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

Water Quality of Rivers in the Coal Catchment

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

PART 3

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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.

2.2 General Ionic Composition

Samples for characterising the ionic composition of waters in the catchment were collected on a quarterly basis from a subset of sites in the catchment. These sites are listed in detail below and referred to by their site labels in the following graphs. The analyses included determination of apparent colour, hardness, alkalinity, suspended solids and dissolved minerals and salts. Many of these reflect the geochemical composition of the rocks and soil of the area, although some parameters can be influenced by human related activities such as agriculture. The Coal River passes through various geological formations and rock types. From the headwaters the Coal flows primarily through Triassic sediments and Jurassic dolerite intrusions. From Campania to Colebrook the river flows through upper Triassic sediments, and at some places it has cut narrow gorges through dolerite bodies. From Campania to Pitt Water the river flow is through basalt and sandy-clay (Bennison, 1975).

Site Label	Site Name
CR1	Duckhole Rivulet at Colebrook Road
CR3	Coal River at Richmond weir
CR4	Coal River at Fingerpost Road
CR6	White Kangaroo Rivulet
CR11	Coal River downstream of Craigbourne Dam
CR12	Wallaby Rivulet near sewerage ponds
CR13	Coal River at Eldon Road Bridge
CR17	Coal River at Wattle Hill Road

A table presenting the summary statistics for all parameters covered by these analyses is shown below (Table 2.5). For the purpose of this section, all values have been reported and discussed in mg/L.

Table 2.5: Summary statistics for ionic parameters from the Coal River Catchment. Samples collected every three months.

	Lab pH	**Lab EC25** (uS/cm)	**Total Dissolved Solids** (mg/L)	**Total Suspended Solids** (mg/L)	**Apparent Colour** Hazen units
Median	7.1	800	475.5	<10	40
Max	8.7	3400	2100	74	225
Min	5.8	318	194	<10	5

	Alkalinity (mg/L)	**Chloride** (mg/L)	**Fluoride** (mg/L)	**Sulphate** (mg/L)	**Hardness** (mg/L)	**Iron** (mg/L)
Median	122	160	<0.1	16.5	208.5	0.29
Max	484	990	0.76	210	742	4.63
Min	31	48	0.02	0.49	70.3	0.034

	Manganese (mg/L)	**Calcium (mg/L)**	**Potassium (mg/L)**	**Magnesium (mg/L)**	**Sodium (mg/L)**	**Silica (mg/L)**
Median	0.04	37.4	2	27	66	10
Max	0.881	126	7.6	130	500	33
Min	0.005	13.8	0.6	8.71	27	0.1

The boxplots presented below present a visual representation of the statistics for some of of these parameters. The apparent colour of river water usually reflects the amount of dissolved organic matter (ie. humic substances) and suspended particles in the water column. Colour can also be affected by the presence of natural minerals such as iron hydroxides. Apparent colour is caused by coloured particulates and the refraction and reflection of light on suspended particulates and is measured in Hazen Units. In natural waters, colour can range from <5 in very clear waters to >300 in dark peaty waters with high levels of humic and other organic substances. Colour can also be correlated to river flow, with higher concentrations recorded during flood events when surface runoff brings organic and fine inorganic material to the river. Polluted water may also have quite a strong apparent colour (UNESCO, 1992), and water with high apparent colour can often affect taste and interfere with chlorination and other aspects of the water treatment process.

In the Coal River catchment, 5 of the 8 sites sampled had a median apparent colour of 30 units. The highest median value was 70 units at Duckhole Rivulet at Colebrook Road (Figure 2.26). This site shows a high level of variability in apparent colour measurements over the study period. It is a site that is greatly modified by surrounding landuse activities and for the majority of the time it was reduced to a pond, often with considerable algal and macrophyte growth. It is also interesting to note that while the median level at White Kangaroo Rivulet (CR6) is lower, the degree of variation is similar to that of Duckhole Rivulet (CR1).

High individual measurements of colour were also recorded at Wallaby Rivulet (CR12), which receives discharge from the wastewater treatment plant at Colebrook. The data also shows that as the Coal River emerges from the upper catchment it has a higher median colour, which declines in a downstream direction. The exception to this trend is Duckhole Rivulet.

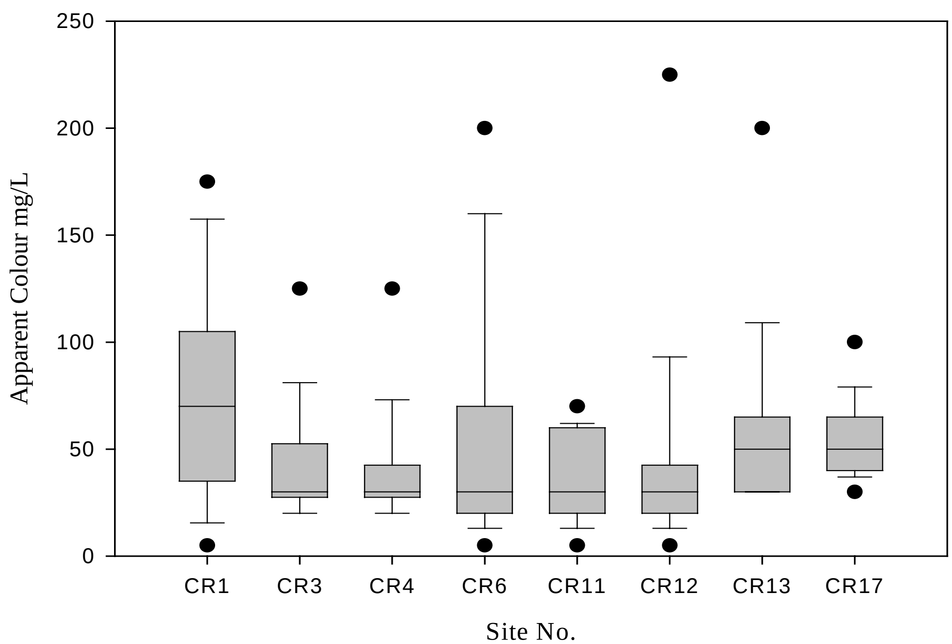

Figure 2.26: Statistical plot of apparent colour at sites in the Coal catchment (February 99 - December 2001).

Total suspended solids (TSS) and total dissolved solids (TDS) consist of silt, clay, fine particles of organic and inorganic matter, soluble organic compounds, plankton and other microscopic organisms. TSS and TDS correspond to non-filterable and filterable residue, respectively. The type and concentration of these two parameters control the level of turbidity and transparency in surface waters (UNESCO, 1992). Turbidity can often be related to TSS. TDS is the fraction that remains behind, in liquid state after water has been evaporated from the sample.

As Table 2.5 shows, results for total suspended solids analysis reflect the generally good level of clarity of surface waters in the Coal River catchment (<10mg/L). It must be noted that laboratory detection limits for total suspended solids is 10mg/L. The maximum level of 74 mg/L occurred in October 2001 at Duckhole Rivulet (CR1). As mentioned above, this site was often reduced to a severely stagnant pond with lots of algae present in the water.

During rainfall events, there are considerably higher concentrations of total suspended solids in rivers and streams as a result of surface runoff. Figure 2.27 demonstrates the relationship between turbidity and total suspended solids at site CR3 (Coal River at Richmond weir) during a rain event in March 1999. As the rain event peaks there is a corresponding rapid increase in both total suspended solids and turbidity levels. This is then followed by a gradual decline as runofffrom the rain event declines. The relationship between turbidity and total suspended solids is discussed in detail in Section 3.

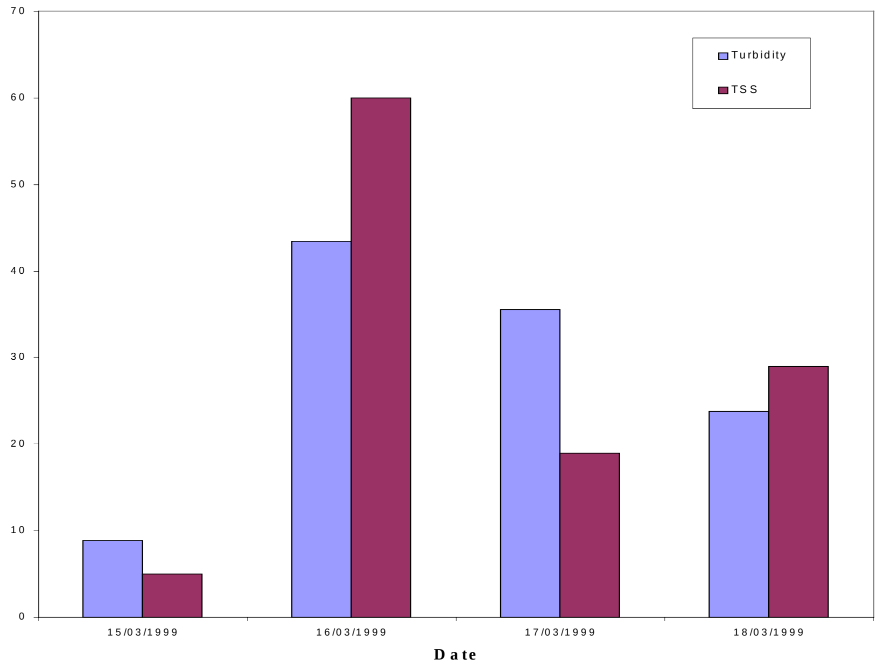

Figure 2.27: Turbidity (NTU) and total suspended solids (mg/L) in the Coal River at Richmond weir (CR3).

The hardness of most fresh, surface waters in Australia lie between 25 – 400 mg/L as $CaCO_3$. Water hardness is a total measure of the major cations (predominantly calcium and magnesium) and it is an important parameter in freshwaters as it can have a major effect on the toxicity of metals. Water hardness can range from <1 mg/L (very soft) to >400 mg/L (very hard) (ANZECC, 2000). Of the 8 sites sampled in the Coal River catchment, 2 had median hardness values above 400 mg/L (Figure 2.28). Sites with elevated hardness were Duckhole Rivulet (CR1) at the bottom of the catchment and Wallaby Rivulet (CR12), which receives discharge from the wastewater treatment plant at Colebrook. There was a trend in the Coal River for increasing hardness with distance from source, with lowest median hardness (70.3 mg/L) at Wattle Hill Road (CR17) and highest median hardness at CR3 (Richmond weir). Concentrations of calcium (Figure 2.29) and magnesium mimicked this pattern.

The hard nature of water in the Coal River is also demonstrated by the high concentrations of iron and other constituents like potassium (Figure 2.30) and sodium (Figure 2.31). Increasing calcium and magnesium concentrations in waters (hardness) is usually associated with increases in alkalinity (ANZECC, 2000). Concentrations of both potassium and sodium showed a slight to moderate increase in concentration down the length of the Coal River (Figure 2.30 & 2.31), although potassium concentrations in Wallaby Rivulet (CR12) were not as elevated as other parameters.

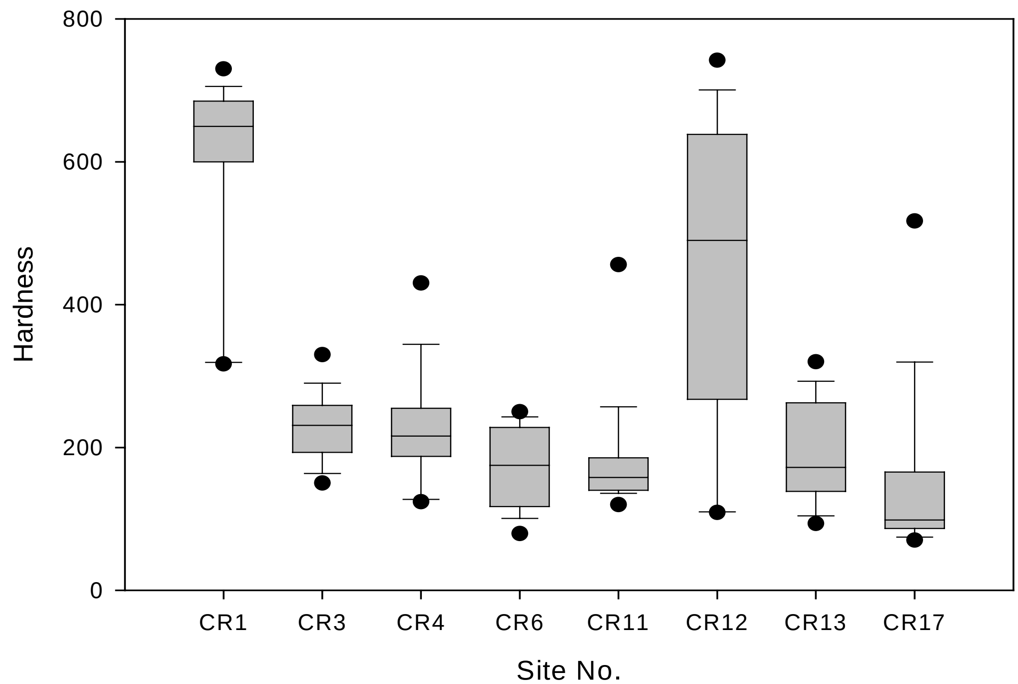

Figure 2.28: Statistical plot for hardness at sites in the Coal catchment (February 1999-December 2001).

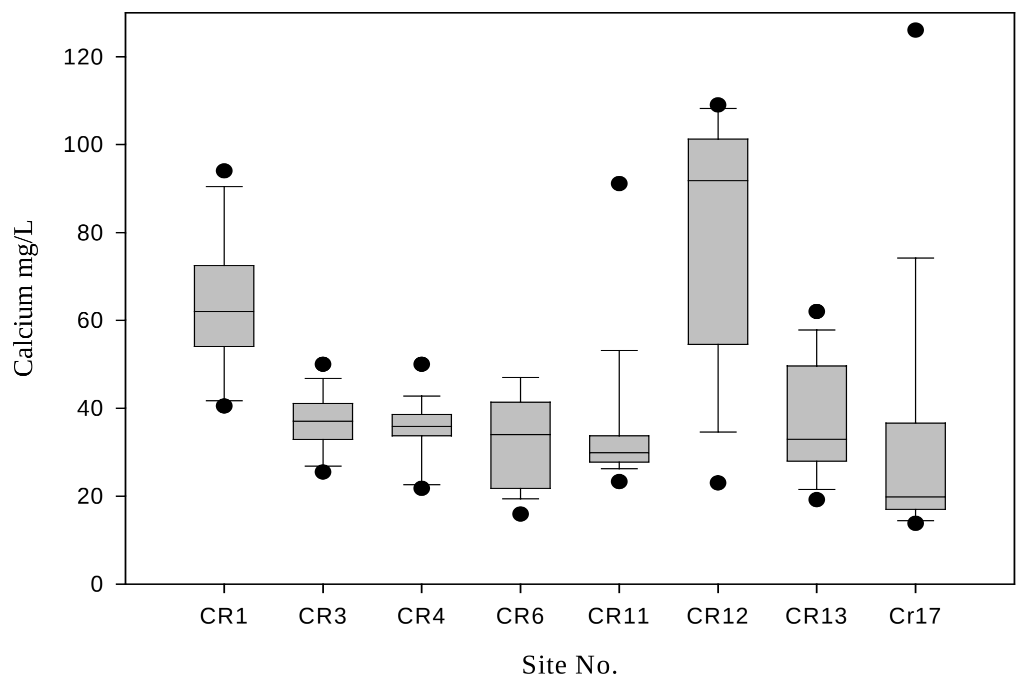

Figure 2.29: Statistical plot of calcium concentrations at sites in the Coal catchment (February 1999-December 2001).

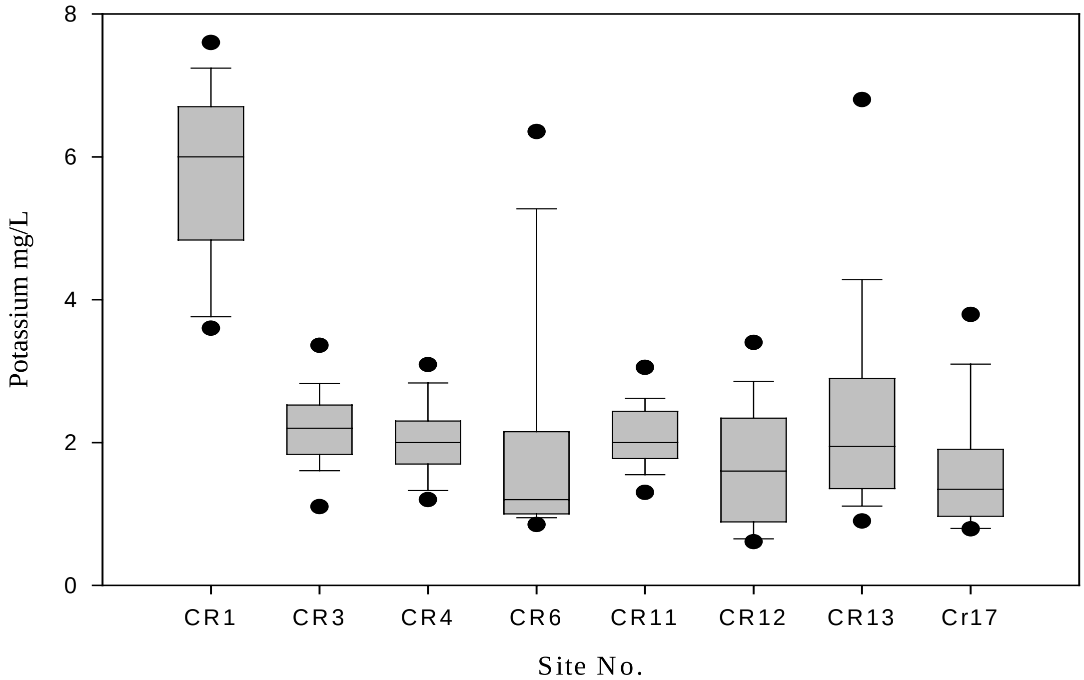

Figure 2.30: Statistical plot of potassium concentrations at sites in the Coal catchment (February 1999-December 2001).

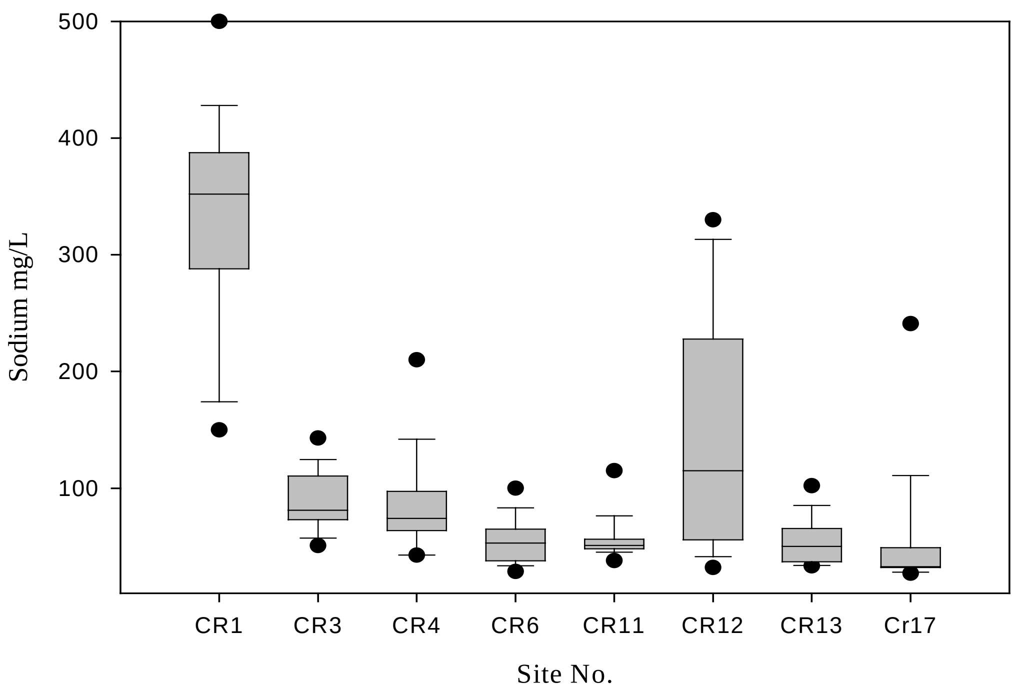

Figure 2.31: Statistical plot of sodium concentrations at sites in the Coal catchment (February 1999-December 2001).

Sulphate is naturally present in surface waters as SO_4^{2-}, and originates from the atmospheric deposition of ocean aerosols or from geological processes such as the leaching of sulphite minerals from sedimentary rocks (UNESCO, 1992). In Tasmania studies have shown that sulphate concentrations in natural waters are usually around 5mg/L (Bobbi, Fuller & Oldmeadow, 1996). Streams receiving some form of polluting effluent often have higher sulphate concentrations (15-30mg/L). All sites monitored in the Coal River catchment for this project recorded median concentrations above 5mg/L (Figure 2.32), suggesting that there is some broad-scale factors or mechanisms contributing sulphate to the system. With the exception of CR1 (Duckhole Rivulet), higher concentrations occurred at sites in the upper catchment. The highest sulphate level was 210mg/L, recorded at the Coal River at Wattle Hill Road (CR17) on the 6th of February 2001 (Figure 2.33), when very high conductivity was also recorded. This level of sulphate was considerably higher than the level recorded at all other sites and has been omitted from Figure 2.33 as it is an outlier.

While the high sulphate concentrations in waterways draining the upper catchment may be influenced the application of fertilisers to surrounding pastures, it is more likely that they reflect the geological characteristics of the upper catchment which contains Permian and Triassic sedimentary sequences. The elevated concentrations recorded at CR1 low in the catchment are more likely to be influenced by local land use activities, which are more intense in this area.

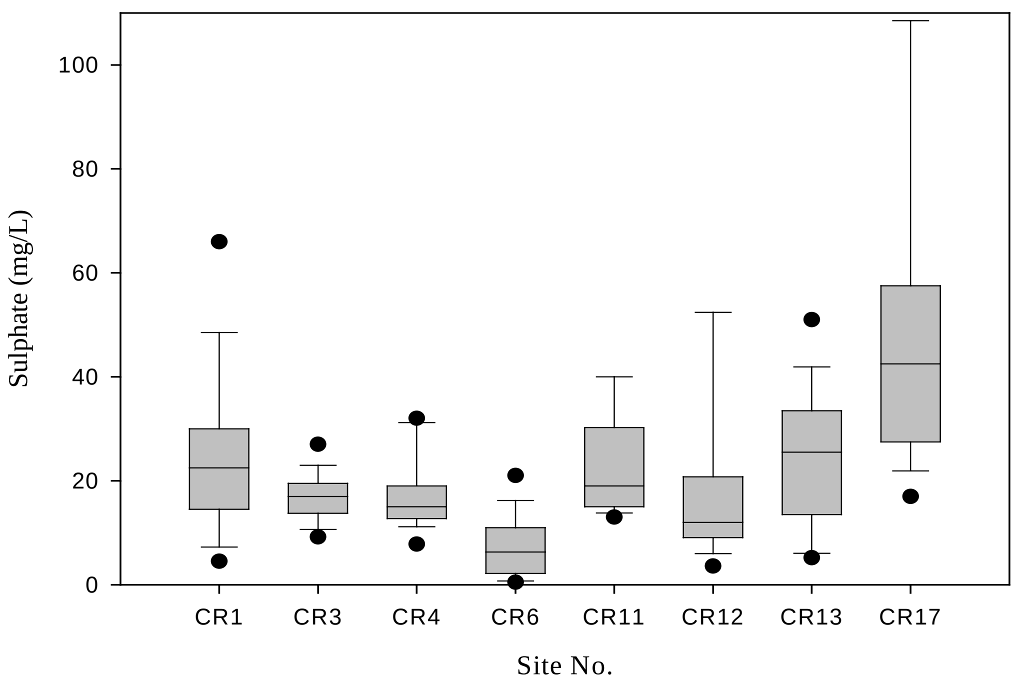

Figure 2.32: Statistical plot of sulphate concentrations at sites in the Coal catchment (February 1999-December 2001).

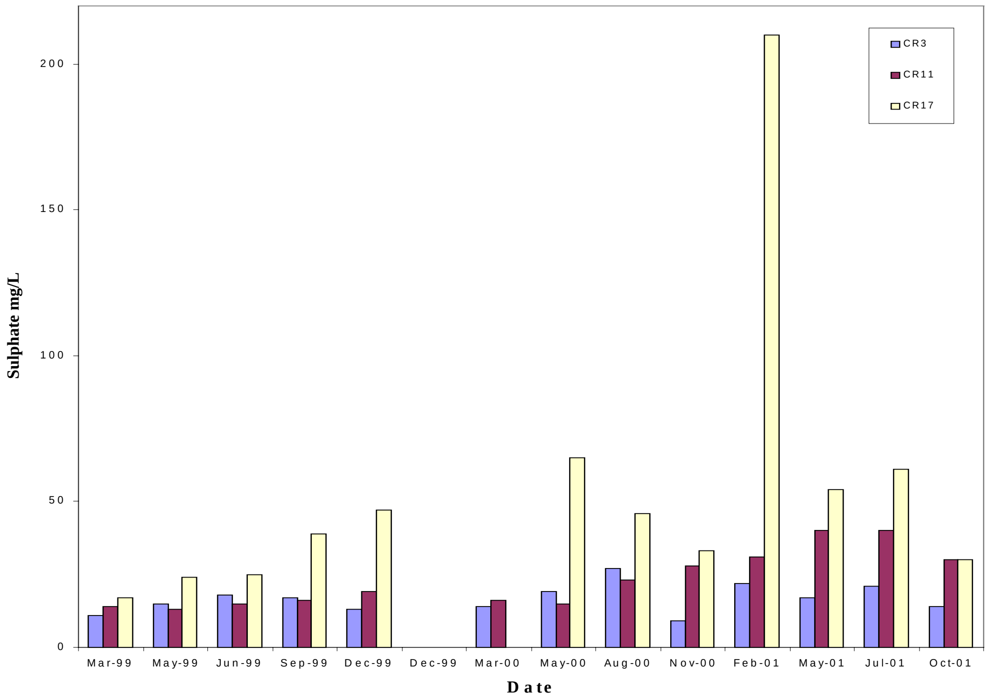

Figure 2.33: Sulphate concentrations at sites in the Coal catchment (February 99-Dec01).

2.3 Nutrient Results

Nutrient pollution can impact on ecosystems directly and indirectly. One of the most common problems is the stimulation of growth of algae (including potentially toxic blue-green algae) and nuisance plants that can dominate and change the structure of an aquatic ecosystem. The most bioavailable forms of nitrogen and phosphorus are ammonia (NH_3^+), nitrate (NO_3^-) and dissolved reactive phosphorus (ANZECC, 2000). The concentrations of nutrients in water draining agricultural areas can be quite variable and may be heavily impacted by specific activities (eg. Fertiliser applications, pasture drainage, stock access, etc) or site condition (eg. River-bank erosion, silt deposition, etc). It is important to view water quality data in conjunction with local land-use and river management information.

Monthly sampling of nutrients was carried out at 8 sites in the catchment (refer to Table 2.1). Samples were tested for total concentrations of nitrogen and phosphorous as well as for nitrate, nitrite, ammonia and dissolved reactive phosphorous. Samples were collected during conditions of low flow in the Coal River (0 to 4 cumecs) and then processed by a NATA (National Association of Testing Authorities) accredited laboratory. Duplicates and blank samples were taken as a means of checking field sampling and preservation techniques as well as for quality assurance checks on laboratory processing.

2.3.1 Total Nitrogen

Total nitrogen (TN) in environmental waters is the sum of organic nitrogen, nitrate nitrogen (NO_3/N) and nitrite nitrogen (NO_2/N), although NO_2/N is normally detected at only very low concentrations unless there is some local form of effluent entering the waterway. Nitrogen in natural environments is generally derived from the atmosphere and incorporated into organic forms through the process of nitrogen fixation by plants. From then on there is a multitude of complex pathways by which nitrogen is converted to ammonia, nitrate and other forms of nitrogen (Nitrogen Cycle). Nitrogen in waterways is also influenced by human activities such as intensive animal husbandry, sewage effluent treatment discharges and agricultural fertiliser application. All these activities have the potential to increase substantially the concentrations of nitrogen species in rivers and streams. Total nitrogen concentrations can vary from as low as 100-200 μg/L in pristine streams, to in excess of 10,000 μg/L in heavily polluted rivers (ANZECC, 2000).

The data for monthly TN concentrations in the Coal River catchment is presented in Figure 2.34. There is a tendency for elevated TN concentrations at sites CR1 (Duckhole Rivulet) and CR6 (White Kangaroo Rivulet), with highest TN concentrations (4930 μg/L) being recorded at White Kangaroo Rivulet. These high TN concentrations may be a result of NH_3 being released form decaying organic material on the bottom of the river during the winter months, as ammonia concentrations at that time were also very high (see later section). The elevated TN concentrations at CR1 are likely to reflect the combined influence of local landuse practices and low flows in this stream.

The median data for TN concentrations (Figure 2.34) at all sites was above the 480μg/L level recommended by ANZECC (2000) for Tasmanian streams and rivers.

The data show that there is a general trend for increasing concentrations in a downstream direction in Coal River. The median concentration of TN at sites in the upper catchment is about 550 μg/L increasing to a median concentration of approximately 700 μg/L in the lower catchment. Site CR11 on the Coal River downstream of Craigbourne Dam had the highest median TN concentrations (907 μg/L), and clearly reflects the influence the impoundment has on TN levels. The high concentrations of TN in the impoundment are partly a reflection of the nutrient storage capacity of the dam, and the large biomass of blue-green algae that is now almost permanently a feature of this waterway. High concentrations of TN were recorded during studies prompted by the development of blooms of *Anabaena circinalis* in the mid-1990's (Bobbi, 1997a), and monitoring at that time suggested a strong link between algae biomass in the water column and TN concentration.

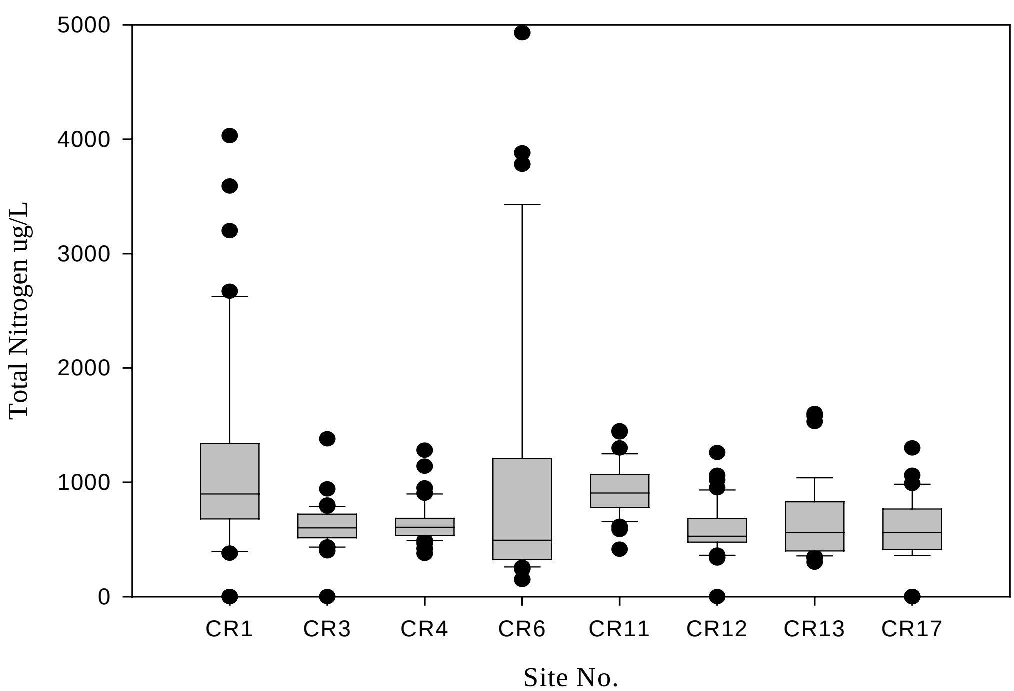

Figure 2.34: Statistical plot of monthly total nitrogen (μg/L) concentration at sites in the Coal River catchment (February 1999 – December 2001).

The time series plots given in Figure 2.35 compares the pattern of change in monthly TN concentrations at 3 sites on the Coal River. The plot shows that although there is not a distinct seasonal change in TN concentration at all sites, there is a tendency for higher TN concentrations in autumn, and lower concentrations in winter and spring.

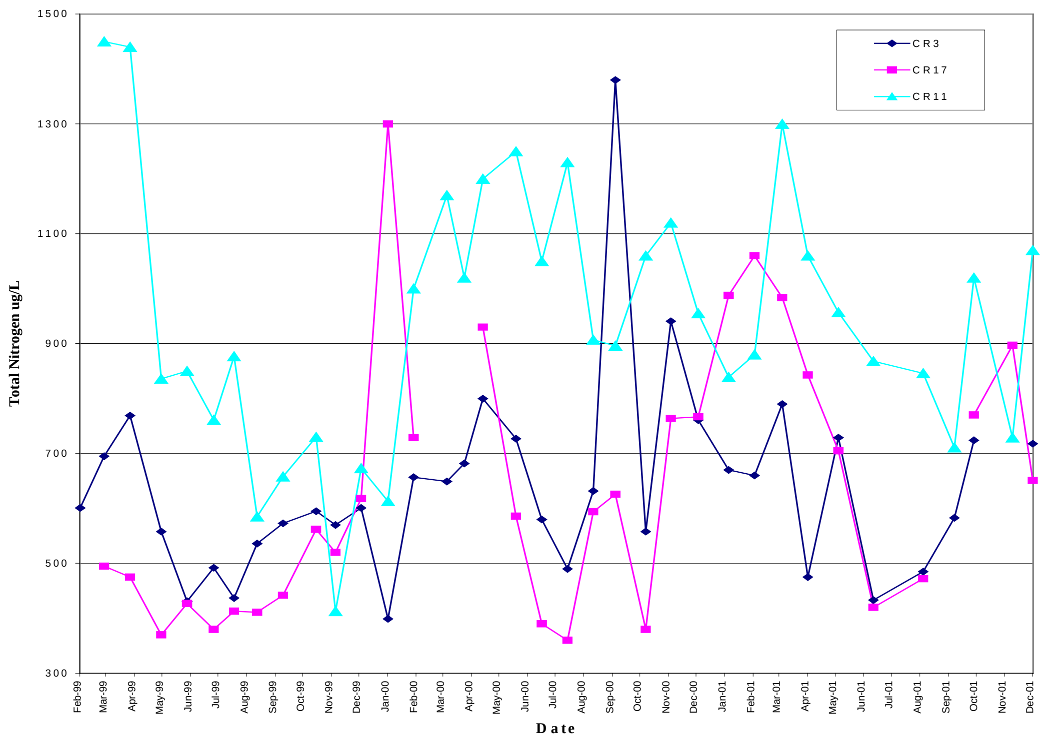

Figure 2.35: Time series plot of total nitrogen concentration at three sites in the Coal River (February 1999 – December 2001).

2.3.2 Nitrate Nitrogen

Nitrate Nitrogen (NO_3/N) is the soluble form of total nitrogen and easily passes from soils into groundwater where it can influence surface water concentrations during baseflow conditions. Natural sources of NO_3/N originate from geological processes and the breakdown of plant and animal material and in rural environments from the use of inorganic fertilisers and increased levels of animal and plant wastes (UNESCO, 1992). Land clearing for pasture and cropping can increase soil aeration and enhance the action of nitrifying bacteria, and this can further increase soil NO_3/N concentrations. Nitrate often varies on a seasonal basis, with higher concentrations generally occurring in winter, when NO_3/N is leached from the soil profile by pore-water movement (Kladivko, *et al.,* 1991) and lower plant uptake (Wright, *et al.*, 1991).

Nitrate concentrations are usually higher in industrial, urban and agriculturally developed areas. Nitrate concentration often shows a complex pattern of behaviour with changing flows in rivers. As streamflow increases following rainfall, the influence from point sources decrease as they become diluted, however diffuse sources of NO_3/N from agricultural land may result in temporarily higher concentrations. During the low flows of summer, in-stream processes often decrease NO_3/N concentrations during the summer months by denitrification (Neale, 2001).

ANZECC (2000) recommend that oxides of nitrogen should not exceed 190 µg/L for upland streams in south eastern Australia. The spatial pattern for NO_3/N concentrations across the catchment is shown in Figure 2.36. Results show that concentrations can temporarily be significantly higher than the recommended levels, but the median level at all sites is less than 190 µg/L. Once again, the median concentration (100µg/L) at CR11 (Coal River d/s Craigbourne Dam) is significantly greater than all other sites and reflects the influence of conditions within Craigbourne impoundment, which is seasonally affected by substantial algal blooms.

Periodic high concentrations of NO_3/N were also detected at CR6 (White Kangaroo Rivulet), where two measurements in excess of 500 µg/L being recorded. The cause of this is not clear, but may be influenced by seasonal rainfall and leaching of stored NO_3/N from the soil profile, as both of these were recorded during higher baseflow conditions following recent rainfall.

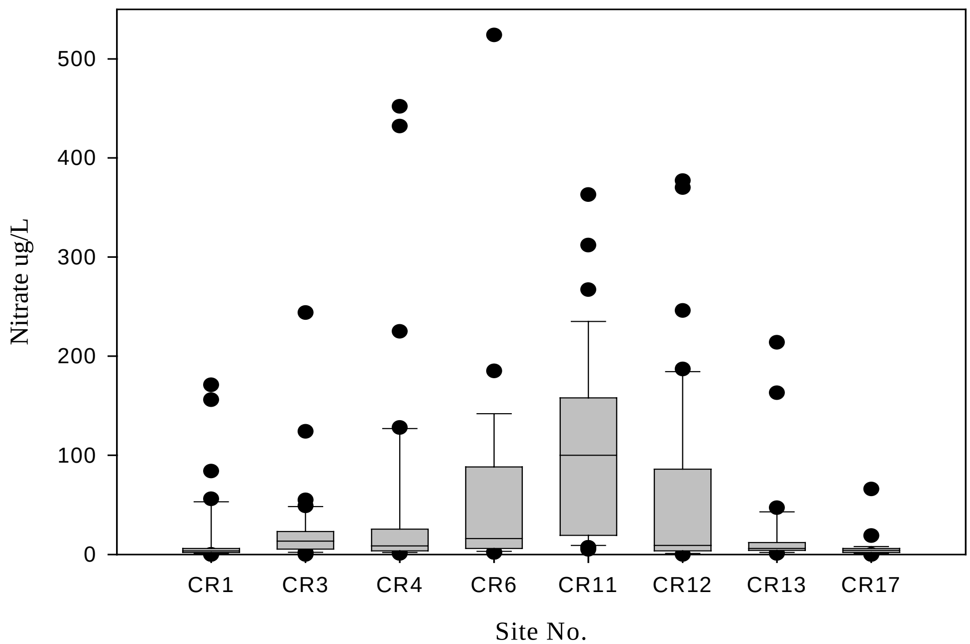

Figure 2.36: Monthly nitrate concentrations on the Coal River (February 1999 – December 2001). An outlier for CR6 of 696µg/L was omitted from the graph.

The seasonal pattern of change in NO_3/N concentration for three sites in the Coal catchment, CR4, CR6 and CR11 is shown in Figure 2.37. The concentration of NO_3/N tends to increase at most sites in late winter and early spring, depending on rainfall. The influence of rainfall on NO_3/N concentration in rivers in the catchment is best illustrated by the data for January 2000, which was collected 24-hours after the commencement of significant rainfall across the catchment. As the plot shows, high NO_3/N concentrations were recorded at all sites at that time, and reflect the widespread leaching of stored NO_3/N from the soil throughout the catchment.

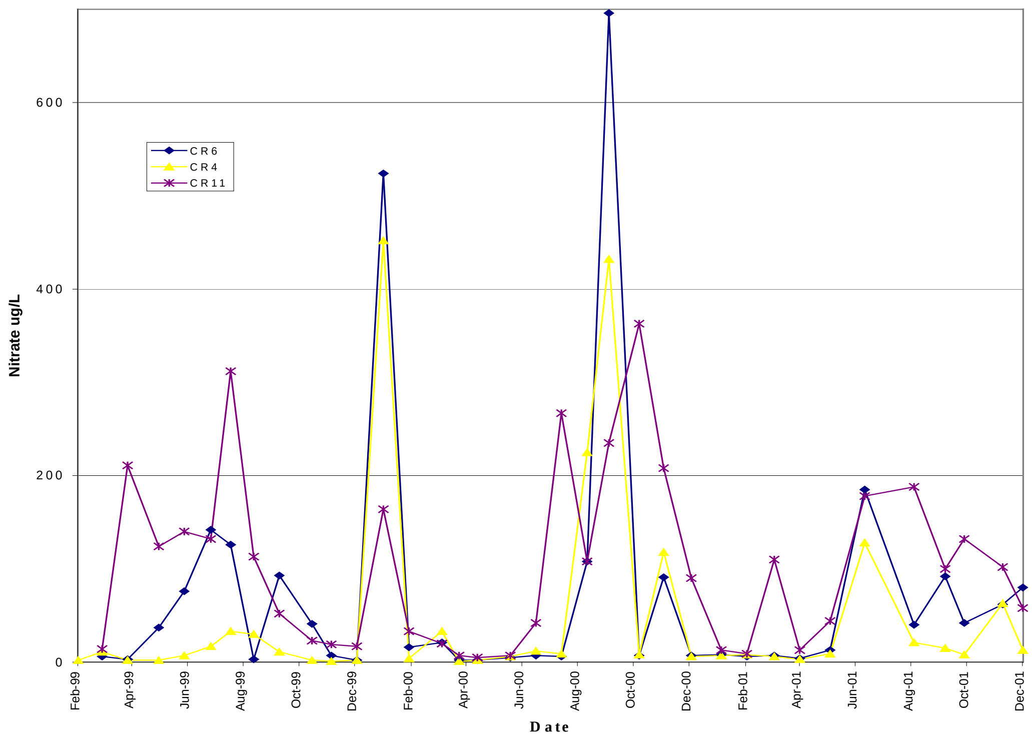

Figure 2.37: Time series plot of nitrate concentration at three sites in the Coal River catchment (February 1999 – December 2001).

2.3.3 Ammonia Nitrogen

Ammonia (NH_3/N) naturally occurs in surface water as a result of the breakdown of organic and inorganic materials and excretion from biota. High concentrations NH_3/N can be an indicator of organic pollution. The toxicity of ammonia to aquatic life increases with decreases in dissolved oxygen concentrations and pH (UNESCO, 1992). ANZECC (2000) recommends that at a pH of 8 NH_3/N concentrations should not exceed 900 μg/L in order to protect ecosystems that are 'moderately disturbed'.

Extremely high NH_3/N concentrations were recorded at White Kangaroo Rivulet (CR6) during a lengthy period of no flow in winter 2000. The NH_3/N recorded at this time was 4380 μg/L (Figure 2.38), which at that time comprised almost 90% of the total nitrogen at this site. This site is prone to ponding, and is home to a large population of ducks, which is the most probable explanation of these extremely high concentrations. Depleted dissolved oxygen levels were also recorded at CR6 when NH_3/N concentrations were at their highest. This could increase the toxicity of ammonia and could cause significant stress to the aquatic biota restricted to this location by the lack of flow. Ammonia concentrations at all other sites sampled in the Coal catchment did not exceed the recommended ANZECC (2000) guideline value.

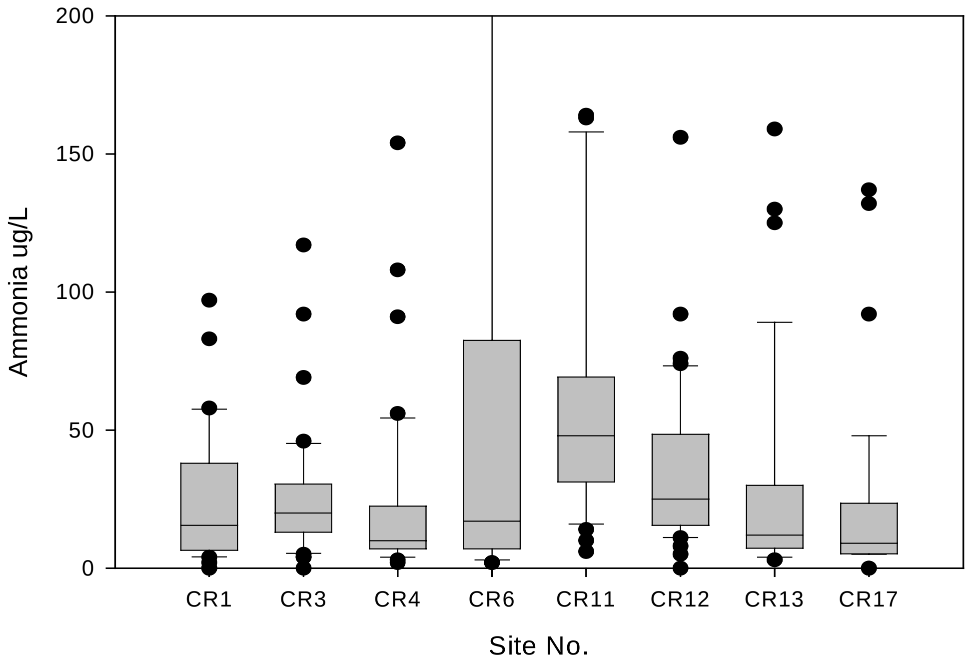

Figure 2.38: Monthly ammonia concentrations on the Coal River (February 1999 – December 2001). Three exceptionally high readings recorded at CR6 of 1500 μg/L, 900 μg/L and 4380 μg/L were omitted from this graph.

2.3.4 Total Phosphorus

Phosphorus is one of the nutrients essential for growth of aquatic plants and animals, and is often the underlying factor driving ecosystem productivity. However, in surface waters phosphorus is normally present at very low concentrations and is usually the nutrient that limits the growth of algae. When it is present in excess, it can trigger algal blooms, a feature of eutrophication. Although algae and aquatic plants generally require phosphorus in its dissolved form, once present in a waterway it can change between dissolved and particulate forms depending on environmental conditions and biochemical processes (UNESCO, 1992).

Both diffuse sources (fertiliser use and stock grazing) and point sources (sewerage effluent discharge and urban runoff) can cause increased inputs of phosphorous to rivers, lakes and streams. Phosphorous is normally present attached to organic and inorganic particulate material and can often be related to turbidity levels. Total phosphorous (TP) concentrations can vary from less than 10 μg/L in small near-pristine mountain streams to over 1000 μg/L in heavily polluted rivers (ANZECC, 2000). It is recommended that 13 μg/L be used as the default trigger value for TP concentrations for Tasmanian rivers and streams.

The summary statistics for TP within the Coal River catchment is shown in Figure 2.39. Median values for all sites were between 14 – 44 μg/L, all of which are above the concentrations recommended for Tasmanian rivers. Concentrations were highest and most variable at Duckhole Rivulet (CR1), where TP in excess of 100 μg/L was frequently recorded. Total phosphorus concentrations above 100 μg/L were also recorded at a number of other locations, a number located in the catchment above Craigbourne Dam. Previous sampling in Craigbourne Dam suggested that elevated TP in the impoundment has contributed to the development of blue-green algal blooms in that storage (Bobbi, 1997a). The TP data for CR11, immediately downstream of the dam, supports this conclusion. Together, these data imply that there may be a substantial load of TP entering the impoundment and continuing to support the blooms of toxic blue-green algae that have become almost a permanent feature of this storage over the past 5 years. Future measures may be needed to reduce total phosphorous loads entering the storage if the frequency and intensity of blue-green algal blooms in Craigbourne Dam are to be reduced. Successful management of blooms will also have flow-on benefits for the Coal River environment and water users downstream.

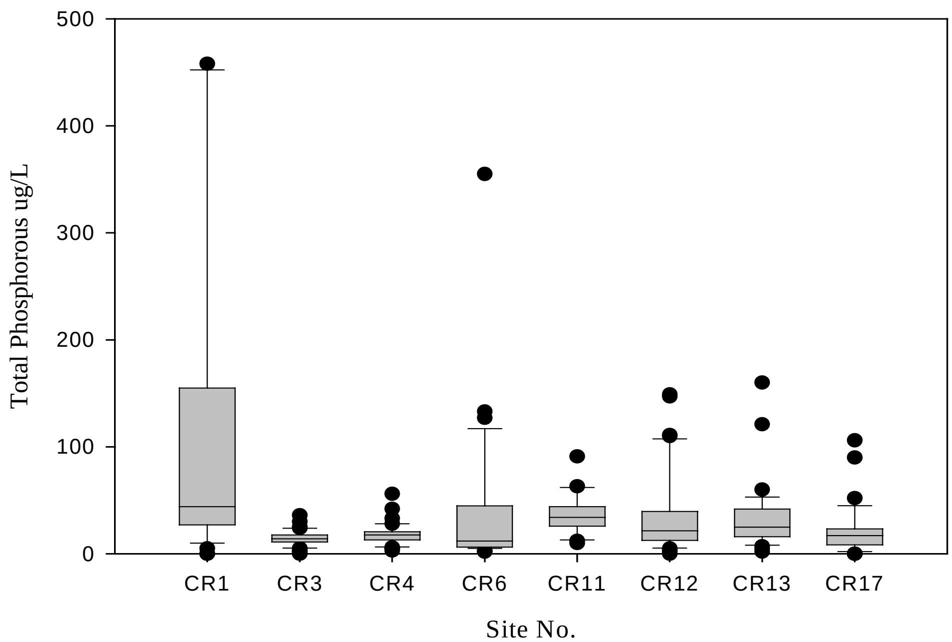

Figure 2.39: Monthly total phosphorous concentrations on the Coal River (February 1999 – December 2001).