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PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

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Water Quality of Rivers in the Inglis – Flowerdale Catchment

PART 4

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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.

3.6 Diurnal Water Quality Variations

Temporary monitoring equipment was deployed at two sites in the catchment for a 2-day period in early January 2000 to assess the scale of diurnal changes in temperature, dissolved oxygen and pH. The sites investigated were:

IF13 – Calder River at Takone Rd;

IF16 – Flowerdale River at Preolenna Rd

In addition to these deployments, monitoring equipment that had been installed at IF4 in the lower Inglis River to record river level simultaneously collected data on the diurnal changes in water temperature in this reach of the river for comparison. The following discussion presents the data collected during these logging events and discusses the time series in relation to site characteristics and the river management practices being utilised at the time of the investigation.

Site IF13 is located in the upper reaches of the Calder River, where the river flows through low gradient, pasture land. This reach of the Calder River is characterised by a near-total lack of riparian vegetation (Figure 3.34), and this along with the added input of nutrients from stock access, has encouraged extensive invasion of nuisance aquatic weeds (*Typha* spp) and blooms of green algae during the summer months.

Figure 3.34: Photo of the Calder River upstream from site IF13

The monthly monitoring data presented in Section 3.1.5 showed that oxygen levels in this reach of the river were wildly variable, and the nutrient data from the snapshot surveys showed that there was some enrichment of this site relative to other headwater sites located in nearby rivers.

A short-term water quality monitoring event was carried out in the middle of January 2000 when conditions in the catchment were dry and warm. The data from this event (Figures 3.35 and 3.36) show that peak water temperature at this site reached an extremely high 30 ^{o}C, which is likely to also have been the maximum air temperature for the period.

The data for dissolved oxygen shows that the daily change in saturation levels was also extreme, with daytime levels peaking at about 120% and nighttime levels plummeting to about 50%. While this has also influenced changes in pH at this site to some degree (Figure 3.36), it is the magnitude of the changes in dissolved oxygen that are most significant. The scale of this daily variation is indicative of a highly modified and out-of-balance ecosystem, and is likely to cause acute stress to any aquatic organisms inhabiting this stretch of the Calder River.

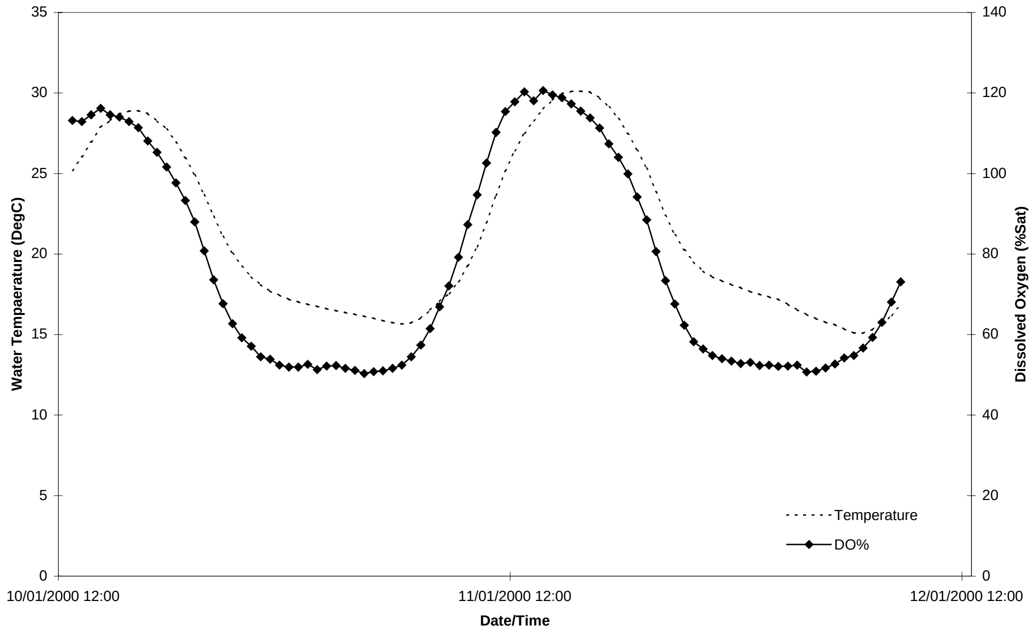

Figure 3.35: Short-term time series showing diurnal changes in water temperature and dissolved oxygen (% saturation) at IF13 (Calder River u/s Takone Rd) in January 2000.

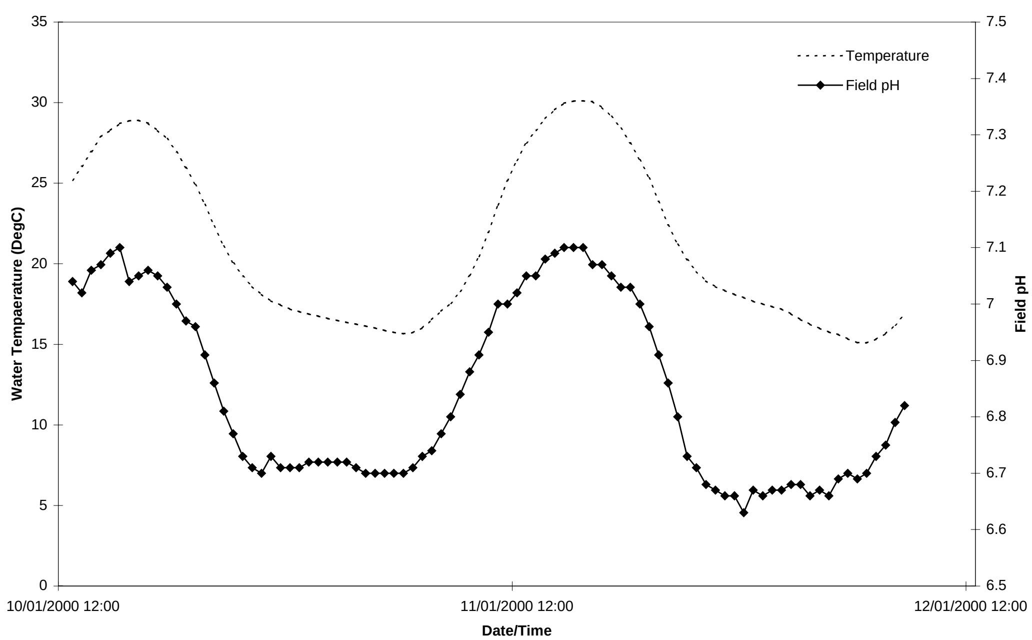

Figure 3.36: Short-term time series showing diurnal changes in water temperature and pH at IF13 (Calder River u/s Takone Rd) in January 2000.

Simultaneous short-term monitoring was also carried out at IF16 on the lower Flowerdale River, along with continuous monitoring of water temperature at site IF6 on the Inglis River. At the time of the logging event (January 2000), both these reaches of the Flowerdale and lower Inglis Rivers were totally enclosed by dense infestations of Crack Willow (*Salix fragilis*), and this has a marked influence on the scale of diurnal changes in water quality at these two sites.

As can be clearly seen from the data from IF16 (Figure 3.37 & 3.38), the magnitude of the daily change in water temperature, dissolved oxygen and pH was much less than was recorded in the upper Calder River over the same time period. The daily change in temperature at both IF16 and IF6 was about 3 ^{o}C, with a midday maximum of only 20 ^{o}C. This was much less than the overall change of 15 ^{o}C and peak temperature of 30 ^{o}C that was recorded at IF13, and reflects the huge influence shading by willows (or other dense riparian vegetation) can have on water temperature in rivers.

The scale of daily change in dissolved oxygen at IF16 (Figure 3.37) was also significantly dampened by the presence of willows, which through the provision of shade reduced the level of instream algal and microbiological activity. The presence of extensive willow roots on the banks and in the bed of the river is also likely to have reduced near-bed flows and increased the depositional characteristics of the river, leading to greater deposition and decomposition and an increased demand for oxygen. This is the most likely explanation as to why saturation levels vary within a much narrower range at this site, and do not exceed 80% during the daylight hours.

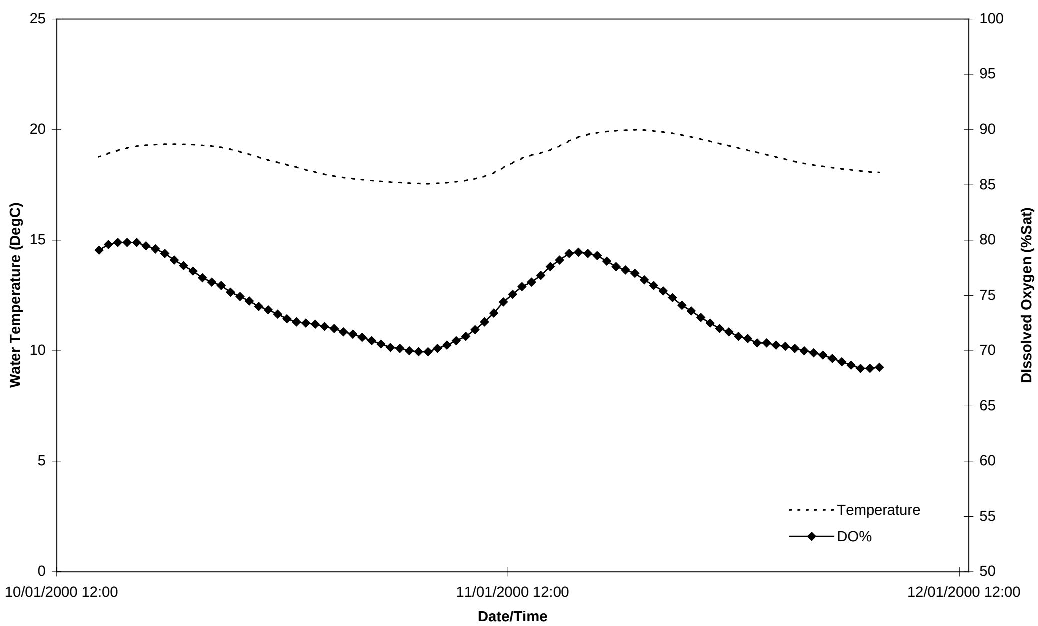

Figure 3.37: Short-term time series showing diurnal changes in water temperature and dissolved oxygen (% saturation) at IF16 (Flowerdale River at Preolenna Rd) in January 2000.

The more restricted scale of change in dissolved oxygen concentration at this site also means that pH (Figure 3.38) is much more stable. In addition, the ionic characteristics of the water in the lower Flowerdale River are such that, while still being fairly dilute, it has some ability to buffer against changes in pH that might be caused by changes in the concentration of dissolved oxygen. As a result of these two factors, the pH at IF16 is much more stable than was measured at IF13, varying by less than 0.1 over the period of the logging event.

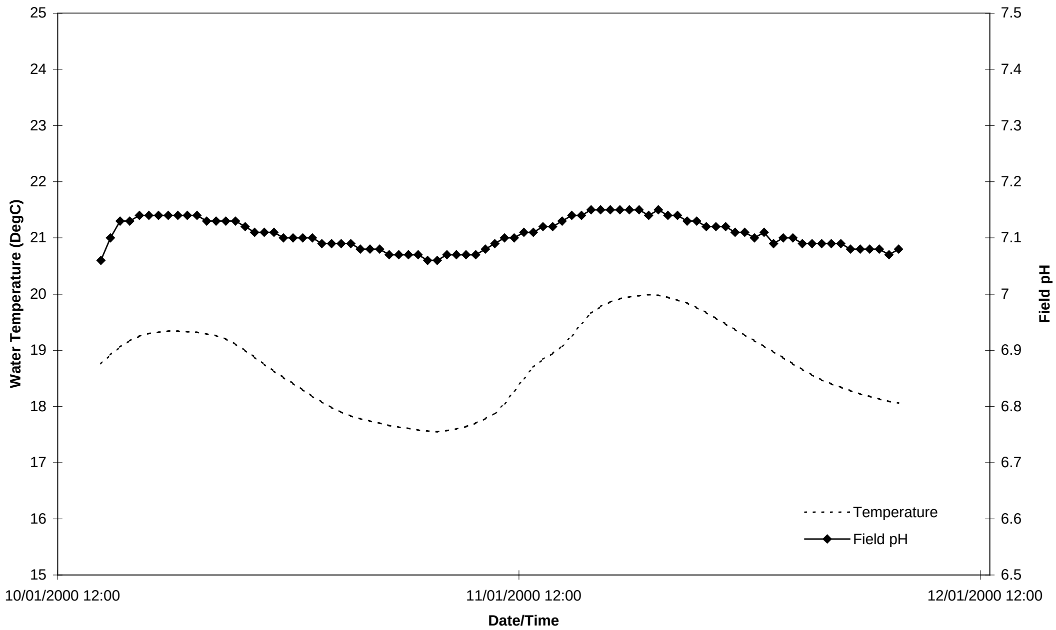

Figure 3.38: Short-term time series showing diurnal changes in water temperature and pH at IF16 (Flowerdale River at Preolenna Rd) in January 2000.

Following the short-term monitoring event conducted in January 2000, extensive willow removal was undertaken throughout the lower regions of the Inglis-Flowerdale catchment. While any remnant native riparian vegetation still living was left standing, the removal of all willows along large stretches of the river system meant that long reaches of rivers and streams were left totally exposed to the sun. The huge increase in light penetration that resulted is likely to have dramatically altered the energy dynamics of the aquatic ecosystem of these streams, the most obvious being higher daytime water temperatures and massive increases in algal productivity. Unfortunately, no additional short-term, diurnal monitoring was carried out at IF16 following willow removal, however some indication of the scale of the impact of willow removal on water temperature was recorded at IF6 on the lower Inglis River (Figure 3.39), where data was collected prior to and following willow removal. The time series from this site clearly shows that the removal of shade from the river caused the daily variation of water temperature to increase by more than 5 ^oC.

Table 3.4: Water temperature, dissolved oxygen and flow data from monthly monitoring at IF16 immediately prior to and following willow removal from the lower Flowerdale River in 2000.

Date	Water Temperature (^oC)	Dissolved Oxygen mg/L - %Sat	Estimated Flow (m^3s^{-1})
20/01/2000 8:50	17.5	6.22 (65%)	0.65
12/02/2000 8:50	18.1	6.13 (64%)	0.77
---------- **Willow removal carried out** ----------			
30/03/2000 8:24	14.4	7.8 (76%)	0.57
12/04/2000 9:55	13.3	7.72 (74%)	0.52

Examination of the monthly monitoring data from IF16 (Table 3.4) also gives some general indication of the change this had on mid-morning concentrations of dissolved oxygen. While this does not give any indication of the scale of change in the diurnal fluctuations at this site, it does suggest that nighttime dissolved oxygen minima were lifted following willow removal.

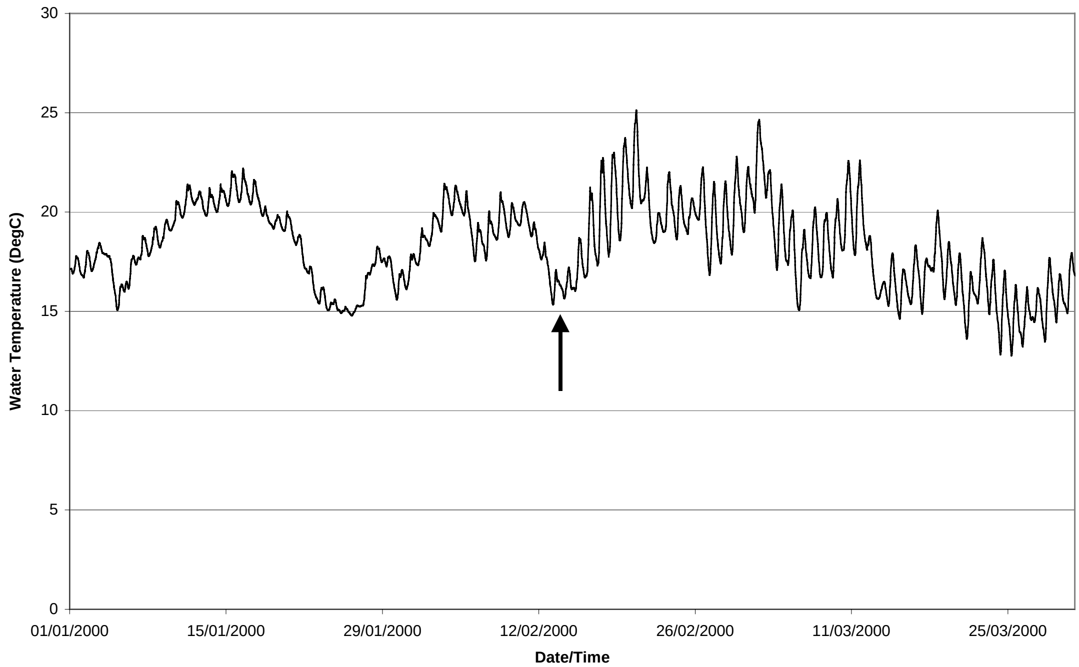

Figure 3.39: Time series showing the effect of willow removal (indicated by the arrow) on diurnal river water temperature in the lower Inglis River at IF4. Daily variation following removal increased to more than 5 ^{o}C.

4 Nutrient Load Estimates

4.1 Background

Nutrient load estimates for the Inglis River were derived from data collected at the railway bridge monitoring site (IF6), which is located approximately 7 km upstream of the catchment outlet at Wynyard. The site is situated above the confluence with the Flowerdale River, and so nutrient load estimates only apply to the Inglis River sub-catchment. Data used in the derivation of the load estimates was based on the combined data from regular monthly sampling and opportunistic sampling of higher flow events. A total of 35 monthly samples were collected from IF6 between February 1999 and December 2001, and up to 132 additional samples were collected from high flow events.

4.2 Monthly sampling

A brief summary of the turbidity, total suspended solid and nutrient concentrations for the 3-year monitoring period are shown in Table 4.1. It should be noted that total suspended solids concentrations in 12 of the 14 samples fell below laboratory detection limit of 10 mg/L, and where this occurred values were assigned a default value equivalent to the detection limit.

Table 4.1: Summary statistics for turbidity, nutrient and suspended solids collected from the Inglis River at IF6 during monthly sampling conducted between February 1999 and December 2001.

	Total suspended solids (mg/L)	Turbidity (NTU)	TN (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Ammonia (mg/L)	TP (mg/L)	DRP (mg/L)
N=	14	34	35	35	35	35	35	35
Mean	16.43	10.12	0.499	0.205	0.002	0.035	0.030	0.004
95% conf. int.	9.50	4.75	0.084	0.054	0.000	0.014	0.018	0.001
Median	10	4.89	0.425	0.166	0.002	0.020	0.017	0.003
Minimum	10	3.09	0.225	0.009	0.002	0.004	0.002	0.002
Maximum	60	69.30	1.300	0.617	0.003	0.180	0.309	0.014

Total suspended solids concentrations were low during the majority of the monthly samples, with most samples recording levels that were at or below laboratory detection limits. Peak monthly concentration occurred in late May 1999 (50 mg/L) and late July 2000 (60 mg/L), which coincided with initial winter catchment flushes and a peak flow event respectively.

Mean and median turbidity levels (Table 4.1) were typical for the region and fell within the normal range for lowland rivers as defined by ANZECC (2000). A peak turbidity of 69.3 NTU was recorded in July 2000, coinciding with elevated total suspended solids concentrations associated with a major flow event of 154 cumecs, which peaked four days prior to sampling.

Mean TN and TP levels fell below the ANZECC (2000) guideline values for these parameters in lowland rivers. Maximum TN and TP levels did not coincide with one another, nor did they coincide with peak monthly total suspended solids or turbidity, but occurred during initial catchment flushes in 2000 and 2001 respectively. This indicates that these nutrients were readily transported by initial catchment flushes and do not appear to be associated with significant amounts of particulate matter, and so were probably derived from fertiliser and faecal contamination or a combination of both sources given that agriculture is a primary land use in the lower catchment.

Nitrate levels were also elevated in relation to ANZECC (2000) guidelines, with highest concentrations coinciding with high flows in July 1999 and 2000.

4.3 Flood sampling

Flood sampling targeted elevated flows on an opportunistic basis. Water samples collected during high flows provided information on nutrient concentrations during events, which were then used to complement monthly monitoring data in the derivation of load estimates for the catchment. Water quality and flow monitoring equipment was installed for this study at site IF6 on the Inglis River, however this equipment was severely damaged by willow debris during flooding in mid 2000. River level monitoring equipment was reinstated at the end of this year however high levels of channel instability resulted in unreliable data for the site, and so flow data from this site was not sufficiently reliable for the derivation of load estimates.

A rainfall runoff model was therefore developed for the catchment in order to provide estimated hourly flow data for this site. Two types of flow estimates were developed based on; 1) catchment scaling and 2) rainfall/runoff modelling, both using data from the Flowerdale River flow monitoring station (IF17) for calibration.

Following inspection of time series plots based on both estimation methods, the scaled data was used to derive load estimates as it was more responsive to fine time-scale changes in flow, particularly during falling flows. The identification of this difference in estimates (scaled versus modelled) was critical, as load estimates were based on relationships between rising and falling flows in relation to nutrient concentrations, and reliable relationships between flow and nutrient concentrations could not be developed using modelled flow data. Figure 4.1 shows the scaled flows at the Inglis River at the Railway Bridge (site IF6).

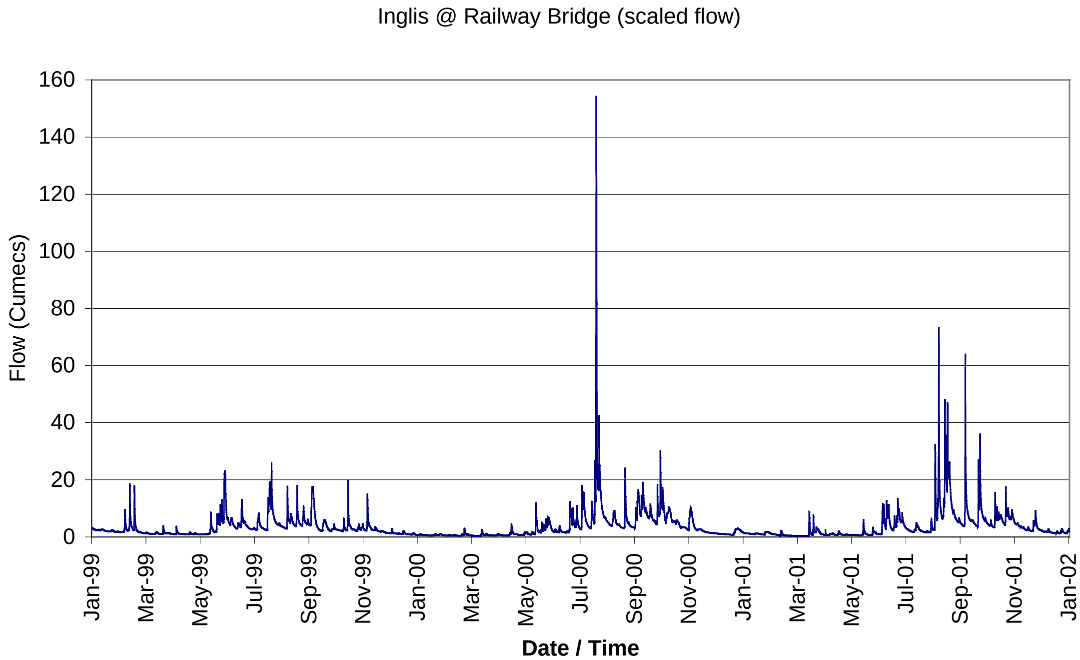

Figure 4.1: Estimated flows in the Inglis River at IF6 derived from catchment scaling and based on flow data from the adjacent Flowerdale catchment.

The season pattern of discharge in the Inglis River is distinctive. Flow increased from baseline levels in late autumn and peaked in mid winter before tailing off to low levels again in late spring. The highest flow for the study period occurred in 2000, peaking at 154 cumecs in July. The highest estimated annual discharge was also recorded in 2000 (122 045 ML), which was marginally higher than the estimated discharge for 2001 (120 968 ML) and significantly higher than that calculated for 1999 (105 079 ML).

Most flood samples were collected in the winter of 2000 and 2001, due to the higher incidence of high flow events during these years. Summary statistics for the nutrient samples collected during high flow events are shown in Table 4.2. While all the turbidity records collected during sampling are included in this table, nutrient results are limited to only the 53 sub-samples that were submitted for laboratory analysis. Sub-sampling was undertaken in order to contain analysis costs. Nitrate, nitrite, ammonia and dissolved reactive phosphorus were determined for approximately half of the nutrient samples that were collected during flood sampling.

Table 4.2: Summary statistics for turbidity, nutrients and suspended solids from the Inglis River at site IF6 during event sampling conducted between March 1999 and August 2001.

	Total suspended solids	**Turbidity (NTU)**	**TN (mg/L)**	**Nitrate (mg/L)**	**Nitrite (mg/L)**	**Ammonia (mg/L)**	**TP (mg/L)**	**DRP (mg/L)**
Count	37	132	53	26	26	26	52	26
Mean	69.16	44.06	1.110	0.540	0.003	0.033	0.078	0.005
95% conf. int.	12.16	4.69	0.117	0.047	0.001	0.008	0.015	0.002
Median	70	44.70	1.180	0.509	0.002	0.031	0.081	0.004
Minimum	10	3.45	0.064	0.378	0.002	0.009	0.009	0.002
Maximum	127	142.00	1.860	0.904	0.009	0.108	0.282	0.020

These data show that all the main nutrients increase substantially during floods, with average concentrations of TN and TP increasing at least 2-fold. Total nitrogen, nitrate, turbidity and total suspended solids levels were typical of flood flows in a Tasmanian context, and were similar to flood concentrations recorded from Pipers River in earlier studies (Bobbi *et. al.*,1999). It is interesting to note, however, that total suspended solids concentrations were almost double those recorded in the Duck and Montagu Rivers for the same period, which was highly unusual given the lower levels of turbidity recorded during monthly monitoring at this site during the study. During winter flooding, this resulted in instantaneous loads of more than 1,000 $kg.s^{-1}$ of sediment being transported down-river. It is likely that these higher than expected flood concentrations (and loads) were due mainly to the suspension and transport of locally derived sediment disturbed during the willow removal activity discussed in Section 3.6.

The flood concentration of TN and TP in the Inglis River were similar to levels recorded in the Pipers River (Bobbi *et al.*,1999), and were significantly lower that flood concentrations recorded from the Montagu and Duck Rivers. Nitrate levels were also similar to those recorded from the Duck and Montagu catchment (Bobbi, *et. al*., - in press), however dissolved reactive phosphorus and nitrite concentrations were very low. These data broadly reflect the much lower level of animal husbandry occurring in the Inglis River catchment compared to the Duck and Montagu catchments, where dairy farming is particularly extensive.

Figure 4.2 and Figure 4.3 show the relationship between turbidity and nutrient concentrations in the lower Inglis River. Correlations between turbidity and both TN and TP were relatively strong, with R^2 values in excess of 0.7 in both cases. Identification of nutrient/turbidity relationships is a useful tool, as significant relationships facilitate estimation of nutrient concentrations based on instantaneous or spot turbidity readings. Where sites have continuously logged turbidity records, turbidity/nutrient relationships are pivotal in allowing more accurate estimation of nutrient loads and export coefficients.

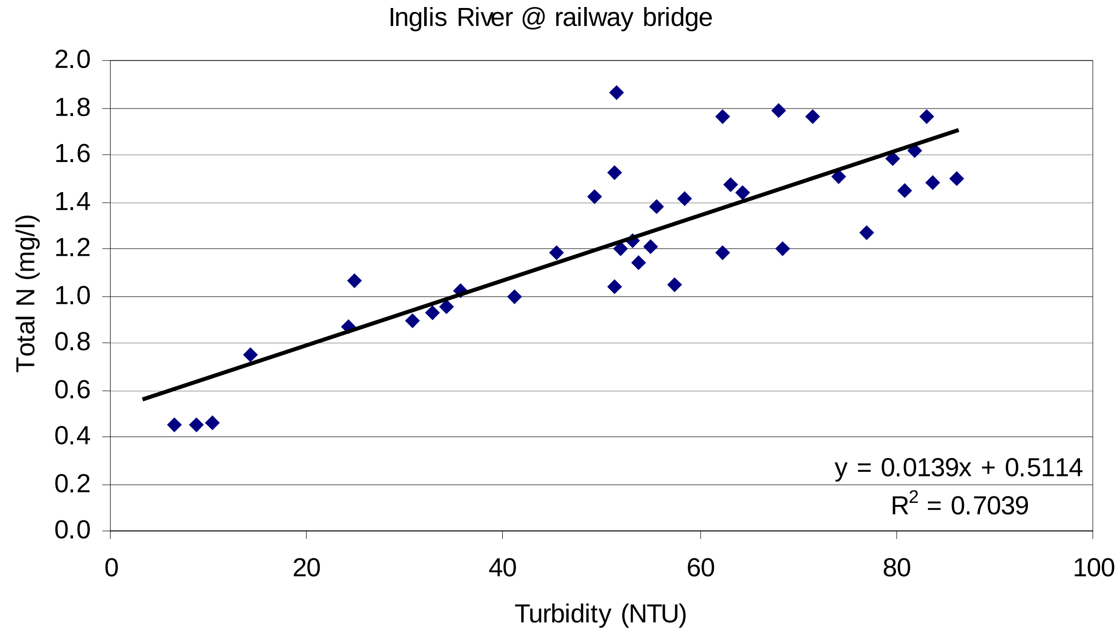

Figure 4.2: Regression of turbidity versus TN concentration at site IF6 on the Inglis River derived from flood data collected between February 1999 and December 2000.

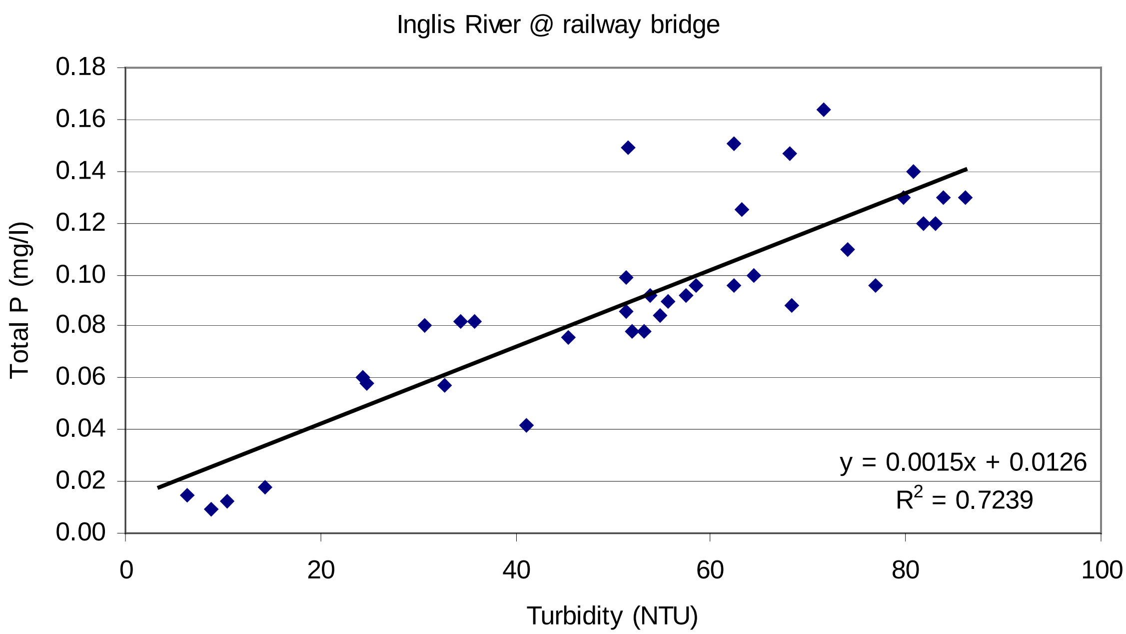

Figure 4.3: Regression of turbidity against TP concentration at site IF6 the Inglis River derived from flood data collected between February 1999 and December 2000.

Unfortunately, continuous turbidity data was not available from this site as floods had damaged the logging equipment as discussed earlier in this section, and so load estimation was derived from relationships between rising/falling flows and nutrient concentrations. A reliable relationship between total suspended solids and flow could not be developed due to limitation of the data, however relationships were developed for rising and falling flows relative to total nitrogen and total phosphorus concentrations. These regression and their corresponding correlation coefficients are shown below.

Total Nitrogen

Rising flows	$y = 0.0903x + 0.2829$ ($R^2 = 0.6326$), n = 34
Falling flows	$y = 0.0598x + 0.419$ ($R^2 = 0.3652$), n = 47

Total Phosphorus

Rising flows	$y = 0.0084x + 0.0098$ ($R^2 = 0.539$), n = 34
Falling flows	$y = 0.0051x + 0.0135$ ($R^2 = 0.5259$), n = 47

Derivation of these regressions relies on the collection of adequate numbers of nutrient samples covering a range of flows. The correlation coefficients listed above, particularly the R^2 values associated with the falling flow total nitrogen regression, indicate that only moderate relationships between variables could be developed, and as such the load estimates derived from these regressions are of only moderate to low accuracy. It should also be remembered that the flow data used in the derivation of these regressions was based on estimated data scaled from flows in an adjacent catchment, and therefore the error margins associated with the derivation of the flow data will reduce the accuracy of the load estimates even further. Nevertheless, the loads derived using these equations, while having a lower than optimum accuracy, serve as reasonable indicators of the loads of nutrient being exported from the catchment.

To derive monthly load estimates from these relationships, the flow record was divided into rising and falling flow components and the above equations were applied to each subset of the flow record. Table 4.3 shows the monthly load estimates and mean monthly TP and TN concentrations for the Inglis River at IF6 for the period January 1999 to December 2001. Total discharge over the 36-month study period was 348,091 ML, and during this time approximately 407,739 kg of phosphorus and 28,702 kg of nitrogen were exported past this point. Maximum monthly nutrient loads occurred in July 2000 and were associated with the 154 cumec flood event which transported 100,225 kg of nitrogen and 8,229 kg of phosphorus past IF6. In comparison, peak monthly loads of 259,079 kg of nitrogen and 93,364 kg of phosphorus were discharged from the Montagu River at Stuarts Rd in July 2000 during corresponding studies in that catchment.

Highest total annual nitrogen and phosphorus loads were recorded in 2000 (total N=175 254 kg, total P=12 944 kg) followed by 2001 (total N=146 430 kg, total P=10 392 kg) and 1999 (total N=86 054 kg, total P=5 366 kg).

Table 4.3: Monthly nutrient loads at the Inglis River @ railway bridge between January 1999 and December 2001.

Date	Discharge (ML)	Mean Monthly TN (mg/L)	Total Monthly TN (kg)	Mean Monthly TP (mg/L)	Total Monthly TP (kg)
Jan-99	6,013	0.533	3,228	0.026	158
Feb-99	7,731	0.604	6,041	0.032	369
Mar-99	3,439	0.472	1,646	0.020	72
Apr-99	2,879	0.470	1,372	0.019	57
May-99	11,149	0.671	12,368	0.039	874
Jun-99	12,023	0.700	9,069	0.040	537
Jul-99	15,640	0.785	15,759	0.047	1,058
Aug-99	14,597	0.756	12,396	0.045	779
Sep-99	12,973	0.733	12,318	0.043	819
Oct-99	8,410	0.600	5,777	0.031	329
Nov-99	7,071	0.574	4,591	0.029	250
Dec-99	3,153	0.468	1,490	0.020	64
Jan-00	1,916	0.431	825	0.017	32
Feb-00	1,761	0.430	755	0.017	31
Mar-00	1,679	0.425	729	0.016	29
Apr-00	2,321	0.454	1,105	0.018	47
May-00	7,320	0.568	4,905	0.029	283
Jun-00	8,540	0.607	6,164	0.032	365
Jul-00	33,201	1.241	100, 225	0.088	8,229
Aug-00	13,664	0.729	11,243	0.042	686
Sep-00	22,027	0.970	23,552	0.065	1,628
Oct-00	17,943	0.832	18,137	0.051	1,194
Nov-00	7,883	0.604	5,674	0.031	331
Dec-00	3,792	0.494	1,939	0.021	88
Jan-01	3,276	0.478	1,573	0.020	66
Feb-01	1,829	0.447	840	0.017	33
Mar-01	3,282	0.470	1,893	0.020	98
Apr-01	2,300	0.449	1,038	0.018	42
May-01	2,718	0.463	1,345	0.019	59
Jun-01	12,867	0.722	11,083	0.043	712
Jul-01	6,538	0.556	3,766	0.027	185
Aug-01	34,859	1.281	67,583	0.092	5,269
Sep-01	22,023	0.964	33,521	0.063	2,498
Oct-01	16,919	0.817	14,867	0.051	956
Nov-01	9,636	0.639	6,508	0.034	363
Dec-01	4,722	0.505	2,414	0.023	112
Totals	**348,091**		**407,739**		**28,702**

4.4 Export Coefficients

The derivation of export coefficients for catchments with annual nutrient load information allows comparisons to be made between catchments of different sizes and water yields. The equations used in the derivation of export coefficients are included in the glossary at the beginning of this report.

Table 4.3 shows the catchment area, annual discharge, total phosphorus and total nitrogen export coefficients for 1999, 2000 and 2001. The table shows that nutrient export coefficients in the Inglis River during the study were related to discharge, with highest total nitrogen and total phosphorus export coefficient recorded in 2000, when annual discharge was highest. Lowest nutrient export coefficients were recorded in 1999, which was also the year of lowest discharge during the study.

Table 4.3: Export coefficients for the Inglis River catchment - 1999, 2000 and 2001.

Year	Catchment area (km^2)	Discharge (ML)	Total P ($kg/mm/km^2$)	Total N ($kg/mm/km^2$)
1999	175	105,079	0.051	0.82
2000	175	122,045	0.106	1.44
2001	175	120,968	0.086	1.21

Table 4.4 shows a list of export coefficients that have been calculated for 11 Tasmanian rivers assessed during 'State of River' studies conducted over the last decade. Results for rivers with more than one year of data have been averaged. Comparison of the export coefficients listed in the table shows that nutrient export from the Inglis River is moderate, particularly in comparison to the Duck and Montagu Rivers, which are the closest adjacent Tasmania rivers that have been assessed. The Duck and Montagu Rivers exhibited extremely high N:P ratios (3:1), reflecting the impact of intensive agriculture on nutrient loads leaving these catchments. The Inglis catchment, however, has an N:P ratio that is similar to less impacted rivers (14:1), and while its catchment area is smaller and mean annual discharge is higher, its nutrient export coefficients were very similar to those reported for the Pipers River catchment.

Table 4.4: Export coefficients for 11 Tasmanian rivers. Results for catchments where data have been collected for more than one year have been averaged.

Catchment	Years of data	Catchment area (km^2)	Mean annual dishcharge (ML)	Total P ($kg/mm/km^2$)	Total N ($kg/mm/km^2$)
Inglis R @ Railway Bridge	**3**	**175**	**116,030**	**0.081**	**1.16**
Montagu R @ Stuarts Rd	3	323	98,778	0.8	2.66
Duck R @ Scotchtown	3	339	141,172	0.532	1.71
Pipers River	1	298	96,700	0.083	1.17
Brid River	1	136	40,986	0.066	1.13
Meander R @ Strath Bridge	3	1,012	427,904	0.058	0.67
Liffey River	3	224	80,661	0.052	0.78
South Esk R @ Perth	3	3,280	624,508	0.034	0.66
Break O'Day River	3	240	53,177	0.065	0.94
Huon R @ Judbury	1	2,097	2,562,475	0.01	0.33
Kermandie River	1	130	36,760	0.122	1.42

4.5 Summary

Unfortunately, flood damage to the logging station located at the railway bridge resulted in unacceptably large gaps in the discharge and turbidity records for the catchment. Flow in the

Inglis River was therefore modelled using flow data from the adjacent Flowerdale River scaled for the Inglis River on the basis of catchment area. The largest flood of the study occurred in July 2000, when flow in the river was estimated to have reached a peak of 154 cumecs.

Although there were a number of factors reducing the accuracy of nutrient export estimates, catchment loads were calculated from nutrient/flow relationships derived from scaled flow, total nitrogen and total phosphorus sample data. As expected, peak nitrogen and phosphorus loads coincided with elevated catchment discharge. Unexpectedly high concentrations of suspended solids were also recorded, and although comprehensive load estimates for suspended sediment could not be made, instantaneous loads of more than 1,000 $kg.s^{-1}$ were recorded. It appears that riverbed and bank disturbance caused by whole sale willow removal along the lower reaches of the Inglis River was the main cause for elevated sediment transport from this area.

Export coefficients derived from nutrient load estimates for this river indicate that export from the Inglis catchment is moderate in a Tasmanian context and is similar to those recorded from Pipers River on the State's north coast, but was well below those recorded for the nearby Duck and Montagu Rivers. In summary, the results of the survey indicated that current land use practices have a moderate influence on nutrient loads in the catchment.

5 Discussion and Summary

The extended catchment drained by the Inglis and Flowerdale rivers, Camp Creek and Seabrook Creek encompasses a patchwork of land-use and river management activities that can influence water quality. In broad terms, agricultural production is more concentrated on the eastern side of the catchment, at the lower end of the Inglis and Flowerdale rivers, over the upper sections of the Calder River, and throughout most of the area drained by Camp Creek and Seabrook Creek. Many parts of these river reaches contain little or no riparian vegetation and there was fairly widespread stock access at the time of this study. The data collected during this study has shown the impact this has had on water quality in these rivers, particularly with respect to nutrient levels, which were quite elevated in the rivers and streams draining the Yolla – Henrietta – Kellatier area.

In the latter half of the monitoring period a willow removal program was commenced and this had significant environmental consequences, particularly on the levels of suspended solids measured during floods. Although comprehensive event load estimates could not be made, it is likely that sediment disturbed during willow removal resulted in massive export of sediment from the catchment during the winter of 2000. This has consequences for the condition and state of the river-mouth and estuary at Wynyard, as well as the near-coastal sub-tidal environment.

Data collected during the study also showed that complete exposure of streams to sunlight can cause an extreme imbalance in water temperature and dissolved oxygen, as well as promote invasion of the river by weed species such as Cumbungi and Crack Willow. While infestation of rivers and streams by willows also has implications for environmental condition and water quality, their complete removal from large stretches of river systems also has negative consequences. Progressive and incremental willow removal, as recommended by the States 'Willow Management Guidelines', is the current best practice and poses least threat to the aquatic environment.

In the centre of the catchment, on the east and west banks of the Inglis River, a large number of gravel quarries, along with a network of gravel roads have been established. Although many of these may no longer be in operation, data collected during this study suggests that both the quarries and the gravel roads may continue to make significant contributions to sediment loads in the Inglis River. Opportunistic sampling during an intense thunderstorm in the catchment in February 1999 showed that runoff from gravel roads leading to the river can cause enormous increases in turbidity and deliver substantial sediment directly to the river through the road drainage system.

To the west of the Inglis River, a much larger proportion of the land is covered by forest, be it State Forest or privately owned forest plantations, and while this may have consequences with respect to contamination of water by pesticides and herbicides (an aspect not investigated during this study), this has generally resulted in better water quality in the Flowerdale River compared to the Inglis River or many of the smaller tributaries. In a similar manner, reasonably intact and extensive forests along the middle reaches of the Inglis River provides some protection to water quality in this part of the river, as the focus of agricultural activities lies on the hilltops above the river (along Calder Road).

The data collected during this 3-year study has provided valuable information on the current state of water quality in the Inglis-Flowerdale catchment, and has drawn attention to areas where future management or remedial activities might be focussed. The main aim of the study has been on the collection of 'baseline' data, against which future condition can be assessed, and as such was not able to provide comprehensive data that could resolve all of the issues raised. Additional study may be required to adequately identify the nature and scale of some of the problems raised during this report, and the issue of herbicide and pesticide contamination should be given some consideration, given the level of community concern expressed at the time of the study.

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