Tasmania

DEPARTMENT *of*
PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Water Quality of Rivers in the Coal Catchment

A Report Forming Part of the Requirements for State of Rivers Reporting

PART 1

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Natural Heritage Trust
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The Department of Primary Industries, Water and Environment provides leadership in the sustainable management and development of Tasmania's resources. The Mission of the Department is to advance Tasmania's prosperity through the sustainable development of our natural resources and the conservation of our natural and cultural heritage for the future.

The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

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Executive Summary

This report details the results of a 3-year study of water quality of the rivers and streams within the Coal River catchment. Between 1999 to 2001 sampling was conducted on a monthly basis at a number of sites on the Coal River and several of its tributaries. More intensive sampling using "snapshot' surveys was conducted during summer and winter periods. Multi-parameter dataloggers were deployed at a number of sites to examine short-term fluctuations in selected water quality variables.

The information contained in this report should be viewed together with the associated reports on aquatic ecology, hydrology and river condition. These four reports together form the "State of River" Report for the Coal River catchment.

The major findings from the investigation of water quality in the catchment are:

- Salinity in the Coal River catchment is a natural phenomenon, however surface water conductivity at many locations was well in excess of 1500 µS/cm, and far above the level recommended for Tasmanian rivers (ANZECC, 2000). The presence of salt at these levels in waterways has significant consequences for agricultural use, particularly where water is taken from the lower reaches of the river and used to irrigate crops in Stage 2 of the irrigation scheme. Existing land use practices, and a trend for declining rainfall in south east Tasmania are likely to exacerbate this problem.

- The Coal River system is naturally 'ephemeral', and tributary streams are frequently reduced to a series of ponds and stagnant pools. During these periods, water quality is often extremely poor, with elevated conductivity, turbidity and nutrient concentrations, and depleted oxygen levels. This was particularly noted in Pages Creek, Duckhole Rivulet, White Kangaroo Rivulet, Native Hut Rivulet and Inverquharity Rivulet. There was a general trend for increased concentrations of total nitrogen from the headwaters progressing downstream to sites lower in the catchment.

- Nutrient export from the Coal River catchment was relatively low in comparison with other Tasmanian catchments that have been studied, and this is likely to reflect the very rainfall and low discharge that occurred during the period of the study. A significant proportion of nutrients and sediment being generated from the upper catchment are likely to be trapped in Craigbourne Dam and utilised by blooms of toxic blue-green algae that are now a regular occurrence at this storage.

- The estimated monthly loads of dissolved salt transported by the Coal River were significantly higher than those that were estimated for nitrogen and phosphorus. The total salt load that was estimated as passing through the Richmond weir between January and September 1999 was 1,278 tonnes. During this period, approximately 1,783 ML of water was extracted from this location for use in Stage 2 of the South East Irrigation Scheme, and it was estimated that this water contained about 248 tonnes of salt. The transfer of this salt to this part of the catchment is likely to have serious implications for the long-term sustainability of agriculture in this area.

A GLOSSARY OF TERMS

Baseflow
Flow in a stream is essentially a function of overland flow, sub-surface flow and groundwater input. During periods when there is no contribution of water from precipitation, flow in a stream is composed of water from deep sub-surface and groundwater sources and is termed 'baseflow'.

Box and Whisker Plots
One common method of examining data collected at various sites is to plot the data from each site as a 'box and whisker' plot. These plots display the median (or the middle of the data) as a line across the inside of the box. The bottom and top edges of the box mark the first and third quartiles respectively, indicating the middle 50% of the data. The ends of the whiskers show the extremes of the data and together enclose 95% of the data.

Catchment
The land area which drains into a particular watercourse (river, stream or creek) and is a natural topographic division of the landscape. Underlying geological formations may alter the perceived catchment area suggested solely by topography (limestone caves are an example of this).

Discharge
The volume of water passing a specific point during a particular period of time. It usually refers to water flowing in a stream or drainage channel, but can also refer to waste water from industrial activities.

Dissolved Oxygen
Oxygen is essential for all forms of aquatic life and many organisms obtain this oxygen directly from the water in the dissolved form. The level of dissolved oxygen in natural waters varies with temperature, turbulence, photosynthetic activity and atmospheric pressure. Dissolved oxygen varies over 24 hour periods as well as seasonally and can range from as high as 15 mg/L to levels approaching 0 mg/L. Levels below 6 mg/L will begin to place stress on aquatic biota and below 2 mg/L will cause death of fish.

Ecosystem
An environment. The physical and chemical parameters that define it and the organisms which inhabit it.

Electrical Conductivity (EC)
Conductivity is a measure of the capacity of an aqueous solution to carry an electrical current, and depends on the presence of ions; on their total concentration, mobility and valence (ie. the amount of electrical charge on each ion). Conductivity is commonly used to determine salinity and is mostly reported in microSiemens per centimetre (μS/cm) or milliSiemens per metre (mS/m) at a standard reference temperature of 25^{o} Celsius.

Export Loads / Export Coefficients
The calculation of export loads of nutrients, or any other parameter, involves using nutrient concentration data collected over a wide variety of flow conditions and from various seasons. This information, when plotted against flow at the time of collection, can reveal relationships between flow and concentration which can then be used to estimate the load of a particular nutrient leaving the catchment (estimates of export loads should be regarded as having no greater accuracy than +/- 15%).

The export coefficient (also known as the Runoff Coefficient) corrects for catchment size so that export loads from variously sized catchments can be compared. The most commonly used formula to perform this correction is;

Discharge (ML) / **Catchment Area** (km^2) = **X** (mm km^{-2})

Total Load (kg) / **X** = **Y** (kg mm^{-1})

Y / **Catchment Area** (km^2) = **Export Coefficient** (kg $mm^{-1}km^{-2}$)

Where Z is the Export Coefficient and is equivalent to Total Load (kg) / Discharge (ML).

Faecal Coliforms (also known as 'thermotolerant coliforms' - eg. *E.coli*)
Faecal coliform bacteria are a sub-group of the total coliform population that are easy to measure and are present in virtually all warm blooded animals. Although measurement of this group is favoured by the NHMRC (1996) as suitable indicators of faecal pollution, it is recognised that members of this group may not be exclusively of faecal origin. However their presence in samples implies increased risk of disease. Pathogenic bacteria are those which are considered capable of causing disease in animals.

Hydrograph
A plot of flow (typically in a stream) versus time. The time base is variable so that a hydrograph can refer to a single flood event, to a combination of flood events, or alternatively to the plot of all flows over a month, year, season or any given period.

Median
The middle reading, or 50^{th} percentile, of all readings taken.

i.e. Of the readings 10, 13, 9, 16 and 11
{Re-ordering these to read 9, 10, 11, 13 and 16}
The median is 11.

The **Mean** (or Average) is the sum of all values divided by the total number of readings (which in this case equals 11.8).

Nutrients
Nutrients is a broad term which encompasses elements and compounds which are required by plants and animals for growth and survival. In the area of water quality the term is generally used with only phosphorus and nitrogen in mind, though there are many other elements that living organisms require for survival.

pH and Alkalinity
The pH is a measure of the acidity of a solution and ranges in scale from 0 to 14 (from very acid to very alkaline). A pH value of 7 is considered 'neutral'. In natural waters, pH is generally between 6.0 and 8.5. In waters with little or no buffering capacity, pH is related to alkalinity, which is controlled by concentrations of carbonates, bicarbonates and hydroxides in the water. Waters of low alkalinity (< 24 ml/L as CaCO3) have a low buffering capacity and are susceptible to changes in pH from outside sources.

Riparian Vegetation
Riparian vegetation are plants (trees, shrubs, ground covers and grasses) which grow on the banks and floodplains of rivers. A 'healthy' riparian zone is characterised by a homogeneous mix of plant species (usually native to the area) of various ages. This zone is important in protecting water quality and sustaining the aquatic life of rivers.

Suspended Solids
Suspended solids are typically comprised of clay, silt, fine particulate organic and inorganic matter and microscopic organisms. Suspended solids are that fraction which will not pass through a 0.45μm filter and as such corresponds to non-filterable residues. It is this fraction which tends to contribute most to the turbidity of water.

Total Nitrogen (TN)
Nitrogen in natural waters occurs as nitrate, nitrite, ammonia and complex organic compounds. Total nitrogen concentration in water can be analysed for directly or through the determination of all of these components. In this report, total nitrogen has been calculated as the sum of nitrate-N + nitrite-N + TKN.

Total Phosphorus (TP)
Like nitrogen, phosphorus is an essential nutrient for living organisms and exists in water as both dissolved and particulate forms. Total phosphorus can be analysed directly, and includes both forms. Dissolved phosphorus mostly occurs as orthophosphates, polyphosphates and organic phosphates.

Turbidity
Turbidity in water is caused by suspended material such as clay, silt, finely divided organic and inorganic matter, soluble coloured compounds and plankton and microscopic organisms. Turbidity is an expression of the optical properties that cause light to be scattered and absorbed rather than transmitted in a straight line through the water. Standard units for turbidity are ‘nephelometric turbidity units’ (NTU’s) standardised against Formazin solution.

Units and Conversions

mg/L = milligrams per litre (1000 milligrams per gram)
μg/L = micrograms per litre (1000 micrograms per milligram)
eg. 1000 μg/L = 1 mg/L
μS/cm = Microsiemens per centimeter
m^3s^{-1} = cubic metre per second (commonly referred to as a ‘cumec’)
ML = 1 million litres (referred to as a ‘megalitre’)

Acronyms

ANZECC - Australian and New Zealand Environment and Conservation Council
ARMCANZ - Agricultural and Resource Management Council of Australia and New Zealand
DPIWE - Department of Primary Industries, Water and Environment
DPIF - Department of Primary Industry and Fisheries (replaced by DPIWE)
NHMRC - National Health and Medical Research Council

B SUMMARY OF NATIONAL GUIDELINES FOR WATER QUALITY

Australian Water Quality Guidelines as per ANZECC (2000)

As part of a National strategy to 'pursue the sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development' the Australian and New Zealand Environment and Conservation Council (ANZECC) has been developing guidelines for water quality for a range of Australian waters. Since 1992, a document titled 'Australian Water Quality Guidelines for Fresh and Marine Waters (1992)' has been available for use as a reference tool for catchment management plans and policies. Since 1995, these guidelines have been under review and have now been superseded by new and more rigorous guidelines (ANZECC, 2000). The new approach has changed the emphasis of guideline setting, suggesting a 'risk assessment' approach which utilises the concept of increased risk with increasing departure from 'safe' levels. It also restates the principle that they are simply guidelines to be used in the absence of local data, and that where local data can be obtained, they should be used to develop local water quality standards.

For some water quality parameters, this approach has been taken, with data from Tasmanian systems (where available) being used to develop guidelines for use in Tasmania. In the National document, Tasmanian rivers have been broadly classified as upland or alpine rivers. It was considered that virtually no Tasmanian rivers can be categorised as lowland, when compared with mainland Australia, so only the guidelines for upland rivers have been used. A summary of these 'Tasmanian specific' guidelines is presented below.

Table 1: Trigger Levels for Nutrients, pH and Dissolved Oxygen (ANZECC, 2000).

Ecosystem Type	TP μg/L	FRP μg/L	TN μg/L	NOx μg/L	pH	DO (%sat)
Upland River	13	5	480	190	6.5 to 7.5	<90 & >110
Lakes and Reservoirs	10	5	350	10	6.5 to 8.0	<90 & >110

Table 2: Trigger Levels for Conductivity and Turbidity (ANZECC, 2000).

Ecosystem type	Salinity ($\mu S/cm^{-1}$)	Explanatory notes
Upland Rivers	30–350	Conductivity in upland streams will vary depending upon catchment geology. Low values found in Victorian alpine regions (30 μScm^{-1}) and eastern highlands (55 μScm^{-1}), high value (350 μScm^{-1}) in NSW rivers. Tasmanian rivers mid-range (90 μScm^{-1}).
Lakes/ Reservoirs	20–30	Conductivity in lakes and reservoirs are generally low, but will vary depending upon catchment geology. Values provided are typical of Tasmanian lakes and reservoirs.

Ecosystem type	Turbidity (NTU)	Explanatory notes
Upland Rivers	2–25	Most good condition upland streams have low turbidity. High values may be observed during high flow events.
Lakes & Reservoirs	1–20	Most deep lakes and reservoirs have low turbidity. However shallow lakes and reservoirs may have higher natural turbidity due to wind-induced resuspension of sediments. Lakes and reservoirs in catchment with highly dispersable soils will have high turbidity.

Proposed Microbiological Guidelines

Primary contact

The median bacterial content in samples of fresh or marine waters taken over the swimming season should not exceed:

- *150 faecal coliform organisms/100mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 600 organisms/100mL);*

- *35 enterococci organisms/100mL (maximum number in any one sample: 60-100 organisms/100mL).*

Pathogenic free-living protozoans should be absent from bodies of fresh water. (It is not necessary to analyse water for these pathogens unless the temperature is greater than 24°C.)

Secondary contact

The median bacterial content in fresh and marine waters should not exceed:

- *1000 faecal coliform organisms/100mL (minimum of five samples taken at regular intervals not exceeding one month, with four out of five samples containing less than 4000 organisms/100mL);*

- *230 enterococci organisms/100mL (maximum number in any one sample 450 – 700 organisms/100mL).*

National Health and Medical Research Council - Drinking Water

For drinking water, guidelines published by the National Health and Medical Research Council (NHMRC, 1996) suggest that no thermotolerant coliforms (eg *E. coli*) should be present in water used for drinking

Water Quality of the Coal Catchment

1 Historical and Other Data

1.1 Background

The Coal River Catchment is located within the south east of Tasmania and encompasses approximately 540 square kilometres. The catchment lies within the driest region of Tasmania and has typically been prone to drought conditions. The average annual rainfall is betwween 500-600mm. Mountains on the west of the catchment place much of the valley within a rainshadow, and rainfall is highly variable from year to year and month to month (Gallagher, 1997). There is a considerable volume of groundwater; however, some shallow groundwater and some surface waters show high to severe levels of salinity. The Coal River catchment is a naturally saline environment, with salts coming from weathering of rocks, groundwater inputs and deposition via precipitation. Human-related changes in the catchment are likely to have significantly exacerbated these conditions.

The Coal River system is an elongate valley formed by extensional Tertiary faulting (90-60 million yrs BP). The valley is bounded by dolerite capped ridges beneath which are outcrops of Triassic sandstones and Permian mudstone. Parts of the valley are filled with clayey Tertiary sediments of alluvial and lacustrine origin. Soils in the catchment develop on a wide range of materials including dolerite, sandstone, mudstone, windblown sands and Tertiary sediments. Many short streams enter from side valleys, each forming a fan or pediment making for a complex stratigraphic and soil pattern. High levels of exchangeable sodium and magnesium occur in the lower lying soils of the valley. Along the Coal River Estuary and Pitt Water there are tertiary sedimentary deposits, while basalt extends between Campania and Richmond on the Coal River Plain. The stream valleys throughout the catchment are primarily quarternary alluvial deposits (Leaman 1971). Wetlands characterise the low relief areas that border the Pitt Water estuarine zone.

The Coal River catchment has a long history of agriculture and a diversity of land uses, including pastureland grazing, forestry, conservation, recreation, irrigated cropland and rural-residential development. The Pitt Water Estuary lies at the bottom of the catchment and has been listed under the ‘Ramsar Convention’ as a wetland site of international significance. The estuary also sustains a successful aquaculture industry and is home to a number of threatened species and migratory birds.

As a result of land clearance within the Coal River catchment, less of the rain that falls is used by vegetation, but soaks into the ground, filling the shallow aquifers and bringing natural salt to the surface. In the drier summer months, when a number of the major waterways in the catchment are prone to low or no flow, the surface water flows are sustained by groundwater stores. The Coal River catchment has a considerable volume of groundwater (Leaman 1971) despite the relative lack of perennial streams or springs within the catchment.

In the winter-spring months baseflows are higher and more continuous. Flood and high flow events in the catchment are highly variable in magnitude and timing, both within and between years. A number of landowners with river frontage have water extraction rights which provide them with the right to extract a restricted quantity of water for stock and domestic use, or for irrigation purposes. The allocation and management of these water rights is the responsibility of the Rivers and Water Supply Commission. The increasing regulation of the Coal River by dams and weirs and the diversion of water for consumptive uses have compounded the lack of natural flushing within the system (Davies, 2002).

Craighbourne Dam has had a considerable effect on the flow regimes in the middle and lower reaches of the Coal River. Significant changes in the natural flow regime of the Coal River may also have resulted prior to the construction of the dam, with the effects of land clearing throughout the catchment. Since the construction of the dam there has effectively been a reversal in the natural flow regime of the river, with higher flows being released in the summer months when demand from the irrigators is greater.

1.2 Pitt water Orielton Lagoon Ramsar Site

The Coal River flows into the Pitt Water-Orielton Lagoon area, which is recognised as internationally significant under the Convention on Wetlands (‘Ramsar Convention’). The area is visited by numerous different species of migratory birds. A number of threatened species are also found in the Pitt Water reserve, such as the threatened star fish *Patriella vivipara* and six threatened plant species. Orielton Lagoon also provides an important refuge for the threatened great crested grebe *Podiceps cristatus*. Furthermore, the school shark *Galeorhinus galeus* and gummy shark *Mustelus antarticus* utilise the Pitt Water reserve as a nursery area (Natural Heritage Trust program, 2002).

The land surrounding Pitt Water has been cleared or significantly altered due to intensive agricultural practices, grazing and residential development. As a result declines in water quality is perceived as a considerable threat to this land-locked estuary. The estuary receives significant sediment and nutrient inputs from erosion, fertilisers, sewage and stormwater pipes.

1.3 South East Irrigation Scheme

Low summer flows in the Coal River catchment made it necessary for irrigators to investigate the feasibility of an irrigation scheme. In 1985 the South East Irrigation Scheme was devised and Craigbourne Dam was proposed. The dam was completed in time for the irrigation season of 1986/87, and impounds approximately 12,400 ML. The increased availability of water has allowed for diversification and an increase in agricultural productivity in the valley, and has subsequently led to a move away from dryland cropping and grazing production to higher value irrigated crops. Irrigated crops include vineyards, vegetable seeds, orchards, poppies and peas. Consequently, there is the potential for salt redistribution under irrigated agriculture that may lead to increased soil and water salinity.

1.4 Soil salinity in Pages Creek catchment

Studies conducted by Finnigan (1995) found approximately fourteen percent of land in the South East Irrigation area to be saline land. There is an increase in the distribution of salt affected soils from north (below Craighbourne Dam) to south. Todd (1999) conducted a hydrological investigation of Pages Creek Catchment, in the Coal River valley to determine the relationship between groundwater flow, hydrochemistry, and salinisation.

Pages Creek has been identified as one of the most saline streams in the Coal River valley (Finnigan 1996). High relative chloride and sodium concentrations in the groundwaters of this small sub-catchment suggest that much of the dissolved salt is derived from a ‘cyclic’ source (saline aerosols). Irrigation provides a second input of salt to Pages Creek Catchment (Todd, 1999). Research is currently continuing in this catchment in relation to soil salinity (Cambium Land and Water Management Pty. Ltd., 2002). The technique that is being employed allows the distribution of salinity to be recorded at a paddock scale.

1.5 Waterwatch monitoring

Waterwatch activities began in the Coal River region in 1998 as a council initiative to get Waterwatch into the local schools. The main drive of the group was educational. In November 2001 the South East Waterwatch group was established and is sponsored by the Clarence and Sorrel Councils as a joint partnership program. The South East Waterwatch group aims to provide community awareness and capacity building, in addition to the ongoing support and involvement with Waterwatch activities in local schools. The Clarence and Sorrel councils provide administrative and in-kind support such as creating a special web site for the South East Waterwatch group and providing interaction with their environmental health officers. Since 1998, the South East Waterwatch group have received financial assistance through NHT and the Clarence and Sorell Councils.

The primary concern for the group is the increasing levels of salinity in the Coal River catchment. As such, the primary focus of the Waterwatch group has been to monitor salinity in the Coal River Valley. Future Waterwatch activities will involve a comparison of flow regimes with macroinvertebrate communities along the Coal River below Craigbourne Dam. Measurements of phosphorous and nitrate are also planned.

1.6 Algal blooms in Craigbourne Dam

The first recorded bloom of blue-green algae occurred in Craigbourne Dam in June 1997. The potentially toxic *Anabaena circinalis* was detected throughout the water column and in significant concentrations up to 4 km downstream of the dam. The cause of the bloom was unknown, and it is rare that an algal bloom can be attributed to a single factor. However, it has been found that under certain favourable conditions, usually a combination of stable warm weather and nutrient enrichment, blue-green algae can become dominant and form 'blooms' (Reynolds, 1987). There is the potential for these blooms to have a significant adverse effect on water quality, as the blue-green algae can produce toxins and odours.

The blue-green algal bloom that occurred in the Craigbourne Dam in 1997 was found to be non toxic, however, it did reach proportions which could cause problems with water usage. Bobbi (1997a) conducted routine monitoring of sites both within the dam and downstream of the dam as far as Richmond. Sampling continued for nine weeks until the bloom collapsed. The distribution of algae in the dam was found to be very variable in both time and space. The highest concentrations were found in the bay where the Coal River flows into the storage (Table 1.1). Nutrients in the dam were primarily bound up in the algal biomass during the bloom. Data collected during an algal bloom from 12th – 28th July found concentrations of *Anabaena circinalis* to be lower at the Wallaby Rivulet inflow (CD3) than at the other two monitoring sites (Bobbi, 1997a).

Table 1.1: Surface concentration of algae at CD1, CD2 and CD3 using all data collected between 12 June and 28 July 1997.

Site ID	Average (Cells/mL)	Median (Cells/mL)
CD1(dam site)	82,920	49,310
CD2 (Coal inflow)	406,795	50,410
CD3 (Wallaby inflow)	34,102	39,310

On most monitoring occasions, highest surface concentrations of *A. circinalis* occurred at the inflow to the Coal River (CD2) which suggests that this area was potentially the original 'seeding area' for the bloom. This part of the Craigbourne Dam is shallow and well protected from prevailing westerly winds, providing an ideal 'nursery' area from growth and reproduction of the algae. Furthermore, this region receives inflow from the upper Coal River. During flood events significant amounts of sediments and nutrients can become trapped within the bay, and there was visual evidence of this when water levels in the storage were low.

Figures taken from the summary report on the Craigbourne Dam blue-green algal bloom (Bobbi, 1997a) show the vertical distribution of *A. circinalis* at the dam site, CD1, during the final stages of the bloom (Figure 1.1). The plot shows the change in the vertical distribution of algae at the site over the final month with the 'median' profile showing the "average" vertical distribution in the water column prior to the collapse of the bloom.

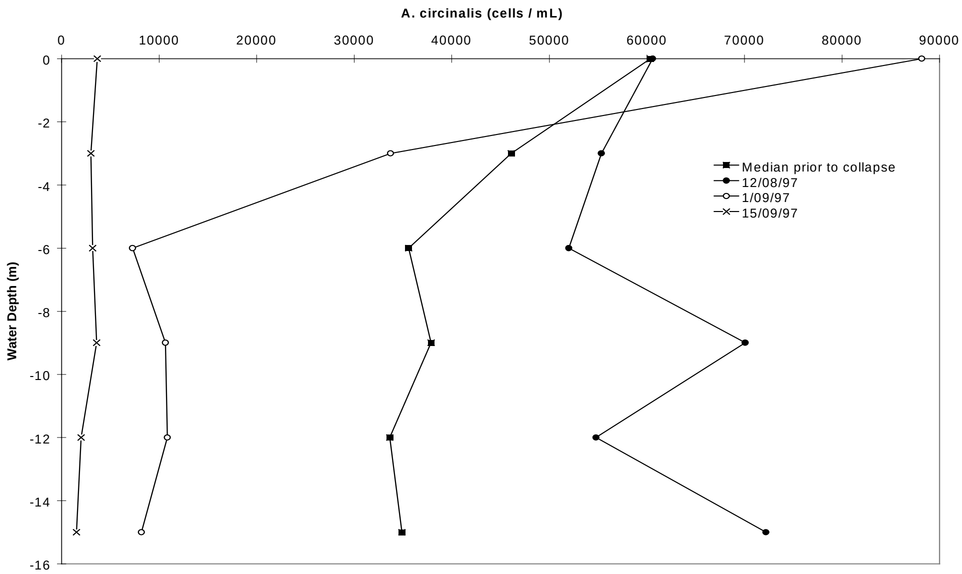

Figure 1.1: A comparison of the final stages of bloom at CD1 with the median at all depths from sampling prior to its collapse (Bobbi, 1997a).

The time series of cell concentrations at all three dam sites is plotted in Figure 1.2. This plot highlights the collapse of the bloom, which was very dramatic, falling from over 100,000 cells/mL to 3,000 cells/mL in one week. There was a corresponding drop in turbidity levels from normal bloom levels of around 15-20 NTU to about 2 NTU (Bobbi, 1997a).

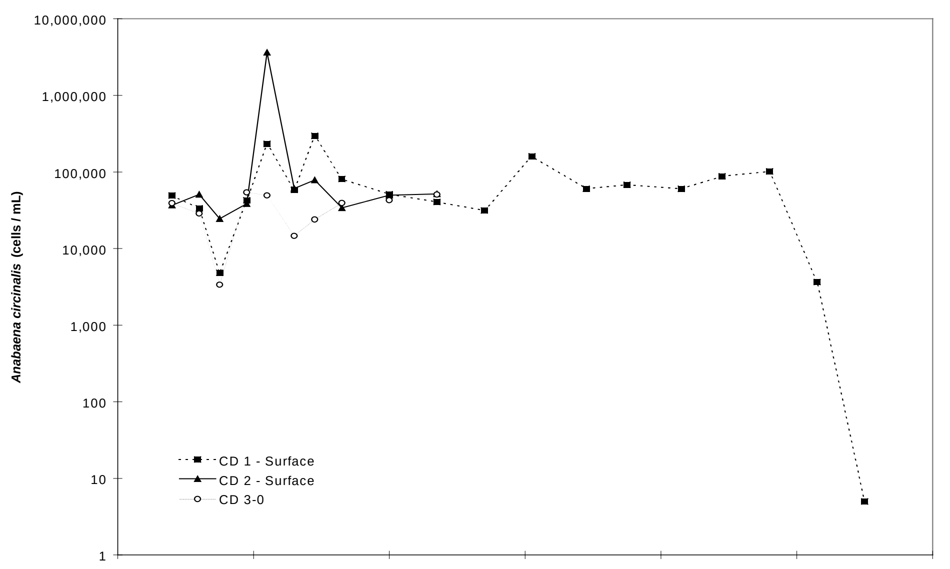

Figure 1.2: Time series of *A. circinalis* cell concentrations in surface samples from all three reservoir sites (monitoring was discontinued at sites CD2 and CD3 after the 28/7/97) (Bobbi, 1997a).

The average concentrations of *A. circinalis* at riverine sites downstream of Craigbourne Dam are shown in Figure 1.3. This plot highlights the progressive downstream decline in *A.circinalis* concentration in the Coal River.

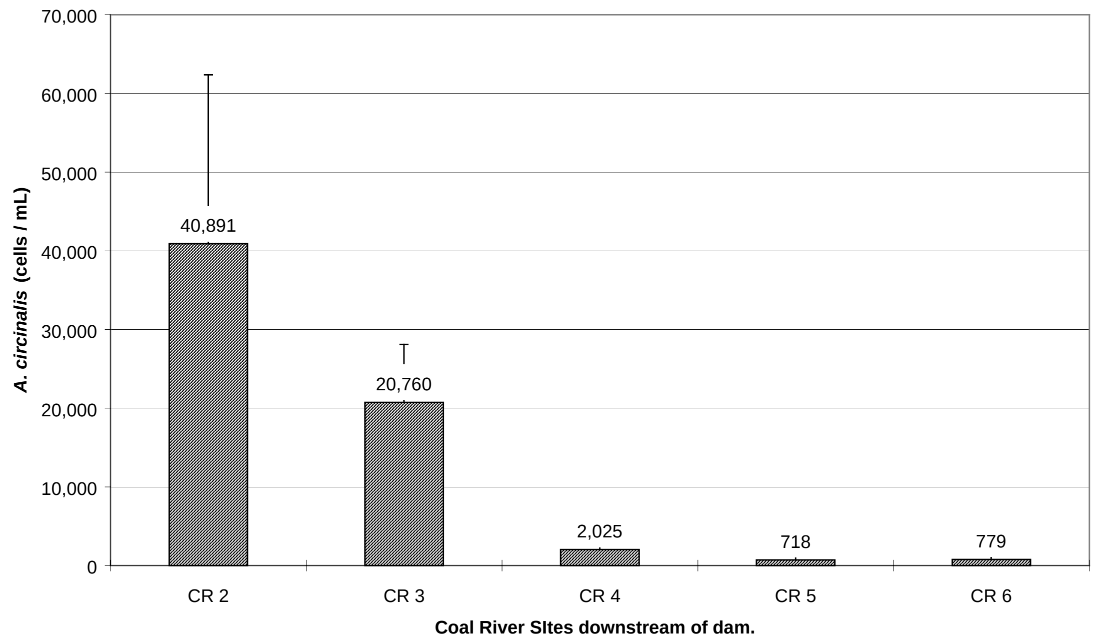

Figure 1.3: Average cell numbers from riverine sites downstream of Craigbourne Dam (Bobbi, 1997a)

Once an algal bloom has become established in a water body it is highly likely that it will re-occur. This has been the case for the Craigbourne Dam where blooms have been reported annually since the original sighting, and over time blooms have been caused by the toxic species *Microcystis* spp, which now dominates the system. It is still not clear what major factors contribute to the establishment of a bloom, but it is likely that nutrient loading to the lake during floods followed by prolonged periods of dry, calm weather and possible stratification of the dam are playing a significant part in the establishment of algal blooms in Craigbourne Dam.

1.7 Historical Data from the State database HYDROL

Historical records for water quality data for sites in the Coal River Catchment was extracted from the DPIWE managed water database HYDROL. Substantial records were found for sites on the Coal River between Baden and Richmond, and from White Kangaroo Rivulet. Tables containing a summary of these data are shown in Tables 1.2 – 1.6. The statistics of most importance in all these tables is that for median, which gives the most accurate representation of the 'usual' or 'average' condition of the water quality at that site.

There are currently four operational stream gauging stations in the Coal River catchment. They are situated on the Coal River at Baden (#3203), Coal River at Richmond weir (#3208), Coal River below Craigbourne Dam (#3206) and White Kangaroo Rivulet (#3209) (Refer to Hydrology section of 'State of Rivers' report for the Coal Catchment). Sites located on the Coal River downstream of the Craigbourne Dam have received regulated flows since 1986.

Coal River at Richmond Weir (#3208)

Figure 1.4 shows water level recorded in the Coal River at Richmond weir during each visit when water quality monitoring was carried out. Of the reported river levels 85% were less than 0.39 meters, which corresponds approximately to flows of less than 2.5 m^3s^{-1}. One visit was carried out during a high flow event in mid-1996, when water level in the weir reached 2.5 metres. Ratings to convert river level to flow for this site (especially during high flow events) is very uncertain due to a lack of high flow measurements, and it must be noted that sandbags were installed between 1999 and November 2000. As a result, it is not possible to accurately determine the size of floods and high flow events at this site.

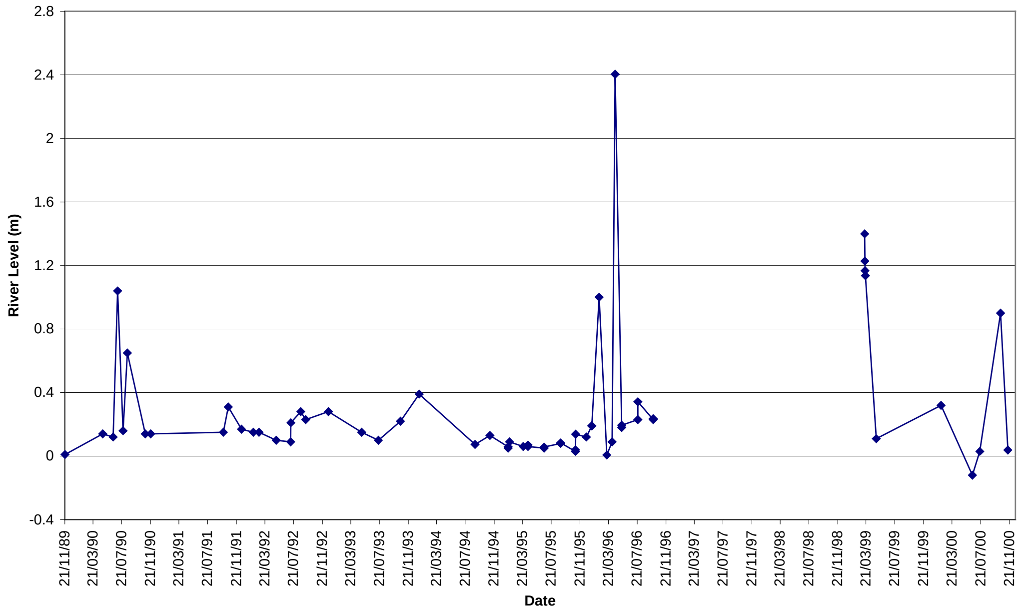

Figure 1.4: River level recorded in the Coal River at the Richmond weir (#3208) during site visits when water quality records were taken.

Continuous readings for level, temperature, conductivity and turbidity have been recorded from the Coal River at Richmond weir since January 1995 until the present. Some water quality sampling occurred between 1987 to 2001. Table 1.2 provides the statistics of the water quality data collected at this site. The median statistic for turbidity (6 NTU) and colour (92.5) indicates that water clarity is reasonably good for the majority of the time, although the maximum levels show that the system can become quite turbid usually during high flow periods. The highest colour and turbidity levels were recorded during flood flows of approximately 140 m^3s^{-1} at the Richmond stream gauging station in April 1996. In 1995 and 1996, samples were collected more frequently as part of the Craigbourne Dam study and sent to the laboratory where they were analysed for a wider range of parameters.

pH levels recorded at the Richmond weir site indicate that conditions are generally neutral to slightly alkaline. Dissolved salt concentrations and the conductivity data show that the Coal River water is quite saline in its lower reaches, and this is most pronounced when there is no water being released from Craigbourne Dam. The high salinity is caused by elevated concentrations of both chloride and sodium, although magnesium and calcium are also high. The alkalinity and hardness data are also indicative of a disturbed system with hardness falling into the very hard category (CCREM, 1987). The maximum and minimum dissolved oxygen levels recorded at this site were 90% 68% saturation, respectively. The median dissolved oxygen saturation at this site is 78%, which falls outside the recommended levels for maintenance of a healthy river system (ANZECC, 2000). There is extensive nutrient data for this site, and it shows that concentrations of all the major forms of nutrients (nitrate, total phosphorous and ammonia) can be moderately elevated at times (maximum of 0.2 mg/L, 1.13 mg/L and 1.3 mg/L, respectively).

Table 1.2: Summary statistics for data contained on the HYDROL samples database for the Coal River at Richmond weir. N = number of readings taken. Data was collection from 1987 to 2000.

Coal River at Richmond weir (3208)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Temperature	^{o}C	59	3.4	22	13.34	12.85
Apparent Colour	Hazen Units	12	30	250	109.2	92.5
pH lab		52	6.4	8.5	7.7	7.75
pH field	Closed	21	6.3	8.3	7.2	7.3
Tot suspended solids	mg/L	15	1	512.2	42.4	3.0
Conductivity at 25°C Field	uS/cm	41	202	1249	676.7	620
Conductivity at 20°C Field	uS/cm	9	674	1355	899.9	768
Conductivity at 25°C Lab	uS/cm	52	235	1250	694.6	680
Turbidity	NTU	22	1	69.7	12.3	6
Dissolved Oxygen	mg/L	9	7.2	9.4	8	8
Reactive Phosphorous	mg/L	13	0.002	0.024	0.009	0.006
Boron as B	mg/L	42	0	0.09	0.02	0.01
Total Calcium as Ca	mg/L	57	11	56	35.5	36
Total Chloride as Cl	mg/L	37	0	310	151.5	148
Flouride as F	mg/L	12	0.1	1.1	0.2	0.1
Total Magnesium as Mg	mg/L	57	7.9	54	30.3	30
Total Iron as Fe	mg/L	55	0	5.7	0.53	0.2
Total Manganese as Mn	mg/L	55	0	0.07	0.014	0.01
Nitrite as NO_2	mg/L	13	<0.005	0.01	0.006	0.005
Nitrate as NO_3	mg/L	49	0	0.2	0.05	0.005
Ammonia as NH3	mg/L	13	0.005	1.3	0.119	0.019
Total Sulphur as S	mg/L	44	2	10	5.31	5
Total phosphorous	mg/L	52	0	1.13	0.05	0
Total Potassium as K	mg/L	55	1	14	2.85	2.4
Total Sodium as Na	mg/L	57	25	136	78.8	78
Total Zinc as Zn	mg/L	39	0	0.16	0.01	0
Total Sulphate as SO4	mg/L	12	5.8	21	12.4	11.5
Total Alkalinity	mg/L	12	19	145	71.6	71
Total Hardness as CaCo3	mg/L	22	60	330	182.9	188.5
Total molybdenum as Mo	mg/L	39	0	0.12	0.01	0.01
Chloride as Cl	mg/L	13	45	240	123.7	125
Total Copper as Cu	mg/L	39	0	0.21	0.01	0
Total dissolved solids	mg/L	13	200	700	389.6	385
Dissolved oxygen	% sat	5	63	90	78	78
pH field sensor TC		8	6.8	7.82	7.5	7.55
River level	metres	61	-0.12	2.4	0.296	0.15
Total Dissolved Salts		23	309	743.2	477.8	461.5
Molybdate reactive S	mg/L	12	2.4	12	7.72	8.65

Coal River u/s White Kangaroo (#1102)

Continuous records of river level were recorded at the Coal River upstream of White Kangaroo Rivulet site for 30 year, between 1963 and 1993. The majority of water quality samples were collected between 1987 to 1993 (Table 1.3). The data from this site shows that conditions are very similar to those downstream at the Richmond weir site. The water at the site is neutral to slightly alkaline, and has slightly lower median conductivity than further downstream at Richmond weir. However, relatively high levels of nitrate and total phosphorous were also recorded at this site (maximum values were 0.3mg/L and 1.01 mg/L, respectively).

Table 1.3: Summary statistics for data contained on HYDROL database for the Coal River at White Kangaroo Rivulet. Data was collection from 1987 to 1993.

Coal River u/s White Kangaroo (1102)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
pH lab		33	7.5	8.6	7.91	7.9
Conductivity at 25c Lab	us/cm	33	450	1750	720	630
Boron as B	mg/L	34	0	0.12	0.0165	0.01
Total Calcium as Ca	mg/L	35	22	78	39.69	35
Total Chloride as Cl	mg/L	32	0	650	152.1	126.5
Total Magnesium as Mg	mg/L	35	16	91	33.1	26
Total Iron as Fe	mg/L	35	0	0.5	0.163	0.1
Total Manganese as Mn	mg/L	35	0	0.13	0.012	0
Nitrate as NO_3	mg/L	33	0	0.3	0.045	0
Total Sulphur as S	mg/L	35	2	13	6.35	6
Total phosphorous	mg/L	35	0	1.01	0.057	0
Total Potassium as K	mg/L	35	1	13.8	3.02	3
Total Sodium as Na	mg/L	35	42	207	79.9	67
Total Zinc as Zn	mg/L	35	0	0.16	0.01	0
Total molybdenum as Mo	mg/L	34	0	0.14	0.017	0.01
Total Copper as Cu	mg/L	35	0	0.2	0.014	0
Salts Total Dissolved	mg/L	16	288	1026.9	476	401.95

Coal River at Baden (#3203)

Continuous recordings for level have been recorded from July 1971 until October 2002 at the Baden weir site. Water quality samples were collected from 1974 to 1996 and in the year 2000 (Table 1.4). The data for pH at the Baden station is indicative of a more elevated catchment site, with median conditions that are more neutral or even slightly acid compared to sites lower in the catchment. Field pH values range from 5.4 to 6.8. This site is higher in the catchment and less disturbed than the lower sites.

Lower conductivity was recorded for this site, with a median reading of 272.5 μS/cm at TRef 25°C, which falls within the levels recommended by the ANZECC (2000), and indicates that there is less saline discharge to the river from this part of the catchment. The median statistic for turbidity in the Coal River at the Baden station shows that water clarity is reasonably good for the majority of the time. River level and temperature where the two most frequently recorded variables at this site. Because of the small size of the river at this location and its inland position, the data clearly shows that the Coal River in this area is prone to quite high water temperatures during the dry and warm summer months. Water temperatures of this level will cause stress to aquatic biota, particularly trout.

Table 1.4: Summary statistics for data contained on HYDROL database for the Coal River at Baden weir. The data was collected between 1974-96 and in 2000.

Coal River at Baden (3203)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Apparent Colour	hazen	11	30	125	67.7	60
Field Conductivity @ TRef 20	μS/cm	8	76	330	235.9	252.5
Field Conductivity @ TRef 25	μS/cm	22	88	582	289.9	272.5
Filtered Residue (103-105)	mg/L	11	104	190	132.6	122
Laboratory pH		46	6.25	7.9	7.2	7.2
Field pH (closed)		44	5.4	8.5	6.76	6.8
River Level	metres	101	-0.03	1.2	0.085	0.03
Suspended solids	mg/L	11	1	6	2.73	2
Turbidity	NTU	3	4.88	9.3	6.49	5.3
Turbidity	Hellige	10	1.7	18.5	9.94	9.35
Temperature	°C	100	0	24	10.59	9.9

Coal River downstream of Craigbourne Dam (#3206)

There are continuous records for river level (recorded from October 1986 until the present) for the Coal River immediately downstream of Craigbourne Dam. Water quality samples were collected and analysed from 1990 to 1997 and in a separate study in 2002 (Table 1.5). The sampling frequency for these parameters was very low with the majority being sampled only once. Water temperature, river level and conductivity were sampled more frequently. The median conductivity level was 481 μS/cm at TRef 25°C. Limited data taken from this site prior to construction of Craigbourne Dam, shows that dissolved oxygen concentrations were around 10 mg/L, which is indicative of a healthy ecosystem (Gallager, 1997).

Table 1.5: Summary statistics for data contained on HYDROL database for the Coal River downstream of the Craigbourne Dam. The data was collected between 1990-1997 and in 2002.

Coal River ds Craigbourne Dam (3206)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Water Temperature	DegC	22	4.4	25	12.8	11.6
Chloride as Cl	mg/L	1	82	82	82	82
Dissolved oxygen	mg/L	2	8.74	9.27	9.01	9.01
Dissolved oxygen	% Saturation	2	92.5	94.6	93.55	93.55
Iron (Total) as Fe	mg/L	1	0.63	0.63	0.63	0.63
Magnesium (Total) as Mg	mg/L	1	14	14	14	14
Sodium (Total) as Na	mg/L	1	37	37	37	37
Suspended solids	mg/L	1	8	8	8	8
Total dissolved solids	mg/L	1	250	250	250	250
Redox Europe Stnd Ox	MV	3	45	87	68.3	73s
Manganese (Total) as Mn	mg/L	1	0.07	0.07	0.07	0.07
Calcium (Total) as Ca	mg/L	1	21	21	21	21
pH lab		1	8.3	8.3	8.3	8.3
pH field	Closed	11	6.7	9.1	7.77	7.5
Conductivity at 25°C Field	uS/cm	14	299	619	459.1	481
Conductivity at 20°C Field	uS/cm	5	556	670	611.8	615
Turbidity	NTU	2	3.21	5.43	4.32	4.32
River level	Metres	22	0.03	0.54	0.17	0.18

Coal River at Craigbourne Road (#3201)

The historical data from the Coal River at Craigbourne Road on the Hydrol database spans from 1974 - 1980 (Table 1.6). Continuous measures of level were recorded between July 1961 and January 1981. The median conductivity at this site for the period was 555 µS/cm, indicating that between Baden and this location there is some salt contribution to the river. The maximum recorded conductivity was 1580 µS/cm. This is very saline and can pose risks to in-stream ecological processes (Murray-Darling Basin Ministerial Council, 1999). The pH for this site ranges from 6.3 to 8.9 with a median value of 7.9. The median turbidity level of 4.32 NTU for this site suggests that the river is quite clear, however high flow events can cause elevated turbidity levels.

Table 1.6: Summary statistics for data contained on HYDROL database for the Coal River at Craigbourne Road. Data was collection from 1974 to 1980.

Coal River at Craigbourne Road (3201)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Albuminoid Ammonia	mg/L	25	0.08	0.6	0.34	0.32
Anionic Surfactants	mg/L	14	0.01	0.13	0.06	0.05
Apparent Colour	Hazen	74	5	240	50.67	30
Biochemical Oxygen	mg/L	24	0.5	12	3.39	2.5
Boron as B	mg/L	13	0	0.1	0.05	0.04
Calcium as C	mg/L	14	11.6	120.2	53.9	51
Chloride as Cl	mg/L	25	9	459	204.9	202
Confirmed Faecal Strep	Count/100n	21	15	810	185.3	130
DDT	mg/L	8	0	0	0	0
Dieldrin	mg/L	8	0	0	0	0
Dissolved oxygen	mg/L	62	5.4	13.6	10.5	10.5
Filtered residue (103-105)	mg/L	76	120	2880	637.1	559
Flouride as f	mg/L	14	0.003	0.11	0.05	0.05
Free Ammonia as NH_3	mg/L	25	0.02	0.4	0.14	0.16
Hexachloro (HCB)	mg/L	8	0	0	0	0
Iron (Total) as Fe	mg/L	25	0.04	9.1	1.11	0.55
Lab Cond @ TRef 20°C	uS/cm	12	216	1580	739.2	555
Laboratory pH		104	6.3	8.9	7.9	7.9
Manganese (Total) as Mn	mg/L	20	0.01	69.5	21.7	15.95
Mercury (Total) as Hg	mg/L	12	0	0.1	0.01	0
Nitrate as N	mg/L	21	0	0.66	0.16	0.12
Nitrite as N	mg/L	18	0	0.01	0.004	0.003
Potassium (Total) as K	mg/L	15	1.2	3.5	2.3	2.5
River level	Metres	104	0	0.65	0.13	0.1
Silica as SiO_2	mg/L	14	7.9	17.3	11.8	11.6
Sodium (Total) as Na	mg/L	14	13	134	70.1	70.5
Stream flow	Cumecs	21	0	2	0.34	0.08
Sulphate (Total) as S	mg/L	14	5	39	16.1	14.9
Suspended solids	mg/L	75	0.5	869	25.1	7
Thermotolerant coliforms	cfu/100mL	20	6	910	271.5	194
Total Bromeresol-Green	mg/L	25	4.8	241.2	124.2	134
Total Coliform 100mL	mg/L	21	16	970	321	252
Total hardness (CaCO3)	mg/L	20	78	550	287.5	272.9
Total Phosphate	mg/L	25	0	0.5	0.04	0.01
Turbidity Hellige	Hellige unit	76	0.9	141	13.91	7.5
Water Temperature	Degrees C	96	3	23.5	11.45	11

White Kangaroo Rivulet (#3209)

Data was collected at White Kangaroo Rivulet upstream of the confluence with the Coal River from 1987 to 1996 (Table 1.7). The median statistic for both lab and field pH shows that conditions are neutral to slightly alkaline. The minimum for the field pH is slightly lower than the pH values recorded from bottled samples analysed in the laboratory. Dissolved salt concentrations and conductivity data show White Kangaroo Rivulet is slightly saline, but compared to the site on the Coal River immediately upstream (#1102), salt levels are generally less. Nutrient concentrations (as indicated by total phosphorus and nitrate nitrogen concentrations) are similar to those recorded for sites in the Coal River.

Table 1.7: Summary statistics for data contained on HYDROL database for White Kangaroo Rivulet. The collection period was from 1987 to 1996.

White Kangaroo Rivulet (3209)						
Parameter	**Units**	**N**	**Min**	**Max**	**Average**	**Median**
Boron as B	mg/L	38	0	0.11	0.012	0.01
Calcium (Total) as Ca	mg/L	40	13	75	36.27	36.4
Copper (Total) as Cu	mg/L	36	0	0.2	0.013	0
Field Cond at Tref 20°C	mg/L	19	241	1010	533	460
Iron (Total) as Fe	mg/L	40	0	1.9	0.478	0.3
Lab Cond at Tref 25°C	µS/cm	35	240	920	554.3	540
Lab pH		34	7.4	8.2	7.8	7.8
Magnesium (Total) as Mg	mg/L	40	8	52	24	25
Nitrate as N	mg/L	34	0	0.2	0.05	0
pH Field		16	6	7.9	7.1	7
Potassium (Total) as K	mg/L	40	0	13.1	1.83	2
Redox Europe Stnd Ox	mV	5	21	161	70.8	51
River Level	metre	26	0.003	0.74	0.15	0.12
Salts Total Dissolved	mg/L	20	179	557.2	363	371
Sodium (Total) as Na	mg/L	40	23	134	58.5	56.5
Total Molybdenum as Mo	mg/L	35	0	0.13	0.01	0.01
Total Chlorine as Cl	mg/L	33	0	190	103.6	99
Total hardness ($CaCO_3$)	mg/L	9	115	273	182.4	184
Total phosphorous	mg/L	36	0	1	0.055	0
Total Sulphur as S	mg/L	40	0	4	2.02	2
Water Temperature	Degrees	26	5.5	21.6	11.5	10.1
Zinc (Total) as Zn	mg/L	36	0	0.15	0.005	0