DEPARTMENT of
PRIMARY INDUSTRIES,
WATER and ENVIRONMENT
Tasmania

Water Quality of Rivers in the North Esk Catchment

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

PART 5

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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.

2.6 Diurnal Water Quality Variations

Remote and unattended monitoring equipment was deployed in the North Esk River and St Patricks River to record the diurnal changes in some selected water quality parameters. It is well known that various water quality characteristics undergo changes on a 24 hour cycle (diurnal) and it is possible that parameters which appear to be within acceptable limits during daylight hours may fall below suggested trigger levels after sunset. Where rivers are receiving organic pollution or nutrient enrichment that encourages algal and aquatic plant growth, there can be large changes in pH and dissolved oxygen (Cooke & Jamieson, 1995) which can have detrimental impacts on aquatic invertebrates and fish. Streams in New Zealand which have depleted oxygen levels have been linked to elevated nutrients and organic loads (Wilcock *et al.*, 1995).

For the purpose of this study, four sites were chosen for investigation. They were Kings Meadows Rivulet at Punchbowl (NE3), North Esk River downstream of Norwood sewerage treatment plant (NE2), North Esk River at Ballroom (NE27) and St Patricks River upstream of the confluence of the North Esk River (NE29). Independent and fully submersible monitoring equipment (Sondes) were deployed at these sites for a period of approximately 48 hours over a number of different months throughout the year. The Sondes were programmed to record water temperature, dissolved oxygen, pH, and conductivity at half hourly intervals. The main aim of these deployments was to collect data representative of ‘normal’ base flow conditions.

2.6.1 Temperature

Diurnal changes in temperature were evident at all sites. Kings Meadows Rivulet at Punchbowl and North Esk River downstream of the Norwood sewerage treatment plant exhibited higher temperatures compared to St Patricks River upstream of the confluence of the North Esk River and North Esk River at Ballroom further up the catchment. Temperature at all sites increases throughout the day, peaks in the early evening and troughs in the morning.

At Ballroom (NE27) and St Patricks River (NE29) both the seasonal and diurnal changes in water temperature are well defined. The most pronounced diurnal changes occurred in November (Figure 2.6.1a) and December (Figure 2.6.1b) with overnight temperatures changing by approximately 4°C at Ballroom (NE27) and 7°C at St Patricks River (NE29). The most probable explanation for the variation in temperature between both sites is linked to the flow and degree of riparian shading both these sites experience. At NE29 the St Patricks River is wide and has relatively little shading from riparian vegetation and is therefore less buffered from changes in air temperature compared to NE27, where the river is more confined and heavily shaded.

Figures 2.1.6 c-d illustrate the diurnal patterns for temperature at Kings Meadows Rivulet (NE3) and North Esk River downstream of the Norwood sewerage treatment plant (NE2). In comparison to NE27 and NE29, NE2 and NE3 have produced plots which are flatter and less symmetrical. Unlike the middle catchment sites (NE27 and NE29), both NE2 and NE3 are have been modified and are extensively impacted by urban activities. This is particularly evident at Kings Meadows Rivulet when temperature during the January deployment behaved somewhat more erratically suggesting a short-term pollution incident (Figure 2.6.1c). While it is not clear what precisely occurred, the erratic behaviour of temperature during the January run was also picked up in all of the parameters measured.

Due to either their size, the degree of riparian shading and shallow water depth, NE2 and NE3 are also likely to more closely reflect changes in air temperatures. For example while both the St Patricks River (NE29) and North Esk River downstream of Norwood STP (NE3) are wide at these points, NE3 is shallow and therefore more likely to remain relatively consistent with air temperature producing a flatter plot, compared to the deeper waters at NE29. The effect of shading by riparian vegetation will also be reflected in the pattern of peaks and troughs of diurnal fluctuations.

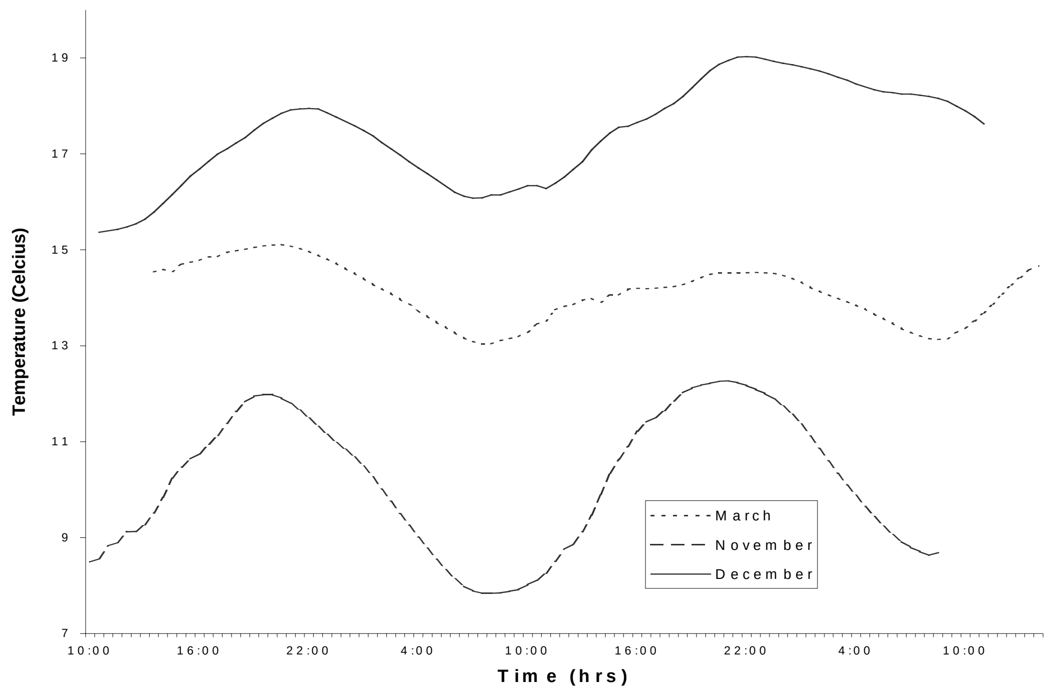

Figure 2.6.1a: Short-term changes in water temperature in the North Esk River at Ballroom (NE27) recorded for March, November and December 1999.

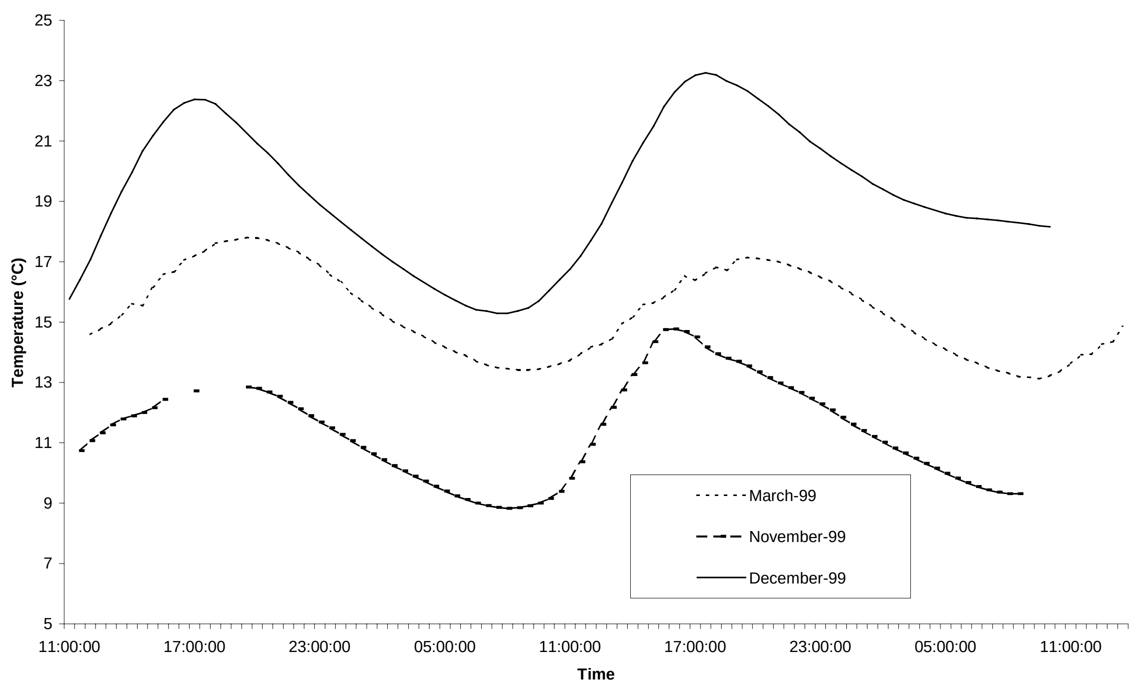

Figure 2.6.1b: Short-term changes in water temperature in the Patricks River upstream of the confluence of the North Esk River (NE29) recorded for March, November and December 1999.

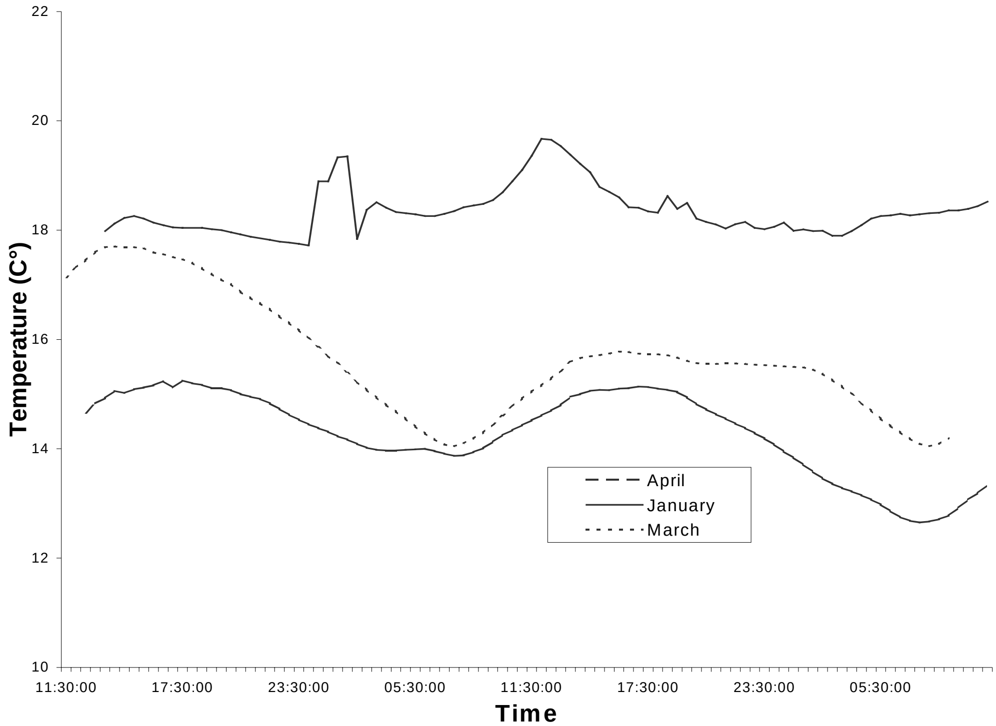

Figure 2.6.1c: Short-term changes in water temperature in Kings Meadows Rivulet at Punchbowl (NE3) for January, March and April 2000.

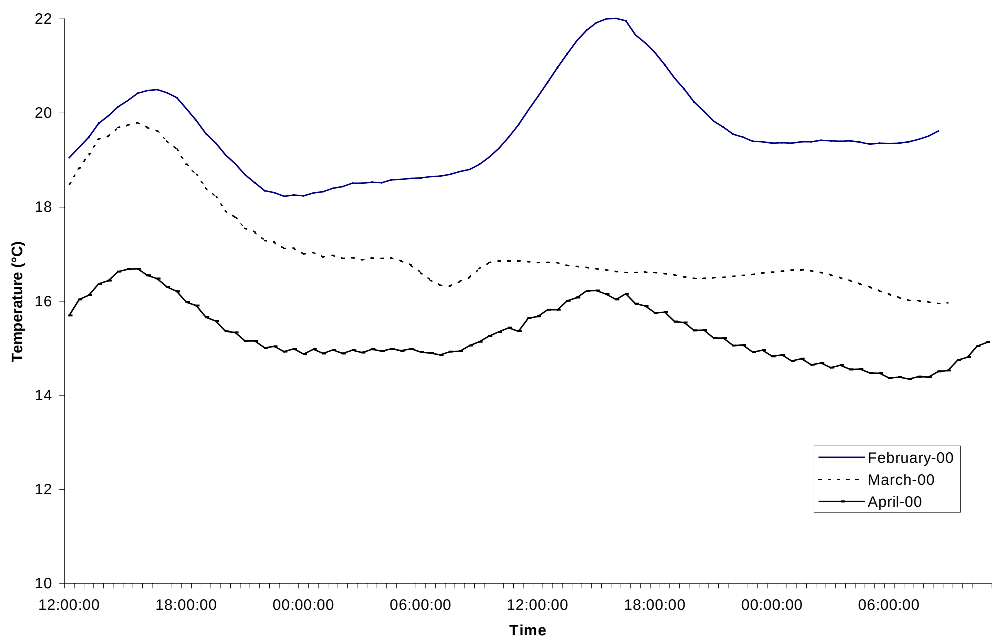

Figure 2.6.1d: Short-term changes in water temperature in the North Esk River downstream of the Norwood sewerage treatment plant (NE2) for February, March and April 2000.

2.6.2 Dissolved oxygen

Dissolved oxygen (DO) concentration varies with temperature, salinity, biological activity and rate of transfer from the atmosphere (ANZECC, 2000). Cooler waters are more capable of holding dissolved oxygen than warmer water (Refer to Section 2.1.5) and hence, there are generally higher dissolved oxygen levels in the cooler winter months Figure 2.6.2 provides an example the influence changes in temperature regime has on diurnal dissolved oxygen fluctuations. This is also the case with salinity with the solubility of oxygen increasing with decreasing salinity.

Diurnal fluctuations in dissolved oxygen levels can be quite considerable, with night-time levels much lower than those that occur during the day. Figure 2.6.2 illustrates diurnal fluctuations in dissolved oxygen concentrations at North Esk River at Ballroom (NE 27) in December 1999 where there is a variation of approximately 14% saturation. This figure also demonstrates the relationship between dissolved oxygen concentration and water temperature as discussed in section 2.4.1.4.

Dissolved oxygen concentrations for the majority of deployments at the four sites reflected levels indicative of a healthy system, particularly those at the North Esk River at Ballroom (NE27) and St Patricks River upstream of the North Esk River (NE29) (Figures 2.6.3a to b). Deployments at King Meadows Rivulet at Punchbowl (NE3) and on one occasion at North Esk downstream of the Norwood sewerage treatment plant (NE2) showed that levels of dissolved oxygen fell below concentrations sufficient to maintain aquatic health (approximately < 60% or 5mg/L) (Figure 2.6.3c-d). Figure 2.6.3c illustrates a drop to dangerously low levels at King Meadows Rivulet at Punchbowl during the January deployment (Figure 2.6.1c). In general dissolved oxygen monitored at this site fell below the recommend lower range of 90% saturation suggested by the current ANZECC guidelines (Figure 2.6.3c) during all logging deployments. The significant drop in dissolved oxygen concentrations recorded in January were confirmed against records from hand held meters during deployment and retrieval of the Sonde. As this site is the recipient of urban runoff the low concentrations of dissolved oxygen in combination with erratic changes in temperature, pH and conductivity suggest a sort term localised pollution event. This site warrants further investigation into sampling a greater variety of parameters in order to determine the composition of runoff that this system receives from suburban areas.

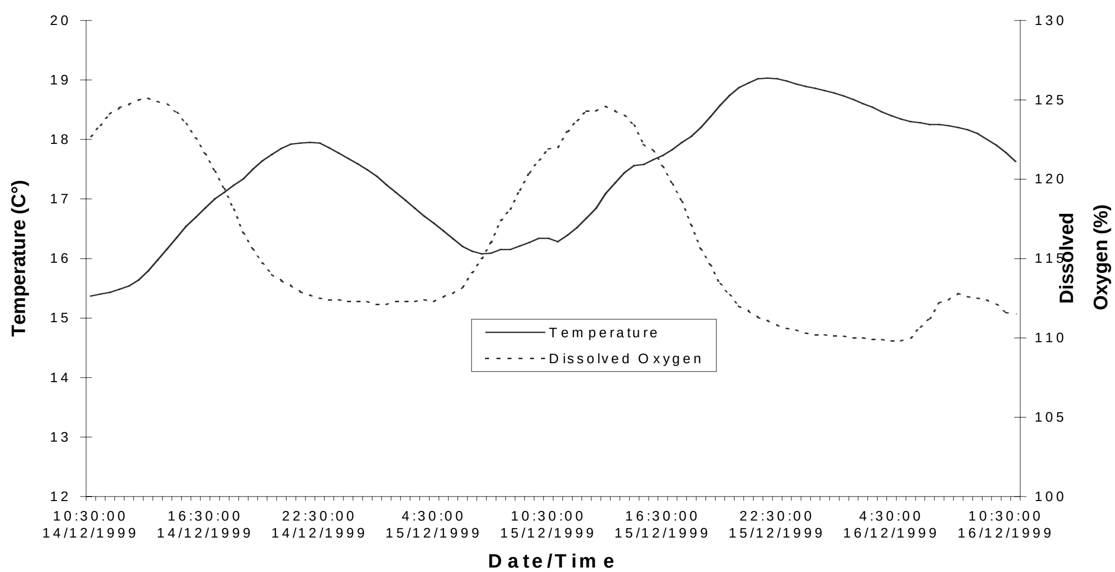

Figure 2.6.2: Dissolved oxygen and temperature levels at North Esk River at Ballroom December 1999.

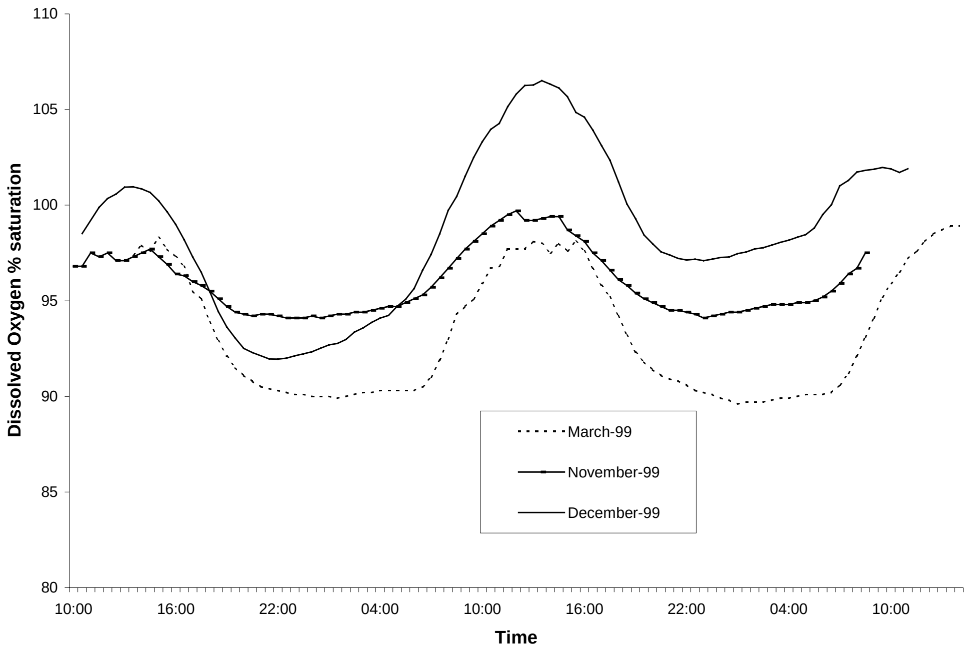

Figure 2.6.3a: Diurnal fluctuations in dissolved oxygen (%) in the North Esk River at Ballroom (NE27) recorded for March, November and December 1999.

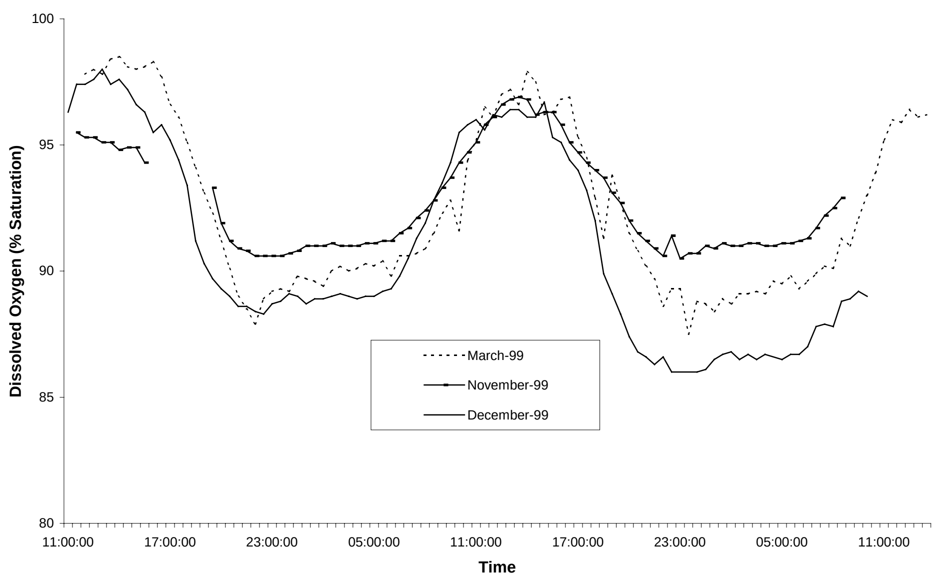

Figure 2.6.3b: Diurnal fluctuations in dissolved oxygen (%) in the St Patricks River upstream of the confluence of the North Esk River (NE29) recorded for March, November and December 1999.

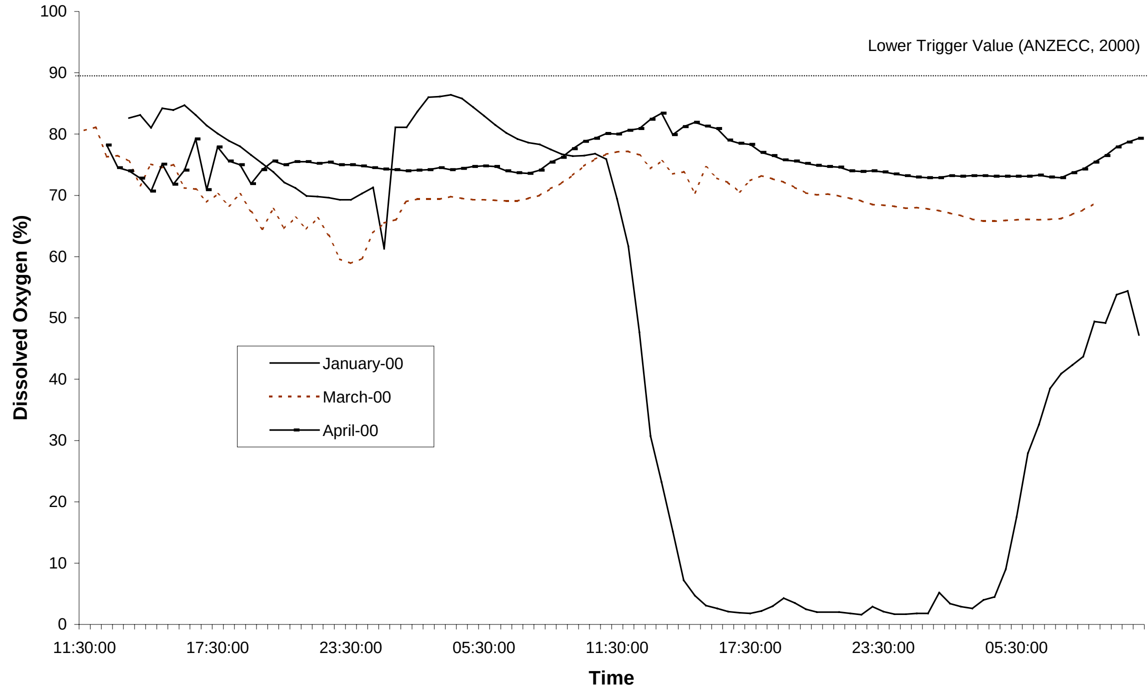

Figure 2.6.3c: Diurnal fluctuations in dissolved oxygen (%) at Kings Meadows Rivulet at Punchbowl (NE3) during Januray, March and April 2000.

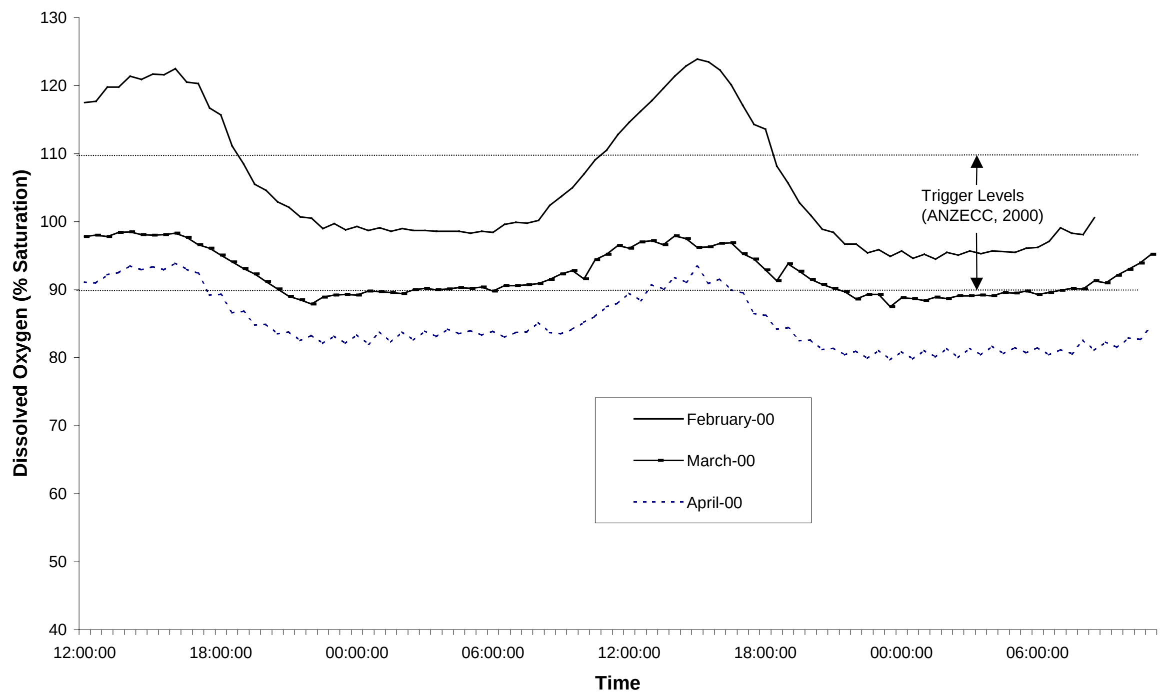

Figure 2.6.3d: Diurnal fluctuations in dissolved oxygen (%) in the North Esk River downstream of the Norwood sewerage treatment plant (NE2) during January, March and April 2000.

2.6.3 pH

The variation in pH recorded by remote loggers at St Patricks River upstream of the confluence of the North Esk River (NE 29) and North Esk River at Ballroom (NE 27) (Figure 2.6.4a and b) showed levels typical of a healthy aquatic ecosystem, and with distinct diurnal variations. Diurnal trends in pH are a result of the influence of primary production in the river, which during the day acts to increase pH as aquatic plants and algae produce an excess of carbon dioxide. Peak pH levels coincide with peak dissolved oxygen levels (Figure 2.6.5). Therefore the data presented here should be viewed alongside dissolved oxygen plots for each site [Figure 2.6.3a-d]. Both pH and dissolved oxygen decrease overnight, with the lowest levels occurring in the early hours of the morning when plant respiration and biochemical oxygen demand depletes oxygen levels in the water column.

Diurnal variations of pH at North Esk River downstream of Norwood sewerage treatment plant (NE 2) and Kings Meadows Rivulet at Punchbowl (NE 3) (Figure 2.6.4 c and d) were less distinct compared to the upper catchment sites. Similar to other parameters measured during deployment, variations in pH at Kings Meadows Rivulet at Punchbowl did not follow any clear diurnal fluctuations (Figure 2.6.4c). As previously commented on the significant drop of approximately 0.6 pH units in January probably suggests a localised short-term pollution event.

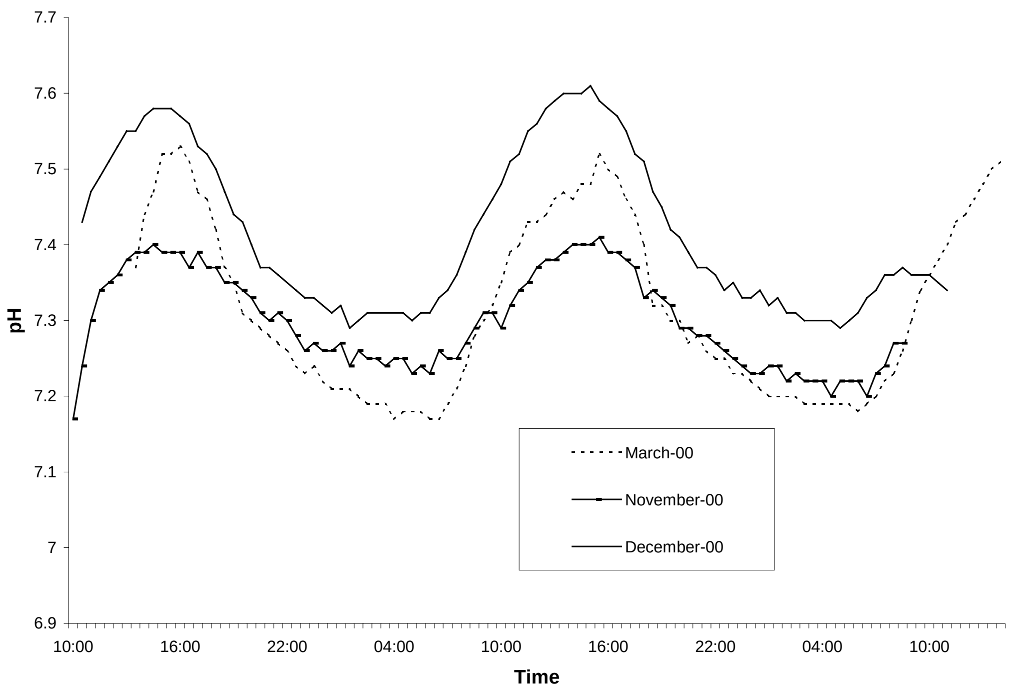

Figure 2.6.4a: Diurnal fluctuations in pH in the North Esk River at Ballroom (NE27) during March, November and December 2000.

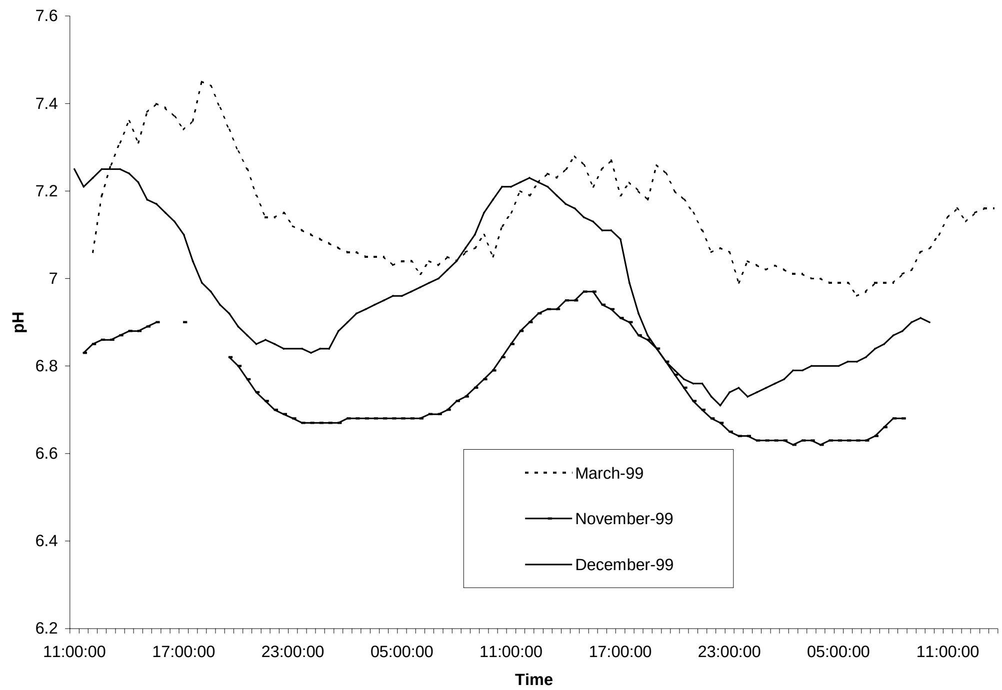

Figure 2.6.4b: Diurnal fluctuations in pH in the St Patricks River upstream of the confluence of the North Esk River (NE29) recorded for March, November and December 1999.

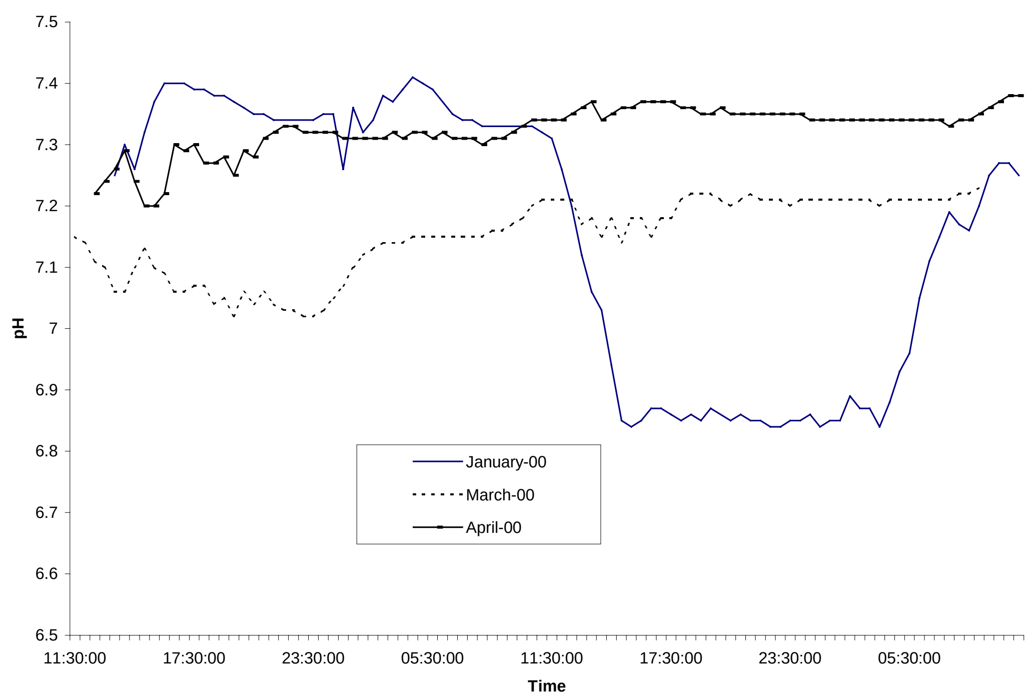

Figure 2.6.4c: Diurnal pH fluctuations at Kings Meadows Rivulet at Punchbowl (NE3) during January, March and April 2000 logger deployments.

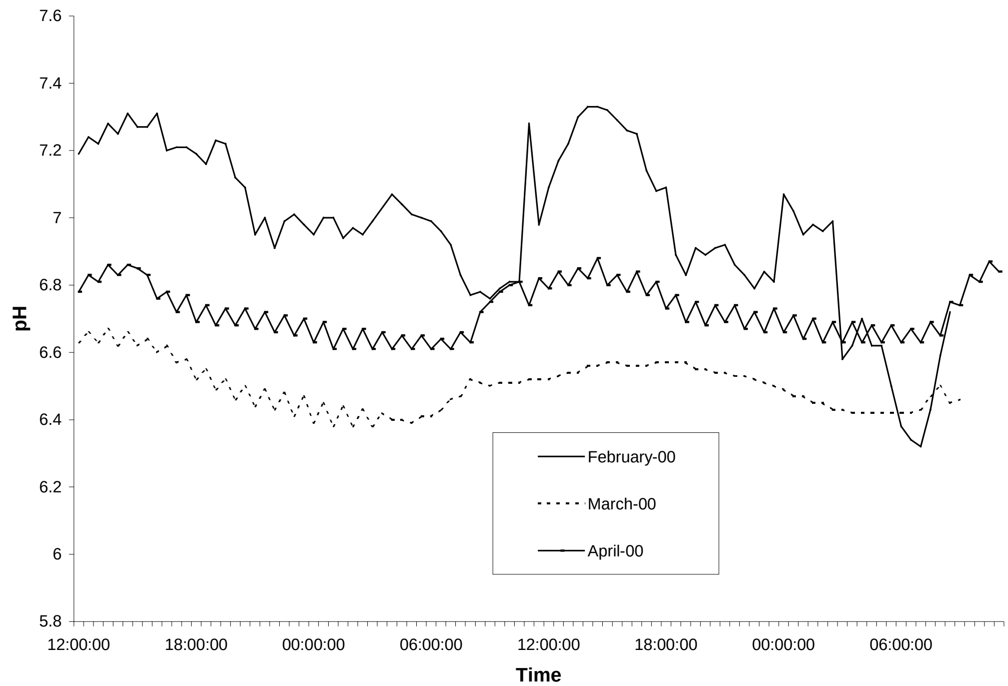

Figure 2.6.4d: Diurnal pH fluctuations in the North Esk River downstream of the Norwood sewerage treatment plant (NE2) during January, March and April 2000 logger deployments.

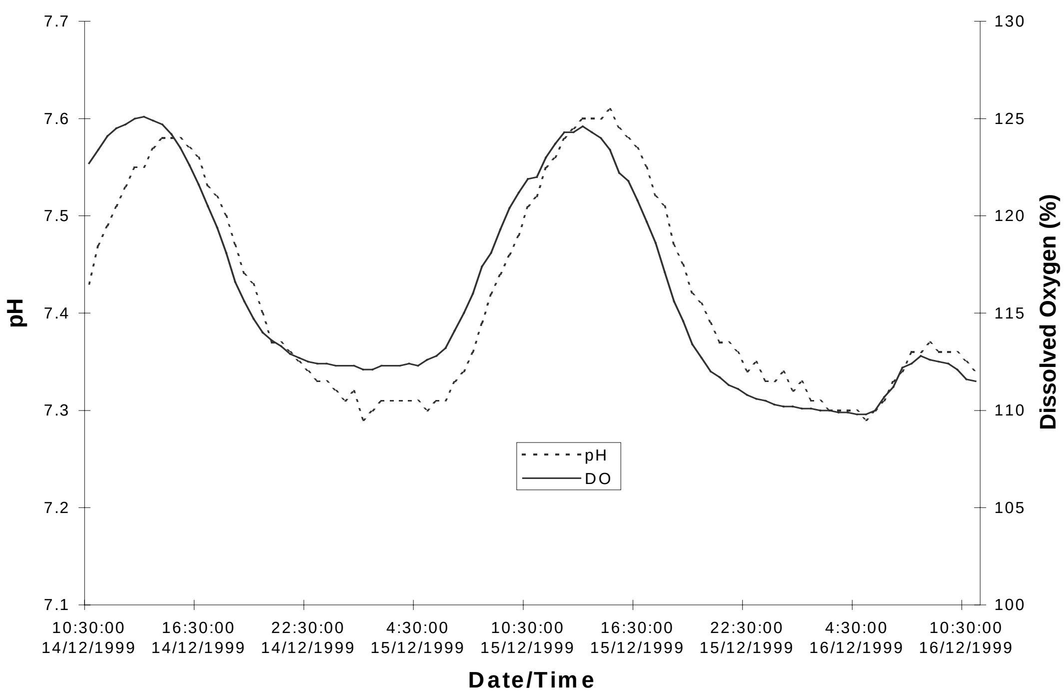

Figure 2.6.5: Diurnal pH and dissolved oxygen (%) values at North Esk River at Ballroom (NE27) December 1999.

2.6.3 Conductivity

Conductivity during all logger deployments generally reflected the dilute nature of waters in the North Esk catchment. Figure 2.6.6 illustrates the difference in conductivity levels between the St Patricks River and upper North Esk River where the waters of the St Patricks River are generally more dilute than those of the North Esk River. Conductivity levels at North Esk River downstream of Norwood sewerage treatment plant were slightly higher (median $114\mu Scm^{-1}$) indicative of a lower catchment site as previously explained by monthly monitoring results (section 2.1.3).

Conductivity at Kings Meadows Rivulet (NE 3) was well above the recommended ANZECC guidelines of 350μScm^{-1}. As mentioned in previous sections of this report these levels may relate to geological influences and the urbanised nature of this site. Figure 2.6.7 illustrates the scale of changes that conductivity that this site can experience. The drop in conductivity level in January indicates the sudden passage of lower salinity water down the rivulet which coincides with the sudden changes of temperature, dissolved oxygen and pH as previously mentioned. In comparison the March deployment recorded a gradual increase in conductivity over a period of approximately three days. Similar changes have also been recorded in other rivers such as the Coal River (DPIWE, unpublished) where the passage of lower salinity waters through surface runoff has diluted baseline conductivity levels with conductivity increasing as higher flows recede and groundwater influences become more dominant. This assumption is further supported by flow records from Launceston City Council monitoring (section 1.3).

Data from logger deployments clearly illustrate the variations in basic water quality parameters between those sites of the North Esk catchment which are mainly influenced by agricultural activities compared to those which are located in urbanised regions. Data from Kings Meadows Rivulet at Punchbowl highlights some of the impacts urbanisation can exert on water quality in urban catchments. Data from both the St Patricks River upstream of the confluence of the North Esk River and North Esk River at Ballroom clearly illustrate variations in water quality parameters which are more indicative of healthy ecosystems. Variations in water quality between both these sites, in particular conductivity also demonstrates that the St Patricks River is relatively more dilute in comparison in waters of the North Esk River upstream of Ballroom.

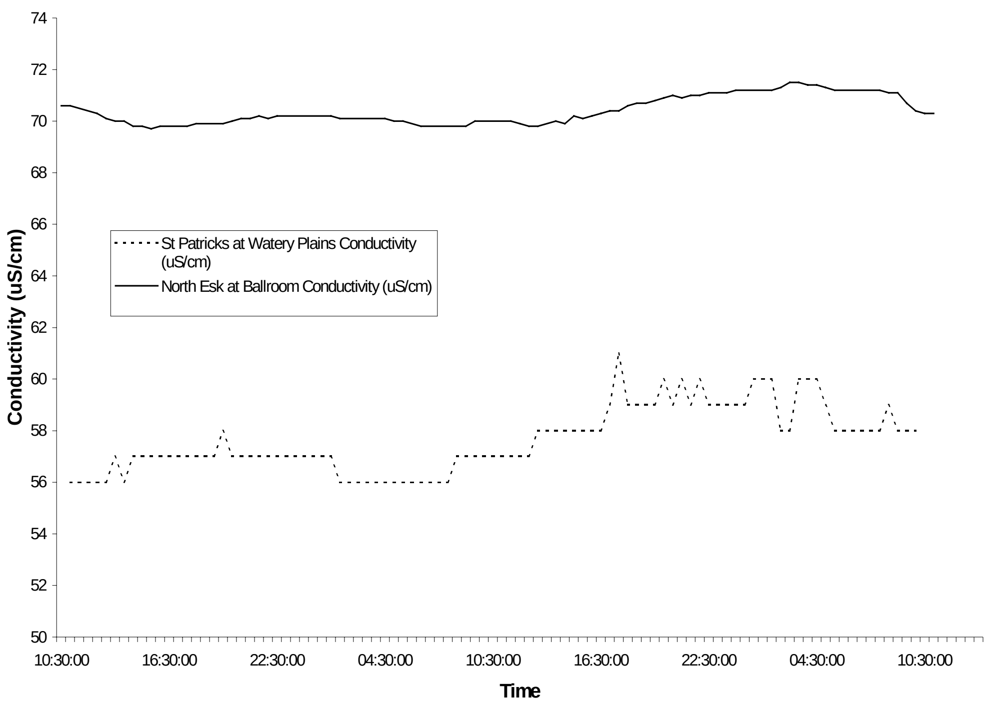

Figure 2.6.6: Conductivity levels for St Patricks River upstream of the confluence of the North Esk River and North Esk River at Ballroom December 2000.

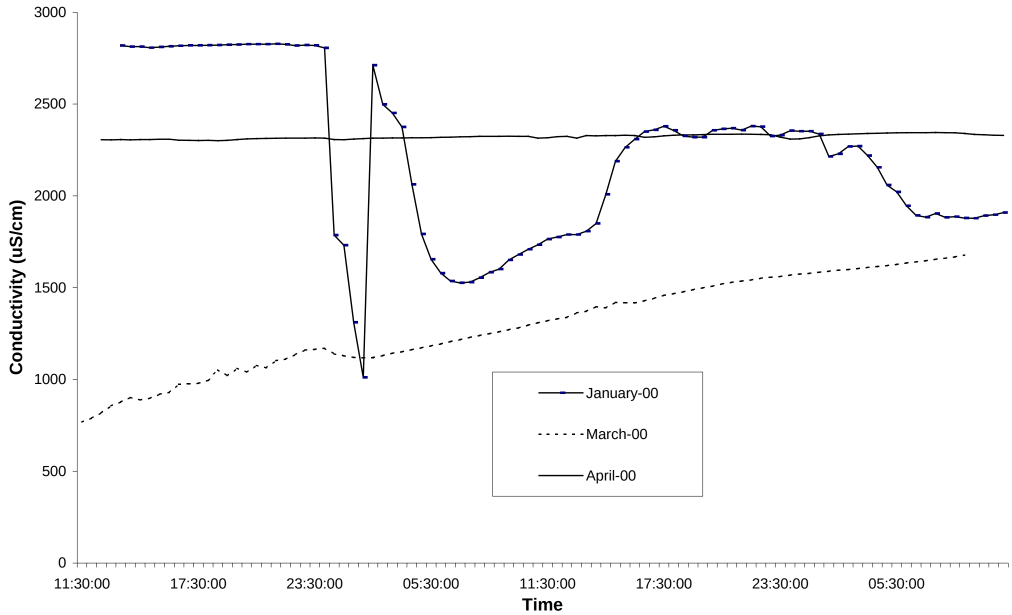

Figure 2.6.7: Conductivity levels in Kings Meadows Rivulet at Punchbowl (NE3) recorded over approximately 48 hours in January and March 2000.

3 Summary and Comments

Data collected by Esk Water of surface waters before treatment at their Distillery Creek and Chimney Hill Saddle Plants confirms results from this study that surface waters in the mid to upper sections of the North Esk River and St Patricks River are dilute. Typically these rivers have low turbidity and conductivity levels, with neutral pH. The data Esk Water has collected on a daily basis for the last 30 years has also provided an opportunity for long-term trend analysis, which has shown that pH has decreased and water temperature has increased during the last 30 years. While the cause of this change is unclear, two possible explanations for these changes are the removal of vegetation in the catchment and long-term climate change.

Analysis of data collected from Kings Meadows Rivulet by the Launceston City Council and this study suggests that this water quality at this site is strongly influenced by the surrounding urban environment. Data collected during the current study characterises the impact urbanisation has on this tributary of the North Esk River, with high water temperatures, turbidity, nutrient concentrations and faecal coliforms (*E.coli)*.

The data from the present study cannot be compared to the CSIRO study of forestry impact on turbidity in Musselboro Creek conducted in the mid-1990's. The data from this study had one site at the bottom of Musselboro Creek, which would encompass possible effects from all activities within the Musselboro catchment. It must be considered that conditions higher up in the catchment may also have changed between these two studies in that the plantation may be established and hence runoff and turbidity levels may now be reduced. Turbidity levels recorded during rainfall events at Musselboro Creek upstream North Esk River (NE 25) did increase substantially. Contributions to turbidity at this site are likely to have been influenced by unrestricted stock access to the creek bank and excavation of nearby drainage lines. Management solutions that would reduce the impact of agriculture in this area could include the fencing and establishment of riparian zones. Allowing drainage lines to become re-grassed would also reduce the amount of sediment which enters surface waters. This issue is particularly relevant for Old Mill Creek. As discussed in section 2.1.4 the impact of in-stream works in Old Mill Creek which was deepened and straightened were immediately detected by an increase in turbidity levels. These levels remained high for the duration of the project.

Monthly monitoring data clearly showed the dilute and relatively good quality of surface waters in the North Esk catchment. These results also highlighted those areas where impacts due to urbanisation and agricultural activities have affected water quality characteristics such as turbidity, temperature, conductivity, dissolved oxygen, faecal coliforms, nitrogen and phosphorous. Those sites which were repeatedly shown to have some form of detrimental impact from the surrounding environment include Kings Meadows Rivulet at Punchbowl (NE3), Rose Rivulet above Patersons Island (NE31), Old Mill Creek at Blessington Road (NE24) and North Esk River downstream of Norwood sewerage treatment plant (NE2). With the exception of Old Mill, there was a tendency for a decline in water quality towards the bottom of the catchment. These conclusions are further support by findings in both the River Health and Index of River Condition reports in this series on the North Esk catchment.

Monthly sampling of nutrient levels at the majority of sites within both the North Esk River and St Patricks River were below the recommended trigger levels for Tasmania (ANZECC, 2000). Higher nitrate-nitrogen concentrations occurred at sites where agricultural activities aid in the mobilisation of nutrients into surface waters through soil disturbance (ie. cropping, unrestricted stock access to water ways). Snapshot surveys clearly highlighted those sites where nutrient levels were high. These were Kings Meadows Rivulet at Punchbowl, North Esk downstream of Norwood sewerage treatment plant, Rose Rivulet above Patersons Island and Old Mill Creek at Blessington Road. Concentrations of phosphorus and ammonia were particularly high at North Esk River downstream of Norwood sewerage treatment plant.

As previously mentioned snapshot analysis highlights variations in water quality at a catchment level. While this type of analysis has some limitations, it provides a necessary tool in pinpointing areas where relatively ‘poor’ water quality exists. Results from summer and winter surveys supported results obtained from the monthly monitoring trips. Sites of particular interest are:

- Kings Meadows Rivulet at Punchbowl (high turbidity, conductivity, elevated *E. coli*, nutrient levels and low dissolved oxygen levels)
- North Esk River downstream of Norwood sewerage treatment plant (high ammonia and total phosphorus levels but low *E. coli*)
- Rose Rivulet upstream of the confluence with the North Esk River (high conductivity, nutrients, low dissolved oxygen)
- Old Mill Creek at Blessington Road (high turbidity, high total phosphorus)

Results of tests for heavy metals were fairly inconclusive with most metals detected at very low levels or below detection limits. The results for aluminium however were much higher. Concentrations of aluminium at many sites was greater than 55µg/L, with a catchment median value of 86µg/L and maximum value of 597µg/L at Old Mill Creek at Blessington Road and 317µg/L at Kings Meadows Rivulet at Punchbowl. While these levels are above the ANZECC 2000 guidelines it is possible that these levels reflect the underlying geology of the area and may not pose a risk to environmental health. However further testing warrants including analysis for the dissolved fraction to determine what is biologically available.

Faecal pollution is greatest in those rivers and creeks draining the lower and middle regions of both the North Esk River and St Patricks River. Faecal concentration in the middle regions of both rivers reflects the influence of animal husbandry in these areas. Stock access to streams draining these areas facilitates faecal contamination of the waterways. Coliform levels in the lower regions of the North Esk River tend to reflect the intensive urbanisation of the region. The higher faecal input into the waterways in these areas constitutes a higher risk to human health, particularly during the summer months when higher water temperatures increase the life-time of coliforms in the environment.

Flood samples collected during the study showed that turbidity, total suspended solids, total nitrogen and total phosphorus concentrations increase as flood waters rise. From bottled water samples and data from in situ probes, nutrient exports were derived. Due to the lack of continuous turbidity and flow at Corra Linn (NE32), export loads were determined based on relationships during flood flows between Corra Linn and Ballroom (NE27). Correlations between these were variable. Poor correlations between the two sites occur because of the variability of rainfall across the catchment and the difference between discharge from the St Patricks River and the North Esk River above Ballroom. Compared to other catchments in Tasmania sediment and nutrient loads exiting the North Esk River were generally low. These results reflect the relatively dispersed nature of agriculture in the catchment and the lower than average total discharge for the catchment during the two years of study.

The data collected during this 2-year study provides valuable information on the current state of water quality in the North Esk River and St Patricks River catchments. While the data presented in this report indicate a relatively healthy state of water quality in the catchment, it has highlighted areas where future management or remedial activities might be focussed.

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Appendix 1.

Table 1A: General framework for applying level of protection to different ecosystems for toxicants. (ANZECC 2000)

Ecosystem condition	Level of protection
1. High conservation/ ecological value	For anthropogenic toxicants, detection at any concentration could be grounds for source investigation and management intervention; for natural toxicants background concentrations should not be exceeded. [a] Any relaxation of these objectives should only occur where comprehensive biological effects and monitoring data clearly show that biodiversity would not be altered. In the case of effluent discharges, Direct Toxicity assessment (DTA) should also be required on the effluent. Precautionary approach taken to assessment of post-baseline data through trend analysis or feedback figures.
2. Slightly to moderately disturbed ecosystems	Always preferable to use local biological effects data (including DTA) to derive guidelines. If local biological effects data unavailable, apply 95% protection levels as default, low-risk trigger values. [b]99% values are recommended for certain chemicals as noted in table 2.4.1.[c] Precautionary approach may be required for assessment of post-baseline data through trend analysis or feedback triggers. In the case of effluent discharges DTA may be required.
3. Highly disturbed ecosystems	Apply the same guidelines as for slightly-moderately disturbed ecosystems. However the lower protection levels provided in the Guidelines may be accepted my stakeholders. DTA could be used as an alternative approach for derviving site-specific guidelines.

[a] This means that indicator values at background and test sites should be statistically indistinguishable. It is acknowledged that it may not be strictly possible to meet this criterion in every situation.

[b] For slightly disturbed ecosystems where the management goals is no change in biodiversity, users may prefer to apply a higher protection level.

[c] 99% values recommended for chemicals that bioaccumulate or for which 95% provides inadequate protection for key test species. Jurisdictions may choose 99% values for some ecosystems that are more towards the slightly disturbed continuum.

Table 2.4.5: E.coli concentrations (colony count per 100ml) in the North Esk during summer and winter snapshot surveys June 1999, January 2000).

	E. coli (Count per 100ml)		
SITE NAME	**Site No**	**Summer**	**Winter**
North Esk d/s confluence with Kings Meadows Riv't	NE 1	490	60
North Esk d/s Norwood STP	NE 2	130	20
Kings Meadows Rivulet at Punchbowl	NE 3	600	2400
North Esk u/s Clarks Ford Bridge & riffle	NE 4	92	30
Distillery Creek u/s confluence with North Esk	NE 5	370	70
Distillery Creek u/s of filtration plant	NE 6	140	50
St Patricks at Nunamara	NE 7	420	210
Patersonia Rivulet at Patersonia Road	NE 8	130	210
Coquet Creek at Tasman Highway (Trout Ck)	NE 9	110	30
St Patricks at Pecks Hill Road	NE 10	170	60
Patersonia Rivulet at Targa Hill	NE 11	70	10
Barrow Creek at Tasman Highway	NE 12	270	230
Bennies Creek at Tasman Highway	NE 13	390	10
St Patricks at Targa Hill Road	NE 14	180	40
Seven Mile Creek at Tasman Highway	NE 15	730	10
St Patricks at Corkerys Road	NE 16	40	70
St Patricks at East Diddleum Road	NE 17	30	30
Camden Rivulet at Diddleum Road	NE 18	130	150
North Esk off Camden Road	NE 19a	10	80
North Esk @ Phillps Road	NE 19b	130	130
North Esk at Camden Road	NE 20	430	70
Ford River at Upper Blessington	NE 21	590	100
North Esk at Burns Creek Road	NE 22	490	80
River O'Plain Creek at Blessington Road	NE 23	90	160
Old Mill Creek at Blessington Road	NE 24	80	160
Musselboro Creek u/s North Esk	NE 25	830	10
North Esk at Musselboro Road	NE 26	710	60
North Esk at Ballroom	NE 27	520	30
North Esk u/s confluence with St Patricks	NE 28	900	90
St Patricks u/s of confluence with North Esk	NE 29	150	30
North Esk @ White Hills	NE 30	140	80
Rose Rivulet above Patersons Island	NE 31	40	140
North Esk at Corra Linn	NE 32	210	30