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

Tasmania

Water Quality of The Brid River

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

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Executive Summary

The Brid River catchment is an area extensively used for agriculture and forestry. The catchment covers approximately 145 km^2 and drains northward into Bass Strait through Bridport. This report presents and discusses the results of a 1 year study of water quality in the catchment which was undertaken in 1998 as part of a program of 'State of Rivers' studies in the northeast of Tasmania. The results should also be examined in the light of other studies into hydrology, stream condition and aquatic ecology which were also undertaken concurrently and which are reported separately.

Some of the major findings of this study are:

⇒ Dorset Waterwatch studies in Cox's Creek have showed that effluent from the Scottsdale sewage treatment plant has a significant impact on water quality in the creek, but the data also shows that water quality improves with distance down stream.

⇒ pH levels in the Brid River are slightly acidic in the upper catchment but become more neutral as the river flows through State Forest area in the lower catchment. Other evidence demonstrates that water quality shows some improvement in the area of the State Forest as catchment inputs to the river are less.

⇒ Turbidity is moderately high throughout the length of the river, however data shows that at lower flows sediment appears to settle out of the water column in the middle and lower reaches and may be deposited on the river bed in these areas.

⇒ Although there is a seasonal pattern of change in dissolved oxygen concentrations in the river, levels are generally indicative of a healthy ecosystem. Lower summer concentrations in the upper catchment may indicate the effects of nutrient loads entering the river in this region.

⇒ Salt levels in the catchment are generally low, however water in Shanty's Creek was found to be highly saline, with conductivity levels as high as 5,000 µS/cm.

⇒ Nitrate levels in the river are very similar to those in the nearby Ringarooma and Great Forester rivers. Concentrations in the Brid River appear to be linked to streamflow, with higher concentrations occurring during higher baseflows in winter. The Little Brid River was identified as having highest concentrations in the catchment.

⇒ Average phosphorus concentrations are 0.034 mg/L, but fluctuate widely based up rainfall and runoff. In the Brid River there is a strong link between phosphorus and turbidity.

⇒ Snapshot bacterial testing showed that during summer conditions faecal contamination may be highest in the upper catchment, where animal industries are most intensive. Further monitoring is require to ascertain the seriousness of this problem and identify feasible solutions.

⇒ Continuous measurement of turbidity at the bottom of the catchment has showed that levels during floods can reach as high as 150 NTU, which is 10 times higher than levels during baseflows. This record was used to calculate sediment and nutrient export from the catchment. During 1998 an estimated 925 tonnes of sediment, 2.2 tonnes of phosphorus and 38 tonnes of nitrogen were exported from the Brid catchment.

⇒ A comparison of export figures with those from other Tasmanian catchments showed that export of nutrients from the Brid catchment is the highest of any catchment yet measured.

⇒ One of the major issues arising from the data collected during this study is that activities in the upper catchment are having the most significant impact on water quality. These tend to revolve around management of runoff from intensively farmed land and a lack of riparian buffering of the river. Implementation of better riparian management practices are singled out as one positive step towards improving water quality in the Brid River.

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A GLOSSARY OF TERMS

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

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

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

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

Dissolved Oxygen
Oxygen is essential for all forms of aquatic life and many organisms obtain this oxygen directly from the water in the dissolved form. The level of dissolved oxygen in natural waters varies with temperature, turbulence, photosynthetic activity and atmospheric pressure. Dissolved oxygen varies over 24 hour periods as well as seasonally and can range from as high as 15 mg/L to levels approaching 0 mg/L. Levels below 5 mg/L will begin to place stress on aquatic biota and below 2 mg/L will cause death of fish.

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

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

Eutrophication
The enrichment of surface waters with nutrients such as nitrates and phosphates, which cause nuisance blooms of aquatic plants and algae.

Export Loads / Export Coefficients
The calculation of export loads of nutrients, or any other parameter, involves using nutrient concentration data collected over a wide variety of flow conditions and from various seasons. This information, when plotted against flow at the time of collection, can reveal relationships between flow and concentration which can then be used to estimate the load of a particular nutrient leaving the

catchment (estimates of export loads should be regarded as having no greater accuracy than +/- 15%).

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

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

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

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

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

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

General Ions
General ions are those mineral salts most commonly present in natural waters. They are primarily sodium, potassium, chloride, calcium, magnesium, sulphate, carbonates and bicarbonates. Their presence affects conductivity of water and concentrations variable in surface and groundwaters due to local geological, climatic and geographical conditions.

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

Macroinvertebrate
Invertebrate (without a backbone) animals which can be seen with the naked eye. In rivers common macroinvertebrates are insects, crustaecans, worms and snails.

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

i.e. Of the readings 10, 13, 9, 16 and 11

{Re-ordering these to read 9, 10, 11, 13 and 16}

The median is 11.

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

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

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

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

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

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

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

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

Units and Conversions

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

Acronyms

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

B SUMMARY OF NATIONAL GUIDELINES FOR WATER QUALITY

Australian Water Quality Guidelines as per ANZECC (draft - 1998)
As part of a National strategy to “pursue the sustainable use of the nation’s water resources by protecting and enhancing their quality while maintaining economic and social development’ the Australian and New Zealand Environment and Conservation Council (ANZECC) has been developing guidelines for water quality for a range of Australian waters. Since 1992, a document titled ‘Australian Water Quality Guidelines For Fresh and Marine Waters (1992) ’ has been available for use as a reference tool for catchment management plans and policies. At the time of its release, the guidelines were based on the best scientific information available.

Since 1995, that document has been under review, and a new draft has recently been released for public comment (ANZECC, draft 1998). The updated version has changed the emphasis of guideline setting, suggesting a ‘risk assessment’ approach which utilises the concept of increased risk with increasing departure from ‘safe’ levels. It also restates the principle that they are simply guidelines to be used in the absence of local data, and that where local data can be obtained, they should be used to develop local water quality standards. This needs to be kept in mind when examining the following tables which summarise the new draft guidelines. The figures quoted are suggested as interim trigger levels for assessing risk of adverse effects on different ecosystem types (for essentially natural ecosystems).

1. Proposed Trigger Levels for Nutrients

Ecosystem Type	**TP** (µg/L)	**TN** (µg/L)	**Key Ecosystem-specific factors**
Lowland River	37	1600	- light climate (turbidity)
			- flow
			- grazing
			- bioavailable nutrient [ ]
Upland River	35	340	- light climate (turbidity)
			- substrate type
			- bioavailable nutrient [ ]
			- grazing
Lakes and Reservoirs	50	440	- light climate (turbidity)
			- mixing (stratification)
			- bioavailable nutrient [ ]

2. Proposed Trigger Levels for Dissolved Oxygen, Suspended Particulate Matter and Turbidity.

Ecosystem Type	**DO** (%sat)	**Susp. Solids#** (mg/L)	**Turbidity** (NTU)
Lowland River	90	6*	10
Upland River	92	2*	5
Lakes and Reservoirs	90	2*	4.5

Recommend additional work to establish load based trigger levels;
* Professional judgement

3. Proposed Trigger Levels for Conductivity, Temperature and pH.

Ecosystem Type	**EC (µS/cm)**	**Temp. Increase**	**Temp. Decrease**	**pH**
Lowland River	> 500*	< 80th %ile	>20th %ile	6.6 - 8.0
Upland River	> 110*	< 80th %ile	>20th %ile	6.5 - 7.5
Lakes and Reservoirs	> 60*	< 80th %ile	>20th %ile	7.8 - 8.3

* Professional judgement;

4. Proposed Microbiological Guidelines

The new guidelines for recreational waters propose a ‘Bacterial Indicator Index’ which requires routine sampling (at least 5 samples over a regular period not exceeding one month). It utilises statistics of the entire dataset to form the index in the following manner;

Bacterial Indicator Index = 2.5 x median/100mL + 80th percentile/100mL

Using this formula to calculate the index, the following guideline has been suggested;

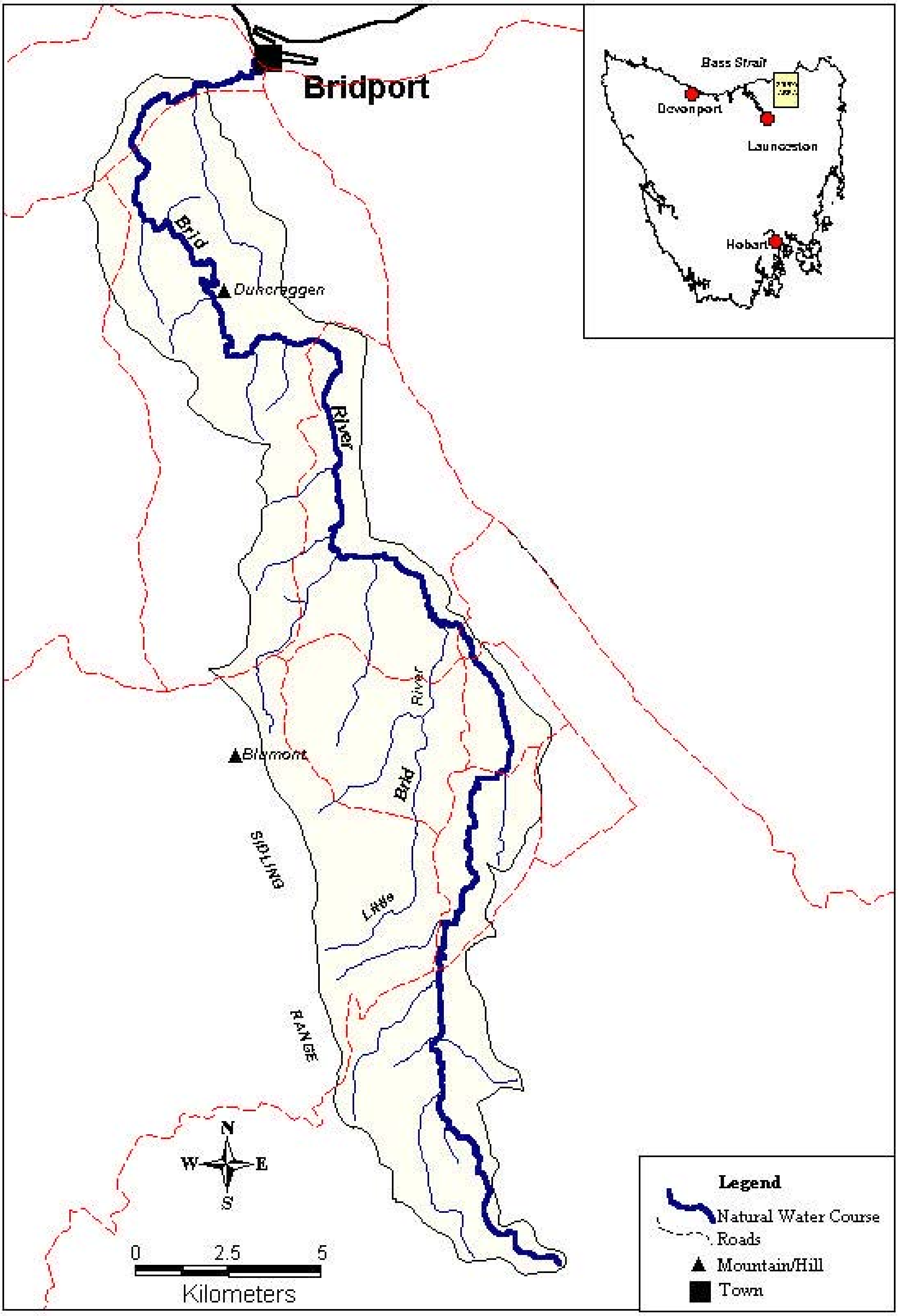
Primary Contact (eg swimming)
Bacterial Indicator Index should not exceed 800 for thermotolerant coliforms
or 300 for enterococci
Where more intensive monitoring is carried out the index should not exceed 550 for thermotolerant coliforms, or 200 for enterococci

Secondary Contact (eg boating)
Bacterial Indicator Index should not exceed 5000 for thermotolerant coliforms
or 2000 for enterococci

National Health and Medical Research Council - Drinking Water

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

Figure 1.0: Brid River Catchment



Water Quality of the Brid River Catchment

1 Historical Data

The only historical water quality data which is readily accessible is for the Brid River at the stream gauging site located several kilometres upstream of the tidal limit (Site #19200 on HYDROL). Interrogation of the HYDROL database for water quality data showed that there has been two general types of data collected at this site. Between 1974 and 1989 there has been some intermittent collection of water quality data, mainly of the parameters which can be measured on-site such as temperature and pH. Later in that period (1985 - 94) samples were collected and taken to a laboratory for more detailed analysis.

During a short period between 1994 - 96 sampling on a 10 week basis was carried out following the installation of water quality monitoring equipment at this site. These samples were analysed for a wider range of parameters.

Table 1.1a-c gives the summary statistics for the water quality data collected during the early period (1974 - 89). The statistic of most importance in all these tables is that for the median, which gives the most accurate representation of the ‘usual’ or ‘average’ condition of the water quality in the river. To make it easier to visualise, some of the parameters which have larger datasets are also plotted in Figures 1.1 to 1.4. The river level, which has been noted on all occasions where water quality has been tested, is also plotted to indicate the hydrological condition under which testing was performed.

Table 1.1a Statistics of historical water quality - Brid River 2.6 km upstream of tidal limit. (Hydrol #19200).

	River Level	Lab pH	Field pH (Litmus)	Temperature
Parameter Number	100.00	15401	15408	10100
Number of Readings	155	81	73	147
Period of Record	1974 - 1994	1974 - 1989	1982 - 1994	1974 - 1994
Maximum	1.065	8.6	7.7	22.0
Minimum	0.018	5.9	5.3	3.0
Median	0.245	6.7	6.5	12.0
Average	0.230	6.7	6.6	12.0

Table 1.1b Statistics of historical water quality - Brid River 2.6 km upstream of tidal limit. (Hydrol #19200).

	Turbidity (NTU)	Field Conductivity Tref 25°C (µS/cm)	Apparent Colour (Hazen Units)	Suspended Solids (mg/L)
Parameter Number	13601	14101	12301	17100
Number of Readings	19	31	21	21
Period of Record	1985 - 1989	1983 - 1994	1985 - 1989	1985 - 1989
Maximum	20	277	150	42
Minimum	3.3	95	50	4
Median	10.4	153	70	11
Average	11.0	161	75	15

Table 1.1c Statistics of historical water quality - Brid River 2.6 km upstream of tidal limit. (Hydrol #19200).

	REDOX (mV)	Filterable Residues (mg/L)
Parameter Number	15200	32901
Number of Readings	5	21
Period of Record	1990 - 1991	1985 - 1989
Maximum	89	209
Minimum	42	25
Median	66	99
Average	69	109

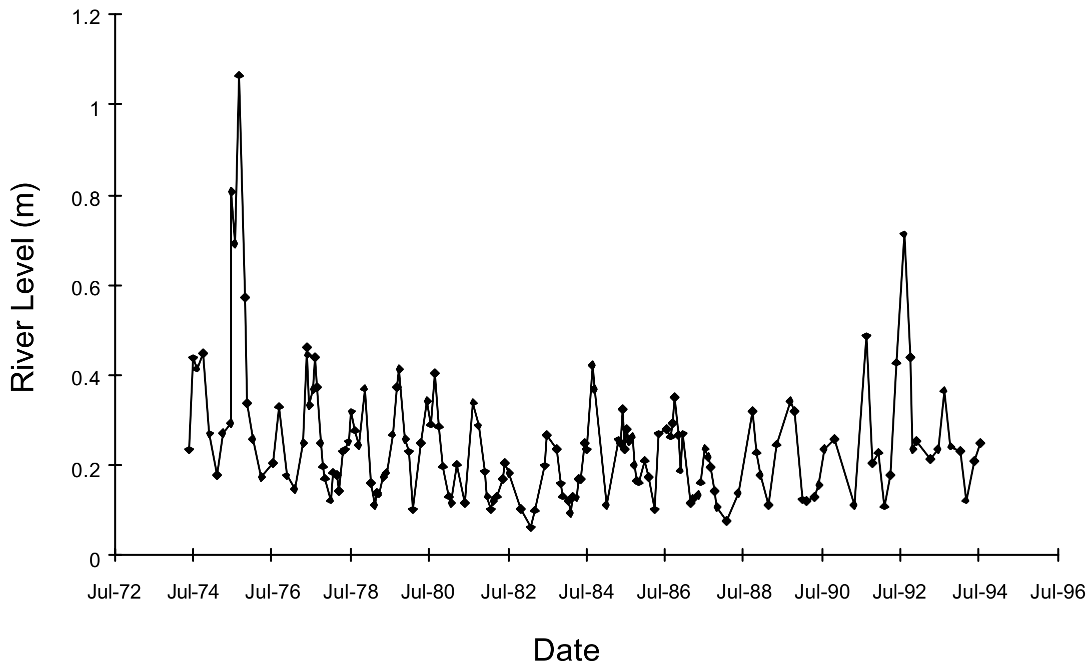


Figure 1.1 River level recorded during site visits when water quality testing occurred at the Brid River (HYDROL # 19200) between 1974 and 1994.

The data shows that the majority of water testing took place when river level was between 0.1m and 0.4m. From the statistics shown in the tables and presented in the graphs below, it can be seen that water in the Brid River is moderately dilute (filterable residues and conductivity), has a measurable load of sediment (suspended solids and turbidity) and is mildly acidic (pH). Water temperature at the bottom of the catchment has been measured as low as 3 ^{o}C and as high as 22 ^{o}C.

The plot for temperature (Figure 1.2) shows the strong seasonal variation, with the highest and lowest temperatures occurring in 1982. The data also suggest that for the period from 1974 - 1981, there may be a trend for increasing water temperature. The time series for pH shown in Figure 1.3, which combines the data from both field and laboratory based measurements, indicates that pH can fluctuate widely but over the longer term does not show any apparent trend.

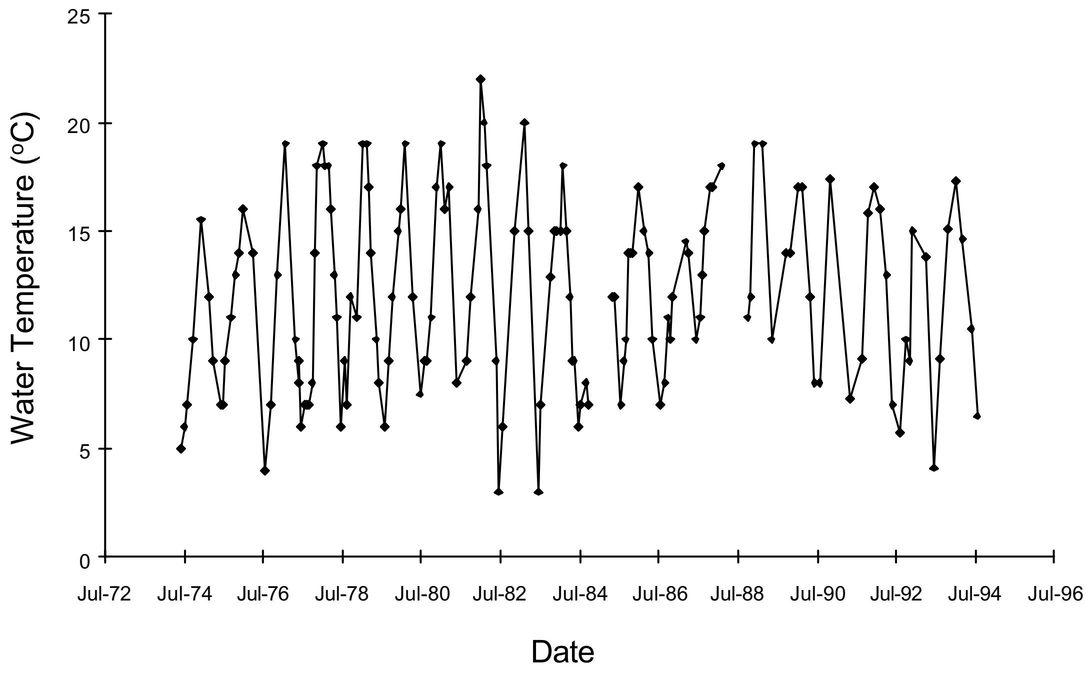


Figure 1.2 Water temperature recorded during site visits when water quality testing occurred at the Brid River (HYDROL # 19200) between 1974 and 1994.

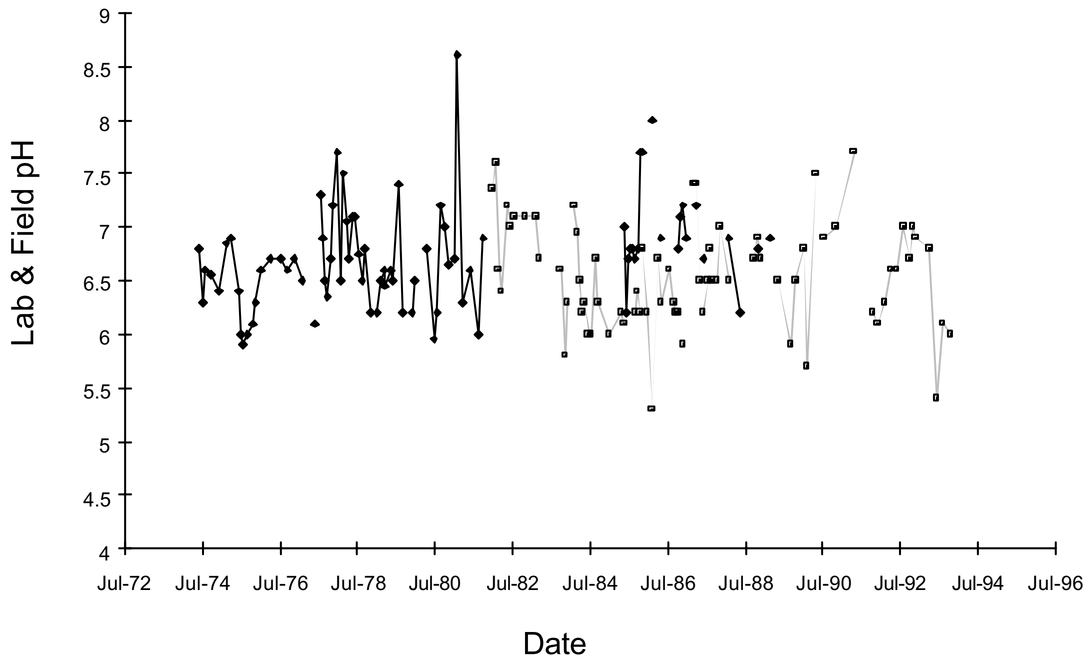


Figure 1.3 pH (measured on site or from bottle samples) from the Brid River (HYDROL # 19200) between 1974 and 1994.

The data for conductivity is more sparse, with two groups of data, one from about 1983 and the other stretching from 1989 to 1994. Both show that like pH, conductivity in the lower Brid River also varies substantially. However, the average is about 150 µS/cm.

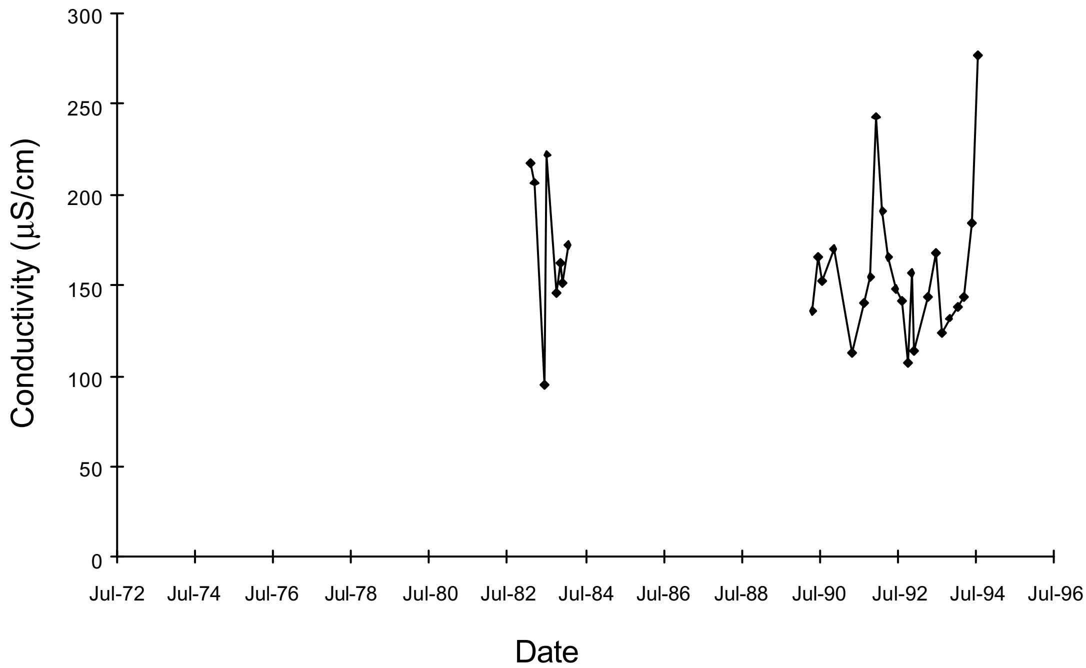


Figure 1.4 Field conductivity (Tref 25) recorded during site visits to the Brid River (HYDROL # 19200) between 1974 and 1994.

Some of these data are graphically represented using box & whisker plots (Figures 1.5 and 1.6 below). This is simply another way of illustrating and comparing statistics between water quality parameters.

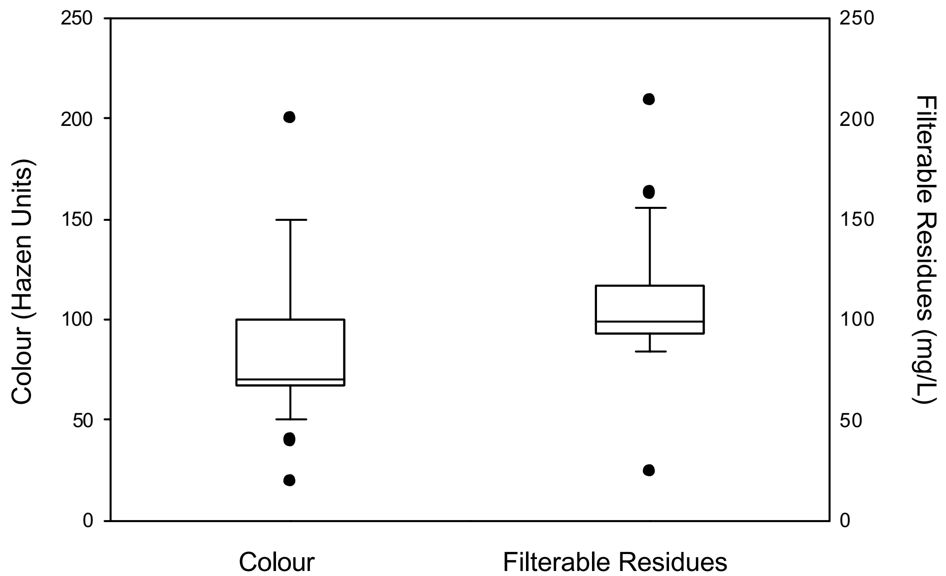


Figure 1.5 Boxplots showing the distribution and basic statistics of the data for Apparent Colour and Filterable Residues extracted from the HYDROL database.
(n=33 for colour, n=21 for filt. res.) 1985 - 96.

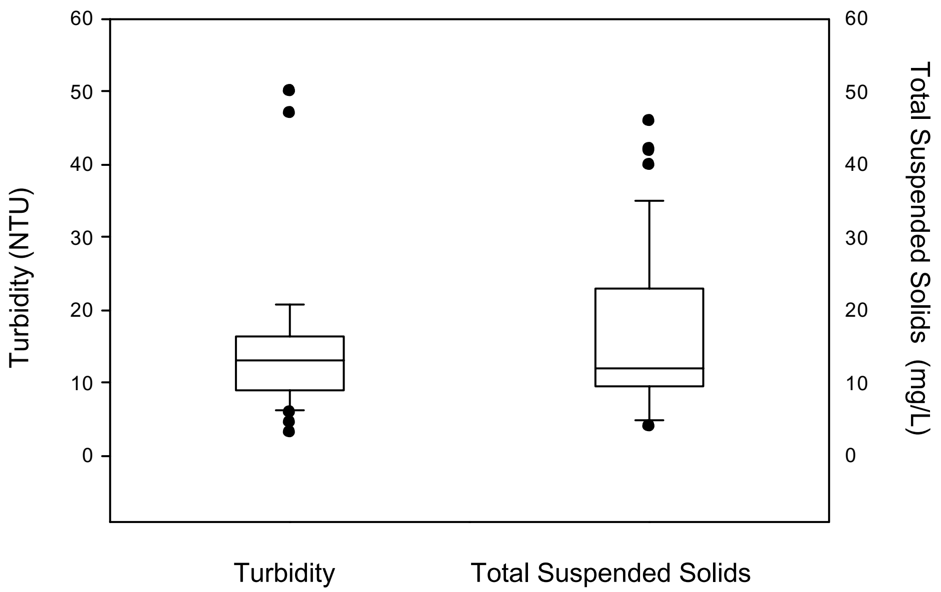


Figure 1.6 Boxplots showing the distribution and basic statistics of the data for Turbidity and Total Suspended Solids extracted from the HYDROL database.
(n=29 for turb, n=32 for TSS). 1985 - 96.

Between 1994-'96 some routine sampling for nutrients was undertaken on about a 10 weekly frequency. This data was collected following the installation of turbidity and conductivity monitoring equipment at the stream gauging station. For the purposes of this report, it has been kept separate from the other historical data as it is considered as indicative of more recent conditions.

The data shows that nitrate nitrogen (NO_3/N) concentrations are between 0.2 - 0.5 mg/L, and contribute about 40% to total nitrogen (TN) concentrations. The peak TN concentration measured was 1.45 mg/L, which is much higher than the median of 0.93 mg/L. That concentration was recorded twice during high flows in the Brid River when the load of suspended material was elevated. On both those occasions, total phosphorus (TP) concentrations were also high (0.098 & 0.11 mg/L). The data in Figure 1.8 shows that the median TP concentration in the lower Brid River are about 0.05 mg/L. The same figure also shows the concentrations of ammonia nitrogen (NH_3/N), which is generally lower than other nutrients, but can reach very high concentrations as indicated by the upper whisker and outlier.

Box plots illustrating the statistics of the data for dissolved salts and minerals are presented in Figures 1.9 and 1.10. They show that chloride, sodium and silica are the major ions present in the Brid River and calcium, sulphate and iron are present in lesser amounts. These data will be referred to when discussing the results of testing during the present study.

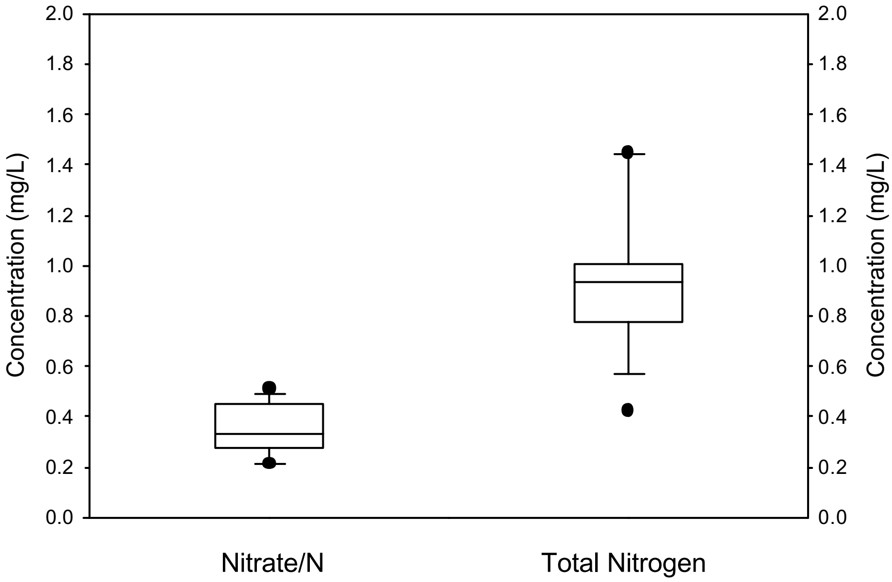


Figure 1.7 Boxplots showing the distribution and basic statistics of the data for Nitrate/N and Total N extracted from the HYDROL database (n = 11; data from period 1994-96). 1994 - 96.

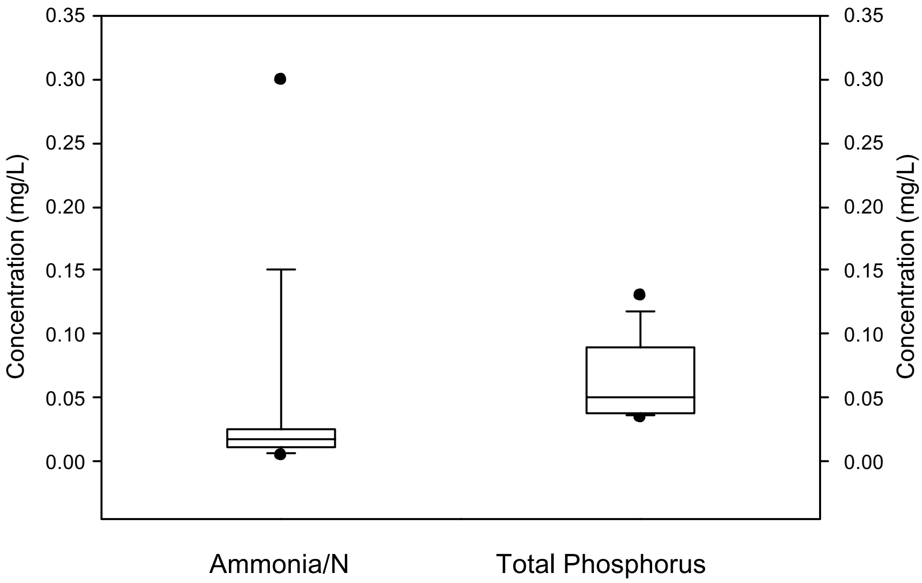


Figure 1.8 Boxplots showing the distribution and basic statistics of the data for Ammonia/N and Total P extracted from the HYDROL database (n = 11; data from period 1994-96). 1994 - 96.

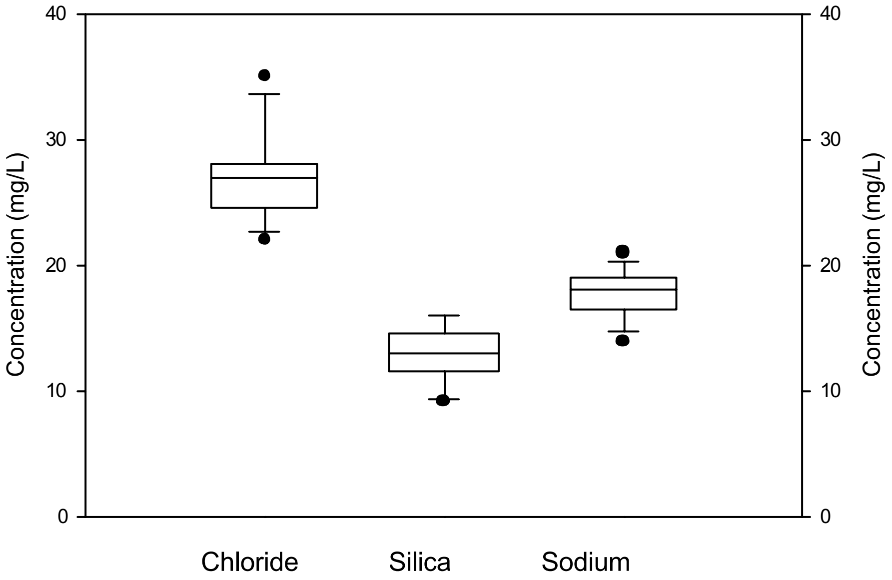


Figure 1.9 Boxplots showing the distribution and basic statistics of the data for total Chloride, Silica and Sodium extracted from the HYDROL database (n = 12; data from period 1994-96). 1994 - 96.

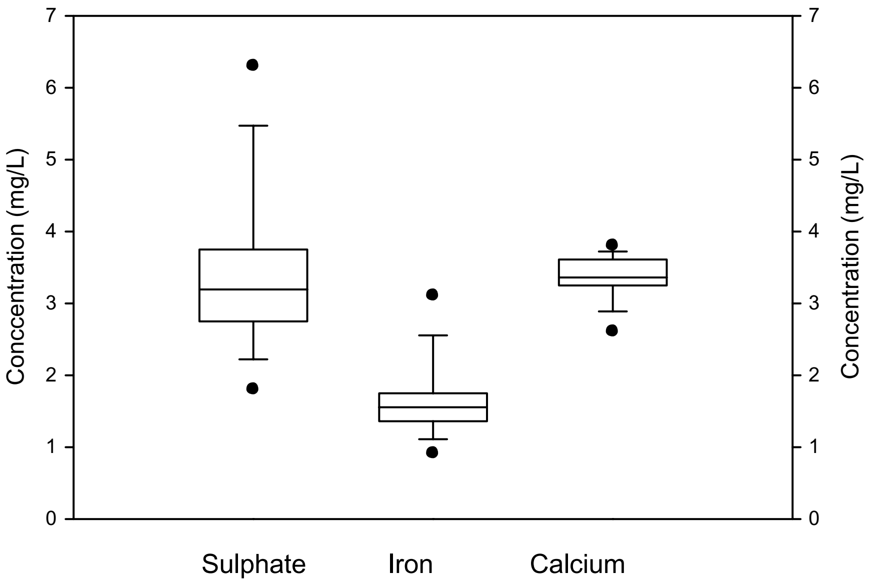


Figure 1.10 Boxplots showing the distribution and basic statistics of the data for total Sulphate, Iron and Calcium from the HYDROL database (n = 12; data from period 1994-96).

2 Waterwatch Activities

Waterwatch activities began in the Scottsdale area following the accidental release of pyrethrum and caustic soda into the Great Forester River in April 1994. The spill killed all of the macroinvertebrate and fish life in a section of the Great Forester River, and together with mounting community concern over other pollution incidents and perceptions of atrazine contamination of town water resulted in a public meeting from which 'Dorset Waterwatch' was formed. The members of this group represent a wide range of interests including education, forestry, local government, agriculture, aquaculture, industry, health services and recreation.

The Dorset Sustainable Development Strategy, developed by Dorset Council through consultation with all stakeholders and sectors of the community, has identified water as a key issue in terms of protection of natural resources. Dorset Council have been most supportive of Waterwatch and provided a chairperson in the initial stages of forming the group and $3,000 for the purchase of chemicals and equipment. They continue to provide administrative support in the form of office space, computer, phone, postage, photocopying and an annual audit. Since 1996 Dorset Waterwatch have received financial assistance through NHT to employ a regional coordinator.

The group monitors water quality in the 3 major rivers in the municipality, the Brid, Ringarooma and Great Forester as well as Cox's Rivulet and waterways in the Waterhouse Protected Area. The data is used to gain a picture of baseline results as well as highlighting areas in need of improvement. The group also runs a community education campaign which has been fuelled by issues such as elevated turbidity levels during flood events in the major rivers and high phosphate levels in Coxs's Rivulet.

In the Brid River system, Waterwatch has sampled at 6 sites since the start of monitoring in 1995. Most data has been collected at one site in the upper catchment (BRI 010) and another site lower down on the Brid River (BRI 070).

Table 2.1 Location of sites sampled by Dorset Waterwatch group between June 1995 and November 1998.

Site	Code	Easting	Northing	Site Visits
Upper Brid - Midson's	BRI 010	538600	5432500	11
Brid at Tasman Hwy	BRI 020	538400	5435300	2
Brid at Sledge Track	BRI 040	540000	5440400	4
Brid at Duncraggen Rd	BRI 050	535300	5452300	3
Brid at Briddale	BRI 070	530200	5457500	15
Brid at Stream Gauging Station	BRI 080	532100	5459200	5

Data collected between August,1995 - October, 1998.

Some sampling has also been undertaken in Cox's Rivulet (sites listed in Table 2.2, below), a small catchment running north between the Brid River and Great Forester River catchments. This sampling was carried out to examine the influence of outfall discharge from the Scottsdale sewage treatment plant on water quality in Cox's Creek and lower down on Cox's Rivulet. Some of this data was collated and reported in a Dorset Waterwatch document circulated in April, 1998. The results showed that several water quality measures deteriorated immediately below of the discharge point, but did recover to some degree further downstream. Plots showing some of the results from that report are presented in Figure 2.1 and 2.2.

Table 2.2 Cox's Creek STP Impact Study - site locations.

Site	Code	Easting	Northing
Cox's Creek u/s waste outfall	COX 002	543500	5445000
Cox's Creek at waste outfall	COX 004	543500	5445100
Cox's Creek 500m d/s waste outfall	COX 006	543500	5445200
Cox's Rivulet at Burnside Rd	COX 010	543400	5446600
Moore's Dam on Cox's Rivulet	COX 020	542700	5447400
Cox's Rvt 500m d/s Moore's Dam	COX 021	542700	5447500
Cox's Rivulet at irrigation pump inlet	COX 030	541800	5450000
Cox's Rivulet at Boddington's Rd	COX 070	538100	5456500

Courtesy of Dorset Waterwatch.

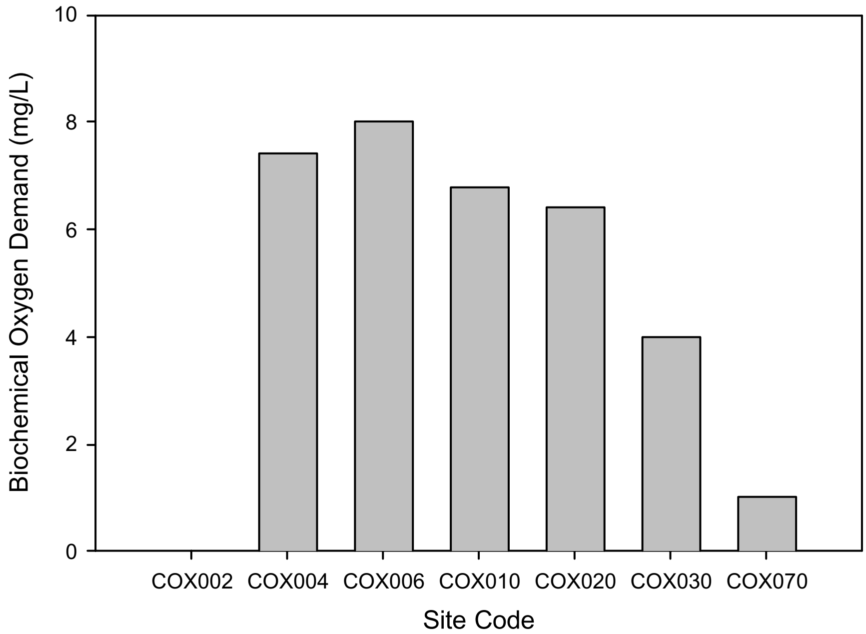


Figure 2.1 Distribution of BOD levels in Cox's Creek as measured by Dorset Waterwatch, April 1998.

In the Brid River itself, Dorset Waterwatch has collected most records from a location in the upper Brid and at 'Briddale' down near the bottom of the catchment. At several other sites there have been up to 4 visits, but as these have been infrequent the data will not be discussed. Testing covered most of the common Waterwatch parameters (pH, turbidity, conductivity, temperature and dissolved oxygen) and also included field analysis for nitrate nitrogen and ortho-phosphorus.

Examination of the data from the upper Brid and 'Briddale' illustrates the effects catchment activities have on water quality by the time it reaches the coastal area. The site in the upper Brid River has slightly higher dissolved oxygen levels (Figure 2.3), and much lower conductivity (Figure 2.4) than the site low in the catchment. Ortho-phosphorus concentrations were below the limit of detection by Waterwatch in the upper Brid site (Figure 2.5), while at 'Briddale' ortho-P was frequently detected by the test kits. It should be noted that Waterwatch kits measure in 0.015 mg/L steps.

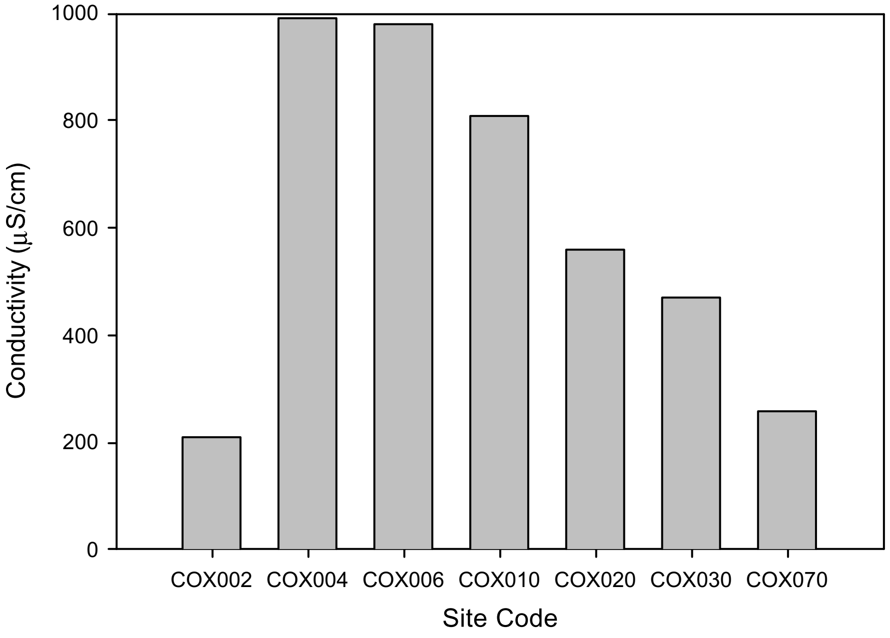


Figure 2.2 Conductivity variation in Cox's Creek as measured by Dorset Waterwatch, April 1998.

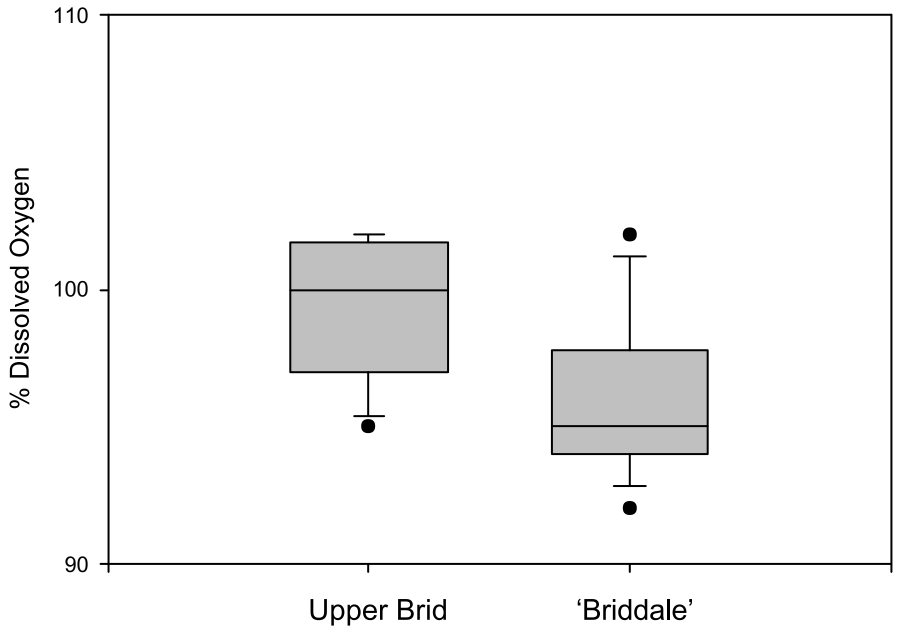


Figure 2.3 Comparison of dissolved oxygen (% saturation) measured by Dorset Waterwatch at two sites on the Brid River. Data collected between 1995 - '98.

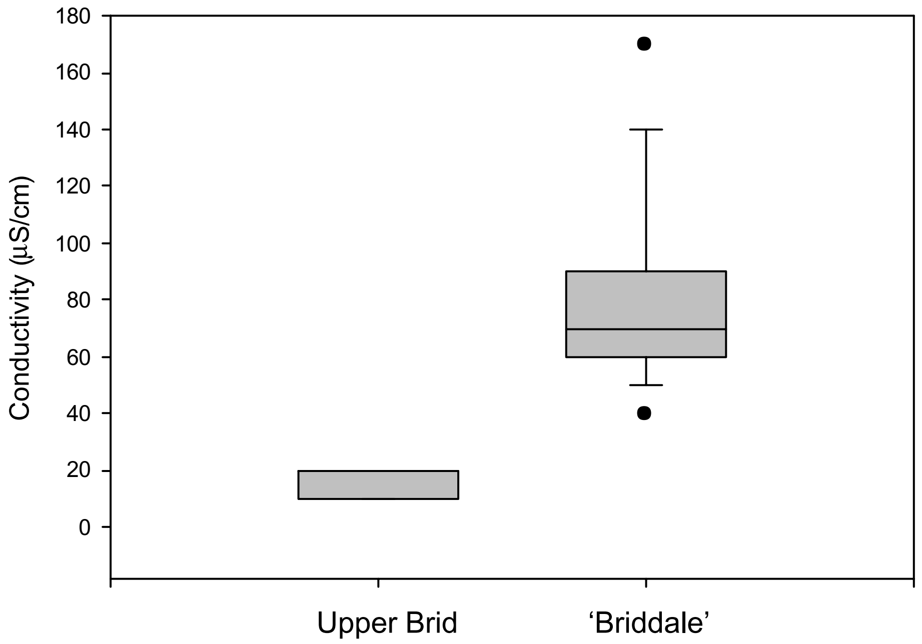


Figure 2.4 Comparison of conductivity measured by Dorset Waterwatch at two sites on the Brid River. Data collected between 1995 - '98.

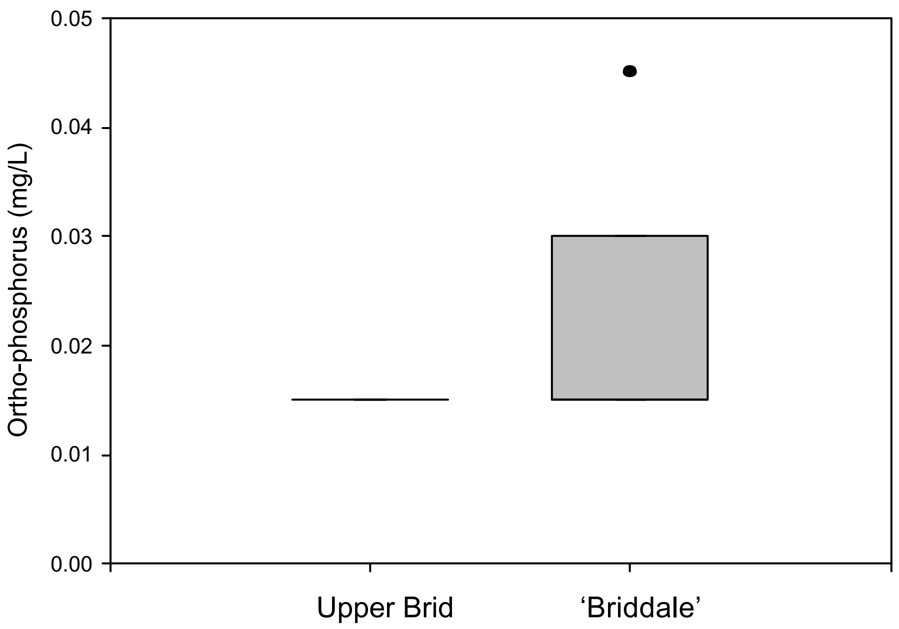


Figure 2.5 Comparison of ortho-phosphorus concentrations measured by Dorset Waterwatch at two sites on the Brid River. Data collected between 1995 - '98.

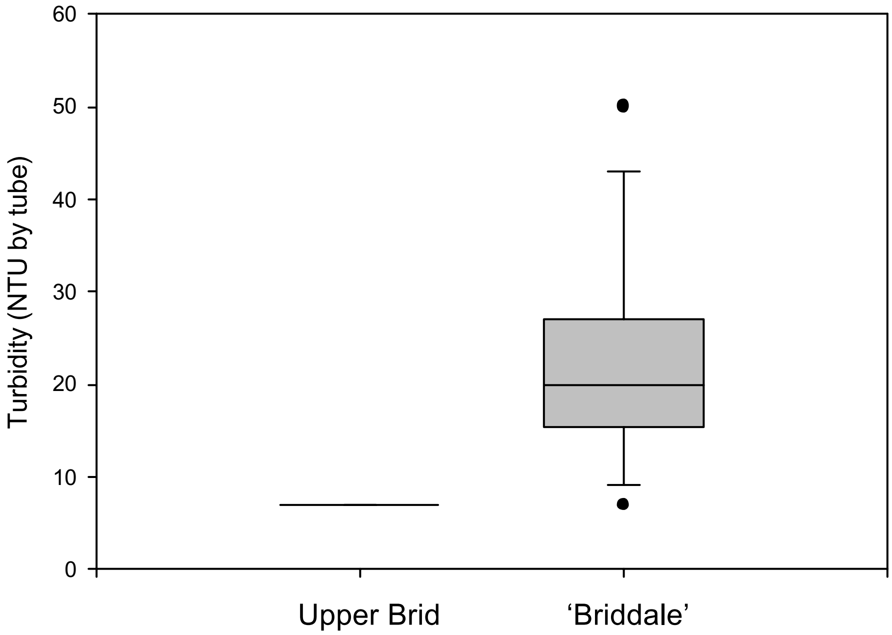


Figure 2.6 Comparison of turbidity measured by Dorset Waterwatch at two sites on the Brid River. Data collected between 1995 - '98.

The data for turbidity (Figure 2.6) reflects the pattern for ortho-P, with a significant increase in turbidity at Briddale compared to the upper Brid site. This data, along with the other data collected by Dorset Waterwatch, helps to further develop a picture of the water quality in the Brid River. It is clear from Waterwatch data that while water quality is good in the upper reaches, by the time water reaches the coastal plain it has deteriorated markedly.

3 Current Study

The following water quality data was collected during 1998 in conjunction with a studies of rivers in the Ringarooma and Great Forester catchments. The main aim of sampling in the Brid River was to collect current data on the ambient quality of water and report on background conditions in the river. These data, when viewed in conjunction with land use and river condition information, should assist in identifying sites or areas which could be targeted for remediation activities in the future.

The collection of data was carried out at several levels. Monthly visits were undertaken at two sites to determine the physico-chemical nature of water quality. Due to resource limitations, sampling for nutrients and dissolved salts was carried out at only one of these sites. The second level of sampling involved catchment-wide 'snapshot' surveys covering a multitude of sites along the length of the river. During these surveys, field testing was performed at 12 sites, with samples for laboratory analysis being taken at a subset of these. The third tier of sampling involved the use of in-stream logging equipment to examine diurnal changes in dissolved oxygen and other water quality parameters at one site in the middle reaches of the Brid River. In-stream monitoring of some water quality variables is also performed in association with streamflow monitoring at the lowermost site on the Brid River. At this site, turbidity, conductivity and temperature is currently monitored on a continuous basis. When the data from this source is combined with nutrient concentrations from samples collected during flood events, calculations of nutrient fluxes for the period can be made. The results of these calculations will also be presented during this report.

Monthly sampling was carried out at the station on the Brid River just upstream of the tidal limit where streamflow monitoring is carried out. Monthly field testing for physico-chemical parameters was carried out at another site on the main river in the upper part of the catchment. The location and grid references of these two sites is listed in the Table 3.1.

Table 3.1 Location of sites where monthly water quality monitoring was carried out during the present study.

Site Name	Code	Easting	Northing	Monitoring Type
Brid River at Golconda Rd	BR1	539000	5444500	Phys-chem
Brid River u/s Tidal Limit	BR2	532125	5459225	Phys-chem+ Samples

The physico-chemical parameters tested in the field included pH (compensated for temperature), electrical conductivity (corrected to reference temperature 25 ^{o}C), water temperature, turbidity and dissolved oxygen. Water samples were taken and analysed in a NATA registered laboratory for the following nutrients; ammonia nitrogen (NH_3/N), nitrate nitrogen (NO_3/N), nitrite nitrogen (NO_2/N), Kjeldahl nitrogen (TK/N), dissolved reactive phosphorus (DR/P) and total phosphorus (TP). Total nitrogen (TN) was derived using the formula;

$$TN = TK/N + NO_3/N + NO_2/N.$$

Every 2 months samples were also taken for laboratory analysis to determine general ion content and factors affected by levels of dissolved salts. These included determination of iron, calcium, magnesium, sulphate, chloride, sodium, potassium, silica, hardness, colour, alkalinity and suspended solids concentrations.

3.1 Physico-chemical properties

Water Temperature

The difference between water temperature in the Brid River at Golconda and at the stream gauging station near the coast was not great during autumn and winter (Figure 3.1) but on two occasions differed by more than 3 ^{o}C. On all monitoring rounds, water temperature at the site low in the catchment was greater than at Golconda Rd.

The variation in daily average water temperature for 1998 in the lower Brid River, as recorded by continuous monitoring equipment, is plotted in Figure 3.2. The graph shows both the seasonal pattern of change in water temperature and also the large differences between days, which tends to reflect frontal activity and other shorter term climatic variation. It does not show the maximum and minimum water temperatures associated with diurnal warming and cooling.

The data for water temperature can also be summarised through duration analysis, which is an analysis which partitions the data according to time spent within defined temperature ranges. A duration analysis for the record collected during the period of the study is shown in Table 3.2. It shows that over the 365 days of 1998, water temperature was within the range 5 - 20 ^{o}C for more than 90% of the time.

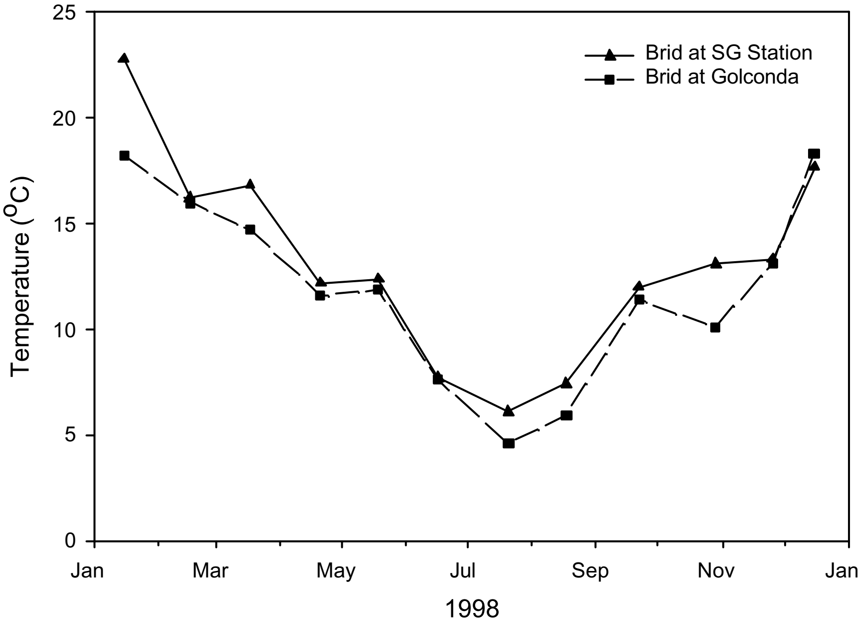


Figure 3.1 Time series plot of water temperature at two sites in the Brid River. The site at Golconda Rd is located halfway up the catchment.

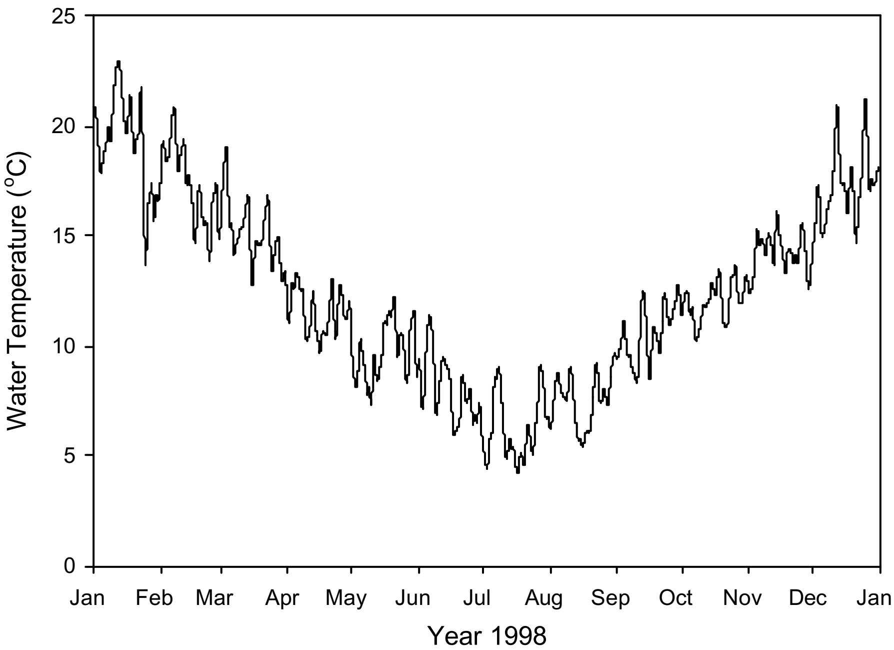


Figure 3.2 Time series plot of water temperature in the Brid River 2km upstream of the tidal limit. Daily average data was used.

Table 3.2 Duration analysis for water temperature at Brid River 2.4 km u/s Tidal limit for the period 1-Jan-98 to 31-Dec-98.

Temperature Ranges (^{o}C)	% Time within Range
0 - 5.0	2.14
5.0 - 10.0	31.17
10.0 - 15.0	38.0
15.0 - 20.0	23.3
20.0 - 25.0	5.4
25.0 - 30.0	0.02

The seasonal change in the distribution of the time spent within the various temperature categories is given in Table 3.3. The data for this table includes the entire record collected at that site.

Table 3.3 Seasonal duration analysis for water temperature in the lower Brid River using all record (Mar-1994 to July-1999).

	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sep-Oct	Nov-Dec
Bounds	265 days	365 days	365 days	284 days	305 days	279 days
0 - 5.0	0.025	0.004	2.923	14.612	0.111	0.000
5.0 - 10.0	0.111	10.392	75.890	83.876	37.824	0.219
10.0 - 15.0	5.088	62.410	21.187	1.512	60.231	45.015
15.0 - 20.0	66.417	26.267	0.000	0.000	1.834	50.461
20.0 - 25.0	28.060	0.927	0.000	0.000	0.000	4.304
25.0 - 30.0	0.299	0.000	0.000	0.000	0.000	0.000

In-stream pH

The ambient pH of water was tested during each monitoring visit using an instrument which corrects for temperature. The 'in situ' pH at Golconda Rd was slightly more acidic than lower down the river (Figure 3.3) where pH levels show that water was almost neutral. This contrasts strongly with data from both the Great Forester and Ringarooma rivers, where the water is generally more acidic (Bobbi, 1999a) (Bobbi, 1999b). All the data included in Figure 3.3 was collected during site visits conducted daylight hours, and as a result represents only pH levels which exist during times when plant photosynthesis is most active. For a discussion of diurnal patterns of pH change, see the section on diurnal changes in water quality (Section 3.5).

Conductivity

The conductivity of water in the Brid River is generally low, but displays an increase towards the lower reaches of the river. This is a natural feature common to most unregulated rivers. At Golconda Rd the average conductivity is 100 µS/cm while at the stream gauging station the median is 160 µS/cm. The variation in conductivity at the lower site is also much greater, as indicated by the whiskers on the boxplot in Figure 3.4. The cause of this is discussed in Section 3.3 where data collected by the continuous conductivity probe at this site is presented. Briefly, it appears that this site, which is downstream of dairy milking sheds, may be affected by localised rainfall runoff from the dairy.

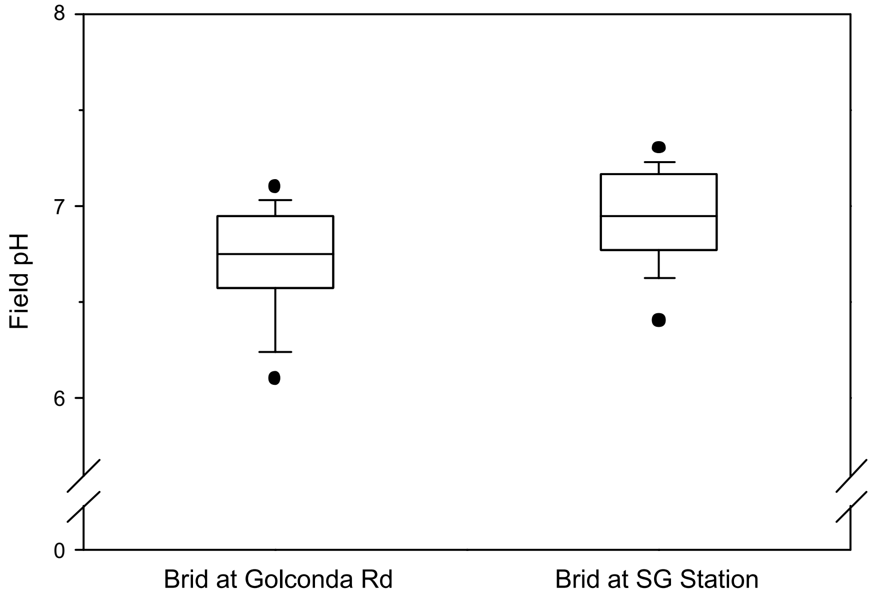


Figure 3.3 Field pH at two sites in the Brid River. Data collected during monthly monitoring visits, 1998.

Figure 3.4 Field conductivity at two sites in the Brid River. Data collected during monthly monitoring visits, 1998.

Turbidity

Turbidity of water in waterways reflects the amount of suspended material being carried by the water. This suspended matter can be organic (ie plant material or algal particles) or inorganically derived (ie clays, silt, etc). In the Brid River, which is a prime agricultural catchment, turbidity is most likely to be caused by soil disturbance and stream bank erosion. Drainage activities can also increase water velocities, allowing the water to carry higher concentrations of suspended matter. When seeking to establish 'baseline' water quality it is therefore important that monthly monitoring avoid higher flow events where possible. Separate sampling during floods can then be compared with what the river is normally like and is useful in showing how turbidity levels increase with entry to the river of rainfall runoff from the catchment.

The monthly data from the Brid River (Figure 3.5) reveals that there is no significant difference between the upper and lower sites. Both sites have average turbidity levels of around 15 NTU, which is above the 10 NTU trigger levels suggested in the ANZECC (1998 draft) water quality guidelines for the protection of aquatic ecosystems. The data tends to indicate that much of the turbidity entering the Brid River may be derived from the catchment above Golconda Rd and is not settling out to any significant degree by the time it reaches the coastal area. These turbidity levels are much higher than was found by recent studies in the Ringarooma (Bobbi, 1999a) and Great Forester (Bobbi, 1999b) catchments.

Figure 3.5 Turbidity at two sites in the Brid River. Data collected during monthly monitoring visits, 1998.

Dissolved Oxygen

Dissolved oxygen is one of the parameters most commonly used to measure the health of the aquatic ecosystem. During this study oxygen concentrations in the river were measured on site using portable field probes which employ membrane diffusion along with silver/gold anode for oxygen detection. At both sites, dissolved oxygen was measured in flowing water.

The data is displayed in Figure 3.6 and while both sites displayed healthy oxygen concentrations, the variation was greater at the site low in the catchment. Examination of the time series from both sites

Figure 3.6 Dissolved oxygen at two sites in the Brid River. Data collected during monthly monitoring visits, 1998.

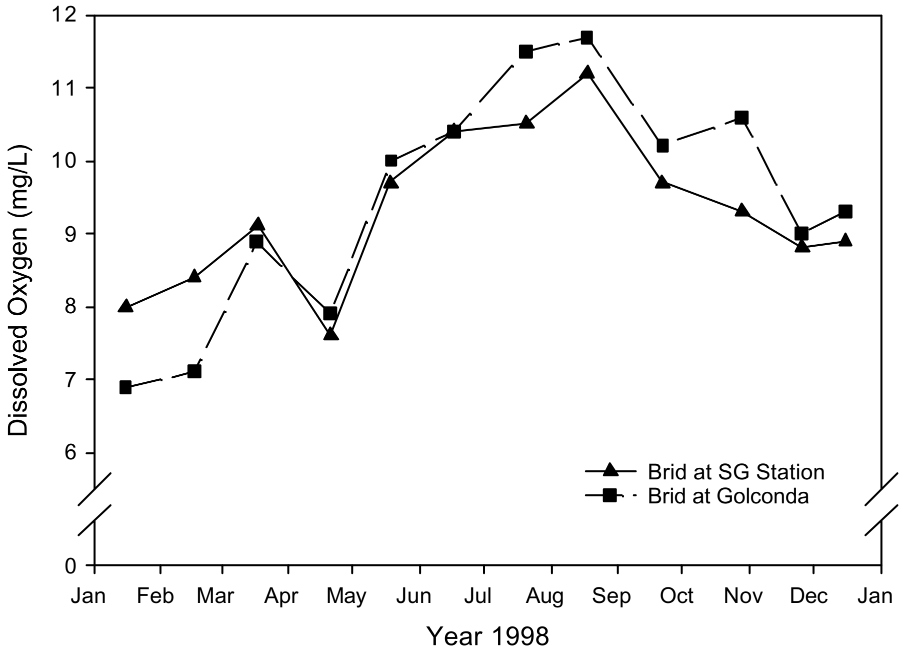


Figure 3.7 Monthly changes in dissolved oxygen recorded at two sites in the Brid River during monthly monitoring, 1998.

(Figure 3.7) shows that oxygen levels were much lower at Golconda Rd during the January and February site visits, when river flow was very low (see accompanying report 'Hydrological Analysis of the Brid River Catchment'). During the rest of the study, dissolved oxygen concentrations were consistently lower at the stream gauging station at the bottom of the catchment. However, across the whole year, oxygen levels were reflective of a relatively healthy system.

For a discussion of diurnal changes in dissolved oxygen and other water quality parameters, see Section 3.5.

3.2 General Ionic Composition

As chemical testing took place at only one site on the Brid River, monitoring results will be discussed and compared with the data which was collected during the period between 1994 and 1996. During this study, samples for ionic analysis were taken every two months, as these constituents are generally considered to be 'conservative' and vary only slightly over time. The ionic character of water typically reflects the influence of soils and the underlying geology of a catchment. Where water flows through limestone rock types, it will generally have a higher concentration of calcium and magnesium, and consequently have a higher hardness and alkalinity. Where rivers flow through a dolerite dominated landscape, they will generally have lower amounts of dissolved 'salts', though silica and iron can be greater.

In the Brid River, the underlying geology is a rather complicated mix of tertiary basalts, granodiorite and mudstone sequences in the upper catchment. Further down the catchment, the river flows through and area underlain by the Mathinna Beds and Holocene aged sands and gravels. As the conductivity results from the Waterwatch group indicate, salt levels are very low in the upper catchment. It is likely that the majority of the dissolved salts in the Brid River is added by the soils and geology in the middle and lower catchment. This area, particularly on the western side, is dominated by the Mathinna Beds.

The data for ionic composition shows that Brid River water has moderate to low levels of dissolved salts and is reasonably soft (indicated by hardness values in Figure 3.8). Compared to water in the Ringarooma and Great Forester rivers, concentrations of most parameters are higher, with the exception of iron, which was very similar. As a comparison, hardness in the Great Forester and Ringarooma rivers was generally around 15 mg/L and 11 mg/L, respectively. In the Brid River, hardness varies between 19 mg/L and 34 mg/L. As Figures 3.8 and 3.9 show, the data for ionic composition measured during this study is very similar to that collected during sampling in 1994-'96, although the degree of scatter in the data is not as great.

Sulphate concentrations (Figure 3.9) are also very similar to those measured in both the Great Forester and lower Ringarooma rivers. Sulphate is naturally present in surface waters as SO_4^{2-}, and generally originates from ocean aerosols or geological sources such as leaching from sulphite minerals in sedimentary rocks (UNESCO, 1992). In Tasmania, several studies have shown that concentrations in many natural waters is around 5 mg/L (Bobbi, Fuller & Oldmeadow, 1996) (Bobbi, 1997) (Bobbi, 1998) (Bobbi, 1999a) with streams receiving some form of polluted effluent having sulphate concentrations significantly higher than this (15 - 30 mg/L).

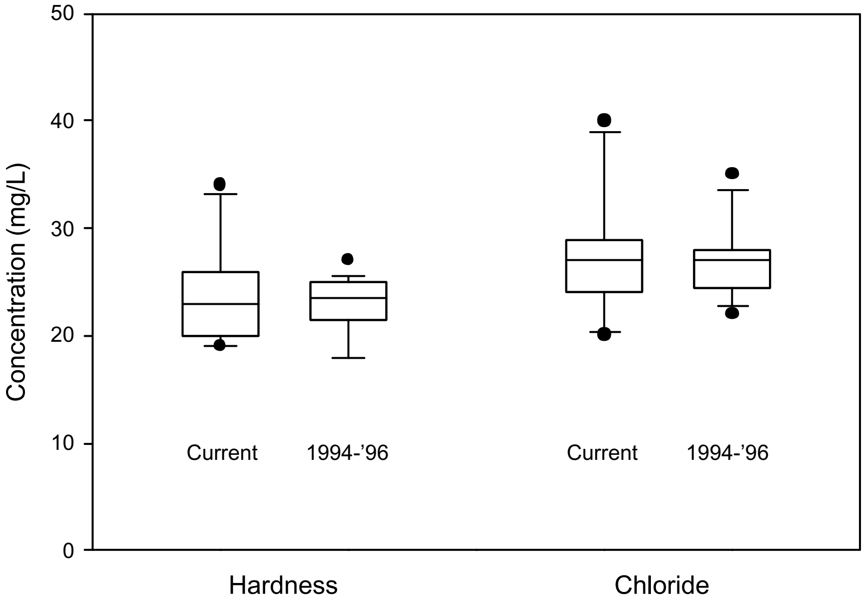


Figure 3.8 Statistics for hardness and total chloride in the Brid River at the stream gauging station for data collected during the current study (n = 6) and data collected during the period 1994-'96 (n = 12).

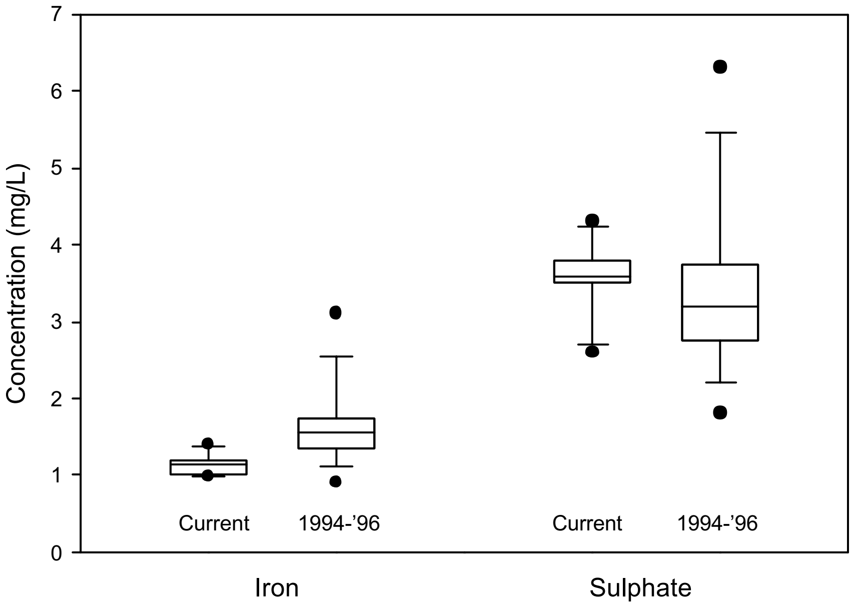


Figure 3.9 Statistics for iron and sulphate in the Brid River at the stream gauging station for data collected during the current study (n = 6) and data collected during the period 1994-'96 (n = 12).

3.3 Nutrient Results

The concentrations of nutrients in water draining agricultural areas can be quite low. Nutrients such as nitrate, ammonia, organic nitrogen and the various forms of phosphorus are generally present at levels which preclude field based analysis, as field testing kits cannot operate accurately at these low levels and often lack the precision needed. Therefore samples were taken and delivered to a registered laboratory which could measure down to the required levels (around the 0.01mg/L level). These laboratories operate under strict quality control and are able to deliver results which are quality assured under NATA (National Association of Testing Authorities). Occasional duplicates and blank samples were tested as a means of checking field sampling and preservation operations.

Nitrogen

Total nitrogen (TN) is the sum of organic nitrogen, nitrate nitrogen (NO_3/N) and nitrite (NO_2/N), though NO_2/N is not normally detected in environmental waters unless there is some form of local pollution. The data for TN concentrations during monthly monitoring is shown in Figure 3.10 along with the flow in the river at the time of sampling.

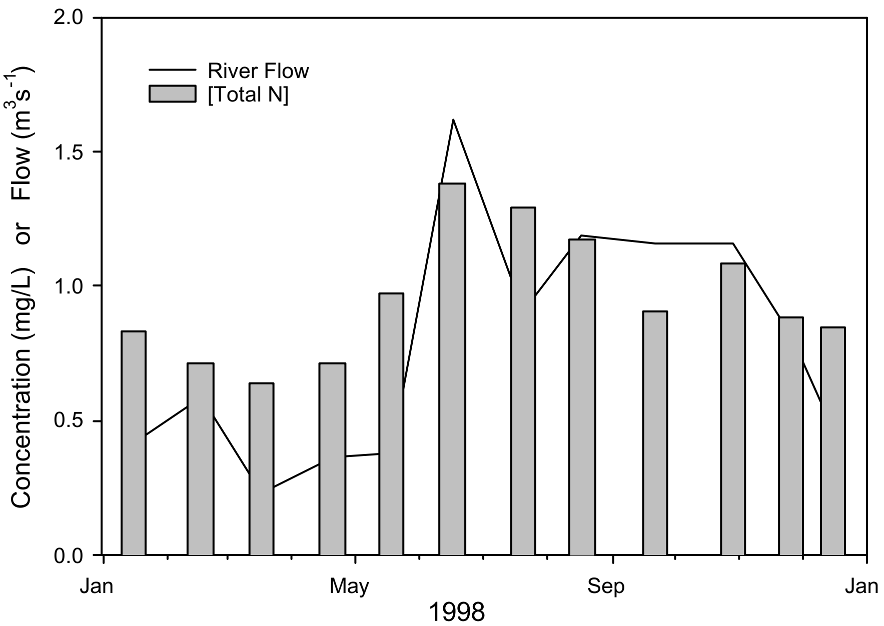


Figure 3.10 Diagram of changes in Total N concentration and river flow at the Brid River site during the study period.

Total N concentrations ranged between about 0.65 mg/L during lower flows earlier in the study, to as high as 1.35 mg/L during higher baseflows in winter. The link between concentrations and flow is quite clear. Looking more closely at the nitrogen data, specifically the NO_3/N component (Figure3.11), it is apparent that NO_3/N may be the major factor influencing the overall pattern of TN concentration. The baseflow concentration of organic nitrogen (median of 0.43 mg/L) is more constant than NO_3/N concentration, if the sample from June is disregarded.

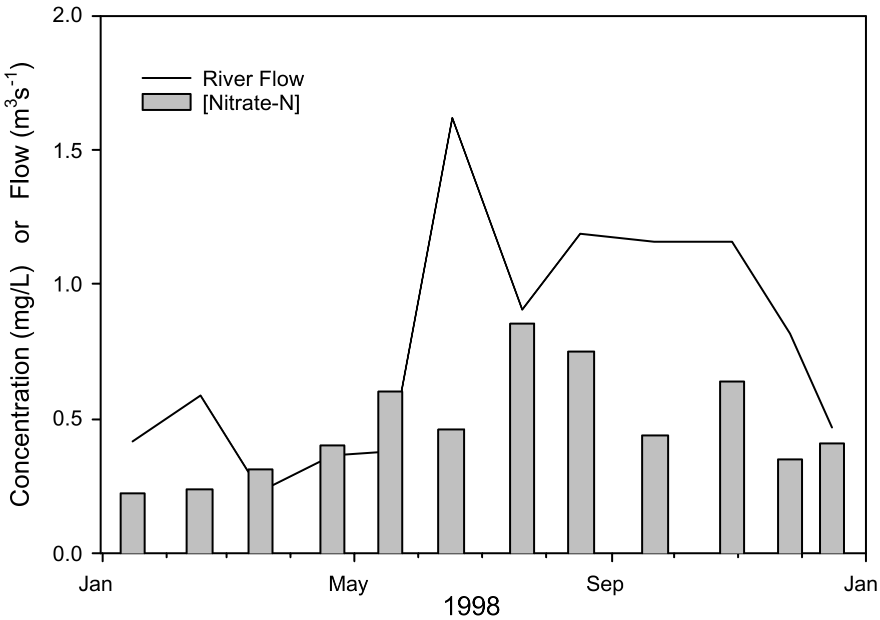


Figure 3.11 Diagram of changes in Nitrate/N concentration and river flow at the Brid River site during the study period.

On average, NO_3/N comprises about 48% of the TN concentration present in the river under baseflow conditions. During the early stages of flooding, when the river is carrying higher loads of suspended material, the proportion of nitrate can be lower. Later in an event, as groundwater starts to contribute more to river flows, nitrate concentrations often increase (Bobbi & Fuller, 1996) as nitrate is flushed out of the soil profile (Cambardella *et al.*, 1999). This pattern can also be confused where agricultural fertilisers are used in sufficient quantities to affect nutrient concentrations in rivers.

Nitrate levels often also vary on a seasonal basis (Bobbi *et al.*, 1996) (Bobbi, 1999a) (Bobbi, 1999b) (Jaynes, Hatfield & Meek, 1999) (Kladivko *et al.*, 1991), with concentrations higher during winter when concentration is influenced by several factors including leaching of nitrate from the soil profile by groundwater movement and the lack of plant uptake of nitrogen due to dormancy (Neill, 1989).

Comparison of NO_3/N concentrations during this study with concentrations measured during 1994-96 (Figure 3.12) shows that the median concentration during this study (0.425 mg/L) was slightly, but not significantly higher than that for the period 1994-96 (0.33 mg/L). The variation in NO_3/N concentration measured during this study is also larger. The minimum NO_3/N concentration in both sets of data is 0.22 mg/L. Overall, the NO_3/N levels measured in the Brid River are very similar to those described for the middle reaches of the nearby Ringarooma River (Bobbi, 1999a) and the lower section of the Great Forester River (Bobbi, 1999b).

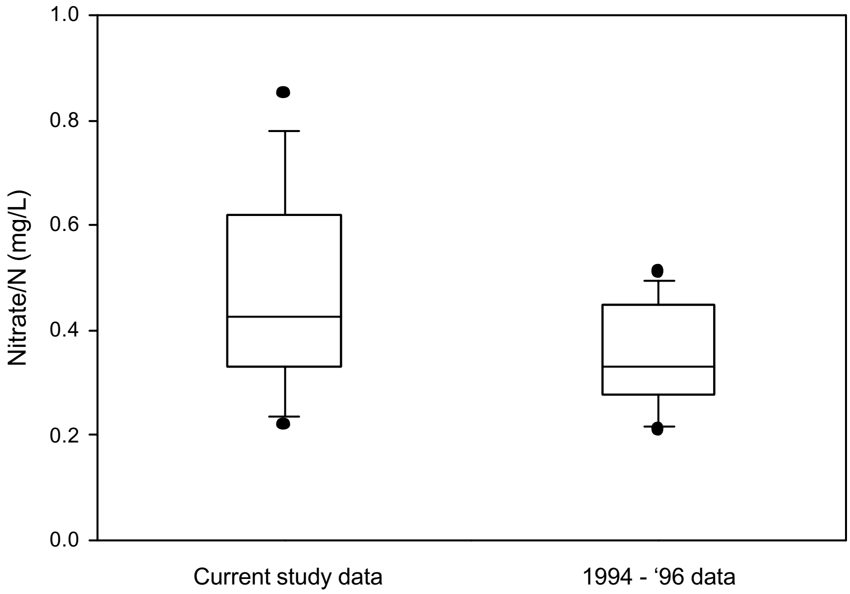


Figure 3.12 Statistics for NO_3/N in the Brid River at the stream gauging station for data collected during the current study (n = 12) and data collected during the period 1994-'96 (n = 11).

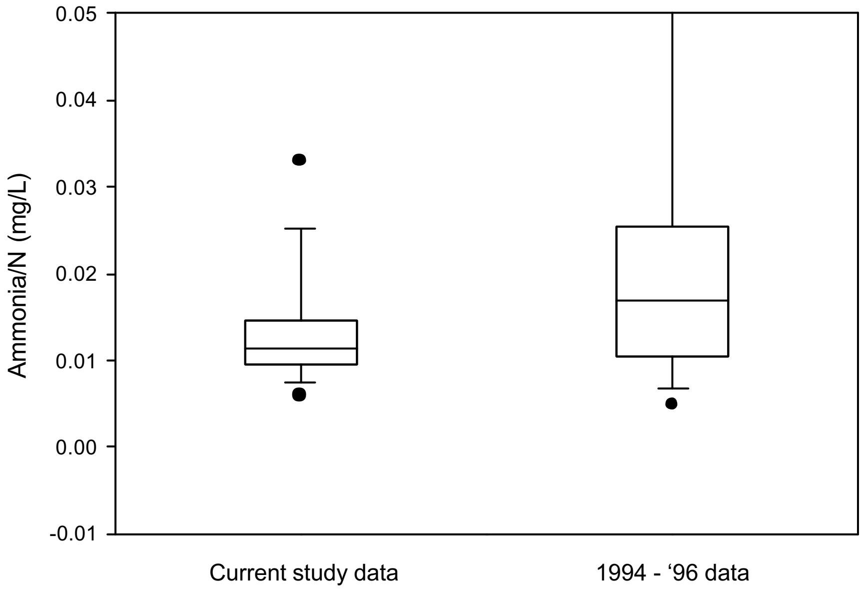


Figure 3.13 Statistics for NH_3/N in the Brid River at the stream gauging station for data collected during the current study (n = 12) and data collected during the period 1994-'96 (n = 11).

The data for NH_3/N concentrations in the lower Brid River (Figure 3.13) reveals that concentrations are also similar to those in the middle reaches of the Ringarooma River (Bobbi, 1999b), with maximum concentrations during the current study reaching 0.033 mg/L. The peak concentration in the data from 1994-96 is 0.05 mg/L, indicating that levels can get quite high. Ammonia is naturally present in surface water and normally comes from the breakdown of organic and inorganic material. However, higher levels (in Tasmania greater than about 0.02 mg/L) can be an indicator of organic pollution (UNESCO, 1992). In the UK, high NH_3/N concentrations have been used as an indicator of impact by intensive dairying on water quality (NRA, 1992) (Foy & Kirk, 1995). Considering the data in light of this, it might be suggested that water in the lower Brid River is showing the signs of at least intermittent impact by intensive animal industries.

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 levels and is usually the nutrient which limits growth of algae. When it is present in excess due to land use practices or disturbance, it can trigger algal blooms which are a feature of eutrophication. Although 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 biological processes (UNESCO, 1992). Therefore where there is a catchment activity which may produce increases in phosphorus, it is best to measure total phosphorus (TP), which includes both particulate and dissolved forms, as at some stage all of this may become available for plant uptake. Most phosphorus is also normally found attached to organic and inorganic particulate matter and can often be related to turbidity levels. This relationship is further discussed in Section 3.3.

In the Brid River, the median concentration of TP measured during the current study is 0.034 mg/L (Figure 3.14), which is lower than the median of the data from 1994-96. Both datasets show that TP concentration can get very high at times (above 0.1 mg/L). More detailed examination of the data with respect to river flows (Figure 3.15) shows that these high concentrations do not always occur during high flow events. The data shows that there have been several occasions when high concentrations have been detected during moderate flows and that there is no clear relationship between flow and concentration.

There are various possible explanations for this. The first, and most obvious, is that there is some localised activity which is contributing to higher phosphorus levels in the river. The area around the site where water quality was monitored is a dairy farm which extends for some distance both up and down the length of the river. At several places along the river cattle have direct access to the river and have created trampled and compacted ‘ramps’ which would facilitate the entry to the river of phosphorus rich faecal material.

Other factors which may also be responsible for the high concentrations of TP in the river are catchment drainage activities which make delivery to the river of nutrients and sediment more direct. As has been shown in Section 3.1, turbidity levels are reasonably high and appear to be originating in the upper half of the catchment, where agricultural and drainage activity id most intense. The suspended solids responsible for this higher turbidity would increase the ability of the river to transport higher levels of nutrients, especially at lower flows. There is also a considerable amount of sediment stored in the river bed and this could be acting much like a leaking sponge, releasing phosphorus during lower river flows when suitable conditions for phosphorus release are likely to occur. Never the less, data from both this study and the recent sampling shows that TP concentrations are at or above the trigger levels suggested by the ANZECC (1998-draft) guidelines for the protection of aquatic ecosystems.

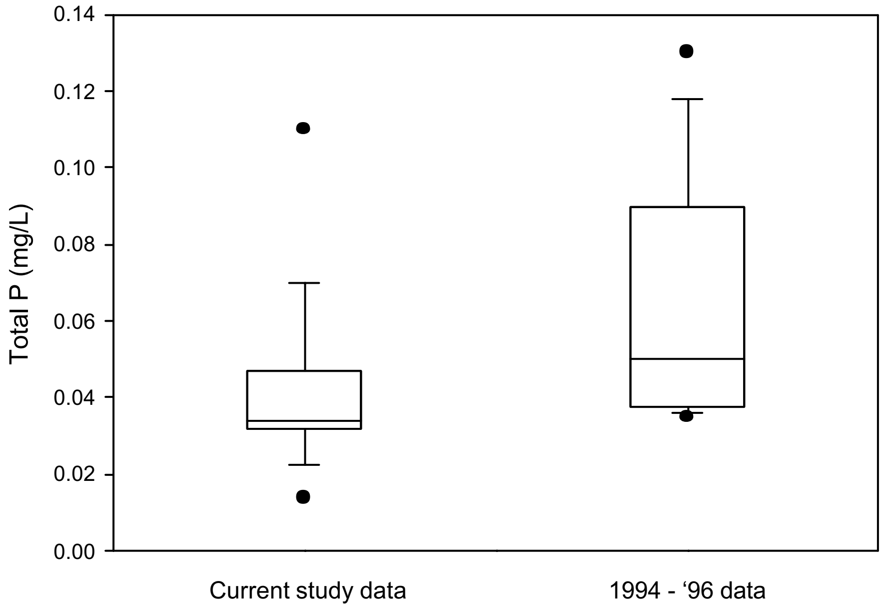


Figure 3.14 Statistics for TP in the Brid River at the stream gauging station for data collected during the current study (n = 12) and data collected during the period 1994-'96 (n = 11).

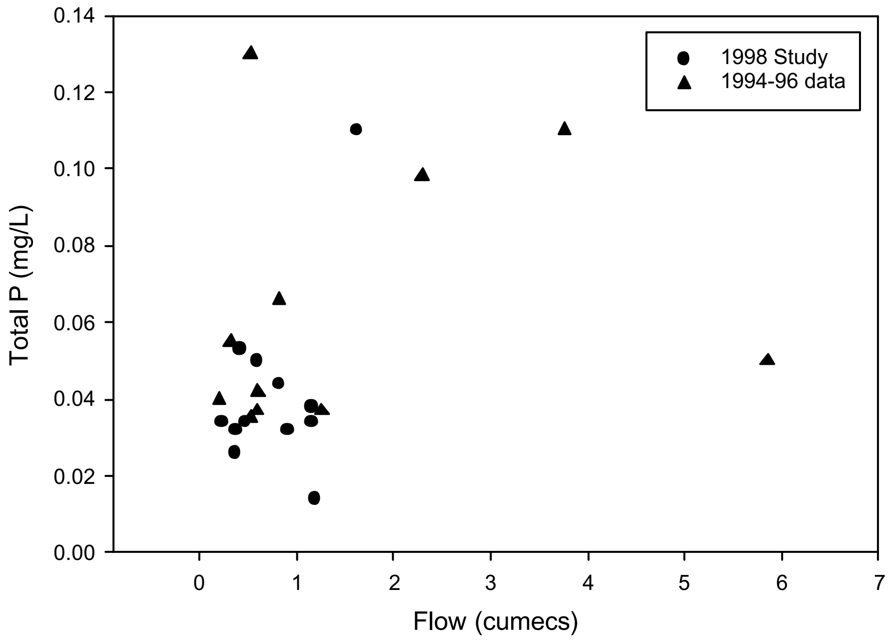


Figure 3.15 Total phosphorus concentrations plotted against river flow using recent data from the Brid River upstream of the tidal limit.

3.2 Catchment Survey

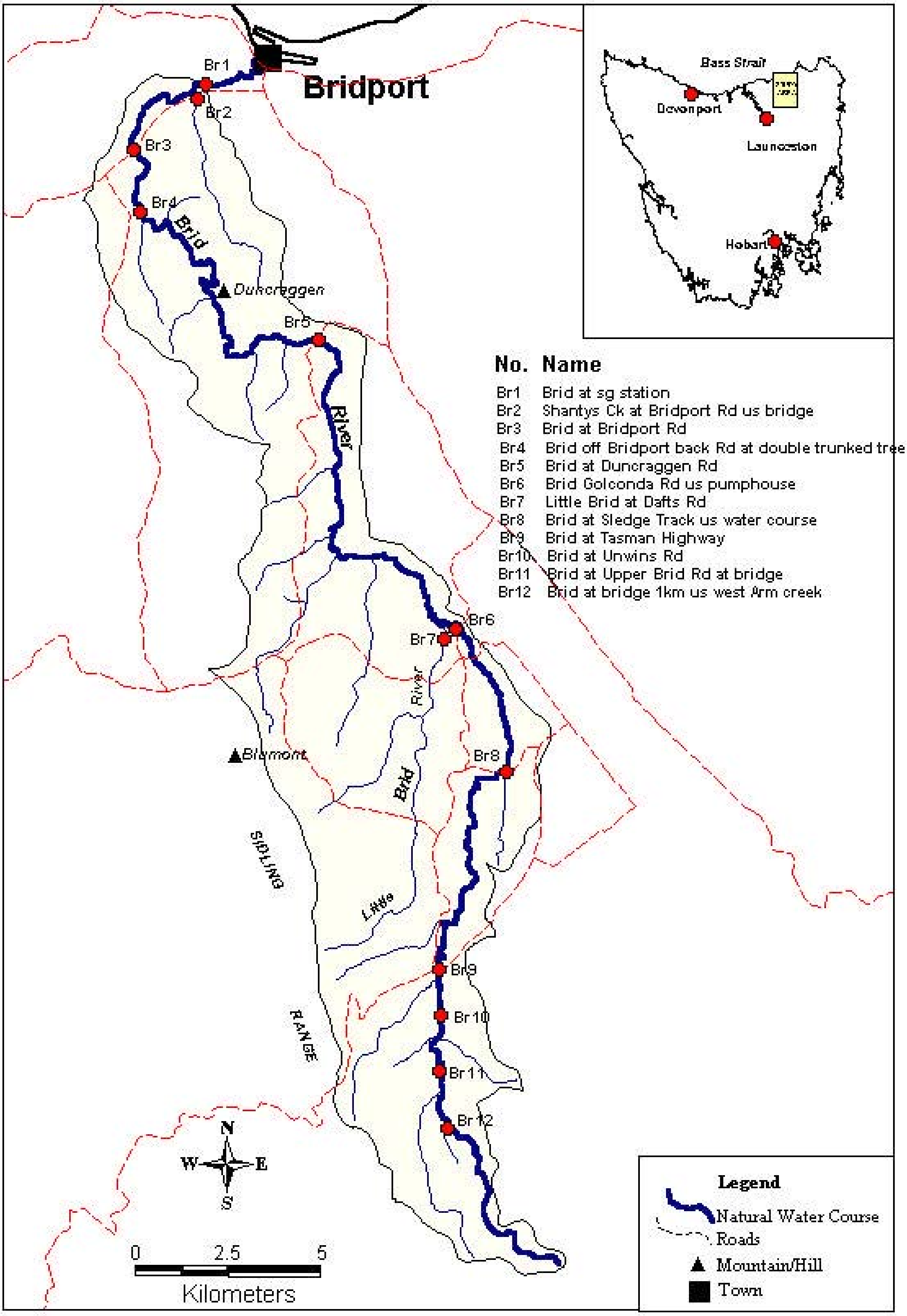
Because the Brid River lies within a long and very narrow valley, many of the smaller feeder streams and tributaries are dry for at least part of the year or have been used for the purposes of off-stream water storages. As a result of this, 'catchment snapshot' surveys of the Brid River catchment were essentially confined to sites on the main river and the Little Brid River. The locations of all sites sampled during the surveys is shown in Figure 3.16. The aim of this 'snapshot' approach is to highlight areas where water quality is degraded relative to the rest of the catchment. This technique has been used in the past both in Tasmania (Bobbi *et al.*, 1996) (Bobbi, 1997) (Bobbi, 1998) and interstate (Grayson *et al.*, 1997) and has proved useful.

Surveys of these sites were carried out on three separate occasions. The first was undertaken during low summer flows in December 1997 and involved field testing only. The second was carried out on January 20, 1998 and the thrird was carried out during stable winter flows on August 25, 1998. During all surveys, a total of 12 sites were visited, however during Survey #2 Shanty's Creek was dry and therefore not able to be tested.. At all sites physical-chemical testing was performed. During the second and third surveys a subset of sites (4 in January and 6 in August) were sampled, and analyses performed for nutrients, heavy metals and bacteria.

As most sites were located on the main stem of the Brid River, longitudinal plots of the data can reveal most of the pattern of variation in water quality and how it relates to location on the river. The data for water temperature (Figure 3.17) shows two distinct features. The first and most obvious is that water temperature in the river was much lower during survey #3 (winter) and there is no significant change in temperature down the length of the river. The second feature relates to the data collected during summer low flows (survey #1 and #2). Both of these plots show that there is a significant increase in water temperature towards the bottom of the catchment. This is most clearly demonstrated by the data from survey #1, when water temperature at the top of the catchment is about 3 ^{o}C lower than lower down the river. During the second survey most of the increase in water temperature occurred between BR12 (the top site) and BR8 (Brid at Sledge Track). This section of river is most affected by riparian management practices which have resulted in a lack of riparian vegetation, allowing sunlight to cause significant elevation in water temperature. Further downstream riparian cover shades the river, preventing increases in water temperature.

The pattern for instream pH is somewhat similar to that for summer water temperature (Figure 3.18) in that pH levels lower down the river are higher than in the headwaters. The pattern of change on all three occasions is very similar. The water in the upper half of the river (from headwaters to site BR6) is generally more acidic, with values between 6.3 and 6.5. The pH measured in the Little Brid River (site BR7) is similar to that measured nearby in the Brid River at BR6. Downstream of BR6 pH appears to increase markedly, though water is still mildly acidic in character. This may be linked to the change in land use as the river leaves farmland and flows through forested area (State Forest). This explanation is supported recent studies in New Zealand which found that larger, continuous blocks of riparian vegetation are more likely to result in water quality improvements than smaller discontinuous strips (Scarsbrook & Halliday, 1999). Sites BR3 and BR1 are located back in cleared farmland and once again pH levels are reduced. The very low pH recorded in this section of river is indicative of the effects of land clearance and drainage in the upper valley. It is known that the removal of vegetation from around rivers which lack base cations (calcium and magnesium) can lead to acidification (Cresser & Edwards, 1988), as vegetation in these situations can be the only contributor of these buffering minerals.

Figure 3.16: Brid River Study Sites



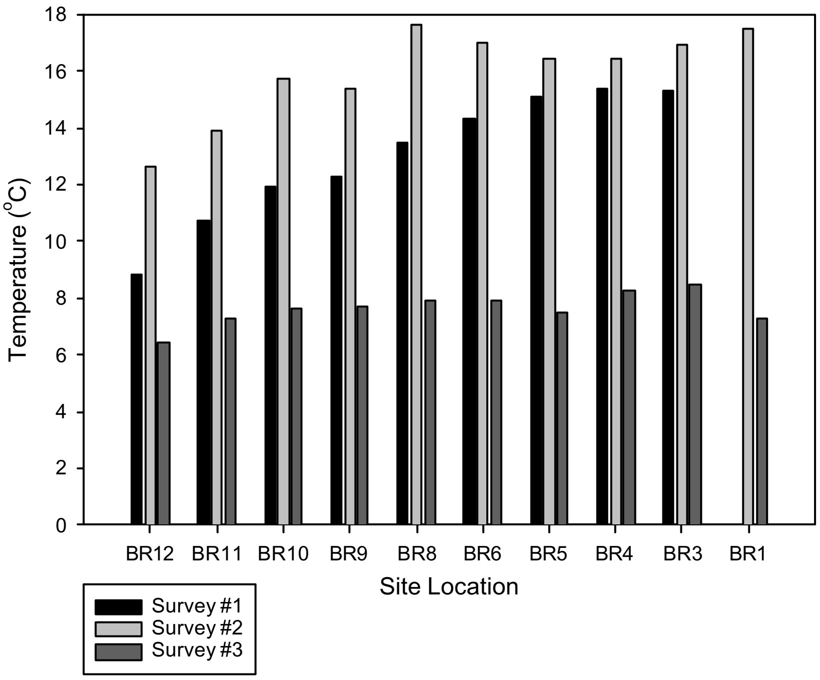


Figure 3.17 Longitudinal changes in water temperature in the Brid River recorded during three catchment surveys undertaken in the period Dec '97 to Aug '98.

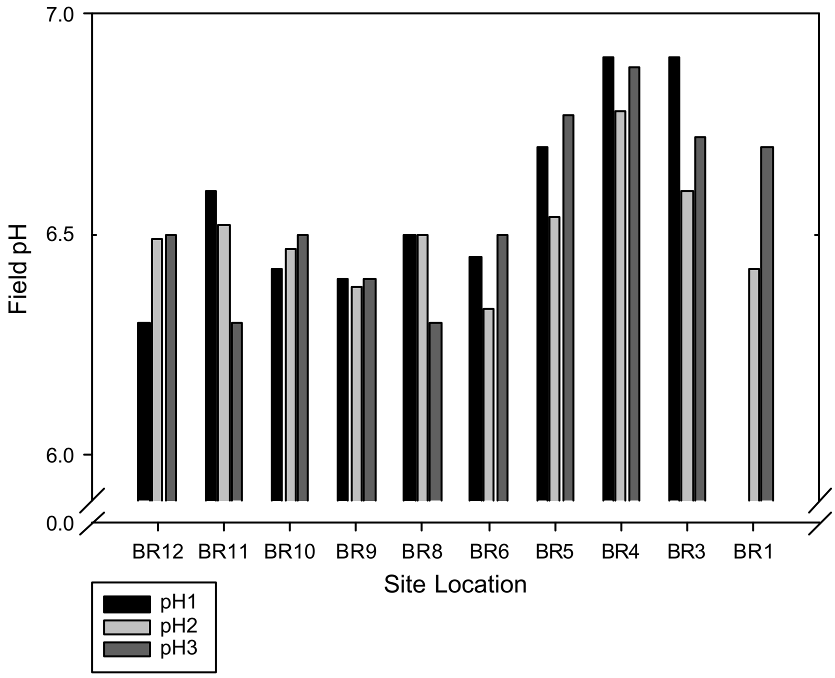


Figure 3.18 Longitudinal changes in pH in the Brid River recorded during three catchment surveys undertaken in the period Dec '97 to Aug '98.

The changes in conductivity also show a pattern for increasing concentrations downstream (Figure 3.19). Like pH, conductivity increases most between BR8 and BR3 which possibly provide further support to the reasons given for pH increase in this area due to better riparian vegetation. The increase in conductivity levels indicate that there are increased levels of salts entering the river in the area of State forest, which would provide more buffering against low pH levels. However these conductivity readings broadly indicate that salt levels in the Brid River are relatively low and should not interfere with either ecological functioning or agricultural use (ANZECC, 1992).

Conductivity in the small tributary of Shantys Creek, which enters the Brid River just downstream of BR1, is highly saline. Conductivity in this tributary was measured at 4970 µS/cm on survey #1 and 2520 µS/cm when it was flowing more strongly during survey #3.

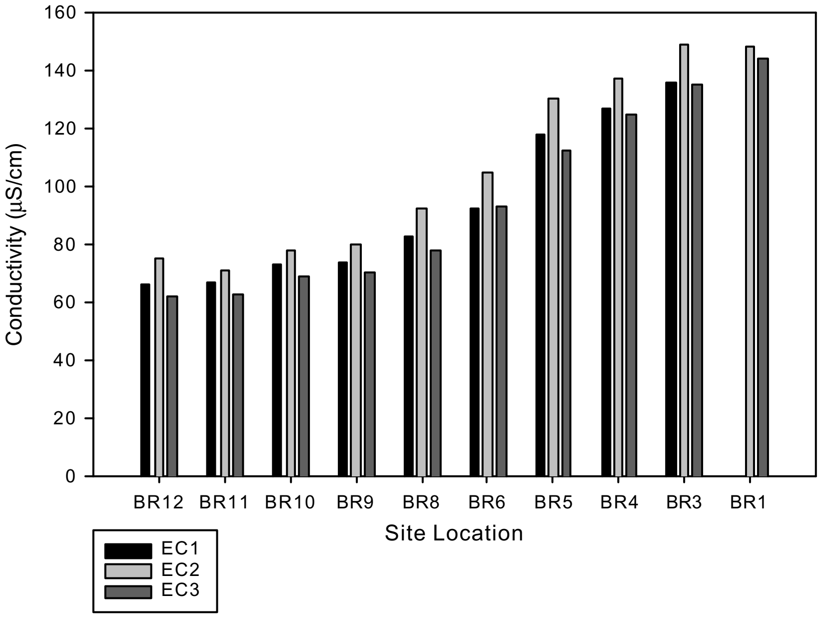


Figure 3.19 Longitudinal changes in conductivity in the Brid River recorded during three catchment surveys undertaken in the period Dec '97 to Aug '98.

The data for turbidity is displayed in Figure 3.20. The data from all three surveys are very similar for the sites down as far as BR6, with turbidity showing a uniform increase. However, for both the summer surveys (#1 & #2) turbidity levels downstream of BR6 decline, stabilising at about 8 NTU in the bottom reaches of the river. The implication from this data is that there are reduced inputs to the river in the area of the State forest and this has a positive impact on water quality. During the winter survey (#3), when baseflows were higher, turbidity continued to increase downstream of BR6, reaching a plateau of about 22 NTU in the bottom stretches of the river. This shows that during higher flows, turbidity in the lower reaches is either sustained by the more effective transfer of sediment through the middle reaches or that sediment continues to enter the river from tributaries in a fairly uniform way down its length. In either case it clearly illustrates that during winter, sediment (and therefore nutrient) delivery to the estuary at Bridport is greatest. During summer, turbidity decreases as the river flows through the area of State Forest, indicating that sediment is deposited in this stretch and that input to the river is minimal.

Turbidity in the Little Brid River upstream of the junction with the Brid River proper was found to be similar to that in the Brid River at BR6 during both summer and winter surveys.

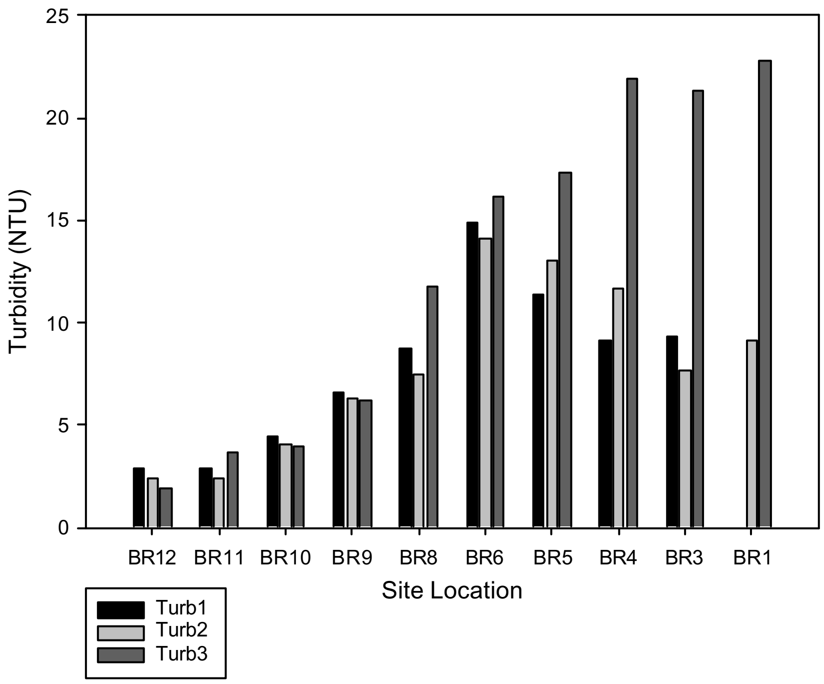


Figure 3.20 Longitudinal changes in turbidity in the Brid River recorded during three catchment surveys undertaken in the period Dec '97 to Aug '98.

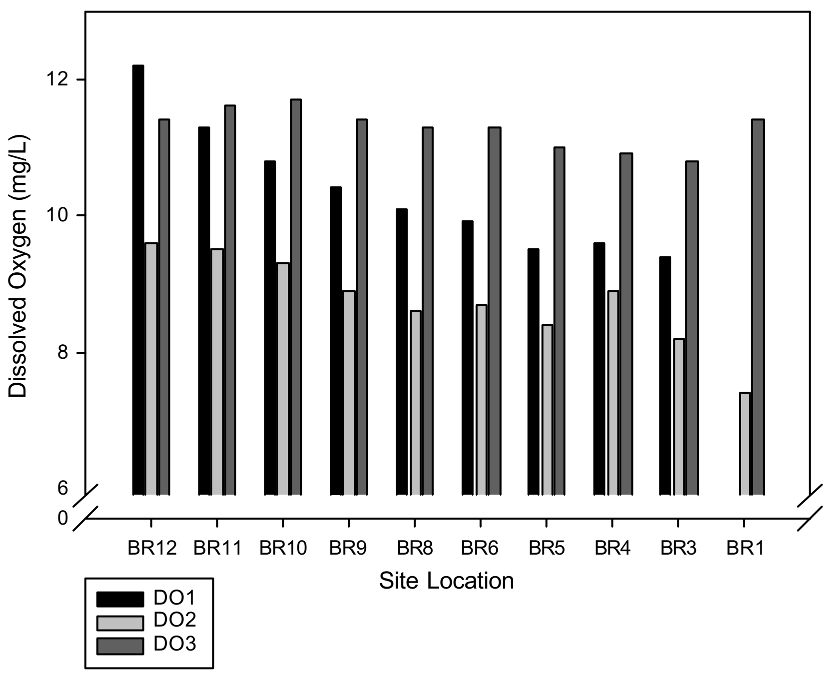


Figure 3.21 Longitudinal changes in dissolved oxygen in the Brid River recorded during three catchment surveys undertaken in the period Dec '97 to Aug '98.

The pattern for dissolved oxygen is typical of most natural rivers (Figure 3.21). During survey #1, oxygen concentrations at the top of the catchment were very healthy (above 11 mg/L), but decreased steadily to a minimum around 9.5 mg/L at site BR5. Oxygen concentrations downstream of BR5 were steady around 9.5 mg/L. During survey #2 the pattern of change was similar but the drop between BR12 and BR5 was less marked as levels at sites in the upper catchment were generally lower than those recorded in survey #1. The lowest oxygen concentration recorded during survey #2 was at BR1, where concentration was low (7.4 mg/L) but still within the range of values typically found in healthy streams. Healthy dissolved oxygen levels were recorded in the Little Brid River during all three surveys.

During the winter survey, conditions throughout the length of the Brid River were much more uniform and healthy (range between 10.8 - 11.7 mg/L), demonstrating that conditions in throughout the length of the river are much improved during higher winter flows.

Nutrient concentrations were measured at four sites during survey #2 and at six sites during survey #3. The data for TN concentrations (Figure 3.22a&b) suggest that there are not significant differences in the pattern of variation between summer and winter. The data of most interest is that from the Little Brid River, which shows that on both occasions concentrations of TN are higher in this tributary than in the Brid River just upstream. During the summer survey, the concentration of TN at BR1 at the bottom of the catchment is similar to that at BR9 higher up the river, despite the elevated concentration in the Brid River prior to its entry into the State forest. This reinforces the data for turbidity (Figure 3.20) and the conclusion that water quality improves in the section flowing through the State forest during low summer flows due to the reduced level of catchment disturbance and a relatively intact riparian zone. The data for winter shows that TN is easily transferred to the bottom of the catchment by higher flow in the river.

Nitrate nitrogen (NO_3/N) is a major component of TN concentrations in both the Brid and the Little Brid rivers. In the Little Brid River, NO_3/N was higher than any site in the Brid River on both summer and winter surveys (Figure 3.23a&b) indicating that this tributary may be a significant contributor to NO_3/N levels in the Brid River. In the main river, NO_3/N concentrations during winter generally show an increase to BR6 then drop slightly by the time the river reaches BR1 at the bottom of the catchment. This pattern is more noticeable during the summer survey, despite fewer sites being sampled.

The concentration of NH_3/N throughout the catchment during the summer survey was higher than during winter (Figure 3.24a&b). During summer, high levels of NH_3/N were measured at BR9 and at BR1, both of which have substantial dairy farms in the area around the river where the sites are located. These levels reflect the impact of low level organic pollution to the river near or upstream of these sites. Levels at both BR9 and BR1 are lower during the winter, as are concentrations at all other sites in the catchment. During the winter survey, site BR7 on the Little Brid River had the highest NH_3/N concentrations (0.02 mg/L).

Figure 3.22a: Brid River Summer Nitrogen Levels (mg/L)

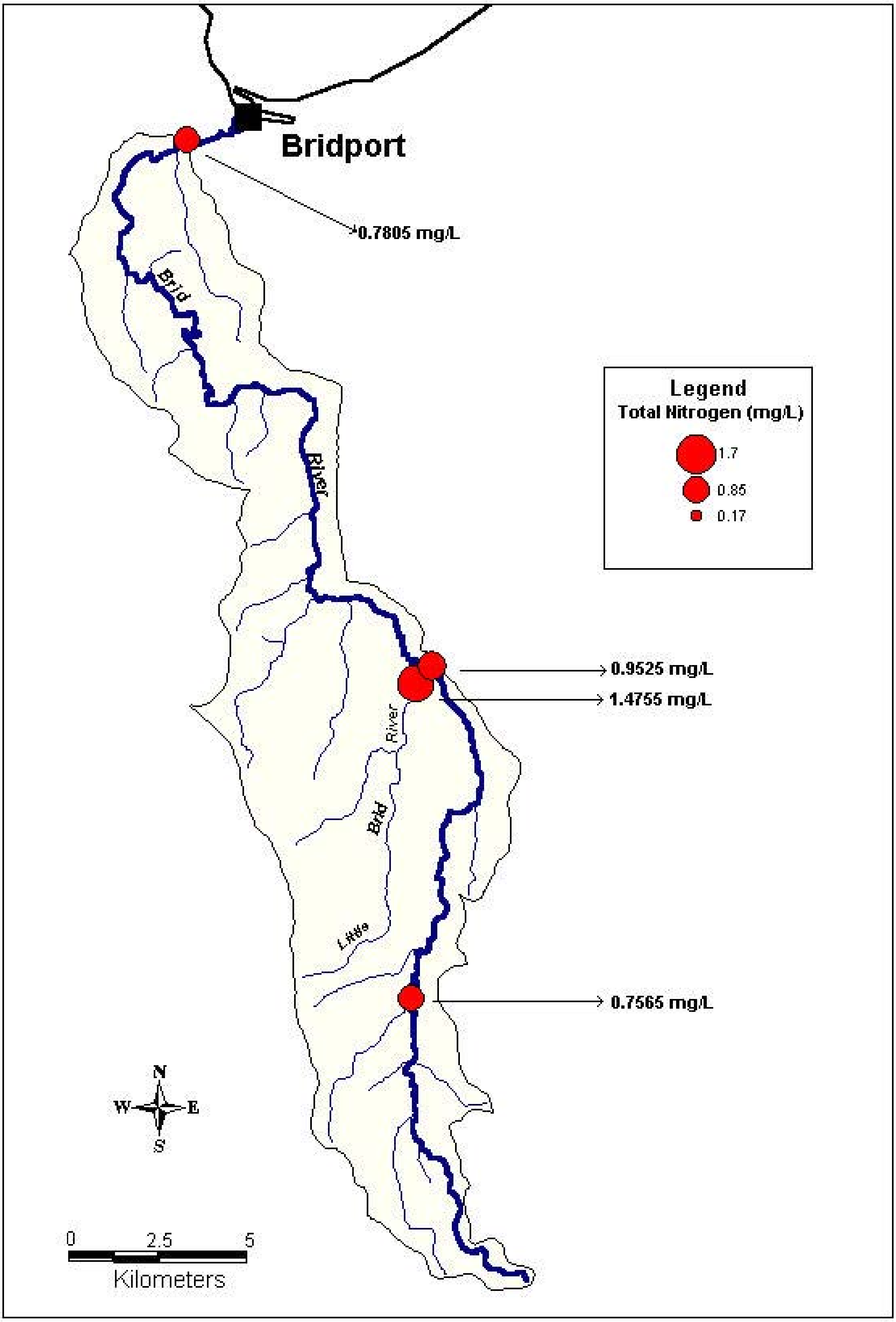


Figure 3.22b: Brid River Winter Nitrogen Levels (mg/L)

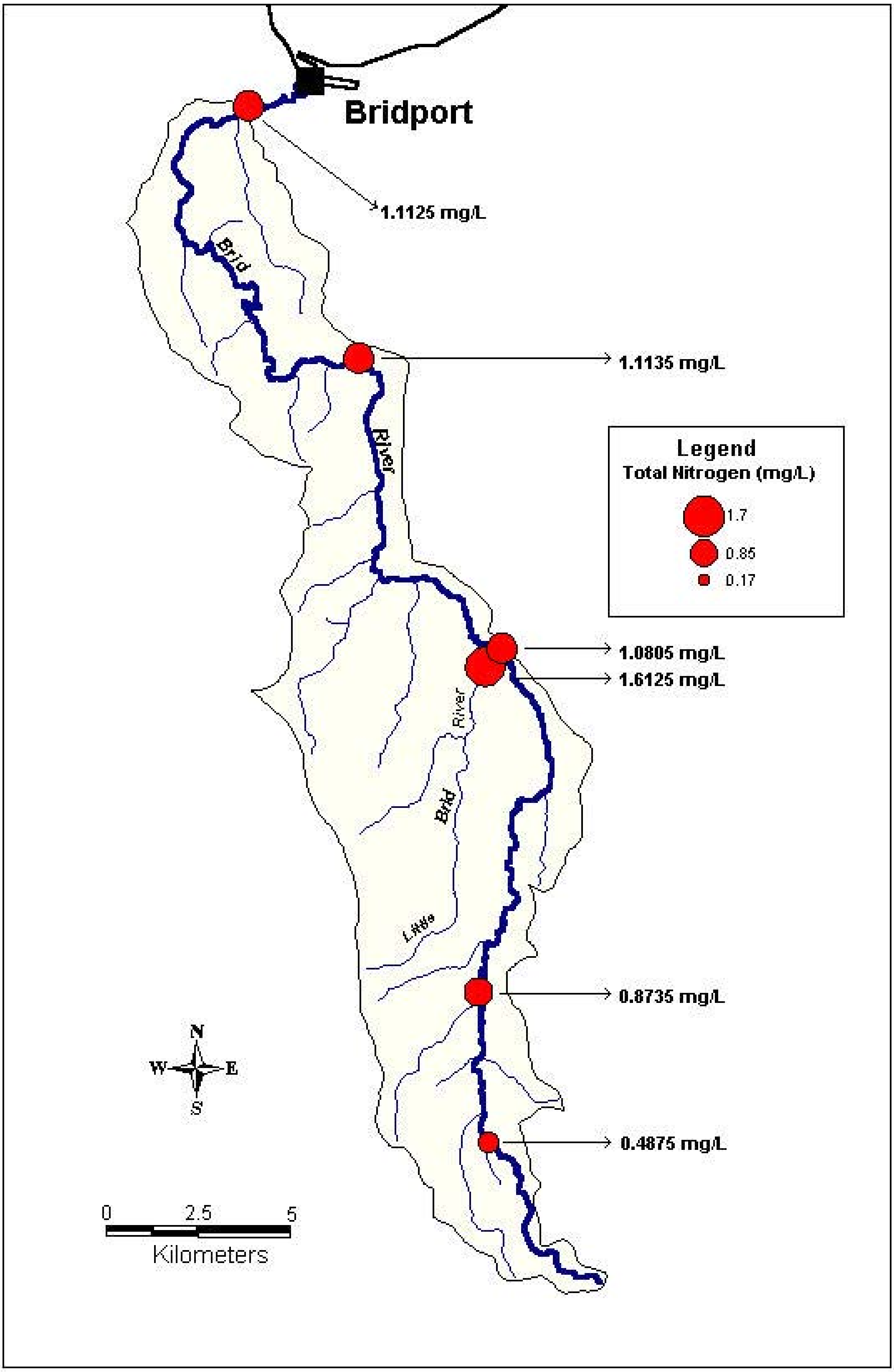


Figure 3.23a: Brid River Summer Nitrate Levels (mg/L)

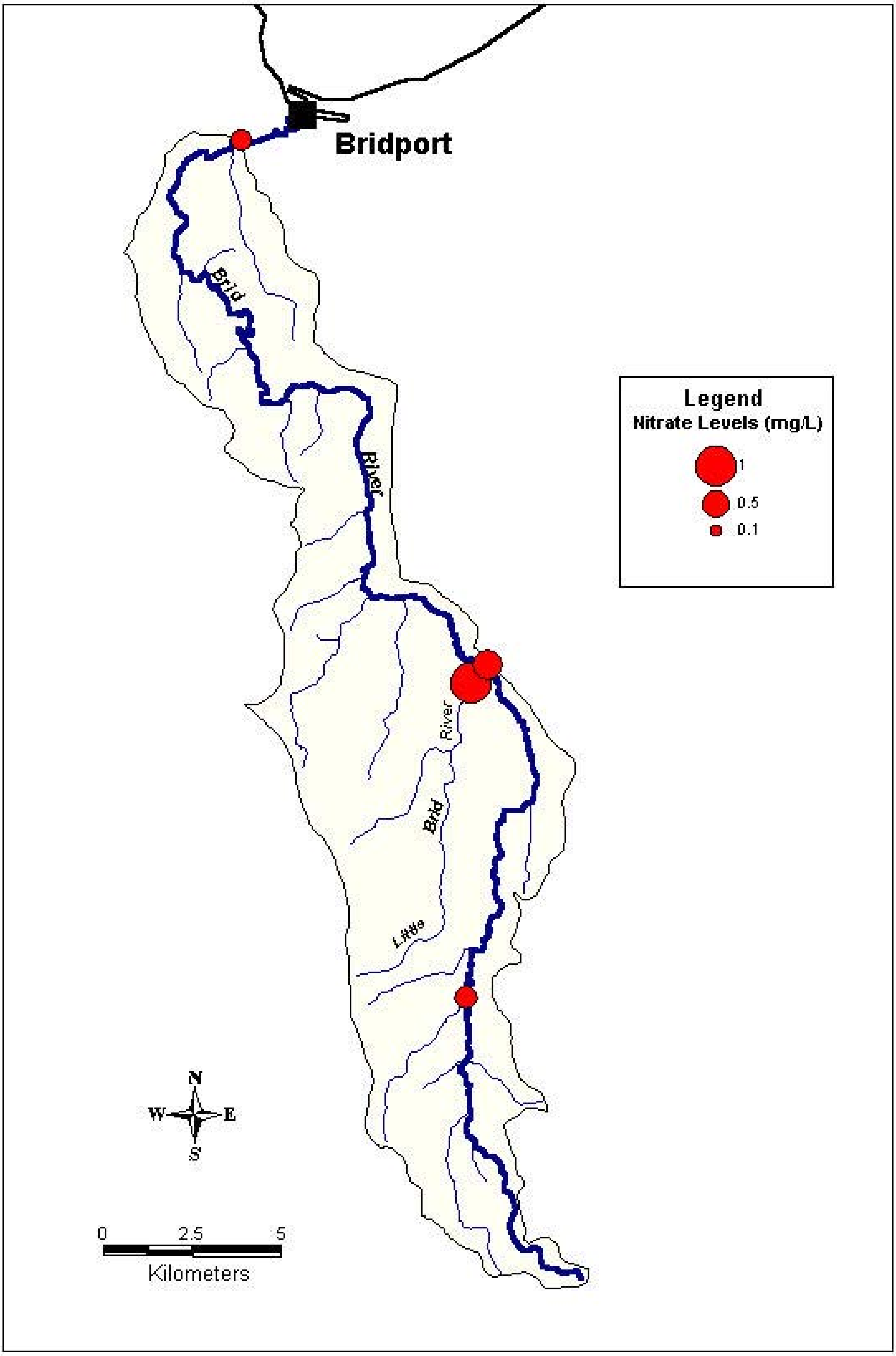
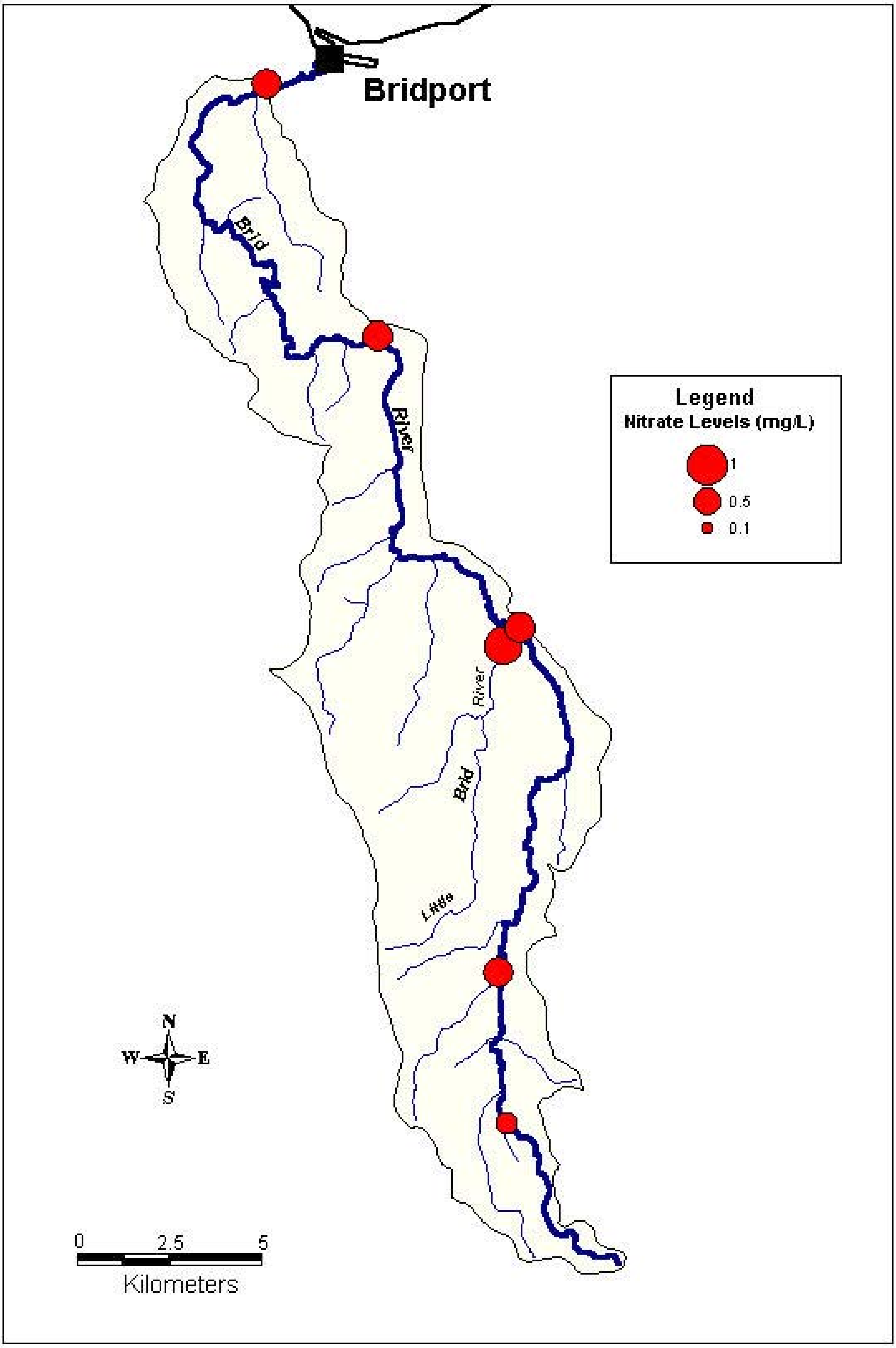


Figure 3.23b: Brid River Winter Nitrate Levels (mg/L)



Figurre 3.24a: Brid River Summer Ammonia Levels (mg/L)

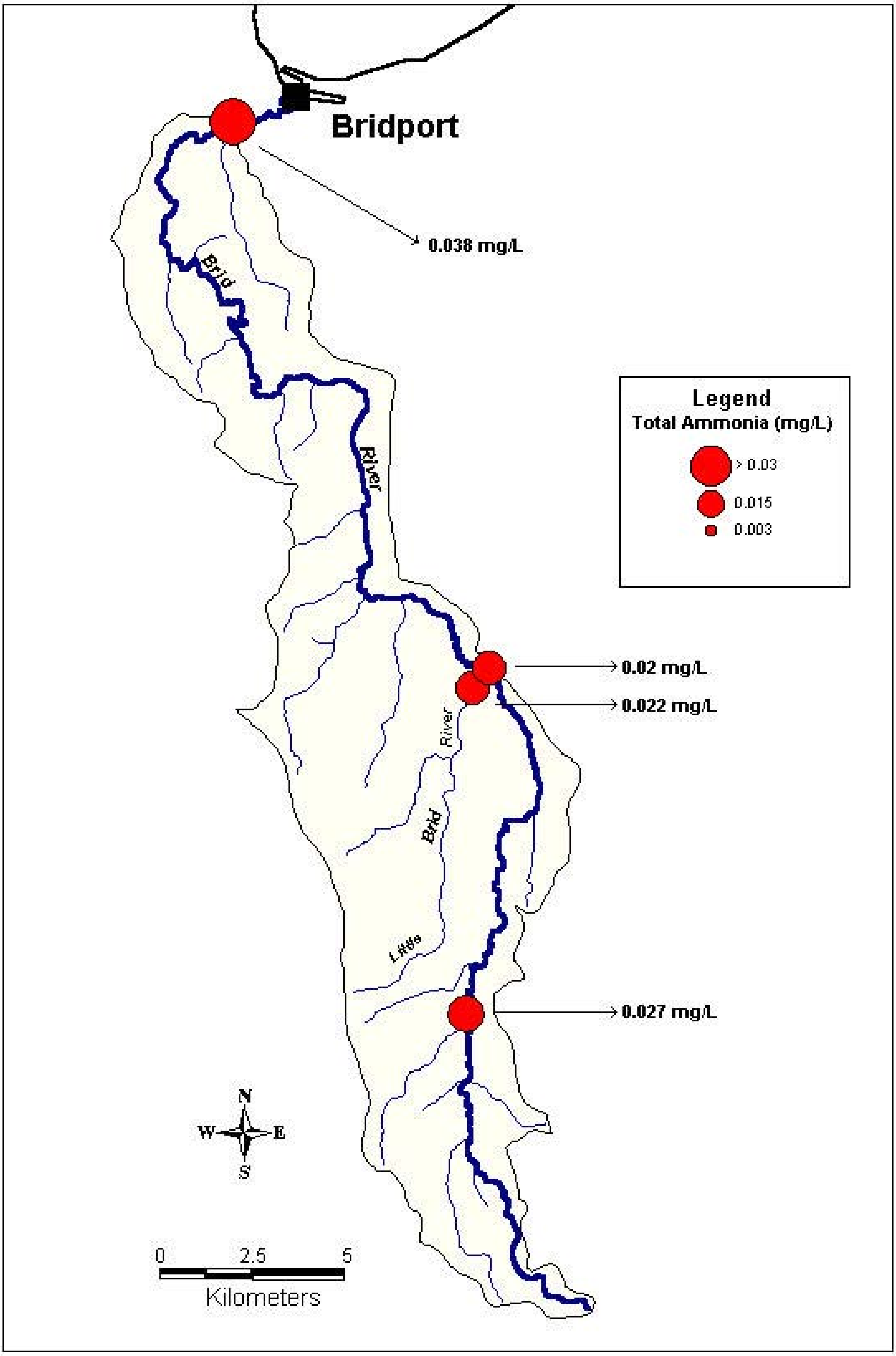
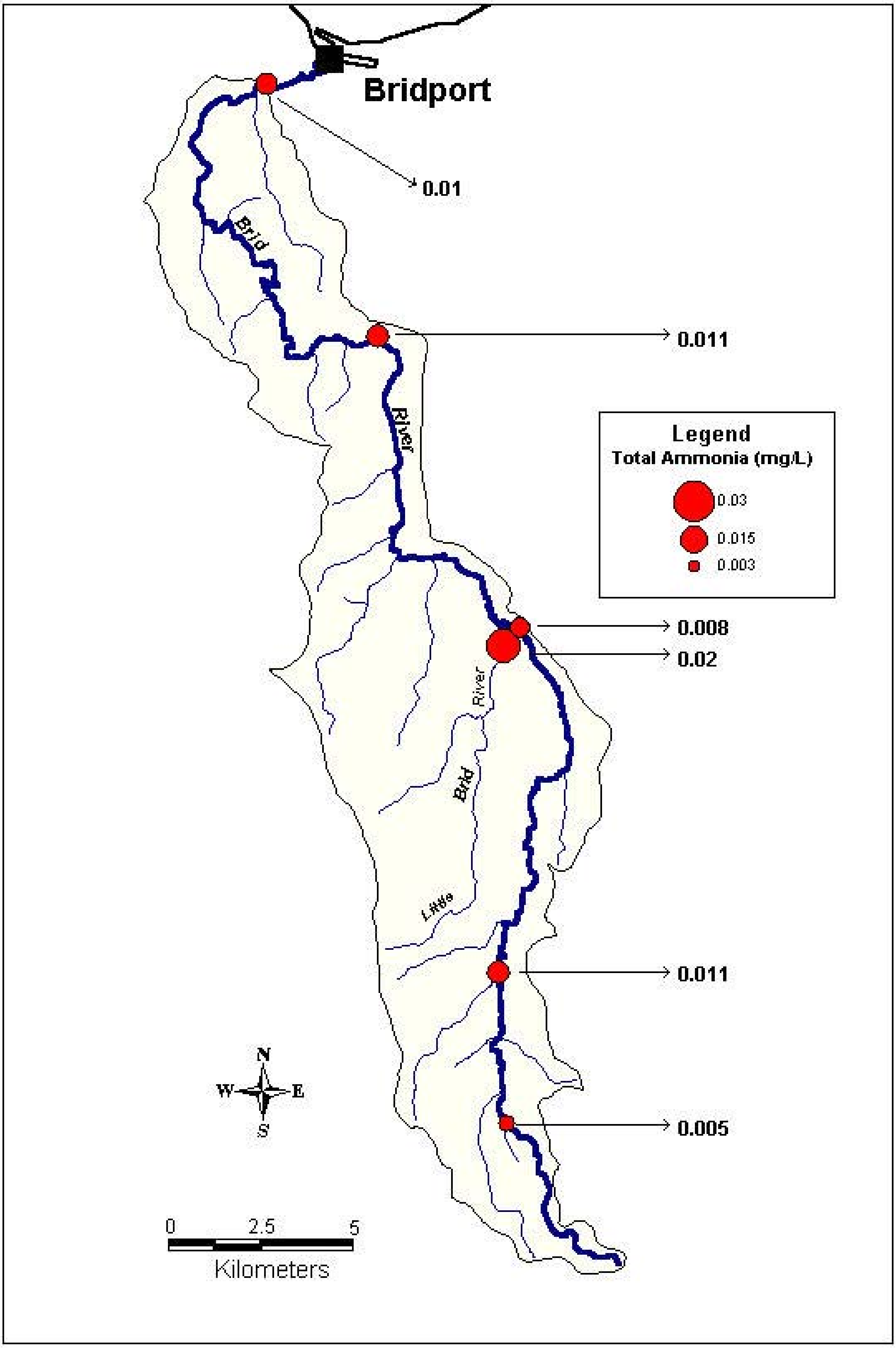


Figure 3.24b: Brid River Winter Ammonia Levels (mg/L)



Although the survey results for TP show that concentrations were generally slightly lower during the winter (Figure 3.25a&b), the pattern is very similar for both sets of results. The most significant feature of both diagrams is that TP concentration in the Little Brid River are higher than any of the sites in the main river. It is clear that catchment activities in the area around West Scottsdale are having an impact on nutrient levels in both the Little Brid and Brid rivers. This is an area where intensive cattle grazing (beef and dairy) and cropping (primarily poppies and potatoes) occurs.

The results of bacterial testing during both the summer and winter surveys is shown in Figure 3.26a&b. It is clear that during summer (survey #2), coliform levels are higher despite the lower river flows. This is most probably a result of two factors. Firstly, during the summer season increased water temperature in the river (14-18 ^{o}C) would lengthen the survival of coliforms in the environment. Combined with this is the reduced flow in the river which would lessen the dilution potential for any faecal inputs to the river.

The data from both surveys show that highest coliform levels were found at the uppermost site (BR9), where beef and dairy activities are most intense. During the summer survey, coliform concentrations in the Little Brid River (BR7) were also high (530 cfu), though all sites covered during ‘snapshot’ sampling showed faecal coliform levels which indicate that the water may exceed ANZECC (1992) guidelines for primary contact. Further sampling during summer is required to establish whether this condition is common throughout the summer period. The winter snapshot suggests that this may be the case at least at some sites on the Brid River.

All together the data from the catchment ‘snapshots’ is useful in that it provides further detail and builds on the data collected at the monitoring sites. The most significant feature of the ‘snapshot’ data has been the positive impact the State forest has on some water quality parameters. This may simply be due to the presence of an adequate buffer zone protecting the river, though the land use practices present in the upper part of the catchment are missing in the State forest area and consequently inputs are less. The main point that arises from this is that the establishment of an adequate and functional riparian strip in the upper catchment can potentially bring about significant improvements in water quality in the river.

3.3 Continuous Monitoring

Continuous water monitoring probes currently operate on the Brid River. They are located at the stream flow recording station which is approximately 2.4 km upstream of the limit of tidal influence. At this site water temperature, electrical conductivity and turbidity are recorded on a 20 minute cycle. As the probes are permanently immersed in the river, it is necessary to both clean them regularly and also check the accuracy of the data they collect against other regularly calibrated field instruments. When cleaning and field checking is not performed frequently enough, there can be drift in the data, particularly the turbidity data, and this can reduce the confidence in the data when used at a later date.

During this study, regular monthly monitoring visits as well as site visits during flood events ensured frequent cleaning and calibration checks of the probes. An example of the data collected is given in the following two figures (Figure 3.27 and 3.28). In Figure 3.27 the change in conductivity in the river is plotted together with the variation in flow during a flood event late in July, 1998.

Figure 3.25a: Brid River Summer Phosphorous Levels (mg/L)

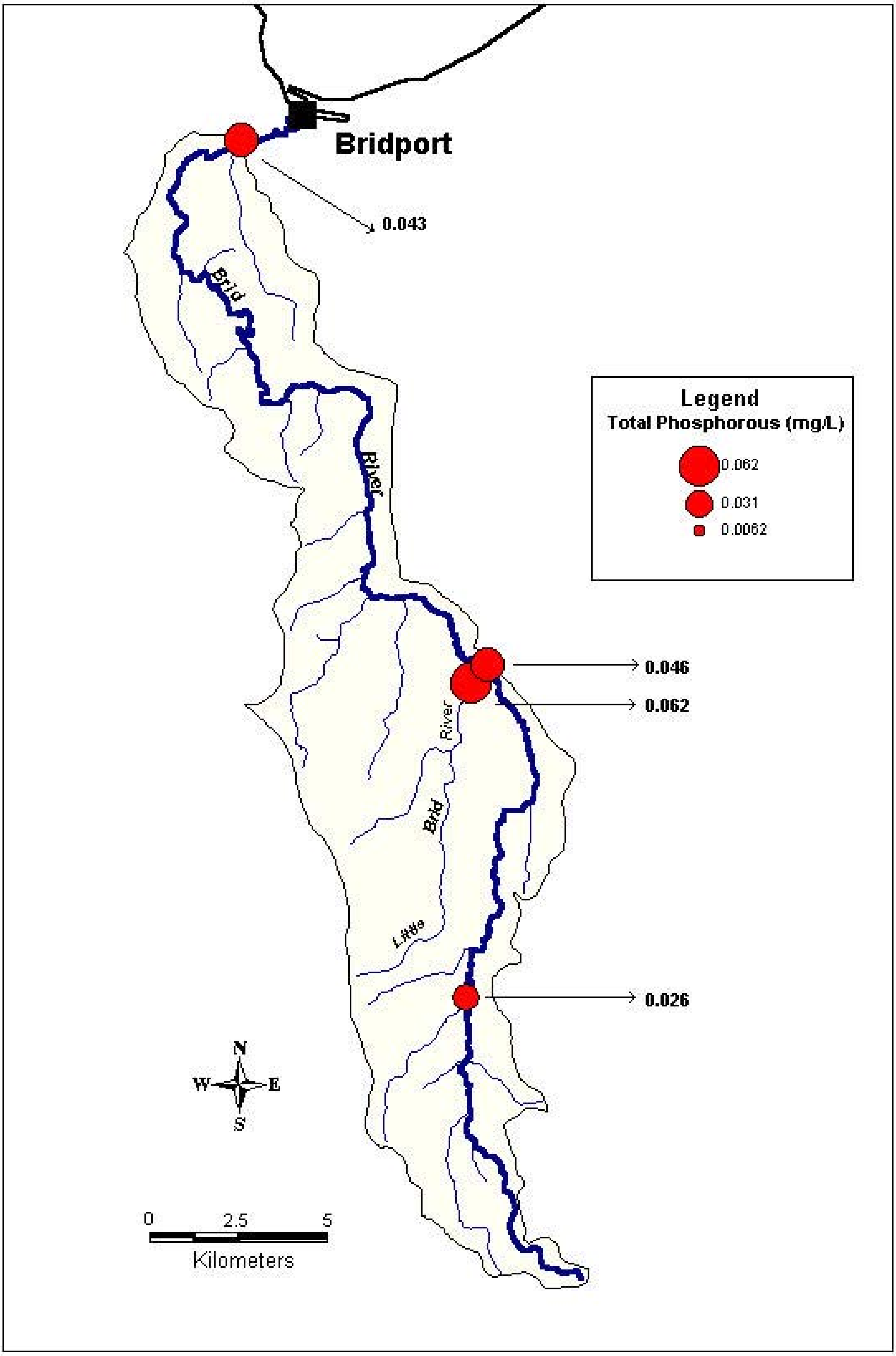


Figure 3.25b: Brid River Winter Phosphorous Levels (mg/L)

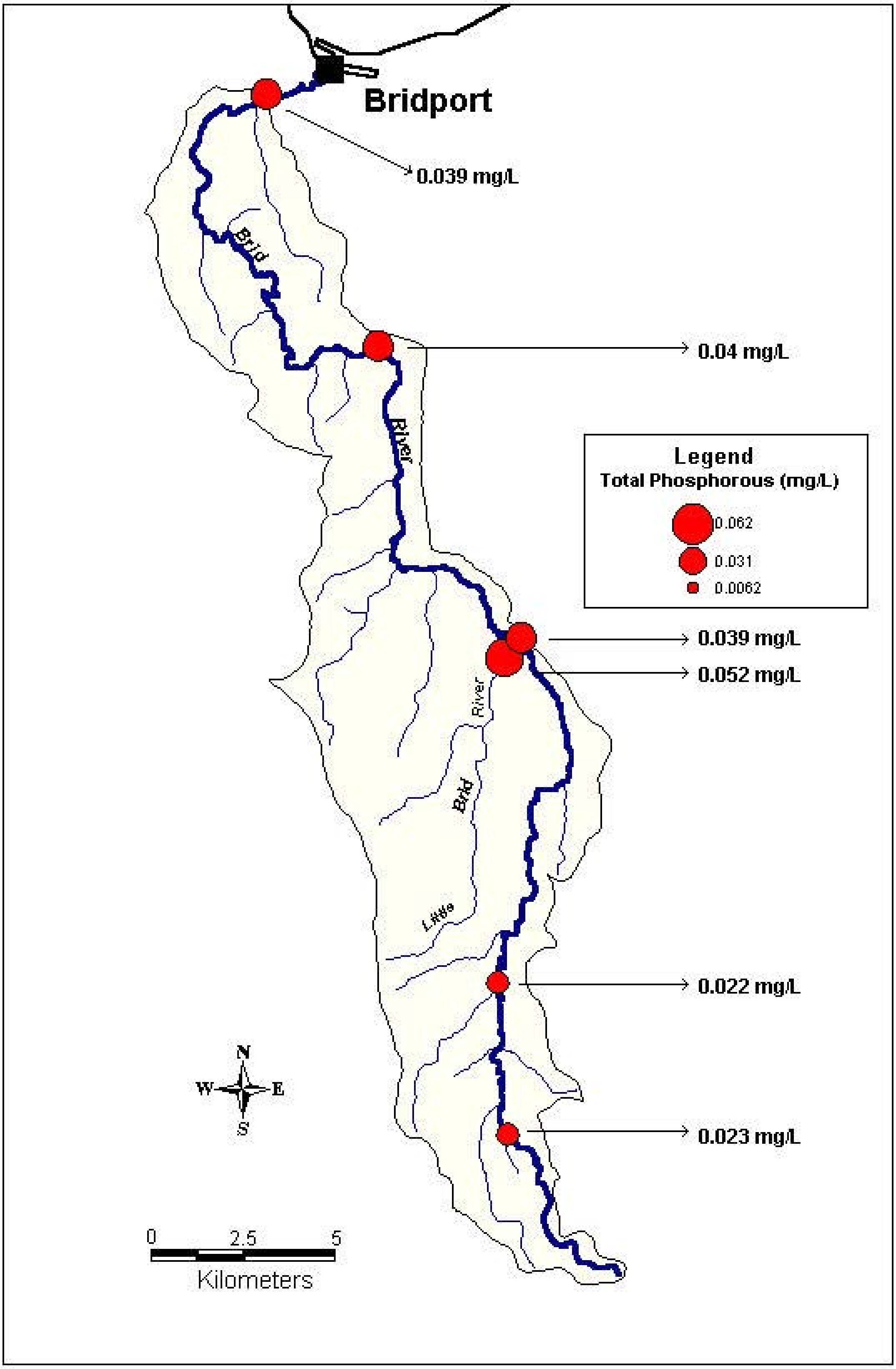


Figure 3.26a: Brid River Summer E. coli Levels (100mls)

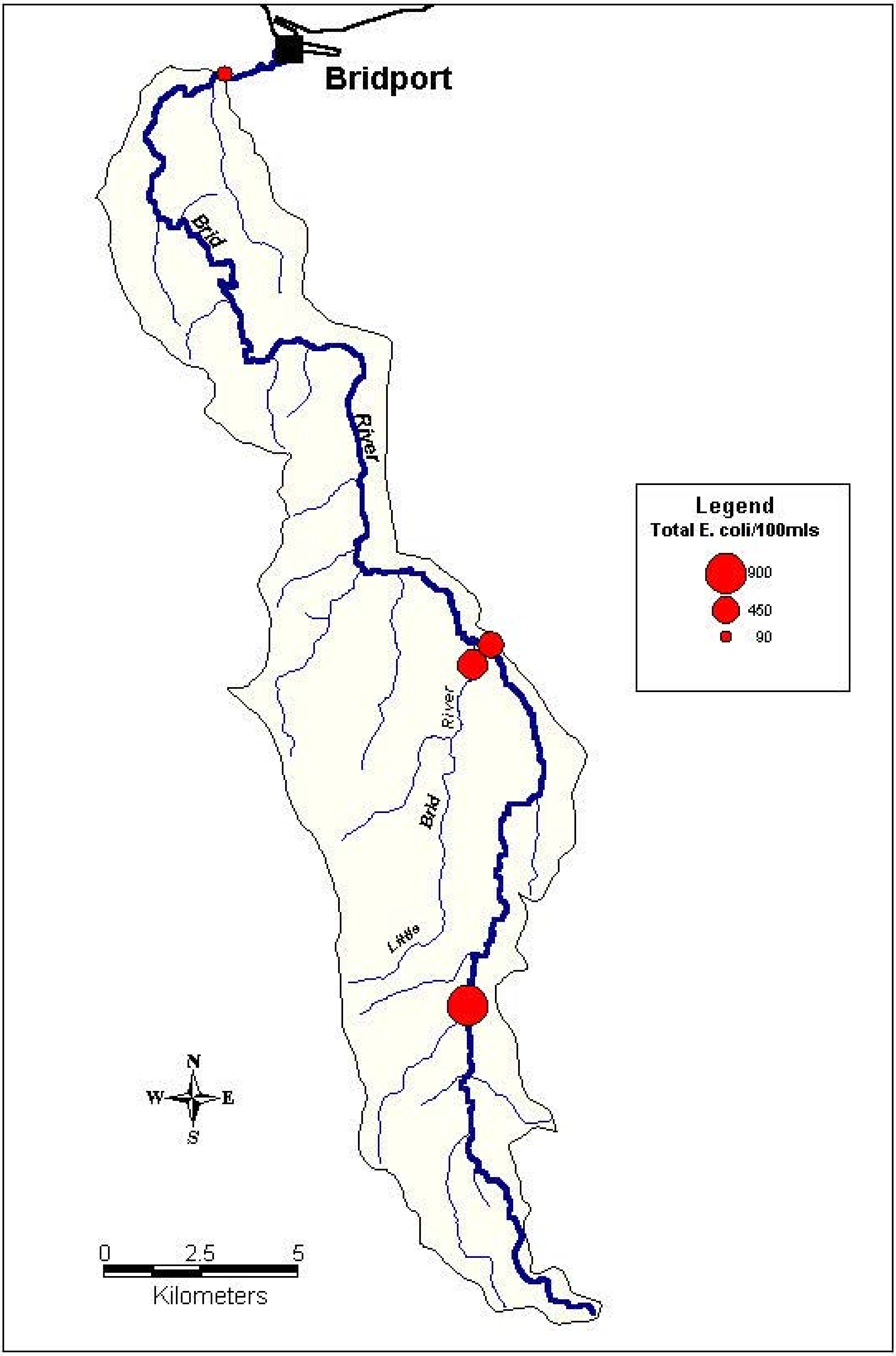
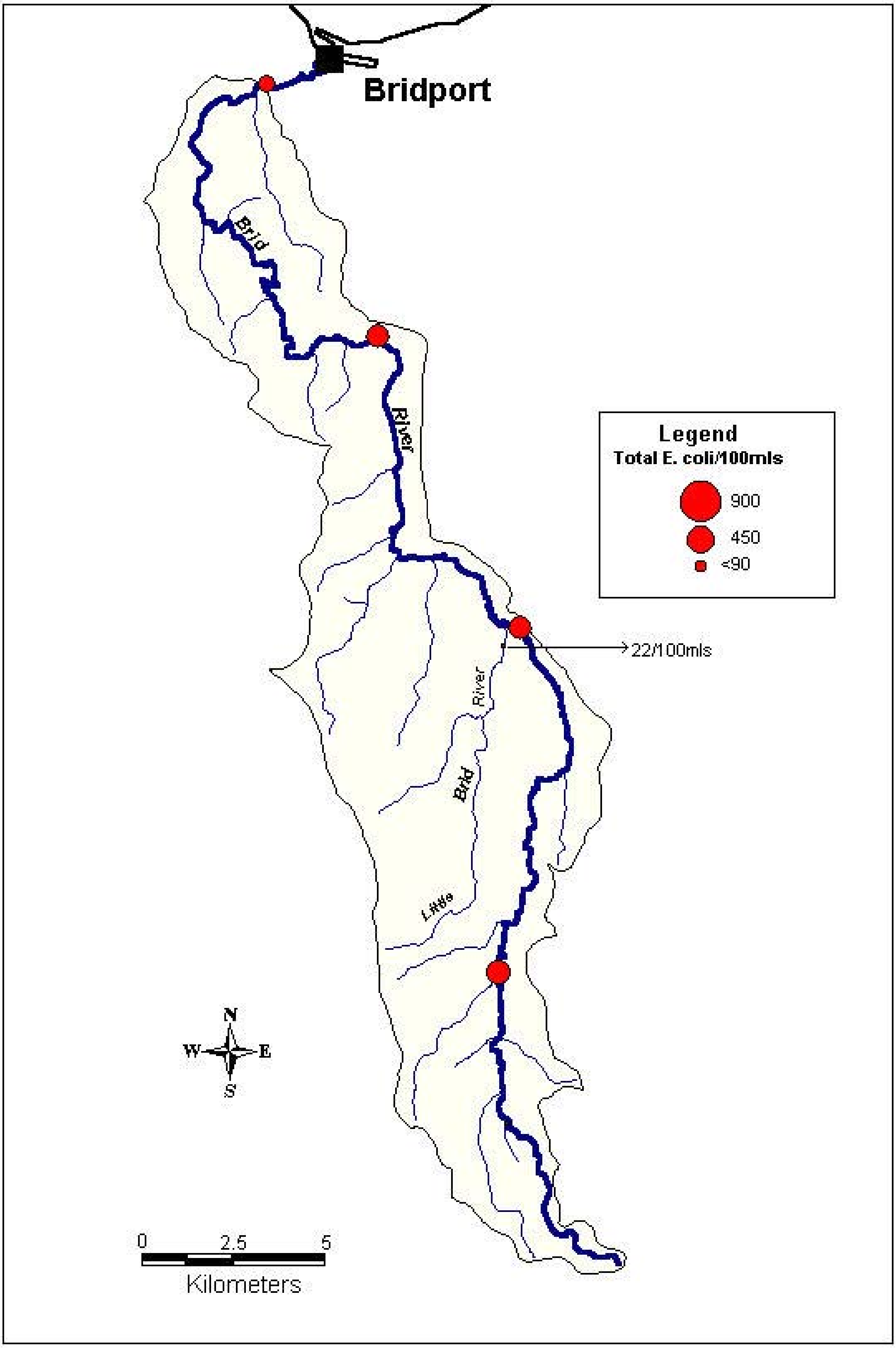


Figure 3.26b: Brid River Winter E. coli Levels (100mls)



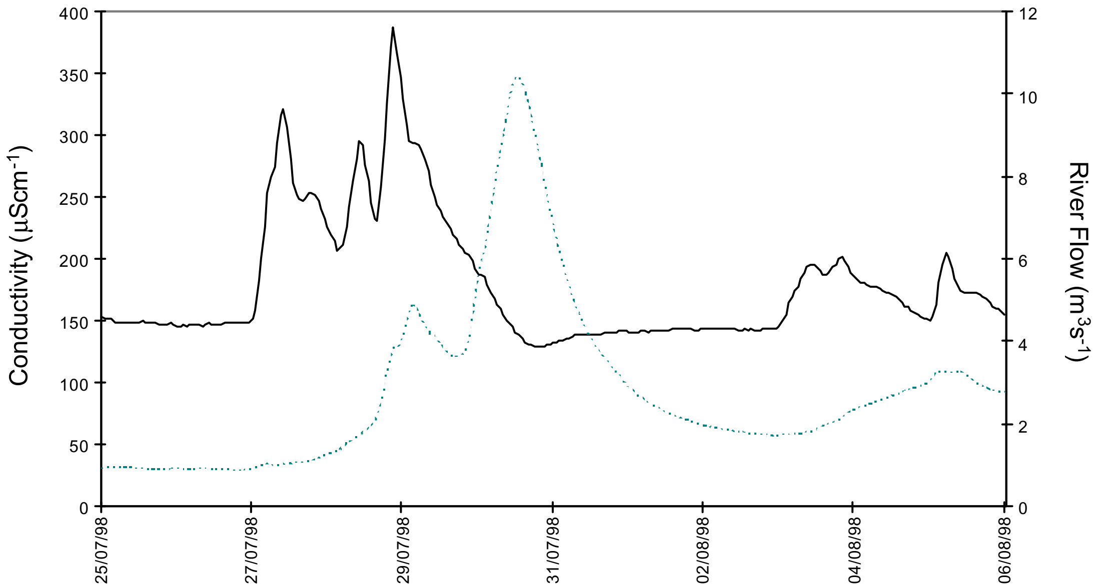


Figure 3.27 'In situ' changes in conductivity in the Brid River during a flood event in July, 1998. Dotted line shows changes in river flow. # Conductivity temperature compensated to reference of 25 ^{o}C.

The plot shows that at this site in the Brid River, the conductivity actually increases quite dramatically almost 20 hours before the arrival of flood flows. This is very different to what normally happens in other Tasmanian rivers, where conductivity levels generally decrease as dilution takes place due to the entry of runoff to the river (Bobbi *et al.*, 1996) (Bobbi, 1997). Rather than the rapid decrease in conductivity early in floods which is characteristic of most rivers, the spikes in the Brid River indicate inflow of more concentrated water. The cause of the marked increase at this site appears to be due to runoff from the dairy located immediately upstream. It has been shown elsewhere that runoff from dairy sheds and the area in the immediate vicinity can be a significant source of dissolved and suspended solids (NRA, 1992) and the sudden entry of this 'flush' to the river would occur prior to the arrival of floodwaters from further upstream. Any stormwater drains from such an area would facilitate this effect.

One method of summarising the continuous conductivity data is to perform a duration analysis, which separates the data according to time spent in particular ranges. For the conductivity data from the Brid River, eight range categories were arbitrarily chosen and the resulting duration analysis is shown in Table 3.4. The results show that for at least 77% of the time, conductivity in the lower reaches of

Table 3.4 Duration Analysis for Conductivity at Brid River station.
Season: Full Year
Period Processed 1787 days - 1/3/94 to 27/4/99

Band	Value Range	% Time within Range	% Time >= Bound
1	0 - 100 (µScm^{-1})	0.12	100
2	100 - 125 (µScm^{-1})	8.94	99.9
3	125 - 150 (µScm^{-1})	45.04	90.9
4	150 - 175 (µScm^{-1})	32.40	45.9
5	175 - 200 (µScm^{-1})	7.66	13.49
6	200 - 225 (µScm^{-1})	2.48	5.84
7	225 - 250 (µScm^{-1})	1.19	3.36
8	> 250 (µScm^{-1})	2.17	2.17

the Brid River is in the range 125 - 175 μScm^{-1} (agreeing with the earlier results from the monitoring data). For about 6% of the time, conductivity levels are above 200 μScm^{-1} which is indicative of the temporal impact of nutrient rich flushes on the river as discussed above.

An example of some of the turbidity data which has been recorded by the equipment at this site is shown in Figure 3.28, plotted along with river flow. The graph shows the variation in turbidity and river flow for July 1998 and demonstrates that turbidity during moderate floods can reach levels as high as 150 NTU. That is about 10 times higher than occurs during normal baseflows (see Fig. 3.5). Although turbidity levels during floods generally reflects the size of the flood, the conditions prior to an event are also important. Heavy rainfall following a long period of dry weather will usually generate higher turbidity levels than similar rainfall which follows wetter weather. A notable feature of the July 1998 plot is that turbidity increases very quickly early in the event, peaking several hours before flood levels reach their peak. This demonstrates how quickly loose material in and on the banks of the river become mobilised. It is during this time that rivers are carrying their greatest sediment and nutrient load. In basic form, unlike conductivity, the pattern of turbidity change in the river is very similar to the pattern of change for river flow.

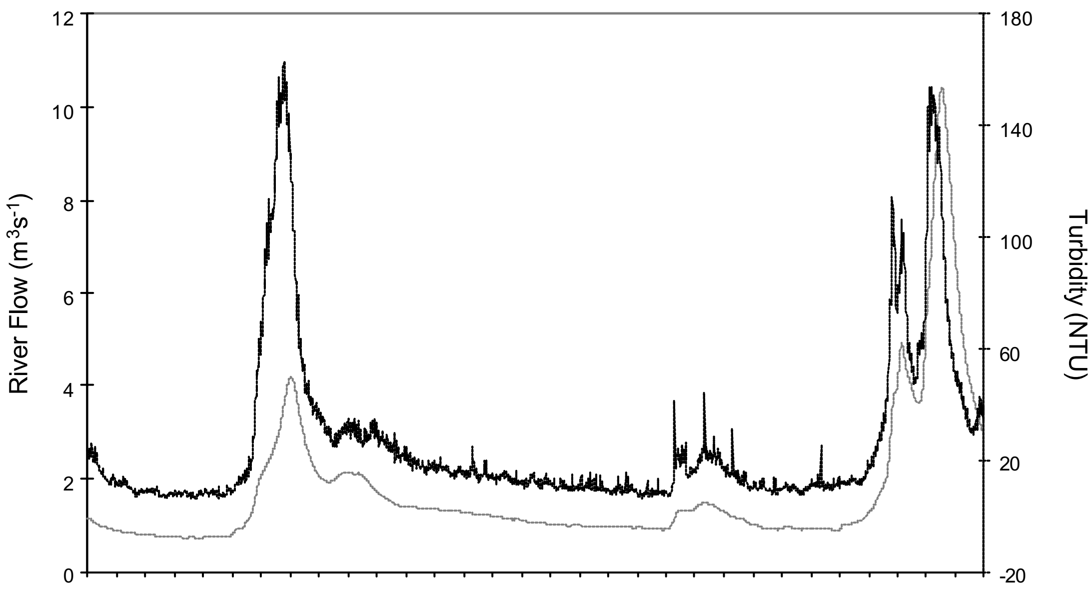


Figure 3.28 Variation in turbidity and its relationship with river flow in the Brid River during July, 1998. River flow is represented by the dashed line.

As well as showing how turbidity changes with variation in river flow, the turbidity record can also be used to give reasonably accurate estimates of nutrient and sediment export from the catchment. In many rivers, turbidity can be a major determinant of the level of nutrient carried by the river, as suspended solids often carry the majority of the nutrients. The next section discusses some of these details and presents export loads for the Brid River catchment.

3.4 Nutrient Load Estimates

As mentioned in the preceding section, turbidity was monitored in the Brid River using an 'in situ' sensor. A pumping mechanism was also used to help maintain a clean sensor surface, ensuring that data collected remained relatively free of interference from algal growth and sediment deposition. Regular checking against a portable meter was performed, both during flooding and during low flows. An example of the turbidity change during a single flood event is presented in Figure 3.29.

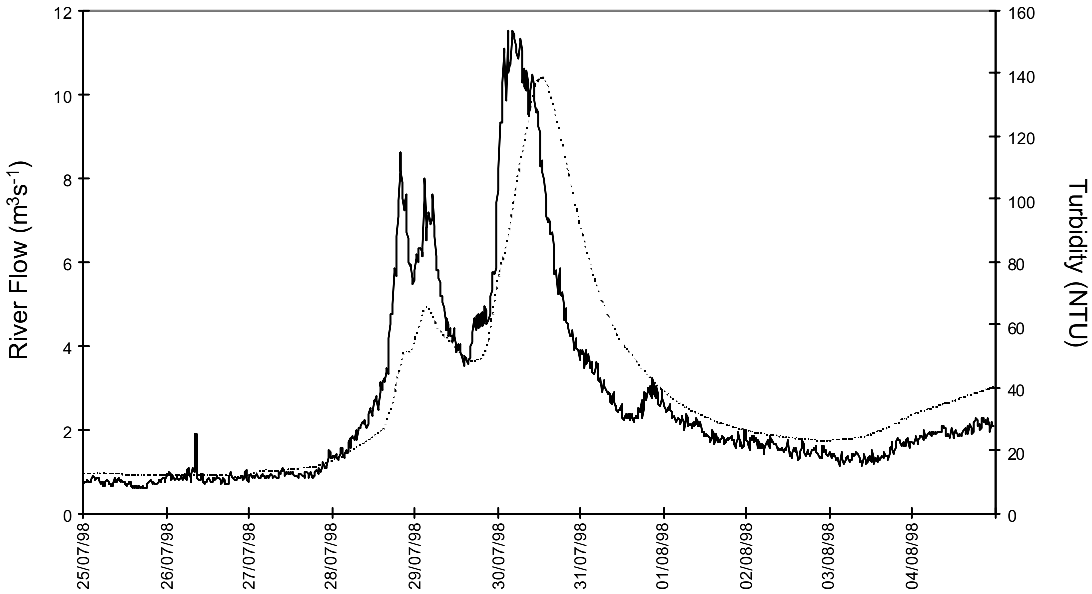


Figure 3.29 Variation in turbidity and river flow in the Brid River during a flood in July, 1998. River flow is represented by the dotted line.

Continuous turbidity data was recorded for the period October 1997 through to December 1998, and quality checked. To make some estimate of nutrient loads being exported from the catchment, it was proposed to develop relationships between turbidity and the major nutrients of P and N and for suspended solids. Therefore, in addition to the routine monthly monitoring, samples were taken during higher flows using an automated pump sampling machine which was triggered by rising river levels. These samples were then later collected and analysed for turbidity, suspended solids and nutrients. A summary of these data is presented in Table 3.5.

Table 3.5 A summary of concentrations of Suspended Solids, Total N and Total P recorded during flood flows in the Brid River during 1998.

	Suspended Solids (mg/L)	Total N (mg/L)	Total P (mg/L)
Number of Samples	27	40	40
Average	127	2.12	0.18
Maximum	210	3.91	0.40
Minimum	60	1.24	0.05

This data was then used for two purposes. The first of these was to calibrate and check the quality of the turbidity data recorded by the 'in situ' probes. Where necessary, correction of the record was then performed. The results from analysis of samples was also used to derive relationships between turbidity and the major parameters of TN, TP and suspended solids. It was found that significant linear relationships existed between all three parameters and turbidity.

These are;

Total suspended solids
[TSS] = 1.3576*turbidity -10.525
$R^2 = 0.968$, n = 27.

Total Nitrogen
[TN] = 0.0177*turbidity + 0.64
$R^2 = 0.72$, n = 40.

Total Phosphorus
[TP] = 0.002*turbidity + 0.01
$R^2 = 0.895$, n = 40.

The relationship for TN concentration and turbidity is not as significant as the others, as a proportion of all the nitrogen being exported from the catchment is in the dissolved form (ie NO_3) and is not linked to turbidity. As was discussed in an earlier section, in general nitrate comprises more than 45% of the total nitrogen present in the river.

Using the derived relationships for the Brid River, the time series of turbidity was then able to be transformed to a synthetic record of TN, TP and total suspended solids concentrations, which could then be used to estimate export loads. As an example, the total estimated load from the single event of July 1998 (shown above) has been calculated at;

Total Suspended Solids	= 159,336 kg
Total Nitrogen	= 3,565 kg
Total Phosphorus	= 284 kg

The total discharge volume of this event was 1,914 megalitres (6% of the total discharge of the Brid River for the year 1998).

There are some inaccuracies and assumptions associated with this load estimation method. The first of these is that the turbidity record is an accurate record of turbidity in the river and although there were various checks of the 'in situ' sensor against another instrument, it is fair to state that some of the record is likely to deviate from the true turbidity levels in the river. During low flows the affect of this on load estimates should be fairly inconsequential, however during high flows there are fewer checks on the sensor readings. Checks that were made did show the 'in situ' sensor to be accurate to within 15% during higher turbidity events.

Another common source of error in load estimates is the recording of flow in the river, and there is significant growth of aquatic weed at the gauging station which might have reduced the accuracy of ratings. However regular gaugings of the river during the period of the study were able to ensure that the flow record was within +/- 5% of the rating.

Bearing these assumptions in mind, Table 3.6 gives the estimated export load of suspended solids, TN and TP for the Brid River for the 15 months of turbidity record. Also included is the total monthly discharge volume for the river in megalitres (10^6 litres).

Table 3.6 Estimated monthly nutrient load, suspended solids load and discharge for the Brid River between October 1997 and December 1998.

MONTH	TSS Load (kg)	TP Load (kg)	TN Load (kg)	Discharge (ML)
Oct-97	23,844	106	2,472	2,780
Nov-97	36,188	112	2,265	2,307
Dec-97	8,731	51	1,278	1,497
Jan-98	5,932	37	952	1,125
Feb-98	7,359	38	910	1,048
Mar-98	1,114	18	518	648
Apr-98	26,621	72	1,333	1,268
May-98	12,280	55	1,286	1,449
Jun-98	61,783	160	2,920	2,721
Jul-98	250,665	487	6,868	4,631
Aug-98	60,909	200	4,143	4,308
Sep-98	236,600	491	7,432	5,593
Oct-98	154,534	398	7,195	6,665
Nov-98	86,148	193	3,149	2,606
Dec-98	21,464	79	1,731	1,868
TOTALS	**994,172**	**2,497**	**44,452**	**40,514**

While the accuracy of these export load estimates is difficult to assess, they do provide a reasonably accurate estimation of the nutrients being exported from the catchment. To compare this level of nutrient and sediment loss with other catchments, the export figures need to be corrected for catchment area and discharge (ie catchment runoff). The derivation of these 'export coefficients' allow catchments of different sizes and rainfall patterns to be compared (see 'Glossary of Terms' at the front of this document). The export coefficients for the Brid catchment derived from the data from this study are given in Table 3.7.

TABLE 3.7 Export coefficients for the Brid River derived from data collected during the period January to December '98.

Catchment	Discharge (ML)	Suspended Solids (kg/mm/km^{-2})	Total P (kg/mm/km^{-2})	Total N (kg/mm/km^{-2})
Brid River	33,930	27.27	0.066	1.13

\# Brid River catchment area = 136 km^{-2}.

These coefficients can be compared to others which have been calculated for rivers elsewhere in Tasmania (Bobbi *et al.*, 1996) (Bobbi, 1998). Some of the figures in Table 3.8 are averages calculated over several years, while others were calculated from a single years worth of data. This is important to keep in mind when looking at export coefficients, as the amount of rainfall in a catchment will determine the amount of nutrient exported, and hence the export coefficient for that catchment. If export coefficients are calculated from data collected during a period with 'below average' rainfall, they can underestimate the level of export, and vice versa for wetter years. It is therefore worth noting that the total discharge from the Brid River catchment during the period of this study was slightly below average (about 34,00 ML compared with the annual average of about 41,000 ML).

TABLE 3.8 Export coefficients for other catchments in Tasmania. In some cases data are averages calculated over several years. For others coefficients are estimated from only a single year of data.

Catchment	Years of Data	Catchment Area (km^2)	Mean Annual Discharge (ML)	Total P ($kg/mm/km^{-2}$)	Total N ($kg/mm/km^{-2}$)
Brid River	1	136	40,986	0.066	1.13
Meander River at Strath Bridge	3	1,012	427,904	0.058	0.67
Liffey River	3	224	80,661	0.052	0.78
South Esk at Perth	3	3,280	624,508	0.034	0.66
Break O'Day River	3	240	53,177	0.065	0.94
Huon River above Judbury	1	2,097	2,562,475	0.010	0.33
Kermandie River	1	130	36,760*	0.122	1.42

* Estimated flow data

When compared to figures from other catchments in Tasmania, the Brid River export coefficients for both phosphorus and nitrogen are near the upper end of those for other agricultural catchments in Tasmania. This appears to be more so for TN than for TP. It should also be noted that for the Kermandie River, export figures include nutrients discharged to the river from the Geeveston sewage treatment plant.

3.5 Diurnal Water Quality Variations

Remote unattended monitoring equipment was deployed during May and June to record the diurnal changes in some selected water quality parameters, most notably dissolved oxygen. It is well known that various water quality characteristics change on a 24 hour cycle (diurnal) and it is possible that parameters which appear to be within acceptable limits during daylight hours may well be of concern after sunset. Where rivers are receiving organic pollution or nutrient enrichment which 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 invertebrates and fish life. Streams in New Zealand which have depleted oxygen levels have been shown to be linked to elevated nutrients and organic loads (Wilcock *et al.*, 1995).

During this study equipment was deployed in the Brid River at Duncraggen Rd, and was programmed to record dissolved oxygen, pH, water temperature, conductivity and river level at half-hourly intervals. The data loggers were deployed for between 36-48 hours on May 18 and June 16, 1998. During the May deployment, flows in the river were very similar to the preceding summer (ie quite low), while the June deployment was done two days after a moderate rain event. The differences in flow between these two periods is reflected in the pattern of change shown in the following plots.

The variation in pH during the May deployment (shown in Figure 3.30 below) is typical of what occurs during normal river behaviour. Instream pH peaks in early afternoon when algal photosynthesis is most active. The effects of photosynthetic activity on dissolved oxygen levels are seen clearly in Figure 3.31, with peak oxygen levels coinciding with peak pH levels. Both pH and dissolved oxygen decrease during the hours of darkness, with lowest levels occurring just before dawn when both plant respiration and biochemical oxygen demand act to strip oxygen from the water column. This correlation between pH and oxygen levels is not unusual, as dissolved oxygen, along with carbon dioxide, is important influence on pH in water.

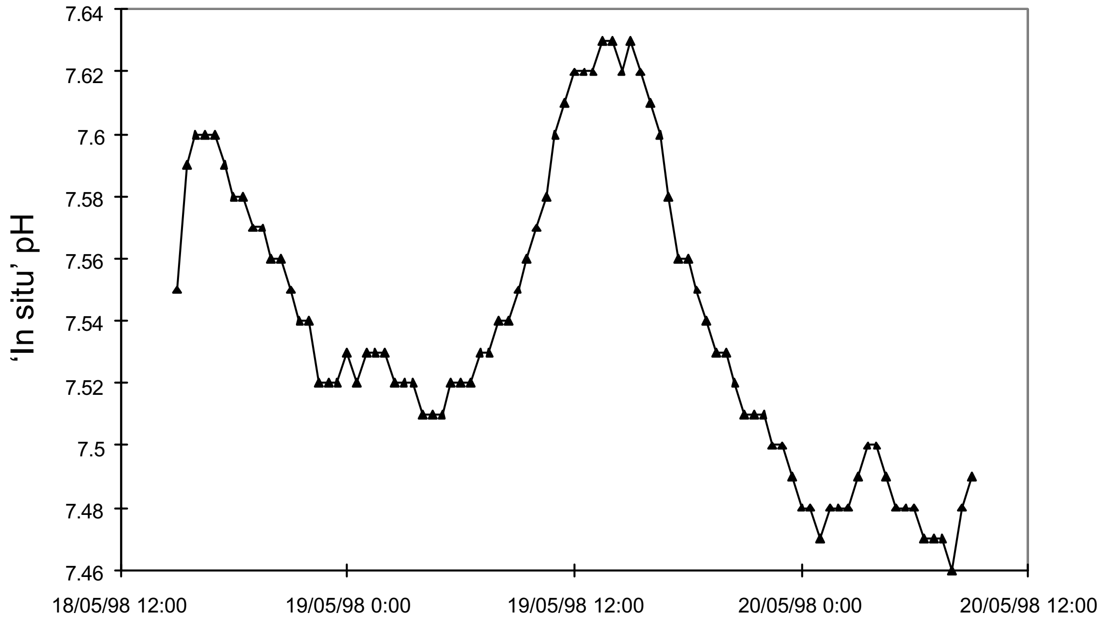


Figure 3.30 'In situ' pH changes in the Brid River at Duncraggen Rd between 18th - 20th May, 1998. River level was stable during the entire period.

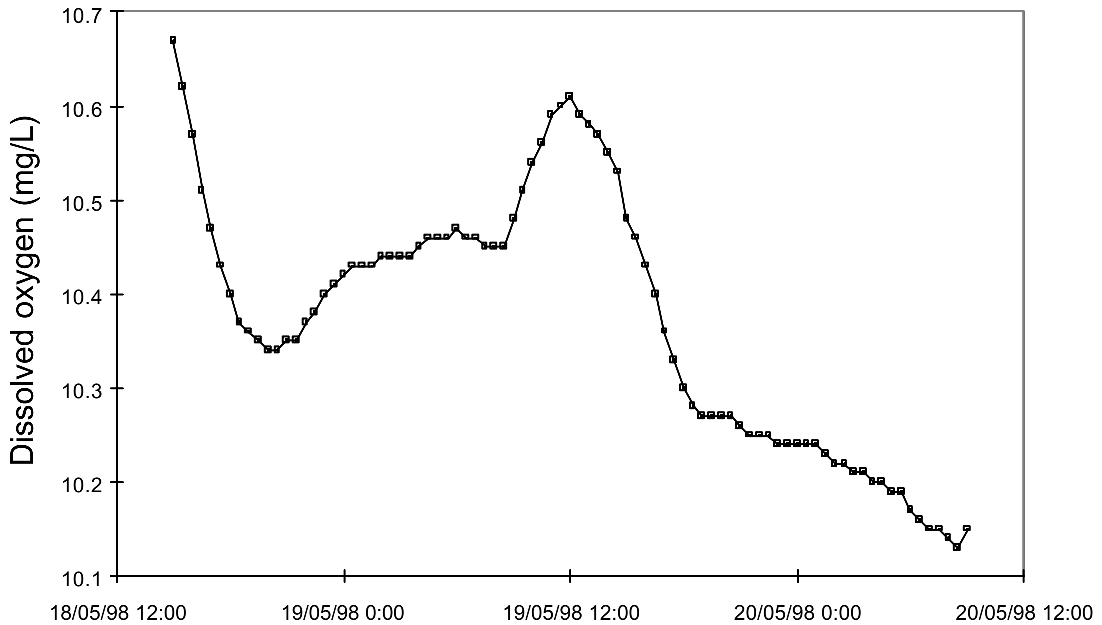


Figure 3.31 Diurnal changes in dissolved oxygen in the Brid River at Duncraggen Rd between 18th - 20th May, 1998. River level was stable during the entire period.

During the June deployment of the data loggers, both pH and dissolved oxygen did not display the same pattern of variation as was found in May. Both variables showed a relatively steady increase during the 40 hour period over which monitoring occurred (Figures 3.32 and 3.33). The remnant of some diurnal pattern is still evident in both plots, but is not as dominant as was found in the May deployment.

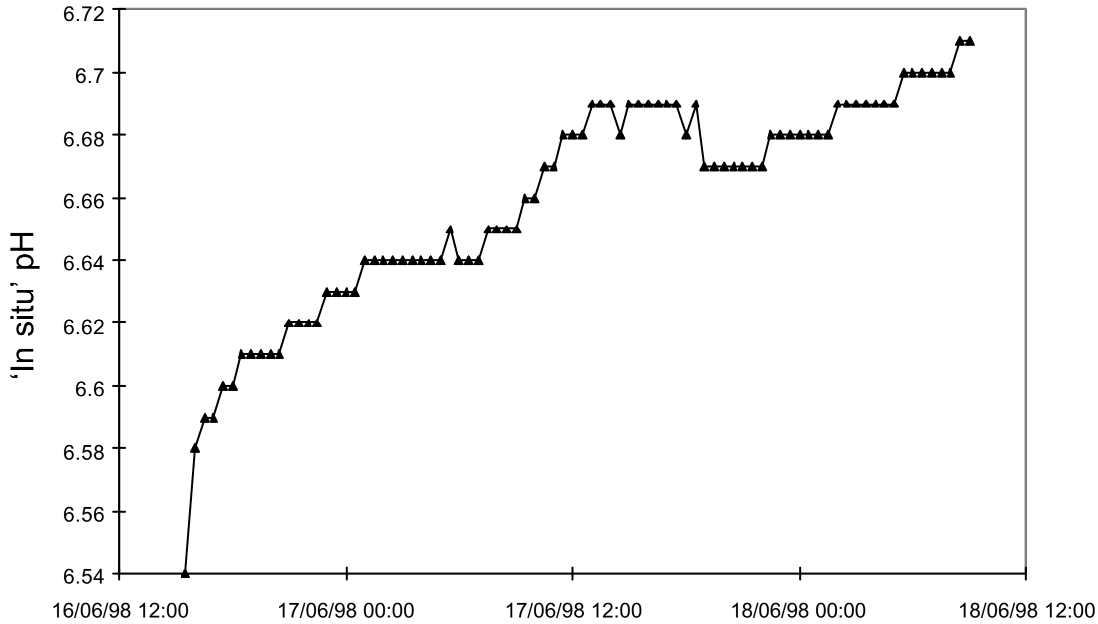


Figure 3.32 'In situ' pH changes in the Brid River at Duncraggen Rd between 16th - 18th June, 1998. River level during the period decreased by 100 mm during the period of monitoring.

The other major difference between the results of the May and June deployments is that pH was significantly lower during June (range 6.54 to 6.71). This is most likely a reflection of the influence of dilute runoff from the rainfall which fell prior to the deployment and which would have caused low pH values earlier in the monitoring period. In line with healthier stream flows in June, dissolved oxygen levels were also higher than were recorded during the May deployment.

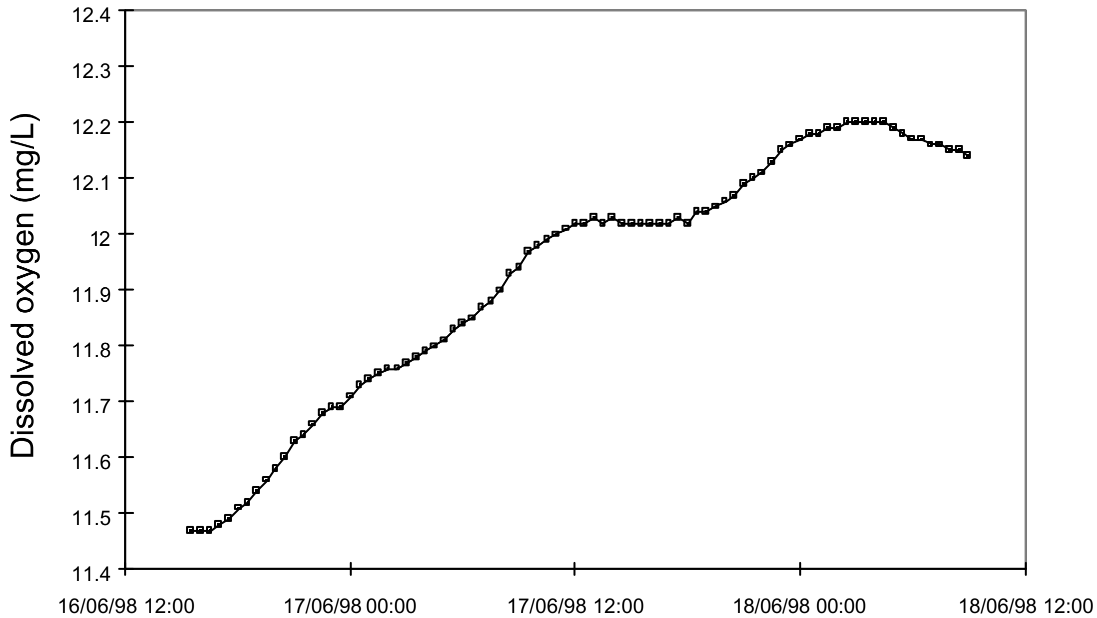


Figure 3.33 Diurnal changes in dissolved oxygen in the Brid River at Duncraggen Rd between 16th - 18th June, 1998. River level during the period decreased by 100 mm during the period of monitoring.

A comparison of conductivity data recorded during both deployments is made in Figure 3.34. From the graph it is clear to see that during June the conductivity of the river was less, but like both dissolved oxygen and pH, was increasing during the period of monitoring as river flow returned to baseflow conditions. The slight variations in conductivity which occurred during both deployments indicates the passage of slightly more dilute water down the river rather than any diurnal change.

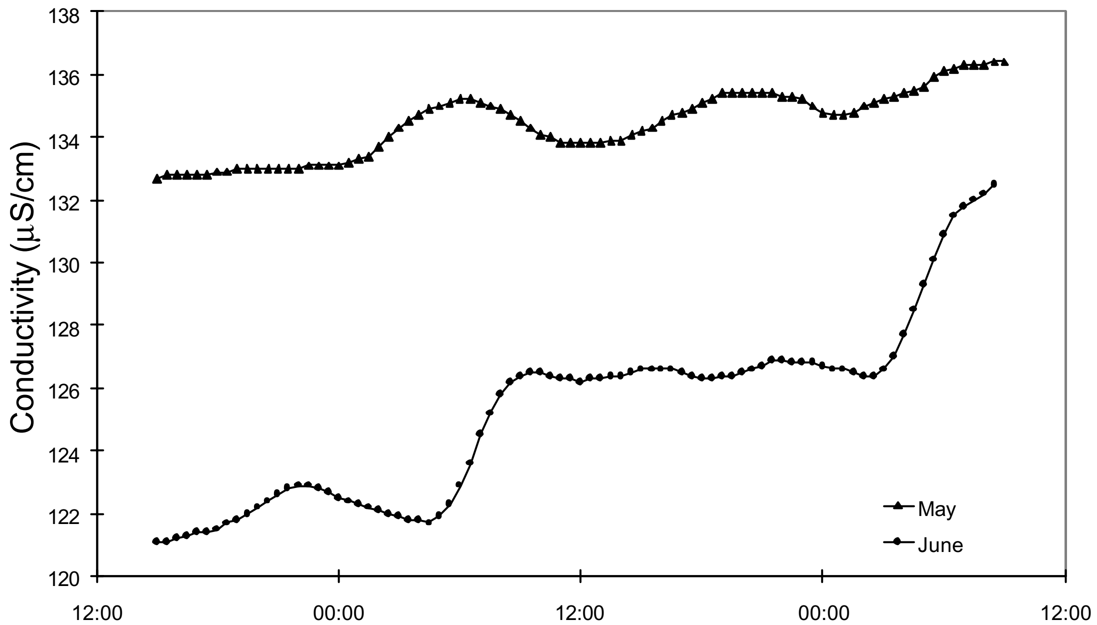


Figure 3.34 Conductivity measured in the Brid River at Duncraggen Rd during two data-logging deployments in 1998.

The data collected during both deployments of the data-logging equipment showed some of the variations in water quality which occur during normal river behaviour. Dissolved oxygen levels during both periods was indicative of a healthy system, however similar such deployments should occur during summer periods when lower flows and higher temperatures may cause some stress on the river. Due to other commitments, the equipment used in this study was not available for use during the summer period.

3.6 Summary and Comments

The data presented and discussed in this report has shown that water in the Brid River is turbid and carries a substantial sediment and nutrient load. Some of the individual parameters characterising the overall water quality have indicated that there is a noticeable impact on water quality high in the catchment. Snapshot surveys also show that for some of these parameters there is an improvement as water passes through the area of State forest in the middle and lower catchment. It was thought that intensive land use and a lack of protective riparian vegetation are probably the main reasons for poorer water quality in the upper catchment and these data should be viewed together with the data on stream condition presented in a separate report.

While further monitoring at sites in the upper catchment may help to identify the source of nutrient inflow to the river, it is relatively clear from the data in this report that impacts on water quality revolve around management of runoff from intensively farmed land and a lack of riparian buffering in the upper catchment. While it is recognised that this part of the catchment may contain the most fertile and productive land, effort to minimise loss of this through erosion and implementation of better riparian management practices could be a positive step towards improving the water quality of the Brid River and its tributaries. The presence of a good riparian strip along both sides of rivers and streams in the catchment will ensure more productive soil is retained on the land and less nutrients will be transported to the river during rain events.

The retention of soil and nutrients on the land will also reduce the impact of both these factors on the estuary and coast at Bridport, where the river meets the coast. Reducing the amount of sediment entering the estuary at Bridport will provide at least two obvious benefits. The first of these is decreased silting of the estuary, which is also used as commercial and recreational fishing port. The other benefit is to the environmental functioning of the estuary. Reducing the levels of nutrients and sediment being deposited in the lagoon will reduce the possibility of algal blooms and fouling in the lagoon. Eutrophication of coastal lagoons in other parts of Australia has been a significant source of both public and environmental concern (ie National State of Environment Report) and activities which can prevent it occurring are worthy of attention.

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