ASSESSMENT OF THE AQUATIC FAUNA CONSERVATION ASSETS OF WETLANDS IN THE HUTT RIVER / HUTT LAGOON CATCHMENTS

Report to

Department of Environment and Conservation, Mid-West Regional Office

by

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INTRODUCTION

Project background

A survey of the biological diversity of the Western Australian South-west Agricultural Zone (henceforth referred to as the Wheatbelt) was undertaken between 1997 and 2003 (Keighery *et al.* 2004) as part of the State Government's Salinity Action Plan/State Salinity Strategy. Analyses of that dataset by Walshe *et al.* (2004) produced a set of potential 'Natural Diversity Recovery Catchments' (NDRCs) that, in combination and with appropriate management, had the potential to support the region's salinity threatened aquatic and terrestrial diversity.

Several NDRCs were selected based on previously identified biodiversity priorities before the Wheatbelt Survey was completed. These were Toolibin, Bryde, Muir-Unicup and Warden. The Drummond (DNDRC) and Buntine Marchagee (BMNDRC) natural diversity recovery catchments have been selected since, based, in part, on the Walshe analyses. The BMNDRC was nominated in 1999 and work commenced in 2001.

One of the remaining additional catchments suggested by Walshe *et al.* (2004) is the Greenough (Hutt), which incorporates the Hutt River Catchment, the Hutt Lagoon Catchment and some smaller sub-catchments to the south. However, the Walshe analysis was based on relatively sparse data, with just 4 sites located in the Hutt Catchment itself and only a few others in nearby catchments. This survey was designed to more comprehensively document the aquatic biodiversity values of the Hutt River and Hutt Lagoon catchments (herein referred to as the Hutt Catchments) as a contribution to making a decision about the suitability of the Hutt region as a Natural Diversity Recovery Catchment.

In particular, we aimed to answer the following questions:

- What are the aquatic biodiversity assets of the study area?
- Does the Hutt region have significant biodiversity assets not well represented in the other recovery catchments?
- Which assets are the least well conserved at the scale of the south-west and locally within the study area?
- Which assets are most important for biodiversity conservation, including consideration of local/regional endemism, phylogenetic importance, level of threat and potential economic importance?

This report focuses on the aquatic invertebrate and waterbird fauna, with incorporation of vegetation data only for analysis of the degree of representation of the Halse *et al.* (2004) assemblages. More detailed analysis of the region's flora will be presented separately.

The Hutt Catchments

Description

The Hutt River Catchment and the adjacent but separate Hutt Lagoon system are located approximately 75 km north of Geraldton in the Geraldton Hills IBRA subregion of Western Australia, within the Shire of Northampton (Figure 1).

The Hutt River Catchment covers an area of 131,842 ha, dominated by the 60 km long main channel of the Hutt River (Figure 2). The upper parts of the catchment consist mainly of ephemeral to seasonal basins and channels that are mostly secondarily salinised, whereas the middle and lower parts of the catchment have some spring-fed perennial tributaries (Department of Environment, 2005), including some that are fresh The largest tributary of the Hutt River is Kennedy Creek, although Yarder Gully and Swamp Gully are also important as they contribute fresh spring water to the Hutt. In most summers the Hutt River is significantly fresher than in winter and spring as these fresh tributaries become the dominant source of water. The river enters the ocean 2 km south-east of Hutt Lagoon.

The Hutt Lagoon is a 2 x10 km long evaporative lagoon, located within the Greenough-Coastal Catchment (43,032 ha). It has developed over the last 6000 years by separation from the ocean and a bypass of the lagoon by the Hutt River (Post *et al.* 1983) and, through evapoconcentration, now has salinity exceeding 180 g/L. The lagoon system covers an area of 3000 ha and comprises Hutt Lagoon itself plus lakes and marshes immediately north of the lagoon, including Utcha Swamp (Environment Australia 2001). Hutt Lagoon and Utcha Swamp are listed in the Directory of Important Wetlands in Australia (DIWA) (Environment Australia 2001).

Land use and the conservation estate

The dominant land use within the Geraldton Hills IBRA subregion is dryland agriculture (65.78%), with lesser areas of conservation (13.84%), grazing native pastures (13.21%) and UCL and Crown Reserves (6.47%) (McKenzie *et al.*, 2003). Hutt Lagoon is used for the commercial production of beta-carotene; a natural food-colouring agent derived from the alga *Dunaliella salina* (Post *et al.* 1983). Clearing of native vegetation for agriculture has been extensive and has resulted in altered groundwater and surface water hydrology and associated secondary salinisation, especially in upper parts of the catchment. This has increased salinity and discharge in the Hutt River. Stock access and grazing within the channel and riparian zone have contributed to weed invasion, bank and catchment erosion, siltation of streams and poor water quality (Department of Environment, 2005).

Over 98% of the area in the conservation estate within the subregion is contained within two reserves: Kalbarri National Park (183004 ha) and Wandana Nature Reserve (54821 ha). The remainder of the subregion has very few reserves, the majority of which are small and on agriculturally unproductive land and many of which are threatened by salinity (McKenzie *et al.*, 2003). Only 0.17% of The Hutt River Catchment is within the conservation estate (Chilimony NR and NR12657). The adjacent Hutt Lagoon Catchment has only one nature reserve (Utcha Well Nature Reserve, 292 ha, representing 0.7% of the catchment) but this fragmented into several parcels.

Table 1: Summary of the foreshore condition of the Hutt River and Kennedy Creek as detailed in the *Hutt River Foreshore Assessment* (Department of Environment 2005).

Condition Rating	Total Length	Total %
A (Very Good)	10.7km	11%
B (Good)	22.7km	23%
C (Moderate)	57.9km	60%
D (Poor)	5.8km	6%
Total	**97.1km**	

Hydrology

Base flow in the lower Hutt River is maintained by discharge from freshwater to mildly saline springs, seeps and spring fed creeks. River flow, rainfall and conductivity for the Hutt River at the Yerina gauging station can be accessed on the internet: http://kumina.water.wa.gov.au/waterinformation/telem/stage.cfm.

The Hutt lagoon lies five metres below sea level at its deepest and holds 50-75 cm of water following winter rainfall (Post *et al.* 1983). In summer water evaporates from the lagoon leaving a salty 5 cm thick crust. The lagoon does, however, receive some surface inflow from groundwater seepage (especially from coastal dunes) and from several minor creeks off the plateau (Environment Australia 2001).

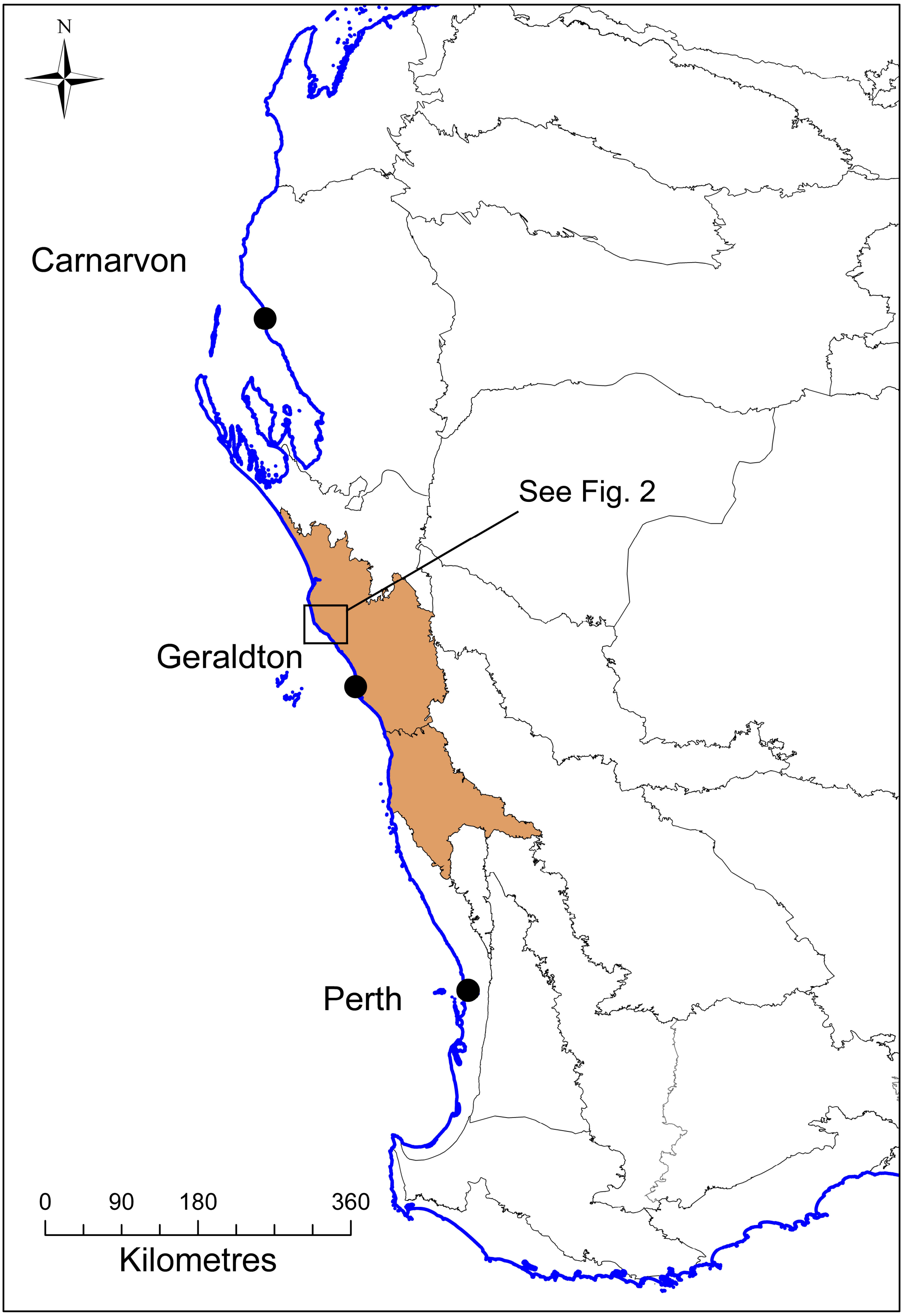


Figure 1: Western Australia showing major towns and the Geraldton Sandplains IBRA region (shaded) with the top half being the Geraldton Hills subregion.

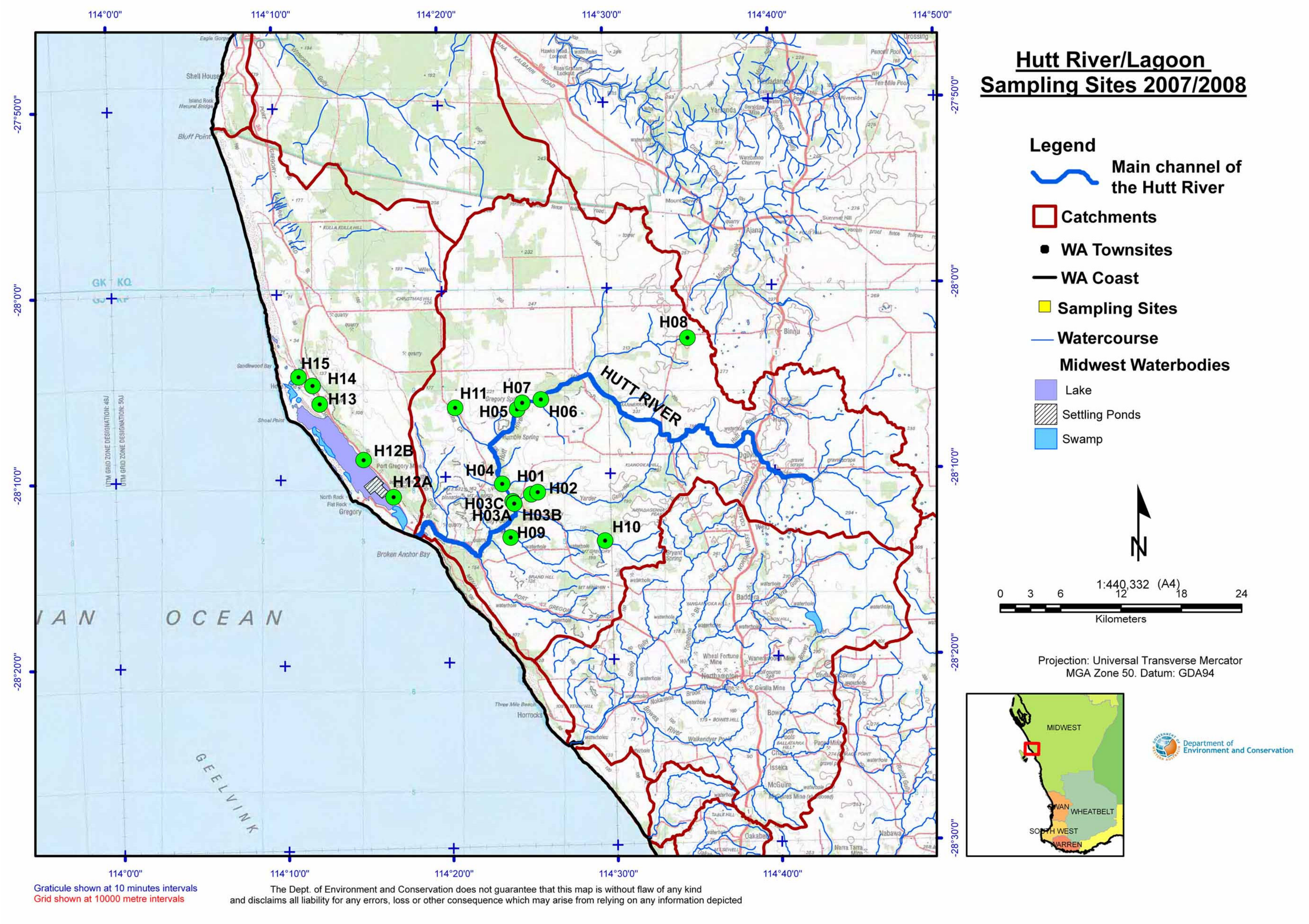


Figure 2: Hutt River / Hutt Lagoon Catchment areas showing wetland sites sampled during 2007 and 2008

Climate

The region experiences a warm dry Mediterranean climate with mild wet winters, and warm dry summers. The mean annual rainfall for the area is 354.9 mm falling mainly during the winter months (May-August) (Figure 3). Temperatures range from an average of 23.1°C in winter through to an average of 32.6°C in summer months (December-March). Average monthly temperatures and rainfall for Kalbarri are shown in Figure 3 below.

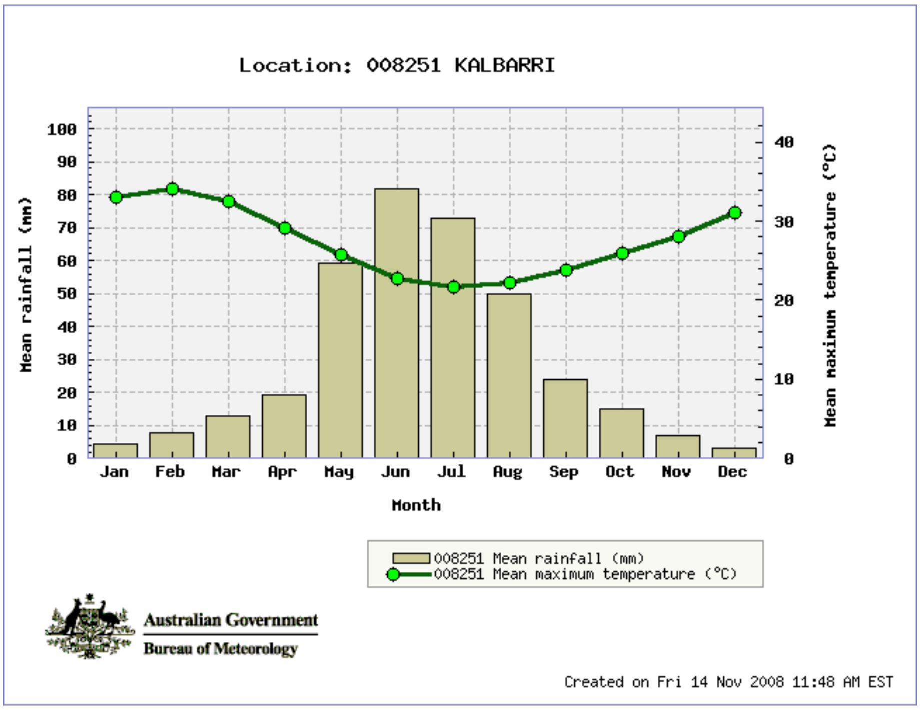


Figure 3: Climate data for Kalbarri (http://www.bom.gov.au/climate/averages/tables/cw 008251.shtml).

Previous studies

Published information on the Hutt Catchments includes the biological survey of the Wheatbelt (herein referred to as the SAP survey), regional scale information on vegetation types and pre-European settlement vegetation extent, an assessment of the condition of the Hutt River foreshore and a regional scale geological map of the area. There are also some flooding magnitude/intensity mapping and assessments, and some information on surface water of the Hutt River Catchment from the Department of Water's (DoW's) gauging station located 10 km upstream from the mouth of the Hutt River.

Gauging station details are as follows:

WIN Site Id	Site Type	Feature Type	AWRC Reference	AWRC Context Name	AWRC Name	Zone	Easting	Northing
9332583	Surface	Stream gauging	701010	HUTT RIVER	YERINA	50	242859.00	6875831.00

Source: Water Information (WIN) database - discrete sample data. Provided 29/10/2008. Department of Water, Water Information Provision section, Perth Western Australia.

Previous work in Western Australia with directly comparable invertebrate and vegetation taxonomy are the surveys of the Carnarvon Basin (Halse *et al.*, 2000), the Salinity Action Plan Wheatbelt survey (Halse *et al.*, 2004; Pinder et. al., 2004), the SAP/State Salinity Strategy Wheatbelt Monitoring Program (Cale *et al.*, 2004 and unpublished data held by DEC), the Lake Bryde NDRC survey (Cale *et al.*, 2008), the Drummond wetlands report (Cale *et al.* 2005), the Pilbara Biological Survey (Pinder *et al.*, in prep.), surveys of mound springs near the town of Three Springs (Pinder *et al.* 2002, 2006) and work for the Avon Catchment Council (DEC unpublished data). The monitoring program at the Buntine-Marchagee NDRC (Lynas *et al.* 2006; Storey *et al.* 2004ab) is also relevant and useful but the invertebrate taxonomy is partly incompatible due to the lack of consistent naming of undescribed taxa (morphospecies) between WA research groups.

In 2001-02, the Department of Environment and Conservation undertook an audit of the State's terrestrial biodiversity (McKenzie *et al.* 2003). Within the Geraldton Hills IBRA subregion Desmond and Chant (2003) identified the Hutt Lagoon samphire communities as a rare feature, springs in the Northampton region as wetlands of subregional significance and noted that the Hutt Lagoon and adjacent wetlands are together listed as a wetland of national significance (Directory of Important Wetlands [DIWA]). They also noted that the lower Hutt River had better riparian condition than most of the subregion's other major rivers. The report also identified conservation priorities, ecosystems and species at risk, management responses, data gaps and research priorities. In particular, the Hutt Lagoon system was seen as being at risk from rising groundwater and a systematic fauna survey was identified as a knowledge gap.

A foreshore assessment of the Hutt River was conducted by the Northern Agricultural Catchments Council in collaboration with the Department of Water in 2003 (Department of Environment 2005). The aim of the foreshore assessment was to assess and document the current uses, disturbances and condition of the Hutt River and its major tributaries, including Kennedy Creek. A summary of the foreshore assessment of the Hutt River is provided in Table 1 below.

A complete list of aquatic birds for the area is detailed in Appendix 2 of this report. A total of 71 waterbird species are listed by Birds Australia for the area shown in Figure 4, 15 of which were recorded during the present Hutt survey. Baillons Crake, recorded at Utcha Swamp during this survey, is not listed by Birds Australia.

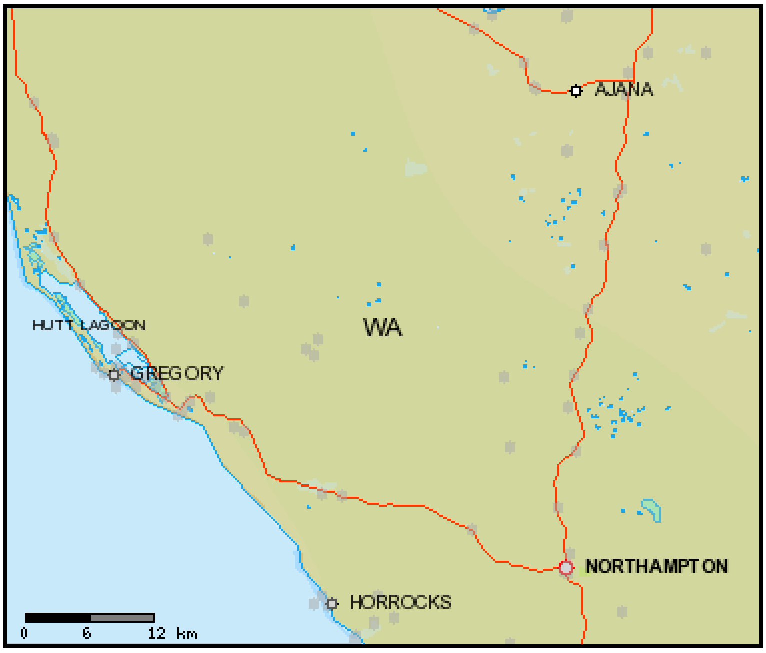


Figure 4: Area defined in "Birdata" to generate an "Atlas Bird List" from the Birds Australia database. (Source: http://www.birdata.com.au/).

METHODS

Site Selection

Adrian Pinder and Rowan Dawson (DEC Geraldton) undertook a reconnaissance trip in August 2007 to identify potential sampling sites. Eighteen sites, representing high condition representatives of most of the wetland types known to exist in the catchments (rivers, creeks, springs, soaks, swamps etc.) were selected for inclusion in the study (Table 2
Figure 2). This number of sites is comparable to the sampling intensity of both the Buntine-Marchagee NDRC (Storey *et al.* 2004a; 2004b; Lynas *et al.* 2006), and Lake Bryde NDRC surveys (Cale 2008) and sampling methods are compatible with these studies and those employed during previous DEC Science Division wetland biodiversity surveys (e.g. Halse *et al.* 2000, Pinder *et al.* 2004) and with the Wheatbelt wetland monitoring program (Cale *et al.* 2004). At each site, the sampling location was marked with a fence dropper and its position recorded with GPS (datum GDA94).

Site Descriptions

A total of 18 sites detailed in Table 2 and shown in the following photographs, were selected for the study. Co-ordinates are given in Universal Transverse Mercator (UTM). The datum used was GDA94.

HUT001: Yarder Gully spring

HUT002: Yarder Gully

HUT003A: Hutt River at Yarder Gully confluence

HUT003B: Hutt River granite seepages

HUT003C: Hutt River south of Yarder Gully confluence

HUT004: Hutt River on Glenorie Stn. between HUT003 and HUT005


HUT005: Hutt River downstream of Gregory Spring

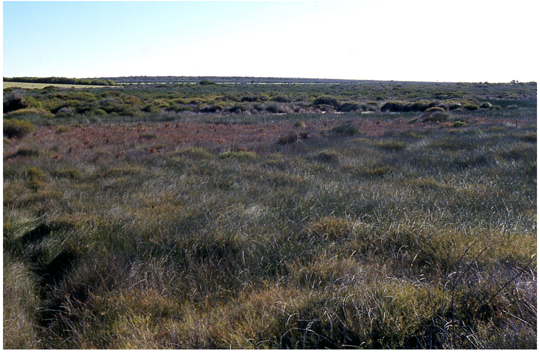

HUT006: Hutt River N of Gregory Spring


HUT007: Gregory Spring


HUT008: Feast Soak


HUT009: Harry Spring creek


HUT010: Swamp Creek tributary



HUT011: Yerina Spring

HUT012A: Hutt Lagoon – south-east
(photo not at site – taken 1999)

HUT013: *Baumea*/*Cyperus* fringed swamp

HUT014: Utcha Swamp 2007

Utcha Swamp 1999

HUT015: Subsaline sedgeland

Gaps in Sampling

Wetlands not sampled during the survey include secondarily saline streams and wetlands in the upper part of the Hutt River Catchment, saline areas immediately north of Port Gregory and dune wetlands west of Hutt Lagoon. The upper Hutt secondarily saline wetlands were considered unlikely to have significant conservation values, the saline areas near Port Gregory are tidally influenced and the dune wetlands are difficult to access. There is a large private reservoir and very many smaller farm dams that will support additional invertebrate taxa and populations of waterbirds. There are probably also smaller seepage areas along the lower Hutt River that may contain additional species. The coastal limestone, and possibly areas of the sandstone geology along the river channels, may contain subterranean aquatic habitats with stygofauna but this has not been assessed.

All wetlands (except site 3C) were sampled in spring (11th to 15th September 2007) by David Cale because this was when aquatic invertebrate communities would have been fully established following the cooler wetter winter period. However, flows in the lower Hutt River normally become dominated by the fresher spring-fed lower tributaries once the more saline flow from the upper catchment ceases. For this reason some sites were also sampled in summer (February 2008) to examine whether the expected lower flows and salinity within the Hutt River was associated with altered community composition. Unfortunately, unusually high summer rainfall in 2007/8 led to fluctuating flows and salinity in the lower catchment prior to summer sampling and the summer freshening was not so pronounced or continuous in this year.

The mean monthly discharge (m^3/s) and mean monthly TDS (mg/L) were plotted from January 2007-March 2008 (Figure 5). It is evident that the monthly discharge for January and February 2008 was higher (0.002 m^3/s and 0.008 m^3/s) than for the same months the previous year (0.002 m^3/s and 0.001 m^3/s) and higher than the long-term average for these months (0.002 m^3/s for both months). Similarly, the average monthly TDS (mg/L) for January and February 2008 was 2080 mg/L and 2028 mg/L, as opposed to 1440 mg/L and 1369 mg/L for the same months in 2007.

Table 2: Site List for the Hutt Catchment Survey for all sites sampled during 2007 and 2008.

SiteCode	Subsite	Site name	Date	Northings	Eastings	Description
HUT001	A	Yarder Gully spring	11/09/2007	6879663	246685	Spring running south of main creek line of Yarder Gully consisting of seepage areas, very shallow flowing water and muddy pools amongst sedges and ferns.
HUT002	A	Yarder Gully	11/09/2007	6879876	247324	Reach of Yarder Gully flowing through dense sedges.
HUT003	A	Hutt River at Yarder Gully confluence	12/09/2007 25/02/2008	6878960 6878777	244831 244973	Main channel of Hutt River immediately upstream and including Yarder Gully confluence. In 2008 sampled only above the confluence
HUT003	B	Hutt River rock pool seepage	12/09/2007	6878960	244831	Shallow rock pools capturing seepages which flow into the main channel of the Hutt River just downstream of the Yarder-Hutt confluence. Only pools currently not receiving water from the river were sampled.
HUT003	C	Hutt River south of Yarder Gully confluence	25/02/2008	6878740	244987	Main channel of Hutt River immediately downstream of Yarder Gully confluence.
HUT004	A	Hutt River on Glenorie Station	11/09/2007 25/02/2008	6880697	243788	Braided reach of Hutt River downstream of two seepage inflows from eastern bank
HUT005	A	Hutt R. south of Gregory Springs	13/09/2007 26/02/2008	6888124	245272	A reach where the main channel is bordered by intact vegetation on both sides and passes over bedrock and silty areas. Seepage from Gregory Spring enters the Hutt River just upstream of this site.
HUT006	A	Hutt R. north of Gregory Spring	13/09/2007	6889103	247628	Silty reach of Hutt river upstream of Gregory Spring
HUT007	A	Gregory Spring	13/09/2007	6888774	245773	A seepage area with sedges and numerous small pools up to 3cm deep and (when wet) with water trickling south to the adjacent Hutt River.

Table 2 continued.

SiteCode	Subsite	Site name	Date	Northings	Eastings	Description
HUT008	A	Feast Soak	14/09/2007	6895238	262202	A sedge-filled soak with small areas of shallow open water. The resulting creek-line is highly degraded but the spring itself is in somewhat better condition.
HUT009	A	Harry Spring Creek	14/09/2007	6875374	244637	A heavily vegetated section of a freshwater creek that flows north from Harry Spring. The channel is heavily silted but includes areas of bedrock and overhanging vegetation.
HUT010	A	Upper tributary of "Swamp Creek" north-east of Mount Gregory on Rob Road	12/09/2007	6875065	254012	Narrow deeply incised creek adjacent to road.
HUT011	A	Yerina Spring	14/09/2007	6888276	239110	A sedgeland seepage with wettest areas amongst Typha or where an obstructing roadway impedes seepage.
HUT012	A	Hutt Lagoon - south-east	15/09/2007	6879372	233000	Area of low salinity seepage amongst sedges on eastern shore of Lagoon 2-10m back from furthest extent of sedges into lagoon.
HUT012	B	Hutt Lagoon - north-east	15/09/2007	6883079	230016	Site sampled main water-body of lagoon immediately north of the 'salt works'. Photo taken in July 1999.
HUT013	A	Baumea/*Cyperus* fringed swamp north of Hutt Lagoon	15/09/2007	6888618	225663	Subsaline wetland with areas of open water surrounded by very dense stands of *Baumea articulata* and *Cyperus laevigatus*.
HUT014	A	Utcha Swamp	10/09/2007	6890446	224944	Severe *Typha* encroachment bordering wetland with dense stands of submerged macrophytes. *Typha* encroachment noticeable when compared to a photo of the swamp taken in July 1999 (see photos below).
HUT015	A	Sedge flats north of Hutt Lagoon	15/09/2007	6891302	223555	Shallow sedge-fringed subsaline flats

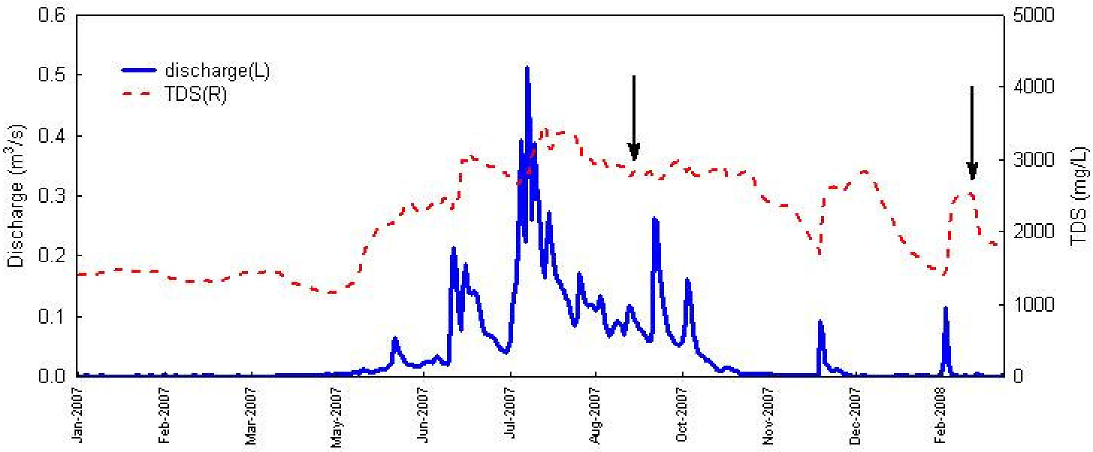


Figure 5: Mean Monthly Discharge (m^3/s) for the Hutt River (taken from Yerina Gauging station) from January 2007-March 2008. Arrows indicate spring and summer sampling times for this project. (Source: Water Information (WIN) database - discrete sample data. Provided 29/10/2008. Department of Water, Water Information Provision section, Perth Western Australia).

On each sampling occasion depth, flow, water chemistry, fringing vegetation, aquatic invertebrates and waterbirds were collected or recorded.

Water Chemistry

Depth, electrical conductivity, pH and temperature of the water were all measured in the field. About 1 litre of water was filtered through a glass microfibre filter paper and the filter paper retained for analysis of chlorophyll. About 125 ml of the filtrate was further filtered through 0.45 µm filter papers for analysis of total filterable N and P. Unfiltered water samples were analysed for colour, hardness, alkalinity, ionic composition and turbidity. Analyses were performed by the Environmental Chemistry Laboratory of the Chemistry Centre (W.A.).

Waterbirds

Waterbirds were surveyed using the same protocols as for the SAP Biological Survey of the South-West Agricultural Zone. All waterbirds observed were identified and the numbers recorded. A small boat was used to survey Hutt Lagoon.

Invertebrate sampling

At each wetland, two subsamples ("benthic" and "planktonic") were collected. The "benthic" subsample was collected through 50 metres of vigorous discontinuous sweeping using a pond net with 250 µm mesh on a D-shaped frame (350 mm wide and 250 mm high). All identified wetland habitats within wadeable depth were sampled including water column, submerged vegetation, bottom sediment, along submerged logs, around tree trunks etc. Lake substrates were vigorously disturbed with repeated sweeping and/or kicking. Where necessary, contents of the pond-net were emptied into a bucket several times during sampling to reduce resistance of the net in the water. After elutriation to remove inorganic sediment and washing to remove large organic debris, the sample was preserved in 100% ethanol.

The "planktonic" subsample was collected by 50 metres of more gentle, discontinuous sweeping using a pond net with 50 µm mesh to sample all water column habitats (including gentle sweeping through small amounts of vegetation). The sample was preserved in buffered formalin (about 5% formaldehyde after dilution with sample).

The nets were thoroughly rinsed between each site and air-dried to eliminate the risk of transfer of material between sites.

Invertebrate sample processing

In the laboratory each invertebrate sample was separated into three size fractions (2 mm, 500 µm and 250 µm fractions for 'benthic' samples and 2 mm, 90 µm and 50 µm fractions for 'plankton' samples). Representatives of each species were picked out using a dissecting microscope and the species scored for abundance on a log scale (1 – 10 animals = 1, 11 – 100 = 2, 101 – 1000 = 3, etc.). Rotifers and cladocerans were identified by Dr. Russell Shiel (University of Adelaide).

As far as possible, all micro- and macroinvertebrates were identified to species level, consistent with the taxonomy used in Pinder *et al.* (2004), other than where this has been updated.

Representatives of some species were included in the DEC aquatic invertebrate reference collection. All other specimens were retained in vials of alcohol at order level.

Data Management

All data were entered onto the Department of Environment and Conservation (DEC) Science Division Aquatic Projects Research Database and will eventually be made available on WetlandBase and NatureBase.

Data Analysis

The Bray-Curtis index was used to produce a site dissimilarity matrix (based on presence-absence of species) using PATN v3.5 (Belbin 1993). This produces a matrix of values which reflect how dissimilar the species composition is between sites. This matrix was then used to produce clusters of sites using the agglomerative UPGMA (unweighted pair group arithmetic averaging) routine of PATN, with β-levels of -0.1 respectively. Wetland clusters within the dendrogram were delineated by recognising nodes of high dissimilarity. These groups are indicated on plots of environmental variables.

A distance-based (Bray-Curtis) Redundancy Analysis (a constrained ordination) was performed to investigate relationships between environmental variables and invertebrate community composition using the 'capscale' routine in the 'vegan' package in the 'R' statistical analysis software (Oksanen, 2008). This routine arranges sites according to that component of their invertebrate community similarity that is correlated with measured environmental variables, and indicates the strength and significance of the correlations.

RESULTS

Environmental Parameters

Water Chemistry

Water chemistry data is contained within Appendix 1, except that ionic composition is also presented in Table 3 as percentage milliequivalents. Of the 17 samples collected in 2007, 6 were fresh (<3 g/L), 9 were subsaline (3-10 g/L) and 2 were saline (> 10 g/L). The freshest sites were springs and spring fed creeks (sites 1, 2, 9, 10 and 11). The Hutt River was mostly subsaline, with salinities around the 3 to 7 g/L range during this study.

Salinities were not substantially different in summer compared to the previous spring. Site 3A (Hutt River immediately upstream of the Yarder Gully confluence) was almost twice as saline in summer as in spring, probably through concentration of salts after flow ceased. The site did receive additional flows in the weeks prior to summer sampling but flow had ceased by the time sampling occurred. Site 4 (Hutt River approximately 2 km upstream of Yarder Gully) was less saline in summer than in spring but was probably continuing to receive water from freshwater seepages in the vicinity and was not far downstream of the freshwater Yerina Spring. Site 5 was also on the Hutt River immediately downstream of a spring (Gregory Spring) but had only a marginally lower salinity in summer than in September. This is because Gregory Spring was sub-saline in spring and would have been at least as saline in summer so would not have had a diluting effect on the Hutt River.

Percentage ionic composition is shown in Table 3 and Figure 9. Percentage milliequivalents allow better comparisons between sites as this takes into account molecular weights and valency charges to provide equivalent 'ionic strength' measures for different combinations of ions. Also, while raw concentrations of these ions largely reflect salinity, the relative concentrations reflect catchment geology and sources of salts. All wetlands are NaCl dominated, with order of cation composition being Na^{+}>Mg^{2+}>Ca^{2+}>K^{+} for all wetlands except for the main body of the Hutt Lagoon (HUT012B) which had Na>Mg>K>Ca. Of particular note are the slightly lower contribution of Mg^{2+} and K^{+} at this same site (compensated for by very high Na^{+}), low Mg^{2+} at Yerina Spring (HUT011) compared to other wetlands, and the relatively high contribution of Ca^{2+} at Utcha Swamp (HUT014).

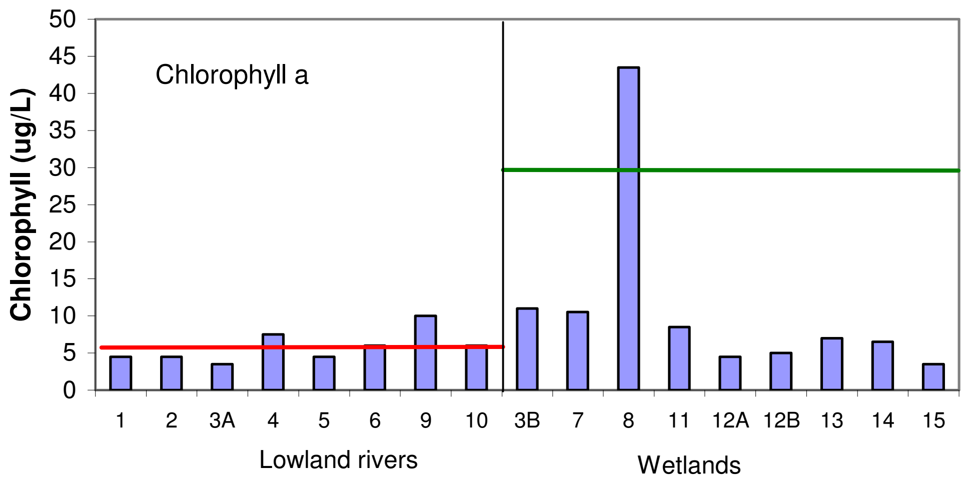
Most sites had Cl^{-}>SO_4^{2-}>HCO_3^{-}>CO_3^{2-} but three wetlands had HCO_3^{-} and SO_4^{2-} reversed. These were the Hutt River downstream of Yarder Gully, Hutt R. south of Gregory Springs in summer (but not in spring) and Utcha Swamp. Utcha Swamp had particularly high HCO_3^{-} which, combined with the relatively high Ca^{2+}, reflects a limestone aquifer water source. At three sites SO_4^{2-} contributed relatively strongly to anion composition: Yerina Spring, Utcha Swamp and the Sedge flats north of Hutt Lagoon.

Table 3. Total dissolved solids and ionic composition of samples from the Hutt Catchment. Blue underlined = fresh (< 3 g/L), green = subsaline (3-10 g/L), bold red = saline (>10 g/L).

				% millequivalent ionic composition							
Site	**Sub**	**Date**	**TDS g.L^{-1}**	**Na^+**	**Ca^{2+}**	**Mg^{2+}**	**K^+**	**Cl^-**	**HCO_3^-**	**CO_3^{2-}**	**SO_4^{2-}**
HUT001	A	11/09/2007	0.68	74.90	3.87	19.17	2.06	85.87	5.07	0.15	8.91
HUT002	A	11/09/2007	1.10	78.06	3.51	17.64	0.78	91.18	3.61	0.09	5.12
HUT003	A	12/09/2007	3.40	77.18	3.47	18.43	0.92	90.21	2.94	0.03	6.82
HUT003	A	25/02/2008	6.40	75.20	3.91	19.59	1.30	90.29	2.06	0.02	7.64
HUT003	B	12/09/2007	8.80	79.41	2.70	16.69	1.19	91.68	1.84	0.01	6.46
HUT003	C	25/02/2008	1.10	76.41	3.62	18.90	1.07	91.19	4.79	0.10	3.93
HUT004	A	11/09/2007	3.30	77.22	3.42	18.46	0.90	89.63	3.31	0.03	7.03
HUT004	A	25/02/2008	1.90	75.72	3.11	19.53	1.63	92.98	3.48	0.05	3.49
HUT005	A	13/09/2007	3.70	77.02	3.33	18.81	0.85	91.96	2.30	0.03	5.72
HUT005	A	26/02/2008	3.50	77.23	3.33	18.46	0.99	93.11	4.14	0.03	2.72
HUT006	A	13/09/2007	4.10	77.38	3.22	18.43	0.98	91.53	2.73	0.03	5.72
HUT007	A	13/09/2007	4.50	72.84	3.89	22.27	1.00	92.18	1.70	0.03	6.09
HUT008	A	14/09/2007	8.00	79.30	1.98	17.77	0.95	91.97	0.82	0.01	7.19
HUT009	A	14/09/2007	2.60	75.22	4.51	19.25	1.02	90.19	1.65	0.04	8.12
HUT010	A	12/09/2007	2.50	75.52	4.41	19.35	0.72	92.64	1.61	0.04	5.71
HUT011	A	14/09/2007	0.88	84.81	2.49	12.00	0.70	80.55	5.31	0.13	14.01
HUT012	A	15/09/2007	**15.00**	73.57	3.85	21.04	1.53	88.77	2.84	0.01	8.39
HUT012	B	15/09/2007	**190.00**	84.08	0.69	13.67	1.57	93.68	0.20	0.00	6.13
HUT013	A	15/09/2007	4.70	71.71	7.28	19.52	1.50	82.38	6.44	1.15	10.03
HUT014	A	10/09/2007	1.60	62.69	17.71	17.77	1.83	63.70	22.95	0.07	13.28
HUT015	A	15/09/2007	8.80	75.70	5.50	17.24	1.56	85.90	0.01	1.08	13.01

Most wetland types had circum-neutral pH, except sites 12A and B, 13 and 15 which were more alkaline (7.98, 8.05, 8.38 and 9.72 respectively).

Nutrient and chlorophyll concentrations were compared with the default trigger values for 'slightly disturbed' wetlands from south-west Western Australia, as detailed in the ANZECC/ARMCANZ (2000) guidelines (Figs 6 and 7). These values are interim concentrations (or ranges of concentrations) that suggest divergence from natural conditions are meant to trigger further investigation. These differ depending on the aquatic ecosystem type and region considered. The sites sampled for the Hutt Catchment Survey would be classed as either "*lowland rivers*" or "*wetlands*". The default trigger values applicable to south-west WA are denoted by coloured lines in Figs 6 and 7, with lowland rivers to the left and wetlands to the right. Water samples from the Hutt survey were measured in terms of total filterable phosphorus (TFP) and total filterable nitrogen (TFN), whereas the default trigger values detailed above are for total phosphorus (TP) and total nitrogen (TN). Total phosphorus and nitrogen are normally greater than total filterable concentrations since the latter removes nutrients contained within planktonic cells. Future work should involve measurement of both total and total filterable nutrients.



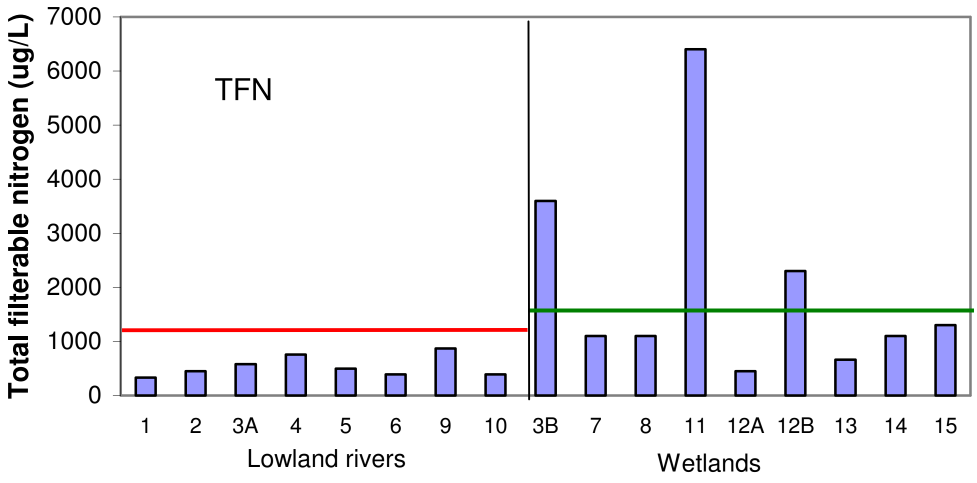


Figure 6: Concentrations of chlorophyll-a and TFN for Hutt Catchment *lowland river* sites and *wetland* sites in spring 2007. ANZECC/ARMCANZ (2000) trigger levels for *lowland rivers* (red line) *wetlands* (green line) are also shown. Note that trigger levels are for TN, not TFN, see text. The chlorophyll concentration for site 8 is unusually high for this type of wetland and should be viewed with caution.

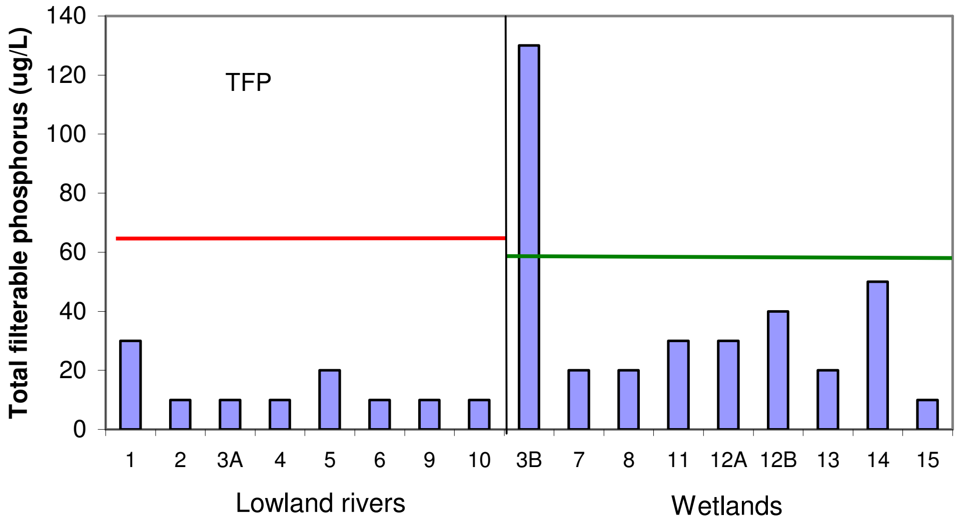


Figure 7: Concentrations TFP for Hutt catchment *lowland rivers* and wetlands in spring 2007. ANZECC/ARMCANZ (2000) concentrations for TP in *lowland rivers* (red line) *wetlands* (green line) are also shown.

All of the chlorophyll-*a* concentrations at '*lowland river'* sites were within or above the trigger range (3-5 µg/L). Harry Spring Creek recorded a concentration of 10 µg/L, which is almost double the default trigger range and 3 sites were above 5 µg/L. Compared to the concentration recorded in spring 2007 (3.5 µg/L), site 3A showed a considerable increase in chl-*a* in summer (32 µg/L – Appendix 1). This greatly exceeds the trigger value for a *lowland river* ecosystem type and may have resulted from a flush of nutrients during summer flows and subsequent high temperatures. Total filterable nitrogen concentrations nearly tripled at this site between spring and summer (Appendix 1). Sites 4 and 5 showed slight decreases in chl-a concentrations between the spring and summer sampling periods. At '*wetland'* sites, chl-*a* concentrations were mostly well under the default trigger value of 30 µg/L, with the exception of site 8 (Feast Soak) with 43.5 µg/L. This value is unusual for a shaded highly vegetated soak with low nutrient concentrations and should be regarded with caution until it can be tested again.

The TN default trigger value of *lowland rivers* and *wetlands* is 1200 µg/L and 1500 µg/L respectively. Of the sites sampled in 2007, no *lowland river* sites were above the TN trigger value; however three of the *wetland* sites were well above the trigger values. These were the rock pool seepage (site 3B), Hutt Lagoon and Yerina Spring. Site 3B also exceeded the TP trigger in summer with a concentration of 1500 µg/L. Other summer TN concentrations were low.

The TP default trigger value is 65 µg/L for '*lowland rivers'* and 60 µg/L for '*wetlands'* (Figure 7). At all Hutt sites, TFP was between 5 and 50 µg/L, except at the rock pool seepages on the lower Hutt (site 3B) where 130 µg/L was recorded. At this site, and probably some others, TP would have been well above the trigger value.

Bar chart plots for each of the environmental parameters and for ionic composition at each site sampled during the Hutt Catchment Survey in 2007 and 2008 are illustrated in Figure 8 and Figure 9. The five main groups recognised from the cluster analysis of sites based on the invertebrate communities (Figure 14) are delineated on the plots. The physical and chemical characteristics of each of the five cluster groups are described after Figure 14.

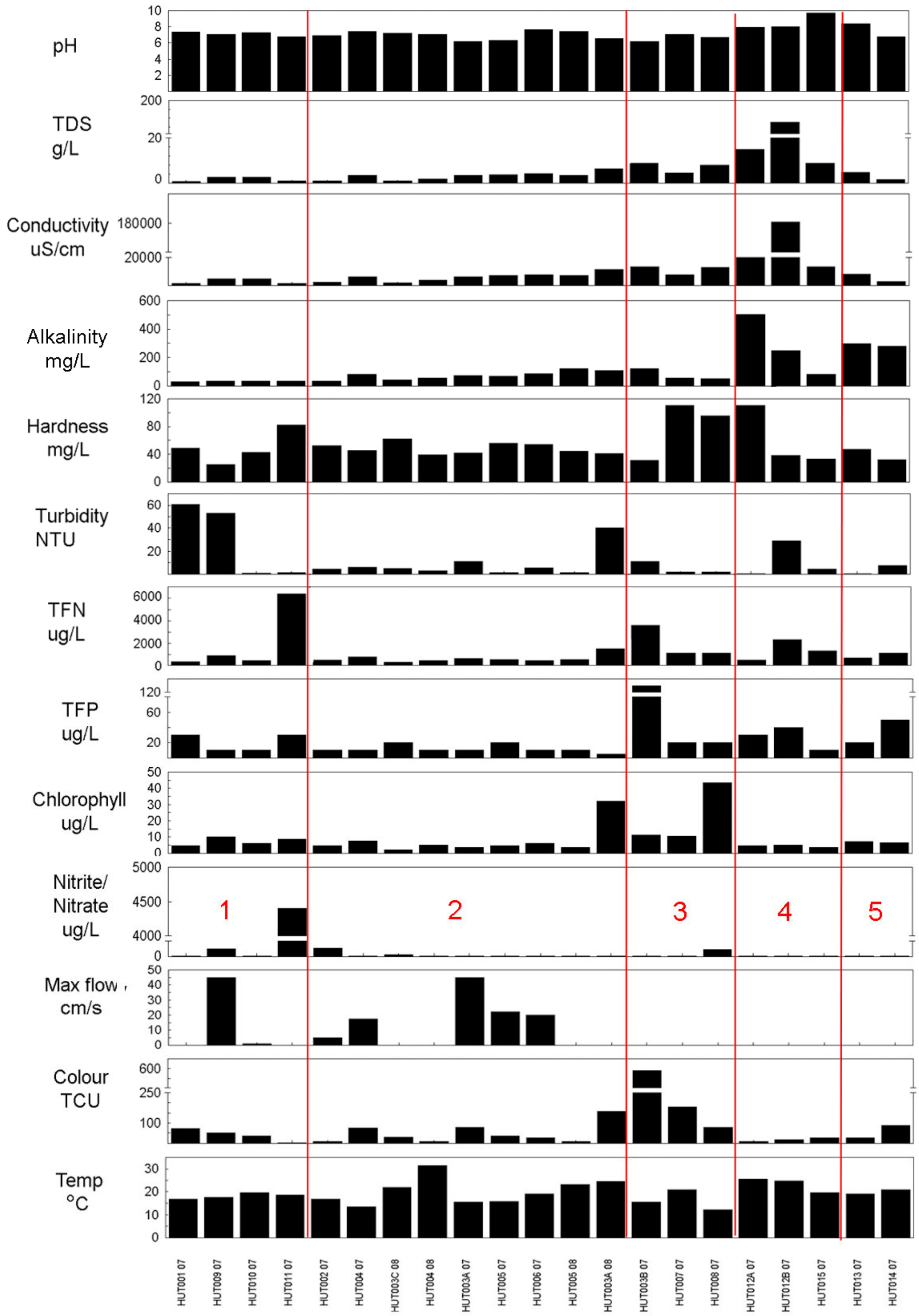


Figure 8: Environmental parameters recorded for each site sampled during the Hutt Catchment Survey in 2007 and 2008. The 5 main groups from the cluster analysis of invertebrate community composition are also shown, delineated by a red line and numbered. Note the scale breaks for some variables.

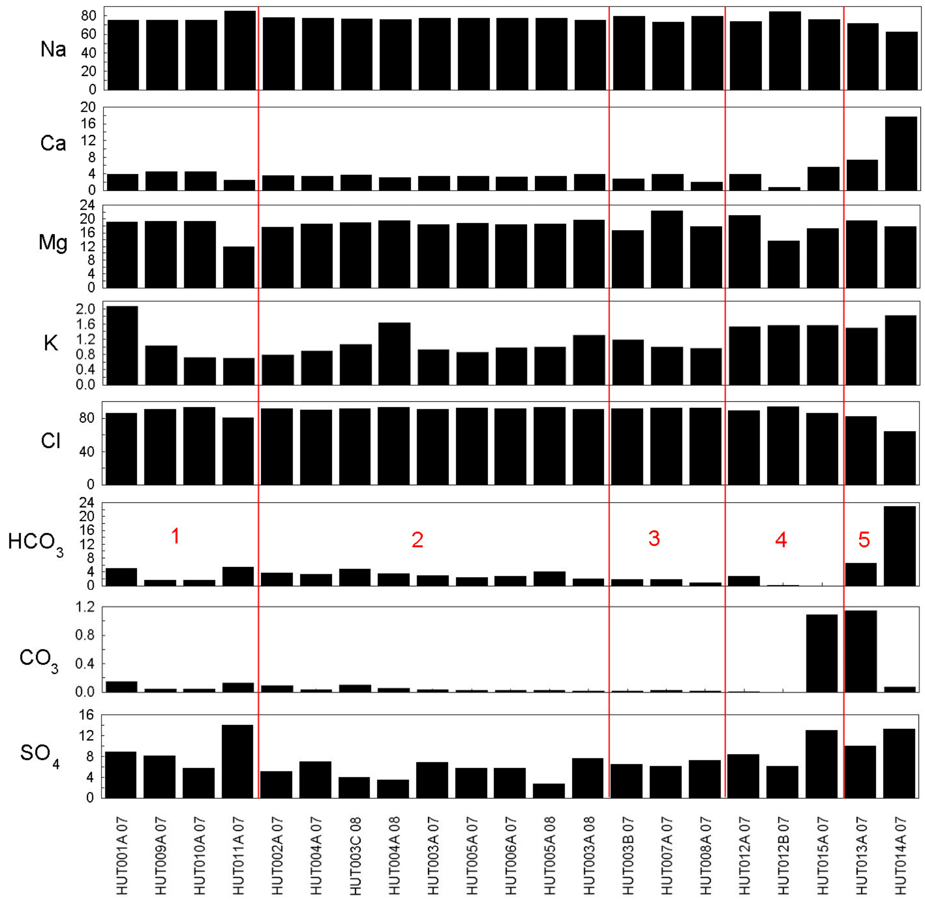


Figure 9: Ionic composition for each site sampled during the Hutt Catchment Survey in 2007 and 2008. The 5 main cluster groups based on aquatic invertebrate composition are also indicated.

Aquatic invertebrates

Invertebrate Diversity

A total of 223 unique taxa (those marked with an asterisk in Appendix 3) were collected from the 18 Hutt catchment wetland sites during this survey. An additional 34 taxa were recorded from the SAP survey (marked with a # in Appendix 3). This compares to about 1050 taxa currently known from the south-west agricultural zone (Pinder *et al.* 2004 and unpublished data, DEC).

Of the 223 taxa recorded during the present project 38% were recorded only in one sample and 69% were recorded from 3 or fewer samples (i.e. individual sampling events not sites). Only 5% were recorded in more than half of the samples. Taxa were recorded at an average of 3.3 samples. This low frequency of occurrence probably reflects the high diversity of wetland types compared to the number of sites sampled.

The mean accumulation of species as number of samples increased (from 1 to 21) is shown in Figure 10 for this survey only. The curve has clearly not flattened out suggesting there remains species not detected. The program EstimateS (Colwell, 2008) was used to estimate what proportion of the regional aquatic invertebrate fauna is likely to have been captured by the survey and, *ipso facto*, what the regional richness is likely to be in the sorts of wetlands sampled (but see above for sampling gaps). The Chao2 estimator, adapted from Chao (1987), suggests regional richness is likely to be about 296 species (95% C.I. 262 – 356) and the ICE (Incidence-based Coverage Estimator) estimator adapted from Lee and Chao (1994) suggests 306 species. These figures suggest the current survey revealed about 72% of the region's aquatic invertebrate fauna inhabiting similar wetlands to those sampled. We consider this to be adequate to describe the general patterns of biodiversity distribution and conservation significance of the region.

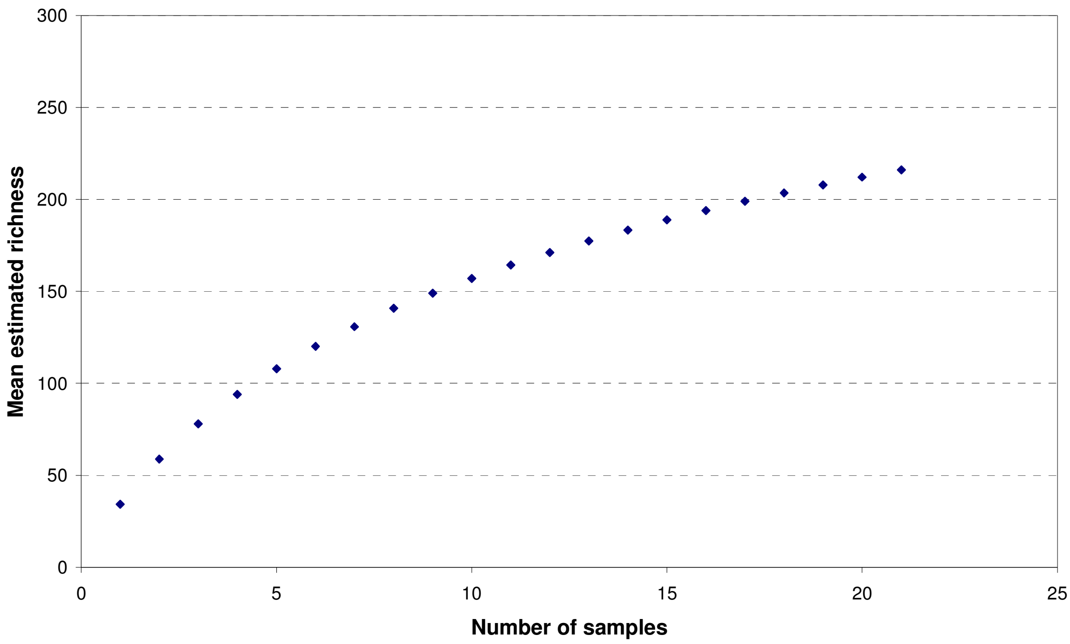


Figure 10: Mean accumulation curve of species with increasing sample number.

Species richness at a site varied from 13 at 12A (Hutt Lagoon) to 59 at site 3B (rock pools adjacent to Hutt River downstream of Hutt-Yarder confluence) during this survey, though 62 taxa were collected from Yerina Spring during the SAP survey. Average richness during this survey was 40.2 ± 2.6, which is about the same as recorded for the wider Wheatbelt (40.1 ± 1.6) by Pinder *et al.* (2004). Richness, however, is strongly dependant on salinity, so comparisons of mean richness values are misleading. Richness values obtained in this study are plotted against salinity along with data from Pinder *et al.* (2005) in Figure 11.

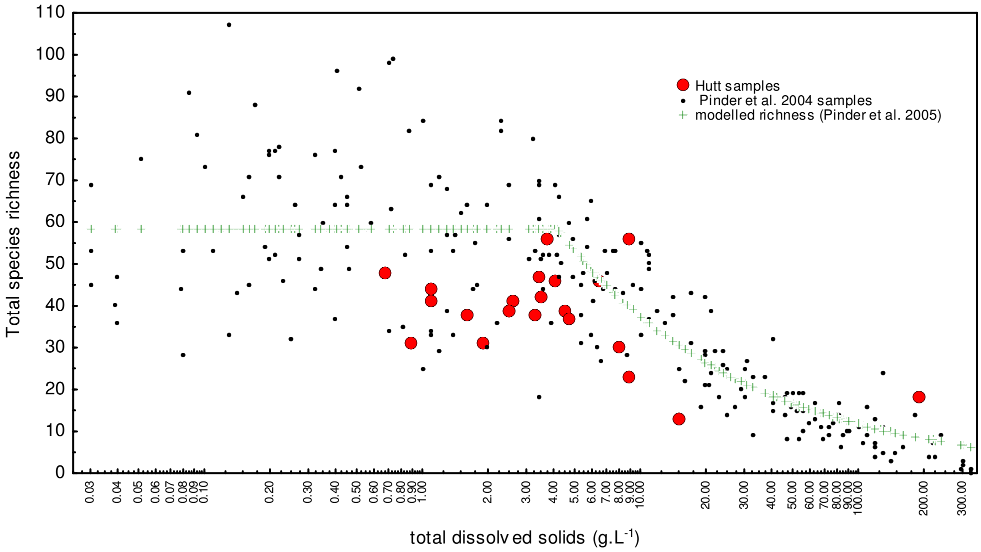


Figure 11: Graph of salinity versus total invertebrate richness, showing data from Pinder *et al.* (2005) (small black dots) the Hutt catchment sites (large red dots) and the line representing the modelled salinity-richness relationship (green + symbols).

It is clear from Figure 11 that invertebrate richness is low compared to wetlands of similar salinity sampled by Pinder *et al.* (2004, 2005) elsewhere in the agricultural zone, except for a couple of the more saline wetlands. However, many of the wetlands in the Hutt Catchment, especially the freshwater springs, have very little habitat diversity and/or are flowing water and/or have little open water, all of which would be expected to result in lower diversity. This low diversity is therefore considered to be characteristic of the wetland types present rather than indicating poor condition.

Comparisons between the present survey and the SAP survey

Four of the wetlands sampled for this survey were sampled during the SAP survey. In 1999, Yarder Gully had 39 species (43 in 2007), Utcha Swamp had 45 (39 in 2007), Yerina Spring had 62 (35 in 2007) and Hutt Lagoon had 14 (18 in 2007). Yerina Spring had more surface water in 1999 than in 2008, which may explain the lower richness when sampled for this project. A total of 111 invertebrate taxa were collected from the four SAP sites in 1999 compared to a total of 223 taxa collected from the Hutt Catchment Survey. Of these, 77 were common to both surveys, leaving 34 taxa collected during the SAP survey but not in the Hutt Survey. These 34 taxa are indicated in Appendix 3 with a # symbol. Hutt Lagoon was also sampled as part of the Resource Condition Monitoring Project in 2008 but no additional taxa were recorded.

Biogeography

Analysis of the distribution of aquatic invertebrates in WA is hampered by inconsistent naming of undescribed taxa in reports prepared by different research groups in WA, so some taxa may be more widespread than believed.

Most species are widespread in the south-west, southern Australia or continentally but some are less common, some are north-west species whose distributions extend into the Mid-west region and some are far south-west species whose distribution extends north to the Mid-west.

'*Rare/rarely collected species*'. Several taxa have not been previously recorded during past DEC surveys or have not been (or have rarely been) recorded previously from the south-west agricultural zone:

- The mosquito *Aedes* nr *camptorhynchus* occurred only in Gregory Spring. It does not resemble any of the species described in Liehne (1991).

- Another mosquito *Culex* sp. 3 has only been recorded once before by DEC at a samphire pan near Lake Moore. It occurred in 2 lower Hutt River sites.

- Two forms of *Forcypomyia* biting midge (species 8 and 9) occurred only in Yarder Gully. These have not been recorded during past DEC projects.

- An unidentified dipteran larva (sp. E) occurred in Yarder Gully and the lower Hutt but has not been recorded in past DEC surveys. It may be a semi-aquatic species.

- The chironomid *Compterosmittia* sp. A was recorded at only a few sites during the SAP survey (Lake Pleasant View, Frog Rock, and un-named swamp near Boyacup Bridge and from Yarder Gully between Geraldton and Northampton). It was also recorded from the Three Springs Mound springs. In the Hutt Survey it was collected from the Hutt River north of Yarder Gully (site 4) in spring. Orthocladiinae sp. P is a halophilic chironomid collected in Hutt Lagoon during both the Resource Condition Monitoring project (2008) and the SAP survey (1998) but not during the present survey. It is otherwise known from a few other sites in the Wheatbelt, south coast and south-west.

- The beetle *Platynectes aenescens* is rare in the Wheatbelt, mostly occurring in the more south-western SAP sites, but did occur in Cockleshell Gully and has been found in the Drummond Nature Reserve wetlands. In the Hutt survey it was recorded only at Gregory Spring.

- The dragonfly *Austrolestes psyche* is uncommon in the Wheatbelt but occurred in the seepage area on the edge of Hutt Lagoon (site 12A).

- The oligochaete *Pristina* nr *sima* - collected at Yerina Spring (site 11) in both this and the SAP surveys and at a granite seepage area of the Hutt River (site 3B). It has otherwise only been collected at one spring site in Pilbara and in one of the Leeuwin-Naturaliste Caves. This probably is *Pristina sima*, which occurs elsewhere in the world but has not been collected outside of WA in Australia to date.

- The undescribed water mite *Austrotrombella* n. sp. was first recorded from Cockleshell Gully and Skelton Gully in the northern wheatbelt (Pinder *et al.* 2004) and later in the Three Springs mound springs (Pinder *et al.* 2002, 2006). It was also collected from Gregory Spring during this survey. This appears to be a regionally endemic species occurring in springs, spring-fed creeks and seepages. Its only congener is known only from South Australia.

- Another water mite, *Arrenurus* sp. does not fit the published descriptions of members of this genus and is not one that has been recorded before in DEC projects.

- The rotifer *Tripleuchlanis plicata* has only been recorded twice before in Western Australia (near the south-coast) but it is also known from Queensland and other continents. In this survey it occurred only in the lower Hutt River. It appears to be widespread but relatively rare.

- The rotifer, *Lecane* n. sp.? "Hutt", was collected only during the SAP survey. Originally thought to be a new species, it may in fact be a specimen of *Lecane grandis* that contracted on preservation.

- *Nitocra* sp. 3 has only been recorded at Yerina Spring (during the SAP survey).

'*Northern species'* Numerous species, almost all insects, have northern or north-western distributions and their occurrence in the Hutt region is probably close to (or even extends) their known southern limit. Many of these northern species have also not been recorded in the Wheatbelt before and some were not recorded in the Carnarvon Basin by Halse *et al.* (2000).

- The beetles *Megaporus ruficeps* and *Hydroglyphus leai* occur across northern Australia but have not previously been recorded south of the Pilbara. Another northern beetle, *Neohydrocoptus subfasciatus*, was not recorded during this survey and was recorded only from Utcha Swamp during the SAP survey.

- The notonectid hemipteran *Anisops stali* is far more common in northern than southern Australia although the Hutt area is well within its southern range. Its congener *Anisops nasuta*, from HUT013, is more strictly a northern species and is about at its southern limit at the Hutt.

- The nepid hemipteran *Laccotrephes tristis*, recorded from the Hutt River and Yarder Gully, is also much more common in northern than southern Australia and was not recorded during the SAP survey.

- Another hemipteran *Paraplea* ANIC sp. 6 (from HUT013) is common in the Pilbara and has been recorded once along the south-coast but the systematics of this group is in need of revision.

- The dragonfly *Orthetrum migratum* was collected from Yarder Gully but is also at its southern limit of distribution in this region and was not collected during the SAP survey.

- The chironomids *Polypedilum leei*, *Tanytarsus* sp. D, G and H are common northern species. *Polypedilum leei* and *Tanytarsus* sp. H were collected in the lower Murchison River during the SAP survey and *Tanytarsus* sp. H has been collected at one other location in the south-west (DEC, unpublished data). Both of these species occurred only in the Hutt River immediately downstream of Gregory Spring in this survey. In the south-west, *Tanytarsus* sp. D and G were recorded only at Yerina Spring during the Hutt survey but both were recorded at one other Wheatbelt site (Pinder *et al.*, 2004 and unpublished data) and the latter was also collected in one of the Three Springs mound springs and does occur sporadically in the south-west. *Nanocladius* sp. 1 is probably also a northern species and was found only in the Murchison River and a site in the Jarrah Forest (Congelin Nature Reserve dam) during the SAP survey.

- A few other insects (*Forcypomyia* sp. 6, psychodid sp. 5 and lepidopteran Pilbara sp. 3) were also not recorded during the Wheatbelt Survey but are known from northern Australia, although species separation in these groups is uncertain.

- The oligochaete *Allonais ranauana* is also a northern/inland species not recorded from the south-west before.

- Finally, *Lecane grandis*, collected during the SAP survey is a northern rotifer not known from south of Hutt Lagoon in WA.

'*South-west species*'. For a smaller number of species, also mostly insects, the new Hutt records are near to (or extend) the northern limit of largely southern mesic distributions:

- The mildly salt-tolerant oligochaete *Ainudrilus nharna*, recorded from the lower Hutt River, is common in the south-west of the state but has not previously been recorded this far north.

- The mosquito *Culiseta atra*, from Yarder Gully, occurs in organic rich swampy wetlands, such as the mound springs near Three Springs (Pinder *et al.* 2002, 2006) but is about at its known northern extent in the Hutt Catchment.

- Another mosquito, *Anopheles atratipes*, is rarely collected north of Perth but was recorded from Gregory Spring in this survey. It has also been recorded in the Buntine-Marchagee Catchment and has recently been collected from the Three Springs Mound Springs (DEC unpublished data). It tends to inhabit coloured wetlands such as *Melaleuca* swamps.

- The copepod *Paracyclops* sp. 1 (nr *timmsi*) was found in several wetlands in the Hutt Catchment (especially river or spring sites) and in the Three Springs mound springs but there are few records elsewhere in the Wheatbelt (Yarder Gully, Dale River), south coast (Mount Le Grand Swamp) or south-west (Noobijup Swamp) and possibly the Muir-Byenup NDRC wetlands.

- The dragonfly *Archaeosynthemis occidentalis*, also from Yarder Gully, is a species of the high rainfall south-west but also occurred in the Three Springs mound springs (ibid).

- Several chironomids are essentially south-west species, rarely occurring in the Wheatbelt: *Tanytarsus palmatus*, a southern Australian chironomid, may not occur much farther north; Orthocladiinae sp. I was recorded from 3 southern sites in the SAP survey, plus the Three Springs mound springs and at some of the springs in the Hutt survey (Yarder Gully Spring, Yerina Spring and Feast Soak); *Polypedilum* nr *convexum* (southern form) is rare in the Wheatbelt, occurring in Lake Wheatfield and Lake Pleasant View near the south-coast, forest streams and in the Three Springs mound springs.

Three microcrustaceans of marine affinity (copepods Lourinidae sp. and *Robertsoniua* sp. and the ostracod *Paradoxostoma* sp.) occurred in Hutt Lagoon and may be related to congeners found in Lake McLeod, another large coastal lagoon surveyed by Halse *et al.* (2000). They have not otherwise been recorded in inland waters of WA, though there are marine species of these genera known from Australia.

Three introduced species were recorded. *Cherax caini* (non-hairy Marron) and *Cherax destructor* (yabbie) are both introduced to the catchment and common in the lower Hutt River and *C. caini* occurs in Yarder Gully. The brine shrimp *Artemia franciscana* in Hutt Lagoon is also almost certainly introduced, as is the case for many of the coastal lagoons in WA. *Artemia* brine shrimp are increasing their ranges in Australia (Ruebhart *et al.* 2008).

Seasonal Differences

The sampling effort undertaken in 2008 was not enough to provide a full comparison of seasonal faunas. However, sampling at sites 3, 4 and 5 were carried out in spring and summer and the comparisons are detailed in below.

Table 4: Species richness comparison between spring and summer sampling periods at Hutt sites 3, 4 and 5.

Site **Season**	**3A** **spring**	**3A** **summer**	**4** **spring**	**4** **summer**	**5** **spring**	**5** **summer**
Total species richness	43	41	32	30	49	37
No. species in common	17		15		20	
No. species different	26	24	17	15	29	17
% in common	39	41	47	50	41	54

Sites 3A and 4 had almost the same richness in summer as in spring but in site 5 summer richness was lower than in spring.

These comparisons show that the summer fauna is not just a subset of the spring fauna – just under half of species present in summer had colonised the site or hatched between sampling events. Of the 87 species that occurred in the four summer samples (above sites plus 3C) eighteen were not recorded at any sites in spring. However, none are likely to be truly summer specialists as all have been recorded in spring in other studies.

Community composition.

Most species (149) making up the invertebrate community were insects (Figure 12). Most aquatic insect orders were represented, with Diptera being the single richest group. Micro-invertebrates (ostracods, copepods, cladocera and rotifers) made up most of the remainder. The percentage of micro-invertebrates contributing to total species richness (21%) is lower than that recorded for similar studies (e.g. 44% for the Carnarvon Basin (Halse 2000), 48% for the Wheatbelt (Pinder *et al.*, 2004) and 41% in the Pilbara (Pinder *et al.*, in prep). This is most likely because a large proportion of wetlands sampled during the Hutt Catchment Survey were streams and springs which generally have less diverse macroinvertebrate faunas compared to open lentic wetlands. Stoneflies are notably absent but they were not recorded north of the Hill River during the AusRivAS project (DEC unpublished data, Halse *et al.* 2006).

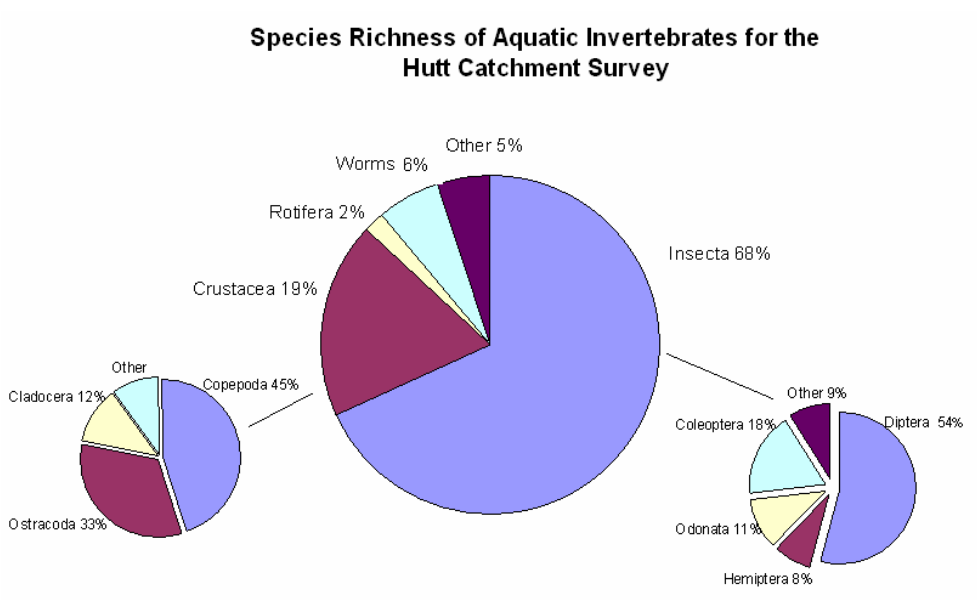
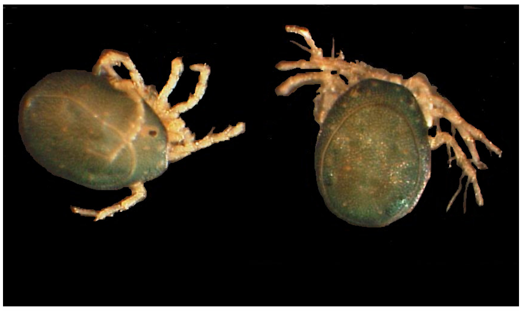


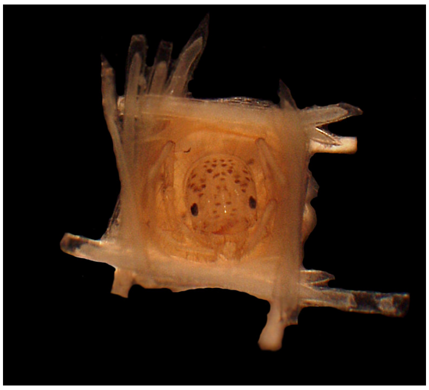
Figure 12: Species richness of aquatic invertebrates for the Hutt Catchment Survey during 2007 and 2008.

Aquatic invertebrate species

A selection of species recorded during the Hutt Catchment Survey are shown below.



Arrenurus sp. (water mite)



Oecetis sp. (caddisfly with detritus case

Oecetis sp. (caddisfly with sand case)

Triplectides sp. (caddisfly with detritus case)

Oxyethira sp. (caddisfly with secreted case)

Non-biting midge (Chironomidae)

Cheumatopsyche sp. (caddisfly)

Hemianax sp. (dragonfly nymph)

Laccotrephes sp. (water scorpion)

Comparisons with other surveys in the region

A total of 77 species were shared between this survey and the surveys of mound springs at Three Springs (Pinder *et al.* 2002, 2006, unpublished data). Of these, 41 species were common to spring sites at Three Springs and spring sites within the Hutt. This includes species such as the mosquitoes *Culiseta atra* and *Anopheles atratipes,* odonates *Archaeosynthemis occidentalis, Archiargiolests pusillus* and the water mite *Austrotrombella* n. sp. that tend to be found primarily in permanently moist habitats and so are rare outside the higher rainfall south-west.

Of the 202 taxa recorded from the Buntine-Marchagee Natural Diversity Recovery Catchment (Lynas *et al.* 2006), at least 62 were found to be present in the Hutt Catchment wetlands, though this excludes records from the first (2003) sampling round in the Buntine-Marchagee Catchment. Species in common include *Polypedilum leei*, one of the northern element and *Limnocythere porphretica* which is widespread in the south-west but not common compared to its congeners.

Wetland classification based on invertebrates

Two hundred taxa were used in analyses for comparison of sites after combining some data because of differences in taxonomic resolution across sites. Removing singleton taxa (species occurring only at one site) made no difference to the classification produced so were left in.

A classification showing groupings of wetland sites based on presence/absence of species is shown in Figure 13. The two main groups, A and B, are indicated in this diagram. Group A is comprised of the Hutt River Catchment wetlands while Group B is comprised of the Hutt Lagoon and wetlands to its north. These can be further sub-divided giving 5 subgroups for the purposes of the following discussion (Figure 14).

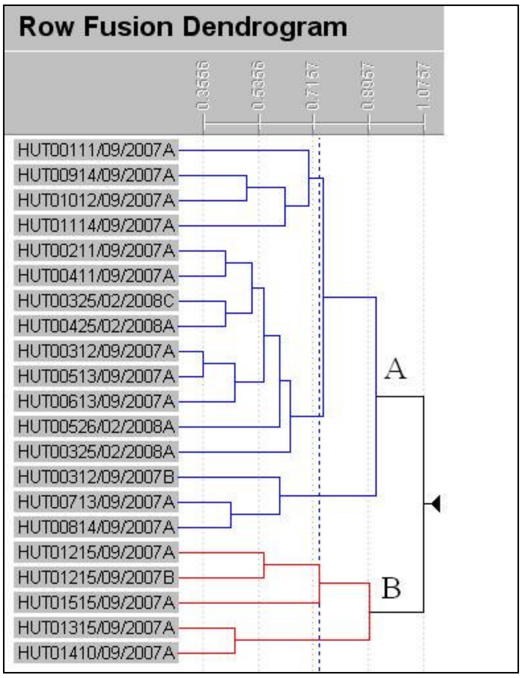


Figure 13: Dendogram showing the two major groups of wetland sites sampled in 2007 and 2008.

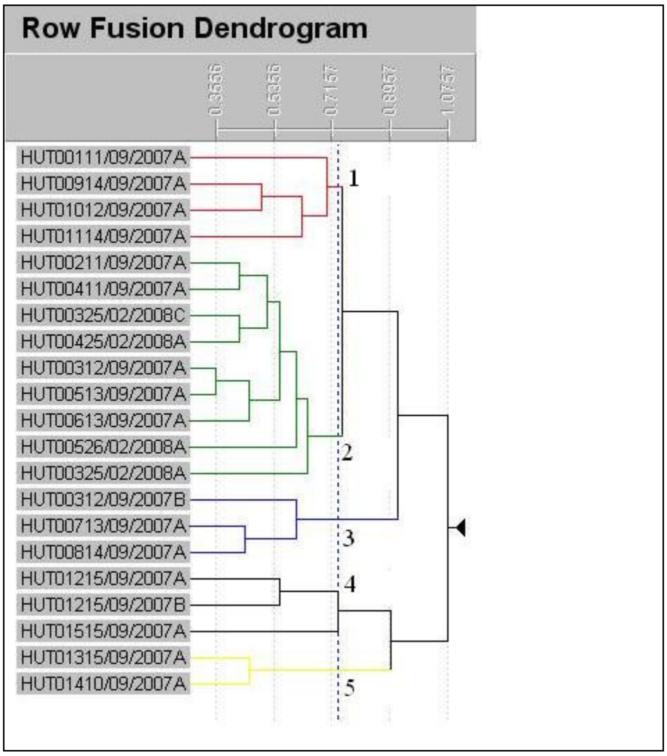


Figure 14: Dendogram showing groups A and B further divided into five major groups of wetland sites.

Group 1 – Freshwater springs and spring-fed creeks. This group includes Yarder Gully Spring, Harry Spring Creek, the tributary of Swamp Creek and Yerina Spring (Sites 1, 9, 10 and 11). Eighty four species where recorded from these sites (average 34), of which 14 (average 6 species per site) were restricted to this site group (Table 5). Species of note include the dragonfly *Archaeosynthemis occidentalis* which is rare in the Mid-West and Wheatbelt, and two northern species (the oligochaete *Allonais ranauana* and another dragonfly *Orthetrum migratum*). Although these are mostly lotic sites, the invertebrates recorded are not strongly associated with flowing water. Sites within this group were all fresh (salinity 0.68 to 2.6 g/L) and had the lowest alkalinity (Figure 8). Yerina Spring had high nitrite/nitrate concentrations (4400 μg/L), and both Yarder Gully Spring and Harry Spring Creek had high turbidity (61 and 53 NTU) compared with the remaining sites (as indicated in Figure 16). Harry Spring Creek also had the equal highest maximum flow recorded of all sites at 45 cm/s.

Group 2 - Hutt River channel. This group consists of all of the main sites along the Hutt River itself (Sites 3A, 3C, 4, 5 and 6) in both seasons, plus the Yarder Gully stream site (site 2). Composition of the invertebrate fauna of this group was most similar to Group 1 (Figure 14). This was the largest group comprising nine samples from six sites with a total of 127 species, and had the highest average number of species per site (40) (Table 5). Fifty three species occurred only in these sites but this high number partly reflected the high number of sites. On average, 11 of these species unique to the site group occurred in each site, which is the second highest rate of the five groups. Species strongly associated with this site group included the mayfly *Tasmanocoenis tillyardi*, the gyrinid (whirligig) beetles *Aulonogyrus strigosus* and *Macrogyrus angustatus*, the blackfly *Simulium ornatipes*, the hydropsychid caddisfly *Cheumatopsyche* AV2 and the hydroptilid caddisfly *Acritoptila* sp. Several of these are characteristic of flowing water. These were the only sites in which yabbies were collected. The chironomid *Harrisius* sp. was collected in several Hutt River samples plus Yarder Gully, but appears to be uncommon in the Wheatbelt and Mid-west regions. The key environmental attribute shared by these sites was spring (but not summer) flow. Site 3A exhibited high chl-*a* concentration in summer as well as elevated turbidity, but the chl-*a* and turbidity levels for the remaining sites within this group were fairly low. Site 3A had become a smaller isolated pool in summer with little canopy cover, which may explain the high chlorophyll and turbidity, whereas the other sites still had some flow and/or dense riparian canopy. Most sites within this group were subsaline, with the exception of site 2 (which is always fresh) and sites 3C and 4 in the main channel of the Hutt sampled in summer, which were both fresh. The low salinity of these sites is reflected in the group's position in Figure 16.

Group 3 – Sub-saline springs/soaks. This group includes Gregory Spring, Feast Soak and the rock pools adjacent to the Hutt River near the confluence with Yarder Gully (Sites 7, 8 and 3B). This group had the second highest average number of species per site (37), the second highest number of species recorded only in this group (30) and the highest average number of species/site restricted to this group (13) (Table 5). Species of particular note are the water mites *Austrotrombella* n. sp. and the possibly new *Arrenurus* sp. and some other taxa whose distributions are unknown but which have rarely been recorded in the Mid-west and Wheatbelt (Orthocladiinae sp. A, *Culex* sp. 3, *Anopheles atratipes*). The main environmental attributes shared by these sites were shallow depth, subsaline waters (4.5 to 8.8 g/L) and higher chl-*a* compared to other sites, as indicated in Figure 16, with Feast Soak recording the highest chlorophyll concentration of 43.5 µg/L. The rock pools (site 3B) had high TFN and TFP as well as the highest colour (590 TCU) of all sites, at least the latter reflecting the seepage of water from adjacent riparian soils. Silica concentrations at Gregory Spring and Feast Soak were also high.

Group 4 – Saline wetlands. This group consists of the Hutt Lagoon sites and the shallow sedge flat north of the lagoon (Sites 12A, B and 15). These sites had the lowest average richness (17), of which an average of 8/site occurred only in this site group (Table 5). Most species were either halophilic (i.e. prefer saline conditions, e.g. the rotifers *Brachionus plicatilis* s.l. and *Lecane thalera* and the copepod *Calamoecia clitellata*) or halotolerant (i.e. generally freshwater species with some tolerance to salinity, e.g. the damselfly *Austrolestes annulosus* and amphipod *Austrochiltonia subtenuis*). This group of sites had high salinity (8.8-190 g/L) and fairly high pH (8-9.7). Site 15 had very high levels of CO_3^{2-} which is clearly illustrated in Figure 8. Hutt Lagoon had very high salinity (190 g/l), alkalinity (505 mg/L) and fairly high pH (pH 8.1), as shown in Figure 16 and Figure 8.

Group 5 – Low salinity northern Swamps. This group consists of Utcha Swamp and the *Baumea/Cyperus* fringed swamp, both of which lie just to the north of the Hutt Lagoon (Sites 13 and 14). These two sites supported 46 species (average 30/site) but had very few species not occurring in other wetlands (Table 5). Alkalinity and bicarbonate were reasonably high within these sites. Utcha Swamp was fresh (salinity of 1.6 g/L) whereas the sedge flat was subsaline.

Table 5 shows that 124 taxa, representing 57% of the species recorded during the survey, were recorded at wetlands within just one of the site groups. None of the wetland groups are redundant in terms of their representation of the region's fauna, although group 5 had only 8 taxa not represented at other wetlands.

Table 5: Number of invertebrate species present within each wetland group and the number of those found only in that group. Refers only to those taxa marked with an * in Appendix X (i.e. where the lowest level of taxonomic resolution has been achieved).

Site group	# species present	average # species per site	# species unique to the site group	Average # species unique to the site group per site
1 (4 samples)	84	34	14	6
2 (9 samples)	127	40	53	11
3 (3 samples)	75	37	30	13
4 (3 samples)	39	17	19	8
5 (2 samples)	46	30	8	6

An unconstrained ordination plot (semi-strong hybrid multidimensional scaling) of all sites from the Hutt Catchment Survey during 2007 and 2008 is shown below in Figure 15. This plot is a visual representation of the relatively similarity of invertebrate communities present in the wetlands and wetland groups. It is clear from this that the site groups from the cluster analysis are reasonably well separated from each other and that there is a gradient of community turnover between groups 1, 2 and 3 along axis 2 and between groups 1, 4 and 5 along axis 2.

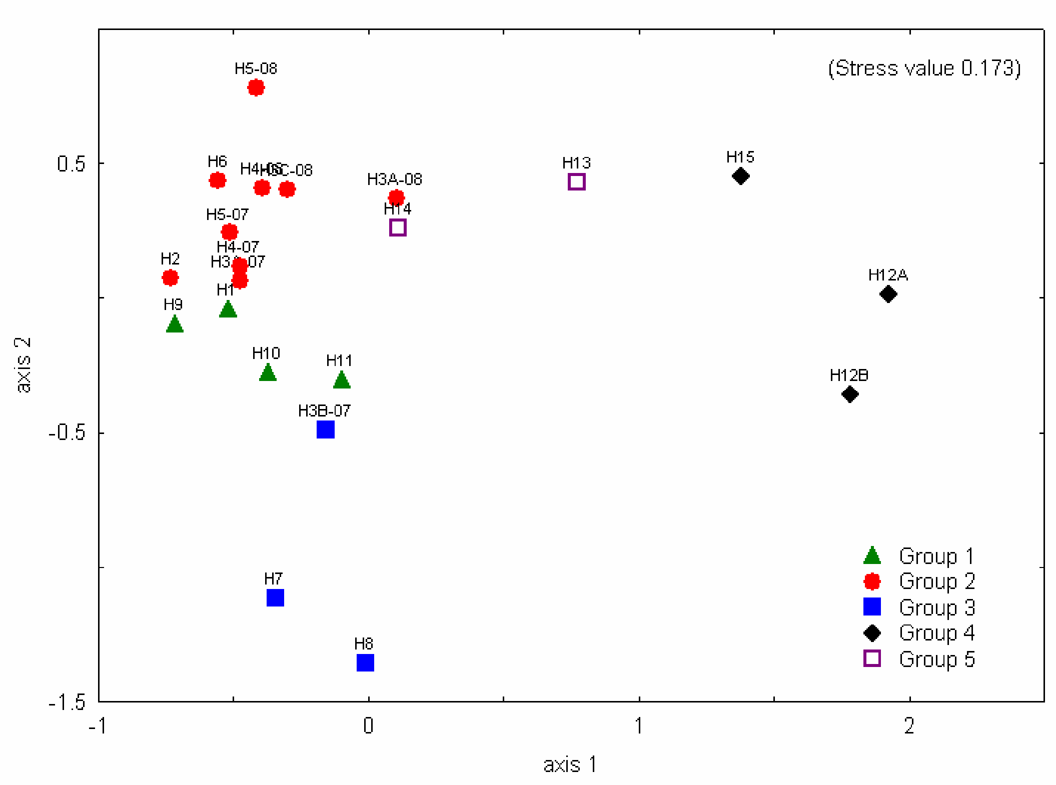


Figure 15: Ordination plot of all samples from the Hutt Catchment Survey. Labels are site numbers and years (for sites 3, 4 and 5).

Aquatic invertebrates and environmental parameters

The above unconstrained ordination attempts to place samples in such a way that the distances between samples on the plot represent the overall similarity of their invertebrate communities. To better investigate the relationships between invertebrate community composition and environmental variables another type of ordination was performed. Constrained ordinations attempt to place sites in relation to each other on the basis only of that component of community similarity that can be related to measured environmental variables. The symbols on the plot essentially represent community composition as predicted from environmental variables. The constrained method used was a distance-based (Bray-Curtis) Redundancy Analysis (db-RDA) using the 'capscale' routine in the 'vegan' package in R (Oksanen, 2008). Figure 16 shows the position of samples in constrained ordination space (axes 1 v 2) in relation to environmental gradients (arrows point in the direction of high values and away from low values in the opposite direction). Figure 17 shows the same ordination of samples but with cluster groups 1 to 5 (as above) circled. This analysis showed that only depth, total dissolved solids, total filterable nitrogen and pH were significantly ($p<0.05$) related to community composition, as determined by a permutation test (1000 randomisations).

Other gradients were present but not statistically significant, though they align with patterns seen in Figure 8. The ordination shows group 4 and to a lesser extent group 5 to have higher pH and salinity, group 2 to have low nitrogen and groups 3 and 1 to be shallower. These gradients are also seen in Figure 8. In Figure 17, based on the db-RDA, the relative positions of the five wetland groups is not that different to the pattern seen in the SSH ordination (Figure 15), suggesting a large proportion of the variation in community composition is related to the measured environmental variables.

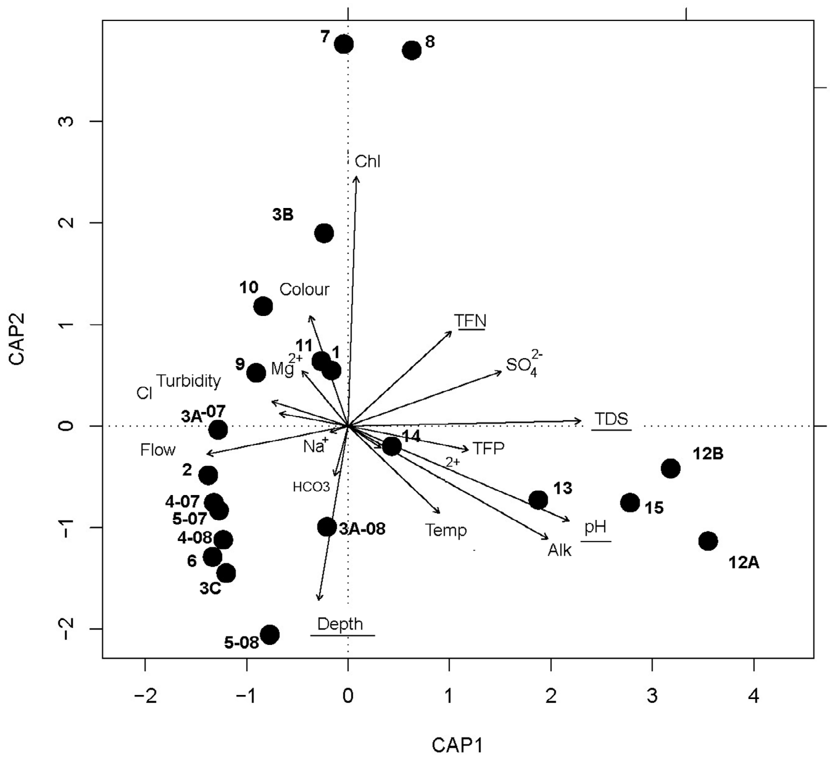


Figure 16: Axes 1 and 2 of db-RDA showing 1) sites positioned according to their scores against axes 1 and 2 as predicted by the available environmental variables and 2) the direction of environmental gradients related to community composition. Underlined environmental variables had a significant relationship to community composition.

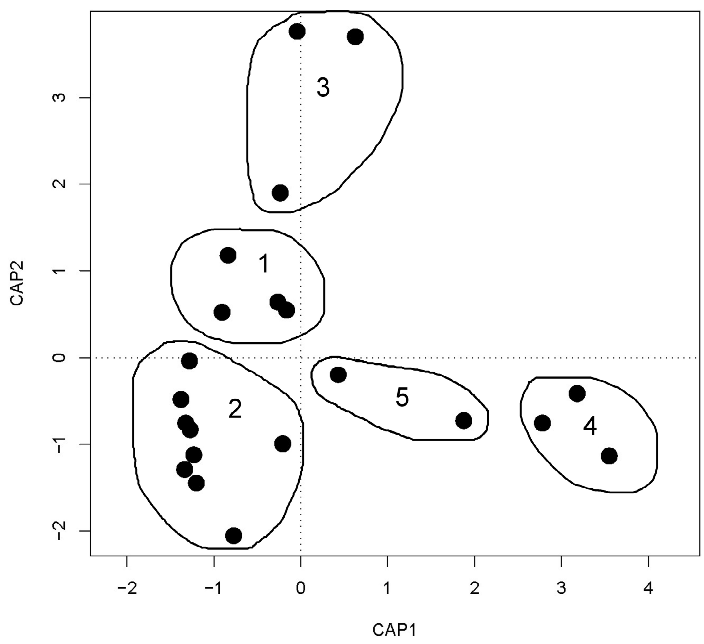


Figure 17: Axes 1 and 2 of the db-RDA showing site group composition from the cluster analysis.

The general similarity between the positions of the site groups in constrained and unconstrained ordination space suggests that community composition is strongly related to environmental variables.

Waterbirds

Sixteen waterbird species (Table 6) were recorded from the study area: 10 at Hutt Lagoon, 7 at Utcha Swamp, 5 from the *Baumea/Cyperus* fringed swamp north of Hutt Lagoon and 4 from the shallow sedge flats north of Hutt Lagoon. Five waterbird species recorded from a previous SAP survey were not recorded during the 2007-2008 Hutt Catchment Survey. These are the Australasian Grebe, Gull-billed Tern, Little Black Cormorant, Pink-eared Duck and the Swamp Harrier.

Other sites, including springs, soaks and main river channels, provide little suitable habitat for waterbirds, though some would use the main channel of the Hutt River at times. In spring 2008 large numbers of waders were recorded at the Hutt Lagoon and wetlands to its north but these were not surveyed. Waterbird richness and abundance were reduced at Utcha Swamp in the Hutt survey compared to counts 10 years earlier in the SAP survey, probably associated with the spread of Typha reducing the amount of open water.

Table 6: Numbers of waterbirds recorded from wetlands during the Hutt Catchment Survey in 2007 and 2008 and the SAP survey. Wetlands with no waterbirds are omitted. Numbers in bold and red type are records from the SAP survey.

Species	**HUT012B**	**HUT013**	**HUT014**	**HUT015**
Australian Shelduck	24, **9**			2
Australasian Shoveler				1,**9**
Australasian Grebe				**2**
Baillons Crake			1	
Banded Stilt	77			
Black-winged Stilt	51, **4**			
Clamorous Reed-Warbler		1	1	
Eurasian Coot			3	**3**
Grey Teal	22, **4**		1	**8**
Gull Billed Tern	**3**			
Hardhead			8	5, **6**
Hoary-headed Grebe		2		
Little Grassbird	5	3	2	7
Little Black Cormorant				**1**
Pacific Black Duck	6	8	20	**10**
Pink-eared Duck				**4**
Red-capped Plover	4, **23**			
Red-necked Avocet	96, **12**			
Ruddy Turnstone	1			
Silver Gull	12, **5**			
Swamp Harrier	**2**			

Wetland plants

Wetland plants were collected from a 100 m^2 transect at each site in spring, generally aligned along the edge of the stream channel at riverine sites or placed to intersect dominant wetland plant communities at lentic wetlands. Some additional collections were made from the same transects in February 2008 and by Greg Keighery in spring 2008. These were identified by Greg Keighery (DEC Science Division). A species list is presented in Table 7 and these data were used to calculate representation of the Halse *et al.* (2004) assemblages in the Hutt Catchments. A more comprehensive account of the region's flora will be provided separately.

Table 7. Wetland plants recorded during survey of Hutt Catchments.

	Wetland Site																
	HUT001	HUT002	HUT003	HUT003A	HUT003B	HUT004	HUT005	HUT006	HUT007	HUT008	HUT009	HUT010	HUT011	HUT012A	HUT012B	HUT013	HUT015
Atriplex cinerea			1														
Cyclosorus interruptus	1																
Cyperus laevigatus														1	1	1	1
Ficinia nodosa								1									
Juncus kraussii			1	1	1												
Lobelia anceps			1				1										
Najas marina			1													1	
Polypogon monspeliensis			1			1	1	1				1	1				
Symphyotrichum squamatum							1						1				
Cyperus gymnocaulos				1				1									
Typha domingensis			1										1				
Triglochin striata															1		
Wilsonia backhousei														1	1		
Cotula coronopifolia				1			1	1		1		1					
Melaleuca viminea				1					1	1			1				
Gahnia trifida									1	1							
Juncus kraussii subsp. *australiensis*						1	1		1	1	1			1	1	1	
Samolus junceus					1												
Samolus repens var. *paucifolius*			1	1	1	1	1	1									
Sporobolus virginicus			1		1				1								1
Suaeda australis															1		
Wilsonia humilis															1		1
Sarcocornia quinqueflora														1	1		1
Triglochin mucronata												1					
Baumea articulata						1	1				1						
Baumea juncea	1	1	1	1	1	1	1		1	1	1					1	1
Baumea rubiginosa	1	1	1	1					1							1	1
Eucalyptus rudis			1	1					1								
Melaleuca rhaphiophylla		1	1	1		1	1										
Triglochin linearis					1							1					1

Representation of SAP assemblages in the Hutt Catchments

Pinder *et al.* (2004) identified 10 assemblages of aquatic invertebrates from Wheatbelt wetlands and Halse *et al.* (2004) identified 21 assemblages of aquatic taxa (combined invertebrates, waterbirds and aquatic and riparian flora). The occurrence of these in the Hutt Catchments is summarised below.

Invertebrate only assemblages (Pinder et al. 2004)

One hundred and sixty two species collected during this survey could be allocated to assemblages identified by Pinder *et al.* (2004) (Table 8). Remaining species were higher taxa or were not recorded during the SAP survey or were excluded from SAP analyses by Pinder *et al.* (2004) because they were singletons and/or only occurred in artificial wetlands. The proportions of species inhabiting Hutt wetlands that belonged to assemblages C, E, F, H and J were disproportionately high compared to the broader Wheatbelt (grey highlights in upper part of Table 8). However, this only indicates which assemblages comprised a higher proportion of the Hutt fauna, not whether these assemblages were, on average, richer in the Hutt than elsewhere in the agricultural zone. Only assemblages C and J had greater average richness in Hutt wetlands compared to the average for the SAP survey, although assemblage F had comparable average richness. These are highlighted with a border in the upper part of Table 8. Assemblages D and E were reasonably well also reasonably well represented compared to the average for the SAP survey.

Assemblage C comprises 19 species showing a preference for freshwater swamps and lakes of the more inland and northern parts of the Wheatbelt. About half of these occurred in the Hutt wetlands. This assemblage made up only a small proportion (4.9%) of the Hutt invertebrate species allocated to the Pinder *et al.* assemblages, but its average richness (1.9 species/sample) in the Hutt wetlands was three times that recorded during the SAP survey (0.6/sample). This assemblage was best represented at Yarder Gully Spring (site 1) and at some sites on the Hutt River (site 3C and site 4 in spring).

Assemblage E consists of 91 widespread and frequently occurring species, dominated by insects, tending to occur in a broad range of fresh to subsaline wetlands. More than half of these, representing just over a third of the Hutt Catchment's species that could be allocated to an assemblage belonged to assemblage E. This compares to only 17% for the larger Wheatbelt, reflecting the low average salinity in Hutt region wetlands. However, average assemblage E richness/sample (11.5) was lower than for the wider Wheatbelt (14.2). This assemblage was well represented at site 3A (in summer) and site 3B on the Hutt River and at Utcha Swamp (this survey and the SAP survey) and Yerina Spring (SAP survey).

Assemblage F consists of 83 species inhabiting fresh to mildly subsaline wetlands and rivers, particularly in more coastal or south-westerly high rainfall areas. In the Hutt, this assemblage made up 18.6% of the region's fauna allocated to one of the assemblages (15.1% in the SAP survey) and average richness was as high (5.4 species) as for the whole wheatbelt (5.3%). This assemblage was particularly well represented in the lower Hutt river sites (3A, B and C), in the upper Hutt River (site 6) and Feast Soak (site 9) during this survey and in Utcha Swamp (site 14) and Yerina Spring (site 11) during the SAP survey.

Assemblage H is a small assemblage of 25 species, mostly occurring in subsaline to moderately saline waters, including streams. In the Hutt region, this assemblage comprised 7.1% of the species allocated to the Pinder *et al.* assemblages (compared to 4.6% for the SAP survey) but average and maximum richness was lower than for SAP wetlands. Wetlands within site group 4 (and to a lesser extent group 3) had good representation of this assemblage, as did Hutt Lagoon when sampled for the SAP and RCM projects.

Assemblage J consists of 34 species inhabiting fresh to subsaline streams in catchments draining to the west coast, of which more than half occurred in the Hutt Catchment. Almost thirteen percent of the Hutt Catchment's species that could be allocated to an assemblage belonged to assemblage J. This compares to 6.2% for the larger Wheatbelt, reflecting the predominance of lotic over lentic wetlands in the region and the presence of numerous freshwater springs and creeks. Not surprisingly, Hutt wetlands also had a higher than average richness of this assemblage (3.3) than recorded during the SAP survey (0.5). Wetlands with good representation of this assemblage are those of site group 2 (Hutt River sites), some wetlands in group 1 (Harry Spring Creek and Yerina Spring) and Yerina Spring during the SAP survey.

Table 8: Representation of SAP assemblages from Pinder *et al.* (2004) (upper table) and Halse *et al.* (2004) (lower table). For the Hutt Catchment, averages are across all samples (rather than summed for a site) for consistency with the SAP survey. Percentages are proportions of all species allocated an assemblage, not proportions of the whole fauna. Shaded cells highlight assemblages that comprised a larger proportion of the Hutt wetland fauna than the larger Wheatbelt (SAP) fauna. Outlined cells indicate assemblages with higher richness in Hutt wetlands than in wetlands sampled for the SAP survey.

Pinder *et al.* (2004) assemblages (invertebrates only)

	SAP survey				Hutt survey			
Invertebrate assemblage	# species in assemblage	% of SAP fauna	average # species in SAP wetlands	maximum # species in SAP wetlands	# species in Hutt wetlands	% of Hutt fauna	average # species in Hutt wetlands	maximum # species in Hutt wetlands
A	148	27.0	2.9	40	14	10.0	1.8	6
B	33	6.0	0.7	16	2	1.4	0.1	1
C	19	3.5	0.6	10	8	5.7	1.9	6
D	56	10.2	1.3	6	10	7.1	1.0	3
E	91	16.6	14.2	41	47	33.6	11.0	19
F	83	15.1	5.3	34	26	18.6	5.4	10
G	38	6.9	0.9	7	1	0.7	0.1	1
H	25	4.6	3.7	15	10	7.1	0.7	5
I	22	4.0	4.2	17	4	2.9	0.5	2
J	34	6.2	0.5	12	18	12.9	3.3	8
Values for all assemblages	549		34.4	85	140		25.7	37
Values for all taxa	957		40.1		217		38.2	

Halse *et al.* (2004) assemblages (combined invertebrates, flora and waterbirds)

	SAP survey				Hutt survey			
Multi-taxa assemblage	# species in assemblage	% of SAP fauna	average # species in SAP wetlands	maximum # species in SAP wetlands	# species represented in Hutt wetlands	% of Hutt fauna	average # species in Hutt wetlands	maximum # species in Hutt wetlands
1	27	2.2	0.6	15	0	0	0	0
2	106	8.5	2.9	29	24	14.2	4	9
3	61	4.9	0.9	12	4	2.4	0.4	2
4	62	5	1	20	14	8.3	2.6	7
5	64	5.2	12.1	39	25	14.8	6.9	13
6	35	2.8	10.8	25	13	7.7	4.1	6
7	31	2.5	2.3	14	4	2.4	0.4	3
8	70	5.6	4.5	20	19	11.2	2.9	6
9	30	2.4	2.2	14	9	5.3	1.4	3
10	100	8.1	3.1	24	4	2.4	0.2	4
11	44	3.5	0.8	19	0	0	0	0
12	63	5.1	1.4	12	1	0.6	0.04	1
13	68	5.5	11.3	33	13	7.7	1.3	9
14	37	3	4.1	25	1	0.6	0.04	1
15	30	2.4	0.5	22	8	4.7	1.1	4
16	51	4.1	1.2	26	3	1.8	0.4	2
17	89	7.2	4.3	49	21	12.4	3.6	7
18	84	6.8	1.2	39	2	1.2	0.4	2
19	32	2.6	0.5	32	0	0	0	0
20	74	6	2.6	34	3	1.8	0.1	1
21	53	4.3	0.8	21	1	0.6	0.1	1
22	26	2.1	0.4	26	0	0	0	0
Values for all assemblages	1237		69.5	85	169		29.9	37

Combined invertebrate, plant and waterbird assemblages (Halse et al. 2004)

Halse *et al*. (2004) combined invertebrate data from Pinder *et al*. (2004), flora data from Lyons *et al.* (2004) and SAP waterbird data to produce 22 multi-biota assemblages. They also highlighted one wetland with high representation of each of these that could form the basis of a recovery catchment. None of these highlighted wetlands were in the Hutt Catchments, the closest being Yarra Yarra Lake (assemblage 12), Arro Swamp (assemblage 7), Skelton Gully (assemblage 4) and Murchison River near Murchison Homestead (assemblage 2). Representation of the Halse *et al.* (2004) assemblages in Hutt wetlands (Table 8) is largely driven by invertebrates because they were much richer compared to plants and waterbirds. Nine of these assemblages (shaded in Table 8) were disproportionately represented amongst the Hutt biota (as a proportion of species that could be assigned to assemblages) compared to the wider Wheatbelt, but richness of these in Hutt wetlands was normally much lower than in SAP survey wetlands. Maximum richness recorded in any Hutt wetland was lower than for the maximum recorded in SAP sites for all assemblages. Only three of the Halse assemblages were present at higher average richness in the Hutt survey sites than in SAP survey sites. These were assemblages 2, 4 and 15, as follows:

Assemblage 2 species were found mostly at low richness in association with subsaline water (mean 10.6 ± 1.1 g/L) throughout the Wheatbelt by Halse *et al.* (2004). These taxa comprised over 14% of the Hutt region's fauna allocated to these assemblages, compared to only 8.5% of the SAP fauna, reflecting the relative preponderance of subsaline wetlands in the Hutt Catchments. Average richness was 4 species/sample compared to 2.9 for the SAP survey. This assemblage was well represented in most Hutt wetlands except at the most saline sites (group 4) and two of the springs (sites 7 and 8) in group 3. Invertebrates in this assemblage were distributed through assemblages C, D and E of Pinder *et al.* (2004) which inhabit fresh and/or mildly saline wetlands.

Assemblage 4 species were associated with fresh to subsaline flowing water (mean 7.1 ± 2.5 g/L), especially on the eastern slopes of the Darling Range, and were well represented in Skelton Gully north of Geraldton. These taxa comprised 8.3% of the Hutt fauna allocated to an assemblage compared to 5% in the SAP survey. Average species richness in Hutt wetlands was 2.6 compared to 1 in the SAP survey. In the Hutt region, these species were best represented in group 2 wetlands (Hutt River channel), plus site 9 (Gregory Spring). The invertebrates in this assemblage were almost all in assemblage J of Pinder *et al.* (2004) as discussed above.

Assemblage 15 was considered by Halse *et al*. (2004) to be artefactual, driven by the co-occurrence of a suite of species in a single wetland (Lake Pleasant View east of Albany), which explains the very low average richness in the SAP data. Most species would be associated with freshwater. The only Hutt wetlands with more than two representatives of this assemblage are sites 1, 2, 13 and 14, which were mostly fresh (site 13 was 4.7 g/L). This assemblage includes Baillons Crake present at site 14, Little Grassbird present at sites 13 and 14 and the marron (*Cherax caini*) present at several Hutt River sites. Other species in this assemblage, such as *Anisops elstoni* and *Chaetogaster diastrophus*, are similarly rare in the inland south-west. Assemblage 15 invertebrates from the Hutt Catchments fell within assemblage A of Pinder *et al.* (2004) which was a group of species mostly occurring in freshwater swamps of the Jarrah Forest and Esperance Sandplains (i.e. south-west).

Two other assemblages with good representation in Hutt wetlands were:

Assemblage 5 was widely distributed in the Wheatbelt in association with fresh to subsaline waters (mean 4.9 ± 0.3 g/L). An average of 14.8% of Hutt species belonged to this assemblage compared to 5.2% of the SAP fauna but Hutt wetlands had an average of only 6.9/sample compared to 12.1 in the SAP survey. In Hutt wetlands the assemblage was richest in some of the Hutt River sites (3A and 5), freshwater creeks (sites 9 and 10), the granite seepage (site 3B) and in site group 5 (the low salinity swamps north of Hutt Lagoon, sites 13 and 14). Assemblage 5 invertebrates from the Hutt Catchments mostly fell within assemblage A of Pinder *et al.* (2004), which was a group of species mostly occurring in the Jarrah Forest and Esperance Sandplains (i.e. south-west).

Assemblage 6 are salt tolerant species (mean occurrence at 23.7 ± 0.9 g/L) best represented along the south coast in the agricultural south-west in the SAP dataset. They comprised 7.7% of the Hutt fauna but only 2.8% of the SAP fauna but had an average richness of only 4.1 species/sample in Hutt wetlands compared to 10.8 in SAP survey wetlands. These were fairly evenly represented across Hutt wetlands but at low richness. Invertebrates of this assemblage recorded in the Hutt wetlands all belonged to assemblage E of Pinder *et al.* (2004) which were species commonly occurring in a range of mildly saline wetlands throughout the Wheatbelt.

DISCUSSION

Aquatic faunal biodiversity assets of the study area

The total of 257 invertebrate taxa recorded from the Hutt wetlands (from 25 sampling events at 15 sites over 3 projects) is on par with what has been found in some established recovery catchments. Cale (2008) recorded 221 species from the Lake Bryde NDRC (21 samples from 7 wetlands) and 202 taxa have been recorded over three sampling rounds in the 21 Buntine-Marchagee wetlands (Storey *et al.* 2004a; 2004b; Lynas *et al.* 2006). About 400 invertebrate species have been recorded in the *Muir-Unicup* NDRC (Andrew Storey, Russell Shiel, Stuart Halse, unpublished data) and 120 species have been collected from the vegetated claypans in Drummond NDRC (DEC unpublished data). About 1050 taxa have been recorded in the Wheatbelt in total (Pinder *et al.* 2002, 2004, 2006, Cale *et al.*, 2008 and DEC unpublished data, but excluding the Buntine Marchagee data) so the Hutt fauna represents just over 20% of that. Further sampling of the Hutt Catchments would probably increase the list to 300 – 400 invertebrate species (both as a result of further sampling at the same wetlands and type of wetlands but also by filling the identified gaps in sampling).

Most species recorded in the Hutt survey are widespread and common in the Wheatbelt but one or two are possibly subregional endemics (the water mites *Austrotrombella* sp. and *Arrenurus* n. sp.) and many appear to be rare in the Wheatbelt. Most of the latter are the northern species sampled at their southern distributional limit or southern mesic species that probably only occur this far north because of the permanent freshwater. A few, mostly larvae of Diptera, are of uncertain distribution. The region is thus part of a biogeographical transition zone between northern and southern faunas that probably extends from about Jurien through to the Murchison River. Some of these southern and northern elements have been recorded in the Mid-west before, especially at the Three Springs Mound Springs (Pinder *et al.* 2002, 2006), as have several others not recorded during the Hutt Survey (see Pinder *et al.* 2004). There are two ways of looking at this aspect of the region's fauna from a conservation perspective. Firstly, it could be argued that populations of these southern and northern species may be at the extremes of their ecological tolerance and that their conservation is likely to be more effective in regions with more optimal environmental conditions. Thus, the northern species are more likely to persist in the Pilbara with less active conservation effort than might be required to preserve them on the edge of their range. Another view is that transition zones might be important in allowing species to cope with climate-change through migration and suitable habitat should be maintained in this corridor. Populations on the extremes may also have genetic resilience not developed in populations in more benign parts of their range. In any case, this is a natural component of the region's fauna and maintaining regional diversity means conserving this component.

The Hutt Lagoon is one of only a few such wetlands in Western Australia. Similar wetlands would include the Leeman Lagoons and Lake McLeod, but both of these wetlands have quite different faunas and hydrogeochemistry, though with some faunal overlap with Hutt Lagoon. Coastal lagoons further south in the state, such as the Yalgorup lakes and the Leschenault Inlet are much less saline and have very different biotas. The unique element within the Hutt Lagoon fauna is the few crustaceans of marine affinity, possibly shared with Lake McLeod.

As mentioned earlier there are still some wetland habitats that were not sampled or were under sampled. In particular, there are areas of limestone geology which may support stygofauna and this may enhance the significance of the Hutt catchments, especially in comparison to other NDRCs. Also, the summer sampling aimed to capture the freshening of the Hutt River channel that frequently occurs at that time of year, but unseasonal rainfall meant that this phenomenon was not pronounced in 07/08. Sampling during a dry summer would help determine whether additional species are found in the Hutt River channel at that time of year, though it is unlikely that this would reveal species not already present in low salinity wetlands elsewhere in the catchment. Other wetlands on the western side of the Hutt Lagoon should also be sampled. Repeat sampling of springs near Mingenew is showing that repeat sampling is required to more fully document the fauna of these. Similar repeat sampling of the freshwater springs in the Hutt Catchment would most likely also reveal additional significant invertebrates.

Does the Hutt region have significant biodiversity assets not well represented in the other recovery catchments?

There are many aquatic invertebrates recorded in this survey which have not been recorded during surveys of the Drummond, Bryde and Buntine-Marchagee Natural Diversity Recovery Catchments and which are unlikely to occur in either the Lake Warden or Toolibin catchments. These are the northern taxa, southern mesic taxa and the few species that are possibly rare and/or restricted. Most of these are uncommon in the Wheatbelt and Mid-west region, though slightly more common in the northern Wheatbelt than elsewhere in the lower rainfall south-west. Some of the mesic southern species may occur in the Muir-Unicup NDRC, though inconsistent naming of morphospecies makes comparisons between species lists from different research groups difficult. The ones that have been recorded in the Muir-Unicup region are the mosquito *Anopheles atratipes* and dragonfly *Archaeosynthemis occidentalis* (as *Synthemis macrostigma occidentalis*). The species of marine affinity in the Hutt would not occur in other recovery catchments. The riverine nature of many of the Hutt wetlands is also a strong contributing factor to this catchment having a very different fauna than occurs in established recovery catchments.

Two of the aquatic invertebrate assemblages recognised during the SAP survey are particularly well represented in Hutt Catchment wetlands, having greater species richness per site in the Hutt than the average of all SAP sites. These were southern Australian species that showed a preference for freshwater swamps and lakes in the inland and northern Wheatbelt (assemblage C) and species inhabiting westerly flowing fresh to subsaline streams (assemblage J). Neither of these two assemblages would be as well represented in other recovery catchments. Furthermore, assemblages E, F and H each represented a greater proportion of the Hutt fauna than they did of the wider Wheatbelt fauna, but all had lower average site richness. Of these, assemblages E and H may be well represented in some other recovery catchments (especially the Buntine-Marchagee, Bryde and Warden catchments) whereas assemblage F is more likely to be better represented in the Hutt Catchments than existing NDRCs, with the possible exception of Muir-Unicup.

Largely equivalent multi-biota assemblages of Halse *et al.* (2004) (2, 4 and 15 with greater average richness than recorded during the SAP survey) were similarly well represented for the same reasons (species of flowing and or fresh to mildly saline wetlands). At least assemblage 4 (species of fresh to subsaline flowing water, largely coincident with invertebrate assemblage J) is likely to be better represented in the Hutt wetlands than other recovery catchments.

Which assets are the least well conserved at the scale of the south-west and locally within the study area?

With the mid-latitude position of the Hutt and the presence of a northern element in the Hutt fauna the original question needs re-phrasing to include the north-west. Almost all of the Hutt region's northern element occurs in the Pilbara. About two-thirds of the Pilbara aquatic invertebrate fauna has been recorded in the Pilbara's reserve system, including most of the northern taxa recorded in the Hutt. Exceptions amongst the northern element of the Hutt fauna are the beetle *Megaporus ruficeps*, the hemipteran *Laccotrephes tristus* and the biting midge *Forcypomyia* sp. 6, but these are nonetheless widespread in the Pilbara.

Similar information is not available (and not readily available where it does exist) for most of the conservation estate in the south-west of WA. The high rainfall south-west has not been as comprehensively surveyed as might be expected. Most of those 'south-west' species that are at the northern extent of southern mesic distributions are probably quite well represented in the south-west conservation estate but this cannot be quantified at present. Other taxa that have been very rarely collected but are less clearly outliers of southern distributions (see rare/rarely recorded species in Results) are likely to be least well conserved. These, plus some of the 'south-west' species, have been recorded relatively few times, though taxonomic impediments hinder proper assessment of the distributions and frequency of occurrence of some taxa. These less common species were more frequently recorded in Hutt site groups 1 and 3 (low salinity springs and spring-fed creeks) which are wetland types that are relatively rare in the Wheatbelt.

Many representatives of both the 'northern' and 'south-west' elements are (or would be) also represented in other wetlands of the Geraldton Sandplains bioregion, such as the many freshwater wetlands west of Eneabba, freshwater reaches of the Arrowsmith and Hill Rivers and the mound springs south-west of Three Springs. These wetlands are also known to support additional 'northern' and 'south-western' taxa not recorded in the Hutt wetlands. Nonetheless, the Hutt Catchment includes a representative selection of suitable wetlands for these elements.

A very small proportion of the Hutt Catchment is within the conservation estate and those wetlands that are within a reserve are not necessarily less threatened than those without. Utcha Swamp is within a nature reserve but has become choked with *Typha domingensis* in recent years, reducing habitat diversity and the amount of open water available for waterbirds.

Which assets are most important for biodiversity conservation, including consideration of local/regional endemism, phylogenetic importance, level of threat and potential economic importance?

An important observation is that the majority of invertebrates were present only in particular groups of wetlands, so conservation all of the major wetland types is required to maintain the full regional diversity.

Hutt Lagoon contains three crustaceans which are of marine affinity but whether they represent actual marine species, described or not, and whether they are the same as congeners in Lake McLeod, is unknown, though specimens of these will be provided to relevant experts. Nonetheless, they represent a rare element in the State's limnic aquatic invertebrate fauna. The introduced *Artemia franciscana* have been present for several decades so would probably not represent a threat to these species. The same may be the case for the beta-carotine production lagoons as it currently operates. Proposed mining activities in the hills to the east of Hutt Lagoon should be managed so as not to interfere with the hydrogeochemistry of Hutt Lagoon.

The main Hutt River channel is mildly salinised but was not particularly nutrient enriched when sampled (at least compared to national water quality criteria). Its riparian zone is in variable condition, with about a third in good to very good condition (Table 1). Analyses by Pinder *et al.* (2005) indicate that salinisation has probably not been sufficient to reduce species richness significantly but would have greatly altered community composition. Numerous species have almost certainly been lost from the main channel. Species inhabiting the Hutt River channel are now mostly common and widespread in the south-west, north-west or more broadly, though a few are uncommon in the Wheatbelt. However, almost a quarter of the taxa recorded in this survey were collected only in the main channel of the Hutt River so the river is important for maintaining richness in the catchment. The major threat to the Hutt Channel are further salinisation, either by greater discharge of salts from the upper catchment or reduction of low salinity discharge from the lowland seepages and springs if groundwater levels decline.

The numerous fresh to subsaline springs and the streams they feed contain a large proportion of what is distinctive about the Hutt region's aquatic invertebrate fauna, as suggested by Desmond and Chant (2003). One or two species inhabiting these springs may be subregionally endemic and one of these, *Austrotrombella* n. sp., is only the second species in its genus, the other being from South Australia. *Arrenurus* water mites frequently have regionally restricted distributions and this may be the case for the species recorded from Feast Soak. Almost one fifth of species in this survey were restricted to springs and spring-fed creeks. The major threats to these wetlands are altered hydrology and possibly salinisation. Some of the springs are already mildly saline but we are unsure whether this is natural or as a result of clearing. If salinity rises much further it is likely that the rarer species would be among the first to disappear.

Utcha Swamp is potentially a very significant wetland in the region because it is a freshwater lentic wetland in an area where such waters are rare. It had only two widespread species not found in other Hutt wetlands, but it shared six other widespread species with just the one other wetland (the swamp north of Hutt Lagoon) with which it grouped in the cluster analysis. Utcha Swamp had the highest species richness of all wetlands sampled. In a regional context it is also important for waterbirds, though this value is declining as *Typha* spreads.

Considering all of the above, a suggested order of priority for wetland fauna conservation is:

1. Springs and spring-fed creeks, especially those that are freshwater such as Yarder Gully and Yerina Spring. They support a large proportion of what is unique to the Hutt Catchment compared to other recovery catchments and what is otherwise uncommon in

the broader Wheatbelt. They are also good representatives of their type within the bioregion. Furthermore, their protection and rehabilitation will help maintain (and possibly restore) the fauna of the main Hutt River channel. These wetlands would be threatened by altered groundwater hydrology and chemistry, weed invasion and feral animal disturbance.

2. Wetlands north of Hutt Lagoon. This area contains a diverse suite of wetlands still in reasonable condition with a high combined invertebrate richness. They are also, together with the Hutt Lagoon, the most important wetlands for waterbirds within the catchment and important in the bioregion. Threats include altered hydrology and weeds. Utcha Swamp is groundwater dependant and both this wetland and associated groundwater are monitored by GMA Garnet as part of their environmental approvals for the nearby garnet mine. Rainfall is probably the dominant source of water for the other shallower wetlands north of Hutt Lagoon so climate change would be a dominant threat to those.

3. The Hutt River is mildly salinised but the riparian zone is in reasonable condition for much of its length (albeit weedy) and input of freshwater via seepages and springs keeps salinity fairly low. This creates the opportunity to rehabilitate the river through management of salinisation in the upper catchment and rehabilitation of the riparian zone. If this were to occur there is a strong likelihood of a freshwater fauna recolonising the main channel of the Hutt River.

4. Hutt Lagoon. A regionally iconic and economically important wetland supporting waterbirds that would otherwise be rare or absent in the catchment and some Crustacea that are otherwise absent in the Wheatbelt. While future mining activities should be managed to maintain the lagoon's hydrogeochemistry, the lagoon is probably not greatly threatened at present. Any effect of the beta-carotine production and introduced *Artemia* (probably both minor) is now irreversible.

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REFERENCES

ANZECC/ARMCANZ (2000). *Australian and New Zealand guidelines for fresh and marine water quality*. www.ea.gov.au/water/nwqms/index.html

Aquatic Research Laboratory (2006). *Buntine-Marchagee Natural Diversity Recovery Catchment (BMRC) Wetland Invertebrate Fauna Monitoring: August 2005.* Report prepared for Department of Conservation & Land Management, Mid-West Regional Office. UWA, WA.

Belbin, L. (1993). *PATN users guide and technical reference*. CSIRO Division of Wildlife and Ecology, Canberra.

Cale, D.J., Halse, S.A. and Walker, C.W. (2004). Wetland monitoring in the Wheatbelt of south-west Western Australia: site descriptions, waterbird, aquatic invertebrate and groundwater data. *Conservation Science Western Australia* **5**: 20-135.

Cale, D.J. (2005). *Drummond Natural Diversity Recovery Catchment Aquatic Invertebrate Survey*. Unpublished report. Department of Environment and Conservation, Perth.

Cale, D.J. (2008). *Wetland survey of the Lake Bryde natural diversity recovery catchment; waterbirds, aquatic invertebrates and water chemistry.* Department of Environment and Conservation, Woodvale, WA. 40 p.

Chao, A. (1987). Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* **43**: 783-791.

Colwell, R.K. (2004). EstimateS: Statistical estimation of species richness and shared species from samples Version 7.

Department of Agriculture (1993). *Kennedy Creek Catchment Management Report: Prepared for The Binnu Land Conservation District*. Report compiled by Mike Clarke, Western Australia.

Department of Environment (2005).*Hutt River Foreshore Assessment.* Department of Environment, Water Resource Management Series No WRM 45.

Desmond, A, & Chant, A. (2003). Geraldton Sandplains 2 (GS2 – Geraldton Hills subregion). In, McKenzie, N.L., May, J.E. & McKenna, S. (eds.). *2002 Biodiversity Audit for Western Australia*. Department of Environment and Conservation, Perth.

Environment Australia (2001). *A Directory of Important Wetlands in Australia. Third Edition.* Environment Australia, Canberra.

Government of Western Australia (1996). *Western Australian salinity action plan.* Government of Western Australia, Perth.

Halse, S.A., Cale, D.J., Jasinska, E.J. &Shiel, R.J. (2002). Monitoring change in aquatic invertebrate biodiversity: sample size, faunal elements and analytical methods. *Aquatic Ecology* **36**:. 395–410

Halse, S.A., Lyons, M.N. & Pinder, A.M. (2004) Biodiversity patterns and their conservation in wetlands of the Western Australian Wheatbelt. *Records of the Western Australian Museum, Supplement* 67, 337-364.

Halse, S.A., Shiel, R.J., Storey, A.W., Edward, D.H.D., Lansbury, I., Cale, D.J. & Harvey, M.S. (2000). Aquatic invertebrates and waterbirds of wetlands and rivers of the southern Carnarvon Basin, Western Australia. *Records of the Western Australian Museum Supplement* **61**: 217-265.

Halse, S. A., Scanlon, M.D. and Cocking, J.S. (2006). *First National Assessment of River Health: Western Australian Program*. Milestone Report 5 and Final Report. Perth, Department of Environment and Conservation**,** 88p.

Keighery, G.J., Halse, S.A., McKenzie, N.L. & Harvey, M.S. (2004). A biodiversity survey of the Western Australian agricultural zone. *Records of the Western Australian Museum, Supplement* **6**, 1-6.

Lee, S.M. and Chao, A. (1994). Estimating population size via sample coverage for closed capture-recapture models. *Biometrics* **50**: 88-97.

Liehne, P. F. S. (1991). *An atlas of the mosquitoes of Western Australia*. Perth, Health Department of Western Australia.

Lynas, J., Storey, A.W., & Shiel, R.J. (2006). *Buntine-Marchagee Natural Diversity Recovery Catchment (BMRC) Wetland Invertebrate Fauna Monitoring*: August 2005. Unpublished report by the School of Animal Biology, the University of Western Australia to the Department of Conservation & Land Management, Mid-West Regional Office. January 2006.

Lyons, M.N., Gibson, N., Keighery, G.J. & Lyons, S.D. (2004) Wetland flora and vegetation of the Wheatbelt of southwestern Australia. *Records of the Western Australian Museum, Supplement,* **67**, 38-89.

McKenzie, N.L., May, J.E. & McKenna, S. (eds.) (2003). *2002 Biodiversity Audit for Western Australia*. Department of Environment and Conservation, Perth.

Oksanen, J., Kindt, R., Legendre, P., O'Hara, R., Simpson, G.L., Solymos, P., Stevens, M.H.H. and Wagner, H. (2008). Vegan: Community Ecology Package, v1.15 (Sep 2008) for R.

Pinder, A.M. (2002). *Interim Report on Invertebrate Sampling at the Organic Mound Springs at Three Springs in August 2001. Unpublished report for Western Australian Threatened Species and Communities Unit*. Department of Conservation and Land Management, Perth.

Pinder, A.M., Halse, S.A., McRae, J.M. & Shiel, R.J. (2004) Aquatic invertebrate assemblages of wetlands and rivers in the Wheatbelt region of Western Australia. *Records of the Western Australian Museum, Supplement* **67**, 7-37.

Pinder, A.M., Halse, S.A., McRae, J.M. & Shiel, R.J. (2005). Occurrence of aquatic invertebrates of the Wheatbelt region of Western Australia in relation to salinity. *Hydrobiologia* **543**: 1-24.

Pinder, A.M., Halse, S.A., McRae, J.M. and Shiel, R.J. (in prep.). An arid zone awash with diversity: Biogeographic patterning of aquatic invertebrates in the Pilbara region of Western Australia. Unpublished manuscript.

Pinder, A.M., Stratford, L. and McRae, J.M. (2006). *Report on August 2001 sampling of invertebrate assemblages at mound springs of the Three Springs area.* Department of Environment and Conservation, Perth.

Post, F.J., Borowitzka, L.J., Borowitzka, M.A., Mackay, B., and Moulton, T. (1983). *The protozoa of a Western Australian hypersaline lagoon. Hydrobiologia.* Volume 105 No. 1 pgs 95-113. Springer Netherlands.

Ruebhart, D. R., I. E. Cock, *et al.* (2008). Invasive character of the brine shrimp *Artemia franciscana* Kellog 1906 Branchiopoda: Anostraca) and its potential impact on Australian inland hypersaline waters. *Marine and Freshwater Research* **59**: 587-595.

Shepherd, D.P., Beeston, G.R. and Hopkins, A.J.M. (2001) *Native Vegetation in Western Australia. Technical Report 249.* Department of Agriculture, Western Australia, South Perth.

Storey, A.W., Shiel, R.J.& Lynas, J. (2004a). *Buntine-Marchagee Natural Diversity Recovery Catchment (BMRC) Wetland Invertebrate Fauna Monitoring*: November 2003. Data analysis and interpretation. Unpublished report by the School of Animal Biology, the University of Western Australia to the Department of Conservation & Land Management, Mid-West Regional Office. May 2004

Storey, A.W., Shiel, R.J.& Lynas, J. (2004b). *Buntine-Marchagee Natural Diversity Recovery Catchment (BMRC) Wetland Invertebrate Fauna Monitoring*: August 2004. Unpublished report by the School of Animal Biology, the University of Western Australia to the Department of Conservation & Land Management, Mid-West Regional Office. December 2004

Thackway, R. and Cresswell, I.D. (Eds) (1995) An Interim Biogeographic Regionalisation for Australia: A Framework for Establishing the National System of Reserves Volume 4. Australian Nature Conservation Agency, Canberra

Walshe, T.V., Halse, S.A., McKenzie, N.L. & Gibson, N. (2004) Toward identification of an efficient set of conservation recovery catchments for Western Australian wheatbelt biodiversity. *Records of the Western Australian Museum, Supplement* 67: 365-384.

Water Information (WIN) database - discrete sample data. Provided 29/10/2008. Department of Water, Water Information Provision section, Perth Western Australia)

APPENDIX 1. Physico-chemical data

SiteCode	Date	Subsite	Depth of invertebrate sample (cm)	TDS g/L	Conductivity (µs/cm)	pH	TFN (µg/L)	TFP (µg/L)	Nitrite/Nitrate (µg/L)	Chlorophyll (µg/L)
HUT001	11/09/2007	A	10	0.68	1298	7.38	330	30	5	4.5
HUT002	11/09/2007	A	20	1.1	2310	6.94	450	10	130	4.5
HUT003	12/09/2007	A	20	3.4	6080	6.2	580	10	5	3.5
HUT003	25/02/2008	A		6.4	11430	6.52	1500	5	10	32
HUT003	12/09/2007	B	40	8.8	13420	6.2	3600	130	5	11
HUT003	25/02/2008	C		1.1	1943	7.25	250	20	30	2
HUT004	11/09/2007	A	40	3.3	6110	7.44	760	10	10	7.5
HUT004	25/02/2008	A		1.9	3860	7.04	400	10	5	5
HUT005	13/09/2007	A	25	3.7	6910	6.36	500	20	5	4.5
HUT005	26/02/2008	A		3.5	6840	7.44	510	10	5	3.5
HUT006	13/09/2007	A	10	4.1	7400	7.62	390	10	5	6
HUT007	13/09/2007	A	2	4.5	7700	7.06	1100	20	5	10.5
HUT008	14/09/2007	A	5	8	12880	6.67	1100	20	110	43.5
HUT009	14/09/2007	A	45	2.6	4600	7.09	870	10	120	10
HUT010	12/09/2007	A	20	2.5	4540	7.31	390	10	5	6
HUT011	14/09/2007	A	10	0.88	1444	6.78	6400	30	4400	8.5
HUT012	15/09/2007	A	5	15	21000	7.98	450	30	5	4.5
HUT012	15/09/2007	B	40	190	180700	8.05	2300	40	5	5
HUT013	15/09/2007	A	30	4.7	7880	8.38	660	20	5	7
HUT014	10/09/2007	A	80	1.6	2610	6.74	1100	50	5	6.5
HUT015	15/09/2007	A	40	8.8	13090	9.72	1300	10	5	3.5

SiteCode	Date	Subsite	Water temperature (ºC)	Maximum flow (m/s)	Turbidity NTU	Colour TCU	Alkalinity (mg/L)	Hardness (mg/L)	Silica (mg/L)	Na^+ (mg/L)
HUT001	11/09/2007	A	16.8	0	61	73	28	120	49	173
HUT002	11/09/2007	A	16.7	5	4.2	9	35	200	52	334
HUT003	12/09/2007	A	15.5	45	11	78	75	580	42	935
HUT003	25/02/2008	A	24.4	0	40	160	110	1400	41	1990
HUT003	12/09/2007	B	15.5	0	11	590	120	1100	31	2160
HUT003	25/02/2008	C	21.9	0	4.9	30	40	200	62	312
HUT004	11/09/2007	A	13.4	17.6	5.9	75	83	570	45	926
HUT004	25/02/2008	A	31.3	0	2.9	8	55	380	39	578
HUT005	13/09/2007	A	15.7	22	1.5	37	70	690	56	1100
HUT005	26/02/2008	A	23.2	0	1.4	8	120	700	44	1140
HUT006	13/09/2007	A	19.1	20	5.7	26	88	710	54	1160
HUT007	13/09/2007	A	20.8	0	1.6	180	55	880	110	1120
HUT008	14/09/2007	A	12.1	0	1.7	80	50	1100	95	2060
HUT009	14/09/2007	A	17.5	45	53	52	33	460	25	675
HUT010	12/09/2007	A	19.6	1	0.9	37	33	460	43	664
HUT011	14/09/2007	A	18.5	0	1.3	0.5	35	90	82	242
HUT012	15/09/2007	A	25.5	0	0.25	8	505	2800	110	3790
HUT012	15/09/2007	B	24.7	0	29	17	250	19000	38	51800
HUT013	15/09/2007	A	19.1	0	0.25	26	298	1100	47	1300
HUT014	10/09/2007	A	20.9	0	7.2	88	280	450	32	361
HUT015	15/09/2007	A	19.6	0	4.5	26	80	1400	33	2210

SiteCode	Date	Subsite	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	K^{+} (mg/L)	Cl^{-} (mg/L)	HCO_3^{-} (mg/L)	CO_3^{2-} (mg/L)	SO_4^{2-} (mg/L)
HUT001	11/09/2007	A	7.8	23.4	8.1	335	34	0.5	47.1
HUT002	11/09/2007	A	13.1	39.9	5.7	631	43	0.5	48
HUT003	12/09/2007	A	36.6	118	19	1640	92	0.5	168
HUT003	25/02/2008	A	90.2	274	58.5	3410	134	0.5	391
HUT003	12/09/2007	B	64.1	240	55	4220	146	0.5	403
HUT003	25/02/2008	C	12.9	40.8	7.4	543	49	0.5	31.7
HUT004	11/09/2007	A	35.8	117	18.3	1590	101	0.5	169
HUT004	25/02/2008	A	20.7	78.8	21.2	1040	67	0.5	52.9
HUT005	13/09/2007	A	41.4	142	20.6	1980	85	0.5	167
HUT005	26/02/2008	A	42.8	144	24.8	1910	146	0.5	75.7
HUT006	13/09/2007	A	42.1	146	24.9	2090	107	0.5	177
HUT007	13/09/2007	A	52.1	181	26.2	2110	67	0.5	189
HUT008	14/09/2007	A	44.8	244	42.1	3970	61	0.5	421
HUT009	14/09/2007	A	35.3	91.3	15.6	1270	40	0.5	155
HUT010	12/09/2007	A	33.8	89.9	10.8	1340	40	0.5	112
HUT011	14/09/2007	A	6.2	18.1	3.4	379	43	0.5	89.4
HUT012	15/09/2007	A	173	573	134	6550	360	0.5	839
HUT012	15/09/2007	B	372	4450	1640	84800	305	0.5	7520
HUT013	15/09/2007	A	115	187	46.1	2290	308	27	378
HUT014	10/09/2007	A	88.9	54.1	17.9	552	342	0.5	156
HUT015	15/09/2007	A	140	266	77.2	3930	0.5	42	807

APPENDIX 2: Aquatic b **Aquatic bird list for one degree square containing the point 114.36502, -28.16914**
Data from Birds Australia

Common Name	Scientific Name	Common Name	Scientific Name
Australasian Gannet	*Morus serrator*	Hoary-headed Grebe	*Poliocephalus poliocephalus*
Australasian Grebe	*novaehollandiae*	Little Black Cormorant	*Phalacrocorax sulcirostris*
Australasian Shoveler	*Anas rhynchotis*	Little Curlew	*Numenius minutus*
Australian Pelican	*Pelecanus conspicillatus*	Little Egret	*Egretta garzetta*
Australian Shelduck	*Tadorna tadornoides*	Little Grassbird	*Megalurus gramineus*
Australian Spotted Crake	*Porzana fluminea*	Little Pied Cormorant	*Phalacrocorax melanoleucos*
Australian White Ibis	*Threskiornis molucca*	Musk Duck	*Biziura lobata*
Australian Wood Duck	*Chenonetta jubata*	Nankeen Night Heron	*Nycticorax caledonicus*
Banded Stilt	*leucocephalus*	Osprey	*Pandion haliaetus*
Bar-tailed Godwit	*Limosa lapponica*	Pacific Black Duck	*Anas superciliosa*
Black-fronted Dotterel	*Elseyornis melanops*	Pacific Gull	*Larus pacificus*
Black Swan	*Cygnus atratus*	Pied Cormorant	*Phalacrocorax varius*
Black-tailed Godwit	*Limosa limosa*	Pied Oystercatcher	*Haematopus longirostris*
Black-tailed Native-hen	*Gallinula ventralis*	Purple Swamphen	*Porphyrio porphyrio*
Black-winged Stilt	*Himantopus himantopus*	Red-necked Avocet	*novaehollandiae*
Buff-banded Rail	*Gallirallus philippensis*	Red-necked Phalarope	*Phalaropus lobatus*
Caspian Tern	*Sterna caspia*	Red-necked Stint	*Calidris ruficollis*
Cattle Egret	*Ardea ibis*	Roseate Tern	*Sterna dougallii*
Clamorous Reed-Warbler	*Acrocephalus stentoreus*	Ruddy Turnstone	*Arenaria interpres*
Common Greenshank	*Tringa nebularia*	Sanderling	*Calidris alba*
Common Sandpiper	*Actitis hypoleucos*	Sharp-tailed Sandpiper	*Calidris acuminata*
Crested Tern	*Sterna bergii*	Silver Gull	*Larus novaehollandiae*
Curlew Sandpiper	*Calidris ferruginea*	Silvereye	*Zosterops lateralis*
Darter	*Anhinga melanogaster*	Sooty Oystercatcher	*Haematopus fuliginosus*
Eastern Reef Egret	*Egretta sacra*	Spotless Crake	*Porzana tabuensis*
Eurasian Coot	*Fulica atra*	Spotted Harrier	*Circus assimilis*
Fairy Tern	*Sterna nereis*	Straw-necked Ibis	*Threskiornis spinicollis*
Flesh-footed Shearwater	*Puffinus carneipes*	Swamp Harrier	*Circus approximans*
Glossy Ibis	*Plegadis falcinellus*	Shearwater	*Puffinus pacificus*
Great Cormorant	*Phalacrocorax carbo*	Whimbrel	*Numenius phaeopus*
Great Crested Grebe	*Podiceps cristatus*	White-bellied Sea-Eagle	*Haliaeetus leucogaster*
Great Egret	*Ardea alba*	White-faced Heron	*Egretta novaehollandiae*
Grey Plover	*Pluvialis squatarola*	Petrel	*Pelagodroma marina*
Grey-tailed Tattler	*Heteroscelus brevipes*	White-necked Heron	*Ardea pacifica*
Grey Teal	*Anas gracilis*	Wood Sandpiper	*Tringa glareola*
Gull-billed Tern	*Sterna nilotica*	Yellow-billed Spoonbill	*Platalea flavipes*
Hardhead	*Aythya australis*		

APPENDIX 3: Aquatic invertebrates, waterbirds and wetland plants recorded in Hutt Catchmentwetlands during the Salinity Action Plan, Hutt Catchment Survey and Resource Condition Monitoring projects

*** = taxa recorded during the Hutt Catchments Survey (2007-8) and included in multivariate analyses**

 # = taxa recorded only during the SAP survey (1999) or the RCM survey (2008)

										Site, subsite and date								
										HUT001	HUT002	HUT003	HUT003	HUT003	HUT003	HUT004	HUT004	HUT005
										A	A	A	A	B	C	A	A	A
	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	11/09/2007	11/09/2007	12/09/2007	25/02/2008	12/09/2007	25/02/2008	11/09/2007	25/02/2008	13/09/2007
1	Invertebrates	Protozoans	BP0101A0	321	Arcellinidae	*	*Arcella* sp. a (SAP)					1				1		
2	Invertebrates	Protozoans	BP0101A2	322	Arcellinidae	*	*Arcella* sp. b (SAP)							1				
3	Invertebrates	Protozoans	BP0101A3	323	Arcellinidae	#	*Arcella* sp. c (SAP)											
4	Invertebrates	Protozoans	BP020101	327	Centropyxidae	*	*Centropyxis aculeata*				1			1	1			
5	Invertebrates	Protozoans	BP020199	328	Centropyxidae	*	*Centropyxis* sp.				1	1				1		1
6	Invertebrates	Protozoans	BP0201A5	5460	Centropyxidae	*	*Centropyxis* cf *kahlii*											
7	Invertebrates	Protozoans	BP030199	334	Difflugiidae	*	*Difflugia* sp.						1			1		
8	Invertebrates	Flatworms	IF999999	379	-	#	Turbellaria											
9	Invertebrates	Nemerteans (Nemertea)	IH999999	383	-	*	Nemertini								1			
10	Invertebrates	Nematodes (Nematoda)	II999999	384	-	*	Nematoda										1	
11	Invertebrates	Rotifers (Rotifera)	JB999999	460	-		Bdelloidea								1			
12	Invertebrates	Rotifers (Rotifera)	JP020219	590	Brachionidae	*	*Brachionus plicatilis* s.l.	H	13									
13	Invertebrates	Rotifers (Rotifera)	JP020308	615	Brachionidae	#	*Keratella procurva*											
14	Invertebrates	Rotifers (Rotifera)	JP030101	635	Lepadellidae	*	*Colurella adriatica*	E	8						1			
15	Invertebrates	Rotifers (Rotifera)	JP060103	677	Euchlanidae	#	*Euchlanis deflexa*											
16	Invertebrates	Rotifers (Rotifera)	JP090110	709	Lecanidae	#	*Lecane bulla*											
17	Invertebrates	Rotifers (Rotifera)	JP090123	722	Lecanidae	#	*Lecane flexilis*											
18	Invertebrates	Rotifers (Rotifera)	JP090127	726	Lecanidae	#	*Lecane grandis*											
19	Invertebrates	Rotifers (Rotifera)	JP090129	728	Lecanidae	#	*Lecane hamata*											
20	Invertebrates	Rotifers (Rotifera)	JP090136	735	Lecanidae	#	*Lecane ludwigii*											
21	Invertebrates	Rotifers (Rotifera)	JP090137	736	Lecanidae	#	*Lecane luna*											
22	Invertebrates	Rotifers (Rotifera)	JP090169	768	Lecanidae	*	*Lecane thalera*	D	3									
23	Invertebrates	Rotifers (Rotifera)	JP0901B4	787	Lecanidae	#	*Lecane* sp. nov. c (Hutt Lagoon)											
24	Invertebrates	Rotifers (Rotifera)	JP120301	806	Euchlanidae	*	*Tripleuchlanis plicata*	A	16						1			
25	Invertebrates	Rotifers (Rotifera)	JP130201	809	Cephalodellidae	#	*Cephalodella gibba*											
26	Invertebrates	Snails (Bassomatophora)	KG040199	978	Thiaridae	*	*Plotiopsis* sp.										1	
27	Invertebrates	Snails (Bassomatophora)	KG060199	991	Ancylidae	*	*Ferrissia* sp.	F	17	1			1	1	1			
28	Invertebrates	Snails (Bassomatophora)	KG0702A5	999	Planorbidae	*	*Glyptophysa* cf. *gibbosa*	F	17			1						
29	Invertebrates	Snails (Bassomatophora)	KG130101	1028	Pomatiopsidae	*	*Coxiella ?striatula*											
30	Invertebrates	Freshwater earthworms (Clitellata)	LO030502	1111	Phreodrilidae	#	*Insulodrilus lacustris* s.l.											
31	Invertebrates	Freshwater earthworms (Clitellata)	LO050201	1151	Naididae	*	*Dero digitata*	C	8	1					1			
32	Invertebrates	Freshwater earthworms (Clitellata)	LO050203	1153	Naididae	#	*Dero furcata*											
33	Invertebrates	Freshwater earthworms (Clitellata)	LO050402	1158	Naididae	*	*Allonais ranauana*			1								
34	Invertebrates	Freshwater earthworms (Clitellata)	LO050502	1162	Naididae	*	*Pristina aequiseta*			1								
35	Invertebrates	Freshwater earthworms (Clitellata)	LO050505	1165	Naididae	*	*Pristina jenkinae*	C	2					1		1		1
36	Invertebrates	Freshwater earthworms (Clitellata)	LO0505A4	2	Naididae	*	*Pristina* nr *sima*								1			
37	Invertebrates	Freshwater earthworms (Clitellata)	LO050701	1168	Naididae	*	*Chaetogaster diastrophus*	A	15									
38	Invertebrates	Freshwater earthworms (Clitellata)	LO051301	1118	Naididae	*	*Limnodrilus hoffmeisteri*				1							
39	Invertebrates	Freshwater earthworms (Clitellata)	LO051401	1121	Naididae	*	*Potamothrix bavaricus*			1					1			
40	Invertebrates	Freshwater earthworms (Clitellata)	LO052101	1133	Naididae	*	*Ainudrilus nharna*	F	8							1		
41	Invertebrates	Freshwater earthworms (Clitellata)	LO059999	1180	Naididae		Naididae					1		1	1	1	1	1
42	Invertebrates	Freshwater earthworms (Clitellata)	LO0599B6	5400	Naididae		Naidinae					1						
43	Invertebrates	Freshwater earthworms (Clitellata)	LO089999	1186	Enchytraeidae	*	*Enchytraeidae*							1		1	1	
44	Invertebrates	Water mites (Hydracarina)	MM010102	1205	Hydrachnidae	*	*Hydrachna australica*											
45	Invertebrates	Water mites (Hydracarina)	MM010199	1206	Hydrachnidae		*Hydrachna* sp.										1	
46	Invertebrates	Water mites (Hydracarina)	MM0101A0	1207	Hydrachnidae	#	*Hydrachna* nr. *approximata* (SAP)											
47	Invertebrates	Water mites (Hydracarina)	MM0509A0	1231	Hydryphantidae	*	*Austrotrombella* sp. nov.	J	4									
48	Invertebrates	Water mites (Hydracarina)	MM2301A2	1353	Arrenuridae		Arrenurus (Truncaturus) sp. (SAP)											
49	Invertebrates	Water mites (Hydracarina)	MM2301D3	5404	Arrenuridae	*	*Arrenurus* sp. HUT008											
50	Invertebrates	Water mites (Hydracarina)	MM999999	1365	-		Acariformes											
51	Invertebrates	Oribatid mites (Oribatida)	MM9999A1	1367	-	*	Oribatida			1		1	1	1	1	1	1	1
52	Invertebrates	Other mites (Mesostigmata)	MM9999A2	1368	-	*	Mesostigmata				1			1	1			
53	Invertebrates	Other mites (Trombidioidea)	MM9999A6	1370	-	*	Trombidioidea											1
54	Invertebrates	Brine shrimp (Anostraca)	OD010199	1375	Artemiidae	*	*Artemia* sp.	E	10									
55	Invertebrates	Water fleas (Cladocera)	OG030212	5253	Chydoridae	#	*Alona rigidicaudis*											
56	Invertebrates	Water fleas (Cladocera)	OG030299	1483	Chydoridae		*Alona* sp.				1							
57	Invertebrates	Water fleas (Cladocera)	OG0302A0	1484	Chydoridae	*	*Alona* cf. *rectangula novaezelandiae*	E	2						1			

	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	HUT001 A 11/09/2007	HUT002 A 11/09/2007	HUT003 A 12/09/2007	HUT003 A 25/02/2008	HUT003 B 12/09/2007	HUT003 C 25/02/2008	HUT004 A 11/09/2007	HUT004 A 25/02/2008	HUT005 A 13/09/2007
58	Invertebrates	Water fleas (Cladocera)	OG031802	1549	Chydoridae	*	*Leydigia australis*										1	
59	Invertebrates	Water fleas (Cladocera)	OG033401	1478	Chydoridae	#	*Armatalona macrocopa*											
60	Invertebrates	Water fleas (Cladocera)	OG040201	1598	Daphniidae	*	*Daphnia carinata*	E	5					1				
61	Invertebrates	Water fleas (Cladocera)	OG040505	1628	Daphniidae	*	*Simocephalus elizabethae*	F	17				1					
62	Invertebrates	Water fleas (Cladocera)	OG040599	1632	Daphniidae		*Simocephalus* sp.											
63	Invertebrates	Water fleas (Cladocera)	OG060201	1646	Macrothricidae	#	*Macrothrix breviseta*											
64	Invertebrates	Water fleas (Cladocera)	OG0602B4	11	Macrothricidae	*	*Macrothrix* cf. *breviseta*	E	5					1				
65	Invertebrates	Seed shrimps (Ostracoda)	OH010203	1696	Limnocytheridae	#	*Limnocythere mowbrayensis*											
66	Invertebrates	Seed shrimps (Ostracoda)	OH010204	1697	Limnocytheridae	*	*Limnocythere porphyretica*	B	21									
67	Invertebrates	Seed shrimps (Ostracoda)	OH060101	1715	Ilyocyprididae	*	*Ilyocypris australiensis*	E	8			1	1					
68	Invertebrates	Seed shrimps (Ostracoda)	OH070101	1720	Candonidae	#	*Candonopsis tenuis*											
69	Invertebrates	Seed shrimps (Ostracoda)	OH080101	1725	Cyprididae	*	*Alboa worooa*	F	5	1		1	1	1				1
70	Invertebrates	Seed shrimps (Ostracoda)	OH080203	1728	Cyprididae	*	*Australocypris insularis*	H	13									
71	Invertebrates	Seed shrimps (Ostracoda)	OH080399	1736	Cyprididae	*	*Bennelongia* sp.											
72	Invertebrates	Seed shrimps (Ostracoda)	OH080403	1742	Cyprididae	*	*Candonocypris novaezelandiae*	E	5	1	1	1	1	1	1	1	1	1
73	Invertebrates	Seed shrimps (Ostracoda)	OH080501		Cyprididae	#	*Cypretta baylyi*											
74	Invertebrates	Seed shrimps (Ostracoda)	OH080599	1746	Cyprididae	*	*Cypretta* sp.					1		1				1
75	Invertebrates	Seed shrimps (Ostracoda)	OH080703	1762	Cyprididae	*	*Diacypris spinosa*	H	13									
76	Invertebrates	Seed shrimps (Ostracoda)	OH081099	1777	Cyprididae	*	*Heterocypris* sp.											
77	Invertebrates	Seed shrimps (Ostracoda)	OH081204	1782	Cyprididae	*	*Mytilocypris mytiloides*											
78	Invertebrates	Seed shrimps (Ostracoda)	OH081999	1807	Cyprididae	*	*Ilyodromus* sp.							1				
79	Invertebrates	Seed shrimps (Ostracoda)	OH090101	1841	Cypridopsidae	*	*Sarscypridopsis aculeata*	E	5	1	1	1	1	1	1	1	1	1
80	Invertebrates	Seed shrimps (Ostracoda)	OH110201	1856	Notodromadidae	*	*Kennethia cristata*	D	17									
81	Invertebrates	Seed shrimps (Ostracoda)	OH130199	1860	Paradoxostomidae	*	*Paradoxostoma* sp.											
82	Invertebrates	Copepods (Copepoda)	OJ110208	1882	Centropagidae	*	*Calamoecia clitellata*	H	13									
83	Invertebrates	Copepods (Copepoda)	OJ110299	1886	Centropagidae		*Calamoecia* sp.			?								
84	Invertebrates	Copepods (Copepoda)	OJ310101	1912	Cyclopidae	*	*Microcyclops varicans*	F	17			1						1
85	Invertebrates	Copepods (Copepoda)	OJ3102A1	1917	Cyclopidae	*	*Metacyclops* sp. 462	D	2									
86	Invertebrates	Copepods (Copepoda)	OJ3102A2	1918	Cyclopidae	*	*Metacyclops* sp. 434 (arnaudi sensu Sars)	E	5									
87	Invertebrates	Copepods (Copepoda)	OJ310301	1926	Cyclopidae	*	*Australocyclops australis*	E	5									
88	Invertebrates	Copepods (Copepoda)	OJ310401	1930	Cyclopidae	*	*Halicyclops ambiguus*											
89	Invertebrates	Copepods (Copepoda)	OJ310601	1938	Cyclopidae	*	*Macrocyclops albidus*	A	18	1	1				1		1	
90	Invertebrates	Copepods (Copepoda)	OJ310703	1942	Cyclopidae	*	*Mesocyclops brooksi*	F				1	1	1	1		1	
91	Invertebrates	Copepods (Copepoda)	OJ310799	1946	Cyclopidae		*Mesocyclops* sp.									1		1
92	Invertebrates	Copepods (Copepoda)	OJ311001	1950	Cyclopidae	*	*Eucyclops australiensis*	C	2	1	1				1	1	1	
93	Invertebrates	Copepods (Copepoda)	OJ311102	1954	Cyclopidae	*	*Paracyclops chiltoni*	C	2	1	1		1	1	1			
94	Invertebrates	Copepods (Copepoda)	OJ311199	1745	Cyclopidae		*Paracyclops* sp.											
95	Invertebrates	Copepods (Copepoda)	OJ3111A1	1958	Cyclopidae	*	*Paracyclops* sp 1 (nr *timmsi*)	A	15	1	1						1	
96	Invertebrates	Copepods (Copepoda)	OJ311201	1963	Cyclopidae	*	*Apocyclops dengizicus*	H	13									
97	Invertebrates	Copepods (Copepoda)	OJ610302	1983	Canthocamptidae	*	*Mesochra baylyi*	I	9									
98	Invertebrates	Copepods (Copepoda)	OJ610402	1988	Canthocamptidae	*	*Cletocamptus dietersi*	D	2				1					
99	Invertebrates	Copepods (Copepoda)	OJ619999	1991	Canthocamptidae		*Canthocamptidae*											
100	Invertebrates	Copepods (Copepoda)	OJ620101	2001	Laophontidae	*	*Onychocamptus bengalensis*	I	8				1				1	
101	Invertebrates	Copepods (Copepoda)	OJ630199	2007	Diosaccidae	*	*Robertsonia* sp.											
102	Invertebrates	Copepods (Copepoda)	OJ6401A3	2021	Ameiridae	#	Nitocra sp. 3 (SAP)											
103	Invertebrates	Copepods (Copepoda)	OJ6401A6	2024	Ameiridae	*	Nitocra? reducta (sp. 5) (CB)	E	8									
104	Invertebrates	Copepods (Copepoda)	OJ659999	2035	Lourinidae	*	Lourinidae											
105	Invertebrates	Copepods (Copepoda)	OJ6999B0	2044	-	*	Harpacticoida sp. 2	A	15	1	1							
106	Invertebrates	Amphipods (Amphipoda)	OP020102	2056	Ceinidae	*	*Austrochiltonia subtenuis*	E	6	1	1		1	1	1	1		1
107	Invertebrates	Isopods (Isopoda)	OR279999	2158	Philosciidae	#	Philosciidae											
108	Invertebrates	Freshwater cryafish (Decapoda)	OV010101	2199	Parastacidae	*	*Cherax destructor*								1			1
109	Invertebrates	Freshwater cryafish (Decapoda)	OV010124	2202	Parastacidae	*	*Cherax caini*	F	15		1				1		1	
110	Invertebrates	Beetles (Coleoptera)	QC060104	2222	Haliplidae	*	*Haliplus fuscatus*	E	8									
111	Invertebrates	Beetles (Coleoptera)	QC060105	2223	Haliplidae	*	*Haliplus gibbus*	F	17					1				
112	Invertebrates	Beetles (Coleoptera)	QC080301	2240	Dytiscidae	#	*Neohydrocoptus subfasciatus*											
113	Invertebrates	Beetles (Coleoptera)	QC090401	2265	Dytiscidae	*	*Hyphydrus elegans*	E	8				1					
114	Invertebrates	Beetles (Coleoptera)	QC090499	2270	Dytiscidae		*Hyphydrus* sp.											
115	Invertebrates	Beetles (Coleoptera)	QC090907	2294	Dytiscidae	*	*Hydroglyphus leai*											
116	Invertebrates	Beetles (Coleoptera)	QC091101	2300	Dytiscidae	*	*Allodessus bistrigatus*	E	5					1				
117	Invertebrates	Beetles (Coleoptera)	QC091205	2306	Dytiscidae	*	*Liodessus inornatus*	E	8	1				1				
118	Invertebrates	Beetles (Coleoptera)	QC091499	2319	Dytiscidae	*	*Paroster* sp.							1				
119	Invertebrates	Beetles (Coleoptera)	QC091899	2363	Dytiscidae	*	*Sternopriscus* sp.					1						
120	Invertebrates	Beetles (Coleoptera)	QC092001	2369	Dytiscidae	*	*Necterosoma penicillatus*	E	13				1	1				

	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	HUT001 A 11/09/2007	HUT002 A 11/09/2007	HUT003 A 12/09/2007	HUT003 A 25/02/2008	HUT003 B 12/09/2007	HUT003 C 25/02/2008	HUT004 A 11/09/2007	HUT004 A 25/02/2008	HUT005 A 13/09/2007
121	Invertebrates	Beetles (Coleoptera)	QC092006	2374	Dytiscidae	*	*Necterosoma darwini*	F	4								1	
122	Invertebrates	Beetles (Coleoptera)	QC092099	2378	Dytiscidae		*Necterosoma* sp.											
123	Invertebrates	Beetles (Coleoptera)	QC092105	2383	Dytiscidae	*	*Megaporus ruficeps*							1				
124	Invertebrates	Beetles (Coleoptera)	QC092199	2387	Dytiscidae		*Megaporus* sp.					1						
125	Invertebrates	Beetles (Coleoptera)	QC092207	2394	Dytiscidae	*	*Platynectes aenescens*	J	4									
126	Invertebrates	Beetles (Coleoptera)	QC092210	4490	Dytiscidae	*	*Platynectes decempunctatus var decempunctatus*	J	4			1						
127	Invertebrates	Beetles (Coleoptera)	QC092299	2397	Dytiscidae		*Platynectes* sp.						1			1		1
128	Invertebrates	Beetles (Coleoptera)	QC092301	2399	Dytiscidae	*	*Rhantus suturalis*	E	5			1	1	1			1	
129	Invertebrates	Beetles (Coleoptera)	QC092399	2402	Dytiscidae		*Rhantus* sp.											
130	Invertebrates	Beetles (Coleoptera)	QC092901	2436	Dytiscidae	*	*Eretes australis*	D	7				1					
131	Invertebrates	Beetles (Coleoptera)	QC092999	2437	Dytiscidae		*Eretes* sp.							1				
132	Invertebrates	Beetles (Coleoptera)	QC093499	2459	Dytiscidae	*	*Onychohydrus* sp.											
133	Invertebrates	Beetles (Coleoptera)	QC099999	2467	Dytiscidae		Dytiscidae									1		
134	Invertebrates	Beetles (Coleoptera)	QC0999A6	2468	Dytiscidae		Bidessini							1				
135	Invertebrates	Beetles (Coleoptera)	QC100105	2473	Gyrinidae	*	*Macrogyrus angustatus*	J	4		1	1	1	1	1		1	1
136	Invertebrates	Beetles (Coleoptera)	QC100199	2484	Gyrinidae		*Macrogyrus* sp.									1		
137	Invertebrates	Beetles (Coleoptera)	QC100201	2485	Gyrinidae	*	*Aulonogyrus strigosus*	J	4		1	1			1	1	1	1
138	Invertebrates	Beetles (Coleoptera)	QC109999	2491	Gyrinidae		Gyrinidae							1				
139	Invertebrates	Beetles (Coleoptera)	QC110404	2497	Hydrophilidae	*	*Berosus approximans*	E	5					1				
140	Invertebrates	Beetles (Coleoptera)	QC110409	2502	Hydrophilidae	*	*Berosus discolor*	H	9									
141	Invertebrates	Beetles (Coleoptera)	QC110499	2526	Hydrophilidae		*Berosus* sp.					1	1					
142	Invertebrates	Beetles (Coleoptera)	QC111204	2550	Hydrophilidae	*	*Helochares tatei*	J	2									
143	Invertebrates	Beetles (Coleoptera)	QC111299	2552	Hydrophilidae		*Helochares* sp.						1					
144	Invertebrates	Beetles (Coleoptera)	QC111401	2555	Hydrophilidae	*	*Limnoxenus zelandicus*	F	17									
145	Invertebrates	Beetles (Coleoptera)	QC111499	2556	Hydrophilidae		*Limnoxenus* sp.					1		1				1
146	Invertebrates	Beetles (Coleoptera)	QC111601	2558	Hydrophilidae	*	*Paracymus pygmaeus*	F	17					1				
147	Invertebrates	Beetles (Coleoptera)	QC111699	2560	Hydrophilidae		*Paracymus* sp.											
148	Invertebrates	Beetles (Coleoptera)	QC119999	2578	Hydrophilidae		Hydrophilidae											1
149	Invertebrates	Beetles (Coleoptera)	QC130399	2611	Hydraenidae	*	*Ochthebius* sp.						1		1			
150	Invertebrates	Beetles (Coleoptera)	QC189999	2621	Staphylinidae	#	Staphylinidae											
151	Invertebrates	Beetles (Coleoptera)	QC209999	2622	Scirtidae	*	Scirtidae sp.			1								
152	Invertebrates	Beetles (Coleoptera)	QC349999	2738	Elmidae	*	Elmidae			1								
153	Invertebrates	Beetles (Coleoptera)	QC359999	2741	Limnichidae	#	Limnichidae											
154	Invertebrates	Beetles (Coleoptera)	QCAM9999	2753	Brentidae	*	Brentidae								1			1
155	Invertebrates	Beetles (Coleoptera)	QCAN9999	2754	Curculionidae	*	Curculionidae											
156	Invertebrates	Fly larvae (Diptera)	QD0199A0	2763	Tipulidae	*	Tipulidae type A	D	2					1				
157	Invertebrates	Fly larvae (Diptera)	QD0199A2	2765	Tipulidae	*	Tipulidae type C	J	4							1		
158	Invertebrates	Fly larvae (Diptera)	QD0199A4	2767	Tipulidae	*	Tipulidae type E	A	4	1	1							
159	Invertebrates	Fly larvae (Diptera)	QD0199A5	2768	Tipulidae	*	Tipulidae type F	J	2									1
160	Invertebrates	Fly larvae (Diptera)	QD0199A7	2770	Tipulidae	*	Tipulidae type H			1		1						1
161	Invertebrates	Fly larvae (Diptera)	QD070101	2814	Culicidae	*	*Anopheles annulipes* s.l.	E	5	1								
162	Invertebrates	Fly larvae (Diptera)	QD070105	2818	Culicidae	*	*Anopheles atratipes*											
163	Invertebrates	Fly larvae (Diptera)	QD070199	2821	Culicidae		*Anopheles* sp.											
164	Invertebrates	Fly larvae (Diptera)	QD070501	2827	Culicidae	*	*Aedes alboannulotus*	A	16					1				
165	Invertebrates	Fly larvae (Diptera)	QD070502	2828	Culicidae	*	*Aedes camptorhynchus*	H	13									
166	Invertebrates	Fly larvae (Diptera)	QD0705A8	5438	Culicidae	*	*Aedes* nr *camptorhynchus*											
167	Invertebrates	Fly larvae (Diptera)	QD070601	2840	Culicidae	*	*Culiseta atra*			1								
168	Invertebrates	Fly larvae (Diptera)	QD070704	2845	Culicidae	*	*Culex globocoxitus*											
169	Invertebrates	Fly larvae (Diptera)	QD070706	2847	Culicidae	*	*Culex (Culex) australicus*	D	7			1		1				
170	Invertebrates	Fly larvae (Diptera)	QD0707A1	2855	Culicidae	*	*Culex* sp. 3							1				
171	Invertebrates	Fly larvae (Diptera)	QD090499	2862	Ceratopogonidae		*Bezzia sp.*											
172	Invertebrates	Fly larvae (Diptera)	QD0904A0	2863	Ceratopogonidae	*	*Bezzia* sp. 2	E	8		1		1			1	1	1
173	Invertebrates	Fly larvae (Diptera)	QD0904A1	2864	Ceratopogonidae	*	*Bezzia* sp. 1	F	8	1		1			1	1	1	1
174	Invertebrates	Fly larvae (Diptera)	QD090899	2869	Ceratopogonidae	*	*Culicoides* sp.	E	6	1	1	1	1	1	1	1		1
175	Invertebrates	Fly larvae (Diptera)	QD091999	2870	Ceratopogonidae	*	*Monohelea* sp.									1		
176	Invertebrates	Fly larvae (Diptera)	QD0919A0	2871	Ceratopogonidae	*	*Monohelea* sp. 1	E	2			1			1		1	1
177	Invertebrates	Fly larvae (Diptera)	QD0919A1	2872	Ceratopogonidae	*	*Monohelea* sp. 2											
178	Invertebrates	Fly larvae (Diptera)	QD0919A3	2874	Ceratopogonidae	*	*Monohelea* sp. 4			1								
179	Invertebrates	Fly larvae (Diptera)	QD092099	2875	Ceratopogonidae	*	*Nilobezzia* sp.						1		1			1
180	Invertebrates	Fly larvae (Diptera)	QD0927A0	2881	Ceratopogonidae	*	*Atrichopogon* sp. 2	A	2				1		1			
181	Invertebrates	Fly larvae (Diptera)	QD092899	2882	Ceratopogonidae		*Forcypomyia sp.*											1
182	Invertebrates	Fly larvae (Diptera)	QD0928A2	2885	Ceratopogonidae	*	*Forcypomyia* sp. 2	D	20	1								
183	Invertebrates	Fly larvae (Diptera)	QD0928A4	2887	Ceratopogonidae	*	Forcypomyia sp. 6 (PSW)											

	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	HUT001 A 11/09/2007	HUT002 A 11/09/2007	HUT003 A 12/09/2007	HUT003 A 25/02/2008	HUT003 B 12/09/2007	HUT003 C 25/02/2008	HUT004 A 11/09/2007	HUT004 A 25/02/2008	HUT005 A 13/09/2007
184	Invertebrates	Fly larvae (Diptera)	QD0928A9	5435	Ceratopogonidae	*	*Forcypomyia sp. 7*			1								
185	Invertebrates	Fly larvae (Diptera)	QD0928B0	5436	Ceratopogonidae	*	*Forcypomyia sp. 8*			1								
186	Invertebrates	Fly larvae (Diptera)	QD0928B1	5437	Ceratopogonidae	*	*Forcypomyia sp. 9*			1								
187	Invertebrates	Fly larvae (Diptera)	QD092999	2888	Ceratopogonidae	*	*Dasyhelea* sp.	E	8		1							
188	Invertebrates	Fly larvae (Diptera)	QD099999	2890	Ceratopogonidae		Ceratopogonidae											
189	Invertebrates	Fly larvae (Diptera)	QD0999A2	2893	Ceratopogonidae		Dasyheleinae							1	1	1	1	1
190	Invertebrates	Fly larvae (Diptera)	QD100202	2917	Simuliidae	*	*Simulium ornatipes*	J	4		1	1				1		1
191	Invertebrates	Fly larvae (Diptera)	QD1299A2	2947	Psychodidae	*	Psychodinae sp. 3	D	2					1				
192	Invertebrates	Fly larvae (Diptera)	QD1299A4	4669	Psychodidae	*	Psychodinae sp. 5				1							
193	Invertebrates	Fly larvae (Diptera)	QD159999	2987	Scatopsidae	*	Scatopsidae			1				1		1		
194	Invertebrates	Fly larvae (Diptera)	QD239999	2952	Tabanidae	*	Tabanidae			1								1
195	Invertebrates	Fly larvae (Diptera)	QD249999	2955	Stratiomyidae	*	Stratiomyidae											
196	Invertebrates	Fly larvae (Diptera)	QD359999	2956	Empididae	*	Empididae					1						
197	Invertebrates	Fly larvae (Diptera)	QD3699A0	2958	Dolichopodidae	*	Dolichopodidae sp. A							1				
198	Invertebrates	Fly larvae (Diptera)	QD459999	2961	Sciomyzidae	*	Sciomyzidae							1				
199	Invertebrates	Fly larvae (Diptera)	QD7899A6	2969	Ephydridae	*	Ephydridae sp. 2	E	7					1				
200	Invertebrates	Fly larvae (Diptera)	QD7899A7	2970	Ephydridae	*	Ephydridae sp. 3	H	13					1				
201	Invertebrates	Fly larvae (Diptera)	QD7899A8	2971	Ephydridae	*	Ephydridae sp. 4	I	2			1		1				
202	Invertebrates	Fly larvae (Diptera)	QD7899B0	2973	Ephydridae	*	Ephydridae sp. 6	H	13									
203	Invertebrates	Fly larvae (Diptera)	QD7899B4	4858	Ephydridae	*	Ephydridae sp. 12											
204	Invertebrates	Fly larvae (Diptera)	QD7899B5	4859	Ephydridae	*	Ephydridae sp. 13							1				
205	Invertebrates	Fly larvae (Diptera)	QD899999	2975	Muscidae	*	Muscidae											
206	Invertebrates	Fly larvae (Diptera)	QD8999A0	2976	Muscidae	#	Muscidae sp. A (SAP)											
207	Invertebrates	Fly larvae (Diptera)	QD999999	2985	-		Diptera											
208	Invertebrates	Fly larvae (Diptera)	QD9999A3	5440	-	*	Diptera sp. E			1	1							
209	Invertebrates	Fly larvae (Diptera)	QDAE0803	3037	Chironomidae	*	*Procladius paludicola*	E	6	1		1	1	1	1	1	1	1
210	Invertebrates	Fly larvae (Diptera)	QDAE0804	3038	Chironomidae	*	*Procladius villosimanus*	E	5									
211	Invertebrates	Fly larvae (Diptera)	QDAE1001	3043	Chironomidae	*	*Alotanypus dalyupensis*	A	17		1			1	1			
212	Invertebrates	Fly larvae (Diptera)	QDAE1102	3046	Chironomidae	#	*Ablabesmyia notabilis*											
213	Invertebrates	Fly larvae (Diptera)	QDAE1201	3050	Chironomidae	*	*Paramerina levidensis*	F	5		1	1		1		1		1
214	Invertebrates	Fly larvae (Diptera)	QDAE12A0	3054	Chironomidae	*	*Paramerina* sp.A (parva?)	J	4		1					1		1
215	Invertebrates	Fly larvae (Diptera)	QDAE1701	3062	Chironomidae	*	*Larsia albiceps*	J	2			1	1					
216	Invertebrates	Fly larvae (Diptera)	QDAF03A0	3075	Chironomidae	*	*Parakiefferiella* sp. A	E	8									
217	Invertebrates	Fly larvae (Diptera)	QDAF04A0	3078	Chironomidae	*	*Nanocladius* sp. 1 (VCD7)											
218	Invertebrates	Fly larvae (Diptera)	QDAF06A2	139	Chironomidae	*	Corynoneura sp. (V49) (SAP)	F	17	1				1				
219	Invertebrates	Fly larvae (Diptera)	QDAF07A0	3088	Chironomidae	*	*Thienemanniella* sp. (V19)	J	4		1	1				1		1
220	Invertebrates	Fly larvae (Diptera)	QDAF1202	3097	Chironomidae	*	*Paralimnophyes pullulus*	F	5	1	1	1		1				1
221	Invertebrates	Fly larvae (Diptera)	QDAF1501	3104	Chironomidae	*	*Cricotopus albitarsus*	C	2	1	1	1			1	1		
222	Invertebrates	Fly larvae (Diptera)	QDAF19A0	3117	Chironomidae	*	*Compterosmittia?* sp. A	A	15		1					1		
223	Invertebrates	Fly larvae (Diptera)	QDAF28A0	3149	Chironomidae	*	*Limnophyes* sp. A	F	17									
224	Invertebrates	Fly larvae (Diptera)	QDAF9999	3171	Chironomidae		Orthocladiinae sp.											
225	Invertebrates	Fly larvae (Diptera)	QDAF99A0	3172	Chironomidae	*	*Orthocladiinae* sp. A (?VSC11)	E	7									
226	Invertebrates	Fly larvae (Diptera)	QDAF99A5	3177	Chironomidae	*	*Orthocladiinae* sp. G	I	9				1					1
227	Invertebrates	Fly larvae (Diptera)	QDAF99A7	3179	Chironomidae	*	*Orthocladiinae* sp. I	A	18	1								
228	Invertebrates	Fly larvae (Diptera)	QDAF99B4	3184	Chironomidae	#	Orthocladiinae S03 sp. A (SAP)											
229	Invertebrates	Fly larvae (Diptera)	QDAF99B5	3185	Chironomidae	#	Orthocladiinae sp. P (SAP)											
230	Invertebrates	Fly larvae (Diptera)	QDAH03A0	3214	Chironomidae	*	*Cladotanytarsus* sp. A	C	2				1					
231	Invertebrates	Fly larvae (Diptera)	QDAH0402	3218	Chironomidae	*	*Tanytarsus barbitarsis*	H	13									
232	Invertebrates	Fly larvae (Diptera)	QDAH0410	3226	Chironomidae	*	*Tanytarsus fuscithorax/semibarbitarsus*	E	6		1	1	1	1	1	1	1	1
233	Invertebrates	Fly larvae (Diptera)	QDAH0420	3236	Chironomidae	*	*Tanytarsus palmatus*			1	1							1
234	Invertebrates	Fly larvae (Diptera)	QDAH04A2	3244	Chironomidae	*	*Tanytarsus* sp. C (=*bispinosus?*)	B	12				1					
235	Invertebrates	Fly larvae (Diptera)	QDAH04A3	3245	Chironomidae	#	*Tanytarsus* sp. D (SAP)											
236	Invertebrates	Fly larvae (Diptera)	QDAH04A6	3248	Chironomidae	#	*Tanytarsus* sp. G (SAP)											
237	Invertebrates	Fly larvae (Diptera)	QDAH04A7	3249	Chironomidae	*	*Tanytarsus* sp. H											1
238	Invertebrates	Fly larvae (Diptera)	QDAH04B9	3221	Chironomidae	*	*Tanytarsus* nr *bispinosus*	F	17	1								
239	Invertebrates	Fly larvae (Diptera)	QDAH0799	3264	Chironomidae	*	*Rheotanytarsus sp.*					1			1	1		1
240	Invertebrates	Fly larvae (Diptera)	QDAI01A0	3276	Chironomidae	*	*Harrisius* sp. A	J	4		1	1				1		1
241	Invertebrates	Fly larvae (Diptera)	QDAI0408	3287	Chironomidae	*	*Chironomus occidentalis*	F	8									
242	Invertebrates	Fly larvae (Diptera)	QDAI04A0	3296	Chironomidae	*	*Chironomus* aff. *alternans* (V24) (CB)	E	5	1	1	1	1	1	1	1	1	1
243	Invertebrates	Fly larvae (Diptera)	QDAI0603	3302	Chironomidae	*	*Dicrotendipes conjunctus*	E	5									
244	Invertebrates	Fly larvae (Diptera)	QDAI0701	3319	Chironomidae	*	*Kiefferulus intertinctus*	E	8				1					
245	Invertebrates	Fly larvae (Diptera)	QDAI0801	3325	Chironomidae	*	*Polypedilum leei*											1
246	Invertebrates	Fly larvae (Diptera)	QDAI0804	3328	Chironomidae	*	*Polypedilum nubifer*	E	5									

	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	HUT001 A 11/09/2007	HUT002 A 11/09/2007	HUT003 A 12/09/2007	HUT003 A 25/02/2008	HUT003 B 12/09/2007	HUT003 C 25/02/2008	HUT004 A 11/09/2007	HUT004 A 25/02/2008	HUT005 A 13/09/2007
247	Invertebrates	Fly larvae (Diptera)	QDAI08A2	3338	Chironomidae	*	*Polypedilum* nr. *convexum* (SAP)	J	3		1		1					
248	Invertebrates	Fly larvae (Diptera)	QDAI1701	3357	Chironomidae	*	*Paraborniella tonnoiri*	F	20		1							
249	Invertebrates	Fly larvae (Diptera)	QDAI1901	3360	Chironomidae	*	*Cryptochironomus griseidorsum*	E	5		1	1	1			1		1
250	Invertebrates	Fly larvae (Diptera)	QDAI2201	3365	Chironomidae	*	*Cladopelma curtivalva*	E	6				1		1	1	1	1
251	Invertebrates	Mayflies (Ephemeroptera)	QE020299	3395	Baetidae	*	*Cloeon* sp.	F	2			1	1	1	1			1
252	Invertebrates	Mayflies (Ephemeroptera)	QE029999	3396	Baetidae		Baetidae											
253	Invertebrates	Mayflies (Ephemeroptera)	QE080101	3414	Caenidae	*	*Tasmanocoenis tillyardi*	C	2		1	1			1	1	1	1
254	Invertebrates	Aquatic bugs (Hemiptera)	QH540106	3448	Hydrometridae	*	*Hydrometra strigosa*				1							
255	Invertebrates	Aquatic bugs (Hemiptera)	QH560101	3451	Veliidae	*	*Microvelia (Pacificovelia) oceanica*	F	17									
256	Invertebrates	Aquatic bugs (Hemiptera)	QH560103	3453	Veliidae	*	*Microvelia (Austromicrovelia) peramoena*	J	2									
257	Invertebrates	Aquatic bugs (Hemiptera)	QH560199	3461	Veliidae		*Microvelia* sp.											1
258	Invertebrates	Aquatic bugs (Hemiptera)	QH569999	3473	Veliidae		Veliidae											
259	Invertebrates	Aquatic bugs (Hemiptera)	QH610101	3542	Nepidae	*	*Laccotrephes tristis*			1								
260	Invertebrates	Aquatic bugs (Hemiptera)	QH650301	3616	Corixidae	*	*Agraptocorixa eurynome*	E	8									
261	Invertebrates	Aquatic bugs (Hemiptera)	QH650399	3622	Corixidae		*Agraptocorixa* sp.						1					
262	Invertebrates	Aquatic bugs (Hemiptera)	QH650502	3626	Corixidae	*	*Micronecta robusta*	E	5				1					1
263	Invertebrates	Aquatic bugs (Hemiptera)	QH650599	3643	Corixidae		*Micronecta* sp.						1					
264	Invertebrates	Aquatic bugs (Hemiptera)	QH659999	3646	Corixidae		Corixidae						1	1				
265	Invertebrates	Aquatic bugs (Hemiptera)	QH670401	3671	Notonectidae	*	*Anisops thienemanni*	E	5		1		1					
266	Invertebrates	Aquatic bugs (Hemiptera)	QH670407	3677	Notonectidae	*	*Anisops elstoni*	A	15	1								
267	Invertebrates	Aquatic bugs (Hemiptera)	QH670418	3687	Notonectidae	*	*Anisops nasuta*											
268	Invertebrates	Aquatic bugs (Hemiptera)	QH670426	3695	Notonectidae	*	*Anisops stali*	A	20				1					
269	Invertebrates	Aquatic bugs (Hemiptera)	QH670499	3700	Notonectidae		*Anisops* sp.											
270	Invertebrates	Aquatic bugs (Hemiptera)	QH679999	3708	Notonectidae		Notonectidae							1				
271	Invertebrates	Aquatic bugs (Hemiptera)	QH680199	3712	Pleidae		*Paraplea* sp.											
272	Invertebrates	Aquatic bugs (Hemiptera)	QH6801A1	4742	Pleidae	*	*Paraplea* n. sp. (ANIC 6)											
273	Invertebrates	Moth larvae (Lepidoptera)	QL019999	3715	Pyralidae		Pyralidae											
274	Invertebrates	Moth larvae (Lepidoptera)	QL0199A0	3718	Pyralidae	*	Pyralidae nr. sp. 39 of J. Hawking	D	13									
275	Invertebrates	Moth larvae (Lepidoptera)	QL999999	3716	-		Lepidoptera			1					1			
276	Invertebrates	Moth larvae (Lepidoptera)	QL9999A1	3717	-	*	Lepidoptera (non-pyralid) sp. 3	F	16	1		1		1				
277	Invertebrates	Moth larvae (Lepidoptera)	QL9999A5	193	-	*	Lepidoptera (non-pyralid) Pilbara sp. 3 not hairy											1
278	Invertebrates	Damselflies (Odonata: Zygoptera)	QO020501	3775	Coenagrionidae	*	*Austroagrion cyane*											1
279	Invertebrates	Damselflies (Odonata: Zygoptera)	QO021001	3786	Coenagrionidae	*	*Ischnura aurora aurora*	E	8	1				1				
280	Invertebrates	Damselflies (Odonata: Zygoptera)	QO021002	3787	Coenagrionidae	*	*Ischnura heterosticta heterosticta*	E	2	1		1						
281	Invertebrates	Damselflies (Odonata: Zygoptera)	QO021301	3797	Coenagrionidae	*	*Xanthagrion erythroneurum*	E	5									
282	Invertebrates	Damselflies (Odonata: Zygoptera)	QO029999	3799	Coenagrionidae		Coenagrionidae			1								
283	Invertebrates	Damselflies (Odonata: Zygoptera)	QO050101	3825	Lestidae	*	*Austrolestes analis*	F	5									
284	Invertebrates	Damselflies (Odonata: Zygoptera)	QO050102	3826	Lestidae	*	*Austrolestes annulosus*	E	6									
285	Invertebrates	Damselflies (Odonata: Zygoptera)	QO050107	3831	Lestidae	*	*Austrolestes psyche*	A										
286	Invertebrates	Damselflies (Odonata: Zygoptera)	QO070401	3845	Megapodagrionidae	*	*Archiargiolestes pusillus*	J	4									
287	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO120201	3850	Aeshnidae	*	*Aeshna brevistyla*	F	17		1				1			
288	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO121201	3863	Aeshnidae	*	*Hemianax papuensis*	E	5			1		1				1
289	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO129999	3865	Aeshnidae		Aeshnidae											
290	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO169999	3898	Corduliidae	*	Corduliidae											
291	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO170701	3911	Libellulidae	#	*Diplacodes bipunctata*											
292	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO171302	3929	Libellulidae	#	*Nannophya dalei*											
293	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO171601	3938	Libellulidae	*	*Orthetrum caledonicum*	E	8		1		1		1		1	
294	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO171608	4731	Libellulidae	*	*Orthetrum pruinosum migratum*			1								
295	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO230101	3978	Synthemistidae	*	*Archaeosynthemis occidentalis*			1								
296	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO300101	3997	Hemicorduliidae	*	*Hemicordulia australiae*											
297	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO300102	3998	Hemicorduliidae	*	*Hemicordulia tau*	E	5		1	1	1	1			1	1
298	Invertebrates	Dragonflies (Odonata: Epiproctophora)	QO999998	4018	-		Epiproctophora (=Anisoptera)								1			
299	Invertebrates	Caddisflies (Trichoptera)	QT030299	4039	Hydroptilidae	*	*Acritoptila sp.*					1			1	1	1	1
300	Invertebrates	Caddisflies (Trichoptera)	QT030499	4054	Hydroptilidae	*	*Hellyethira sp.*	F	17									
301	Invertebrates	Caddisflies (Trichoptera)	QT031099	4145	Hydroptilidae	*	*Oxyethira* sp.	J	2				1			1		1
302	Invertebrates	Caddisflies (Trichoptera)	QT0605A2	4177	Hydropsychidae	*	*Cheumatopsyche* sp. AV2	J	4			1				1	1	
303	Invertebrates	Caddisflies (Trichoptera)	QT069999	4185	Hydropsychidae		Hydropsychidae											
304	Invertebrates	Caddisflies (Trichoptera)	QT080401	4215	Ecnomidae	*	*Ecnomus pansus*	C	2						1			
305	Invertebrates	Caddisflies (Trichoptera)	QT089999	4257	Ecnomidae		Ecnomidae								1			
306	Invertebrates	Caddisflies (Trichoptera)	QT250799	4351	Leptoceridae	*	*Oecetis* sp.					1	1					1
307	Invertebrates	Caddisflies (Trichoptera)	QT251103	4367	Leptoceridae	*	*Triplectides australis*	E	5			1			1			1
308	Invertebrates	Caddisflies (Trichoptera)	QT999999	4994	-		Trichoptera								1		1	
309	Plants						*Cyperus gymnocaulos*		2			1						

	Faunal group	Higher invertebrate group	Lowest IDNC	DEC Code	Family		Lowest level of identification	Pinder et al. assemblage	Halse et al. assemblage	HUT001 A 11/09/2007	HUT002 A 11/09/2007	HUT003 A 12/09/2007	HUT003 A 25/02/2008	HUT003 B 12/09/2007	HUT003 C 25/02/2008	HUT004 A 11/09/2007	HUT004 A 25/02/2008	HUT005 A 13/09/2007
310	Plants						*Typha domingensis*		2									
311	Plants						*Triglochin striata*		3									
312	Plants						*Wilsonia backhousei*		3									
313	Plants						*Cotula coronopifolia*		6			1						1
314	Plants						*Melaleuca viminea*		8			1						
315	Plants						*Gahnia trifida*		9									
316	Plants						*Juncus kraussii* subsp. *australiensis*		9							1	1	1
317	Plants						*Samolus junceus*		9					1				
318	Plants						*Samolus repens* var. *paucifolius*		9			1		1		1	1	1
319	Plants						*Sporobolus virginicus*		9					1				
320	Plants						*Suaeda australis*		9									
321	Plants						*Wilsonia humilis*		10									
322	Plants						*Sarcocornia quinqueflora*		13									
323	Plants						*Triglochin mucronata*		13									
324	Plants						*Baumea articulata*		17							1	1	1
325	Plants						*Baumea juncea*		17	1	1	1		1		1	1	1
326	Plants						*Baumea rubiginosa*		17	1	1	1						
327	Plants						*Eucalyptus rudis*		17			1						
328	Plants						*Melaleuca rhaphiophylla*		17		1	1				1	1	1
329	Plants						*Triglochin linearis*		17					1				
330	Plants						*Atriplex cinerea*											
331	Plants						*Cyclosorus interruptus*			1								
332	Plants						*Cyperus laevigatus*											
333	Plants						*Ficinia nodosa*											
334	Plants						*Juncus kraussii*					1		1				
335	Plants						*Lobelia anceps*											1
336	Plants						*Najas marina*											
337	Plants						*Polypogon monspeliensis*									1	1	1
338	Plants						*Symphyotrichum squamatum*											1
339	Waterbirds						Australasian Shoveler		6									
340	Waterbirds						Eurasian Coot		6									
341	Waterbirds						Grey Teal		6									
342	Waterbirds						Hardhead		6									
343	Waterbirds						Hoary-headed Grebe		6									
344	Waterbirds						Pacific Black Duck		6									
345	Waterbirds						Banded Stilt		10									
346	Waterbirds						Red-capped Plover		10									
347	Waterbirds						Australian Shelduck		13									
348	Waterbirds						Black-winged Stilt		13									
349	Waterbirds						Silver Gull		13									
350	Waterbirds						Red-necked Avocet		14									
351	Waterbirds						Baillon's Crake		15									
352	Waterbirds						Little Grassbird		15									
353	Waterbirds						Clamorous Reed-Warbler											
354	Waterbirds						Ruddy Turnstone											

	HUT005	HUT006	HUT007	HUT008	HUT009	HUT010	HUT011	HUT012	HUT012	HUT013	HUT014	HUT015	SPS188	SPS189	SPS190	SPS192	RCM028
	A	A	A	A	A	A	A	A	B	A	A	A	Utcha Swamp	Hutt Lagoon	Yerina Spring	Yarder Gully	Hutt Lagoon
	26/02/2008	13/09/2007	13/09/2007	14/09/2007	14/09/2007	12/09/2007	14/09/2007	15/09/2007	15/09/2007	15/09/2007	10/09/2007	15/09/2007	21/07/1998	21/07/1998	22/07/1998	23/07/1998	9/10/2008
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	A	A	A	A	A	A	A	A	B	A	A	A	Utcha Swamp	Hutt Lagoon	Yerina Spring	Yarder Gully	Hutt Lagoon
	26/02/2008	13/09/2007	13/09/2007	14/09/2007	14/09/2007	12/09/2007	14/09/2007	15/09/2007	15/09/2007	15/09/2007	10/09/2007	15/09/2007	21/07/1998	21/07/1998	22/07/1998	23/07/1998	9/10/2008
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	A	A	A	A	A	A	A	A	B	A	A	A	Utcha Swamp	Hutt Lagoon	Yerina Spring	Yarder Gully	Hutt Lagoon
	26/02/2008	13/09/2007	13/09/2007	14/09/2007	14/09/2007	12/09/2007	14/09/2007	15/09/2007	15/09/2007	15/09/2007	10/09/2007	15/09/2007	21/07/1998	21/07/1998	22/07/1998	23/07/1998	9/10/2008
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