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

Water Quality of Rivers in the Jordan Catchment

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

PART 5

Katrina Wilson
Abigail Foley
Water Assessment and Planning Branch
Water Resources Division

December 2003

Preferred Citation:

DPIWE (2003) *State of the River Report for the Jordan River Catchment.* Water Assessment and Planning Branch, Department of Primary Industries, Water and Environment, Hobart.
Technical Report No. WAP 03/10

ISSN: 1449-5996

The Department of Primary Industries, Water and Environment

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.

2.5. Diurnal Water Quality Variations

During this study, continuous monitoring equipment was deployed at six sites to record diurnal fluctuations. These sites were:

J5a	- Bagdad Rivulet at Rifle Range Road;
J6	- Jordan River at Elderslie Road Bridge at Green Glory;
J6a	- Grahams Creek at Elderslie Road;
J9	- Jordan River at Roydon Road 300m downstream of bridge;
J13	- Jordan River at Sheepwash Corner on the Lake Highway; and
J19	- Exe Rivulet

Various parameters are subject to variations in their concentrations during a diurnal cycle. Where surface waters receive organic pollution or nutrient enrichment which encourages aquatic plant growth, there can be large fluctuations in pH and dissolved oxygen levels (Cooke and Jamison, 1995). This can have detrimental impacts on aquatic invertebrates and fish life. Elevated nutrient and organic loads in New Zealand streams has been linked to oxygen depletion (Wilcock *et al*., 1995).

The drought conditions which persisted throughout much of the study presented this program with an opportunity to record diurnal fluctuations under a variety of conditions, ranging from stable base flows to reducing and returning flows. The following section presents the data collected during these deployments and discusses the time series in relation to the physical and chemical characteristics of the sites.

2.5.1 Bagdad Rivulet (J5a) and Grahams Creek (J6a)

Simultaneous logging events were carried out at these two sites from 30th November 1999 to 3rd December 1999, when conditions in the catchment were dry and warm. The purpose of this deployment was to characterise diurnal variations in water quality in two tributaries of the Jordan River catchment.

Although conductivity in Bagdad Rivulet was approximately 2000 μScm^{-1} greater than at Grahams Creek, the time series from both sites showed the effects of increasing ground water influences on surface water salinities, with conductivity steadily increasing during the period of deployment (Figure 2.5.1). The deployments at both sites commenced approximately a week following a minor rainfall event, and the plots reflect this, with steadily increasing conductivity. As previously stated it can be assumed from these data that the steady increase in conductivity represents the influence of geology on groundwater at both sites. Bagdad Rivulet travels though an extensive region of tertiary alluvium where as Grahams Creek runs through an area predominantly of dolerite in origin. Although the plot for the 4-day period shows that there was a linear increase in conductivity at both locations, this is likely to have reached a plateau at some point.

Site characteristics influence the pattern of diurnal water quality change, in particular water temperature. The Bagdad Rivulet (J5a) deployment site is situated in a shallow pool where there is minimal riparian vegetation and shading. As a result water temperature at this site undergoes larger daily variations, and is generally warmer than was found at Grahams Creek (Figure 2.5.2), where peak daytime water temperature was about 8-10 °C less due to riparian shading. Peak daytime temperature at Bagdad Rivulet was extremely high (>27 °C).

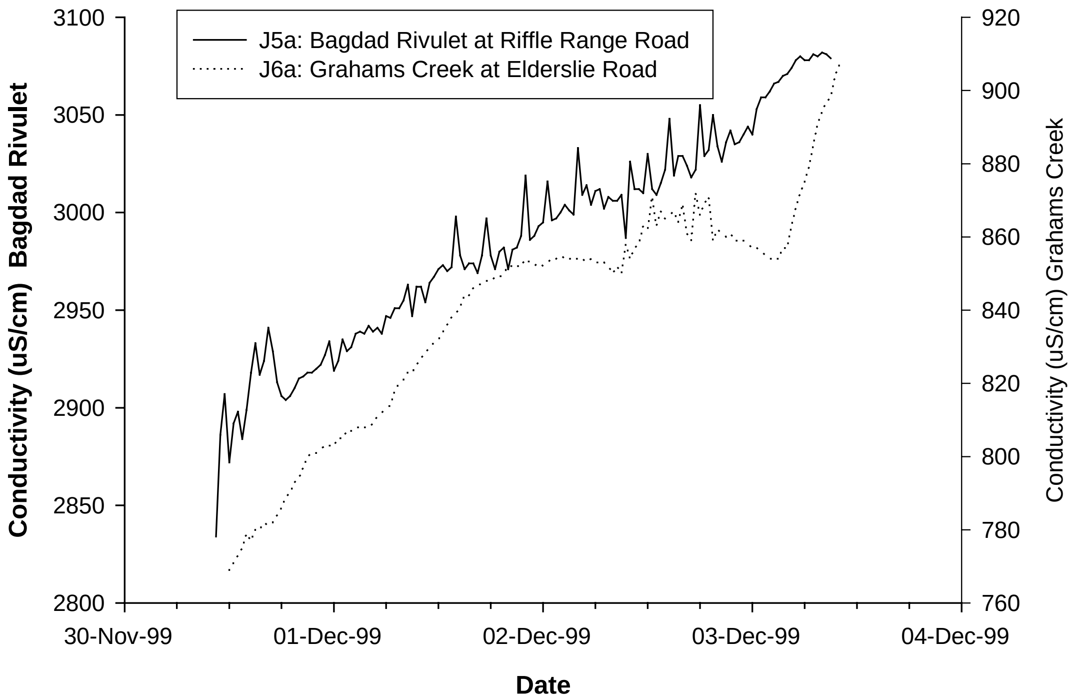

Figure 2.5.1: Variations in conductivity logged between 30th November 1999 and 3rd December 1999 at Bagdad Rivulet (J5a) and Grahams Creek (J6a).

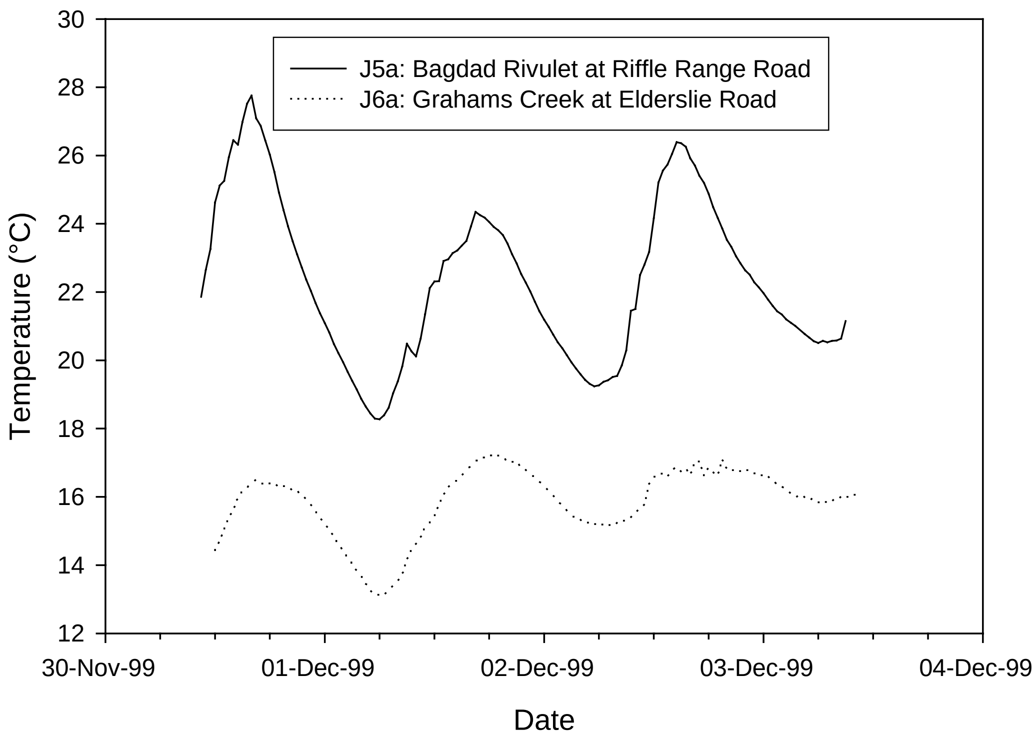

Figure 2.5.2: Diurnal variations in temperature logged between 30th November 1999 and 3rd December 1999 at Bagdad Rivulet (J5a) and Grahams Creek (J6a).

Dissolved oxygen levels at both sites also shows distinct daily variations (Figure 2.5.3). Changes in dissolved oxygen are often driven by the respiration of aquatic plants and aerobic bacteria (Boulton and Brock, 1999). As previously discussed in section 2.2, water temperature also influences the ability of water to hold oxygen, and where there are large changes in water temperature, there are often also large changes in dissolved oxygen. This is illustrated by data from J5a, where peak daytime oxygen saturation was in excess of 140%, and was followed by late night saturation levels of about 40% or less. Dissolved oxygen at both J5a and J6a were below those recommended by ANZECC (2000) and is likely to cause significant stress to aquatic species (Koehn and Connor, 1990). Dissolved oxygen at Bagdad Rivulet is clearly extreme, and while the changes in oxygen have also influenced pH levels at both sites (Figures 2.5.4a & b), it is clear that daily changes at J5a indicate a highly modified and out of balance system. In contrast data for Grahams Creek illustrated a decline in dissolved oxygen levels with less distinctive diurnal peaks (Figure 2.5.3). This was also mirrored by other parameters that influence and are influenced by dissolved oxygen concentrations (ie pH and temperature).

Like dissolved oxygen, diurnal cahnges in pH are often the result of photosynthetic and respiratory activity from aquatic plants and algae. During the day photosynthesis reduces dissolved CO_2, which has the same effect as dissociating carbonic acid (H_2CO_3), resulting in an increase in pH. In contrast, respiration reverses the cycle with in stream flora increasing CO_2, which is hydrated to form carbonic acid thereby lowering pH (Boulton and Brock, 1999). Therefore variations in pH often mirror that of dissolved oxygen, and this is demonstrated by Figures 2.5.4a and 2.5.4.b.

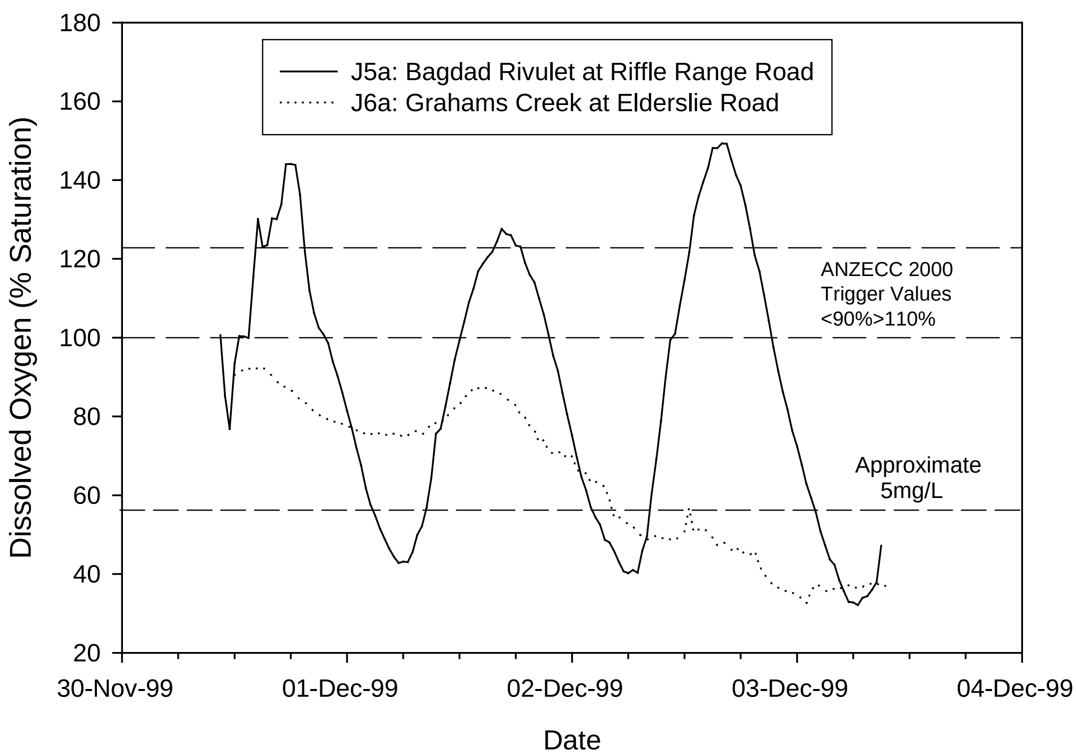

Figure 2.5.3: Diurnal variations in dissolved oxygen concentrations logged between 30th November 1999 and 3rd December 1999 at Bagdad Rivulet (J5a) and Grahams Creek (J6a).

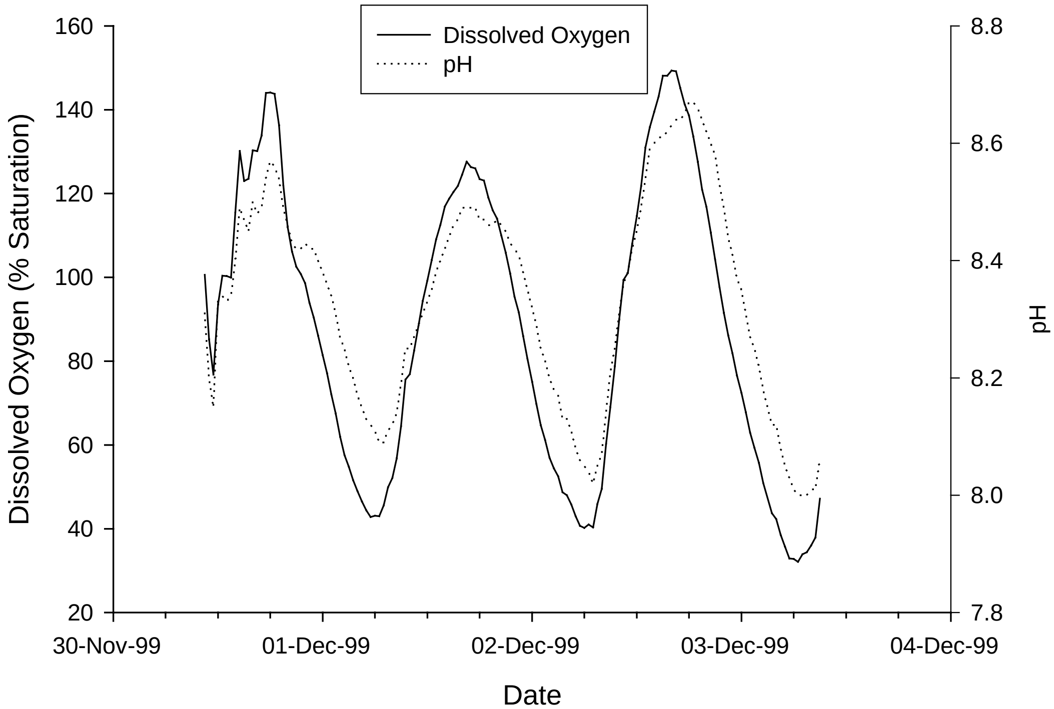

Figure 2.5.4a: Diurnal variations in dissolved oxygen and pH concentrations logged between 30th November 1999 and 3rd December 1999 at Bagdad Rivulet (J5a).

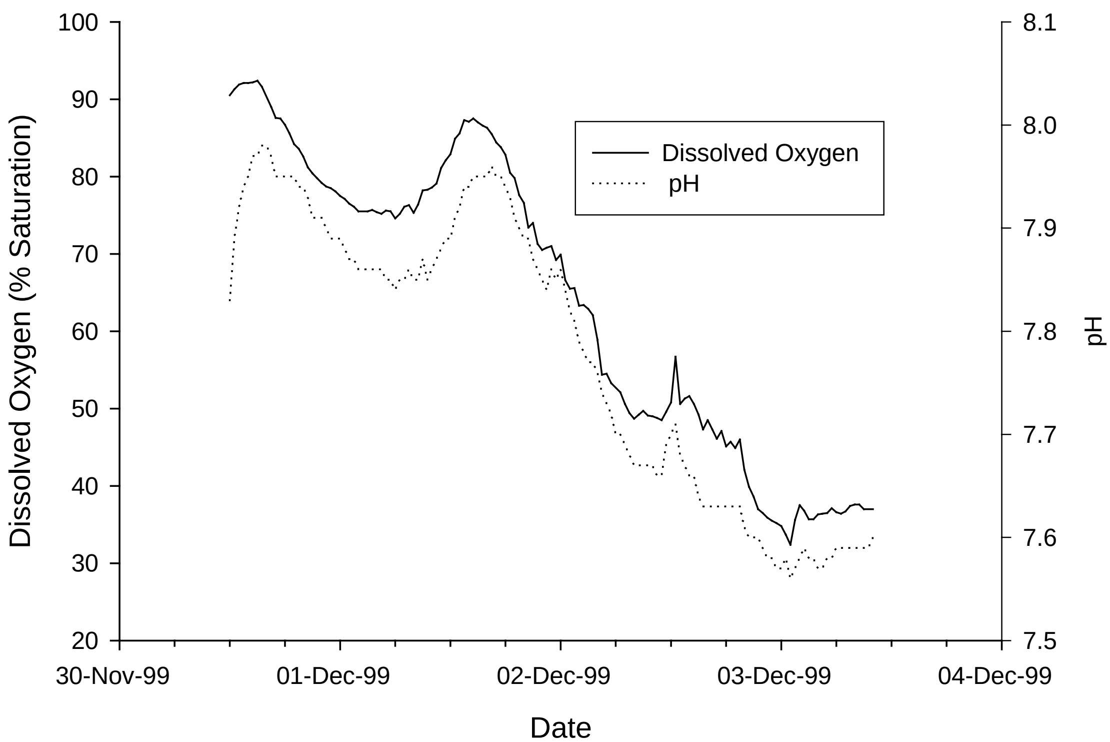

Figure 2.5.4b: Diurnal variations in dissolved oxygen and pH concentrations logged between 30th November 1999 and 3rd December 1999 at Grahams Creek (J6a).

2.5.2 Jordan River at Elderslie Road bridge at Green Glory (J6)

Three logging deployments took place at J6 between 1999 and 2001, during conditions when there was minimal flow at this site (23rd - 25th November 1999 and 31st January - 4th February 2000) and no flow (21st - 25th May 2001). This site represents one of the deeper ‘ponds’ of the Jordan River, and is subject to nutrient inputs from the adjoining dairy. The site is also heavily vegetated along is banks by Crack Willow (*Salix fragilis*). During periods of low or no flow, *Azolla spp* often formed an extensive mat at the weir end of this site. The data for diurnal variations in temperature, dissolved oxygen, and pH illustrates the heavily modified nature of this site. This is further supported by nutrient concentrations monitored at this site as discussed in section 2.3.

During all deployments, dissolved oxygen concentration was generally below 4 mg/L and occasionally below 2 mg/L (Figure 2.5.5). Dissolved oxygen concentrations less than 5 mg/L will adversely affect some aquatic species and below 2 mg/L will result in the death of many fish species (Chapman, 1992; Koehn and O’Conner, 1990). Aquatic environments showing depressed oxygen levels are often related to respiration by plants, animals, and aerobic bacteria (Boulton and Brock, 1999). As illustrated in Section 2, this site contains high concentrations of nutrients. Waterways that receive high concentrations of organic matter often experience low dissolved oxygen concentrations due to decomposition by aerobic bacteria, and organic inputs to rivers in New Zealand by dairy farms have been found to produce chronically depressed dissolved oxygen (Wilcock *et al*, 1995, Wilcock *et al*, 1999). It is clear that this site suffers similar stresses.

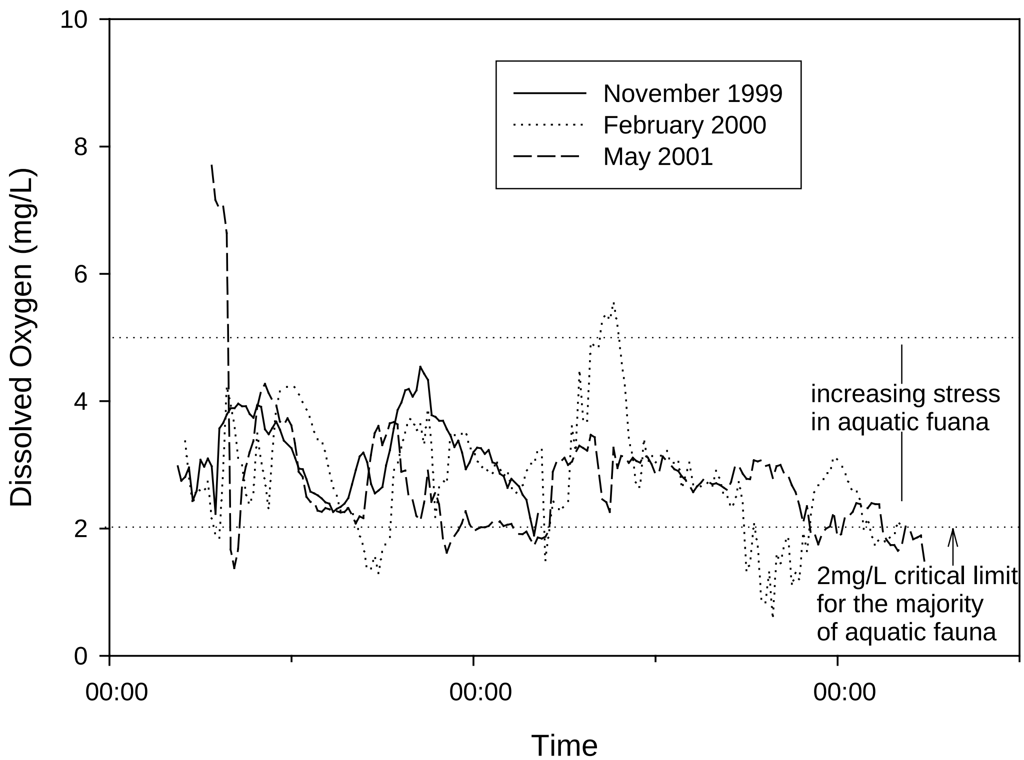

Figure 2.5.5: Diurnal fluctuations in dissolved oxygen concentration in the Jordan River at Green Glory (J6).

The data for pH from all three deployments (Figure 2.5.6) indicate that conditions at this site are generally slightly alkaline (7.2 and 7.7). Environmental pH is controlled by the balance between carbon dioxide, carbonate and bicarbonate ions (Chapman, 1999), and these are often the result of primary production in rivers and reflect closely the changes in dissolved oxygen. Data from the logging deployment of May 2001 clearly demonstrates the relationship between pH and dissolved oxygen concentrations (Figure 2.5.7a). Figure 2.5.7b illustrates the effect of photosynthetic activity as peaks in pH often coincide with peaks in dissolved oxygen concentrations.

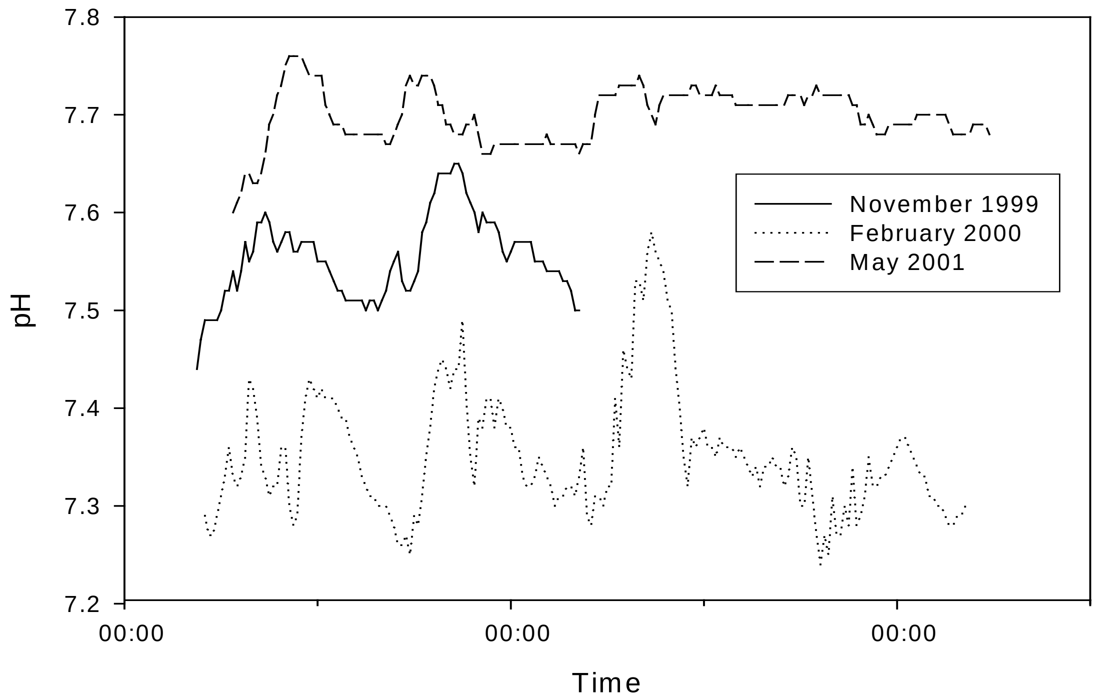

Figure 2.5.6: Diurnal fluctuations in pH in the Jordan River at Green Glory (J6).

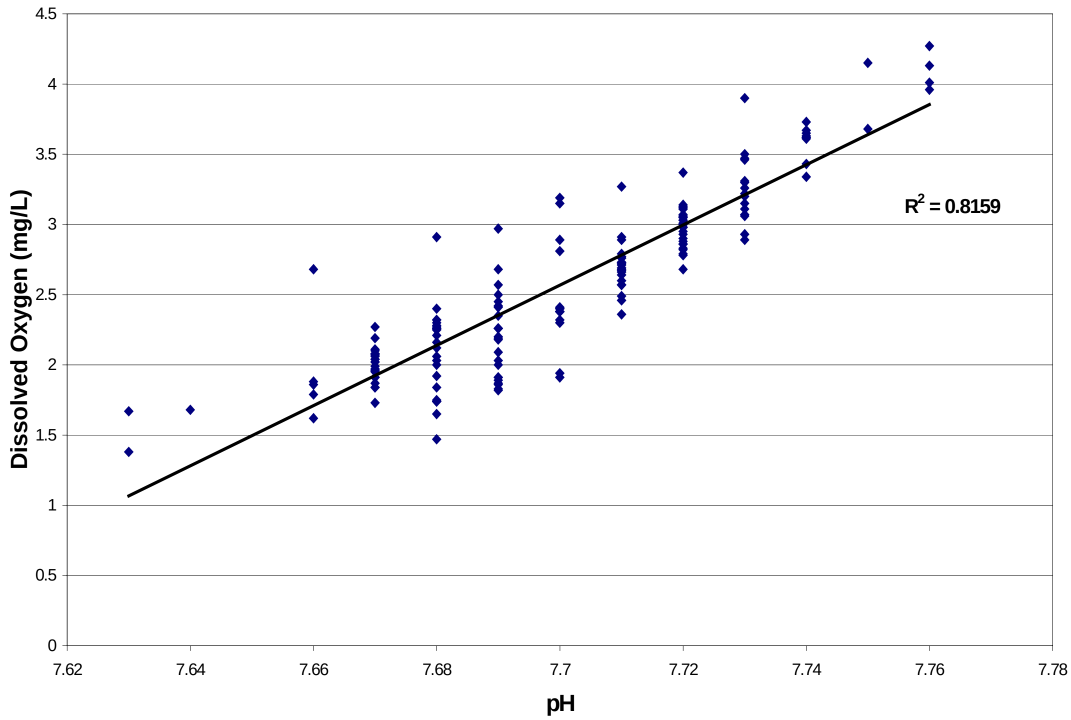

Figure 2.5.7a: Relationship between pH and dissolved oxygen concentrations in the Jordan River at Green Glory from 21st - 25th May 2001.

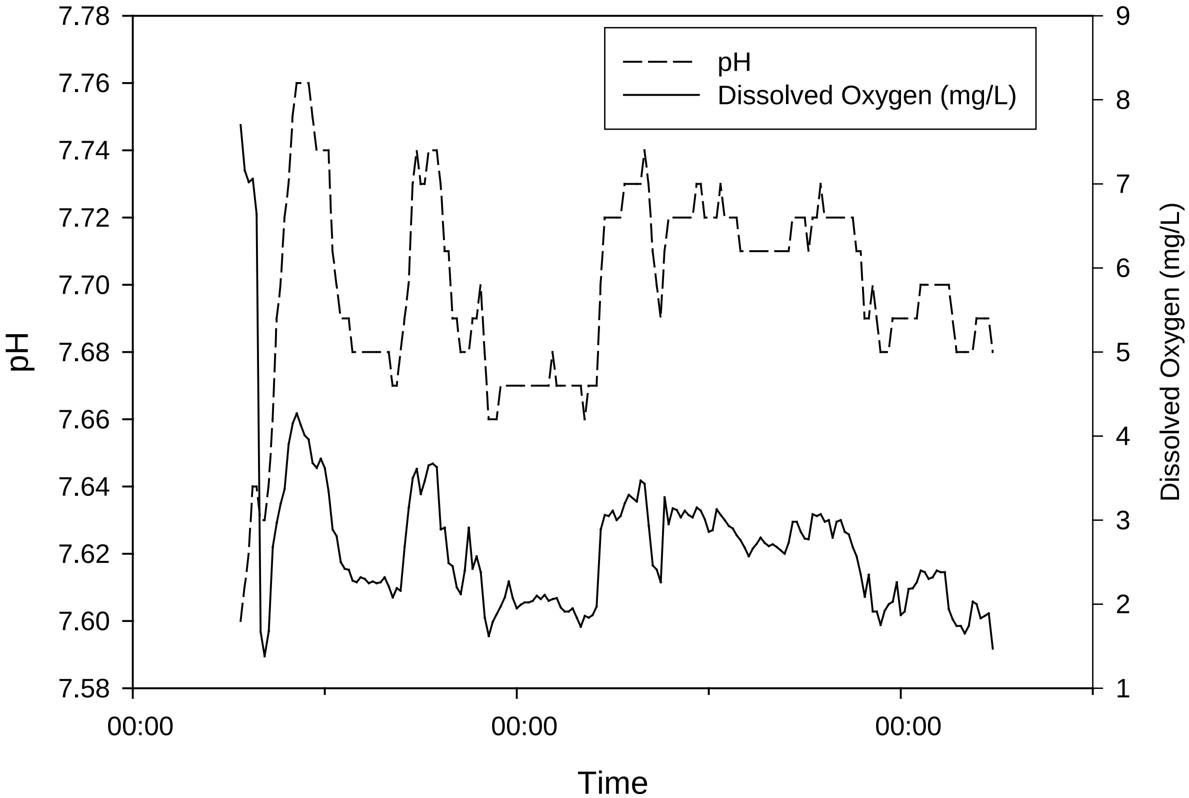

Figure 2.5.7b: Diurnal fluctuations in pH and dissolved oxygen in the Jordan River at Green Glory (J6) from 21st - 25th May 2001.

The data for temperature (Figure 2.5.8a) clearly illustrates seasonal changes, with highest temperatures recorded in early February and lowest temperatures recorded in May. Temperatures generally peaked during the late to early evening and reached its minium during the early to mid hours of the morning. This is illustrated by both the November 1999 and February 2000 deployments. Data for May 2001 is less distinct in comparison to previous deployments (Figure 2.5.8b). The likely explanation for this may be the reduction in exchange of air/water temperature due to the extensive and dense coverage of *Azolla spp* during this deployment, which was not present during the previous two deployments.

Conductivity varied between 1800 $\mu S/cm^{-1}$ and 1000 $\mu S/cm^{-1}$ from November 1999 to May 2001 (Figure 2.5.9a). As previously discussed in Section 2.2.3, this site was subject to fluctuations in conductivity concentrations due increasing/decreasing flow regimes. Figure 2.5.9b illustrates the monthly variation in conductivity at this site. Black circles denote the month in which dataloggers were deployed and provide an indication of site conditions in the months/days prior to deployment. The difference between the monthly and logger data for November 1999 is due to different sample dates. These data indicate that for the month of November 1999 an increase of 268 $\mu S/cm^{-1}$ occurred within 13 days of the monthly spot sample (10th November; 1545 $\mu S/cm^{-1}$) to logger deployment (23rd November; 1813 $\mu S/cm^{-1}$). This illustrates how reducing flows affect conductivity at this site. Lower conductivity concentrations recorded during the February deployment are likely to be representative of diluting flows which occurred during January 2000. By May 2001 there was no flow at this site. Conductivity steadily increased but was lower in comparison to those values recorded during the November 1999 deployment. The likely explanation for this is can be attributed to diluting flows which occurred at this site in late September 2000. These flows reduced conductivity concentrations at this site to 661 $\mu S/cm^{-1}$ in November 2000 with May 2001 concentrations affected by an increase in groundwater contributions.

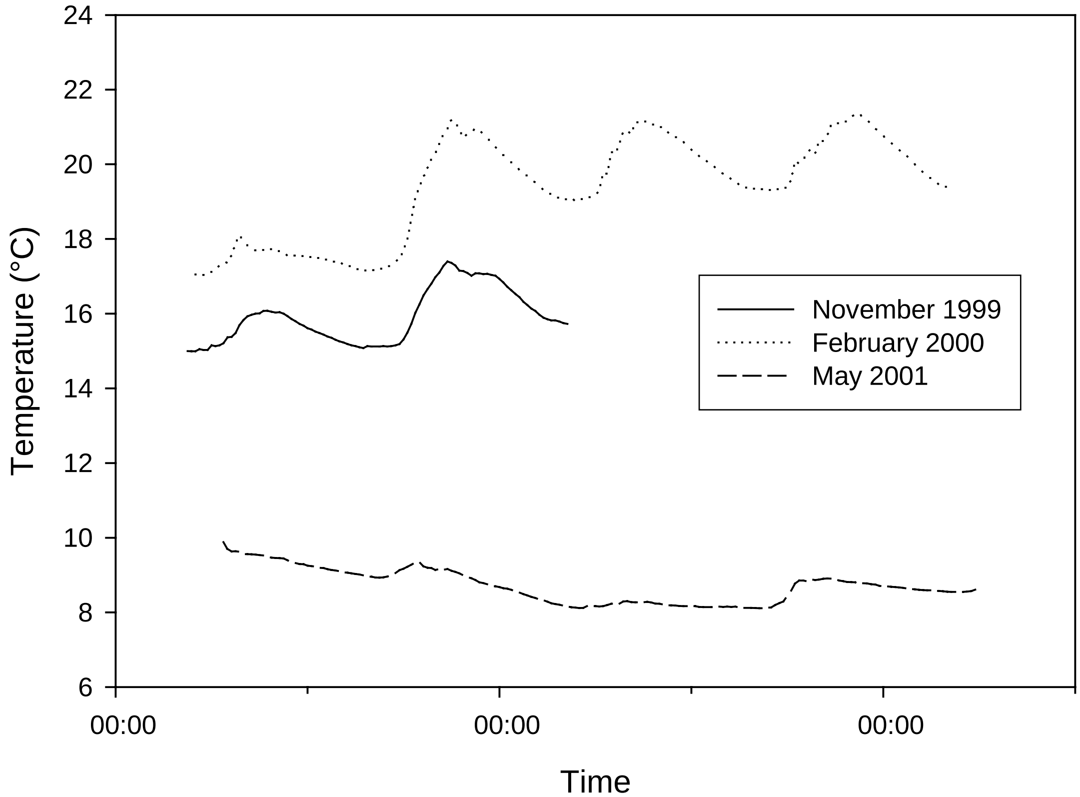

Figure 2.5.8a: Diurnal fluctuations in temperature (°C) in the Jordan River at Green Glory (J6).

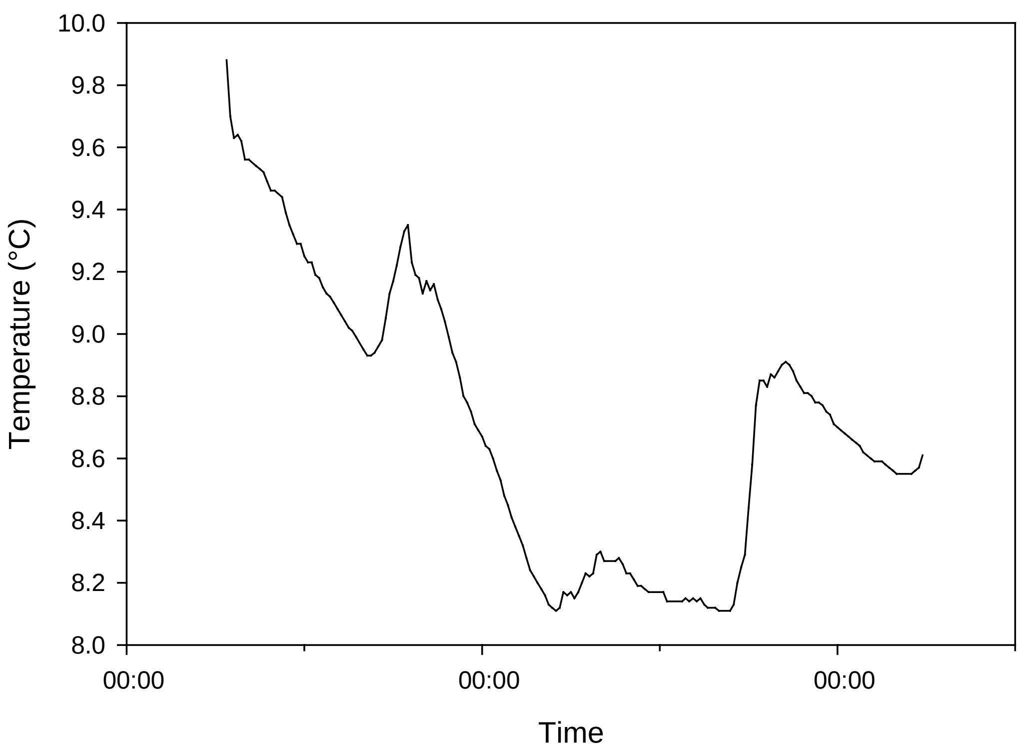

Figure 2.5.8b: Diurnal fluctuations in temperature (°C) in the Jordan River at Green Glory (J6) from 21st May 2001 to 25th May 2001.

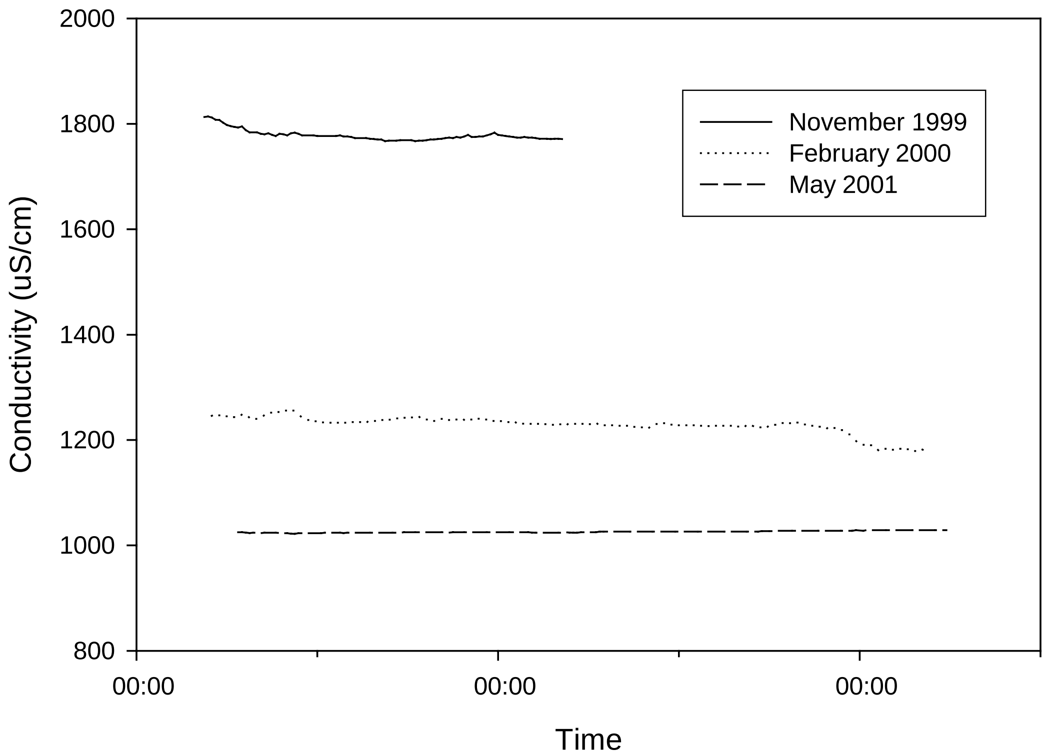

Figure 2.5.9a: Variations in conductivity between three logger deployments in the Jordan River at Green Glory (J6).

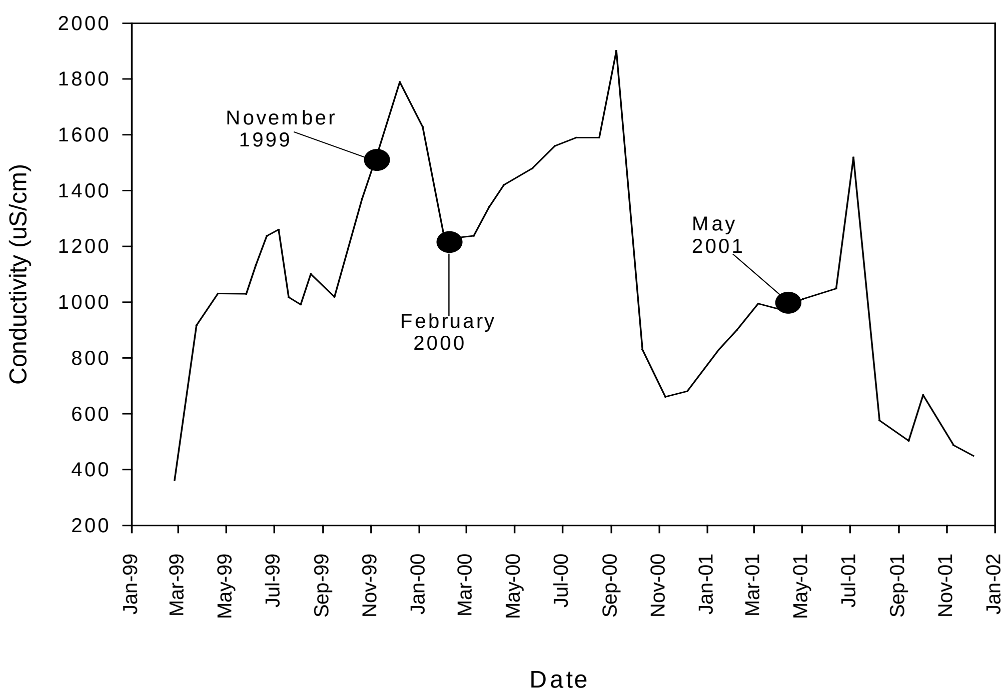

Figure 2.5.9b: Variations in monthly conductivity in the Jordan River at Green Glory (J6) from January 1999 to December 2002. Black circles denote the month when loggers were deployed.

2.5.3 Jordan River at Sheepwash Corner on Lake Highway (J13)

Logging deployments were made at this site simultaneously with Jordan River at Elderslie Road at Green Glory (J6) on 23rd - 25th November 1999 and 21st - 25th May 2001. Climatic conditions in the catchment during November 1999 was stable, dry and warm, while cooler conditions with recent rain was experienced in the May 2001. The data from Jordan River at Sheepwash Corner (J13) illustrates the different climatic regimes experienced between the two deployments (Figures 2.5.10 to 2.5.12). Data for temperature, pH and dissolved oxygen for November exhibit peaks and troughs indicative of "normal" diurnal fluctuations. The pattern of change for these same parameters during the May deployment was significantly dampened, illustrating not only the cooler temperatures experienced in May but also the diluting effect of recent rains in the weeks preceding this deployment. Data for conductivity further support this picture (Figure 2.5.12).

As was found at J6, fluctuations in pH mirrored those for dissolved oxygen at this site (Figure 2.5.11). Conductivity during both deployments varied between 1058 μS/cm-^{1} (November 1999) and 838 μS/cm^{-1} (May 2001).

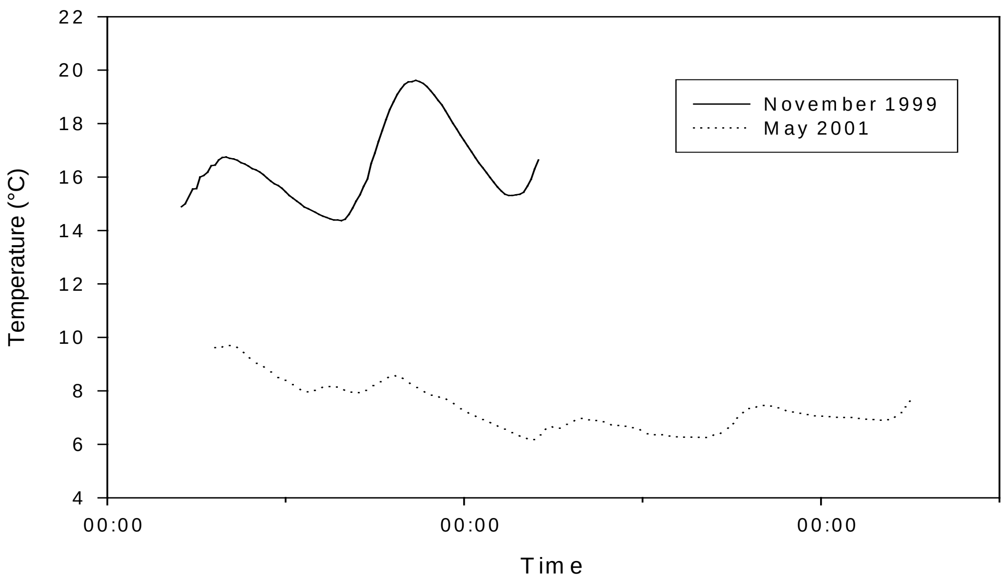

Figure 2.5.10: Diurnal fluctuations in temperature (°C) in the Jordan River at Sheepwash Corner (J13).

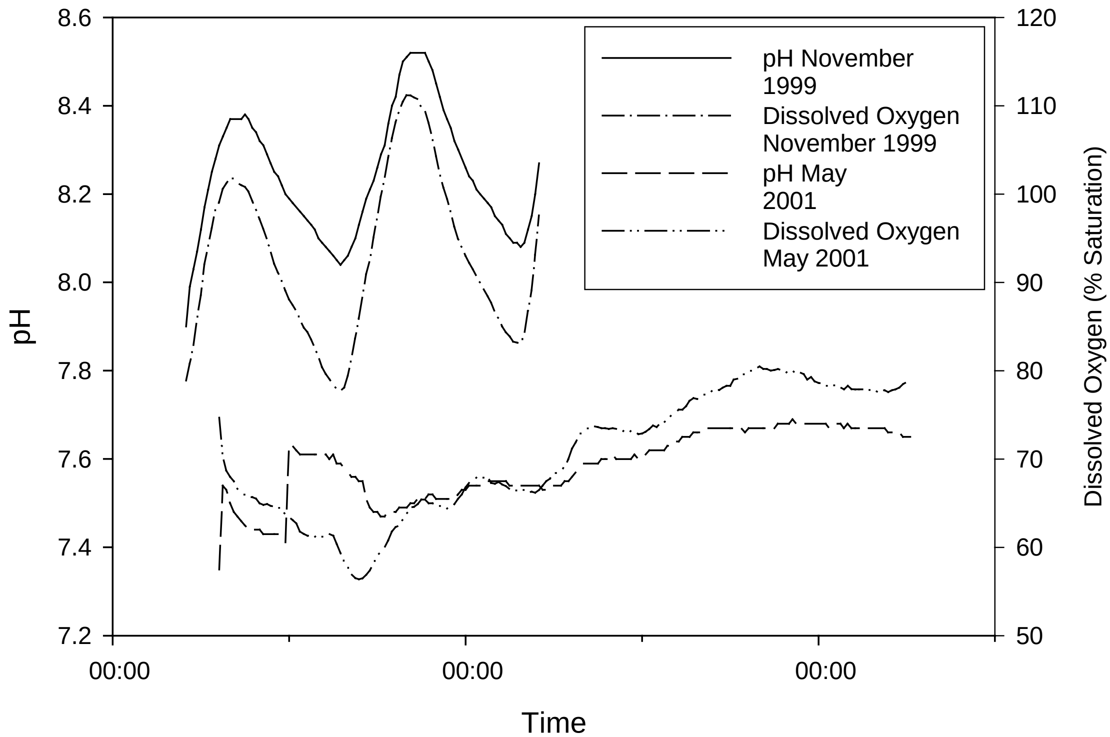

Figure 2.5.11: Diurnal fluctuations in pH and dissolved oxygen (% saturation) in the Jordan River at Sheepwash Corner (J13).

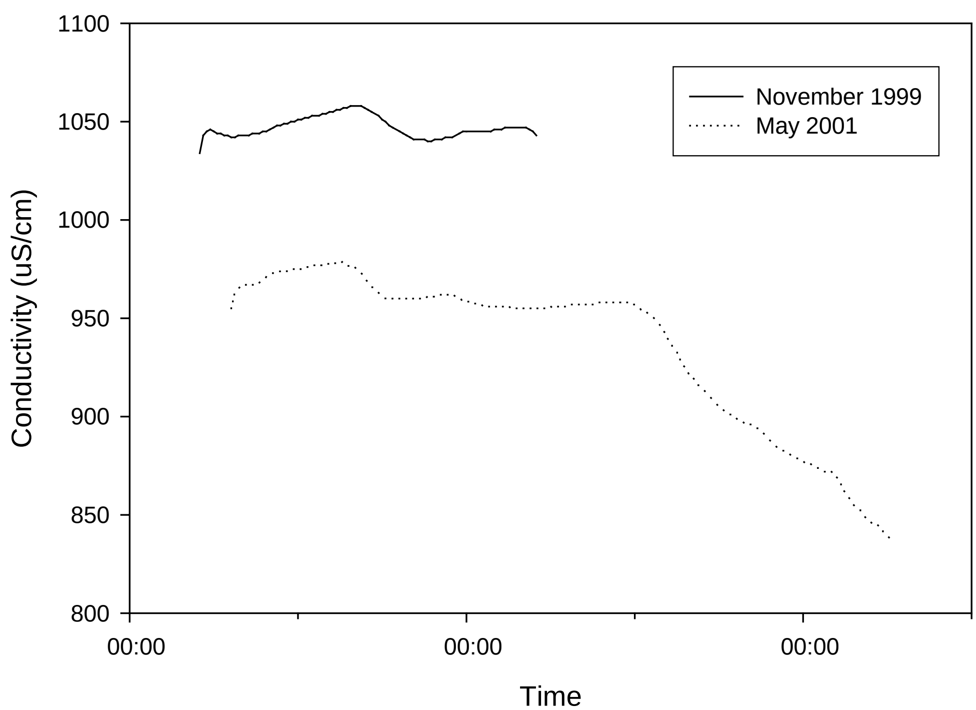

Figure 2.5.12: Variations in conductivity between two logger deployments in the Jordan River at Sheepwash Corner (J13).

2.5.4 Exe Rivulet (J19)

Exe Rivulet is located in the upper catchment and appears to be the major source of flow for the upper Jordan River when there is no discharge from Lake Tiberias. Three datalogger deployments took place between June 2001 and August 2001. These deployments illustrate changes in water quality when autumn rainfall returned flow to this site between the months of March and April 2001.

Data for dissolved oxygen and temperature illustrates the distinctive diurnal fluctuations typical of a healthy system (Figures 2.5.13 and 2.5.14). Diurnal variations in dissolved oxygen are reflective of cooler more turbulent water experienced during the winter. Oxygen saturation generally fluctuated between a minimum of 88% in June to a maximum of 106% in August (Figure 2.5.13). These data are in stark contrast to those that were recorded during the summer deployments at J6, J13 and J6a, where much larger daily changes and much lower minimum dissolved oxygen levels were found.

Figure 2.5.15 shows the cooler temperatures experienced during winter, with a minium of approximately 4 °C recorded in June and a maximum of 7 °C recorded in August. During the June and August deployments temperature generally did not fluctuated by more than 1°C to 1.5 °C. Towards the end of the July 2001 deployment, water temperature decreased by 4°C in approximately 38 hours. This was caused by a cold front that produced a significant rainfall event in the catchment. The effect of this rainfall is particularly evident in the data for conductivity (Figure 2.5.16) and pH (Figure 2.5.15). Rain water is naturally more acidic than receiving waters as it accumulates dissolved carbon dioxide as it falls to the earth. Rainwater can also accumulate more CO_2 as it travels over or percolates through organic and calcareous soils (Boulton and Brock, 1999).

Conductivity data from all three deployments supports that for monthly data (Section 2.2.3). Figure 2.5.16a shows that between June and August conductivity concentrations increased by approximately $150\mu S/cm^{-1}$. This is due to an increase in ground water input as the diluting effect of surface waters generated from rain events between March and June 2001 diminishes. Figure 2.5.16b illustrates monthly variation in conductivity in the Exe Rivulet. The sample points inside the box represent the months in which the Sonde deployments took place giving an indication as to the influence of groundwater inputs. Similar to pH, conductivity concentrations during the July deployment decreased due to the diluting effect of rainfall (Figure 2.5.16a). The sharp increase in conductivity is likely to reflect the initial flushing of salts from the soil profile within the immediate area.

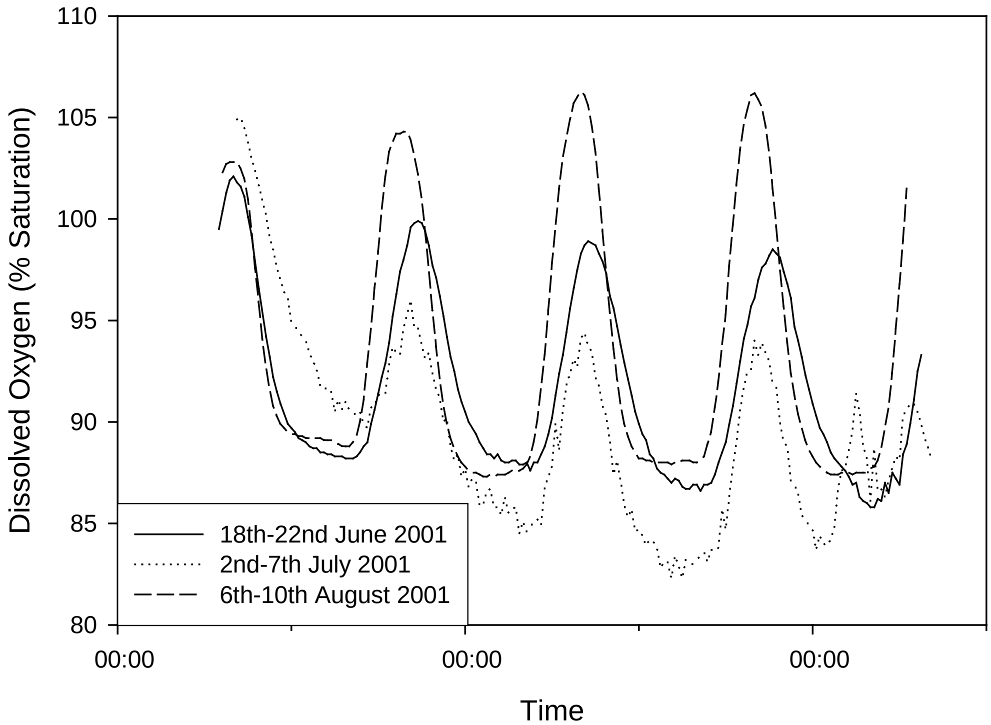

Figure 2.5.13: Diurnal variation in dissolved oxygen (% saturation) in the Exe Rivulet (J19).

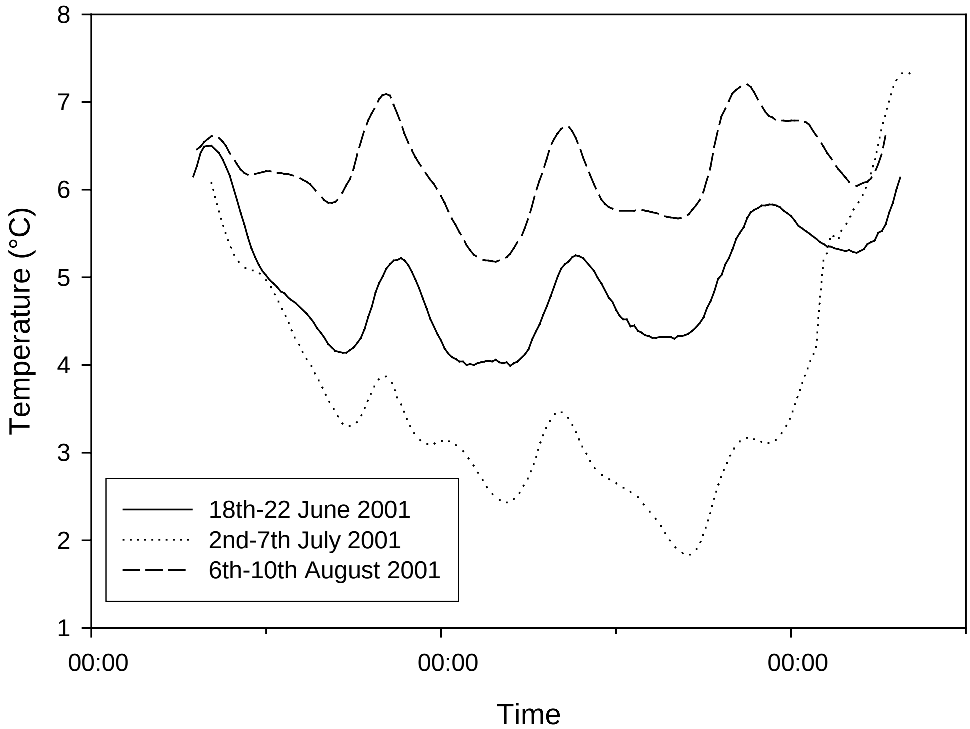

Figure 2.5.14: Diurnal fluctuations in temperature (°C) in the Exe Rivulet (J19).

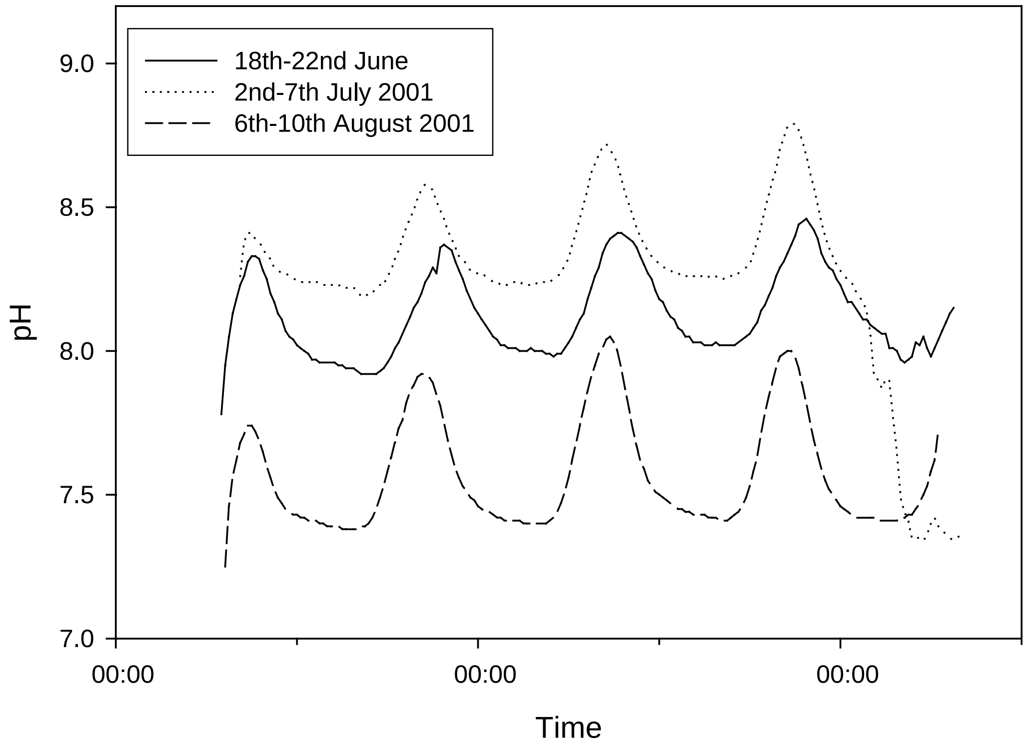

Figure 2.5.15: Diurnal variations in pH in the Exe Rivulet (J13).

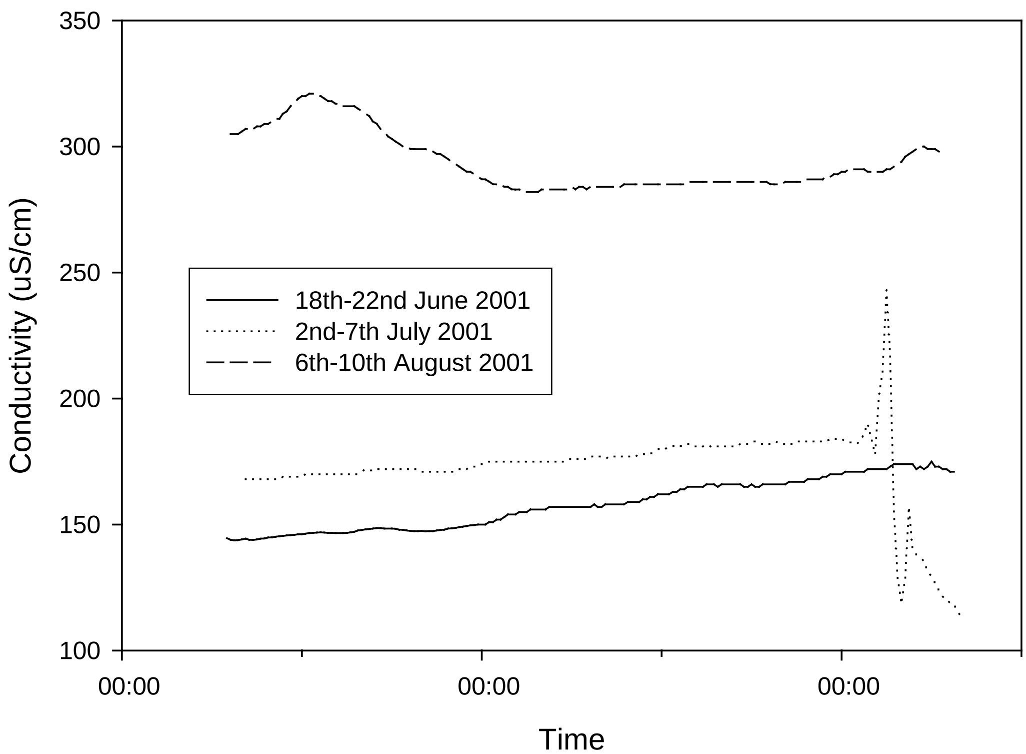

Figure 2.5.16a: Variations in conductivity (μS/cm^{-1}) during three deployments between June and August 2001 in the Exe Rivulet (J19).

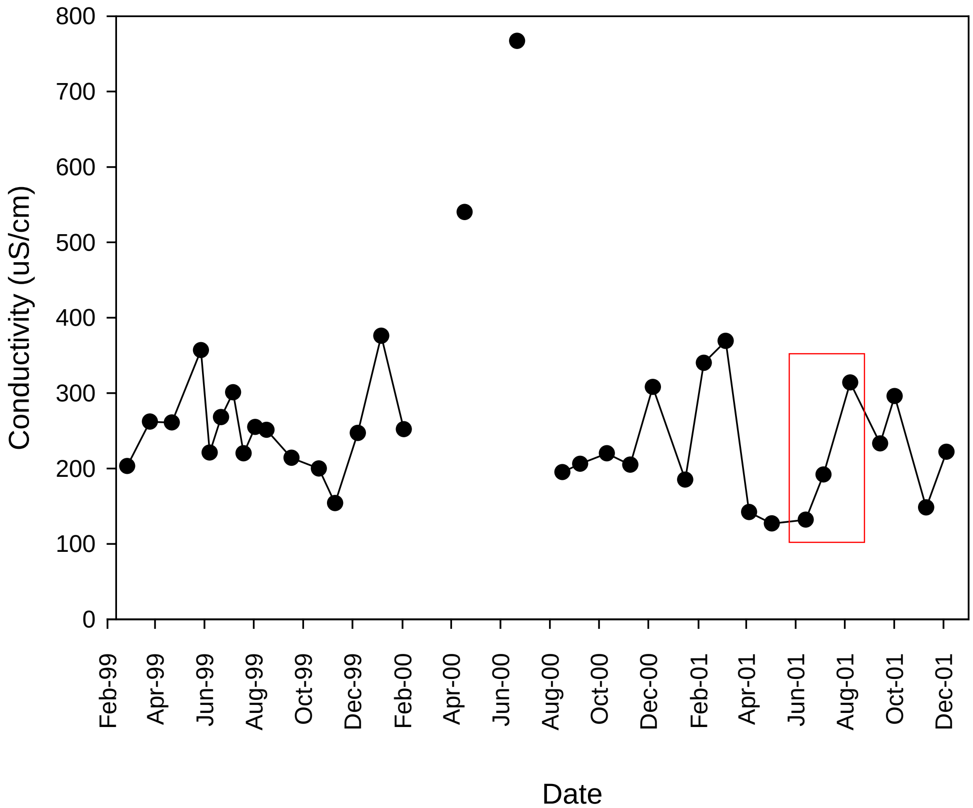

Figure 2.5.16b: Variations in conductivity during monthly sampling at Exe Rivulet (J19).
NOTE: Data points within the box represent those months in which Sondes were deployed.

2.5.5 Jordan River at Roydon Road (J9)

Only one deployment took place in the Jordan River at Roydon Road (J9) from 6th - 10 August 2001, and this was undertaken simultaneously with the deployment in the Exe Rivulet (J19). This part of the river is subject to wetting drying phases typical of many other sites in the Jordan River, and flow had returned to this site in the month prior to this deployment.

Compared to the data from J19, similar variations for temperature, dissolved oxygen and pH are evident. Diurnal changes in pH were less than 1 pH unit and conditions were generally alkaline (Figure 2.5.18). Dissolved oxygen varied between 75% and 103% saturation. This site is heavily vegetated along its banks with Crack Willow (*Salix spp.)* which would contribute a significant amount of organic matter into the system seasonally, but is unlikely to have an impact at this time of year, when the trees are without leaves. Water temperature is indicative of cooler winter conditions, recording a minium of approximately 7 °C and a maximum of 9.5 °C (Figure 2.5.19).

Conductivity over the short period of this deployment increased from 567 $\mu S/cm^{-1}$ to 604 $\mu S/cm^{-1}$. This illustrates the diminishing effect of dilute flows from previous rainfall events, as ground water inflow becomes more dominant in the system (Figure 2.5.20).

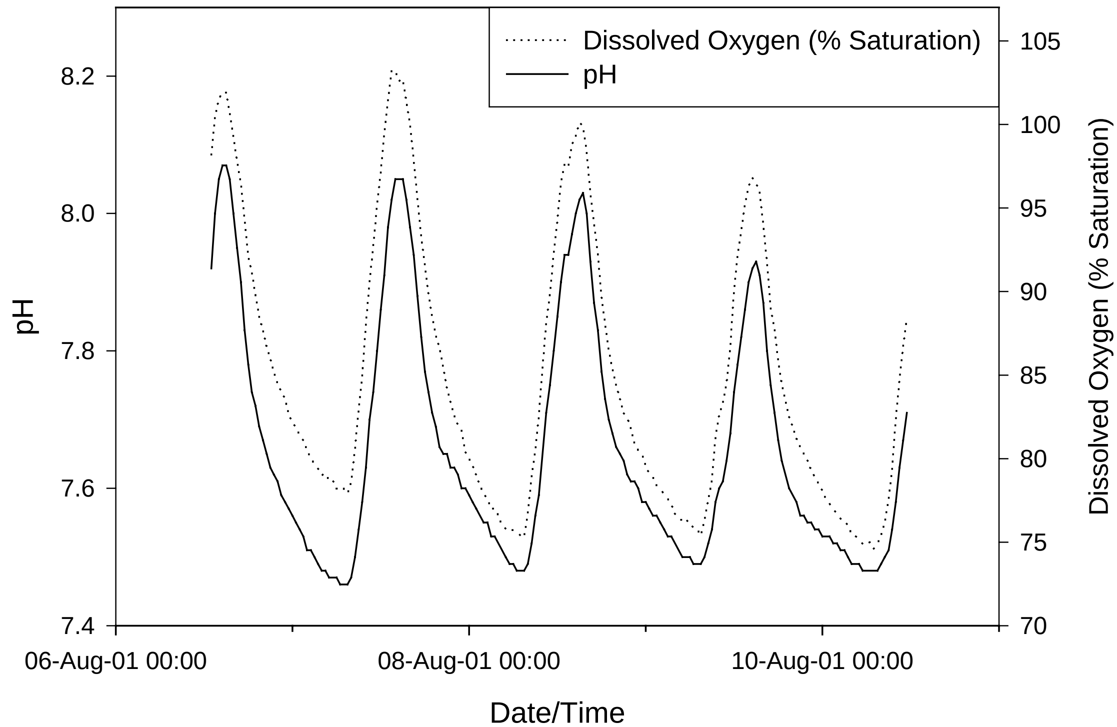

Figure 2.5.18: Diurnal variations in pH and dissolved oxygen in the Jordan River at Roydon Rd (J9).

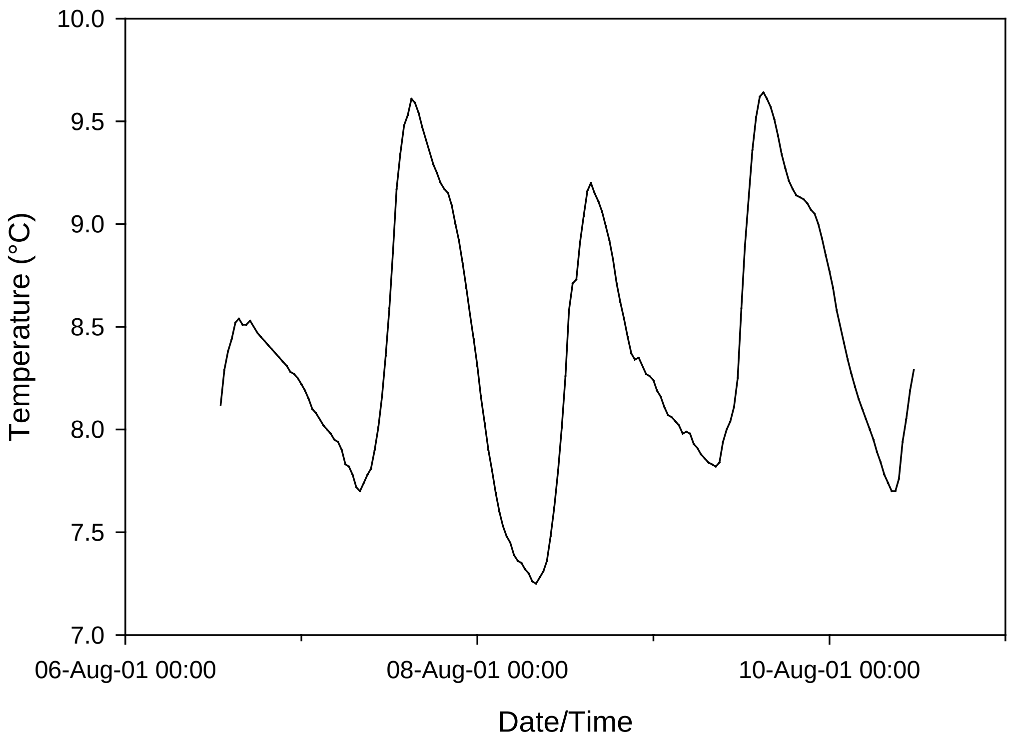

Figure 2.5.19: Diurnal fluctuations in Temperature (°C) in the Jordan River at Roydon Road (J9).

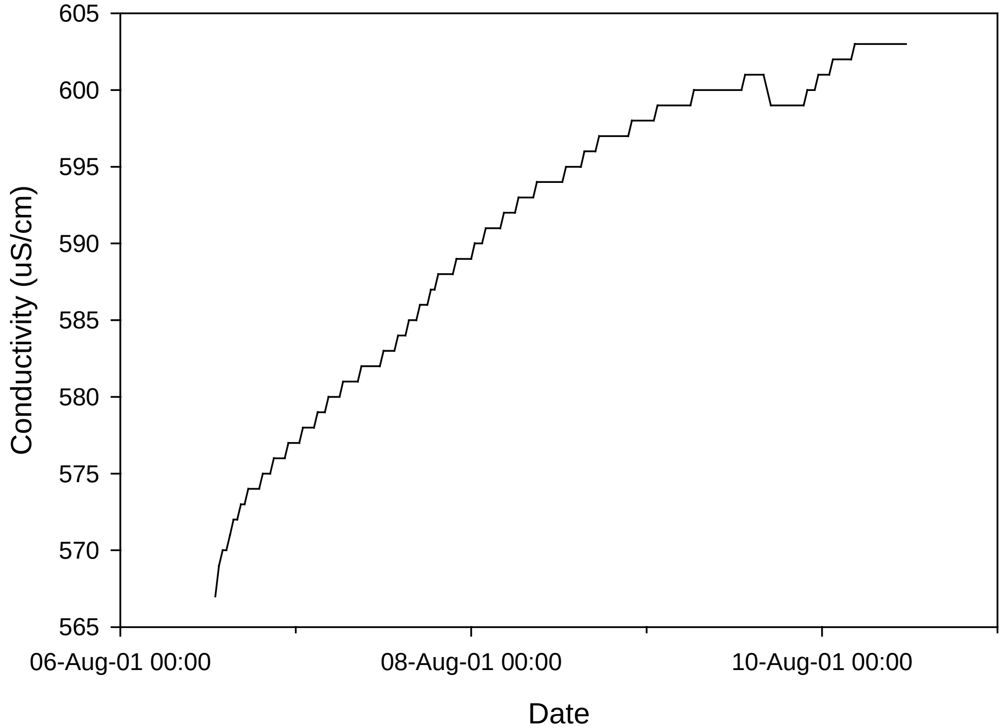

Figure 2.5.20: Conductivity in the Jordan River at Roydon Road (J9) measured over a 5-day period.