Stygofauna baseline survey

Murray Drainage and Water Management Plan and Associated Studies

This report was prepared for the Department of Water

September 2010
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Executive Summary

GHD has been commissioned by the Department of Water (DoW) to prepare a Drainage and Water Management Plan (DWMP) for the Murray area. As part of the planning process, a scientific understanding of surface and groundwater regimes and the Ecological Water Requirements (EWR's) of each selected wetland is critical for identifying potential impacts on the natural environment.

Stygofauna (aquatic subterranean fauna) represent a fauna component only recently identified within groundwater aquifers outside of limestone and karst terrains in the past decade, however it is rapidly becoming apparent that many aquifers contain diverse invertebrate communities (Humphreys 2006). The current study provides a baseline stygofauna survey of the superficial aquifer within the Murray area. This area has never previously been sampled for stygofauna.

The regional survey for stygofauna within the superficial aquifer in the Shire of Murray sampled 20 bores from 5 different wetland areas and recorded stygofauna from 2 bores during a single phase sampling survey. A single new species of cyclopoid copepod (Mixocyclops sp. nov.) and two species of parabathynellid? were recorded. Further identification of the parabathynellid? taxa is currently underway. This indicates the presence of a potentially diverse stygofauna community within the aquifer.

The current single sampling event provides an indication of the presence of stygofauna within the Murray superficial aquifer but can not be relied upon to demonstrate the full diversity and/or distribution of the community. To achieve a better understanding of the community level diversity, a multi season sampling program must be undertaken (Hancock and Bolton 2008). Sampling over multiple seasons will also enable a more confident determination of local species endemism and any regional distribution of the stygofauna community recorded.

The EWR to support this stygofauna community will integrate with the requirements of any groundwater dependent vegetation within the study area. Rapid decreases in standing water levels may adversely affect the stygofauna community, as would draining isolated perched aquifers that may contain highly localised endemic faunas.

The results of the current baseline stygofauna study form the basis for the recommendations below:

- Additional two (2) sampling events for stygofauna within the Murray superficial alluvial aquifer, six (6) months apart;
- Monitoring of water quality for any significant alteration to water quality such as pH or salinity; and,
- As adjacent aquifers are investigated for EWR planning stygofauna baseline surveys should constitute part of survey.
1. Introduction

1.1 Aim of Study

GHD has been commissioned by the Department of Water (DoW) to prepare a Drainage and Water Management Plan (DWMP) for the Murray area. This plan will provide guidance to the Department of Planning, the Shire of Murray, land owners and potential developers to inform future land use planning processes in the area.

As part of the planning process, a scientific understanding of surface and groundwater regimes and the Ecological Water Requirements (EWR’s) of each selected wetland is critical for identifying potential impacts on the natural environment.

Stygofauna (aquatic subterranean fauna) represent a fauna component only recently identified within groundwater aquifers outside of limestone and karst terrains in the past decade, however it is rapidly becoming apparent that many aquifers contain diverse invertebrate communities (Humphreys 2006). The current study aims to provide a baseline stygofauna survey of the superficial aquifer within the Murray area. This area has never previously been sampled for stygofauna. The presence of significant stygofaunal communities in the north of the Swan Coastal Plain (SCP) at Yanchep Caves (Jasinska and Knott 2000) suggests that other stygofauna communities may be present in other suitable habitats on the SCP.

1.2 Subterranean Fauna

Subterranean fauna is a collective term that refers to both troglofauna (terrestrial subterranean fauna inhabiting air voids) and stygofauna (aquatic subterranean fauna) (Humphreys 2000). Stygofauna is commonly divided into several categories that describe a particular species degree of dependence upon the subterranean environment, these are detailed below:

- **Stygobites**: animals that are obligate subterranean species, and mostly show morphological adaptation to subterranean habitats (troglomorphisms) including depigmentation, loss or reduction of eyes, elongation of appendages, flightlessness or wing reduction, and extra sensory hairs.
- **Stygophiles**: animals that may spend their entire life in subterranean habitats but are also capable of living in epigean environments.
- **Stygoxenes**: animals that use the subterranean environment, but require surface environments to complete part of their lifecycle (generally either feeding or breeding). Common trogloxenes are cave dwelling bats and cave crickets that leave subterranean habitats to feed.

The terms above refer to troglofauna when the prefix is altered to troglo (Humphreys 2000). Due to the reliance upon ecological information to determine if a species is a stygobite, it is more reliable to rely upon troglomorphism as evidence for taxa to be obligate subterranean species.

1.3 Study area

The study area of the Drainage Water Management Plan area (DWMP) encompasses an area of 464.6 km² and extends to the Nambeelup Brook catchment in the north; the Lower Serpentine River and Peel Inlet/Harvey Estuary in the west; the Fauntleroy Drain catchment in the south and the Murray River and Darling Range foothills in the east (Figure 1).
1.4 Existing land use
The existing land use within the study area is predominately rural. Urban and urban deferred areas are mainly located around the town sites of Furnissdale, Yunderup, Ravenswood, Pinjarra and North Dandalup. Regional open space areas exist in scattered locations along the Peel Harvey estuary and Murray and Serpentine rivers. Industrial areas exist near Pinjarra and Stake Hill.

1.5 Topography
The topography for the majority of the study area is relatively flat. A rise of elevation from 5 m AHD to 50 m AHD occurs in the east of the study area. There are some localised elevated areas across the study area.

1.6 Geology
The DWMP area lies within the Perth Basin which is an area containing about 8,000 m of Phanerozoic sediments. The area is bounded to the east by the Darling Fault. The geology in the Murray area consists primarily of Quaternary (Pleistocene) deposits of Guildford Formation and Bassendean Sand and form a stratigraphically complex sequence up to 90 m thick. Alluvium and estuarine deposits are also seen to overlie the Pleistocene deposits at isolated locations. These superficial formations unconformably cover Mesozoic sediments.

The superficial formations form an unconfined aquifer which consists predominantly of sand and limestone in the west and of sand and clay in the east where the clay (Guildford Formation) forms an important aquitard in the upper part of the formation.

The Guildford Formation consists of a sand member (west) and a clay member (east). The sand and clay members interdigitate in the central part of the coastal plain and both are seen to outcrop in the study area. The sand member consists predominantly of grey poorly sorted sand which is generally fine to very-coarse grained with minor beds of brown or grey clay and clayey sand. A layer of coffee-brown ferruginized (limonitic) sand is generally found near the water table. The clay member consists predominantly of brown or grey clay and sandy clay. The Guildford Formation extends westwards from the foot of the Darling Scarp to the unconformable contact with the coastal Tamala Limestone. Evidence exists that suggests that the clay member was deposited as alluvial fans, derived from weathering of the Yilgarn Block. The alluvial fans grade laterally into the shallow marine fluvial sediments of the sand member.

The Bassendean Sand consists of white to pale grey and occasionally brown, moderately sorted, fine to medium grained quartz sand containing traces of heavy minerals. The Bassendean Sand unconformably overlies the Guildford Formation. The sand is of eolian origin and forms a thin cover over much of the coastal plain (up to 15 m).

Alluvium consisting of grey and brown silt and clayey sand occurs along the rivers and tributaries. Estuarine and lagoonal deposits comprising black, brown, and grey humic sandy clay, silt, marl, clayey sand, sand and calcarenite unconformably overlay the Guildford Formation.

The geology of the Murray River study area is described in detail in Table 1.
### Table 1  Geology of the Murray River study area

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Area (km²)</th>
<th>Percentage composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvium</td>
<td>8.84</td>
<td>2.36</td>
</tr>
<tr>
<td>Bassendean sand</td>
<td>89.75</td>
<td>24.00</td>
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<tr>
<td>Colluvium</td>
<td>14.24</td>
<td>3.81</td>
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<tr>
<td>Estuarine, lagoonal and lacustrine deposits</td>
<td>20.69</td>
<td>5.53</td>
</tr>
<tr>
<td>Even-grained granitic rocks</td>
<td>0.13</td>
<td>0.04</td>
</tr>
<tr>
<td>Gneissic rocks of Darling Scarp</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>Guildford formation</td>
<td>210.94</td>
<td>56.40</td>
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<td>Laterite</td>
<td>0.15</td>
<td>0.04</td>
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<td>Muchea limestone</td>
<td>2.57</td>
<td>0.69</td>
</tr>
<tr>
<td>Swamp and lacustrine deposits</td>
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<tr>
<td>Tamala limestone</td>
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<td>0.01</td>
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<tr>
<td>Water</td>
<td>6.25</td>
<td>1.67</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>373.98</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

#### 1.7 Hydrogeology

The Guildford clay member forms a significant aquitard in the upper part of the eastern Perth Basin where the water table generally lies within 1 to 2 m below ground surface. The water table depth is much greater in areas where thick sequences of Bassendean Sand (< 30 m) occur.

On a local scale, layers identifiable as aquitards are frequently seen. These are formed by silts and clays which do not persist laterally. These aquitards result in the existence of elevated perched aquifers which are laterally discontinuous.

The superficial aquifer is underlain by Mesozoic sediments which generally have low permeability, though locally both upward and downward leakage occurs.

#### 1.8 Environmental Legislation

Subterranean fauna are subject to Federal and State Acts when undertaking environmental assessments for development projects:

- *Environmental Protection Act 1986,*
- *Wildlife Conservation Act 1950;* and,
In Western Australia, the Environmental Protection Authority (EPA) ensures adequate protection of important habitats for subterranean fauna species. The EPA issues guidance statements in accordance with the Environmental Protection Act 1986, which provide the basis for the EPA’s evaluation of development proposals subject to environmental assessment. Two related guidance statements have been issued relating to subterranean fauna, Environment Protection Authority Guidance Statement No. 54 (Subterranean Fauna) and Environment Protection Authority Guidance Statement No. 54a (Sampling Methods and Survey Considerations). These guidance statements outline the minimum level of information necessary to enable the assessment of subterranean fauna as an environmental factor. The EPA also ensures that developments do not potentially threaten the viability of any subterranean species, in accordance with the Wildlife Conservation Act 1950. This Act is administered by the Department of Conservation and Environment (DEC) who advises the EPA. Fauna species which are recognised as rare, threatened, or have high conservation value, may be specially listed under this Act via the Wildlife Conservation (Specially Protected Fauna) Notice. The Federal Environment Protection and Biodiversity Conservation Act 1999, is relevant where certain threatened species and threatened ecological communities (TECs) listed under this Act may be impacted by a proposed action.

1.9 Previous Studies

In Western Australia, stygofauna have been documented from most regions and areas including the Kimberley, Pilbara (Pilbara craton and Barrow Island), Carnarvon (Cape Range), Murchison, Goldfields, South West (Perth Basin and Leeuwin Naturaliste Ridge), South Coast (Albany and Nullarbor Plain). Stygofauna is widespread and occurs in a range of hydrogeological environments including karstic, fractured rock, vuggy Channel Iron Deposits (CID) and porous aquifers, in addition to springs, parafluvial and hyporheic environments (Eberhard et al. 2005). In the Pilbara region, sampling conducted in the last decade has revealed the Pilbara to be a globally significant hotspot for stygofauna diversity (Humphreys 2000b; Eberhard et al. 2006).

Stygofauna has previously been recorded from Yanchep Caves on the Swan Coastal Plain (SCP), where it is reliant upon aquatic root mats within the caves (Jasinska and Knott 2000). This stygofauna community is currently classified as a Threatened Ecological Community due to falling water levels in the region. No other widespread sampling for stygofauna has previously been undertaken within the SCP.

1.10 Report Limitations and constraints

The study purpose was to provide baseline information on stygofauna occurrence and distribution in relation to the Murray drainage area, and provide a base for future survey work as required. This study was limited to the requirements specified by the client and the extent of information made available to the consultant 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.
2. Stygofauna Baseline Survey

2.1 Methods

Stygofauna were sampled using modified plankton nets in accordance with the Environmental Protection Authority Guidance Statement 54 and 54a (EPA 2003, 2007). Bores were sampled for stygofauna using a plankton net of suitable diameter (32 mm) to match the bore/well. The net (either 125 μm or 50 μm mesh), with a weighted vial attached, was lowered into the bore and then hauled up through the water column.

The net was dropped to the base of the bore then agitated up and down (±1 m) several times to disturb the bottom sediment and any stygofauna contained within. At most bores six hauls of the entire water column were conducted. Three hauls were undertaken with both the 125 μm and the 50 μm mesh nets. Each net haul sample was transferred to a labelled polycarbonate container and preserved in 100% alcohol. Samples with large quantities of sediment were elutriated prior to preservation. To minimise the possibility of stygofaunal cross contamination, the nets were treated with Decon 90 solution and thoroughly rinsed in water and air-dried.

Sorting occurred in the laboratory under a dissecting microscope and was undertaken by Dr Timothy Moulds. Each taxon was identified to the lowest taxonomic rank possible using published keys and descriptions, and the numbers of each taxon were recorded. Specialist identification of copepoda specimens was undertaken by Dr Tom Karanovic.

2.2 Survey Effort and Timing

Sampling for stygofauna was undertaken during a single phase in February 2010. Nineteen (19) water bores in the vicinity of six wetlands within the Murray drainage were sampled for the presence of stygofauna: 3945 (Barragup), 4835 (Airfield), 5032 (Greyhound), 5056 (Phillips Rd), 5724 (Benden Rd), and bore HS-097 (Table 2, Figure 1).

Bores sampled were between 3.6 – 71 m deep, with an average depth of 15.6 m.

2.3 Survey Staff Qualifications

Stygofauna field investigations were undertaken by experienced GHD ecologists and comprised of:

- Dr Timothy Moulds BSc (Hons) Geol., PhD. Invert. Ecol.
- Gaynor Owen BSc (Hons) Env Sc.

Survey work was undertaken under the collection licences issued by the Department of Environment and Conservation:

- SF007278; Licensee T Moulds; Issued 12/02/2010.
### Table 2  Phase 1 Sample Locations

<table>
<thead>
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<th>WRC ID</th>
<th>GHD Bore ID</th>
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<th>Date Sampled</th>
<th>GHD Field No.</th>
<th>Drilled Depth (mbgl)</th>
<th>Cased Depth (mbgl)</th>
<th>Slotted Interval (mbgl)</th>
<th>GW Level</th>
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<tr>
<td></td>
<td></td>
<td>Easting</td>
<td>Northing</td>
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<td></td>
<td></td>
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<td></td>
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<td>62.0 - 68.0</td>
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</tr>
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</table>
3. Stygofauna Results

3.1 Species Diversity and Abundance

Two of 19 bores sampled yielded stygofauna (11%). A single species of cyclopoid copepod was recorded from bore HS108-2A and 2 species of Parabathynellidae were recorded from bore HS099-1A (Figure 1). The survey recorded 2 copepod individuals and approximately 50 Parabathynellids from the two bores, ranging from adults to juveniles. These bores intersect the superficial alluvial aquifer above the Leederville Aquifer and are slotted with 0.4 mm slots.

The copepod was identified as a new species of *Mixocyclops* Kieffer 1944 and some superficial similarities exist with the recently described genus from the Pilbara region and tropical Queensland (Karanovic *et al.*, in press), but these are two completely different lineages (Karanovic 2010). There are only three species described so far in the genus *Mixocyclops*: one from Crozet Island by Kiefer (1944), one from Tasmania by Shappuis (1951), and one from the Yanchep Caves in Western Australia by Tang & Knott (2009). Not surprisingly, this new species is most closely related to the Western Australian *M. mortoni* Tang & Knott 2009, and some of the most important differences include the following: genital double-somite larger; dorsal setae on caudal rami longer; A1 much shorter, with some very wide segments; Enp2P1 without proximal inner seta; Enp2P2 with no inner seta; and Enp2P3 & Enp2P4 with no inner setae (2 in *M. mortoni*) (Karanovic 2010).

No other stygofauna was recorded from any bores sampled during the regional survey. The parabathynellid specimens are currently undergoing further identification.

3.2 Water Quality

Water quality parameters were collected from each bore sampled for stygofauna by DoW. Values collected are presented below to provide an indication of general water quality for areas sampled.

<table>
<thead>
<tr>
<th>Hole ID</th>
<th>Date of Sample</th>
<th>Temp ºC</th>
<th>pH</th>
<th>EC mS/cm</th>
<th>DO mg/L</th>
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4. Discussion and Recommendations

The regional survey for stygofauna within the superficial aquifer in the Shire of Murray recorded stygofauna from 2 bores during a single phase sampling survey. This indicates the presence of a potentially diverse stygofauna community within the aquifer.

The current single sampling event provides an indication of the presence of stygofauna within the Murray superficial aquifer but can not be relied upon to demonstrate the full diversity and/or distribution of the community. The copepod specimens represent a species new to science, and are closely related to a species recorded from Yanchep National Park situated in the north of the SCP (Karanovic 2010). To achieve a better understanding of the community level diversity, a multi season sampling program must be undertaken (Hancock and Bolton 2008). Sampling over multiple seasons will also enable a more confident determination of local species endemism and any regional distribution of the stygofauna community recorded.

The majority of stygofauna species are restricted to a single aquifer (Humphreys 2008), and further taxonomic identification is currently underway to determine if the species recorded during the current survey are restricted to this aquifer or are found more widely in other aquifers or surface waters. The high degree of aquifer specific endemism worldwide would indicate that the stygofauna taxa recorded in the current survey are likely to represent undescribed species, as there has been no other sampling for stygofauna in this region previously.

The EWR to support this stygofauna community will integrate with the requirements of any groundwater dependent vegetation within the study area. Rapid decreases in ground water levels may adversely affect the stygofauna community, as would draining isolated perched aquifers that may contain highly localised endemic faunas.

The results of the current baseline stygofauna study form the basis for the recommendations below:

- Additional two (2) sampling events for stygofauna within the Murray superficial alluvial aquifer, six (6) months apart;
- Monitoring of water quality for any significant alteration to water quality such as pH or salinity; and,
- As adjacent aquifers are investigated for EWR, stygofauna baseline surveys should constitute part of these investigations.
5. References


Appendix A

Figures

Figure 1  Waterbores sampled for stygofauna in the Murray Drainage
### Document Status

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