Environmental Monitoring and Investigations of Gnangara Mound

Yanchep Cave Streams and East Gnangara (Lexia) – Egerton Spring & Edgecombe Spring: Invertebrate Monitoring

Report to

Department of Water
Government of Western Australia

by

B. Knott, A.W. Storey & D. Tang

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Aquatic Research Laboratory
School of Animal Biology

THE UNIVERSITY OF WESTERN AUSTRALIA

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Frontispiece: Lex Bastian, indicating a much reduced water level in Cave YN555 on Lot 51, 10th October , 2007 (photo: AW Storey).

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EXECUTIVE SUMMARY

Eleven caves in the Yanchep area were visited in spring 2007 to sample the aquatic invertebrate fauna and water chemistry Boomerang Cave (YN99), Cabaret Cave (YN31), Carpark Cave (YN18), Water Cave (YN11), Cave on Lot 51 (YN555), Mire Bowl (YN61), Orpheus Cave (YN256), Gilgie Cave (YN27), Twilight Cave (YN194), Fridge Grotto (YN81) and Spillway Cave (YN565). Gilgie Cave, Mire Bowl, Carpark and Fridge Grotto were dry, and therefore no fauna samples were collected. Twilight Cave and Spillway Cave were considered unsafe and therefore not entered. Two springs on the Gnangara Mound were also sampled; Egerton and Edgecombe Springs. Caves were sampled on 9th & 10th October, and the springs were sampled on 9th October 2007. In addition, several newly discovered springs west of Bullsbrook; Sue's and Bill's springs and Gaston Swamp were sampled in early February 2008, and the results are included here for comparison.

Water Quality and Quantity

Water levels in the caves were generally very low compared to historical levels and no surface water flow was evident. Water quality was relatively consistent across all caves and between years, indicating no fundamental change in basic water quality since the commencement of sampling in 1998. Water quality within the caves was generally characterised by low salinity, circum-neutral pH and medium dissolved oxygen levels, consistent with groundwater flowing from the Gnangara Mound. Ionic composition was as expected for groundwater-derived systems of the Swan Coastal Plain. Elevated concentrations of nitrogen (as nitrate + nitrite) and sulphate were again recorded from YN555.

Water levels in the springs were variable. Egerton Spring was flowing relatively strongly, however Edgecombe Spring had only a very thin film of water running near the discharge point. Water quality of the springs was generally indicative of good quality, fresh water and was relatively constant over time. However, a continuing downward trend in pH levels was evident at Egerton Spring. This decrease is of concern as low pH is detrimental to aquatic fauna, and as Egerton Spring appears to be in a zone of high risk of acid sulphate soils (ASS) the possibility of the influence of ASS on this site should be investigated. Elevated concentrations of nitrogen (as nitrate + nitrite) were recorded from both springs, with levels at Edgecombe Spring approximately 40 times greater than the recommended ANZECC/ARMCANZ (2000) guidelines.

Aquatic Fauna

Faunal sampling of caves again recorded low abundance and diversity. Although there has been no evidence of recovery in the aquatic fauna in the caves, there appears to be some success from the reticulation systems resulting in observable improvement in the condition of the remaining tree root mats. However, root mats observed in Cabaret Cave and Carpark Caves have declined in condition since last year (November 2006), and this likely reflects poor maintenance of the reticulation systems in these caves, both of which were not functioning in October 2007, with the liners predominantly dry.

Caves including the cave on Lot 51 (YN555) exhibited a decline in species diversity this sampling period and the significant ancient cavernicole taxa first recorded in YN555 in spring 2002 were notably absent. However, the amphipod discovered in Orpheus Cave was still present

Results continue to cause concern, particularly as a result of declining water levels. Hydrographs for caves which have had Australian Height Datum (AHD) surveyed, and have a bore in close

proximity, indicate a continuing decline in water levels. Therefore, loss of water from the cave streams continues as the major threat since there is no evidence of a decline in water quality.

With respect to the current state of the root mat communities, it must be hoped that there are some extant cave fauna on root mats located in inaccessible parts of the cave system from where recolonisation may occur. Consequently, it is recommended that the first efforts towards recovering the root mat fauna from any refuge areas should be directed at (1) restoring flowing water to the cave streams, and (2) restoring the growth of extensive root mats in the cave streams. By ensuring the fundamental habitat requirements are catered for (*i.e.* permanent, flowing water and healthy root mats) there is the possibility that fauna may recolonise the caves, should it be present in some unknown nearby refuge.

Recharging the local aquifers under the caves from the newly constructed production bore (to the west) has the potential to increase flows, increase vigour of root mats (*i.e.* sustain habitat) and allow return of fauna from unknown refuge areas, assuming such areas exist. Return of fauna from such areas in unlikely to be rapid, as the cavernicole fauna is not highly mobile. However, monitoring should continue on an annual basis, whilst recharge occurs, to document any changes in water quantity, quality and in fauna assemblages. Unfortunately delays in implementing the recharge system, combined with inadequate maintenance of the existing reticulation systems, have resulted in the decline in condition of root mats in some caves. It is hoped they recover once the reticulation system is operational.

Species richness at Egerton Spring was again high, with all crustacean groups (Amphipoda, Copepoda, Cladocera, Ostracoda) represented and most in relatively high abundance.

The fauna sampled from Edgecombe Spring comprised one juvenile stages of a dipteran insect with a highly mobile adult phases (a ceratopogonid), only specimen of an ostracod, and an oligochaete that is widespread in the area. This indicates that generally, the crustacean fauna, for which the Edgecombe Spring was noteworthy, is in decline, and the syncarid has not been seen since the original record.

The new springs to the west of Bullsbrook appear very promising in terms of condition, flows and fauna. They are relatively intact, and from discussions with landholders, the springs (and other unvisited springs in the immediate vicinity), flow all year, and are particularly fast flowing in winter. A more intensive sampling of these springs should be implemented in spring 2008, as well as an investigation of other potential springs in the area. These springs may be the best remaining examples on the Gnangara Mound, and worthy of protection before impacted by development.

Recommendations

Based on these results, the following recommendations are made:

- The caves identified by Lex Bastion in his commissioned review of all known caves in the area, which formerly contained water but for which the current status is 'unknown', should be revisited as soon as possible to document their current hydrological regime.
- Encourage local speleologists to continue looking for additional caves with root mats/water.
- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- Active management should be initiated to develop and then maintain extensive root mats in the cave streams to provide suitable habitat to support fauna should it recolonise from inaccessible refuges.
- Continue cave monitoring as per current methods to assess recovery of cave stream communities following recharge by the new recharge system/bores.
- Monitoring of the fauna should be undertaken in September/October when habitat area is likely to be greatest to assess recovery of the fauna, should it occur.
- Boomerang Cave, which dried in 2003, Carpark and Cabaret Caves which dried in 2007 due to issues associated with maintenance of the local recharge system, should continue to be monitored to determine if the TEC has been lost from these sites.
- A gauge for measuring flows should be established on Egerton Spring.
- The influence of Acid Sulphate Soils/Potential Acid Sulphate Soils (ASS/PASS) should be investigated at Egerton Spring, and regular monitoring of pH should be initiated.
- The status of the Edgecombe Spring Threatened Ecological Community (TEC) should be re-assessed and, based on the faunal diversity listed as extinct, monitoring should cease.
- Setting traps in the cave on Lot 51 (YN555) for the goldfish is of high priority.
- Continue monitoring YN555 to determine if the isopod and hydrobiid snail populations return.
- The sampling strategy be revised, and expanded to include a regional focus. The results emerging from the monitoring over the years highlight the significance of the copepod and amphipod elements, but also the decline of these elements. A regional focus of bores should seek to determine greater regional distribution, as well as develop an understanding of what measures should be put in place to conserve these elements, regionally.
- A more intensive sampling of newly discovered springs west of Bullsbrook should be implemented in spring 2008 to fully document their fauna. This survey should also include a floristic survey. In addition, an investigation of other potential springs in the area should be conducted.

1 INTRODUCTION

1.1 Background

The Department of Water (DoW) is required to implement appropriate monitoring programmes as part of the environmental commitments outlined by the Water Authority of Western Australia (1995) and WRC (1997). Key commitments include the ongoing monitoring of cave stream invertebrate fauna and seepage (spring) macroinvertebrates. The aim of ongoing monitoring is to determine whether groundwater abstraction and pine plantation management impact on the identified ecological values of the cave streams in Yanchep National Park, and Edgecombe and Egerton Springs. Monitoring provides valuable information which can be used by the Yanchep Caves Recovery Team, for ongoing management, and in particular for assessing effectiveness of groundwater recharge, and by the DoW for inclusion in the annual and triennial reports to the Environmental Protection Authority (EPA).

This current work represents a one year phase of an ongoing monitoring program and is managed in conjunction with the Department of Environment and Conservation's (DEC; previously Department of Conservation and Land Management's (CALM)) WA Threatened Species and Communities Unit and the Swan-Avon region of the Department of Water (nee Department of Environment / Water & Rivers Commission).

As an addendum to this years report, several new springs were identified by DEC in the Bullsbrook area, and these springs were sampled in early February 2008 at the request of DEC to determine their conservation significance. Data collected from these new springs are here reported to allow comparison with Edgecombe and Egerton Springs.

1.2 Objectives

The aim of this study was to report on the current status of the aquatic invertebrate fauna of the cave streams of Yanchep National Park and two nominated springs (Egerton & Edgecombe Springs) on the Gnangara Mound (East Lexia area): Egerton and Edgecombe Springs, during spring when water levels were anticipated to be at their highest. Resultant data are to be used to assess the status of the Threatened Ecological Community in the cave streams and evaluate the impact of changes in groundwater and wetland water levels. Conclusions will be included in Annual and Triennial reports to the EPA and to aid management of groundwater resources. Data collected will be compared to historical (1998) and more recently collected data (November 2000, September 2001, January 2002, September 2002, September 2003, October 2004 and November 2005).

1.3 Scope

1. In spring 2007 monitor cave stream invertebrate populations in:
    - Boomerang Cave (YN99),
    - Cabaret Cave (YN31),
    - Carpark Cave (YN18)
    - Water Cave (YN11)
    - Cave on Lot 51 (YN555)
    - Mire Bowl (YN61)
    - Orpheus Cave (YN256)

    Sampling is to provide an indication of the status of the invertebrate communities compared against historical data. Of caves previously sampled, Twilight Cave (YN194) and Spillway Cave (YN565) are considered unsafe to enter, and so were not sampled, Gilgie Cave (YN27) has been dry since 1996, and Jackhammer Cave (YN438) appears not to support cave fauna (Knott & Storey 2003).

2. Sampling of water quality parameters should be undertaken concurrently at all caves. This should include temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and Na, Ca, Mg, K, SO_4^{2-}, PO_4^{3-} and NO_X.

3. In consultation with National Park rangers and local caving experts, identify any additional caves in the Yanchep area that hold water and potentially may contain root mats, and sample new caves for aquatic invertebrate fauna and water quality, additional data to be incorporated in this report.

4. In spring 2007, monitor macroinvertebrate populations of:
   - Egerton Spring (East 403508, North 6484428), and
   - Edgecombe Spring (East 404893, North 6481948).

   Access to wetlands on private property will be obtained in consultation with the Department of Water prior to undertaking fieldwork and then with the two property owners.

   Sampling is to provide an indication of the status of the invertebrate communities compared against historical data. It is critical that the macroinvertebrate fauna be sampled from runnels before the discharge point and at the point of spring discharge, and not from the wetland downstream of the discharge, which will contain a diverse fauna of macroinvertebrates cosmopolitan to wetlands of the Swan Coastal Plain.

5. Sampling of water quality parameters should be undertaken concurrently at both springs. This should include temperature, conductivity, salinity, dissolved oxygen, pH, turbidity and Na, Ca, Mg, K, Cl^-, total Fe, SO_4^{2-}, and NO_X.

To allow direct comparison across the existing springs and the newly identified springs at Bullsbrook, the same sampling methods were used and the same suite of water quality parameters were taken from the new springs.

2 METHODS

2.1 Study Sites

2.1.1 Caves

All caves were sampled on 9th and 10th October 2007. All were within the area of the Gnangara Mound Groundwater Resources study area, and with the exception of the cave on Lot 51, all the study sites were within the Yanchep National Park (Figures 1 & 2).

Froend et al. (2004) identified the ecological water requirements of the Yanchep Caves stream fauna to be permanent inundation (i.e. sufficient level of water to inundate cave floor/maintain flowing streams). As such, the ecological values of the caves are considered to be dependant on maintaining adequate water levels within the caves. There is a large number of groundwater monitoring bores in the Yanchep area; however few of these are adjacent to the caves supporting threatened ecological communities (TEC's). Caves and positions of the nearest bores are presented in Table 1. The Australian Height Datum (AHD) of the floor of some of the caves holding TECs have been surveyed and these were used to relate changes in groundwater levels in adjacent bores (reported as mAHD) to levels in cave as inferred by cave floor AHD levels (Table 2).

A total of eleven caves were considered for sampling in 2007, with nine caves visited and five caves actually sampled for fauna (seven caves sampled for water quality). As anticipated, Fridge Grotto (YN81) and Gilgie Cave (YN27) contained no water and were not sampled. Mire Bowl (YN61) contained water in the sump, and this was sampled for water quality, and observations made for fauna, but no fauna sample was taken. Following a recent assessment of the safety of all caves, conducted by DoW, Twilight (YN194) and Spillway caves (YN565) were considered too unstable to enter and therefore were not visited. The various caves known to contain root mats and/or water are listed in Table 1, together with their GPS location and sample date, if visited.

Table 1. Names and codes of caves visited in 2007 and whether sampled.

Cave	Code	Easting	Northing	Visited	Date Visited	Sampled	Nearest Bores[1]
Cabaret Cave	(YN30)	375650	6509600	Yes	9 October 2007	Yes	YN4 (100m SE)
Boomerang Cave	(YN99)	375660	6509520	Yes	10 October 2007	Yes	YN4 (100m SE)
Carpark Cave	(YN18)	375250	6508440	Yes	9 October 2007	Water sample from sump only	YN3 (300m NE) YN2 (400m SE)
Water Cave	(YN11)	374990	6508640	Yes	9 October 2007	Yes	YN7 (1100m SSE) YN5 (1500m NE)
Cave on Lot 51	(YN555)	376921	6505901	Yes	10 October 2007	Yes	YN8 (~910m NW) GNM9 (~820 NNW) GNM10 (~960 NNW) JP23 (~600m NE)
Gilgie Cave	(YN27)	375714	6506702	Yes	9 October 2007	No (dry)	-
Twilight Cave	(YN194)	375778	6506788	No	9 October 2007	No (unsafe)	-
Spillway Cave[2]	(YN565)	374404	6509263	No	9 October 2007	No (unsafe)	-
Orpheus Cave	(YN256)	373673	6512354	Yes	10 October 2007	Yes	-
Fridge Grotto	(YN81)	373844	6511733	Yes	9 October 2007	No (dry)	-
Mire Bowl	(YN61)	374254	6511387	Yes	9 October 2007	Water sample from sump only	-

[1] Long-term groundwater monitoring bores developed by DoW and monitored on a monthly basis.
[2] New cave visited November 2005.

Table 2. AHD of the floor of the caves containing root mat communities listed as TECs.

Cave	mAHD
Carpark Cave	7.660
Water Cave	6.186
Cabaret Cave	11.175
Boomerang Cave	11.316

Figure 1. Aerial showing location of Cave YN555 on Lot 51 relative to encroaching market garden and turf farms to the north and south-west.

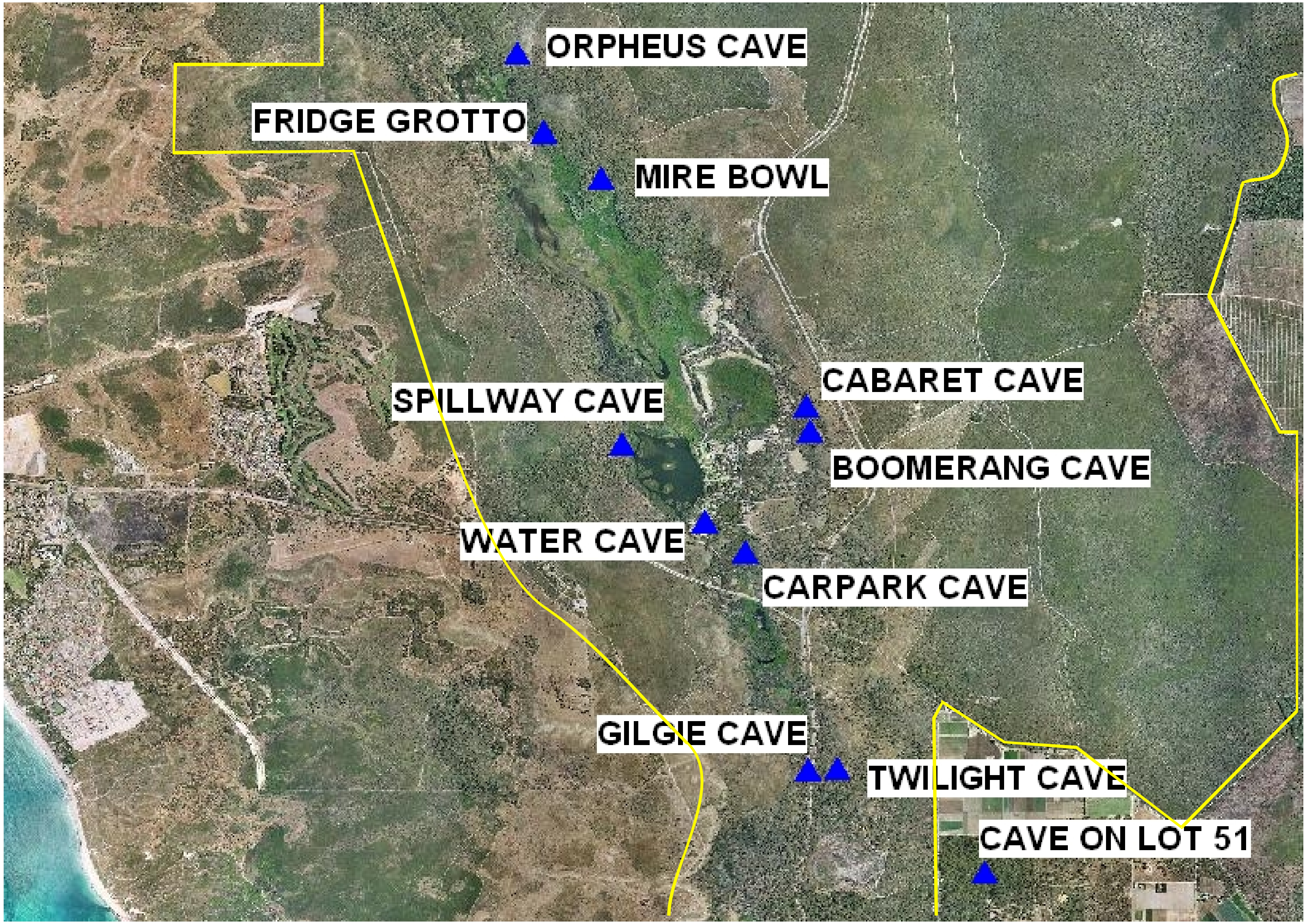


Figure 2. Aerial showing location of Yanchep caves. Yellow outline indicates border of Yanchep National Park.

2.1.2 Springs

Both Egerton and Edgecombe springs were sampled on 9th October 2007. The ecological value of the springs is considered to be dependant on water levels. Bore water levels adjacent to Edgecombe and Egerton Springs have been monitored since 1994. From April 1994 to February 1996, water depth in bore B10 (144 m upstream of Edgecombe Spring) was reasonably constant at approximately 14.0 – 14.5 m AHD. Water depth on Bore B25 (130 m upstream of the Egerton Spring) was also reasonably constant at approximately 39 m AHD. Bore data supplied for the current trend analysis commenced in March 2000 for both bores, and levels at the start of the data series were comparable to levels recorded pre-2000.

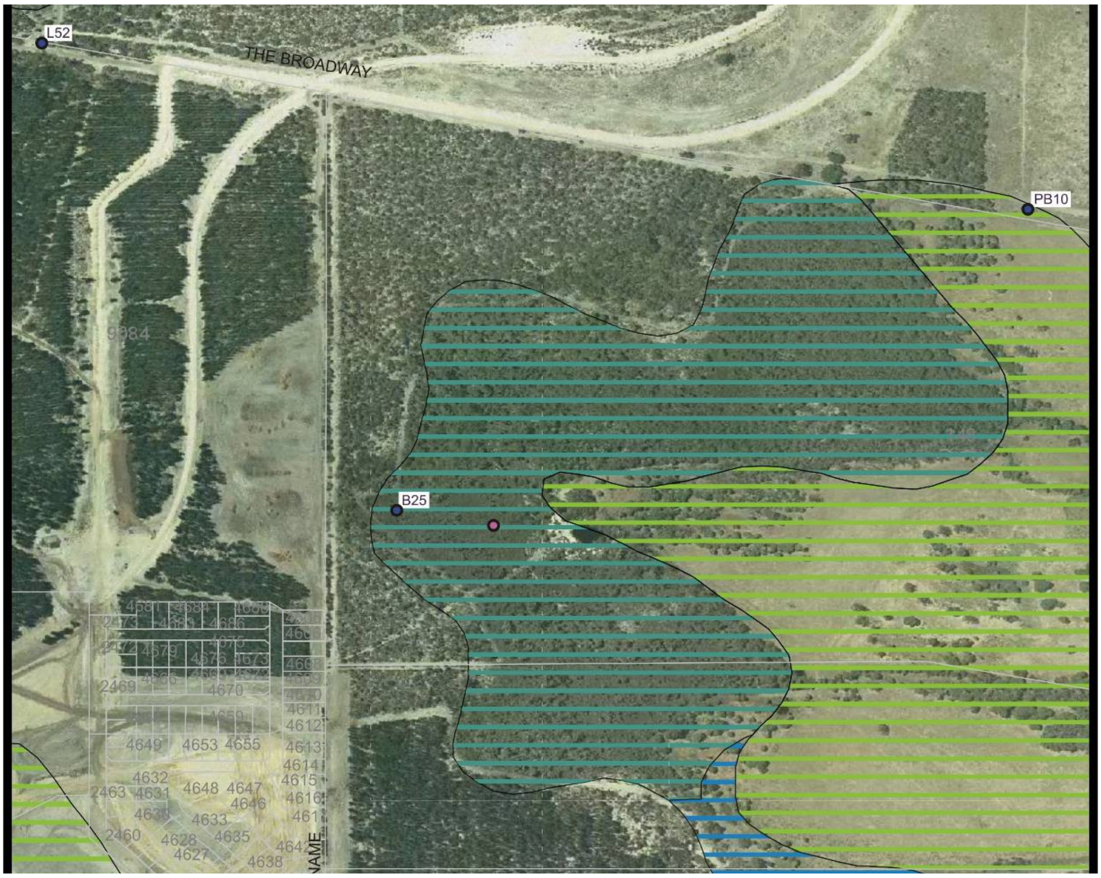
Egerton Spring

The tumulus spring (WGS84 E403508 N6484428) is located in the northwest section of Egerton Stud, Ellenbrook. The spring is a permanent limnocrene spring *sensu* Williams (1983) with water welling vertically to ground level and discharging from a peat mound. The biological significance of the structures relates to the provision of humid microhabitats in the midst of an essentially xeric environment. Forms now restricted to the extreme southern region of the State persist in these moist microhabitats. The Egerton tumulus spring, consequently, assumes considerable scientific importance and is a feature worthy of detailed study of its structure and hydrological dynamics. Low reeds and rushes, liverworts and club mosses grow over the mound. Urban development has encroached to the west and south of the spring, and development is planned to the north. The extent of urban development and encroachment in December 2006 compared with January 2004 is evident in Figure 3. The current state of development (October 2007) is significantly more than in December 2006. This development will undoubtedly affect the hydrology of the site.

Edgecombe Spring

The Edgecombe Spring (WGS84 E404893, N6481948), is located on Lot 15 Gnangara Rd, at the eastern end of Gnangara Road, Ellen Brook. The spring was a permanent rheocrene spring *sensu* Williams (1983), with water flowing along an epiphreatic conduit formed in quartz sand under about 0.15 m of dark, organic soil (Jasinska & Knott 1994). The spring, wedged between paddocks at higher elevation some 30 m to the west and an impoundment 15 m to the east, upon emerging flowed through a wide band of vegetation (of reeds, rushes, bracken fern, fig, *Eucalyptus* and *Melaleuca*) to the dam.

When sampled on the 25th of April, 1999, there was only a thin veneer of moisture at the normal outflow point of the spring, with almost imperceptible flow. By 9th November 2000, stronger flow was observed, but a fire break had been cleared along the fence-line of the property and the spring area cleared and badly degraded which altered the lines of discharge, with substantial flow noted along the tractor wheel ruts. As noted by Horwitz & Knott (2002) the area immediately about the spring continues to repair to its original semblance and the discharge through the original spring channel was slow. However, since monitoring in 2003, the area immediately west of the spring site and encroaching to within a few metres has been cleared for suburban development. This is likely to cause major change and possible destruction of the spring. The extent of urban development and encroachment in December 2006 compared with January 2004 is evident in Figure 4. This will undoubtedly affect the hydrology of the site.



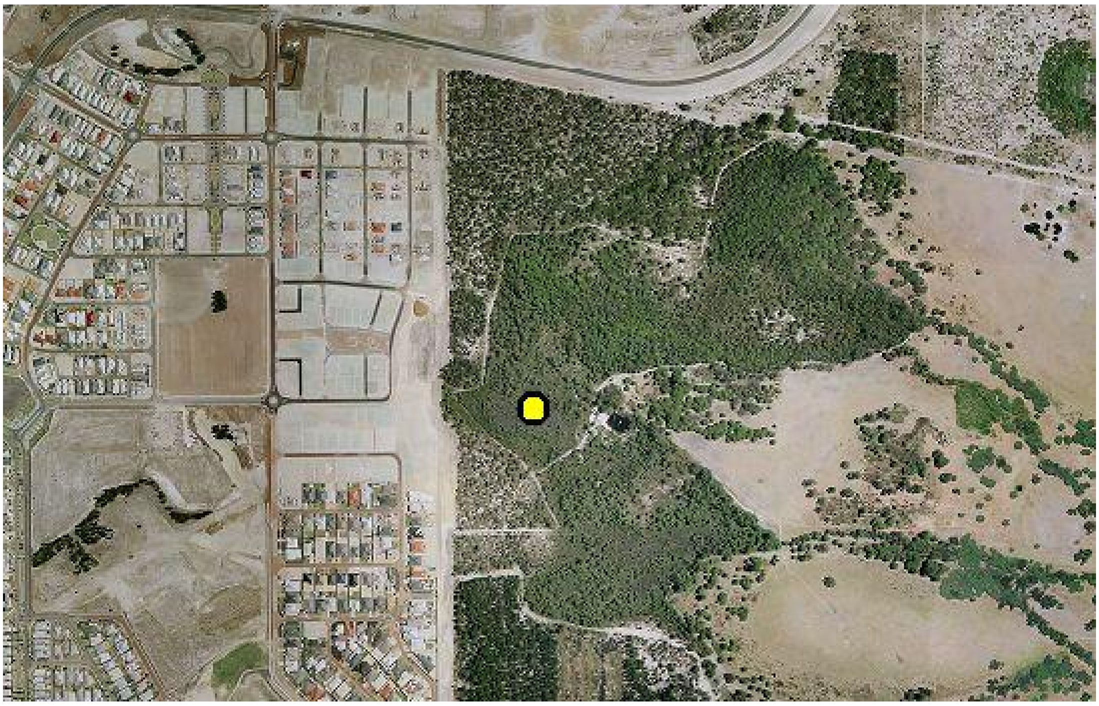


Figure 3. Aerial photos showing location of Egerton Spring (approx location of the spring is indicated with the yellow marker) and encroaching urban development; TOP = January 2004, BOTTOM = December 2006.

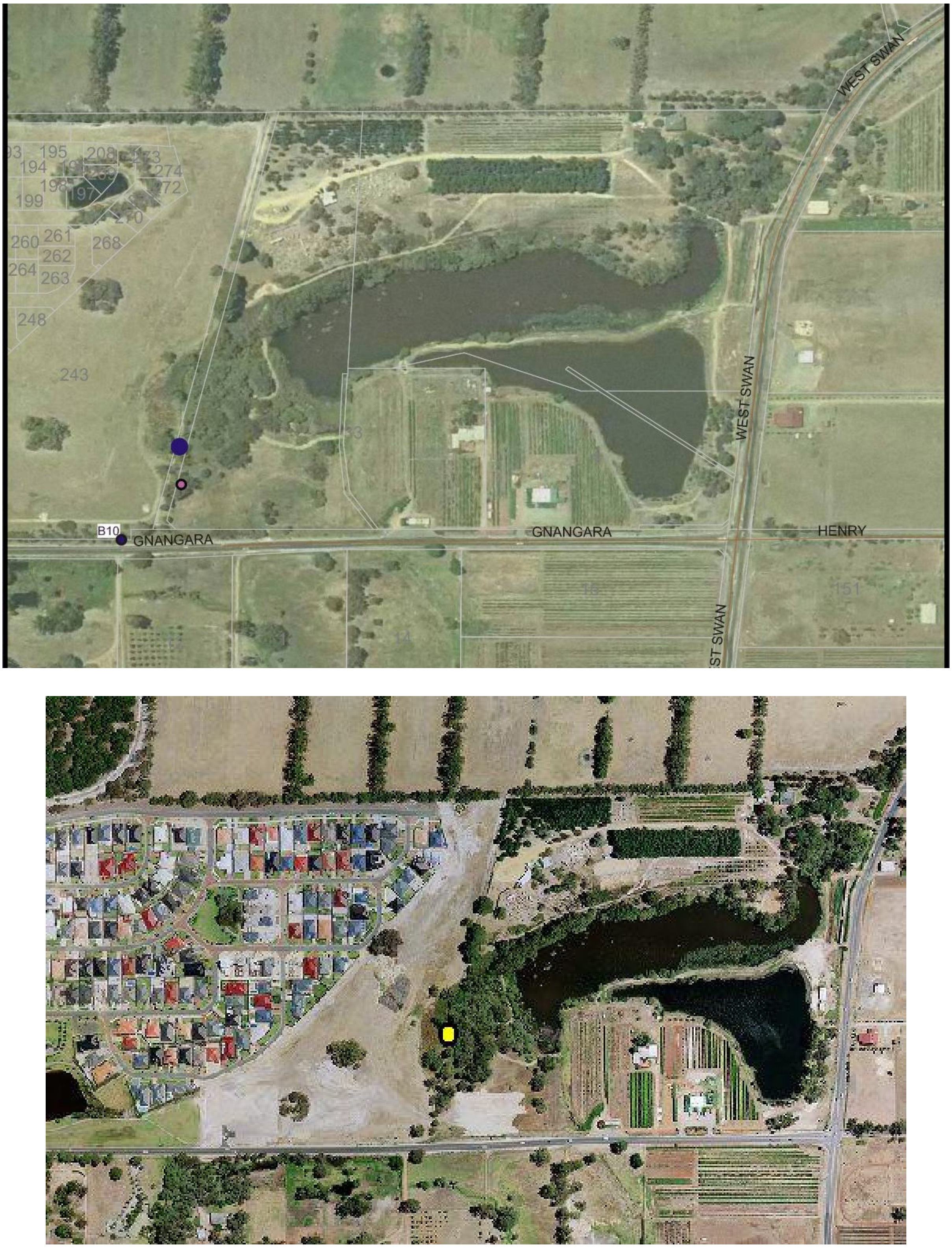


Figure 4. Aerial photos showing location of Edgecombe Spring (approx location of the spring is indicated with the yellow marker) and encroaching urban development: TOP = January 2004, BOTTOM = December 2006.

2.1.3 Additional Gnangara Mound Springs

Environmental surveys conducted as part of a proposed realignment of the Great Northern Highway, to bypass Bullsbrook and the Pearce Airbase, have revealed the existence of a series of previously unknown mound springs and wetland seeps. Apparently land owners were aware of these springs on their properties, but were loath to notify authorities as they were concerned about land acquisitions and land being placed in conservation reserves. DEC staff, in association with the land owners have identified 3 – 4 springs/wetland seeps towards the east end of Neaves Road. The landowners were approached in early February 2008 and permission sought to sample the springs. Three sites were sampled, these being Sues Spring South, Bill's Spring and Gaston Swamp. An additional spring was identified but not sampled, Sue's Spring North, and discussions with landholders suggested there were additional springs in the area, which should be visited in the future. Locations of the springs sampled are presented in Table 3 and the approximate locations are shown in Figure 5.

Table 3. Names and locations (WGS84) of new springs visited in February 2008 and whether sampled.

Spring	Easting	Northing	Visited	Date Visited	Sampled	Nearest Bores
Sue's Spring South	402481	6498461	Yes	01 February 2008	Yes	
Sue's Spring North	402400	6498450	Yes	01 February 2008	No	
Bill's Spring	402441	6498561	Yes	01 February 2008	Yes	
Gaston Swamp	402771	6498892	Yes	01 February 2008	Yes	

2.2 Water Quality

2.2.1 Caves

In-situ measures of water quality were made at each site using Wissenschaftlich-Technische-Werkstätten (WTW) water quality meters (Table 4). Undisturbed water samples were taken from each site, using pre-cleaned 500 ml and 125 ml bottles for laboratory analyses of additional water quality parameters (Table 4). Laboratory analyses were conducted by the Environmental Chemistry Section of the Chemistry Centre of WA, a National Association of Testing Authorities (NATA) accredited laboratory.

Table 4. *In-situ* and laboratory-determined water quality parameters measured in each cave in 2006.

In-situ water quality measures	*Laboratory-determined water quality measures (mg/L)*
Dissolved Oxygen (mg/L)	Calcium (Ca)
Dissolved Oxygen (% sat.)	Potassium (K)
Salinity (ppt)	Magnesium (Mg)
Conductivity (µS/cm)	Nitrate and nitrite (N_NO3)
pH	Sodium (Na)
Water Temperature (˚C)	Soluble reactive phosphorus (P_SR)
	Sulphate (SO4_S)

2.2.2 Springs

In-situ measures of water quality were made at each site using WTW water quality meters (Table 5). Undisturbed water samples were taken from each site, using pre-cleaned 500 ml, 125 ml and 50 ml bottles for laboratory analyses of additional water quality parameters (Table 5). Laboratory analyses were conducted by the Environmental Chemistry Section of the Chemistry Centre of WA, a NATA accredited laboratory.

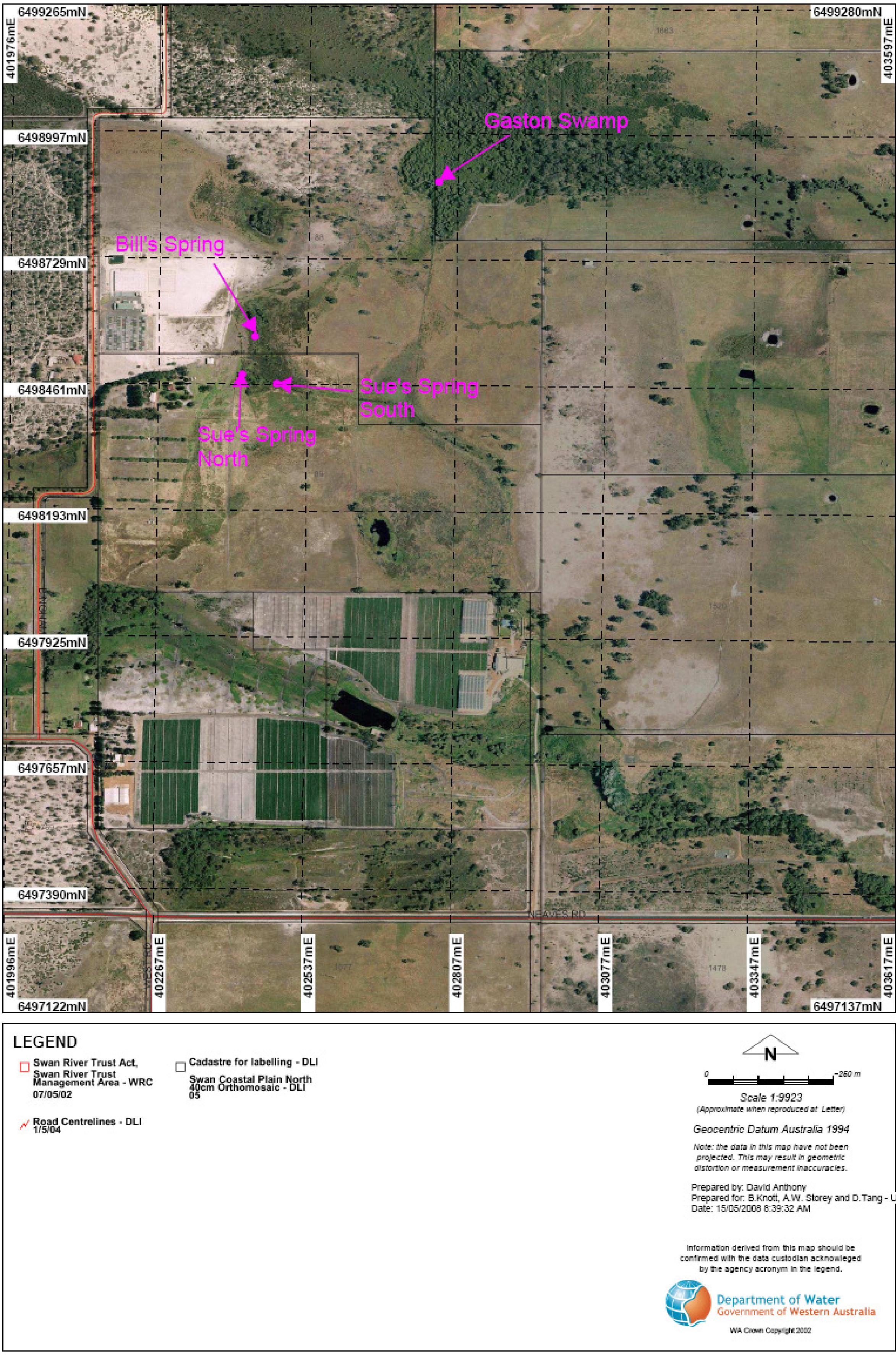


Figure 5. Aerial photo showing the east end of Neaves Road, Bullsbrook, with the location of new mound springs sampled in February 2008.

Table 5. *In-situ* and laboratory-determined water quality parameters measured at each spring in 2006.

In-situ water quality measures	***Laboratory-determined water quality measures (mg/L)***
Dissolved Oxygen (mg/L)	Sodium (Na)
Dissolved Oxygen (% sat.)	Potassium (K)
Turbidity (NTU)	Magnesium (Mg)
Salinity (ppt)	Calcium (Ca)
Conductivity (µS/cm)	Total Iron (Fe)
pH	Chloride (Cl)
Redox	Nitrate and nitrite (N_N03)
Water Temperature (˚C)	Sulphate (SO4_S)

2.3 Aquatic Invertebrate Fauna

Sampling in the caves was conducted using the modified sampling regime developed when sampling caves in mid-January 2002 (Knott & Storey 2003). The aim of the sampling technique was to collect as many species as possible whilst causing the least disturbance and damage to the remaining root mats. This was achieved by taking composite sweep samples across all accessible submerged root mat habitat in each cave using small (~ 10 cm diameter), custom-made fine-mesh nets (70 µm mesh aperture). Each sample was placed in a sealed, labelled plastic bag covered with water from the site, returned to the laboratory under cool, light-tight conditions and sorted alive in the laboratory under a dissecting microscope.

Fauna at each spring was collected as close to the point of the spring discharge as possible, and of not accessible, along the runnels as they exit from the mound. Access to the actual point of discharge was often difficult due to the density of the vegetation on the mounds. Using a 500 µm mesh sieve, sediment and detritus were sampled and bulked in a sealed, labelled plastic bag, covered with water from the site, and returned to the laboratory for sorting of live specimens under a dissecting microscope. The new springs at Bullsbrook were sampled using the same method.

Photographic Voucher Collection

A photographic voucher identification collection of invertebrates was prepared, displaying diagnostic features with appropriate microscope scaling. The voucher includes all invertebrate species collected, where possible. Some photographs were based on historically collected voucher specimens, if specimens were not collected during the current sampling, or if only single specimens were collected. Specimens deemed new species were included in the voucher and allocated an interim name.

3 RESULTS

3.1 Caves

3.1.1 General Condition

Sampling was timed to take place when water levels were expected to have been at their highest (*i.e.* mid spring). However, water levels were very low when compared to historical levels (*cf* 1990s) and no surface water flow was evident. Water levels in the vicinity of root mats in Cabaret, Boomerang and Carpark caves continue to be artificially maintained using sumps, pumps, floats and black plastic liners, however the pump system in Carpark Cave was not working and the liners were all dry. The water levels in the sumps were low, with pumps struggling for water at a time of year when levels should be at their highest. Water levels in each cave at the time of sampling are summarised below:

- *Cabaret Cave* – there was no natural surface flow in this cave, with the only water present being in the first small liner on the left as you enter the main chamber. The only water of sufficient depth to measure water quality was in the sump well, which was ~ 1 m below the floor of the cave, so measurements were taken on the assumption that the water present was representative of the water in the cave. The root mats in this first pool on the left appeared healthy, but were infested with 30 – 40 dipteran larvae crawling across their surface (Plate 1).

  The pump in the second sump in this cave was not functioning, with water levels 0.5 – 0.6 m below the floor of the cave. The main, most extensive liner along the right hand side of the cave was totally dry. Similarly, the pump in the small sump at the back of the cave was not working, and the liner and root mats at the back of the cave were dry.

Plate 1. Dipteran larvae over the exposed root mat in Cabaret Cave when sampled in October 2007.

Plate 2. The main liner in Cabaret Cave was dry when sampled in October 2007.

- *Boomerang Cave* – the cave and root mats were dry as the pump system was broken.
- *Carpark Cave* – the entrance stream was dry and the pump in the cave was not operating and the liner was dry. All root mats were dry. The water level was ~ 0.3 m below the floor of the cave. A water sample was taken from the sump for analysis, but no fauna sample was taken.
- *Water Cave* – this cave still contained a relatively deep pool, however water levels were 0.6 – 0.8 m below the high water mark, and down from last year and all accessible root mats were exposed and dry, well above the water table. The organic layer at the bottom of the pool was sampled for fauna. One crayfish was seen in the pool.
- *Cave YN555 on Lot51* – this cave was almost dry, with levels much lower than the previous year. The water level in the far right chamber was 0.2 – 0.25 m lower than last year. No isopods were observed this year. A goldfish (*Carassius auratus*) was observed in the pool; as

well as an unidentified 'grey' fish (possibly a Nightfish). Attempts to catch and remove the goldfish from the cave were unsuccessful, and similarly, attempts to identify the second fish were unsuccessful.

- *Twilight Cave* – the roof of the cave was considered unstable, therefore access was deemed unsafe.
- *Spillway Cave (YN565*) – this cave was considered unsafe to enter this year.
- *Mire Bowl (YN61)* – the floor of the cave was dry and cracked. There was water in the standpipe, with water level ~ 0.3 m below the floor of the cave. A water sample was taken from the sump for analysis. Fauna were not sampled.
- *Orpheus Cave* – water level appeared lower than the previous year, but was approx 0.2 m higher than when visited by Lex Bastian in July 2007. Three amphipods were sighted, but were not sampled.
- *Fridge Grotto* – this cave was dry.

3.1.2 Water Levels

Comparison of water levels (mAHD) in adjacent groundwater bores with the surveyed AHD of the floor of the caves (see Table 2) indicated that the maximum winter water level was 0.9 m and 1.1 m below the AHD of Cabaret and Boomerang Gorge caves respectively (Figure 6). The minimum summer water level in the bore closest to Carpark Cave (Figure 6) was at least 3 m above the AHD of the cave, suggesting the cave always contains water. However, the stream in Carpark Cave dries in summer which may indicate that local topography and local ground water levels are critical, and bore YN3 is too far away from Carpark Cave to be representative. In bores YN3 and YN4 there is a continuing, almost linear decline in water levels, with no indication of the rate of decline decreasing with time.

Water levels in four groundwater bores in the vicinity of the cave on Lot 51 (YN555) also show an almost linear decline in water levels for the past ten years (Figure 7). The maximum winter water levels for 2007 were almost half a metre lower than the average for the previous 5 years at each of the four bores, and water levels in bore JP23 dropped by almost 4 m over the past 30 years. In all four bores there is a continuing decline in water levels, with no indication of the rate of decline decreasing with time. This is reflected in water levels in the cave pools, which have declined over the last three years (Plates 3 – 5).

Although there are no groundwater water level monitoring bores in the vicinity of Orpheus Cave, water levels there have also declined in recent years (Plates 6 – 8). However, water level in October 2007 was higher than in July 2007 (pers. comm. Lex Bastian).

Plate 3. Sampling a pool in the cave on lot 51 (YN555), in 2005.

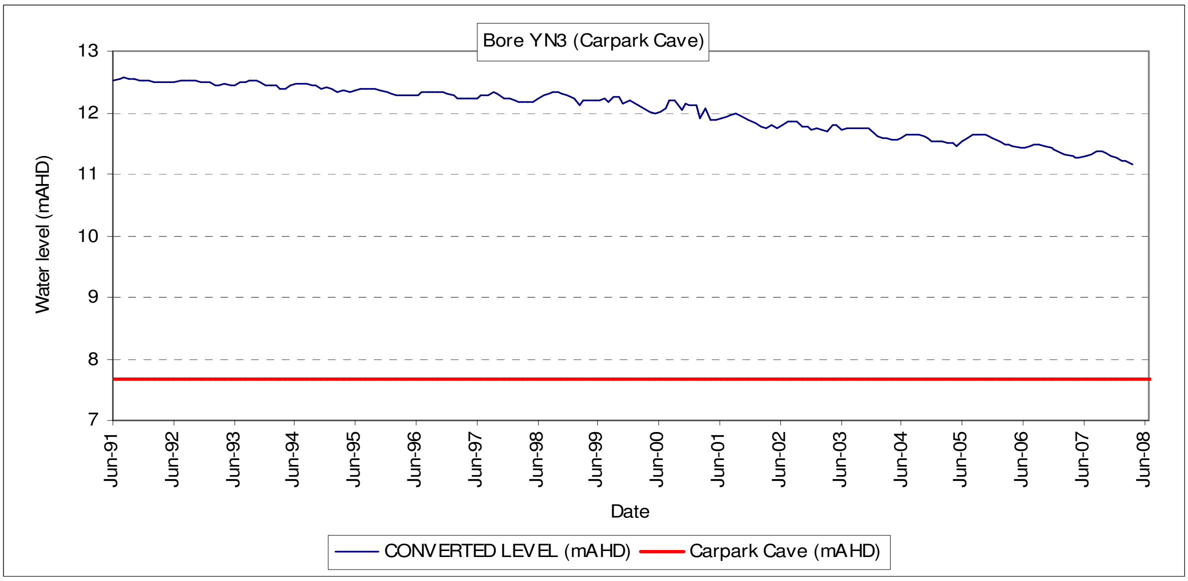
Plate 4. . Showing extent of water loss in pool in the cave on lot 51 (YN555), in 2006.

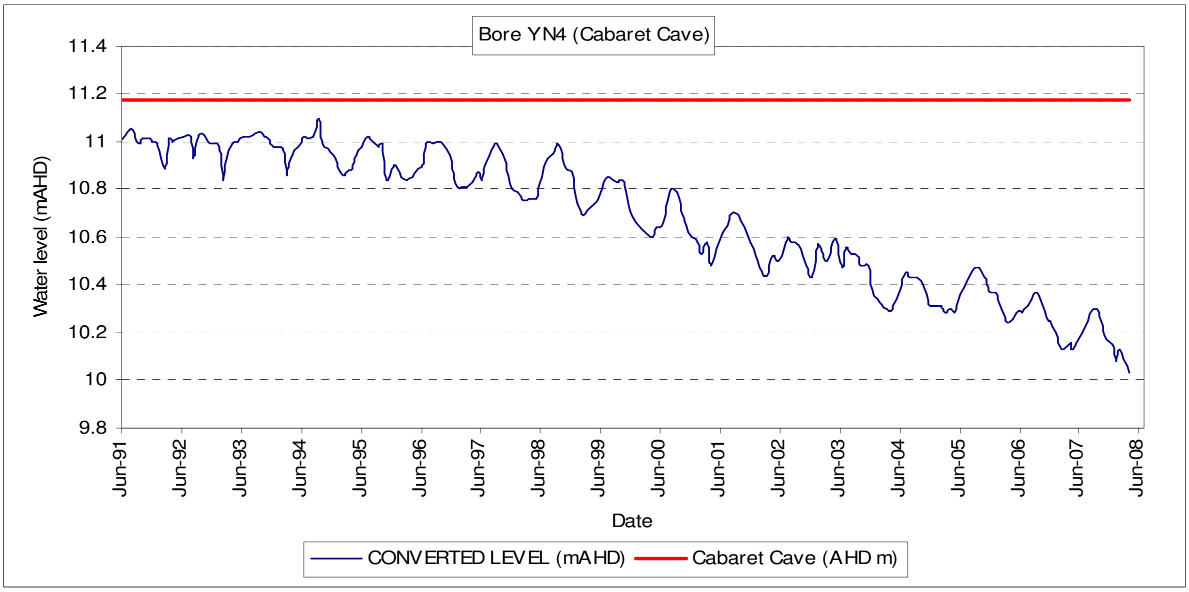
Plate 5. Extent of water loss in the same pool in the cave on lot 51 (YN555), in 2007.

Plate 6. Pool in Orpheus Cave, 2005. Arrow indicates water level

Plate 7. Pool in Orpheus Cave, 2006. Arrow indicates water level

Plate 8. Pool in Orpheus Cave, 2007. Arrow indicates water level.





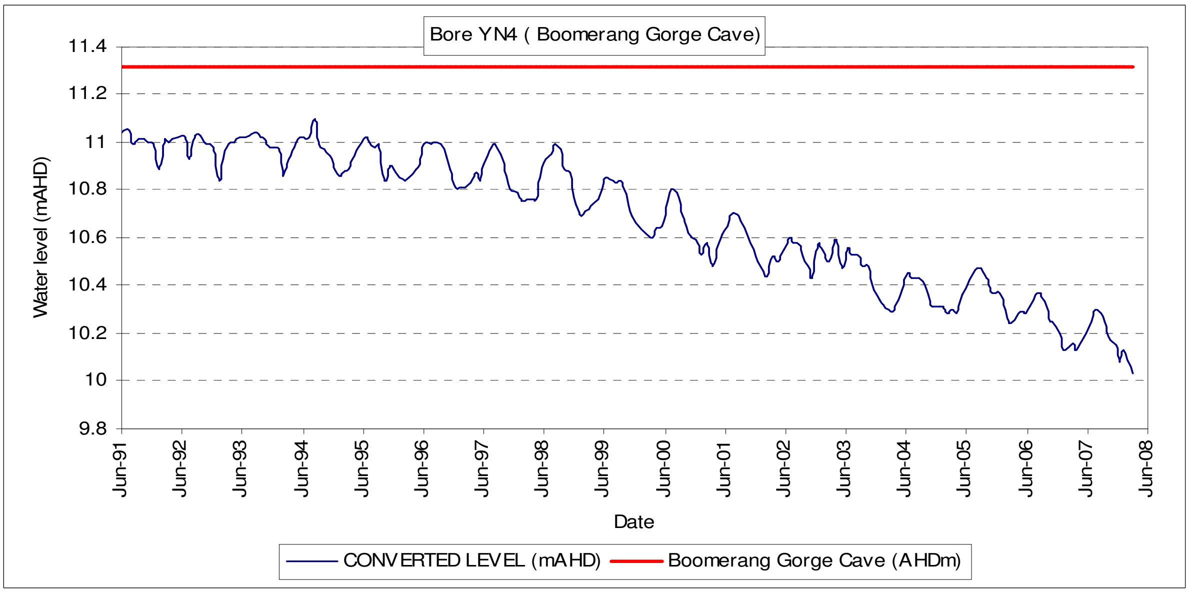


Figure 6. Temporal changes in water levels (mAHD) in monitoring bores YN3 and YN4 against surveyed bed levels (mAHD) of adjacent caves in Yanchep National Park.

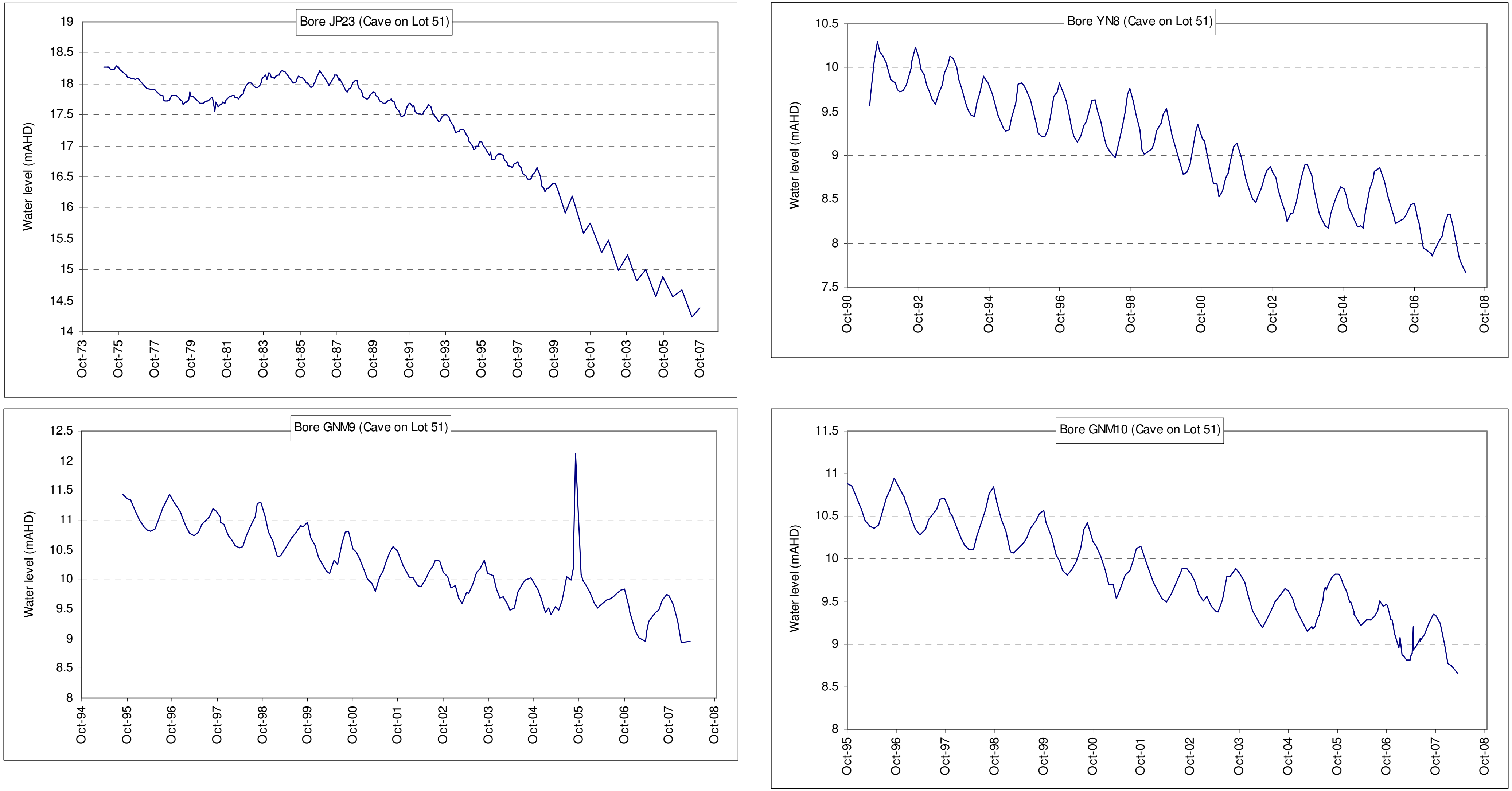


Figure 7. Temporal changes in water levels (mAHD) in monitoring bores JP23, YN8, GNM9 and GMN10 near the cave on Lot 51 (YN555).

3.1.3 Water Quality

As in previous reports (Knott & Storey 2001, 2002, 2003, 2004; Cook & Janicke 2005; Knott *et al.* 2006, 2007) *in-situ* water quality parameters were relatively consistent across caves and constant over time in those caves repeatedly sampled (November 2000 to current study) (Table 7, Appendix 1). Values in those caves sampled for the first time in 2002 and again this year (Spring 2007) were relatively constant across years and comparable to levels in caves previously sampled (Table 7, Appendix 1).

Dissolved oxygen (DO) levels varied over time. Levels in caves sampled this year were within the range measured on previous occasions (Table 7, Appendix 1). This indicates that the low levels of DO recorded in 2005 were likely due to a fault subsequently discovered in the DO probe.

Salinity in all caves was <= 0.5 ppt, during the current sampling period, except YN555 on Lot 51, which was 0.56 ppt. Levels were generally consistent across all occasions indicating that the water was fresh (< 0.5 ppt, (Department of Environment 2003)). Lot 51 experienced 'spikes' in salinity during 2003 and 2005 (Figure 8) which may reflect some evapoconcentration of salts in the waterbody in the cave on Lot 51. Sulphate showed similar spikes (Figure 8).

All caves had circum-neutral pH (pH 6.5 – 7.5), reflecting the influence of the Gnangara groundwater, combined with some dissolution of calcium carbonate into the water of caves with a long residence time (*i.e.* Water and Orpheus caves). The cave on Lot 51 had slightly higher pH (7.46), which may reflect the supersaturation of calcium carbonate crystals noticed in the pool (Lex Bastian, pers.comm., 2007). This could reflect the lower water levels in this pool and some effect of evapoconcentration.

Water temperatures were very comparable across caves, being less than 20 °C in all caves, with Cabaret Cave and cave on Lot 51 having the lowest temperatures of 15.5 °C and 14.4 °C respectively.

Concentrations of laboratory-determined parameters also were relatively consistent across caves and years (Table 7, Appendix 1). As in previous years, the composition of cations was dominated by calcium (Ca) and sodium (Na), with lower levels of potassium (K) and magnesium (Mg). YN555 on Lot 51 had the highest Na concentrations (90 mg/L compared with 85.9 mg/L in 2006), and this correlated with the consistently higher conductivities recorded from this cave.

In most caves, levels of nitrogen (nitrate + nitrite) were below the recommended guideline concentrations for protection of aquatic ecosystems (ANZECC/ARMCANZ 2000), using the guideline for southwest WA wetlands (Table 6). There were three caves which exceeded the guideline. As in 2006, YN555 on Lot 51 recorded 0.85 mg/L of nitrogen (nitrate + nitrite), compared with 0.99 mg/L in November 2006. Levels in Mire Bowl (YN61) and Boomerang Gorge (YN99) marginally exceeded the trigger value. A precautionary approach should be used when applying ANZECC/ARMCANZ (2000) trigger values, as guidelines specifically applicable for groundwater ecosystems have yet to be developed. The elevated levels of nitrogen may indicate anthropogenic influences, or could reflect a high organic loading in the caves, particularly Mire Bowl and Boomerang which were almost dry, with samples taken from shallow water with high organic deposits.

Concentrations of soluble reactive phosphorus were generally low in all caves (≤ 0.01 mg/L) and were below the recommended guideline concentrations for protection of aquatic ecosystems

(ANZECC/ARMCANZ 2000) (Table 6), the exception being Mire Bowl, which exceeded the trigger value with a concentration of 0.13 mg/L TRP.

Sulphate levels were low in most caves; with YN555 having the highest level of 13.8 mg/L, compared with 18.2 mg/L at this site in 2006. This level was considerably lower than those recorded in previous years (Figure 8; Appendix 1). A trend between sulphate levels and conductivity is apparent in YN555 (Figure 8). While there are currently no Australian guideline limits for sulphate in freshwaters, overseas guidelines indicate levels greater than 50 - 100 mg/L are likely to be detrimental to aquatic biota (refer BC Ministry of Environment Lands and Parks (2000)). Elevated sulphate in southwest Western Australian wetlands is used to indicate disturbance of acid sulphate soils.

Apart from water quality in YN555 (Lot 51), concentrations of parameters measured over time were very consistent when compared with levels recorded in 1998 (Cabaret Cave), and 2000 and 2001 (Carpark and Water caves) (Table 7, Appendix 1). This indicated no fundamental change in basic water quality over time, as would be expected for well buffered waters arising from the Gnangara groundwater system.

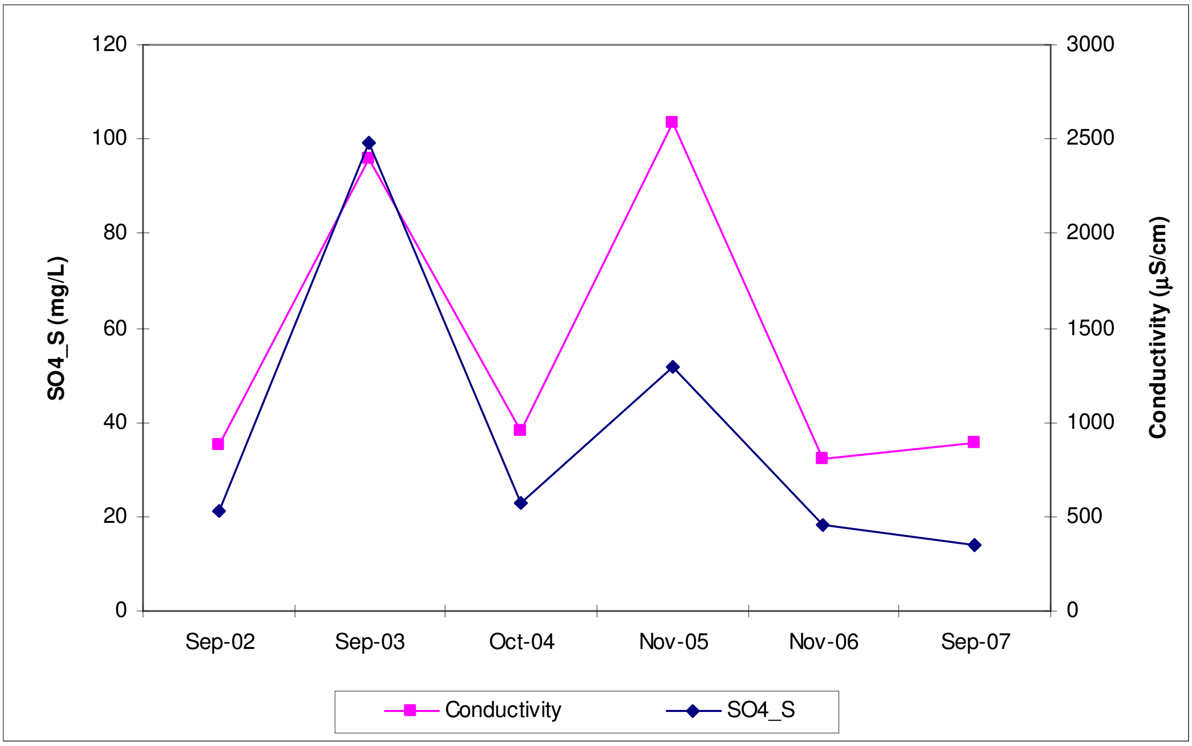


Figure 8. Conductivity (µS/cm) and sulphate (SO4_S, mg/L) over a five year sampling period for the cave on Lot 51 (YN555).

Table 6. ANZECC/ARMCANZ (2000) trigger values for nutrients, dissolved oxygen and pH for the protection of aquatic ecosystems, applicable to south-west Western Australia (TP = total phosphorus; FRP = filterable reactive phosphorus; TN = total nitrogen; NOx = total nitrates/nitrites; NH_4^+ = ammonium).

	TP (mg/L)	FRP (mg/L)	TN (mg/L)	NO_x (mg/L)	**NO_3 (mg/L)	**NO_2 (mg/L)	NH_3 (mg/L)	NH_4^+ (mg/L)	DO % saturation[2]	pH
Aquatic Ecosystem										
Upland River[1]	0.02	0.01	0.45	0.2	NP	NP	0.9[5]	0.06	90	6.5 – 8.0
Lowland River[1]	0.065	0.04	1.2	0.15	NP	NP	0.9[5]	0.08	80 - 120	6.6 – 8.0
Lakes & Reservoirs	0.01	0.005	0.353	0.01	NP	NP	0.9[5]	0.01	90	6.5 – 8.0
Wetlands[3]	0.06	0.03	1.5	0.1	NP	NP	0.9[5]	0.04	90 - 120	7.0 – 8.5[4]

** Where 1mg/L NO3-N = 4.43 mg/L NO3; 1 mg/L NO2-N = 3.29 mg/L NO2.
NP = value not provided.
1 All values during base river flow not storm events.
2 Derived from daytime measurements; may vary diurnally and with depth; data loggers required to assess variability.
3 Elevated nutrients in highly coloured wetlands do not appear to stimulate algal growth.
4 In highly coloured wetlands, pH typically ranges 4.6 – 6.5.
5 General level for slightly-moderately disturbed ecosystems and not specifically formulated for south-west WA; figure may not protect species from chronic toxicity.

Table 7. *In-situ* and analytically-determined water quality parameters measured in 2007. Shading indicates elevated levels.

		Cabaret Cave YN30	Carpark Cave YN18	Water Cave YN11	Cave on Lot 51 YN 555	Orpheus Cave YN256	Mire Bowl YN61	Boomerang TN99
In-situ								
Dissolved Oxygen	**%**	104	73	78	91	63	63	97
Dissolved Oxygen	**mg/L**	10.2	6.7	7.3	9.1	6.1	6.3	9.7
Conductivity	**µS/cm**	520	695	545	893	710	607	644
Salinity	**ppt**	0.27	0.35	0.28	0.46	0.36	0.31	0.33
pH		7.08	7.25	7.19	7.46	7.53	7.38	6.97
Temperature	**˚C**	15.5	17.1	19.0	14.4	18.5	18.1	16.5
Laboratory determined								
Calcium (Ca)	**mg/L**	35.9	58.3	44.5	85.8	65.5	59.4	43
Potassium (K)	**mg/L**	2.3	2.5	2.6	1.9	2.4	3.5	2.1
Magnesium (Mg)	**mg/L**	6.0	6.2	5.4	7.6	6.3	6.3	5.2
Sodium (Na)	**mg/L**	52.8	75.7	61.8	90.0	72.9	53.1	67
Conductivity	**mS/m**	73.3	70.5	57.3	92.1	74.4	71.5	70
Nitrate/nitrite (N_NO3)	**mg/L**	0.08	0.02	0.14	0.85	0.11	0.28	0.32
Total reactive phosphorus	**mg/L**	<0.01	<0.01	0.01	<0.01	0.01	0.13	<0.01
Sulphate (SO4_S)	**mg/L**	10.5	11.5	7.5	13.8	16.3	17	11.6

3.1.4 Aquatic Fauna

Species richness recorded from root mat samples taken in October 2007 ranged from zero in Carpark Cave to four in Cabaret cave (Table 8; Figures 9 & 10). Abundance of each species was very low, generally consisting of one specimen of each of the forms listed in Table 8. The specimens collected comprised, three widespread marine and freshwater interstitial species, one species sourced from Loch McNess, one insect species with terrestrial adult and aquatic larval stages and six unclassified species (Table 8).

The fauna of Cabaret Cave included four aquatic forms this year.

Water Cave yielded one taxon, a copepod, and one crayfish was observed but left in the cave.

YN555 on Lot 51, outside Yanchep National Park yielded three taxa; a copepod, an ostracod. and an oligochaete. The isopods and gastropods recorded in previous years were not recorded or observed.

No live specimens were recovered from Orpheus Cave, although several amphipods were observed during sampling, but were left in the cave.

A photographic voucher collection of specimens not included in the 2005 report (Knott *et al.* 2006) is presented in Appendix 3.

Cabaret Cave, Water Cave and Cave on Lot 51 each contained one copepod species (Table 8). Of interest were two undescribed taxa, one in the genus *Australoeucyclops* Karanovic, 2006 and the other belonging to *Eucyclops* Claus, 1893. The former taxon is currently being described by Dr. Tomislav Karanovic (University of Tasmania). Taxonomic resolution and description of remaining Copepoda specimens from the caves is currently being undertaken by Danny Tang (UWA), and results will be produced in a separate report and paper. The cyclopoid species so far identified are listed in Table 9, along with the site and dates collected. Future reports will include the updated species list.

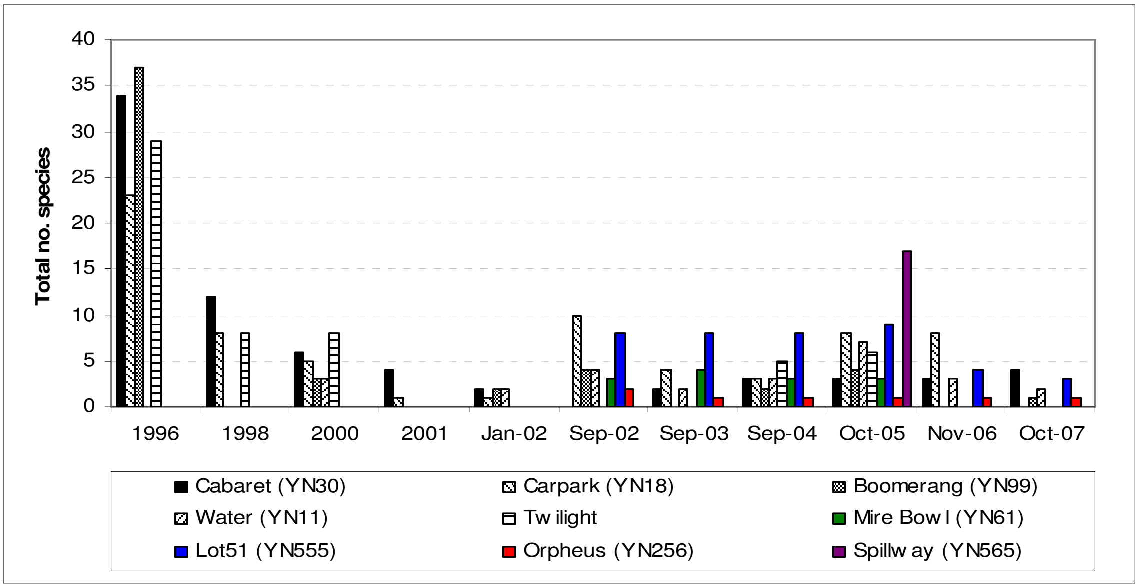


Figure 9. Total number of taxa over the entire sampling period.

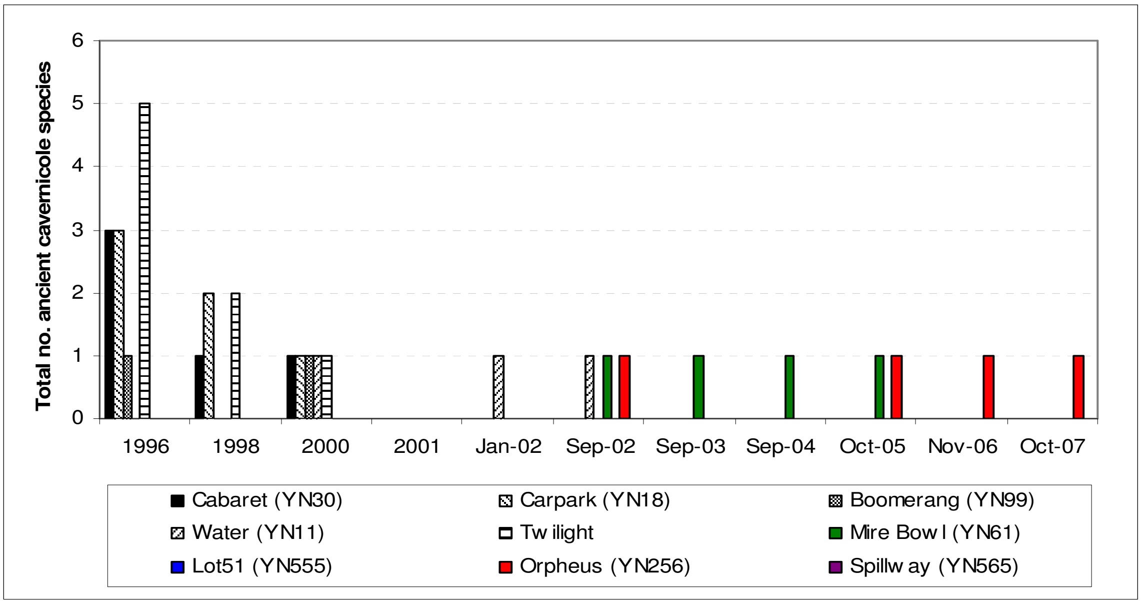


Figure 10. Total number of ancient cavernicole (stygofauna) taxa over the entire sampling period.

Table 8. Systematic list of aquatic invertebrates recorded from Yanchep Caves in October 2007. The source of each taxa, as classified by Jasinska is indicated whereby I = widespread marine & freshwater interstitial fauna, S = derived from surface waters of Loch McNess, T = insects with terrestrial adults and aquatic larval stages, A = ancient cavernicoles (stygofauna), and U = unclassified. Taxa present are highlighted

			TAXON	Source of fauna	Cabaret (YN30)	Carpark (YN18)	Water (YN11)	Lot51 (YN555)	Orpheus (YN256)	Boomerang ((YN99)
PLATYHELMINTHES										
	TURBELLARIA		Turbellaria spp.	I	1					
NEMATODA			Nematoda spp.	U						
ANNELIDA										
	APHANONEURA	**Aeolosomatidae**	*Aeolosoma* sp.	I						
	OLIGOCHAETA	**Enchytraeidae**	Enchytraeidae UWA1	I						
		Tubificidae	*Pristine aequiseta*	U	1			1		1
CRUSTACEA										
	DECAPODA	**Parastacidae**	*Cherax* sp.	S			1		1	
	AMPHIPODA	**Paramelitidae Gen 3**	Paramelitidae Gen 3	A						
	COPEPODA									
	Cyclopoida		*Australoeucyclops* sp. nov.	U				1		
			Eucyclops sp. nov.	U	1					
			Paracyclops chiltoni	I			1			
	OSTRACODA	**Darwinulidae**	*Gomphodella* sp.	U						
			Candona sp.	U				1		
ARACHNIDA										
	ACARINA									
	Acariformes									
	Oribatida		Oribatida spp.	U						
	Parasitiformes									
	Mesostigmata		Mesostigmata spp.	U	1					
INSECTA										
	COLEOPTERA	**Curculionidae**	Curculionidae spp. (L)	S						
	DIPTERA	**Empididae**	Empididae spp.	T						
			Total number of taxa recorded		**4**	**0**	**2**	**3**	**1**	**1**
			No. taxa in each group recorded							
			Ancient cavernicoles (stygofauna)	A						
			Widespead marine & freshwater interstitial fauna	I	1		1			
			Surface waters of Loch McNess	S			1		1	
			Insects with terrestrial adult and aquatic larval stages	T						
			Unclassified	U	3		3	3		1

Table 9. Updated taxonomic decisions for cyclopoid copepods recorded in Yanchep Caves. Numbers of specimens from each sampling period are given.

		Cabaret (YN30)							Carpark (YN18)	Boomerang (YN99)			Cave in Boomerang Gorge (YN7)	Mire Bowl (YN61)				Lot51 (YN555)					Orpheus (YN256)	Twilight (YN194)			Spillway (YN565)	Gilgie Cave (YN27)		Water (YN11)		Jackhammer (YN438)	Fridge Grotto (YN81)
TAXON	**Source of fauna**	1/06/1990	19/06/1990	27/01/1991	5/02/1992	29/07/1993	9/10/2007	?	?	17/07/1992	28/08/1994	14/11/1996	17/07/1992	17/07/1992	18/09/2002	22/09/2003	2005	2003	2004	2005	2006	2007	17/07/1992	2/06/1996	27/11/1996	2005	2005	17/03/1993	28/08/1994	19/09/2003	9/10/2007	4/10/2003	17/07/1992
Cyclopoida copepodites	U	1									3	2								1						1							
Cyclopidae: Eucyclopinae																																	
Tropocyclops confinis	S																	2															
Macrocyclops albidus	S																										24						
Paracyclops chiltoni	S	1	3									1													5		2				2		
Australoeucyclops sp. nov.	S†	15		16	10	1		15	4					2	1	2	4	10	5	114		19	1	1	4		2	8	11	14		409	3
Eucyclops sp. nov.	S†						1																										
Cyclopidae: Cyclopinae																																	
Mesocyclops brooksi	S																	1	4	31							1						
Mixocyclops sp. nov.	S†												2								1							1					

For Source of fauna column: U = Unclassified; I = widespread freshwater interstitial; S = derived from surface waters of Loch McNess; S† = Not known for sure, but suspected to be surface water species, maybe stygophiles (able to live both surface and underground).

3.2 Springs

3.2.1 Water Quantity

Data from groundwater water level monitoring bores adjacent to Egerton (B25) and Edgecombe (B10) Springs have shown similar patterns of low and slightly decreasing water levels in the late 1990s and early 2000, but both have shown a trend of increasing winter maxima and summer minima at both locations (Figure 11). This is even n light of a very dry winter in 2005. Increasing water levels may reflect greater local recharge as a result of urban development immediately to the west of both sites (see Figures 3 & 4). The AHD for Egerton and Edgecombe Springs is unknown and so the relationship between bore water levels and the surface level of the springs cannot be determined. However, it is known that Edgecombe Spring ceased flowing in spring/summer 1999. Therefore by inference it may be assumed that at this time the minimum groundwater level in bore B10 fell below the AHD of Edgecombe Spring. Estimated AHD of the springs and the trend on minimum summer water levels in bores B10 (Edgecombe) and B25 (Egerton) are presented in Figure 11. The direct relevance of data from these bores to the respective springs is unknown, but given their relative close proximity to the springs it is assumed that water levels in these bores relate relatively closely to flow from the springs.

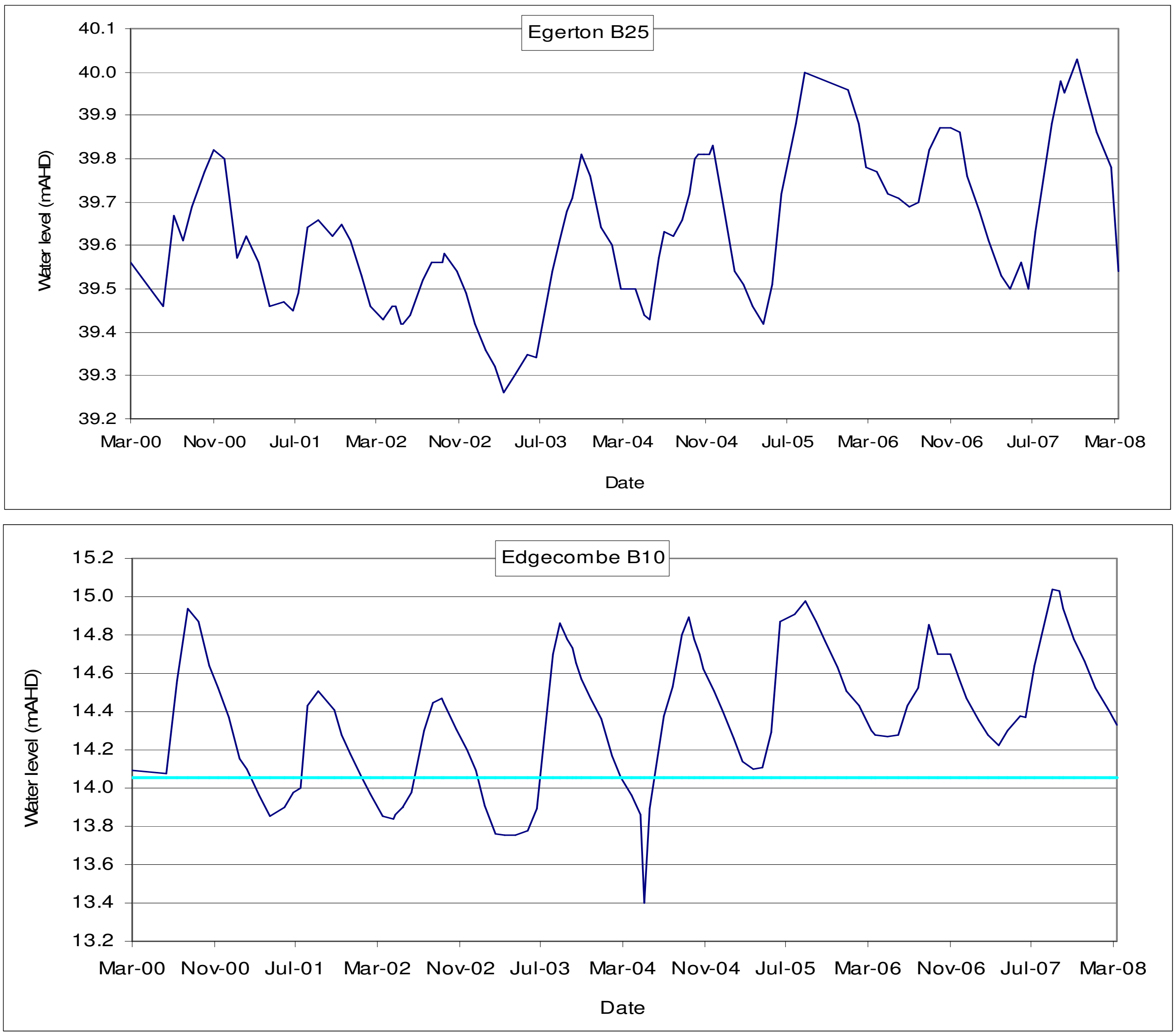


Figure 11. Temporal changes in water levels in Bores B10 and B25. Estimated bed level (m AHD) of Edgecombe Spring is illustrated, based on drying in spring/summer 1999.

3.2.2 Water Quality

Water levels were very low at Edgecombe Spring, but in Egerton Spring they appeared to have been maintained, and water in the runnels appeared to be flowing more strongly than last year, and there was more water near the base of the mound (pers obs. B. Knott, UWA).

As in previous reports (Horwitz & Knott 2002, 2004; Cook & Janicke 2005; Knott *et al.* 2006) *in situ* and laboratory determined water quality parameters were generally indicative of good quality, fresh water and were relatively constant over time. Salinity at both springs was less than 0.5 ppt and fresh[3] while pH ranged from circum-neutral (pH 6.68) at Edgecombe to strongly acidic (4.36) at Egerton Spring. Data collated over the past eight sampling periods show a strong upward trend in salinity at Edgecombe Spring (Figure 12) and a strong downward trend in pH at Egerton Spring (Figure 13).

Concentrations of other water quality parameters were relatively consistent over time (Table 10, Appendix 1). The composition of cations at Egerton Spring was dominated by sodium (Na) with lower levels of magnesium (Mg), calcium (Ca) and potassium (K) (Table 10). In contrast Ca was dominant in waters at Edgecombe Spring, with Na sub-dominant (Table 10). Levels of nitrogen (as nitrate + nitrite, NO_X) exceeded ANZECC/ARMCANZ guidelines (Table 5, Figure 14) at both springs. Levels of sulphate at both springs appear to be variable over time (Figure 15).

Table 10. *In-situ* and analytically-determined water quality parameters measured in 2007. Levels of concern are indicated by shading.

		Egerton Spring	Edgecombe Spring
In-situ			
Dissolved Oxygen	%	86.0	75
Dissolved Oxygen	mg/L	8.6	6.9
Conductivity	µS/cm	292	773
TDS	mg/L	150	399
pH		4.36	6.68
Temperature	˚C	15.5	17.5
Laboratory determined			
Calcium (Ca)	mg/L	4	68.7
Potassium (K)	mg/L	3.4	16.4
Magnesium (Mg)	mg/L	7	11.8
Sodium (Na)	mg/L	42.2	62.6
Chloride (Cl)	mg/L	69	79
Conductivity	mS/m	40.4	86.3
Total iron4	mg/L	0.38	11
Nitrate/Nitrite (N_N03)	mg/L	0.48	19
Sulphate (SO4_S)	mg/L	16.9	111

[3]Department of Environment (2003) *Stream and catchment hydrology*, River Restoration Report No. RR19, Department of Environment, Perth.
[4] Includes the deposit and in solution iron.

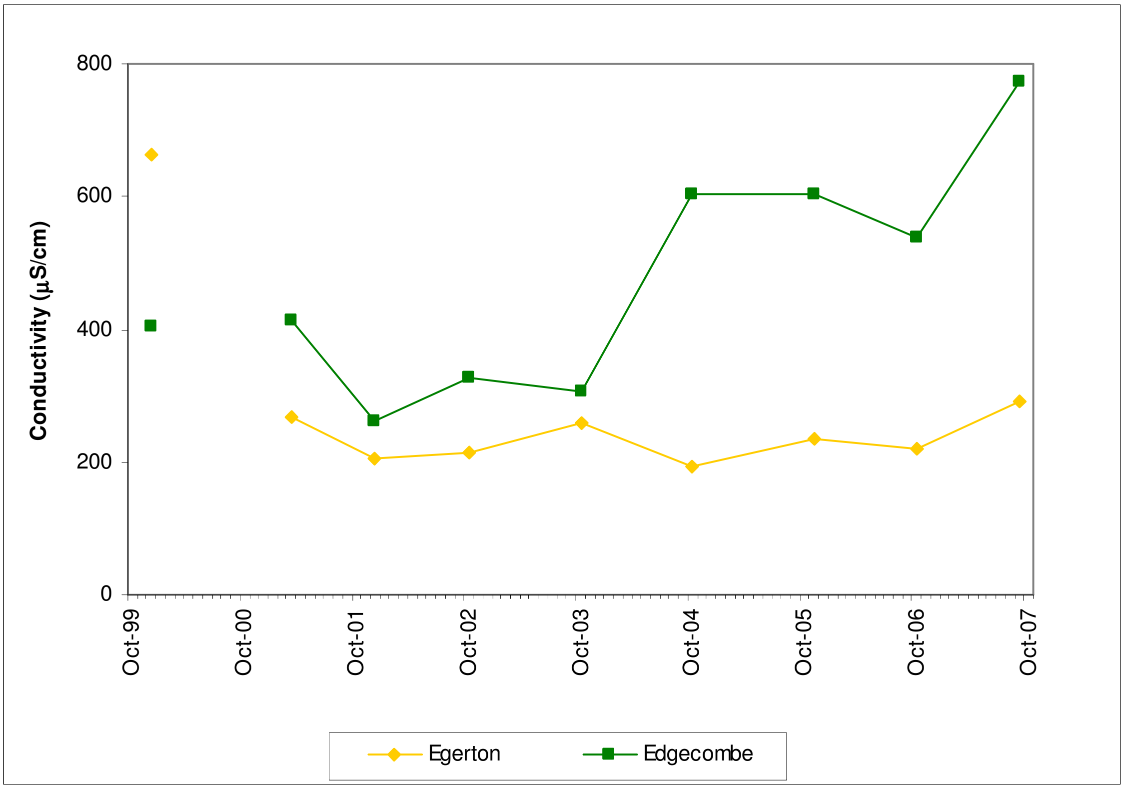


Figure 12. Salinity (ppt) over time for Egerton and Edgecombe Springs.

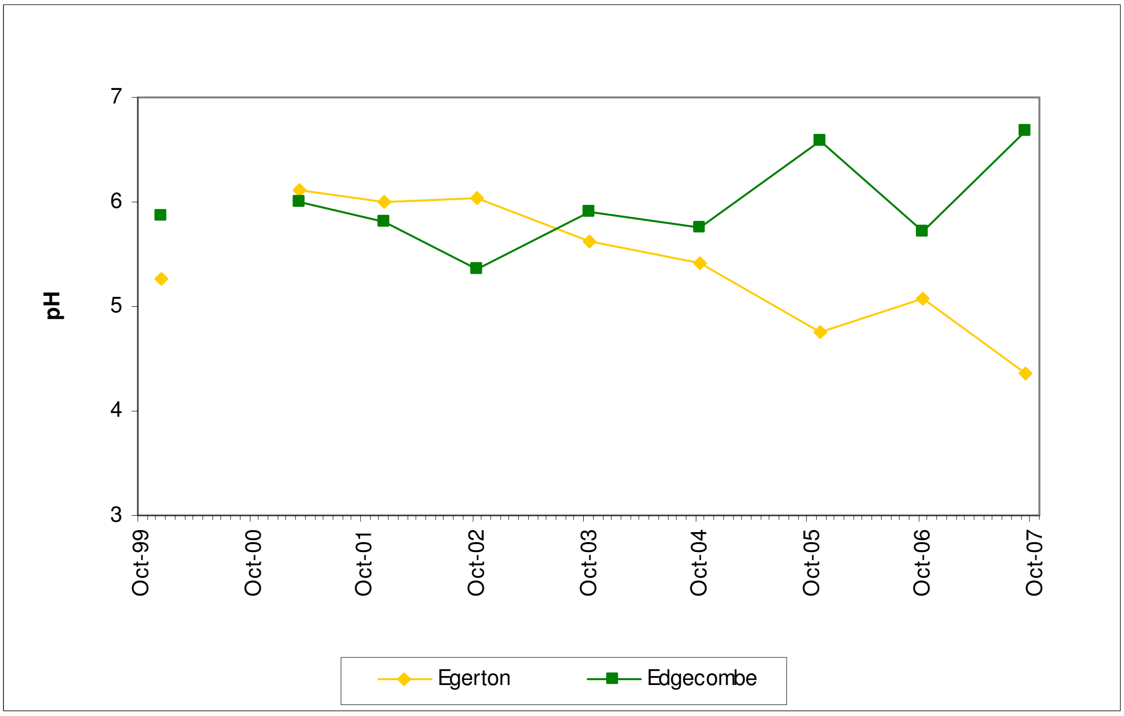


Figure 13. pH over time for Egerton and Edgecombe Springs.

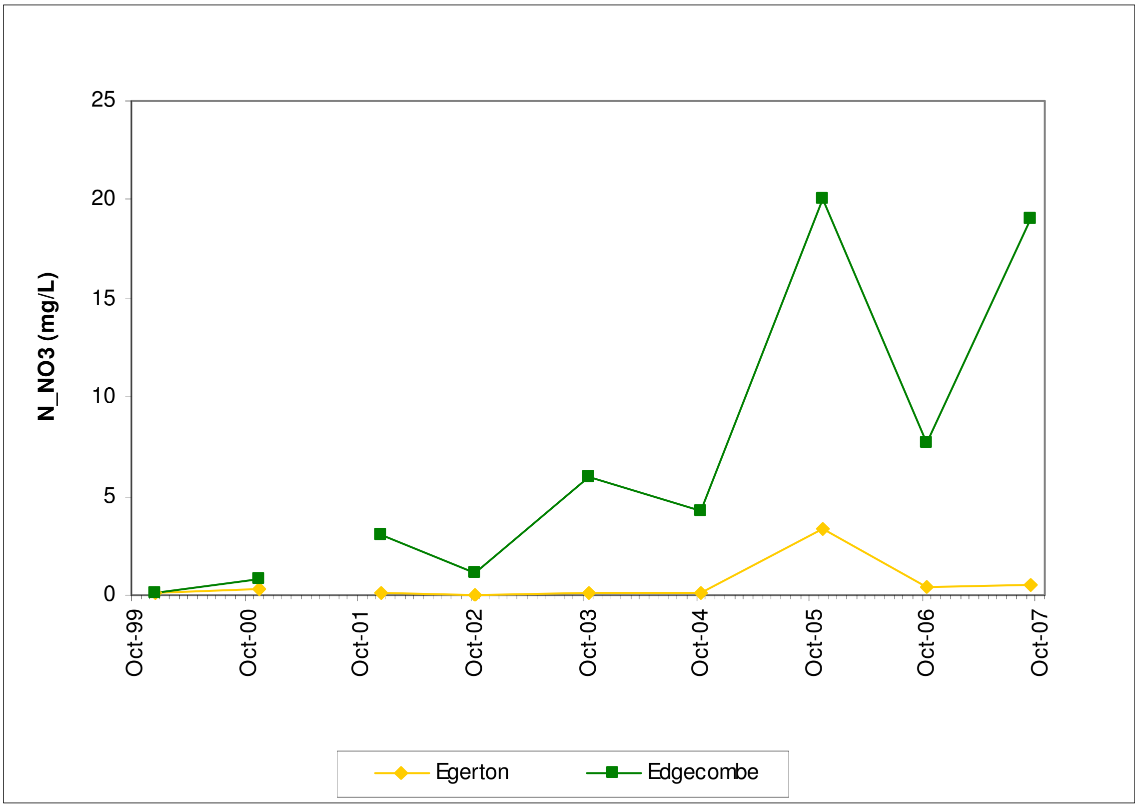


Figure 14. Nitrate and nitrite levels (mg/L) over time for Egerton and Edgecombe Springs.

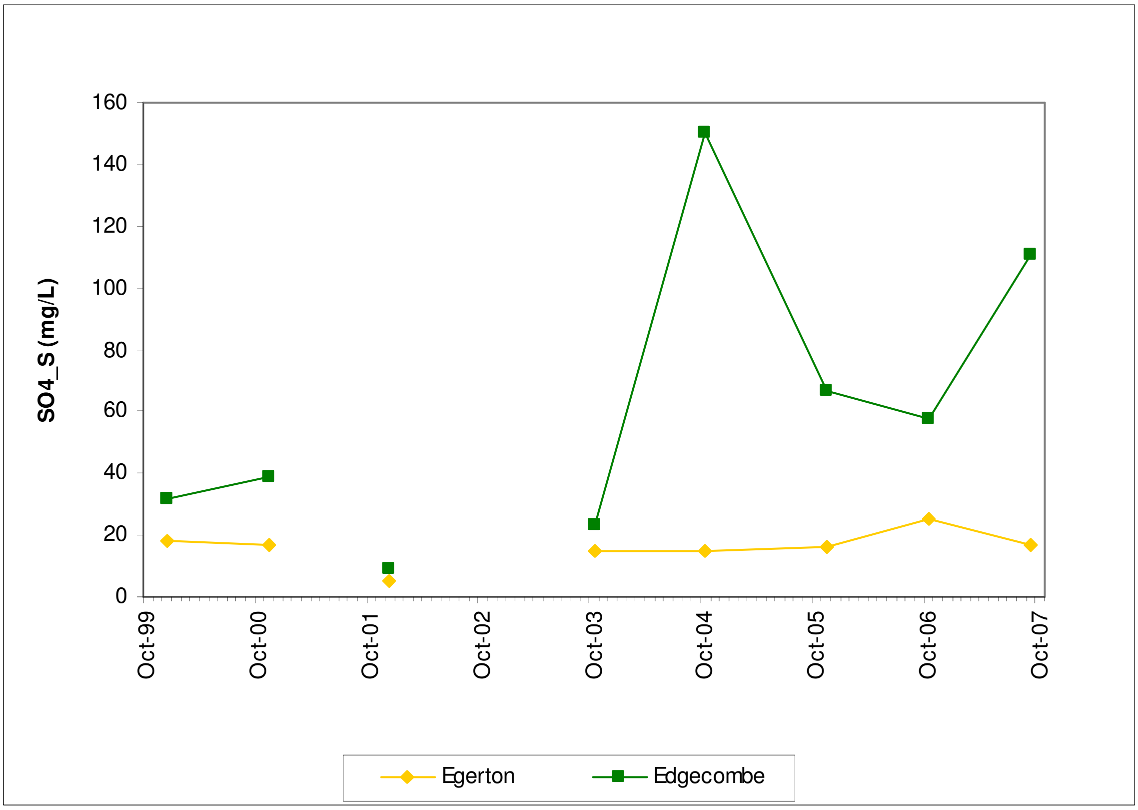


Figure 15. Sulphate (SO4_S mg/L) over time for Egerton and Edgecombe Springs.

3.2.3 Aquatic Fauna

Species richness at Egerton Spring was again relatively high (Table 11), with all crustacean groups (Amphipoda, Cladocera, Copepoda, Ostracoda) represented and most in relatively high abundance. Four copepod taxa were collected (Table 11). Of interest were an undescribed species of *Paracyclops* Claus, 1893, the same undescribed species of *Eucyclops* as that found in Cabaret Cave, and a harpacticoid copepod of the family Canthocamptidae not encountered during previous collection trips.

The fauna sampled from Edgecombe Spring was very depauperate, and comprised the juvenile stages of an insect with a highly mobile adult phases (a ceratopogonid), an oligochaete: and also a crustacean (an ostracod) (Table 11).

As with the cave copepods, taxonomic resolution and description of Copepoda specimens from the springs, most notably the undescribed species of *Paracyclops*, is currently being undertaken by Danny Tang (UWA), and results will be produced in a separate report and paper. Future reports will include the updated species list.

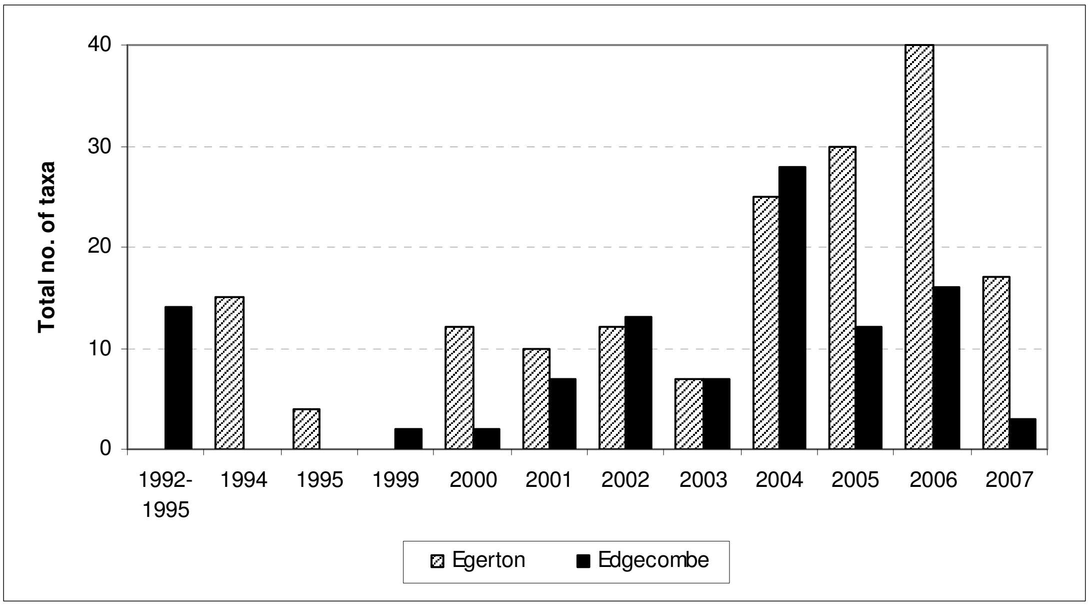


Figure 16. Total number of taxa recorded at the springs over the entire sampling period.

Table 11. Systematic list of aquatic invertebrates recorded from sites at Egerton and Edgecombe Springs in October 2007.

			TAXON	Egerton	Edgecombe
TURBELLARIA			Turbellaria spp.	1+1	0
NEMATODA			Nematoda spp.	1	0
ANNELIDA					
OLIGOCHAETA	**Tubificidae**				
		Naidinae	*Pristina aequiseta*	1	1
			Pristina leidyi	0	0
			Pristina cf osborni	0	0
	Phreodrilidae		*Insulodrilus bifidus*	0	0
			Insulodrilus lacustris s.l (form WA28)	1	0
			immature Phreodrillidae with similar ventral chaetae	0	0
ARTHROPODA					
CRUSTACEA					
Cladocera	**Ilyocryptidae**		*Ilyocryptus* sp.	1	0
Copepoda					
	Cyclopidae				
		Eucyclopinae	*Paracyclops* sp. Nov	1	0
			Eucyclops sp. nov	1	0
	Canthocamptidae		Canthocamptid sp.	1	0
			Attheyella (*Chappuisiella*) *hirsuta* .	1	0
Ostracoda					
	Darwinulidae		*Darwinula sp.*	0	0
	Candonidae		*?Candona* sp.	1	1
Amphipoda	**Paramelitidae**		Paramelitidae gen. nov.	1	0
CHELICERATA					
ACARINA					
Oribatida			Oribatida spp.	0	0
Prostigmata	**Hygrobatidae**		Hygrobatiidae spp.	0	0
	Limnesiidae		Anisitsiellinae sp. nov.	1	0
	Trombidioidea		Trombidioidea spp.	0	0
INSECTA					
ODONATA					
Zygoptera	**Megapodagrionidae**		*Archiargiolestes* sp.	0	0
Anisoptera	**Synthemistidae**		*Archaeosynthemis occidentalis*	0	0
HEMIPTERA	**Hebridae**		*Hebrus* sp.		
COLEOPTERA	**Dytiscidae**		*Sternopriscus* sp. (L)	0	0
	Hydrophilidae		*Enochrus ?peregrinus*	1	0
			Enochrus sp. (L)	0	0
	Scirtidae		Scirtidae spp. (L)	1	0
DIPTERA	**Chironomidae**				
		Chironominae	*Polypdedilum ?oresitrophus*	1	0
			Riethia sp. (V4)	0	0
			Riethia sp. (V5)	0	0
			Stempellina ?australiensis	0	0
			Tanytarsus sp.	0	0
		Orthocladiinae	Orthocladiinae sp. V31	0	0
		Tanypodinae	*Apsectrotanypus ?maculosus*	1	0
			Paramerina levidensis	1	0
			Pentamura sp.	0	0
			Chironomidae spp. (P)	0	0
	Ceratopogonidae		Ceratopogoniinae spp.	1	1
	Empididae		Empididae spp.	0	0
	Tipulidae		Tipulidae spp.	0	0
TRICHOPTERA	**Hydroptilidae**		*Oxyethira* sp.	0	0
	Leptoceridae		*Notalina* sp.	1	0
			Total no. of species	19	**3**

3.3 Additional Gnangara Mound Springs

3.3.1 Water Quantity

The new springs to the west of Bullsbrook appear relatively intact and had relatively good flows when visited in mid summer (early February 2008). From discussions with landholders, the springs (and other unvisited springs in the immediate vicinity), are wet all year, and are particularly fast flowing in winter. For example, although Sue's Spring was well vegetated and actual discharge point was not visible, it could be heard flowing, and in winter it has a vigorous, bubbling flow. Although no groundwater monitoring bores were adjacent to these springs, there are bores in the area (Figure 17). Temporal changes in water levels in these bores (Figure 18) showed some were declining and others were variable and steady. The bores closest to the springs (#5384; Old GN24) indicated an approximate 50 cm drop in summer minimum water levels over the last ~ 30 years, whereas bores to the south showed a drop of 8 m (AM26) and 20 m (AM26B) over the last 30 years. So, it appears that water levels in the area are very variable, and although current levels appear constant close to the springs, there is obviously potential for large declines in the locality.

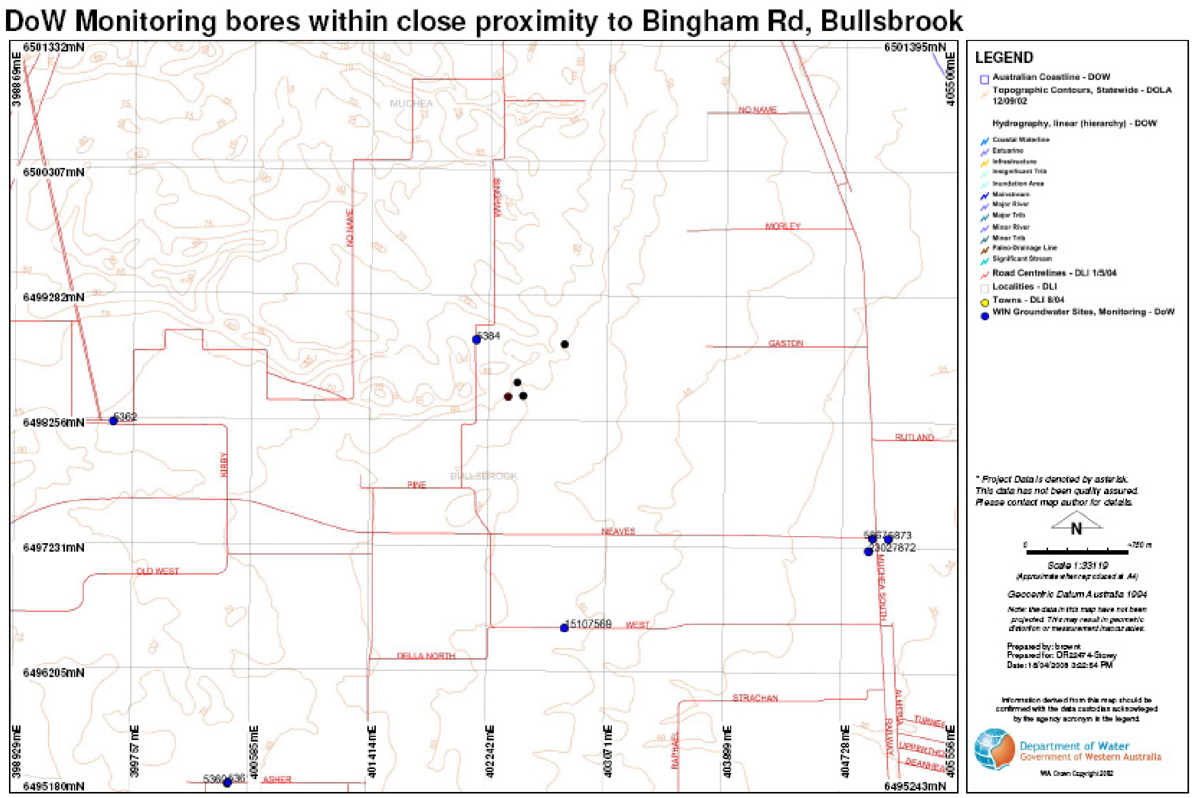
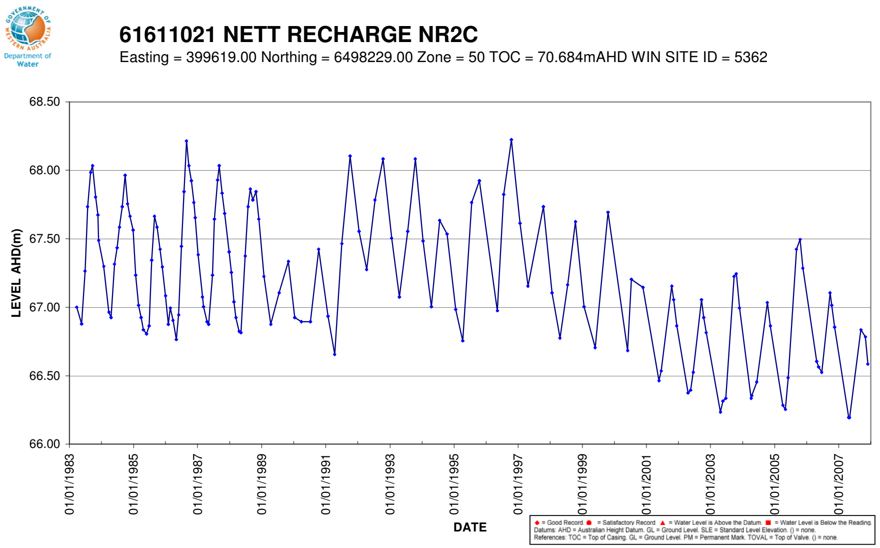
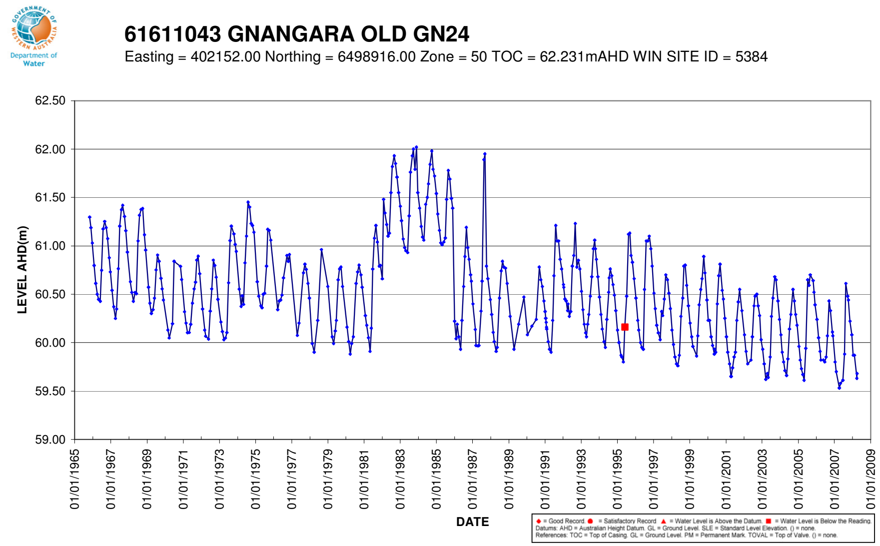
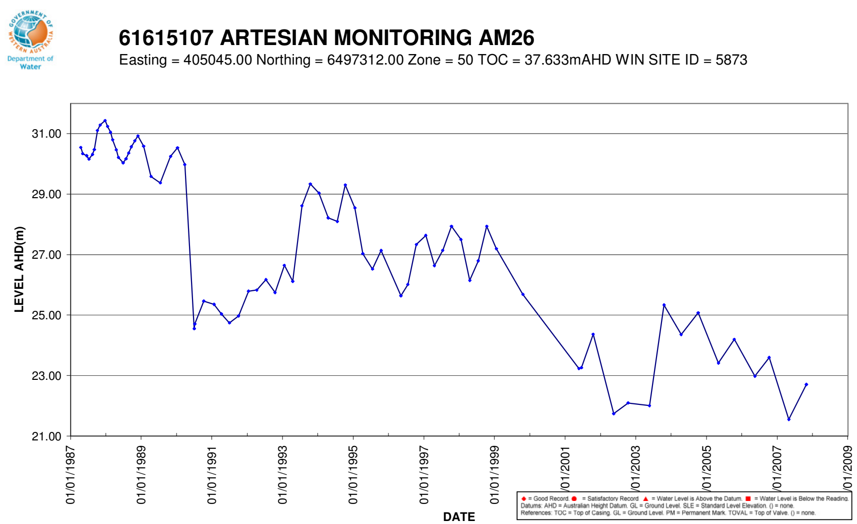


Figure 17. Groundwater water level monitoring bores in the vicinity of new springs at Bullsbrook.







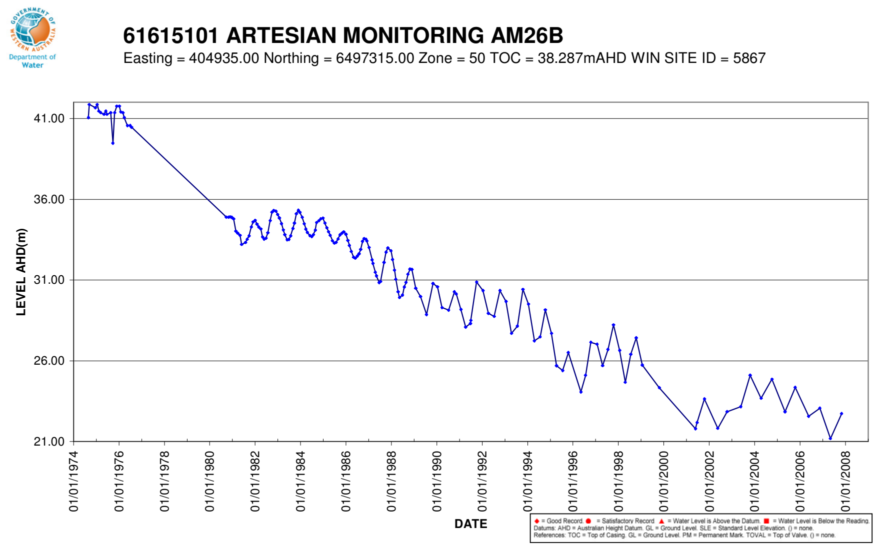


Figure 18. Temporal changes in water levels (m above AHD) in groundwater monitoring bores near the new springs at Bullsbrook (bore codes, from top left clockwise: 5362 (61611021 NETT RECHARGE NR2C), 5384 (61611043 GNANGARA OLD GN24), 5873 (61615107 ARTESIAN MONITORING AM26) & 5867 (61615101 ARTESIAN MONITORING AM26B).

3.3.2 Water Quality

In situ and laboratory determined water quality parameters were generally indicative of good quality, fresh water at the new springs. Salinity was less than 0.5 ppt and fresh[5] while dissolved oxygen was high at Sue's Spring and Gaston Swamp (> 100%), but reduced at Bill's Spring (57% saturation). pH ranged from slightly acidic (pH 5.66) at Sue's Spring to strongly acidic at Bill's (4.28) and Gaston Swamp(4.13) (Table 12).

The composition of cations was dominated by sodium (Na) with lower levels of magnesium (Mg), calcium (Ca) and potassium (K) (Table 12). Ca was sub-dominant in waters at Sue's Spring. Levels of nitrogen (as nitrate + nitrite, NO_x) exceeded ANZECC/ARMCANZ guidelines at Sue's Spring (ref. Table 5).

Table 12. *In-situ* and analytically-determined water quality parameters measured in 2007. Levels of concern are indicated by shading.

		Sue's Spring South	Bill's Spring	Gaston Swamp
In-situ				
Dissolved Oxygen	%	100.4	56.9	105.7
Dissolved Oxygen	mg/L	8.96	4.88	8.57
Conductivity	µS/cm	245	220	216
TDS	mg/L	230	206	202
pH		5.66	4.28	4.13
Temperature	˚C	20.6	21.3	22.2
Laboratory determined				
Calcium (Ca)	mg/L	10.7	1.1	2
Potassium (K)	mg/L	3.6	2.5	0.5
Magnesium (Mg)	mg/L	5.8	4.5	3.5
Sodium (Na)	mg/L	30	29.4	29.7
Chloride (Cl)	mg/L	39	41	38
Conductivity	mS/m			
Total iron	mg/L	0.17	0.88	0.2
Nitrate/Nitrite (N_N03)	mg/L	2.9	<0.1	<0.1
Sulphate (SO4_S)	mg/L	17.7	11.6	9.6

3.3.3 Fauna

A cursory survey of the springs in February 2008 recorded three cyclopoid and one harpacticoid copepod species collected from Sue's Spring South: *Paracyclops chiltoni*, *Macrocyclops albidus*, the undescribed species of *Eucyclops* and *Attheyella* (*Chappuisiella*) *hirsuta*. The first taxon, which was also found in five Yanchep caves (Table 8), is a cosmopolitan species occurring in remote

[5] Department of Environment (2003) *Stream and catchment hydrology*, River Restoration Report No. RR19, Department of Environment, Perth.

locations such as Easter Island, Hawaii, Crozet Island and New Zealand (Karaytug, 1999); Dave Morton (1977) records this species from a number of disjunct populations in eastern Australia and Tasmania, although Morton's specimens are not drawn in full. *Macrocyclops albidus* is another cosmopolitan species (Dussart & Defaye, 2006), and was collected on one previous occasion from Spillway Cave (Table 9). The harpacticoid *A.* (*Ch.*) *hirsuta* is endemic to Australia (Hamond, 1987), and was collected previously from Boomerang Cave, Twilight Cave and Egerton Spring (Appendix 2, Table A2-1).

Given the relatively intact condition of these springs, and the higher flows reported to occur in winter, it is likely that a more thorough survey of the springs, particularly if access is made through the dense vegetation to the source of the springs, would reveal more taxa. It is anticipated that an intensive spring survey would reveal additional taxa, especially those with stygal associations. Additional springs in the area observed in early February, but not visited, looked in similarly good condition, and could also reveal important fauna.

4 DISCUSSION

4.1 Water Quality

Water quality parameters measured from each cave indicated relatively constant conditions both between caves and years (Jasinska 1995, 1996; Jasinska & Knott 2000; Knott & Storey 2001, 2002, 2003, 2004; Cook & Janicke 2005; Knott *et al.* 2006, 2007). In general terms, waters were of low salinity, slightly alkaline pH, with medium to low dissolved oxygen levels consistent with groundwater from the Gnangara Mound. The cation dominance was $Na^{+}>Ca^{2+}>Mg^{2+}>K^{+}$, again consistent with groundwater-derived systems of the Swan Coastal Plain (Davis *et al.* 1993).

Across all years dissolved oxygen levels were variable but generally were above levels likely to pose a threat to fauna. Dissolved oxygen concentrations may be influenced by local factors such as the degree of mixing of the water, particularly with surface waters, the length of time the water has been underground and the levels of biological respiration. Because the water flows through the superficial aquifer and then across the floor of the caves, it is assumed that most aeration occurs via physical processes (i.e. turbulence and riffles), and biological activity (photosynthesis) is absent. The most critical area is the microhabitat occupied by the cave fauna at the interface between the roots and the water body. The absence of flowing water, combined with respiration by the microbial (bacterial/fungal) community coating the roots, upon which the cave fauna grazes, may well result in reduced DO levels in this critical habitat. As a way of counteracting this potential localised oxygen depletion, reticulation lines, sprays and drips have been installed above the root mats to deliver water across the root mats and hopefully generate localised water movement that will minimise any potential depletion at the root surface. There was fresh growth of root material following installation of these drips in 2005/2006, which was encouraging, and indicated better conditions for root mat growth, which may also enhance conditions for the fauna. However, possibly in anticipation of the bore recharge system being implemented, the reticulation systems have not been adequately maintained, and as a result some caves have dried (i.e. Carpark and Cabaret). As a result the root mats in these caves had deteriorated when observed in October 2007.

Cave YN555 on Lot 51 continued to exhibit elevated concentrations of nitrogen (nitrate + nitrite) and sulphate, however levels of sulphate were lower than last year. Levels may indicate anthropogenic influence on groundwater entering these caves, or higher natural organic loading (*i.e.* detritus). Data for the last four years appear to indicate there is a relationship between elevated levels of sulphate and conductivity in YN555 (Figure 6).

Previous sampling has determined water quality parameters from the springs were generally indicative of good quality, fresh water and were relatively constant over time. In general terms the water had a low salinity, pH < 7.0, with medium to low dissolved oxygen levels, consistent with groundwater from the Gnangara Mound. Egerton Spring showed a continuing decline in pH. The decreases in pH at Egerton are of concern, as low pH is detrimental to aquatic fauna. Egerton Spring appears to be in a zone of high risk (Figure 15) of acid sulphate soils (ASS) and potential acid sulphate soils (PASS), therefore the possibility of the influence of ASS on this site should be investigated, particularly given the urban development encroaching on this site.

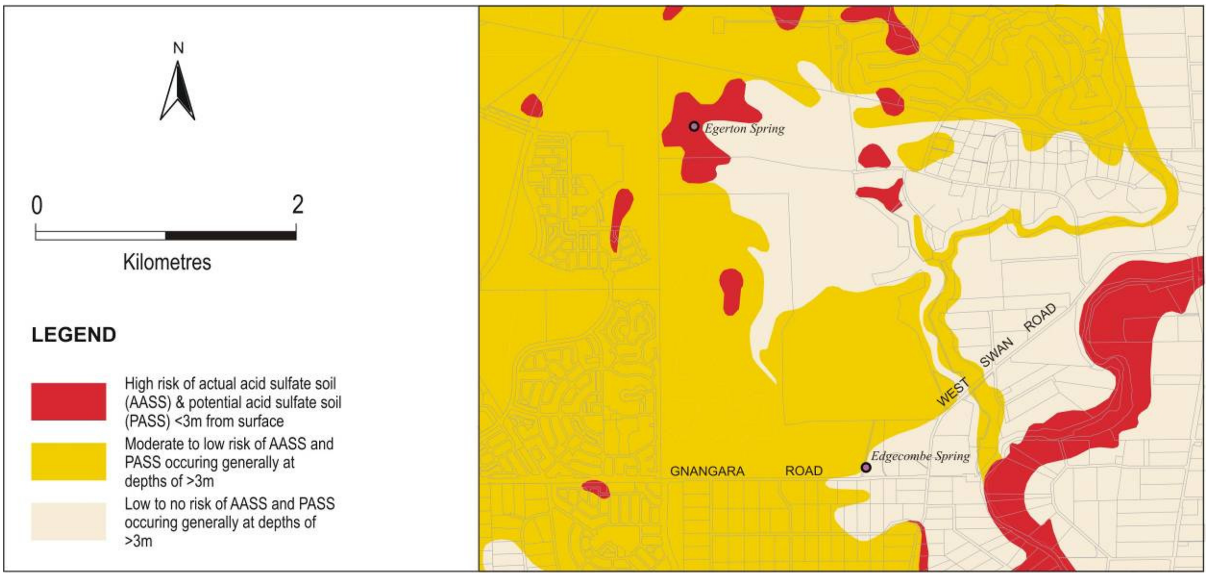


Figure 19. Study area, with areas of acid sulphate soil indicated. (Taken from Figure 2, http://www.wapc.wa.gov.au/Publications/213.aspx).

4.2 Aquatic Invertebrate Fauna

The results continue to indicate that species diversity has been reduced in the caves, at least in those root mat communities accessible to sample. This decline is still attributed to one over-riding cause, namely, the decline in groundwater levels. Another consequence of the lowering water table has been a decline in quality of the root mats, many reducing in extent and now being exposed to the air when previously they were submerged.

The dramatic reduction of water observed in all caves this year is of concern. As previously stated (Knott & Storey 2002, 2003; Knott et al., 2006, 2007), the likely cause for the decline in the fauna is loss of water from the cave streams as there is no evidence of a decline in water quality, only water quantity. There was a lack of noteworthy specimens collected from the caves this year. No aquatic fauna was recovered from Orpheus although the amphipod species was observed, and the isopods and hydrobiid snails were absent from YN555; these absences still are attributed to this decline in water levels. However, the presence of a goldfish and an unidentified fish remains the more immediate threat in YN555, which would likely have contributed to the population decline of macroinvertebrates in the pool we sampled through predation.

With respect to the current state of the root mat communities, it must be hoped that there are some extant cave fauna on root mats located in inaccessible parts of the cave system from where recolonisation may occur (though none is known, presumably only a small percentage of the total root mat habitat is accessible for study). Consequently, it is recommended that the first efforts towards recovering the root mat fauna from any refuge areas should be directed at:

1) restoring flowing water to the cave streams, and
2) restoring the growth of extensive root mats in the cave streams.

By ensuring the fundamental habitat requirements are catered for (*i.e.* permanent, flowing water and healthy root mats) there is the possibility that fauna may recolonise the caves, should it be present in some unknown refuge.

There was extensive clearing of vegetation and encroachment of urban development on the up-hill slopes about the Egerton Spring. Although the spring appeared to be in good health in October, 2007, one can only wonder at the continuing survival of this structure. The developments are situated over the likely recharge areas for the spring. This spring needs to be monitored very carefully.

The critical feature in maintaining the spring communities, undoubtedly, remains: water quantity. This point needs to be understood implicitly against the context that the relevant animal communities occur in a very thin layer: a rapid drop of the water table may well be sufficient to cause local extinctions in populations. This said, water quality may become an issue if disturbance of acid sulphate soils is the cause of decreasing pH levels in Egerton Spring.

One insight that is emerging from the work to date is the diversity and importance of the amphipods and copepods. Tang and Knott (UWA) plan to complete the amphipod descriptions in 2008/9. However, given that sampling of bores in areas of the central and northern Gnangara Mound over the past 20 years has yielded amphipods and copepods as reasonably consistent stygofaunal elements with reasonable diversity, in an area of declining water table, it is becoming clear that the sampling strategy should be expanded to include sampling bores across the Gnangara Mound to develop regional understanding and develop insights how best to sound management protocols that will minimise loss of stygofaunal biodiversity.

Finally, the recognition of new, relatively intact springs west of Bullsbrook, with healthy vegetation and strong flows is very encouraging. These springs should be intensively sampled in spring 2008, following high winter flows, with attempts to penetrate the dense vegetation to the source of the springs in an attempt to see if they support fauna of conservation value.

5 RECOMMENDATIONS

- The caves identified by Lex Bastion in his commissioned review of all known caves in the area, which formerly contained water but for which the current status is 'unknown', should be revisited as soon as possible to document their current hydrological regime.
- Encourage local speleologists to continue looking for additional caves with root mats/water.
- Permanent water flows must be restored to the cave streams, and maintained at a level whereby the majority of the root mats are submerged.
- Active management should be initiated to develop and then maintain extensive root mats in the cave streams to provide suitable habitat to support fauna should it recolonise from inaccessible refuges.
- Continue cave monitoring as per current methods to assess recovery of cave stream communities following recharge by the new recharge system/bores.
- Monitoring of the fauna should be undertaken in September/October when habitat area is likely to be greatest to assess recovery of the fauna, should it occur.
- Boomerang Cave, which dried in 2003, Carpark and Cabaret Caves which dried in 2007 due to issues associated with maintenance of the local recharge system, should continue to be monitored to determine if the TEC has been lost from these sites.
- A gauge for measuring flows should be established on Egerton Spring.
- The influence of Acid Sulphate Soils (ASS/PASS) should be investigated at Egerton Spring, and regular monitoring of pH should be initiated.
- The status of the Edgecombe Spring Threatened Ecological Community (TEC) should be re-assessed and, based on the faunal diversity listed as extinct monitoring should cease.
- Setting traps in the cave on Lot 51 (YN555) for the goldfish is of high priority.
- Continue monitoring YN555 to determine if the isopod and hydrobiid snail populations return.
- The sampling strategy be revised, and expanded to include a regional focus. The results emerging from the monitoring over the years highlight the significance of the copepod and amphipod elements, but also the decline of these elements. A regional focus of bores should seek to determine greater regional distribution, as well as develop an understanding of what measures should be put in place to conserve these elements, regionally.
- A more intensive sampling of newly discovered springs west of Bullsbrook should be implemented in spring 2008 to fully document their fauna. This survey should also include a floristic survey. In addition, an investigation of other potential springs in the area should be conducted.

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7 APPENDICES

7.1 Appendix 1: Water Quality 1998 – 2007

Table A1-1. Caves water quality for the total sampling period 2000 - 2007. Parameters not measured indicated by "-". Levels of concern are highlighted in bold.

		In situ measurements								***Laboratory measurements***							
Parameter		DO	DO	Turbidity	Salinity	Conductivity	pH	Redox	Temperature	Ca	Econd	K	Mg	Na	N_NO3	P_SR	SO4_S
units		(mg/l)	(% sat.)	(NTU)	(ppt)	(µs/cm)			(°C)	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Boomerang	**Oct-07**	9.7	97		0.33	644	6.97		16.5	43	70	2.1	5.2	67	0.32	<0.01	11.6
	Nov-06	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	Nov-05	3.6	37.4	3.4	0.31	603	7.33	277	16.73	45	58.1	2.1	4.4	62.4	**0.56**	0.01	11.7
	Oct-04	12.6	100	3.6	0.314	629	7.68	513	16.97	44.7	-	1.8	4.5	61.1	**0.3**	0.01	11.3
	Sep-03	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	Sep-02	6.1	65	1.8	0.33	561	7.09	-	18.4	46	-	2	5	63	0.17	0.01	10
	Jan-02	6.2	72	-	0.33	664	7.22	-	23.3	-	-	-	-	-	-	-	-
	Sep-01	8.8	82.7	1.8	0.37	769	7.47	253	12.3	73	-	5	10	79	0.01	0.08	12
	Nov-00	3.2	32	22.8	0.33	507	9.43	94	15.2	52	-	2	8	64	0.19	0.02	9
Carpark	**Oct-07**	6.7	73		0.56	695	7.25		17.1	58.3	70.5	2.5	6.2	75.7	0.02	<0.01	11.5
	Nov-06	6.7	66.5	44.1	0.29	685	7.69	137	18.03	63.9	72.8	2.2	6.4	69.1	0.03	<0.01	10.6
	Nov-05	3.6	36.2	132	**0.59**	**1125**	8.04	247	15.9	94.5	108	3.6	10.6	109	0.07	0.01	18.3
	Oct-04	9.1	91	23.3	0.316	632	7.64	496	16.8	56.9	-	1.8	5.8	57.9	0.12	0.01	9.1
	Sep-03	6.8	70	3.1#	0.36	760	8.17	-72	17.1	33.4	-	1.3	4	37.7	0.04	<0.01	11.4
	Sep-02	7.4	76	5.5	0.38	645	7.24	-	17.7	61	-	2	8	62	0.07	0.01	11
	Jan-02	4.9	54	-	0.28	556	7.41	-	19.3	-	-	-	-	-	-	-	-
	Sep-01	6.9	73.9	6.2	0.22	451	6.66	180	18	36	-	3	5	52	0.11	0.01	9
	Nov-00	2.8	29.7	3.1	0.32	488	9.24	81	17.8	31	-	2	6	51	0.09	<0.01	8
Water	**Oct-07**	7.3	78		0.28	545	7.19		19	44.5	57.3	2.6	5.4	61.8	0.14	0.01	7.5
	Nov-06	5.6	60.5	246	0.2	508	7.29	151	19.07	44.6	56.8	3.3	5.4	54.1	0.12	0.01	6.4
	Nov-05	2.8	30.2	0	0.25	526	7.7	260	18.9	44.2	51.4	2.3	4.2	49	0.1	0.01	6.8
	Oct-04	5.3	57	6.2	0.285	570	7.68	488	18.7	45.8	-	2.1	4.6	48.4	0.11	0.01	7.5
	Sep-03	4.4	47.3	0.1#	0.28	576	7.88	265	18.5	36.6	-	1.4	3.9	39.3	0.04	0.01	11.1
	Sep-02	5.2	55	0.8	0.31	532	7.26	-	-	48	-	2	5	54	0.09	0.01	9
	Jan-02	5.8	68	-	0.25	506	7.36	-	21.6	-	-	-	-	-	-	-	-
	Sep-01	6.2	66.7	0.5	0.25	519	7.39	232	18.6	50	-	2	6	56	0.09	0.01	9
	Nov-00	4.2	45.3	6.7	0.27	413	9.42	74	18.6	28	-	2	4	43	0.08	0.01	6
Cabaret	**Oct-07**	10.2	104		0.27	520	7.08		15.5	35.9	73.3	2.3	6	52.8	0.08	<0.01	10.5
	Nov-06	6.8	68.5	52.5	0.17	440	7.37	149	15.74	32.9	48.4	2.2	5.6	51.8	0.07	<0.01	10.3

		In situ measurements								***Laboratory measurements***							
Parameter units		DO (mg/l)	DO (% sat.)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µs/cm)	pH	Redox	Temperature (°C)	Ca mg/L	Econd mS/m	K mg/L	Mg mg/L	Na mg/L	N_NO3 mg/L	P_SR mg/L	SO4_S mg/L
	Nov-05	3.7	36.6	46.8	0.28	512	7.72	300	14.6	35	50.4	2.2	5.8	53	0.09	0.01	12
	Oct-04	8.3	79.8	9.6	0.253	504	7.95	526	16.8	44.7	-	1.9	6.3	52.8	0.01	0.01	11.8
	Sep-03	7.4	71.4	1.9#	0.23	463	7.45	328	13.4	32.1	-	1.4	5.3	44.6	0.01	0.01	15.8
	Sep-02	5.3	56	7	0.3	509	7.17	-	17.7	42	-	3	6	53	<0.01	0.01	10
	Jan-02	6.4	68	-	0.25	503	7.11	-	17.9	-	-	-	-	-	-	-	-
	Sep-01	8.9	90.7	0.5	0.22	450	7.5	235	16	44	-	2	5	50	0.13	0.01	10
	Nov-00	6.8	70.4	62.9	0.26	397	9.49	76	16.9	27	-	2	6	49	0.19	0.01	9
	1998	-	-	-	-	-	-	-	-	36	-	2	5	55	0.17	0.01	8
Mire Bowl	**Oct-07**	6.3	63		0.31	607	7.38		18.1	59.4	71.5	3.5	6.3	53.1	0.28	0.13	17
	Nov-06	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
	Nov-05	2	22.1	10.1	0.3	620	7.67	169	18	56.1	58.8	2.7	6.7	53.1	0.01	0.01	12.1
	Oct-04	11.1	100	5.5	0.311	621	7.52	471	18.6	61.6	-	2.4	7.2	48.2	0.04	0.01	11.6
	Sep-03	2.8	29.4	2.0#	0.38	769	7.96	-17	17.6	55	-	2	6.7	54.3	0.02	<0.01	19.8
	Sep-02	6.4	69	20*	0.35	598	7.14	-	18.8	70	-	2	7	51	0.08	0.05	12
Lot 51	**Oct-07**	9.1	91		0.46	893	7.46		14.4	85.8	92.1	1.9	7.6	90	0.85	<0.01	13.8
	Nov-06	7.2	78.5	-	0.36	810	**8.56**	134	19.4	75.6	86.5	2	6.2	85.9	**0.99**	<0.01	18.2
	Nov-05	1.5	15	11.2	**1.41**	**2582**	7.47	207	14.3	128	223	2.1	14.6	323	**0.88**	0.01	**51.8**
	Oct-04	7.9	74	8	0.478	956	7.67	502	16.6	81.8	-	1.8	6.5	105	**1.36**	0.01	22.8
	Sep-03	3.3	32	1.1#	**1.29**	**2397**	7.86	6	13.5	108	-	1.6	11.6	264	**0.93**	<0.01	**99.3**
	Sep-02	8.2	77	1.8	**0.51**	875	6.65	-	14	78	-	2	6	98	1.6	0.01	21
Orpheus	**Oct-07**	6.1	63		0.36	710	7.53		18.5	65.5	74.4	2.4	6.3	72.9	0.11	0.01	16.3
	Nov-06	7.1	82.4	-	0.28	636	7.33	95	22.2	65.2	70.1	2.3	6	67.7	0.05	<0.01	16.1
	Nov-05	2.7	28.5	4.2	0.4	768	7.94	184	18.27	60.8	73.5	2.3	5.3	76	0.09	0.01	18.5
	Oct-04	4.85	50.6	3.6	0.369	746	7.54	474	19.01	64.5	-	2.3	5.8	71.3	0.08	0.01	17
	Sep-03	3.7	39.1	1.0#	0.42	846	8.26	127	17.7	55	-	1.7	5.2	61.7	0.03	<0.01	23.2
	Dec-02	3.2	67.4	0.9	**0.8**	734	7.81	117	18.1	75	-	3	7	79	0.05	<0.01	19
Twilight	**Oct-07**																
	Nov-06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Nov-05	2.7	27.2	20.1	0.49	922	7.72	201	15	77.7	87	2.3	7.1	91	**4.2**	<0.01	25.6
	Oct-04	-	-	-	0.467	936	7.67	-	-	84.9	-	2.3	7.4	88	**3.89**	0.01	31.5
	Sep-03	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Sep-02	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

		In situ measurements								***Laboratory measurements***							
Parameter		DO	DO	Turbidity	Salinity	Conductivity	pH	Redox	Temperature	Ca	Econd	K	Mg	Na	N_NO3	P_SR	SO4_S
units		(mg/l)	(% sat.)	(NTU)	(ppt)	(µs/cm)			(^{o}C)	mg/L	mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Sep-01	7.6	75.6	0.5	0.44	902	7.51	149	14.9	98	-	2	9	94	**0.75**	0.01	33
	Nov-00	5.4	54.4	7.2	0.47	755	9.49	76	16	53	-	2	7	67	**1**	0.01	25
Spillway (YN565)	**Oct-07**																
	Nov-06	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Nov-05	3.1	34.4	5.7	0.24	495	7.85	98	20.5	30.5	49.7	2.9	5.8	60.5	0.12	0.01	7.8
Jackhammer	**Sep-02**	7.3	79	1.5	0.32	549	6.91	-	18.8	52	-	2	5	53	0.11	0.01	8

* shallow water and fine mud on bottom resulted in unavoidable contamination of the water sample. Visually, turbidity would have been < 2 NTUs
# Turbidity determined by W.A. Chemistry Centre on samples returned to the laboratory

Table A1-2. Springs water quality for the total sampling period 1999 – 2007. "-" indicates parameters not measured.

		Egerton Spring										Edgecombe Spring									
Parameter	**units**	**Dec-99**	**Nov-00**	**Mar-01**	**Dec-01**	**Oct-02**	**Oct-03**	**Oct-04**	**Nov-05**	**Oct-06**	**Sep-07**	**Dec-99**	**Nov-00**	**Mar-01**	**Dec-01**	**Oct-02**	**Oct-03**	**Oct-04**	**Nov-05**	**Oct-06**	**Sep-07**
In situ parameters																					
Dissolved Oxygen	(mg/L)	-	-	-	7.41	8.3	8.5	9.55	3.9	8.85	8.6	-	-	-	5.48	8.4	9.4	6.4	4.3	8.5	6.9
Dissolved Oxygen	(% sat.)	-	-	-	77.4	82	84	98	38.3	89.5	86	-	-	-	61.8	82	94	68	45.2	92	75
Turbidity	(NTU)	-	-	-	-	-	-	-	185	-		-	-	-	-	-	-	-	0	-	
Salinity	(ppt)	-	-	-	-	-	-	-	0.12	-	0.15	-	-	-	-	-	-	-	0.32	-	0.399
TDS	(mg/L)	350	-	134	-	126	131	140	120	113	150	194	-	212	-	192	156	360	320	277	399
Conductivity	(µs/cm)	662	-	269	206	214	258	192	236	220	292	405	-	413	261	327	307	604	604	537	773
pH		5.27	-	6.11	6	6.04	5.63	5.42	**4.76**	**5.07**	4.36	5.87	-	6	5.81	5.35	5.9	5.76	6.59	5.72	6.68
Redox	(mV)	-	-	-	87	121	-	-	60	-		-	-	-	171	123	-	-	269	-	
Temperature	(^{o}C)	-	-	-	-	15.8	15	17.95	14.86	15.1	15.5	19.4	-	20.8	22	17.1	17.5	19.1	18.3	19.6	17.5
Laboratory determined parameters																					
Ca	mg/L	1	1	-	-	-	1.8	2	1.3	2.8	4	13	16	-	-	-	20.3	63.6	42.9	33.8	68.7
Cl	mg/L	93	46	-	-	-	54	52	51	45	69	28	31	-	-	-	43	65	78	81	79
Econd	mS/m	-	-	-	-	-	-	-	23.5	25.6	40.4	-	-	-	-	-	-	-	59.2	53.8	86.3
Fe	mg/L	-	-	-	-	-	-	-	0.33	-		-	-	-	-	-	-	-	0.026	-	
Fe_total	mg/L	-	-	-	0.97	-	0.18	0.54	0.49	4.7	0.38	-	-	-	10	-	0.11	0.42	**200**	6.4	11
K	mg/L	1	<1	-	-	-	0.8	0.85	1	4	3.4	<1	<1	-	-	-	1.5	6.3	11.6	10.5	16.4
Mg	mg/L	5	5	-	-	5	5	5.45	4.7	5.6	7	5	5	-	-	-	6.3	15.4	8.3	7.5	11.8
Na	mg/L	32	32	-	-	-	30.5	32.65	33.1	34.7	42.2	21	20	-	-	-	17.7	37	44.3	43.7	62.6
N_NO3	mg/L	0.13	0.27	-	0.15	0.047	0.1	0.095	3.3	0.43	0.48	0.07	0.82	-	**3**	**1.1**	**6**	**4.3**	**20**	**7.7**	19
SO4_S	mg/L	18	17	-	5.5	-	15.2	15.05	16.4	25.4	16.9	32	39	-	9.1	-	23.2	**150**	**66.9**	**57.5**	111
Chloro_a	mg/L	<0.001	<0.001	-	-	0.00016	-	-	-	-		0.004	0.001	-	-	0.0017	-	-	-	-	
Chloro_b	mg/L	<0.001	<0.001	-	-	-	-	-	-	-		0.002	<0.001	-	-	-	-	-	-	-	
Chloro_c	mg/L	<0.001	<0.001	-	-	-	-	-	-	-		0.003	<0.001	-	-	-	-	-	-	-	
Phaeoph_a	mg/L	<0.001	<0.001	-	-	0.00267	-	-	-	-		<0.001	<0.001	-	-	0.00456	-	-	-	-	
N_NH3	mg/L	<0.01	0.02	-	0.053	0.035	-	-	-	-		<0.01	<0.01	-	0.014	0.009	-	-	-	-	
N_total	mg/L	0.4	0.51	-	0.47	0.48	-	-	-	-		1.2	1.3	-	3.8	2.8	-	-	-	-	
P_SR	mg/L	<0.01	<0.01	-	0.033	0.007	-	-	-	-		<0.01	<0.01	-	0.016	0.007	-	-	-	-	
P_total	mg/L	0.02	0.02	-	0.062	0.013	-	-	-	-		0.01	0.02	-	0.056	0.086	-	-	-	-	
S	mg/L	-	-	-	-	5.6	-	-	-	-		-	-	-	-	5.6	-	-	-	-	
HCO_3	mg/L	3	3	-	-	-	-	-	-	-		18	3	-	-	-	-	-	-	-	

7.2 Appendix 2: Aquatic Macroinvertebrates 1990-2007

Table A2-1. List of macroinvertebrates recorded from Yanchep Caves for the period 1990-2007. Taxa recorded new in 2007 are given in orange lettering. Taxa recorded new in 2006 are given in khaki lettering. Taxa from 2005 are indicated in blue lettering. Taxa from 2004 are indicated in red lettering.

TAXON	Source of fauna	Cabaret (YN30)															
		?	1990	1991	1992	1993	1996	1998	2000	2001	Jan-02	Sep-02	Sep-03	2004	2005	2006	2007
CNIDARIA																	
Hydra sp. 1	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Hydra sp. 2	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PLATYHELMINTHES																	
TURBELLARIA																	
Turbellaria spp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Stenostomum sp. or spp.	I	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	
Macrostomum sp. or spp.	I	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	
RHABDOCOELA: *Temnocephala*	S	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	
Dalyellioida sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Gyratrix hermaphroditus	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Typhloplanidae spp.	I	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
ROTIFERA																	
Rotifera spp.	U	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
NEMATODA																	
Nematoda spp.	U	0	0	0	0	0	1	1	0	1	0	0	0	0	1	1	
Sp. 1 (hooks present)	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Sp. 2 (hooks absent)	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
MOLLUSCA																	
GASTROPODA																	
Hydrobiidae: *Westrapyrgus* sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Glacidorbidae: *Glacidorbis sp.*	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
ANNELIDA																	
APHANONEURA																	
Aeolosomatidae: Aeolosomatidae sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Aeolosoma sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Aeolosoma sp. 1	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Aeolosoma aff. *leidyi*	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Aeolosoma tracanvorense	I	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
Aeolosoma sp. 2	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OLIGOCHAETA																	
Oligochaeta spp.	U						0	0	0	0	0	0	0	0	0	0	
Oligochaete sp. 1	U						0	0	0	0	0	0	0	0	0	0	
Oligochaete sp. 2	U						0	0	0	0	0	0	0	0	0	0	
Oligochaete sp. 3	U						0	0	0	0	0	0	0	1	0	0	
Oligochaete sp. 4	U						0	0	0	0	0	0	0	0	0	0	
Tubificidae: Tubificidae sp. 1	U						1	0	0	0	0	0	1	1	0	0	
Tubificidae sp. 2	U						1**	0	0	0	0	0	0	0	0	0	
Ainudrilus nr WA14	I						0	0	0	0	0	0	0	0	0	0	
immature tubificid with all bifid chaetae	U						0	0	0	0	0	0	0	0	0	0	
Dero digitata	S						0	0	0	0	0	0	0	0	0	0	
Pristina longiseta	U						1	0	0	0	0	0	0	0	0	0	
Pristina aequisita	U						0	0	0	0	0	0	0	0	0	0	1
Pristina sp. 1	U						0	0	0	0	0	0	0	0	0	0	
Pristina sp. 2	U						0	0	0	0	0	0	0	0	0	0	
Pristina sp. 3	U						0	0	0	0	0	0	0	0	0	0	
Pristina sima	I						0	0	0	0	0	0	0	0	0	0	
Enchytraeidae: Enchytraeidae sp. 1	U						1	0	0	0	0	0	0	0	0	0	
Enchytraeidae sp. 2	U						0	0	0	0	0	0	0	0	0	0	
Enchytraeidae sp.3	U						0	0	0	0	0	0	0	0	0	0	
Enchytraeidae sp.	U						0	0	0	0	0	0	0	0	0	0	
Enchytraeidae UWA1	I						0	0	0	0	0	0	0	0	0	0	
Phreodrilidae: *Insulodrilus lacustris*	U						1	0	0	0	0	0	0	0	0	0	
Phreodrillidae sp.	U						0	0	0	0	0	0	0	0	0	0	
Phreodrillidae sp. 1	U						1	1	0	0	0	0	0	0	0	0	
Phreodrillidae sp. 2	U						0	0	0	0	0	0	0	0	0	0	
immature Phreodrilidae with similar ventral chaetae	I						0	0	0	0	0	0	0	0	0	0	
immature Phreodrilidae with dissimilar ventral chaetae	I						0	0	0	0	0	0	0	0	0	0	
HIRUDINEA																	
Erpobellidae: Erpobdellidae spp.	U						1	1	0	0	0	0	0	0	0	0	
TARDIGRADA																	
EUTARDIGRADA																	
Hypsibiidae: *Hypsibius* sp.	U						0	0	0	0	0	0	0	0	0	0	
CRUSTACEA																	
COPEPODA																	
Tropocyclops confinis	I						0	0	0	0	0	0	0	0	0	0	0
Macrocyclops albidus	I						0	0	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni	I		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australoeucyclops sp. nov.	U	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0
Eucyclops sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mesocyclops brooksi	S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	U	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocra lacustris pacifica	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	A	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Attheyella (*Chappuisiella*) *hirsuta*	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australocamptus hamondi	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elaphoidella bidens	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXON	Carpark (YN18)												Boomerang (YN99)												Water (YN11)										
	?	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	1992	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007
CNIDARIA																																			
Hydra sp. 1		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Hydra sp. 2		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
PLATYHELMINTHES																																			
TURBELLARIA																																			
Turbellaria spp.		0	0	0	0	0	0	0	0	1	1	0		0	ns	0	0	0	0	dry	0	1	dry		ns	ns	0	0	0	0	0	0	1	0	
Stenostomum sp. or spp.		1	1	1	0	0	1	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Macrostomum sp. or spp.		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
RHABDOCOELA: *Temnocephala*		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Dalyellioida sp.		1	0	0	0	0	1	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Gyratrix hermaphroditus		1	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Typhloplanidae spp.		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
ROTIFERA																																			
Rotifera spp.		1	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
NEMATODA																																			
Nematoda spp.		1	1	0	0	0	1	1	0	1	1	0		1	ns	0	0	1	0	dry	0	1	dry		ns	ns	0	0	0	1	0	0	1	1	
Sp. 1 (hooks present)		0	0	0	0	0	0	0	1	0	0	0		0	ns	0	0	0	0	dry	1	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sp. 2 (hooks absent)		0	0	0	0	0	0	0	1	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
MOLLUSCA																																			
GASTROPODA																																			
Hydrobiidae: *Westrapyrgus* sp. nov.		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Glacidorbidae: *Glacidorbis sp.*		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
ANNELIDA																																			
APHANONEURA																																			
Aeolosomatidae: Aeolosomatidae sp.		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Aeolosoma sp.		0	0	0	0	0	0	0	0	0	1	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Aeolosoma sp. 1		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Aeolosoma aff. *leidyi*		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Aeolosoma tracanvorense		1	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Aeolosoma sp. 2		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
OLIGOCHAETA																																			
Oligochaeta spp.		0	0	0	0	0	0	1	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oligochaete sp. 1		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	1	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oligochaete sp. 2		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oligochaete sp. 3		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oligochaete sp. 4		0	0	0	0	0	0	0	1	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Tubificidae: Tubificidae sp. 1		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Tubificidae sp. 2		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Ainudrilus nr WA14		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	1	0	
immature tubificid with all bifid chaetae		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Dero digitata		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Pristina longiseta		1	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Pristina aequisita		0	0	0	0	0	1	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry	1	ns	ns	0	0	0	0	0	0	0	0	
Pristina sp. 1		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	1	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Pristina sp. 2		1	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Pristina sp. 3		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Pristina sima		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	1	dry		ns	ns	0	0	0	0	0	0	0	0	
Enchytraeidae: Enchytraeidae sp. 1		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	1	0	0	0	0	
Enchytraeidae sp. 2		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	1	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Enchytraeidae sp.3		1	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Enchytraeidae sp.		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Enchytraeidae UWA1		0	0	0	0	0	0	0	0	1	1	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	1	
Phreodrilidae: *Insulodrilus lacustris*		1	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Phreodrillidae sp.		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Phreodrillidae sp. 1		1	1	1	0	0	1	0	0	0	0	0		0	ns	1	0	0	0	dry	0	0	dry		ns	ns	1	0	1	1	1	0	0	0	
Phreodrillidae sp. 2		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
immature Phreodrilidae with similar ventral chaetae		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
immature Phreodrilidae with dissimilar ventral chaetae		0	0	0	0	0	0	0	0	1	0	0		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
HIRUDINEA																																			
Erpobellidae: Erpobdellidae spp.		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
TARDIGRADA																																			
EUTARDIGRADA																																			
Hypsibiidae: *Hypsibius* sp.		1	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
CRUSTACEA																																			
COPEPODA																																			
Tropocyclops confinis		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Macrocyclops albidus		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Paracyclops chiltoni		0	0	0	0	0	0	0	0	0	0	0		1	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	1
Australoeucyclops sp. nov.	1	0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	1	0	0	0	0
Eucyclops sp. nov.		0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Mesocyclops brooksi	0	0	0	0	0	0	0	0	0	0	0	0		0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov.	0	0	0	0	0	0	0	0	0	0	0	0	1	1	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Nitocra lacustris pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	ns	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Nitocrella sp. nov.	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Attheyella (*Chappuisiella*) *hirsuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Australocamptus hamondi	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Elaphoidella bidens	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	dry	0	0	dry	0	ns	ns	0	0	0	0	0	0	0	0	0

TAXON	Mire Bowl (YN61)							Lot51 (YN555)						Orpheus (YN256)							Twilight (YN194)								Spillway (YN565)				
	1992	Sep-02	2003	2004	2005	2006	2007	Sep-02	2003	2004	2005	2006	2007	1992	Dec-02	2003	2004	2005	2006	2007	1992	1994	1996	1998	2000	2001	2004	2005	Dec-02	2003	2004	2005	2006
CNIDARIA																																	
Hydra sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Hydra sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
PLATYHELMINTHES																																	
TURBELLARIA																																	
Turbellaria spp.		0	0	0	0	dry	dry	0	1	0	1	0			0	0	0	0	0	0			0	0	0	0	0	1	ns	ns	ns	1	ns
Stenostomum sp. or spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	1	1	0	0	0	ns	ns	ns	0	ns
Macrostomum sp. or spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	1	1	0	0	0	ns	ns	ns	0	ns
RHABDOCOELA: *Temnocephala*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Dalyellioida sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Gyratrix hermaphroditus		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Typhloplanidae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
ROTIFERA																																	
Rotifera spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
NEMATODA																																	
Nematoda spp.		0	1	0	1	dry	dry	1	0	0	1	1			0	1	0	0	0	0			1	0	1	0	0	1	ns	ns	ns	1	ns
Sp. 1 (hooks present)		0	0	0	0	dry	dry	0	0	0	0	0			0	0	1	0	0	0			0	0	0	0	1	0	ns	ns	ns	0	ns
Sp. 2 (hooks absent)		0	0	0	0	dry	dry	0	0	5	0	0			0	0	0	0	0	0			0	0	0	0	1	0	ns	ns	ns	0	ns
MOLLUSCA																																	
GASTROPODA																																	
Hydrobiidae: *Westrapyrgus* sp. nov.		0	0	0	0	dry	dry	1	1	50	1	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Glacidorbidae: *Glacidorbis sp.*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
ANNELIDA																																	
APHANONEURA																																	
Aeolosomatidae: Aeolosomatidae sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Aeolosoma sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Aeolosoma sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Aeolosoma aff. *leidyi*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Aeolosoma tracanvorense		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Aeolosoma sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
OLIGOCHAETA																																	
Oligochaeta spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Oligochaete sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Oligochaete sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	1	0	ns	ns	ns	0	ns
Oligochaete sp. 3		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Oligochaete sp. 4		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Tubificidae: Tubificidae sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Tubificidae sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Ainudrilus nr WA14		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
immature tubificid with all bifid chaetae		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
Dero digitata		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
Pristina longiseta		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Pristina aequisita		0	0	0	0	dry	dry	0	0	0	0	0	1		0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Pristina sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Pristina sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Pristina sp. 3		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Pristina sima		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Enchytraeidae: Enchytraeidae sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Enchytraeidae sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Enchytraeidae sp.3		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Enchytraeidae sp.		1	1	0	0	dry	dry	1	1	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Enchytraeidae UWA1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	1	ns	ns	ns	0	ns
Phreodrilidae: *Insulodrilus lacustris*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	0	ns
Phreodrillidae sp.		0	0	0	0	dry	dry	0	0	0	0	0			1	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Phreodrillidae sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			1	1	1	0	0	0	ns	ns	ns	0	ns
Phreodrillidae sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
immature Phreodrilidae with similar ventral chaetae		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
immature Phreodrilidae with dissimilar ventral chaetae		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
HIRUDINEA																																	
Erpobellidae: Erpobdellidae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
TARDIGRADA																																	
EUTARDIGRADA																																	
Hypsibiidae: *Hypsibius* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
CRUSTACEA																																	
COPEPODA																																	
Tropocyclops confinis		0	0	0	0	dry	dry	0	1	0	0	0	0		0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Macrocyclops albidus		0	0	0	0	dry	dry	0	0	0	0	0	0		0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
Paracyclops chiltoni		0	0	0	0	dry	dry	0	0	0	0	0	0		0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	1	ns
Australoeucyclops sp. nov.	1	1	1	0	1	dry	dry	0	1	1	1	0	1	1	0	0	0	0	0	0			1	0	0	0	0	0	ns	ns	ns	1	ns
Eucyclops sp. nov.	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Mesocyclops brooksi	0	0	0	0	0	dry	dry	0	1	1	1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	1	ns
Mixocyclops sp. nov.	0	0	0	0	0	dry	dry	0	0	0	0	1	0	0	0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Nitocra lacustris pacifica	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	ns	ns	ns	0	ns
Nitocrella sp. nov.	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	ns	ns	ns	0	ns
Attheyella (*Chappuisiella*) *hirsuta*	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	ns	ns	ns	0	ns
Australocamptus hamondi	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	ns	ns	ns	0	ns
Elaphoidella bidens	0	0	0	0	0	dry	dry	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	ns	ns	ns	1	ns
Parastenocaris eberhardi	0	0	0	0	0	dry	dry	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	ns	ns	ns	0	ns

Yanchep Caves, Egerton and Edgecombe Springs Invertebrate Monitoring

TAXON	Source	Cabaret (YN30)																Carpark (YN18)											
		?	1990	1991	1992	1993	1996	1998	2000	2001	Jan-02	Sep-02	Sep-03	2004	2005	2006	2007	?	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007
OSTRACODA																													
Darwinulidae: *Darwinula* sp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Gomphodella sp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Gomphodella aff *maia*	U						1	1	0	0	0	0	0	0	0	0			1	1	1	1	1	1	1	0	0	0	0
Candoniidae: Candoniidae sp. 1	U						1	0	0	0	1	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Candona sp.	U						0	0	0	0	0	0	0	0	0	0			1	0	0	0	0	0	0	0	1	1	0
?*Candona* spp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Candonopsis sp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
ISOPODA																													
Janiridae: Janiridae spp.	A						1	1	1	0	0	0	0	0	0	0			1	1	1	0	0	0	0	0	0	0	0
Phreatoicidae: *cf. Paramphisopus palustris*	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
AMPHIPODA																													
Ceinidae: *Austrochiltonia subtenuis*	S						1	1	1	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Perthiidae: *Perthia* sp. 1	A						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Perthia sp. 2	A						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Paramelitidae: Paramelitidae gen. nov.	A						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Paramelitidae Gen 1.	A						0	0	0	0	0	0	0	0	0	0			1	0	0	0	0	0	0	0	0	0	0
Paramelitidae Gen 2	A						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Paramelitidae Gen 3	A						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Hurleya sp.	A						1	0	0	0	0	0	0	0	0	0			1	1	0	0	0	0	0	0	0	0	0
DECAPODA																													
Parastacidae: *Cherax quinquecarinatus*	S						1	1	1	0	0	0	0	0	0	0			1	1	0	0	0	1	0	0	0	0	0
ARACHNIDA																													
ACARINA																													
Acariformes																													
ASTIGMATA																													
Acaridae: Acaridae spp.	U						1	0	0	0	0	0	1	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Sp1 (Acaridae)	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Sp8 (Acaridae)	U						0	0	0	0	0	0	0	3	0	0			0	0	0	0	0	0	0	0	0	0	0
ORIBATIDA																													
Oribatida spp.	U						0	0	0	0	0	0	0	0	1	1			0	0	0	0	0	0	0	0	1	1	0
Oribatid sp. 1	U						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Oribatid sp. 2	U						0	1	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Oribatid sp. 3	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Hydrozetidae: *Hydrozetes* sp.	S						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Malaconothridae: *Trimalaconothrus* sp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Trhypochthoniidae: *Trhypochthoniellus* sp.	U						1	0	0	0	0	0	0	0	0	0			1	0	0	0	0	0	0	0	0	0	0
PROSTIGMATA																													
Halacaridae: *Lobohalacarus weberi*	I						1	0	0	1	0	0	0	0	0	0			1	0	0	0	0	0	0	0	0	0	0
Soldanellonyx monardi	I						1	0	0	0	0	0	0	0	0	0			1	0	0	0	0	1	0	0	0	0	0
Unionicolidae: *Unionicola* sp.	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Arrenurus: *(Truncaturus) sp.*	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	1	0	0
Mideopsidae: *Tillia* sp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Parasitiformes																													
MESOSTIGMATA																													
Mesostigmata spp.	U						0	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	1	0
ENTOGNATHOUS HEXAPOD	U						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
COLLEMBOLLA																													
Hypogastruridae: Hypogastruridae spp.	U						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
INSECTA																													
ODONATA																													
Anisoptera: Anisopteran spp.	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
COLEOPTERA																													
Dytiscidae: *?Liodessus dispar affinis*	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Sternopriscus sp.	S						1	0	1	0	0	0	0	0	0	0			1	0	0	0	0	0	0	0	0	0	0
Sternopriscus marginatus (A)	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Sternopriscus sp. (L)	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Tribe Bidessini spp. (L)	S						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Curculionidae: Curculionidae spp. (L)	S						0	0	0	0	0	0	0	0	0	1			0	0	0	0	0	0	0	0	0	0	0
DIPTERA																													
Diptera larva	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Culicidae: Culicidae spp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	1	1	0	0	0	0
Anopheles sp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Culicinae spp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	1	0	0
Chironomidae: *Corynoneura* sp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Chironomus aff. alternans	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Paramerina levidensis	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Polypedilum sp.	T						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae: Ceratopogonidae spp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Empididae: Empididae spp.	T						0	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	1	0
Tipulidae: Tipulidae spp.	T						1	0	0	1	1	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
TRICHOPTERA																													
Leptoceridae: Leptoceridae spp.	T						1	0	0	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
VERTEBRATA																													
OSTEICHTHYES:																													
Bostockia porosa	S						1	1	1	0	0	0	0	0	0	0			0	0	0	0	0	0	0	0	0	0	0
Total number of taxa recorded							**20**	**7**	**6**	**3**	**3**	**1**	**2**	**2**	**2**	**3**			**11**	**5**	**3**	**2**	**2**	**5**	**3**	**1**	**5**	**5**	**1**
No. taxa in each group recorded on each occasion																													
Ancient cavernicoles (stygofauna)	A						3	1	1	0	0	0	0	0	0	0			3	2	1	0	0	0	0	0	0	0	0
Widespead marine & freshwater interstitial fauna	I						7	2	1	2	0	0	0	0	1	0			7	2	2	0	0	4	0	0	1	3	0
Surface waters of Loch McNess	S						6	4	4	0	0	0	0	0	0	1			2	1	0	0	0	1	0	0	1	0	0
Insects with terrestrial adult and aquatic larval stages	T						3	0	0	1	1	0	0	0	0	0			0	0	0	0	0	1	1	0	1	1	0
Unclassified[1]	U						14	5	0	1	1	0	2	3	2	2			11	3	2	1	1	4	3	3	5	4	0

TAXON	Boomerang (YN99)												Water (YN11)										
	1992	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007	1996	1998	2000	2001	Jan-02	Sep-02	2003	2004	2005	2006	2007
OSTRACODA																							
Darwinulidae: *Darwinula* sp.		1	ns	0	0	0	1	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Gomphodella sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	1	0	
Gomphodella aff *maia*		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Candoniidae: Candoniidae sp. 1		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Candona sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	1	0	
?*Candona* spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	1	0	0	
Candonopsis sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
ISOPODA																							
Janiridae: Janiridae spp.		1	ns	1	0	0	0	dry	0	0	dry		ns	ns	1	0	1	0	0	0	0	0	
Phreatoicidae: *cf. Paramphisopus palustris*		0	ns	a	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
AMPHIPODA																							
Ceinidae: *Austrochiltonia subtenuis*		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Perthiidae: *Perthia* sp. 1		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Perthia sp. 2		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Paramelitidae: Paramelitidae gen. nov.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Paramelitidae Gen 1.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Paramelitidae Gen 2		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Paramelitidae Gen 3		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Hurleya sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
DECAPODA																							
Parastacidae: *Cherax quinquecarinatus*		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	1	0	1	1	0	
ARACHNIDA																							
ACARINA																							
Acariformes																							
ASTIGMATA																							
Acaridae: Acaridae spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sp1 (Acaridae)		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sp8 (Acaridae)		2	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
ORIBATIDA																							
Oribatida spp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	1	1	
Oribatid sp. 1		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oribatid sp. 2		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Oribatid sp. 3		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Hydrozetidae: *Hydrozetes* sp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Malaconothridae: *Trimalaconothrus* sp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Trhypochthoniidae: *Trhypochthoniellus* sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
PROSTIGMATA																							
Halacaridae: *Lobohalacarus weberi*		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Soldanellonyx monardi		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Unionicolidae: *Unionicola* sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Arrenurus: *(Truncaturus) sp.*		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Mideopsidae: *Tillia* sp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Parasitiformes																							
MESOSTIGMATA																							
Mesostigmata spp.		0	0	0	0	0	0	0	0	0	dry		0	0	0	0	0	0	0	0	0	0	
ENTOGNATHOUS HEXAPOD		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
COLLEMBOLLA																							
Hypogastruridae: Hypogastruridae spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
INSECTA																							
ODONATA																							
Anisoptera: Anisopteran spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
COLEOPTERA																							
Dytiscidae: *?Liodessus dispar affinis*		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sternopriscus sp.		1	ns	1	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sternopriscus marginatus (A)		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Sternopriscus sp. (L)		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Tribe Bidessini spp. (L)		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Curculionidae: Curculionidae spp. (L)		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
DIPTERA																							
Diptera larva		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Culicidae: Culicidae spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Anopheles sp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Culicinae spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Chironomidae: *Corynoneura* sp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Chironomus aff. alternans		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Paramerina levidensis		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Polypedilum sp.		1	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Ceratopogonidae: Ceratopogonidae spp.		1	ns	0	0	0	0	dry	0	1	dry		ns	ns	0	0	0	0	0	0	0	0	
Empididae: Empididae spp.		0	ns	0	0	0	0	dry	1	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Tipulidae: Tipulidae spp.		0	ns	0	0	1	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
TRICHOPTERA																							
Leptoceridae: Leptoceridae spp.		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
VERTEBRATA																							
OSTEICHTHYES:																							
Bostockia porosa		0	ns	0	0	0	0	dry	0	0	dry		ns	ns	0	0	0	0	0	0	0	0	
Total number of taxa recorded		**20**	**1**	**3**	**1**	**2**	**2**	**1**	**2**	**2**	**1**		**1**	**1**	**2**	**1**	**2**	**2**	**1**	**3**	**5**	**2**	
No. taxa in each group recorded on each occasion																							
Ancient cavernicoles (stygofauna)		1	0	1	0	0	0	0	0	0	0		0	0	1	0	1	1	0	0	0	0	
Widespead marine & freshwater interstitial fauna		8	0	0	0	0	1	0	0	2	0		0	0	1	0	0	0	2	1	2	1	
Surface waters of Loch McNess		4	0	1	0	0	0	0	0	0	0		0	0	0	0	0	1	0	1	1	0	
Insects with terrestrial adult and aquatic larval stages		4	0	0	0	1	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	
Unclassified[1]		17	0	1	0	1	3	0	2	1	0		0	0	1	0	1	2	0	1	4	2	

TAXON	Mire Bowl (YN61)							Lot51 (YN555)						Orpheus (YN256)						
	1992	Sep-02	2003	2004	2005	2006	2007	Sep-02	2003	2004	2005	2006	2007	1992	Dec-02	2003	2004	2005	2006	2007
OSTRACODA																				
Darwinulidae: *Darwinula* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Gomphodella sp.		0	0	0	0	dry	dry	0	0	0	0	1			0	0	0	0	0	0
Gomphodella aff *maia*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Candoniidae: Candoniidae sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Candona sp.		0	0	0	0	dry	dry	1	1	0	0	1	1		0	0	0	0	0	0
?*Candona* spp.		0	0	1	0	dry	dry	0	0	14	0	0			0	0	0	0	0	0
Candonopsis sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
ISOPODA																				
Janiridae: Janiridae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Phreatoicidae: *cf. Paramphisopus palustris*		0	0	0	0	dry	dry	1	1	50	1	0			0	0	0	0	0	0
AMPHIPODA																				
Ceinidae: *Austrochiltonia subtenuis*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Perthiidae: *Perthia* sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Perthia sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Paramelitidae: Paramelitidae gen. nov.		0	0	0	1	dry	dry	0	0	0	0	0			0	0	0	1	1	1
Paramelitidae Gen 1.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Paramelitidae Gen 2		1	1	1	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Paramelitidae Gen 3		0	0	0	0	dry	dry	0	0	0	0	0			1	0	0	0	0	0
Hurleya sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
DECAPODA																				
Parastacidae: *Cherax quinquecarinatus*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
ARACHNIDA																				
ACARINA																				
Acariformes																				
ASTIGMATA																				
Acaridae: Acaridae spp.		0	0	0	0	dry	dry	0	1	0	0	0			0	0	0	0	0	0
Sp1 (Acaridae)		0	0	0	0	dry	dry	0	0	1	0	0			0	0	0	0	0	0
Sp8 (Acaridae)		0	0	1	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
ORIBATIDA																				
Oribatida spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Oribatid sp. 1		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Oribatid sp. 2		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Oribatid sp. 3		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Hydrozetidae: *Hydrozetes* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Malaconothridae: *Trimalaconothrus* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Trhypochthoniidae: *Trhypochthoniellus* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
PROSTIGMATA																				
Halacaridae: *Lobohalacarus weberi*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Soldanellonyx monardi		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Unionicolidae: *Unionicola* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Arrenurus: *(Truncaturus) sp.*		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Mideopsidae: *Tillia* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Parasitiformes																				
MESOSTIGMATA																				
Mesostigmata spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
ENTOGNATHOUS HEXAPOD		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
COLLEMBOLLA																				
Hypogastruridae: Hypogastruridae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
INSECTA																				
ODONATA																				
Anisoptera: Anisopteran spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
COLEOPTERA																				
Dytiscidae: *?Liodessus dispar affinis*		0	0	0	0	dry	dry	0	0	1	0	0			0	0	0	0	0	0
Sternopriscus sp.		0	0	0	0	dry	dry	1	1	0	0	0			0	0	0	0	0	0
Sternopriscus marginatus (A)		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Sternopriscus sp. (L)		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Tribe Bidessini spp. (L)		0	0	0	0	dry	dry	0	0	0	1	0			0	0	0	0	0	0
Curculionidae: Curculionidae spp. (L)		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
DIPTERA																				
Diptera larva		0	0	0	0	dry	dry	1	0	0	0	0			0	0	0	0	0	0
Culicidae: Culicidae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Anopheles sp.		0	0	0	0	dry	dry	0	0	0	1	0			0	0	0	0	0	0
Culicinae spp.		0	0	0	0	dry	dry	0	0	0	1	0			0	0	0	0	0	0
Chironomidae: *Corynoneura* sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Chironomus aff. alternans		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Paramerina levidensis		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Polypedilum sp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Ceratopogonidae: Ceratopogonidae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Empididae: Empididae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Tipulidae: Tipulidae spp.		0	0	0	0	dry	dry	0	0	1	0	0			0	0	0	0	0	0
TRICHOPTERA																				
Leptoceridae: Leptoceridae spp.		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
VERTEBRATA																				
OSTEICHTHYES:																				
Bostockia porosa		0	0	0	0	dry	dry	0	0	0	0	0			0	0	0	0	0	0
Total number of taxa recorded		**2**	**2**	**4**	**2**	**1**	**1**	**5**	**5**	**6**	**5**	**3**			**2**	**1**	**1**	**2**	**2**	**2**
		(+ 2 acarines)																		
No. taxa in each group recorded on each occasion																				
Ancient cavernicoles (stygofauna)		1	1	1	1	0	0	0	0	0	0	0			1	0	0	1	1	1
Widespead marine & freshwater interstitial fauna		1	0	0	1	0	0	0	1	1	3	0			0	0	0	0	0	0
Surface waters of Loch McNess		0	0	0	0	0	0	0	1	2	2	0			0	0	0	0	0	0
Insects with terrestrial adult and aquatic larval stages		0	0	0	0	0	0	0	0	1	2	0			0	0	0	0	0	0
Unclassified[1]		1	3	2	1	0	0	8	6	4	2	4			1	1	1	0	0	0

TAXON	Twilight (YN194)								Spillway (YN565)				
	1992	1994	1996	1998	2000	2001	2004	2005	Dec-02	2003	2004	2005	2006
OSTRACODA													
Darwinulidae: *Darwinula* sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Gomphodella sp.			0	0	0	0	0	0	ns	ns	ns	1	ns
Gomphodella aff *maia*			1	1	1	0	0	0	ns	ns	ns	0	ns
Candoniidae: Candoniidae sp. 1			0	0	0	0	0	0	ns	ns	ns	0	ns
Candona sp.			1	0	0	0	0	0	ns	ns	ns	0	ns
?*Candona* spp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Candonopsis sp.			0	0	0	0	0	0	ns	ns	ns	1	ns
ISOPODA													
Janiridae: Janiridae spp.			1	1	1	0	0	0	ns	ns	ns	0	ns
Phreatoicidae: *cf. Paramphisopus palustris*			0	0	0	0	0	0	ns	ns	ns	0	ns
AMPHIPODA													
Ceinidae: *Austrochiltonia subtenuis*			0	0	0	0	0	0	ns	ns	ns	0	ns
Perthiidae: *Perthia* sp. 1			1	0	0	0	0	0	ns	ns	ns	0	ns
Perthia sp. 2			1	0	0	0	0	0	ns	ns	ns	0	ns
Paramelitidae: Paramelitidae gen. nov.			1	1	0	0	0	0	ns	ns	ns	0	ns
Paramelitidae Gen 1.			0	0	0	0	0	0	ns	ns	ns	0	ns
Paramelitidae Gen 2			0	0	0	0	0	0	ns	ns	ns	0	ns
Paramelitidae Gen 3			0	0	0	0	0	0	ns	ns	ns	0	ns
Hurleya sp.			1	0	0	0	0	0	ns	ns	ns	0	ns
DECAPODA													
Parastacidae: *Cherax quinquecarinatus*			1	0	0	0	0	0	ns	ns	ns	1	ns
ARACHNIDA													
ACARINA													
Acariformes													
ASTIGMATA													
Acaridae: Acaridae spp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Sp1 (Acaridae)			0	0	0	0	0	0	ns	ns	ns	0	ns
Sp8 (Acaridae)			0	0	0	0	0	0	ns	ns	ns	0	ns
ORIBATIDA													
Oribatida spp.			0	0	0	0	0	0	ns	ns	ns	1	ns
Oribatid sp. 1			1	0	0	0	0	0	ns	ns	ns	0	ns
Oribatid sp. 2			0	0	0	0	0	0	ns	ns	ns	0	ns
Oribatid sp. 3			0	0	0	0	0	0	ns	ns	ns	0	ns
Hydrozetidae: *Hydrozetes* sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Malaconothridae: *Trimalaconothrus* sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Trhypochthoniidae: *Trhypochthoniellus* sp.			1	0	0	0	0	0	ns	ns	ns	0	ns
PROSTIGMATA													
Halacaridae: *Lobohalacarus weberi*			1	0	0	0	0	0	ns	ns	ns	0	ns
Soldanellonyx monardi			1	1	1	0	0	0	ns	ns	ns	0	ns
Unionicolidae: *Unionicola* sp.			0	0	0	0	0	0	ns	ns	ns	1	ns
Arrenurus: *(Truncaturus) sp.*			0	0	0	0	0	0	ns	ns	ns	0	ns
Mideopsidae: *Tillia* sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Parasitiformes													
MESOSTIGMATA													
Mesostigmata spp.			0	0	0	0	0	0					
ENTOGNATHOUS HEXAPOD			0	0	0	0	0	0	ns	ns	ns	0	ns
COLLEMBOLLA													
Hypogastruridae: Hypogastruridae spp.			0	0	0	0	1	0	ns	ns	ns	0	ns
INSECTA													
ODONATA													
Anisoptera: Anisopteran spp.			0	0	0	0	1	0	ns	ns	ns	0	ns
COLEOPTERA													
Dytiscidae: *?Liodessus dispar affinis*			0	0	0	0	0	0	ns	ns	ns	0	ns
Sternopriscus sp.			1	0	0	0	0	0	ns	ns	ns	0	ns
Sternopriscus marginatus (A)			0	0	0	0	0	0	ns	ns	ns	1	ns
Sternopriscus sp. (L)			0	0	0	0	0	0	ns	ns	ns	1	ns
Tribe Bidessini spp. (L)			0	0	0	0	0	0	ns	ns	ns	0	ns
Curculionidae: Curculionidae spp. (L)			0	0	0	0	0	0	ns	ns	ns	0	ns
DIPTERA													
Diptera larva			0	0	0	0	0	0	ns	ns	ns	0	ns
Culicidae: Culicidae spp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Anopheles sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Culicinae spp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Chironomidae: *Corynoneura* sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Chironomus aff. alternans			0	0	0	0	0	1	ns	ns	ns	0	ns
Paramerina levidensis			0	0	0	0	0	1	ns	ns	ns	0	ns
Polypedilum sp.			0	0	0	0	0	0	ns	ns	ns	0	ns
Ceratopogonidae: Ceratopogonidae spp.			1	0	0	0	0	0	ns	ns	ns	0	ns
Empididae: Empididae spp.			0	0	0	0	0	0	ns	ns	ns		ns
Tipulidae: Tipulidae spp.			1	0	0	0	0	0	ns	ns	ns	0	ns
TRICHOPTERA													
Leptoceridae: Leptoceridae spp.			0	0	0	0	0	0	ns	ns	ns	0	ns
VERTEBRATA													
OSTEICHTHYES:													
Bostockia porosa			0	0	0	0	0	0	ns	ns	ns	0	ns
Total number of taxa recorded			**16**	**5**	**4**	**1**	**3**	**3**	**0**	**1**	**0**	**8**	**1**
No. taxa in each group recorded on each occasion													
Ancient cavernicoles (stygofauna)			5	2	1	0	0	0	0	0	0	0	0
Widespead marine & freshwater interstitial fauna			11	4	4	0	0	2	0	0	0	2	0
Surface waters of Loch McNess			2	0	0	0	1?	0	0	0	0	7	0
Insects with terrestrial adult and aquatic larval stages			2	0	0	0	0	2	0	0	0	0	0
Unclassified[1]			9	2	3	0	4	2	0	0	0	7	0

Table A2-2. Egerton Spring macroinvertebrates 1994-2007. Taxa recorded new in 2007 are given in orange lettering. Taxa recorded new in 2006 are given in khaki lettering. Taxa from 2005 are indicated in blue lettering. Taxa from 2004 are indicated in red lettering.

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007
TURBELLARIA										
Turbellaria spp.	1		1	1	1	0	0	1	1	1
NEMATODA										
Nematoda spp.	1		1	1	1	1	0	1	1	1
ANNELIDA										
OLIGOCHAETA										
Oligochaeta spp.	1		1	1	1	1	1	0	0	0
immature with all bifid chaetae	0		0	0	0	0	0	1	0	0
Pristina aequiseta	0		0	0	0	0	0	0	1	1
Pristina leidyi	0		0	0	0	0	0	1	1	0
Pristina cf osborni	0		0	0	0	0	0	1	1	0
?Nais communis	0		0	0	0	0	0	1	0	0
Insulodrilus lacustris s.l (form WA28)	0		0	0	0	0	0	0	1	0
immature Phreodrillidae with similar ventral chaetae	0		0	0	0	0	0	1	0	0
CRUSTACEA										
Chydoridae: *?Alona* sp.	0		0	0	0	0	0	1	0	
Ilyocryptidae: *Ilyocryptus* sp.	1		1	1	1	1	0	0	1	0
COPEPODA										
Eucyclops sp. nov.	0	1	0	0	0	0	0	1	1	1
Paracyclops chiltoni	0	1	0	0	0	0	0	0	0	0
Paracyclops sp. nov.	0	1	0	0	0	0	0	0	1	1
Mixocyclops sp. nov.	0	0	0	0	0	0	0	0	1	0
Cyclopinae copepodite	0	0	0	0	0	0	0	0	1	0
Attheyella (*Chappuisiella*) *hirsuta*	0	1	0	0	0	0	0	0	1	1
Australocamptus hamondi	1	0	0	0	0	0	0	0	0	0
Canthocamptid sp.	0	0	0	0	0	0	0	0	0	1
OSTRACODA										
Ostracod spp	0		0	0	0	0	1	0	0	
Darwinulidae: *Darwinula* sp.	1		1	0	1	1	0	1	1	0
n.sp	0		0	0	0	0	0	1	0	0
Candonidae: *?Candona* sp.	0		0	0	0	0	0	0	1	1
Paramelitidae: Paramelitidae gen. nov.	1		1	1	1	1	0	1	1	1
Perthiidae: *Perthia branchialis*	0		0	0	0	0	1	0	0	
DECAPODA										
Parastacidae: *Cherax quinquecarinatus*	1		1	0	0	0	1	0	0	0
CHELICERATA										
ACARINA										
Oribatida: Oribatida spp.	1		1	1	1	0	0	4	1	
Hygrobatidae: Hygrobatiidae spp.	0		0	0	0	0	0	0	1	
Limnesiidae: *Anisitsiellinae sp. nov.*	0		0	0	0	0	0	0	1	1
Limnesia sp nov	1		0	0	0	0	0	0	0	0
Trombidioidea: Trombidioidea spp.	0		0	0	0	0	0	0	1	0
Acarina sp. 3	0		0	0	0	0	1	0	0	0

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007
Acarina sp. 4	0		0	0	0	0	1	0	0	0
Acarina sp. 5	0		0	0	0	0	1	0	0	0
COLLEMBOLLA										
Sminthuridae: Sminthuridae spp.	0		0	0	0	0	1	0	0	0
INSECTA										
ODONATA										
Megapodagrionidae: *Archiargiolestes* sp.	0		0	0	0	0	0	0	1	0
Anisoptera spp.	1		1	1	1	0	0	0	0	1
Gomphidae: *Austrogomphus lateralis*	0		0	0	0	0	1	0	0	0
Austrocorduliidae: *Lathrocordula metallica*	0		0	0	0	0	1	0	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0		0	0	0	0	0	1	0	0
Archaeosynthemis occidentalis	0		0	0	0	0	0	0	1	0
Archeosynthemis ?leachii	0		0	0	0	0	1	0	0	0
HEMIPTERA										
Hemipteran sp.	0		0	0	0	0	1	0	0	
Hebridae: *Hebrus* sp.	0		0	0	0	0	0	0	1	0
Veliidae: Veliidae spp.	1		0	0	1	0	0	0	0	1
COLEOPTERA										
Dytiscidae: Dytiscidae spp. (L)	1		1	1	1	1	0	0	0	0
Necterosoma sp.	0		0	0	0	0	1	0	0	0
Sternopriscus brownii	0		0	0	0	0	1	0	0	0
Sternopriscus marginatus (A)	0		0	0	0	0	0	1	0	0
Sternopriscus sp. (L)	0		0	0	0	0	0	1	1	0
Hydrophilidae: *Enochrus ?peregrinus*	0		0	0	0	0	0	0	1	0
Enochrus sp. (L)	0		0	0	0	0	0	0	1	0
Scirtidae: Scirtidae spp. (L)	0		0	0	0	0	1	1	1	1
DIPTERA										
Culicidae: *Anopheles* sp.	0		0	0	0	0	0	1	0	0
Chironomidae: Chironomidae spp.	1		1	1	1	1	0	0	1	1
Polypedilum sp.	0		0	0	0	0	0	1	0	0
Polypdedilum ?oresitrophus	0		0	0	0	0	0	0	1	0
Riethia sp. (V4)	0		0	0	0	0	0	0	1	0
Riethia sp. (V5)	0		0	0	0	0	0	1	1	0
Stempellina ?australiensis	0		0	0	0	0	0	1	1	0
Tanytarsus sp.	0		0	0	0	0	0	1	1	0
Chironominae spp.	0		0	0	0	0	1	0	0	0
Limnophyes pullulus	0		0	0	0	0	0	1	0	0
Orthocladiinae sp, V31	0		0	0	0	0	0	0	1	0
Apsectrotanypus ?maculosus	0		0	0	0	0	0	0	1	0
Paramerina levidensis	0		0	0	0	0	0	1	1	0
Pentamura sp.	0		0	0	0	0	0	0	1	0
Tanypodinae spp.	0		0	0	0	0	1	0	0	1
Ceratopogonidae: Ceratopogoniinae spp.	0		0	0	0	0	0	1	1	1
Ceratopogonidae spp.	0		0	0	0	0	1	0	0	0
Empididae: Empididae spp.	0		0	0	0	0	1	0	1	0
Simulidae: Simuliidae spp.	0		0	0	0	0	1	0	0	0
Tipulidae: Tipulidae spp.	0		0	0	0	0	1	0	1	0

TAXON	1994	1995	2000	2001	2002	2003	2004	2005	2006	2007
TRICHOPTERA										0
Ecnomidae: *Ecnomina D group* sp.	0		0	0	0	0	1	0	0	0
Hydroptilidae: *Oxyethira* sp.	0		0	0	0	0	1	1	0	0
Leptoceridae: Leptoceridae spp.	1		1	1	1	0	0	0	0	1
Notalina sp.	0		0	0	0	0	1	1	1	0
LEPIDOPTERA										0
Unidentified lepidopteran	0		0	0	0	0	1	0	0	0
Total no. of species	**15**	**4**	**12**	**10**	**12**	**7**	**25**	**30**	**40**	**17**

Table A2-3. Edgecombe Spring macroinvertebrates 1992-2007. Taxa recorded new in 2007 are given in orange lettering. Taxa recorded new in 2006 are given in khaki lettering. Taxa from 2005 are indicated in blue lettering. Taxa from 2004 are indicated in red lettering.

TAXON	1992-1995	1999	2000	2001	2002	2003	2004	2005	2006	2007
TURBELLARIA										
Turbellaria spp.	0	0	1	0	1	0	1	0	1	0
NEMATODA										
Nematoda spp.	1	1	1	0	0	0	1	1	1	0
ROTIFERA										
Rotifera spp.	1	0	0	0	0	0	0	0	0	0
ANNELIDA										
OLIGOCHAETA										
Oligochaete sp. 3	0	0	0	0	0	0	1	0	0	0
Oligochaete sp. 6	0	0	0	0	0	0	1	0	0	0
Oligochaete sp. 7	0	0	0	0	0	0	1	0	0	0
Tubificidae: *Pristina* sp.	1	0	0	0	0	0	0	0	0	0
Pristina aequiseta	0	0	0	0	0	0	0	0	1	1
Naidinae spp.	0	0	0	0	1	0	0	0	0	0
Phreodrilidae: *Insulodrilus bifidus*	0	0	0	0	0	0	0	1	1	0
Insulodrilus lacustris s.l (form WA28)	0	0	0	0	0	0	0	1	0	0
immature Phreodrillidae with similar ventral chaetae	0	0	0	0	0	0	0	1	1	0
CRUSTACEA										
COPEPODA										
Paracyclops chiltoni	1	0	0	0	0	0	0	0	0	0
Mixocyclops sp. nov	0	0	0	0	0	0	0	0	1	0
Elaphoidella bidens	1	0	0	0	0	0	0	0	0	0
Parastenocaris eberhardi	1	0	0	0	0	0	0	0	0	0
OSTRACODA										
Ostracoda spp.	0	0	0	0	0	0	1	0	0	0
Candona sp.	1	0	0	1	1	1	0	1	1	1
Cypridopsidae: *Darwinula* sp.	1	0	0	0	0	0	0	1	0	
SYNCARIDA										
Bathynellacaea spp.	1	0	0	0	0	0	0	0	0	0
ISOPODA										
Paramphisopus ?palustris	0	0	0	0	0	0	1	0	0	0
Unidentified isopod	0	0	0	0	0	0	1	0	0	0
DECAPODA										
Parastacidae: *Cherax quinquecarinatus*	0	0	0	0	0	0	0	1	0	0
CHELICERATA										
ACARINA										
Acarina sp. 1	0	0	0	0	0	0	1	0	0	0
Acarina sp. 2	0	0	0	0	0	0	1	0	0	0
Acarina sp. 6	0	0	0	0	0	0	1	0	0	0
Acarina sp. 7	0	0	0	0	0	0	1	0	0	0
Hydracarina spp.	0	0	0	0	1	0	0	0	0	0
Limnohalacarida: *Lobohalacarus* sp.	1	0	0	0	0	0	0	0	0	0
Oribatida spp.	1	0	0	0	0	0	0	1	1	0
COLLEMBOLA										
Hypogasturidae: Hypogastruridae spp.	0	0	0	0	0	0	1	0	0	0
INSECTA										

TAXON	1992-1995	1999	2000	2001	2002	2003	2004	2005	2006	2007
ODONATA										
Anisoptera: Anisoptera spp.	0	0	0	0	1	0	0	0	0	0
Synthemistidae: Synthemistidae spp. (imm.)	0	0	0	0	0	0	0	1	0	0
Archaeosynthemis occidentalis	0	0	0	0	0	0	0	0	1	0
Archeosynthemis ?leachii	0	0	0	0	0	0	1	0	0	0
HEMIPTERA										
Hemipteran sp.	0	0	0	0	0	0	1	0	0	0
Veliidae: Veliidae spp.	0	0	0	0	1	0	0	0	0	0
COLEOPTERA										
Dytiscidae: *Liodessus ornatus*	0	0	0	0	0	0	1	0	0	0
Rhantus suturalis	0	0	0	0	0	0	1	0	0	0
Georissidae: *Georissus* sp.	0	0	0	0	0	0	1	0	0	0
Scirtidae: Scirtidae spp. (L)	0	0	0	0	0	1	1	1	1	0
DIPTERA										
Culicidae: *Anopheles* sp.	0	0	0	1	1	1	0	0	0	0
Chironomidae: Chironominae spp.	0	0	0	0	0	0	2	0	0	0
Paramerina levidensis	0	0	0	0	0	0	0	0	1	0
Chironomus sp.2	1	0	0	1	1	1	0	0	0	0
Tanypodinae spp.	0	0	0	1	1	0	2	0	0	0
Ceratopogonidae: Ceratopogoniinae spp.	0	0	0	1	1	1	2	1	1	0
Tipulidae: Tipulidae spp.	1	0	0	1	1	1	1	1	1	0
Psychodidae: Psychodidae spp.	0	0	0	0	0	0	1	0	0	0
Tabanidae: Tabanidae spp.	0	0	0	0	0	0	2	0	0	0
Stratiomyidae: Stratiomyidae spp.	0	0	0	0	0	0	1	0	0	0
TRICHOPTERA										
Hydroptilidae: *Oxyethira* sp.	0	0	0	0	0	0	0	0	1	0
Total no. of species	**14**	**2**	**2**	**7**	**13**	**7**	**28**	**12**	**16**	3

7.3 Appendix 3: Photographic Voucher

- New species and cavernicole and interstitial species are given in detail where possible. If only one specimen was available only whole body images were taken as detailed photographs of diagnostic features often involved dissection which destroys the specimen.
- Photographs taken by L. Chandler and D. Tang unless otherwise indicated.
- Taxonomic confirmation of cladoceran specimen identifications was sought from Dr. Russell Shiel of the University of Adelaide, for this photographic voucher.

OLIGOCHAETA (AQUATIC WORMS)

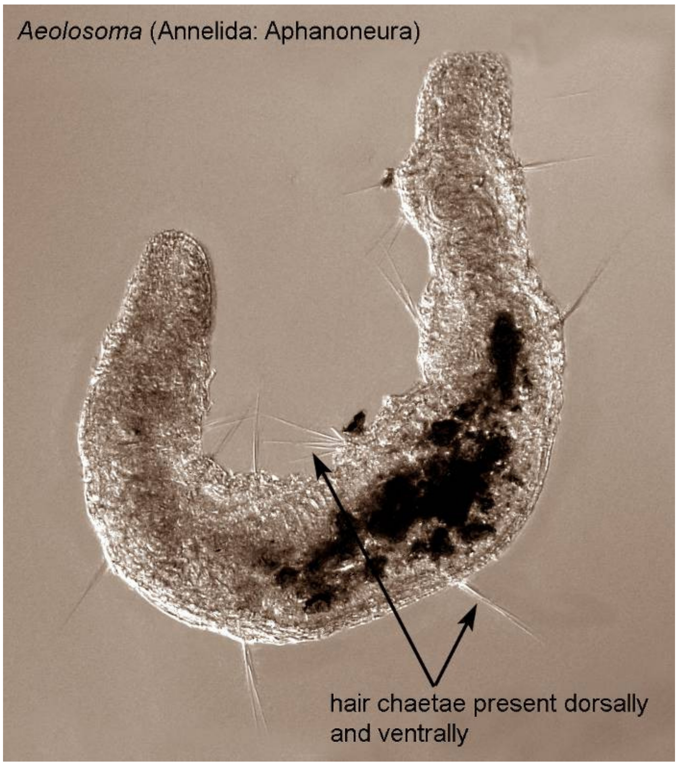


Plate A4. 1. Aeolosoma sp. (Photo: A.W. Pinder).

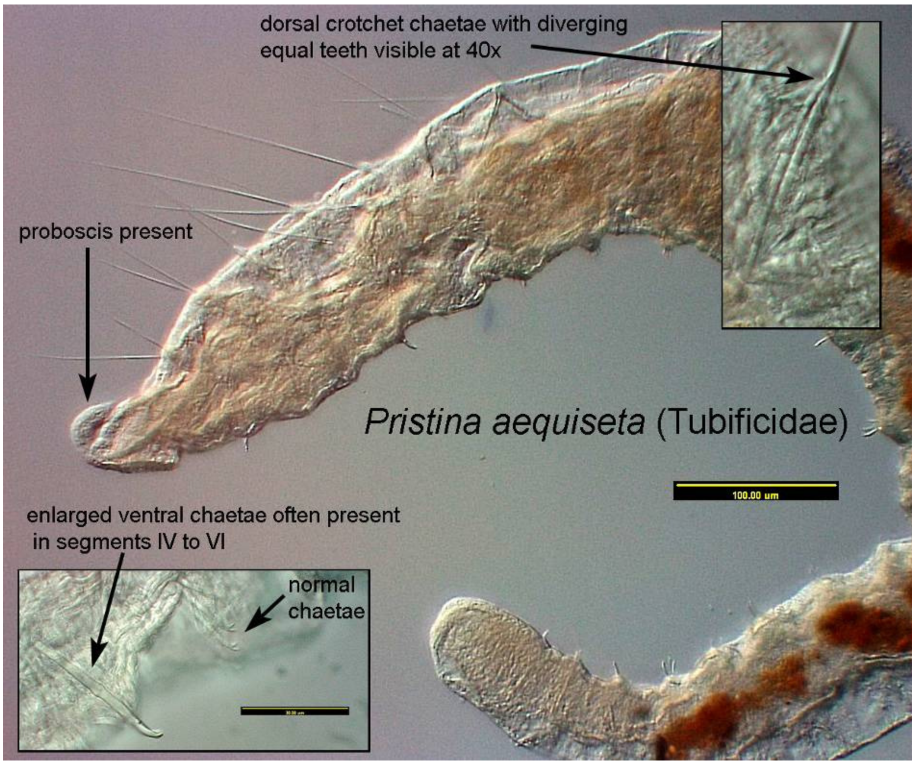
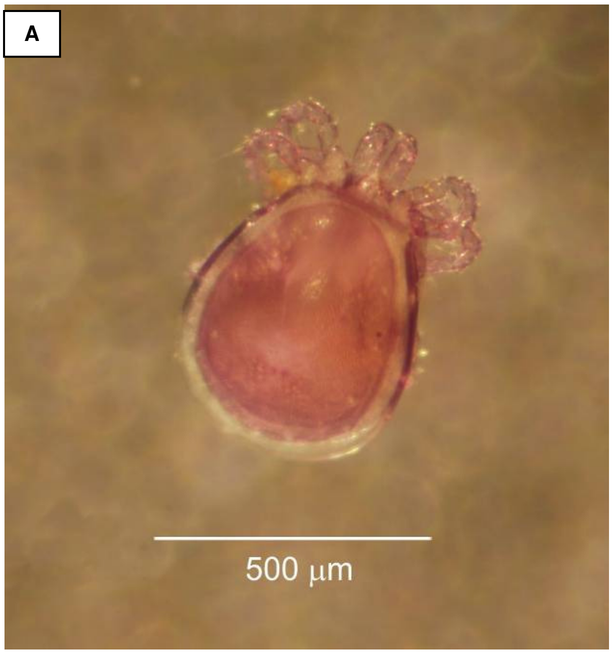


Plate A4. 2. *Pristina aequiseta.* (Photo: A.W. Pinder).

ACARINA (MITES)



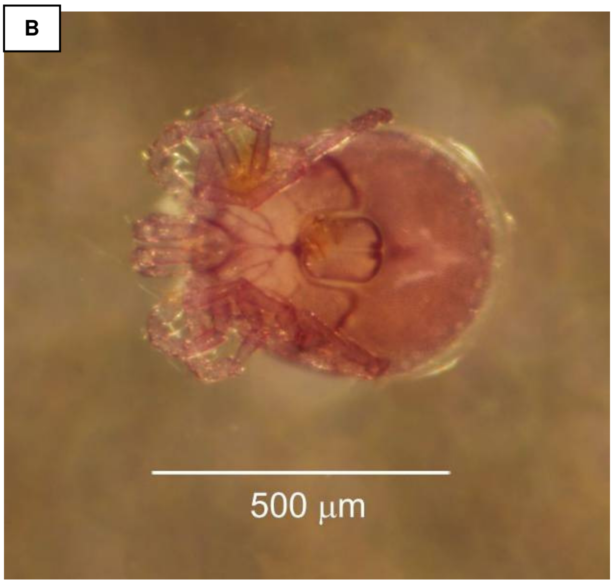


Plate A4. 3. Anisitsiellinae spp. (Limnesiidae) specimen collected from Egerton Spring a) dorsal view, and b) ventral view.

CRUSTACEA

Copepoda

Australoeucyclops sp.

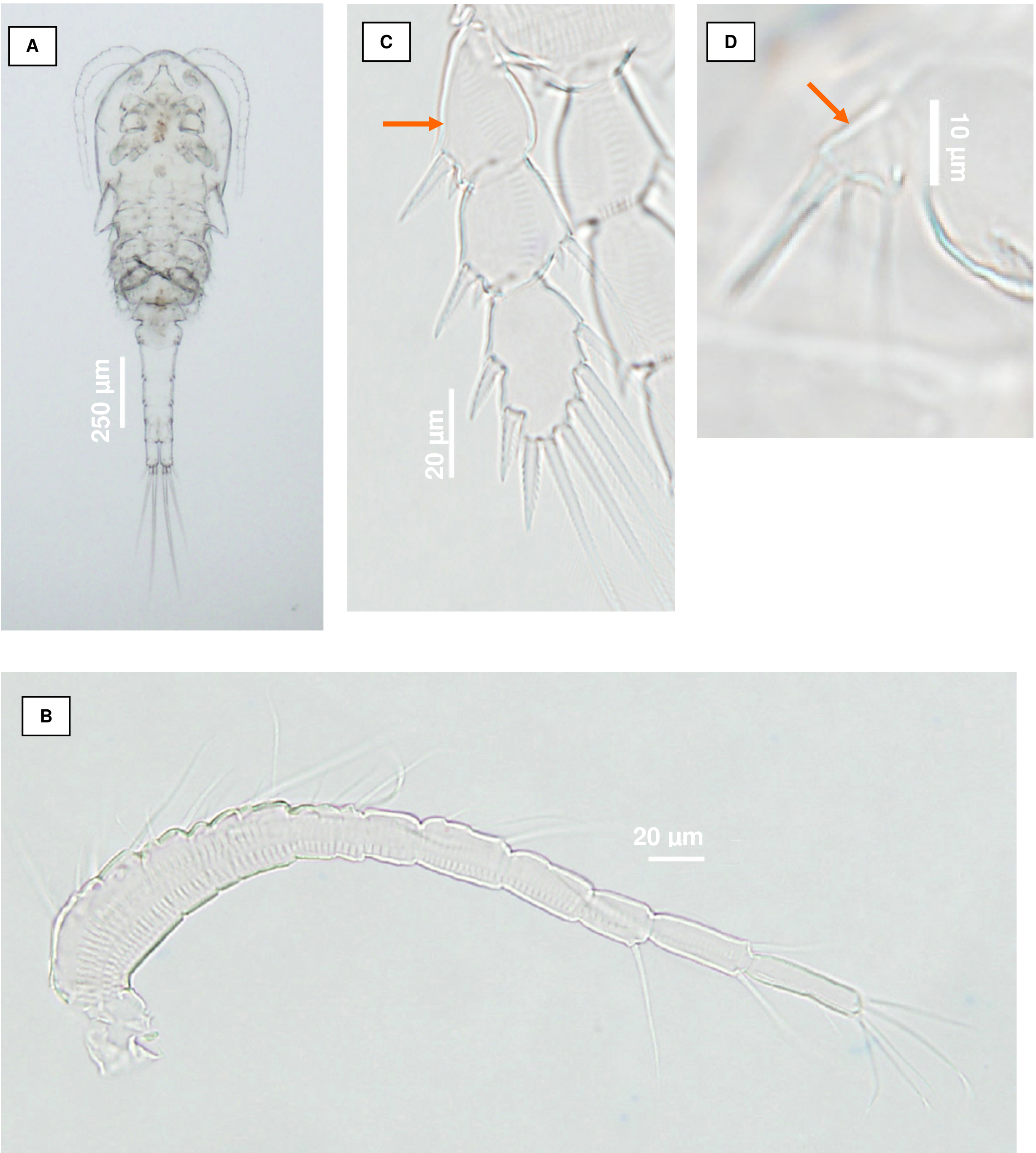


Plate A4. 4. *Australoeucyclops* sp., adult female. a) habitus; b) 12-segmented antennule; c) exopod of fourth leg showing absence of inner seta on proximal segment (arrowed); d) 1-segmented fifth leg (arrowed) showing 3 distal setae/spines.

Eucyclops sp.

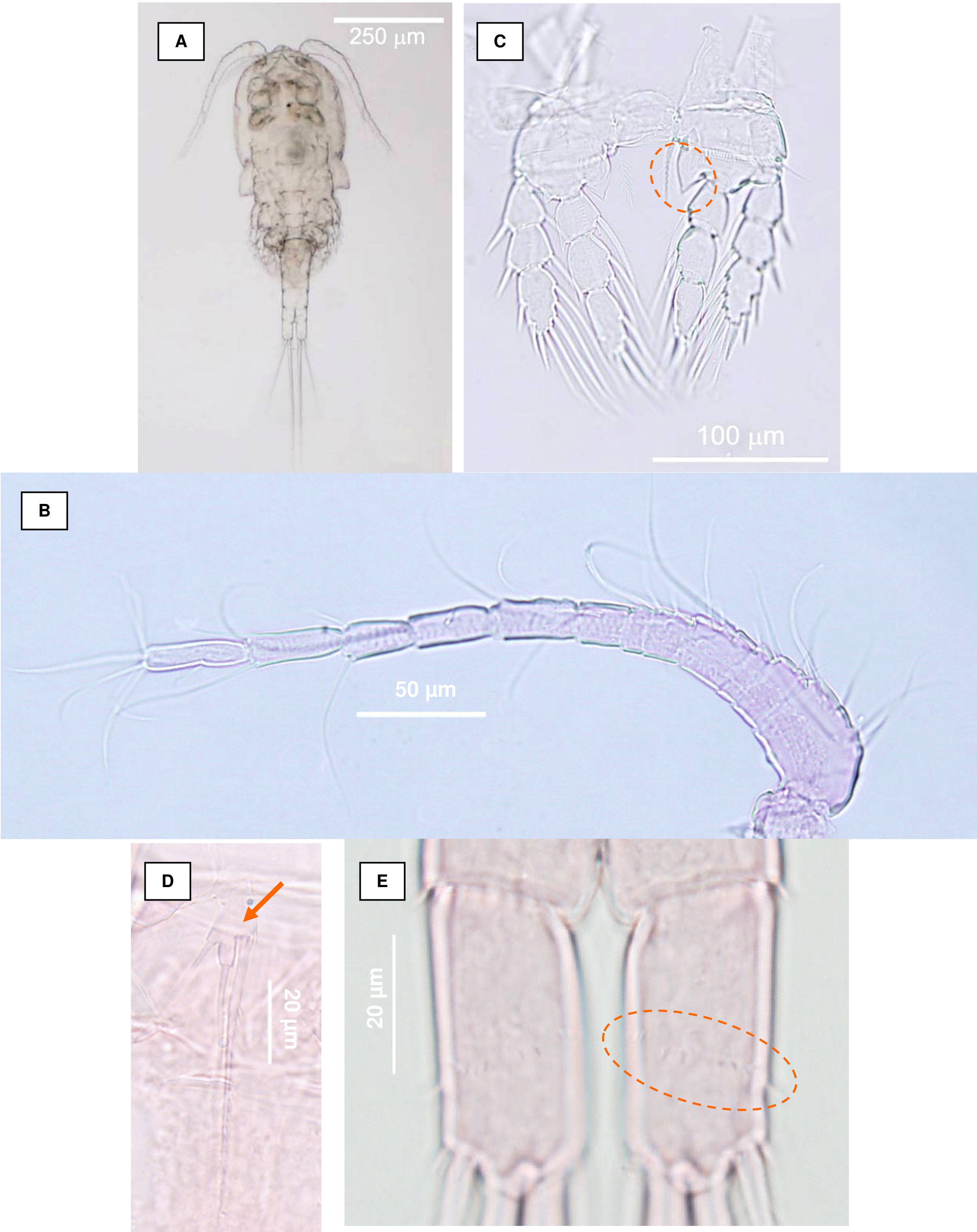


Plate A4. 5. *Eucyclops* sp., adult female. a) habitus; b) 12-segmented antennule; c) fourth leg showing inner distal angle of basis produced into acute process (circled); d) 1-segmented fifth leg (arrowed) showing 3 long setae/spines; e) caudal rami showing small spinules (circled) on ventral surface.

Macrocyclops albidus (Jurine, 1820)

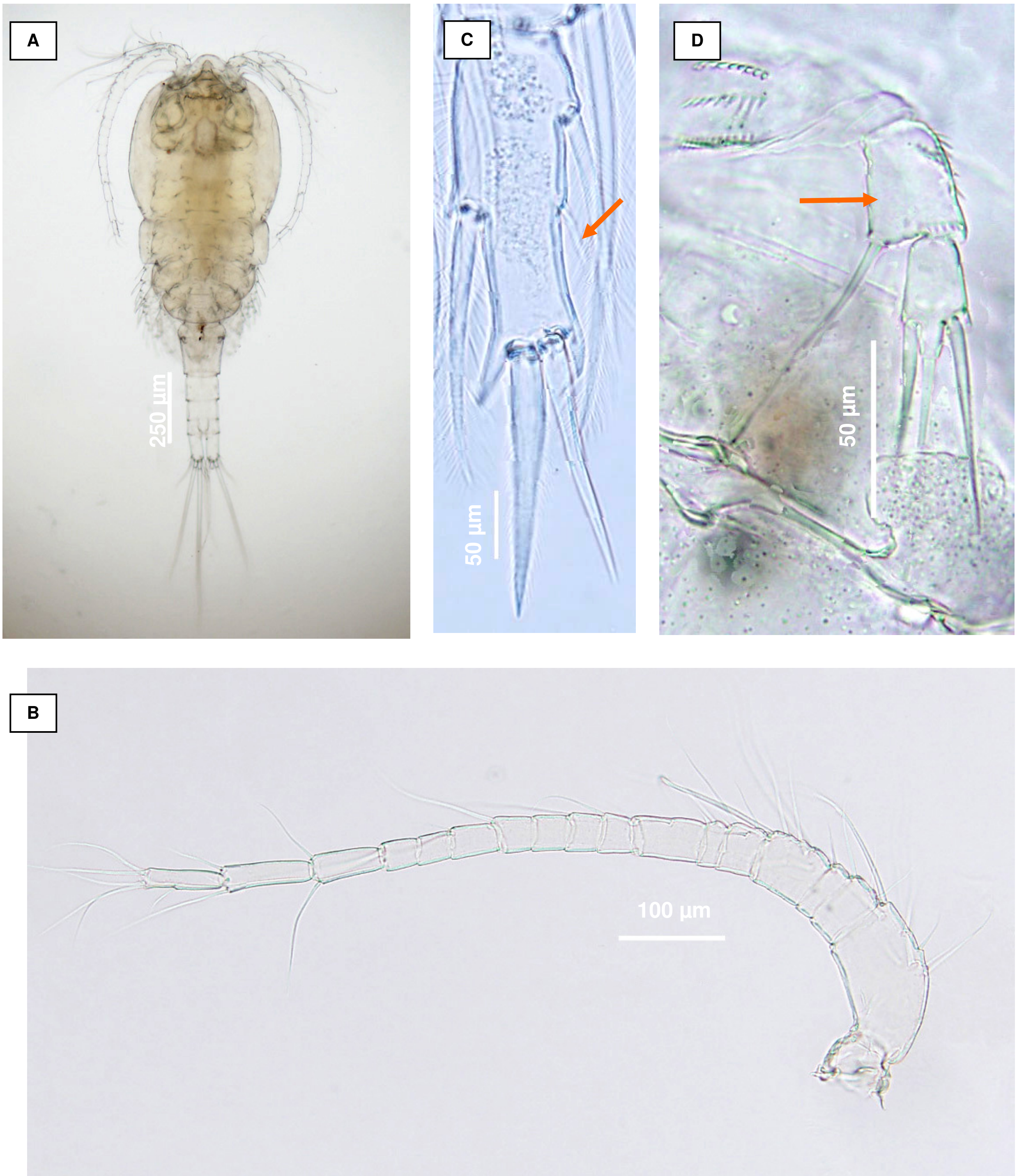


Plate A4. 6. *Macrocyclops albidus* (Jurine, 1820), adult female. a) habitus; b) 17-segmented antennule; c) terminal endopodal segment of leg 4 showing highly reduced inner seta (arrowed); d) 2-segmented fifth leg (arrowed) showing 3 setae/spines on distal segment.

Paracyclops chiltoni (Thomson, 1882)

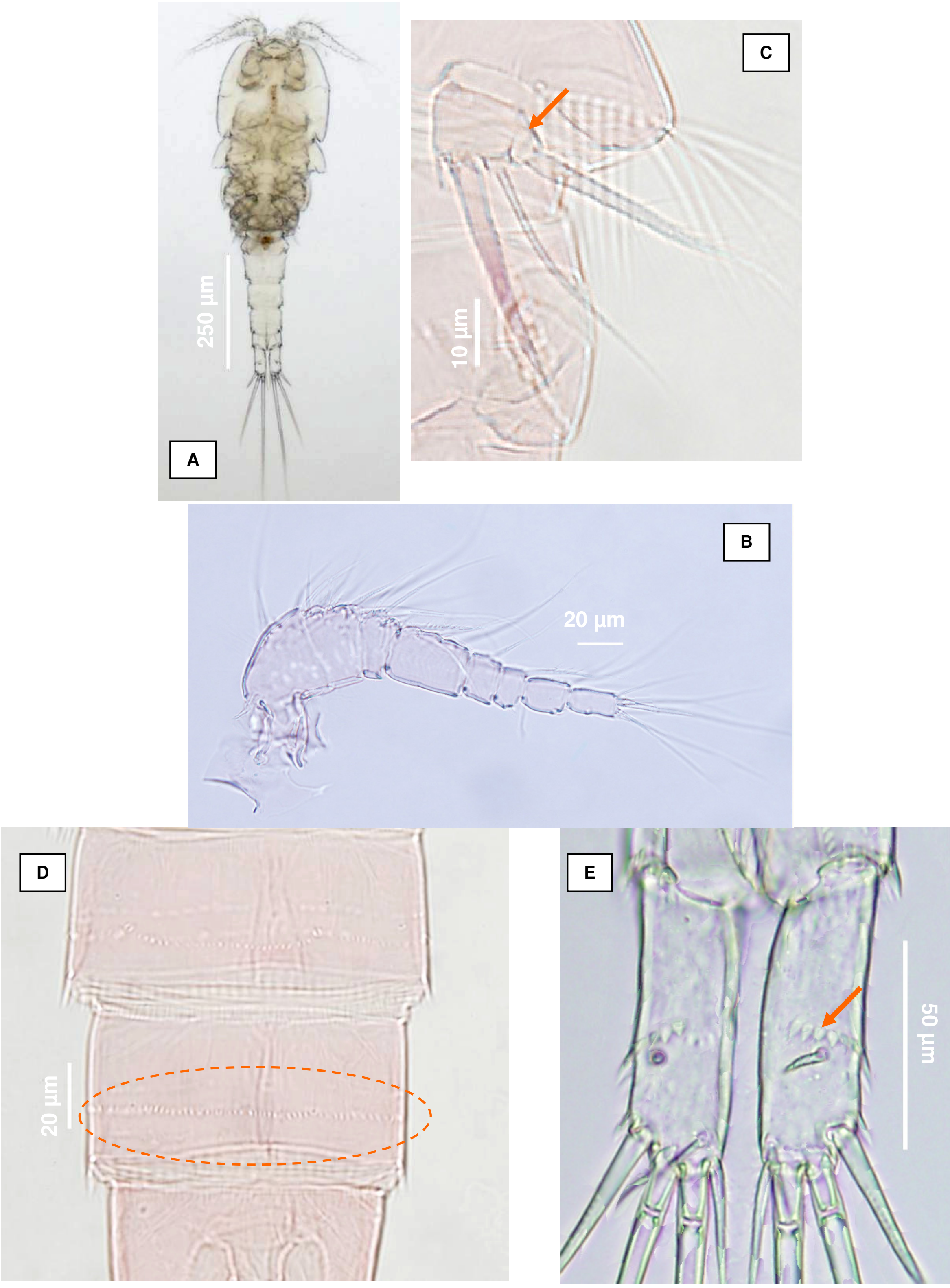


Plate A4. 7. *Paracyclops chiltoni* (Thomson, 1882), adult female. a) habitus; b) 8-segmented antennule; c) 1-segmented fifth leg (arrowed) showing 3 setae/spines; d) cuticular pores (circled) on postgenital somites 1 and 2; e) caudal rami showing large spinules (arrowed) on mid-dorsal surface.

Attheyella (Chappuisiella) hirsuta Chappuis, 1950

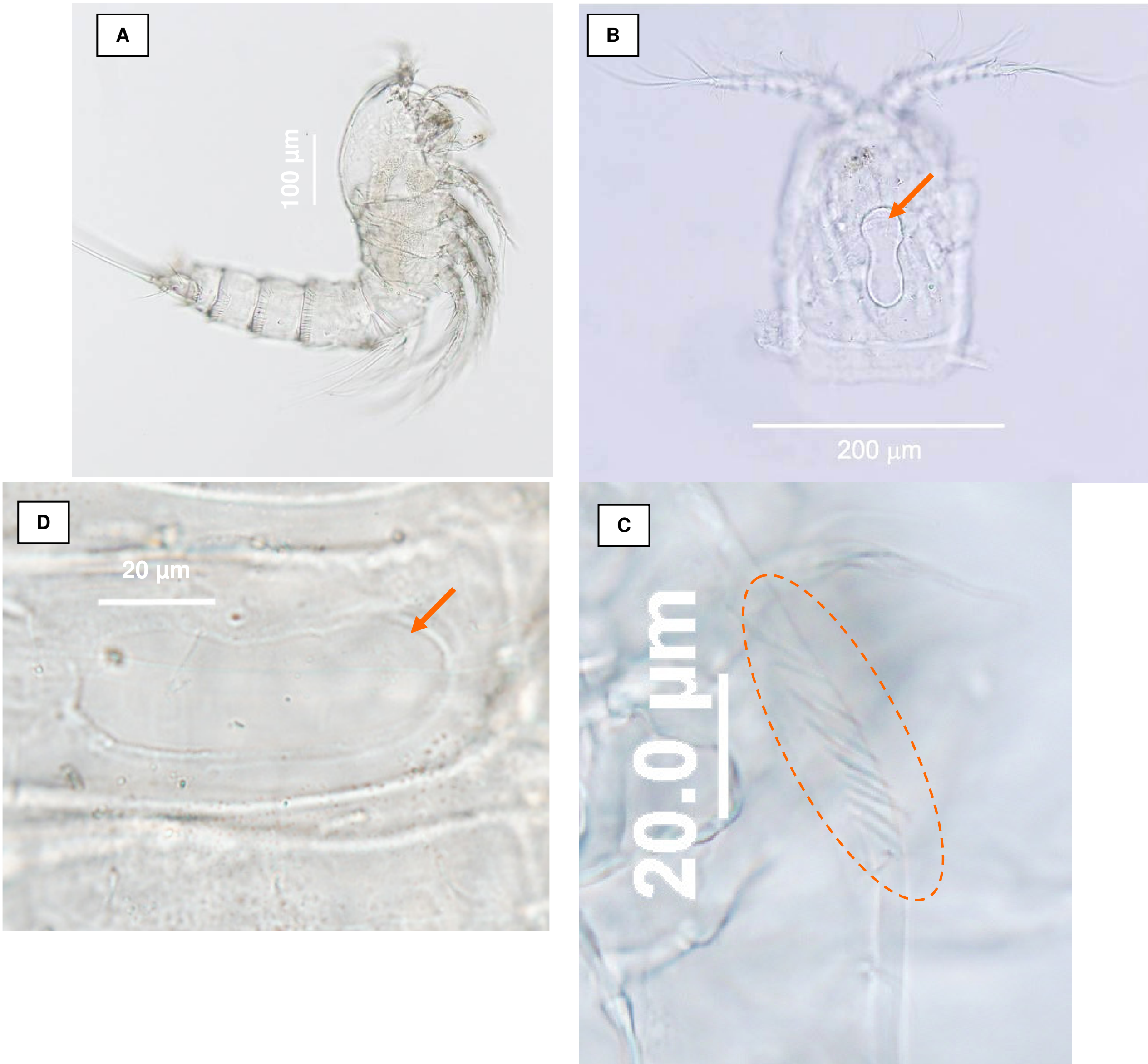


Plate A4. 8. *Atthyella* (*Chappuisiella*) *hirsuta* Chappuis, 1950, adult female. a) habitus, lateral view; b) dorsal view of cephalothorax showing nuchal organ (arrowed); c) spinules (circled) on mid-ventral margin of cephalothorax; d) integumental window (arrowed) on lateral surface of first pedigerous (= second leg-bearing) somite.

Cladocera

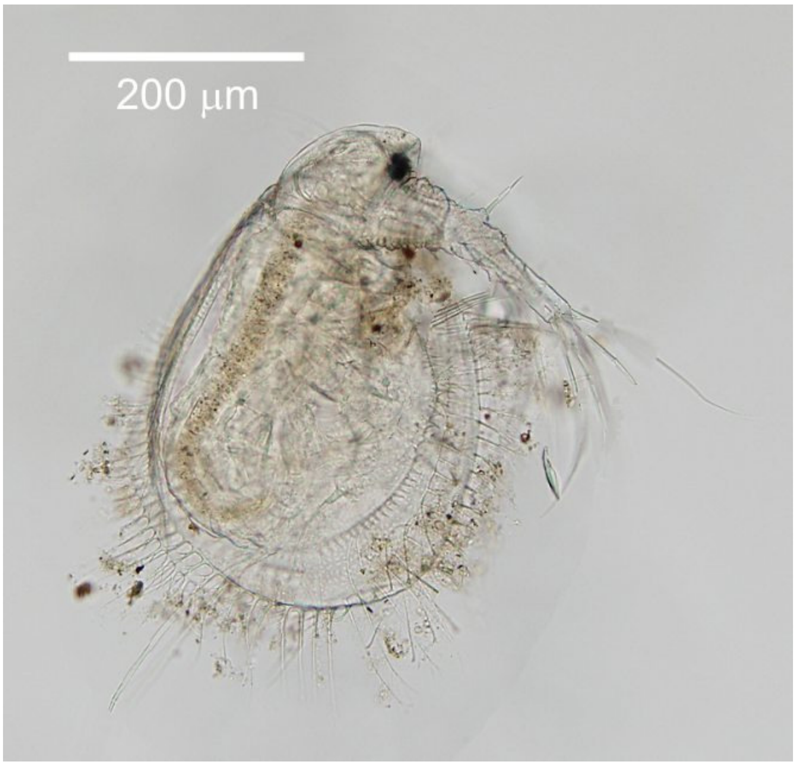


Plate A4. 6. *Ilyocryptus* sp. (Ilyocryptidae) collected from Egerton Spring.