colin Trainor).

The survey program was undertaken with regard to the Technical Guidance – Sampling of short range endemic invertebrate fauna (EPA 2016).

2.1 SRE Desktop Methodology

A search of the WAM databases for Arachnids, Crustacea and Molluscs was undertaken for potential SRE taxa occurring in the Lake Mackay region. In addition, other published reports for the area were examined including several reports from the Bushblitz survey undertaken by Western Australian Museum and Queensland Museum staff in 2015. The desktop analysis was used to identify any potential SRE species that may occur in the Lake Mackay region and target those taxa during the subsequent field survey of the Project area.

2.2 SRE Survey Methodology

The SRE pilot survey was undertaken using a combination of sampling techniques and employed both systematic (timed active searching) and opportunistic (litter collection and transect) sampling. Sites were chosen to maximise SRE habitat including south-facing slopes, gullies, rocky outcrops, dense patches of trees and permanent water bodies.

2.2.1 Pitfall traps

At SRE sites 1- 6, dry pitfall trapping for SRE invertebrates was undertaken in conjunction with the vertebrate fauna survey. This involved the use of 10 x 20L plastic buckets buried in two lines of five at each site with a drift fence of flywire placed along the centre line to direct invertebrates (and vertebrate fauna) into the pitfall traps. These traps were checked once a day for invertebrates and more often for vertebrate fauna. Potential SRE invertebrates were collected using forceps, placing specimens into 70% ethanol.

2.2.2 Active searching

Active searching was undertaken at eight (8) sites within and adjacent to the proposed disturbance areas, focusing on areas more likely to contain SRE fauna. Active searching consisted of sifting of soil and/or leaf litter from suitable habitat areas within each site (millipedes and land snails); the raking of leaf litter (millipedes, land snails, centipedes, mygalomorph burrows); examination of vegetative material below logs and bark (pseudoscorpions, centipedes, millipedes), and an examination of (if present) areas of rock outcrops and associated rock piles.

A minimum of one person hour active searching per site was undertaken.

2.2.3 Litter collection

Leaf litter was collected from each site surveyed and processed in Tullgren funnels for potential SRE fauna. Approximately 6L of leaf litter was collected from each site and stored in sealed plastic garbage bags.

2.2.4 Opportunistic collection

Various areas that may provide habitat for SRE invertebrates were also opportunistically sampled whilst undertaking other surveys in the survey area. This included searching for burrows of mygalomorph spiders and searching under tree bark and logs for potential SRE species.

2.3 Aquatic Macroinvertebrate Survey Methodology

The aquatic macroinvertebrate survey was undertaken by Dr Colin Trainor (Trainor Ecological Solutions) and Gerry Bradley (Agrimin) using timed active sweep netting of aquatic habitats. Sites were chosen in various parts of the lake itself and also in several ephemeral claypans to the south of the lake. Sampling consisted of walking sweep net samples using a 250 µm dip net over a two minute period at each site. The samples were then examined in white plastic trays with all invertebrates collected using forceps and preserved in 70% ethanol.

At each site, a selection of water quality parameters were recorded including temperature (^{o}C), pH, conductivity (µS/cm) and dissolved oxygen (mg/L).

2.3.1 Oxidation reduction potential (ORP)

The oxidation reduction potential (ORP) or redox potential of water is a measure of a system's capacity to oxidise materials through chemical reactions. During reduction-oxidation reactions, one chemical species loses electrons (is oxidised) while another gains electrons (is reduced). Redox is measured indirectly as the ability of an aquatic system to conduct electricity, in millivolts (mV).

The redox state of aquatic environments, i.e. whether they are in an oxidising or reducing environment, is defined by the oxygen content. Typically, in well-aerated aquatic environments, the water provides an oxidising environment and has a positive, or nearing positive, ORP value. Anoxic (zero oxygen) waters are often the result of high biological (BOD) and/or chemical oxygen demand (COD) and have low redox potential (often measured as negative millivolts, mV). The redox potential of aquatic environments controls the reactivity and solubility of many chemical constituents including metals. For example, the redox potential of water has important implications for metal mobility, bio-availability and toxicity.

2.3.2 Temperature

The temperature of ground water in arid Australia is generally fairly constant throughout the year and reflects the average surface temperature of the area. Surface waters are more reflective of the ambient temperatures, with depth and permanency influencing the temperatures recorded.

2.3.3 pH

The concentration of hydrogen ions (H^{+}) is shown as a logarithmic scale, where a low value indicates a high concentration and higher values indicate a more basic solution. The neutral value of 7 is more likely to support aquatic macroinvertebrates.

2.3.4 Electrical conductivity

Electrical conductivity was measured in milli Siemens per centimetre (mS/cm) and provides an indication of salinity. In highly saline waters that are found in salt lakes, the diversity of aquatic macroinvertebrates is generally much reduced with most salt lake ecosystems dominated by brine shrimp (Anostraca). Ephemeral claypans generally contain fresh to brackish water and, hence, can support a more diverse aquatic fauna.

2.3.5 Dissolved oxygen

Dissolved oxygen is usually reported in milligrams per litre (mg/L) or as a percent of air saturation of the water being measured. Dissolved oxygen refers to the level of free, non-compound oxygen present in water and is an important parameter in assessing water quality because of its influence on the aquatic macroinvertebrates that may live in a body of water (Fondriest Environmental, 2013). The amount of dissolved oxygen required for various species varies, with deep profile species requiring less than shallow dwelling species .

Dissolved oxygen levels are dependent upon the temperature, salinity and depth of a water body, with the solubility of oxygen decreasing as temperature and salinity increases (Wetzel 2001).

2.4 Sorting and Curation

Sorting for all samples (SRE and aquatic macroinvertebrates) occurred in the Invertebrate Solutions laboratory using an Amscope 45x dissecting microscope and was undertaken by Dr Timothy Moulds. In the laboratory, fauna was extracted from SRE leaf litter samples using Tullgren funnels and preserved in 100% ethanol. Each taxon was identified to the lowest practical taxonomic rank using published keys and descriptions, and the numbers of each taxon recorded. Each identified taxon was kept in a separate labelled vial and assigned a specimen tracking code. Specimen and site collection data were recorded in an Excel spreadsheet. At the conclusion of the study, all specimens will be lodged at the Western Australian Museum.

2.5 Taxonomy and Nomenclature

Identification of collected invertebrate material was undertaken by Dr Timothy Moulds. Invertebrate groups collected that have no SRE representatives such as ants and flying insects were not identified or reported. The presence of winged adults in most insect groups suggests that they are more capable dispersers and, therefore, less likely to have a restricted range.

The level of specimen identification achievable is dependent on the level of taxonomic knowledge and expertise available. The majority of the taxonomic expertise relating to SRE taxa resides with the staff of the Western Australian Museum, while some groups are also worked on by researchers within other government departments and academic institutions. Taxonomic treatments are available for some invertebrate groups, but not all. The EPA expects that invertebrates collected for identification will be identified to the lowest taxonomic level possible. Ideally, this is to the species level, but there will be limits due to the nature of specimens and the availability of taxonomic keys.

2.6 Short Range Endemic Status

Taxonomic groups known to contain SRE representatives were examined in more detail to determine if the specimens collected in this study are potentially restricted forms. SRE status will be

assigned after comparison with the morphology of other close relatives in the group and current knowledge on their distribution and ecology, where known. Identifications will be confirmed by specialist taxonomists, as necessary.

The allocation of short range endemism status can be difficult due to the often incomplete taxonomic framework of many invertebrate groups and the often frequent need for substantial revision to enable accurate identification. Short Range Endemic status is assigned using the categories described in Table 3, based upon the available information from the WAM database and discussion with appropriate taxonomic authorities for various invertebrate groups. Insufficient information exists for many invertebrate species due to specimens being juvenile, the wrong sex to allow identification, damaged, or inadequate taxonomic frameworks, precluding the assignment of SRE status.

Table 3 Short Range Endemic Status of Species

SRE Status	Definition
Confirmed	A confirmed SRE species. A known distribution of < 10,000 km^2 (after Harvey 2002). Taxonomy of the group is well known. The group is well represented in collections, or via comprehensive sampling.
Likely	Likely to be a SRE species based upon knowledge of the family/genus, where other closely related species show evidence of short range endemism. Where habitats containing the specimens show discontinuity within the landscape.
Possible	Based upon existing knowledge of the genus / family there is a possibility that the species may have a restricted range. Where habitats containing the specimens may show discontinuity within the landscape. Potential SRE species may be assigned one of the sub categories below: A. Data deficient i.e. new species, lack of distribution, taxonomic or collecting knowledge, juvenile specimens, wrong sex for identification B. Habitat indicators C. Morphology indicators D. Molecular evidence E. Research and expertise of WAM staff/taxonomic specialists
Widespread	Not a SRE, a wide ranging distribution of > 10,000 km^2

3. Results

3.1 Desktop SRE Assessment

A search of the WAM databases for potential SRE taxa occurring in the Lake Mackay region was undertaken (WAM 2017a, b, c). Very little data exists for this region and, prior to a Bushblitz survey in 2015 (Whisson and Kirkendale 2015, Baehr 2015), very few records for any invertebrates existed. No crustacean records are present in the WAM crustacean database although it should be noted that many specimens remain to be databased.

The Bushblitz survey (Whisson and Kirkendale 2015) recorded only five species of mollusc (Table 4). This low diversity was not unexpected due to the time of the year (dry season) and the fact that land snails tend to be most common in areas with rock piles,; good amounts of shade and associated vegetation and seasonal wet spots (Solem 1993, Whisson and Kirkendale 2015).

Several arachnid records were retrieved from the WAM arachnid database (WAM 2017a), with those likely to be potential SRE taxa recorded in Table 4. The two mygalomorph spiders were not identified beyond family level making a determination of SRE status difficult. The remainder of the pseudoscorpion and centipede records appear to be widespread species, although the taxonomy of these groups is incomplete.

Table 4 Desktop records from WAM of potential SRE Invertebrates in the Kiwirrkurra/Lake Mackay area

Higher Order	Genus and species	Location	SRE Status
Gastropoda: Pupillidae	*Pupoides adelaidae*	Jupiter Well area; N side of Balgo Road	Widespread in arid zone
	Pupoides beltianus	40km NE of Kiwirrkurra; E of Mt Webb	Widespread in central arid zone
	Pupoides eremicolus	Approx 120km E of Kiwirrkurra	Widespread in central arid zone
	Gastrocopta mussoni	100km E of Kiwirrkurra	Widespread across northern and arid Australia
Gastropoda: Planorbidae	*Leichhardtia* sp.	Mumu (NE of Kiwirrkurra); wetland area; SW edge of lake; Roberts Lake; NW of Lake Mackay	Possible (A, E)
Arachnida: Mygalomorphae Barychelidae	Barychelidae sp.	Morgan Range	Possible (A)
Arachnida: Mygalomorphae Nemesiidae	*Aname* sp.	Lake Mackay, WAM site 1; WAM Site 5	Possible (A)
Arachnida: Pseudoscorpiones: Garypidae	*Synsphyronus* 'Kiwirrkurra 1'	120 km E. of Kiwirrkurra; 12 km SSW. of Kiwirrkurra Community	Widespread

Higher Order	Genus and species	Location	SRE Status
	Synsphyronus 'Kiwirrkurra 2'	100 km E. of Kiwirrkurra; 3 km E. of Mt Webb	Widespread
Chilopoda: Scutigeridae	*Pilbarascutigera incola*?	Lake Mackay, WAM site 6	Widespread

3.2 SRE Field Survey

The SRE field survey recorded 11 taxa of invertebrates from three classes, seven orders and eight families that have the potential to contain SRE taxa (Table 5). Seven taxa were identified as Possible SRE species (refer Table 3) primarily due to the groups being considered data deficient, and the absence of other collections in the region making the assignation of SRE status difficult using the data from a single field survey. The potential SRE taxa identified in Table 5 are discussed further in Section 4.1. The majority of species recorded are widespread in the arid and semiarid regions of Australia, although many do represent new records for Lake Mackay primarily due to the lack of previous collecting in the area.

Table 5 Invertebrates recorded and examined for SRE status

Higher Order	Genus and species	Site	Abundance	SRE Status
Crustacea: Isopoda: Armadillidae	*Buddelundia* sp IS01	SRE 1, SRE 2	2, 1	Possible (A)
	Buddelundia sp IS02	SRE 5, SRE 6, SRE 10	1, 1, 2	Possible (A)
Arachnida: Pseudoscorpiones: Olpiidae	*Indolpium* sp. IS01	SRE 9	1	Possible (A)
	Indolpium sp. IS02	SRE 7	5	Possible (A)
Arachnida: Scorpiones: Buthidae	*Lychas cf. marmoreus*	SRE 1, SRE 3, SRE 4, SRE 5	1, 2, 1, 1	Possible (A)
	Lychas sp. IS01	SRE 3, SRE 5, SRE 6	3, 8, 3	Possible (A)
Arachnida: Scorpiones: Urodacidae	*Urodacus yaschenkoi*	SRE 3, SRE 5, SRE 6	>50	Widespread
Diplopoda: Polyxenida: Polyxenidae	*Unixenus attemsi*	SRE 9	1	Widespread
Chilopoda: Scolopendromorpha: Scolopendridae	*Arthrorhabdus paucispinus*	SRE 1, SRE 2, SRE 6	1, 1, 1	Widespread
	Arthrorhabdus mjobergi	SRE 4, SRE 6	1	Widespread
	Scolopendra mositans	SRE 2	1	Widespread
Insecta: Blattodea: Blattidae	*Megazosteria purpurascens*?	SRE 7, opportunistic	2	Widespread
Insecta: Coleoptera: Carabidae: Cicindelinae	*Cicindela* sp. *cf. mastersi*	Lake Mackay surface	3	Possible (A)

Several species were found to be widespread in the arid zone including the highly abundant scorpion species *Urodacus yaschenkoi* from sand dune areas in the Project area. Likewise, the centipedes recorded were all widespread species including those taxa recorded from the two islands in Lake Mackay. The Polyxenid millipede *Unixenus attemsi* is a widespread species of the pin cushion millipedes, known to occur throughout Bassian Australia.

Plate 1 The widespread arid zone scorpion *Urodacus yaschenkoi* from a sand dune at SRE Site 3 to the south of Lake Mackay

3.3 Aquatic Macroinvertebrate Survey

The aquatic macroinvertebrate sampling undertaken in April 2017 recorded no invertebrates within Lake Mackay. Three of the nine samples were undertaken in claypans to the south of Lake Mackay and these samples recorded eight taxa of aquatic macroinvertebrates from four classes, six orders and six families (Table 6). Few other records exist for the Lake Mackay region for aquatic macroinvertebrates from either the records of the Western Australian Museum or on the Atlas of Living Australia (www.ALA.org) which reflects a paucity of collecting in the region. The most diverse group recorded was the diving beetles with three species (Plate 2, Plate 3).

Table 6 Aquatic macroinvertebrate recorded

Higher Order	Genus and species	Site	Abundance	Notes
Mollusca: Bivalvia: Cyrenidae	*Corbicula australis*	Aquatic Site 9	1	Claypan, widespread
Crustacea: Ostracoda: Darwinulidae	*Penthesilenula brasiliensis*	Aquatic Site 9	25	Claypan, Cosmopolitan southern hemisphere
Arachnida: Acarina	Mesostigmata sp.	Aquatic Site 9	1	Terrestrial species
Insecta: Hemiptera: Heteroptera: Notonectidae	*Anisops stali*?	Aquatic Site 7, Aquatic Site 8	8	Claypan, widespread arid species
Insecta: Odonata: Libellulidae	*cf. Rhodotemis lieftincki?*	Aquatic Site 9	1 (larvae)	Widespread in Northern Australia. Specimen rotting and damaged. Collected dead.
Insecta: Coleoptera: Dytiscidae	*Eretes australis*	Aquatic Site 7	4	Claypan, widespread
	Paroster michaelseni?	Aquatic Site 8	1	Claypan, widespread
	Cybister tripunctatus	Aquatic Site 8	1	Claypan, widespread

Plate 2 The widespread dytiscid diving beetle *Eretes australis* from a claypan near Lake Mackay. Scale 1mm

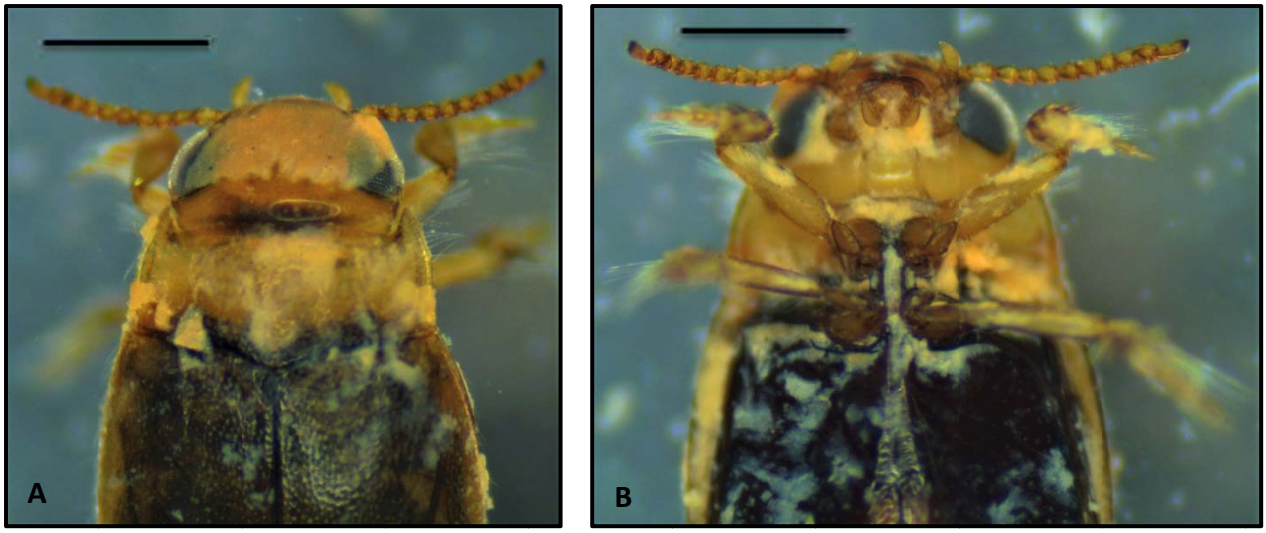

Plate 3 The dytiscid diving beetle *Paroster michaelseni?* from a claypan near Lake Mackay. Scale 1 mm. (A) Dorsal view (B) Ventral view

3.4 Water Quality

The water quality of each site sampled for aquatic macroinvertebrates is shown in Table 7. The shallow depth of most sites means that the water temperature reflects the ambient temperature of the environment. The pH was found to be higher in the ephemeral freshwater claypans, possibly due to higher organic content. The conductivity measurements show the claypans to be fresh to brackish, while the water within Lake Mackay is hypersaline. The ORP was found to be favourable for invertebrates in all habitats while the dissolved oxygen content was higher in the claypans, possibly due to fresher water allowing for greater saturation compared with the hypersaline water in the lake itself.

Table 7 Water quality for the aquatic macroinvertebrate sites

Site	Description	Water Depth cm	Temperature ˚C	pH	Conductivity (µs/cm)	ORP	Dissolved Oxygen %
1A	Lake Mackay, SE corner	<15	22.0	6.22	140,263	95.0	50.8
2A	Lake Mackay	<15	25.4	7.10	167,626	98.2	53.0
3A	Lake Mackay	<15	18.8	6.25	204,787	122.4	40.4
4A	Lake Mackay	<15	23.7	7.11	243,343	100.6	32.8
5A	Lake Mackay	<2	25.4	6.73	261,732	113.5	26.1
6A	Lake Mackay	<15	24.3	7.59	239,504	94.8	34.7
7A	4 ha, claypan	>30	18.5	8.80	402	-3.5	80.7
8A	0.1 ha, tiny claypan	8	23.2	8.54	2,255	95.3	73.7
9A	21 ha, large claypan	>50	22.5	8.95	3,326	109.7	114.9

4. Discussion

4.1 SRE Invertebrate Assessment

The SRE survey recorded seven potential SRE invertebrate species from the Lake Mackay SOP Project area. There were no 'Confirmed' or 'Likely' SRE species recorded during the survey (refer Table 3). The majority of the species determined to be "Possible" SRE taxa is due to incomplete taxonomy and unknown species distributions. Almost all the possible SRE species were found at multiple locations during the survey indicating that their distributions are wider than the current survey could determine. Only a single species, *Buddelundia* sp IS01, was found solely on the lake islands which currently indicates that, in general, the offshore islands are simply more depauperate communities of the normal mainland fauna, however, further surveys in multiple seasons would be required to support this assertion. The taxonomy of the Olpiidae pseudoscorpions and the *Lychas* scorpions is generally poor and so specimens have been placed into the closest species/genus possible and it is unlikely than any of these represent true SRE taxa.

Table 8 Potential SRE invertebrates recorded in the Project area

Higher Order	Genus and Species	Site	Abundance	SRE Status
Crustacea: Isopoda: Armadillidae	*Buddelundia* sp IS01	SRE 1, SRE 2	2, 1	Possible (A)
	Buddelundia sp IS02	SRE 5, SRE 6, SRE 10	1, 1, 2	Possible (A)
Arachnida: Pseudoscorpiones: Olpiidae	*Indolpium* sp. IS01	SRE 9	1	Possible (A)
	Indolpium sp. IS02	SRE 7	5	Possible (A)
Arachnida: Scorpiones: Buthidae	*Lychas* cf. *marmoreus*	SRE 1, SRE 3, SRE 4, SRE 5	1, 2, 1, 1	Possible (A)
	Lychas sp. *IS01*	SRE 3, SRE 5, SRE 6	3, 8, 3	Possible (A)
Insecta: Coleoptera: Carabidae: Cicindelinae	*Cicindela* sp. cf. *mastersi*	Lake Mackay surface	3	Possible (A)

4.1.1 Crustacea

Isopoda: Armadillidae: *Buddelundia* sp IS01 and IS02

The taxonomic framework of slaters in Australia is extremely poorly making assessment of SRE status for this fauna difficult. The armadillid isopods from the Australian genus *Buddelundia* are extremely diverse in arid Australia with over 150 putative species identified in collections, primarily from Western Australia, but requires taxonomic revision at a family level making the proper identification of species difficult (Dalens 1992; Judd and Perina 2013).

Two putative species of *Buddelundia* (IS01 and IS02) were identified during the current survey. The two species do not show sympatric distributions, with *Buddelundia* IS01 currently only recorded from SRE sites 1 and 2 located on the islands in Lake Mackay. The current level of survey does not

allow any definitive assignation of SRE status for either species as both are considered to be data deficient and more extensive surveys would be required to confidently refer to either species as an SRE. These two species are considered as Possible (data deficient) SRE species

4.1.2 Arachnida

Pseudoscorpionida: Olpiidae: *Indolpium* sp. IS01 and IS02

The taxonomy of the Olpiidae is poorly known and, until further taxonomic resolution has been obtained, all species are considered to be Possible SRE species in Western Australia due to a deficiency in data. Molecular sequencing of Pilbara and other Western Australian specimens is currently being undertaken by the Western Australian Museum and these data will be used in the future to determine if species are widespread or restricted in distribution. It must be stated, however, there is considerable difference between molecular and morphological data, with generic and species boundaries highly uncertain making meaningful results unlikely, except in the medium to long term.

The Bushblitz arachnid survey (Baehr 2015) recorded two additional unnamed species of Olpiidae, from the genera *Austrohorus* and *Indolpium*, although neither of these species were recorded during the current survey.

Scorpiones: Buthidae: *Lychas* sp. cf. *marmoreus*

The scorpion genus *Lychas* is a diverse genus in Australia, with multiple undescribed species. The taxonomy of the group, however, remains largely unresolved, making identification and assignation of SRE status difficult. The species *Lychas* cf. *marmoreus* was recorded at four separate sites, mostly sand dune habitats and an island on Lake Mackay, indicating that the species is likely to be widespread. Sandy habitats in the area are continuous and widespread thus indicating that the species is unlikely to be restricted to any of the proposed Project impact areas. The full distribution of *Lychas* cf. *marmoreus* is unknown and so the species has been classified as a Possible SRE species (data deficient).

Scorpiones: Buthidae: *Lychas* sp. IS01

The species *Lychas* sp IS01 appears to be an undescribed species and was recorded at three separate sites along sandy habitats on the southern side of Lake Mackay, indicating that the species is likely to be widespread. Sandy habitats in the area are continuous and widespread thus indicating that the species is unlikely to be restricted to any of the proposed Project impact areas. The full distribution of *Lychas* sp IS01 is unknown and so the species has been classified as a Possible SRE species (data deficient).

4.1.3 Insecta:

Carabidae: Cicindelinae: *Cicindela* sp. cf. *mastersi*

This species was collected at two localities during the day from the bed of Lake Mackay during a walking transect between several of the islands. Cicindelid beetles, commonly known as Tiger beetles, are an extremely diverse subfamily of fast moving predaceous ground beetles that often hunt at night (Lawrence and Britton 1991). The species is considered a Possible SRE species as it may

be restricted to the bed of Lake Mackay based upon some other Cicindelid beetle distributions and behaviour, however, *Cicindela* sp. cf. *mastersi* is not anticipated to be significantly impacted due to the size of Lake Mackay compared to the proposed footprint of the Project.

4.2 Aquatic Macroinvertebrate Assessment

All of the species recorded during the aquatic macroinvertebrate survey are widespread and common throughout the Australian arid zone and, although most records are new for Lake Mackay, they represent an infilling of distributional records rather than range extensions. The water quality data show that Lake Mackay is hypersaline and the ephemeral claypans in the surrounding region are fresh to brackish and provide excellent habitat for aquatic macroinvertebrates.

The most notable absence from this survey is the lack of brine shrimp (Anostraca) from the salt lake samples, although population levels are known to rapidly increase following favourable conditions and then decline rapidly when conditions change. As a result, sample timing may have been a contributing factor in the apparent absence of brine shrimp in the lake.

5. Conclusions and Recommendations

The SRE and aquatic macroinvertebrate survey at the Lake Mackay SOP Project undertaken in April and May 2017 recorded a diverse range of invertebrate species, many of which are new records for the Lake Mackay region. This is primarily due to the lack of previous collecting in the area, rather than the region containing a unique species assemblage any different from other parts of the central arid region of Australia.

The SRE survey recorded seven potential SRE invertebrate species from the Lake Mackay SOP Project area. There were no 'Confirmed' or 'Likely' SRE species recorded during the survey. The majority of the species determined to be "Possible" SRE taxa is due to incomplete taxonomy and unknown species distributions. Almost all the possible SRE species were found at multiple locations during the survey indicating that their distributions are wider than the current survey could determine. Only a single species, *Buddelundia* sp IS01, was found solely on the lake islands which currently indicates that, in general, the offshore islands are simply more depauperate communities of the normal mainland fauna, however, further surveys in multiple seasons would be required to support this assertion. Currently, no impacts to the lake islands are anticipated from the proposed Project and so there are no expected impacts to *Buddelundia* sp IS01.

All the species recorded during the aquatic macroinvertebrate survey are widespread and common throughout the Australian arid zone and, although most records are new for Lake Mackay, they represent an infilling of distributional records rather than range extensions.

The development of the Lake Mackay SOP Project is not anticipated to significantly impact any species recorded in these surveys. When the specific Project footprint and location of infrastructure areas is finalised these conclusions should be revisited to ensure they remain valid. Due to the limited extent of the processing and infrastructure facilities currently being proposed, it is not expected that the outcomes of this assessment would change as a result of changes to the Project footprint and location of infrastructure areas.

5.1 Recommendations

The following recommendations are made with regard to the potential development of the Lake Mackay SOP Project area:

- No further surveys for terrestrial SRE invertebrates are required to meet the EPA Technical guidance, sampling of short range endemic invertebrate fauna (EPA 2016)
- No further aquatic macroinvertebrate surveys are required.

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Appendix 1

Department of Parks and Wildlife Conservation Codes (November 2015)

Department of Parks and Wildlife

CONSERVATION CODES

For Western Australian Flora and Fauna

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

Categories of specially protected fauna and flora are:

T **Threatened species**

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

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

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

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

CR **Critically endangered species**

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

EN **Endangered species**

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

VU **Vulnerable species**

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

EX **Presumed extinct species**

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

IA **Migratory birds protected under an international agreement**

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

CD Conservation dependent fauna

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

OS Other specially protected fauna

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

P Priority species

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

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

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

1 Priority 1: Poorly-known species

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

2 Priority 2: Poorly-known species

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

3 Priority 3: Poorly-known species

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

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

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

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

Appendix 2

SRE Site locations and habitats

SRE Site 1 481797E 7525583N Island in Lake Mackay	
SRE Site 2 484291E 7519290N Island in Lake Mackay	

SRE Site 3 464210E 7493493N Sand ridge near claypan on south side of Lake Mackay	
SRE Site 4 477770E 7487347N Freshwater claypan on south side of Lake Mackay	

SRE Site 5 464687E 7491478N Sand dune and swale on south side of Lake Mackay	
SRE Site 6 442307E 7499962N Sand dune and swale on south side of Lake Mackay	

SRE Site 7 451014E 7502291N Island in Lake Mackay	
SRE Site 8 447315E 7501624N Sandy Island in Lake Mackay	

SRE Site 9 435754E 7499668N Southern lake shore of Lake Mackay	
SRE Site 10 438621E 7497742N Low sand dune on southern side of lake Mackay	

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