DEPARTMENT *of*
PRIMARY INDUSTRY
and FISHERIES

Tasmania

Water Quality Of Rivers In The Huon Catchment

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Executive Summary

A study of the water quality of rivers in the Huon catchment was undertaken by the Tasmanian Department of Primary Industry and Fisheries between October 1996 and November 1997. The study was carried out as part of a commitment to the Huon Valley Council's '*Healthy Rivers and Catchments*' project and a study by the CSIRO of the Huon estuary. This work also forms part of an ongoing commitment by the DPIF to gather and disseminate information about the condition and quality of waterways around the State and will also contribute to the production of future Tasmanian 'State of Environment' reports.

Data was collected on a monthly basis at five sites in the lower catchment to determine the average conditions of key rivers. The main results were;

- Agnes Rivulet at Cygnet was the most degraded waterway and had the highest concentrations of dissolved salts, nutrients and the highest turbidity levels.
- High concentrations of some nutrients in the Kermandie River appeared to be largely caused by the discharge of nutrient rich effluent from the Geeveston sewage treatment plant.
- The best water quality was found in the Huon River at Judbury.

Nutrient export loads were calculated for the Huon catchment upstream of Judbury and the Kermandie catchment. The estimated export load from the upper Huon catchment during the 16 month period from June 1996 to October 1997, was more than 38 tonnes of phosphorus and 1,355 tonnes of nitrogen. Between November 1996 and October 1997, more than 6 tonnes of phosphorus and 71 tonnes of nitrogen were estimated to have been exported from the Kermandie catchment.

Snapshot surveys of the whole of the Huon catchment pinpointed areas where water quality deterioration is occurring relative to the rest of the catchment. It was shown that sites located in the lower part of the catchment are most impacted, with faecal pollution most severe at sites near population centres. The surveys highlighted Golden Valley Creek and Supplices Creek in Cygnet, Scotts Rivulet and the lower Kermandie River in Geeveston, Prices Creek at Franklin, Dover Rivulet and Fourteen Turn Creek at Grove as streams which have high concentrations of nutrients or faecal coliforms.

The findings of this report should assist catchment managers in targeting remedial activities in the catchment and provide a base from which positive improvements can be made. The nutrient load estimates will also provide valuable input into the estuarine models being developed by the CSIRO to determine factors which induce algal blooms in the estuary .

1.0 Introduction

In 1994 the Huon Valley Council adopted a Sustainable Development Strategy for the Huon region. As part of that strategy, the *Huon Healthy Rivers Project* (HHRP) carried out a review of existing data on the water quality of rivers in the region (Gallagher, 1995). It found that although a considerable amount of data exists on water quality in various parts of the catchment, there were problems of data consistency and validation. One of the conclusions of the report was a proposal for a comprehensive water monitoring program at 13 sites in the Huon region (Refer Figure 18 in that report).

2.0 Study Outline

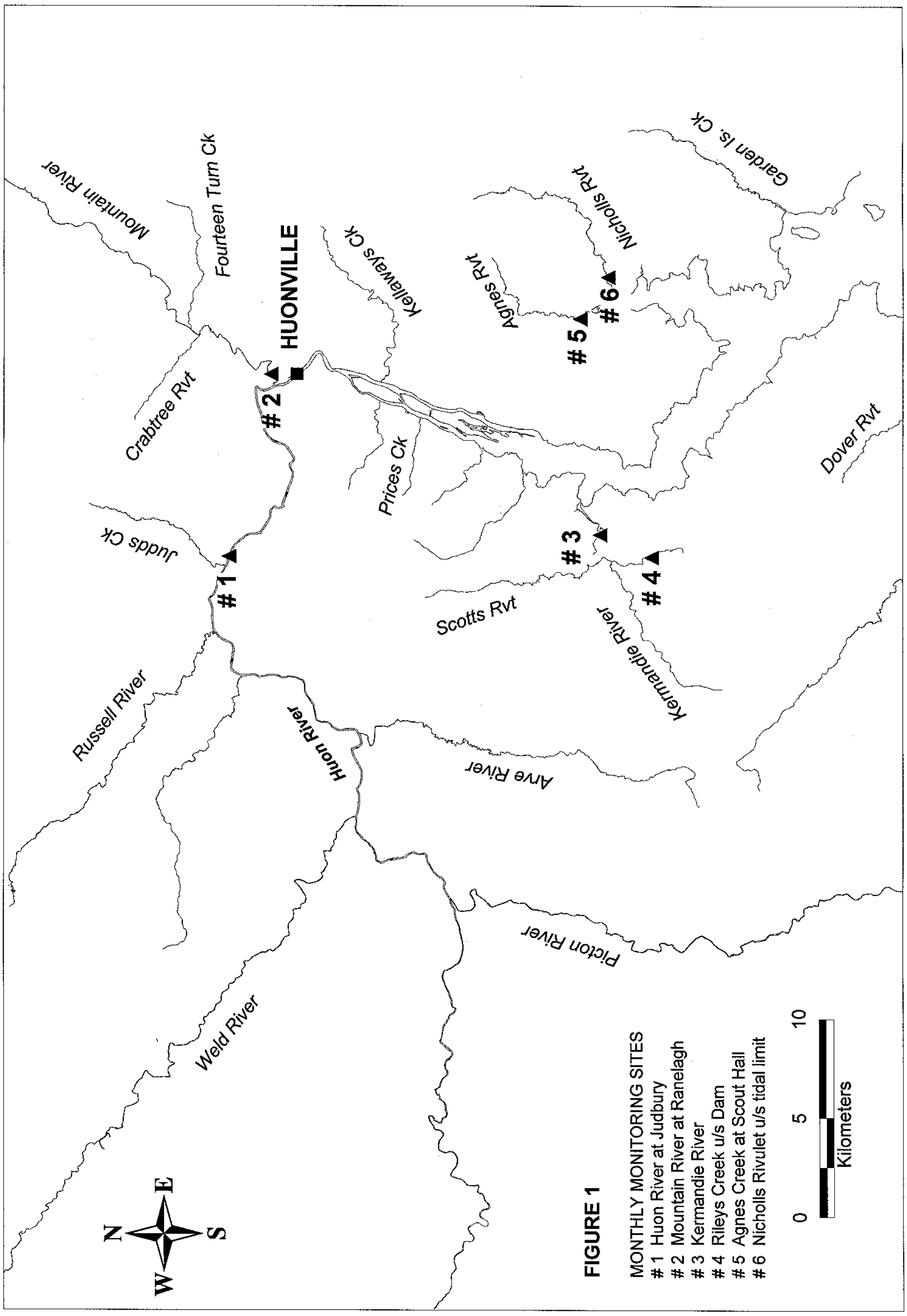
Following an unsuccessful application for funding of the monitoring proposed by the HHRP, the Department of Primary Industry and Fisheries was able to provide some resources for a limited monitoring program, in addition to it's own commitment to longer term monitoring in the catchment. After discussions with the Project Manager of the HHRP (Ian Sansom) and a Principal Investigator of the CSIRO 'Huon Estuary Study' (Phil Morgan), it was decided that monthly monitoring at six key sites for 12 months should be carried out to estimate the average conditions of various key rivers. These are listed below;

Huon River at Judbury
Mountain River at Ranelagh
Kermandie River at Huon Highway (opposite the oval)
Rileys Creek upstream of Rileys dam
Agnes Rivulet at Cygnet (next to the Scout Hall)
Nicholls Rivulet upstream of the Tidal Limit

and their geographical locations shown in Figure 1.

Five of these sites were suggested in the original HHRP data review (Gallagher, 1995). At all sites except Rileys Creek, monthly nutrient and physico-chemical sampling was performed. Further sampling of general ions was carried out on a quarterly basis to establish the ionic character of these rivers. At Rileys Creek upstream of Rileys dam, measurements of physical parameters were made during visits to this site for stream-flow data collection.

Additional sampling for nutrients during four high flow events was carried out in the Huon and Kermandie rivers to provide extra data for estimation of nutrient export loads into the estuary by these two rivers. To aid in this program, the stream flow station at Rileys Creek was also temporarily re-opened.The existing 'in situ' turbidity sensor in the Huon River at Judbury and the stream flow station in the Huon River upstream of Fryingpan Creek, both of which are currently part of the Statewide monitoring system managed by the DPIF, were also seen as beneficial for this part of the study. Estimates of nutrient loads to the Huon estuary were considered a priority for input to the estuarine model being constructed by the CSIRO study.


Mountain River
Fourteen Turn Ck
HUONVILLE
Kellaways Ck
Agnes Rvt
Nicholls Rvt
Garden Is. Ck
Crabtree Rvt
2
Prices Ck
Dover Rvt
Judds Ck
1
3
4
5
6
Scotts Rvt
Kermandie River
Russell River
Huon River
Arve River
Picton River
Weld River
N
E
S
W
FIGURE 1
MONTHLY MONITORING SITES
1 Huon River at Judbury
2 Mountain River at Ranelagh
3 Kermandie River
4 Rileys Creek u/s Dam
5 Agnes Creek at Scout Hall
6 Nicholls Rivulet u/s tidal limit
0
5
10
Kilometers

The other major activities which were proposed were catchment surveys to cover a range of sites across most of the catchment. Two surveys covering 49 sites (locations shown in Figure 2) were proposed and the objective was to obtain a 'snapshot' of water quality across the catchment during low summer flows and winter base flows. It was hoped that this would provide some indication of areas where poorer water quality occurred relative to the rest of the catchment and assist in the identification of areas where remedial action might be needed to correct degradation. Nutrient samples and physical measurements were to be taken during this program.

Monitoring was started at the baseline stations in October, 1996 and completed in November, 1997. The summer catchment survey was carried out between 6-9 January, 1997 and the winter survey was carried out 2-4 June, 1997. Both were performed during stable hydrological conditions to avoid discrepancies due to rainfall variation. This technique has been used before in Tasmania (Bobbi, *et al.*, 1996) and elsewhere in Australia (Grayson *et al.,*1997) to gain rapid information on water quality on a catchment scale. Weather conditions were fairly dry during much of the study, with flows during the winter survey being very similar to those which existed when the summer survey was carried out.

The following sections report on the data collected during this study. It starts with a presentation of data from the monthly monitoring sites and follows with a discussion of how export loads for the upper Huon River and the Kermandie River were calculated, and a discussion of the results. The final section deals with the data collected during the 'snapshot' catchment surveys and includes a discussion of the highlights of this data.

3.0 Routine Monitoring

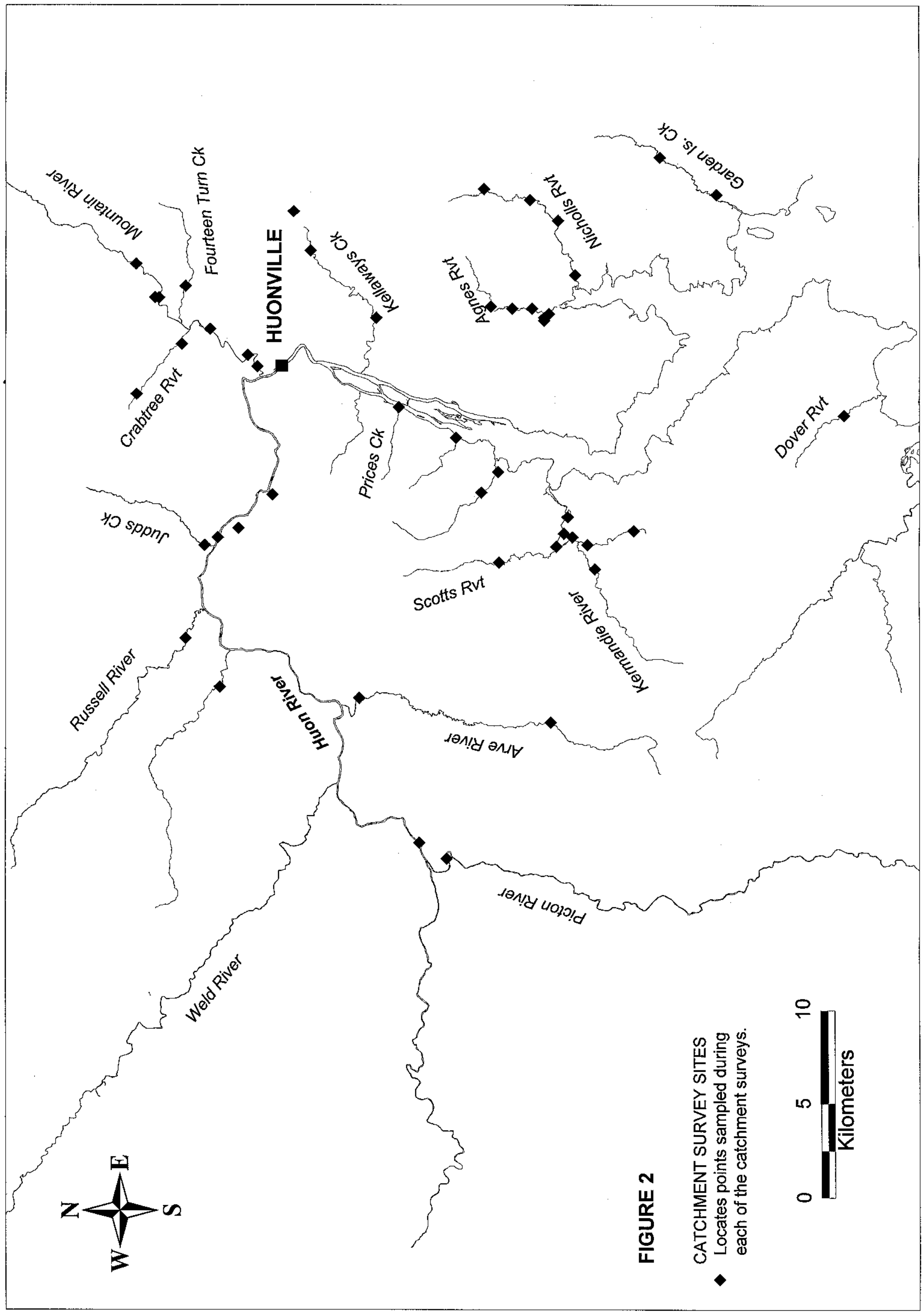
In the following pages, the monthly monitoring data is presented graphically using 'box and whisker' plots. These plots are an easy means of presenting the statistics of data collected at each of the monitoring sites. The boxed areas encompass the central 50% of the data and the whiskers extend outside the boxes to show the spread of the data, not including extreme values (ie outliers). Within each box, a horizontal line marks the median (or middle) value of the dataset. The median is more representative of the 'average' than the mean as water quality data is often skewed.

The data for these plots was usually collected between the times of 09:30 and 14:00 hours. This means that for parameters such as temperature and dissolved oxygen, which have a definite diurnal pattern of variation, data only represents daytime conditions. Most chemical parameters are normally not affected by diurnal processes and therefore can be considered as representative of normal baseflow conditions.

3.1 Physical Parameters

3.1.1 Temperature

Water temperature was recorded monthly at all six of the monthly monitoring sites and broadly shows the seasonal change in temperature through the year. Although skewed by the difference in time of collection, the box and whisker plot (Figure 3)


HUONVILLE
Mountain River
Fourteen Turn Ck
Kellaways Ck
Agnes Rvt
Nicholls Rvt
Garden Is. Ck
Crabtree Rvt
Prices Ck
Dover Rvt
Judds Ck
Scotts Rvt
Kermandie River
Russell River
Huon River
Arve River
Picton River
Weld River
N
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CATCHMENT SURVEY SITES
Locates points sampled during each of the catchment surveys.
0
5
10
Kilometers
FIGURE 2

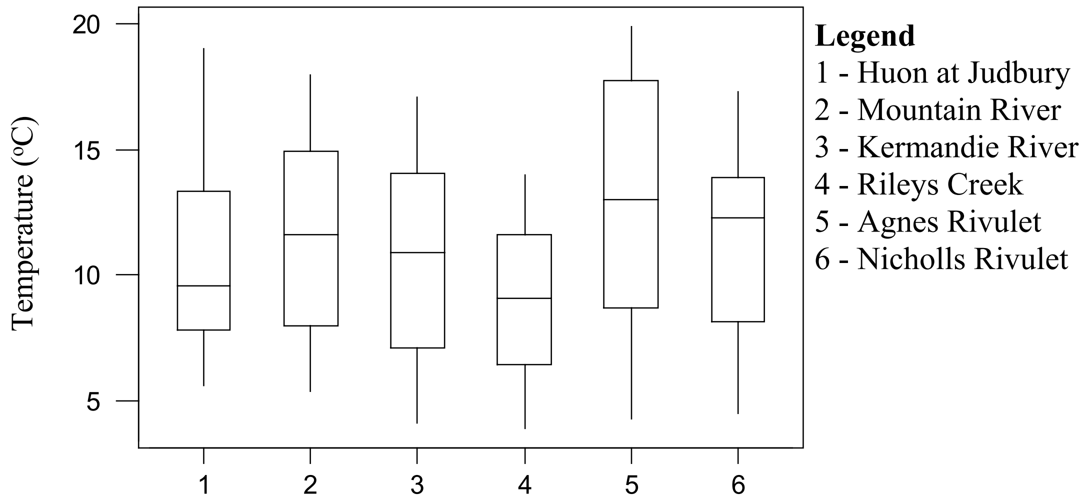

Figure 3 Statistics of monthly temperature readings at monitoring sites.

shows that the site at Rileys Creek and the Huon at Judbury have loweest median temperatures. The upper reaches of Rileys Creek are heavily shaded by wooly tea-tree and the Huon River descends from higher altitude terrain, both of which act to maintain lower water temperature. Agnes Rivulet has both the highest median temperature and the widest range. This is most probably a consequence of the lack of streamside vegetation down most of the length of this creek (following willow clearing) and the increased incidence of sunlight on the rivulet.

The seasonal variation in water temperature at three of the monitoring sites is shown in Figure 4. Water temperature in all three rivers is lowest between May and August and warmest in January and February, although a peak at all sites occurred during a particularly warm period in early November, 1996.

The Huon River is representative of temperature variation in larger rivers and the Kermandie River and Agnes Rivulet of smaller tributaries in the catchment. The trace for the Huon River clearly shows that this river is less variable, changing more evenly as would be expected for a large river with more thermal stability. The lower thermal stability of smaller rivers means that they are influenced more by short term fluctuations in air temperature (ie local climatic conditions).

3.1.2 Conductivity

Conductivity in water is a measure of the amount of dissolved salts in the water, and hence its salinity. During dry periods, when flow in the rivers is sustained mainly by groundwater inputs, conductivity generally reflects groundwater salinity levels. In high flows after rain, conductivity is more indicative of dissolved material in runoff and surface drainage.

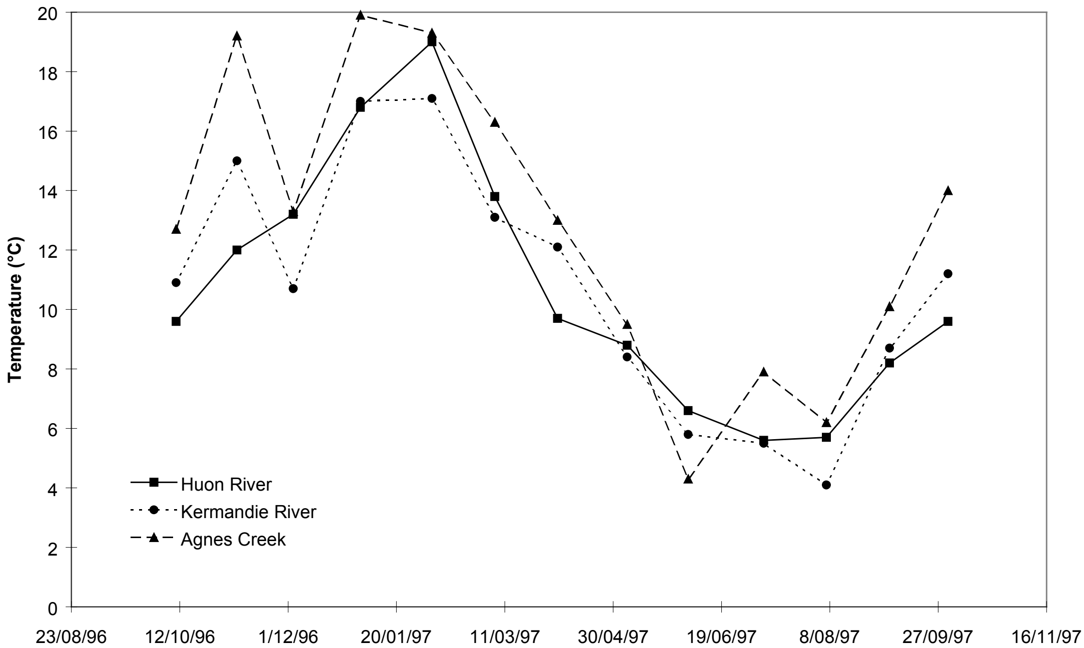

Figure 4 The seasonal change in water temperature in the Huon and Kermandie rivers and Rileys Creek.

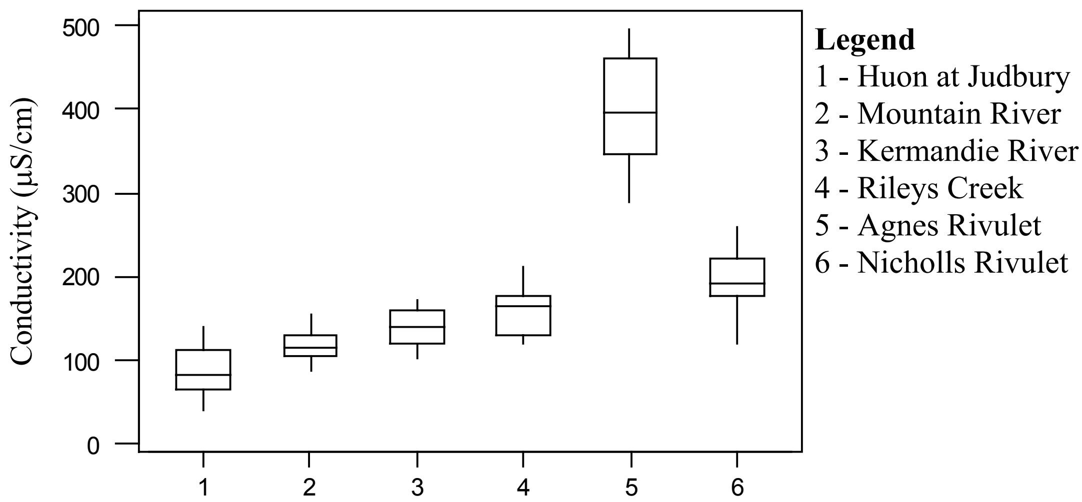

Figure 5 Statistics of monthly conductivity readings at monitoring sites.

In the Huon catchment, river water is generally very dilute in dissolved salts (Figure 5), with most rivers having median conductivity levels below 200µS/cm. The exception to this is Agnes Rivulet, which has a median conductivity of almost 400 µS/cm. The National Guidelines (ANZECC, 1992) state that conductivity levels in fresh should not be permitted to increase above 1,500µS/cm, and compared to this standard all six rivers are moderate to very dilute.

In terms of irrigation use (ANZECC, 1992), Agnes Rivulet is classed as having medium salinity levels, which means that there may be some decrease in production levels from plants with low salt tolerance, especially if there is limited soil drainage.

There is no distinct seasonal pattern to changes in conductivity levels (Figure 6), reflecting the relatively dry period during which the study was carried out. In normal winters, when rainfall contributes more to river flows, lower conductivity should occur. This was not observed during this study. All plots clearly show the impact the heavy rains in late March, 1997 had in lowering conductivity levels in rivers of the catchment.

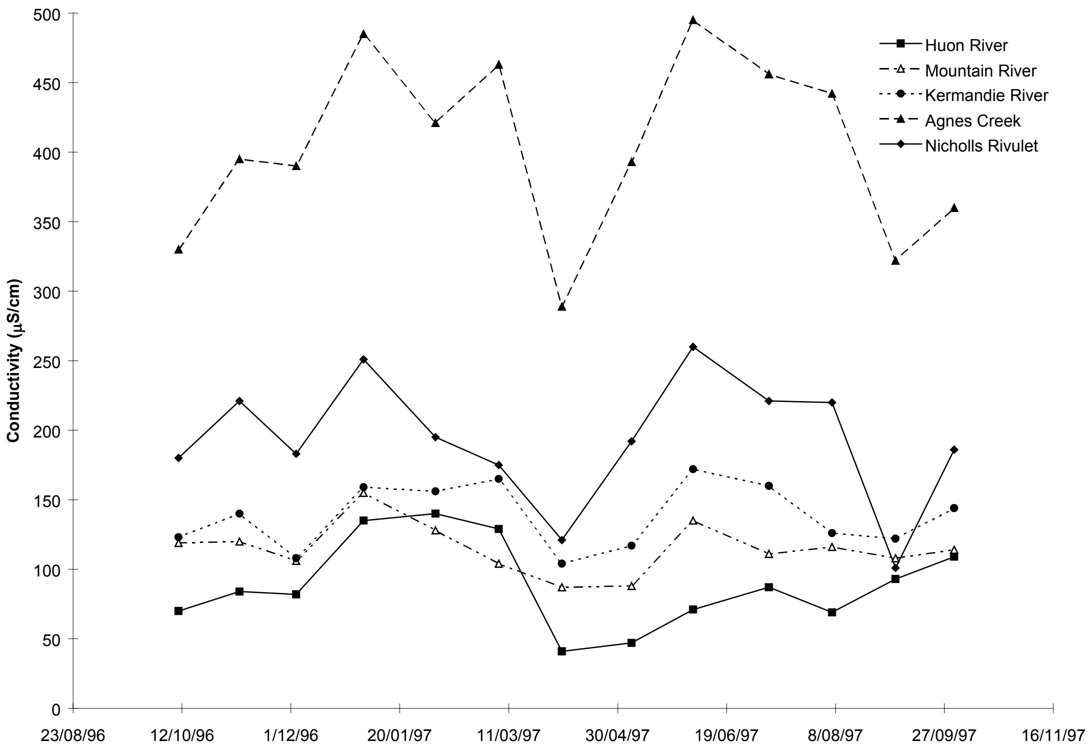

Figure 6 Seasonal variation of conductivity at monitoring sites in the Huon catchment.

3.1.3 Dissolved Oxygen

The level of dissolved oxygen (DO) in rivers is important from an environmental perspective. It has a significant impact on what types of aquatic animals live in the river, as some species require more oxygen to survive than others. The ANZECC (1992) guidelines state that to maintain aquatic health, DO concentrations should not fall below 6 mg/L and that where possible DO should be measured at night when lowest levels occur. In this study only daytime readings were taken.

Dissolved oxygen concentrations at all sites were indicative of healthy systems (Figure 7) although Rileys Creek showed some potential for decreased levels at night. This site had the lowest recorded DO concentration (7.3 mg/L), recorded in mid-January, 1997 during low summer flows. The section of the stream where this site is

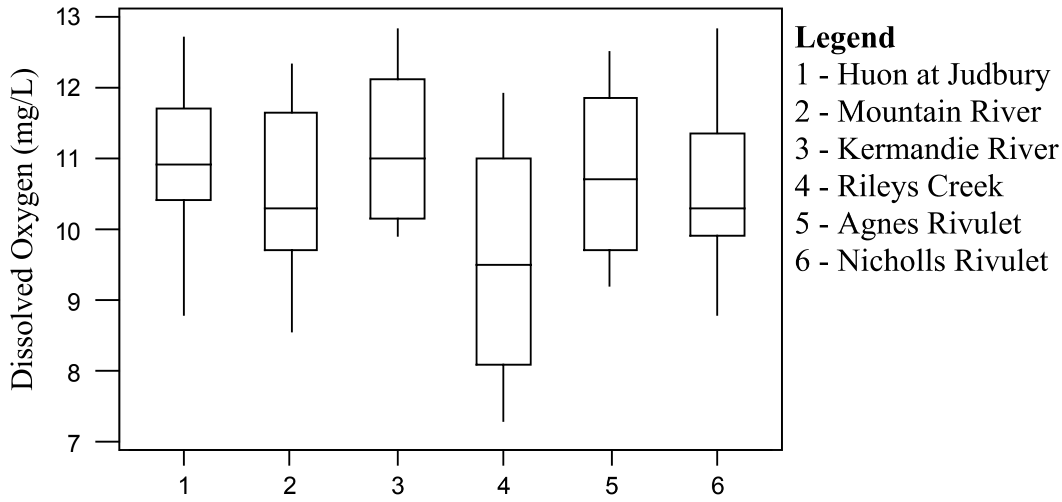

Figure 7 Statistics of monthly dissolved oxygen concentrations at monitoring sites.

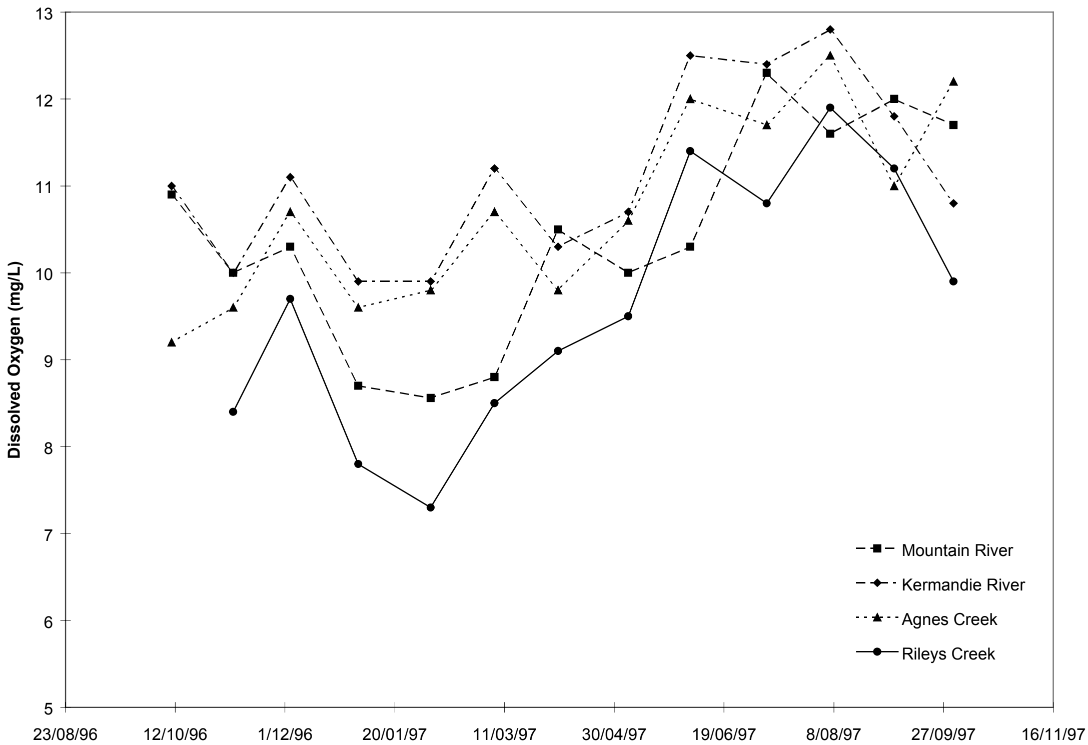

Figure 8 Monthly change in dissolved oxygen concentrations in four tributaries of the Huon River.

located is almost completely sheltered from sunlight and contains substantial silt and organic matter which, during decomposition, removes oxygen from the water.

The monthly change in DO at several rivers is shown in Figure 8. The pattern of change is uniform across all sites, with minimum levels occurring in January and February and maximum levels in July and August. This highlights the inverse relationship between water temperature and dissolved oxygen, with water of higher temperature normally carrying less oxygen than colder water (c.f. Figure 4). Lower flows, with their lower turbulence and re-oxygenation, further enhances this situation.

3.1.4 Turbidity

Turbidity is a measure of the capacity of light to pass through water and generally reflects the amount of suspended material in the water. High turbidity values indicate higher levels of suspended matter and reduced light penetration, while low values indicate clear water.

Turbidity levels at monitoring sites was variable and is shown in Figure 9. Lowest median turbidity occurred in the Huon River followed closely by Mountain River and Nicholls Rivulet. All three of these sites also showed little variability (as demonstrated by the whiskers).

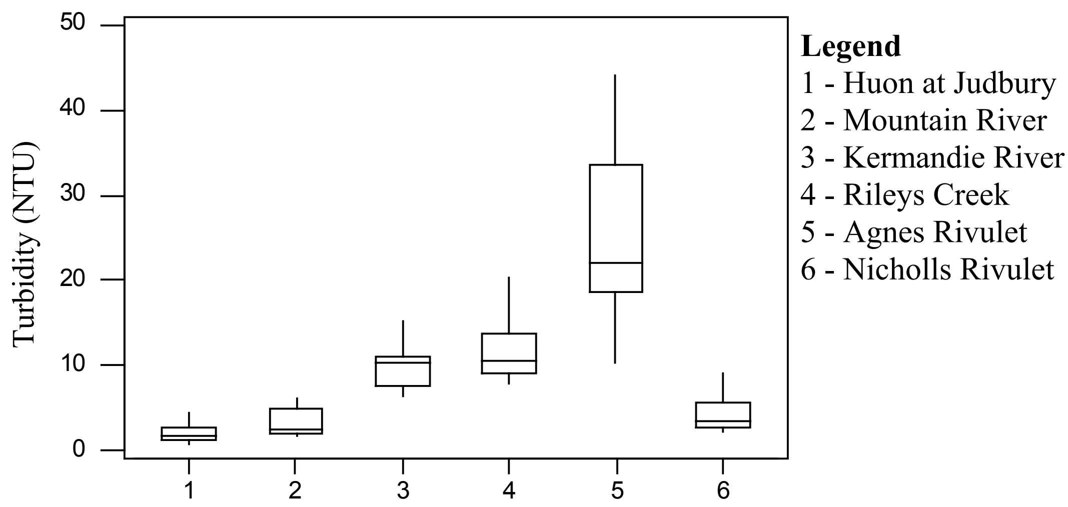

Figure 9 Statistics of monthly turbidity at monitoring sites.

The Kermandie River and Rileys Creek had similar turbidity levels (median of around 10 NTU) and Agnes Rivulet appeared to be most degraded with a median turbidity level of over 22 NTU, probably due to greater impact of land use practices in the area.

Upon closer examination of the monthly data at all sites it was apparent that there was no broad seasonal pattern of change. Plots from the 'in situ' turbidity sensor at Judbury will be presented in a later section.

3.1.5 Field pH

The pH of river water is best measured at the site, as storage in sample containers for any length of time will result in changes in pH values. Changes in the temperature of the sample can also alter pH readings. During the study temperature compensated hand held pH meters were used to measure pH on site.

The comparisons in the following plot (Figure 10) show the difference in temperature compensated pH between sites. The median pH of water at all sites was slightly alkaline (pH greater than 7). On most sampling occasions Rileys Creek was lower than all other sites. The lowest reading at this site was 6.45. Highest pH (8.04) occurred at Agnes Rivulet, which also had the highest median pH.

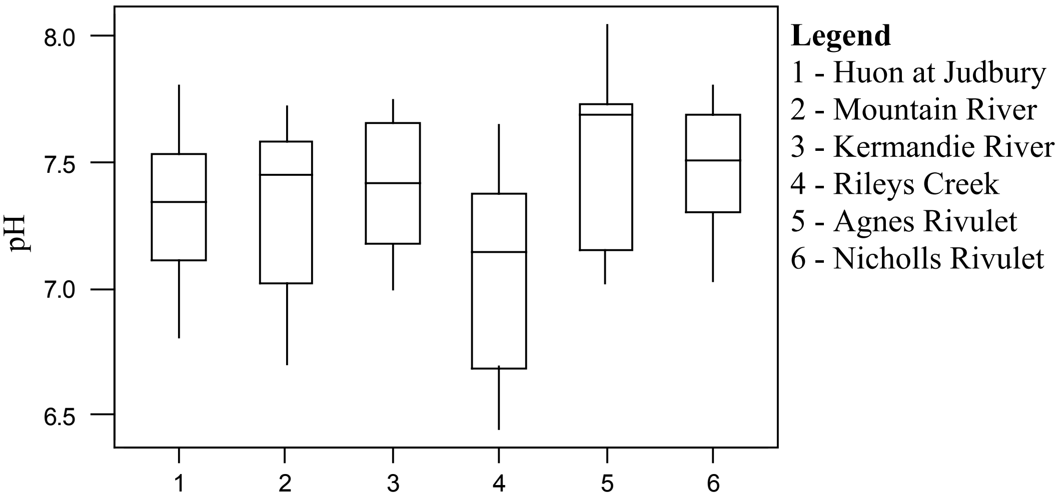

Figure 10 Statistics of monthly pH readings at monitoring sites.

3.2 Nutrients

Nutrient sampling was performed monthly at all monitoring sites except Rileys Creek (Site 4). Sample analysis included the following parameters; Ammonia-nitrogen (NH_3/N), Nitrate-nitrogen (NO_3/N), Nitrite-nitrogen (NO_2/N), Total Kjeldahl-nitrogen (TK/N), Dissolved Reactive phosphorus (DRP) and Total phosphorus (TP). Total nitrogen (TN) is derived through calculation ($TN = TK/N + NO_3/N + NO_2/N$). The following discussion will focus on only the major forms of nitrogen and phosphorus.

3.2.1 Ammonia Nitrogen

The measurement of NH_3/N in water samples is aimed at showing areas where nutrient enrichment occurs. The detection of higher than normal concentrations is usually indicative of organic pollution from piggeries, dairies and sewage treatment plants. Natural seasonal fluctuations in ammonia may also occur through the decay and decomposition of aquatic life, particularly phytoplankton and bacteria in organic rich waters (UNESCO, 1992).

In the Huon catchment, NH_3/N was generally found to be present at or near detection limits (Limit of detection = 0.005 mg/L) with the notable exception of the Kermandie River where the median NH_3/N concentration was 0.074 mg/L (Figure 11). This clearly demonstrates the effect on this stream of effluent from the Geeveston sewage treatment plant. Maximum concentrations were measured when flows in the river were insufficient to adequately dilute effluent entering the stream (0.29 mg/L). Although un-dissociated ammonia is toxic to aquatic life, this is usually only a very small component of the total ammonia at the pH level of this river (7.4). It is therefore considered that these concentrations pose little risk to the health of aquatic life in the lower Kermandie River. Ammonia is also non-persistent in the environment and is not a cumulative toxicant.

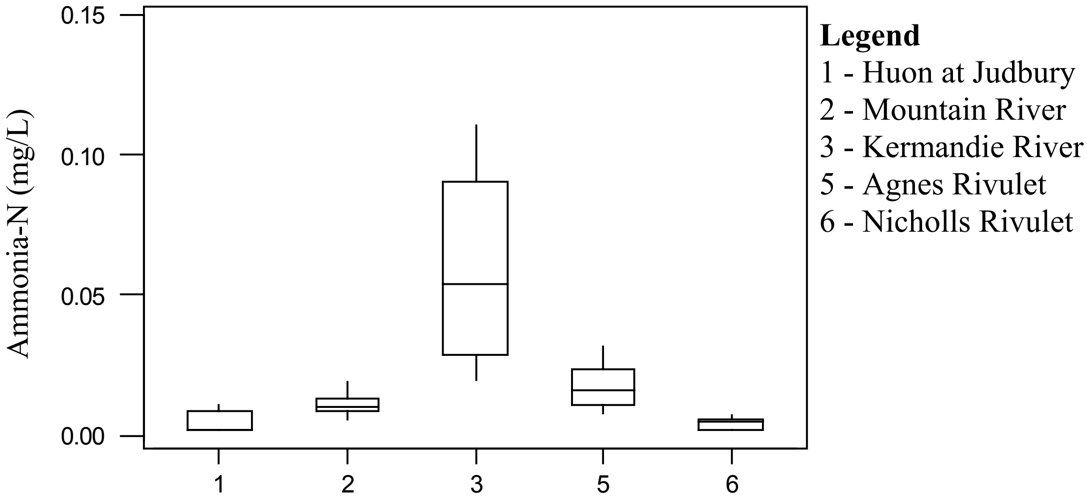

Figure 11 Statistics of monthly Ammonia-N (NH_3/N) concentrations at monitoring sites in the Huon catchment.

3.2.2 Nitrate Nitrogen

The nitrate form of nitrogen (NO_3/N) is generally only present in trace levels (less than 0.1 mg/L) in natural river systems (UNESCO, 1992). Elevated NO_3/N concentrations may be indicative of many things amongst which are industrial, municipal and domestic waste water, fertiliser application and land clearing (Stevens and Hornung, 1988).

Of the five sites monitored monthly in the Huon, two showed median NO_3/N concentrations above 0.1 mg/L (Figure 12). The site on the Kermandie River, which is downstream of the Geeveston sewage treatment plant shows some elevation in NO_3/N (median of 0.11 mg/L) while the median concentration in Agnes Rivulet is significantly higher (0.34 mg/L). The very high NO_3/N concentrations in Agnes Rivulet is most probably a result of both fertiliser application in the catchment (there is intensive horticulture alongside the river upstream) and leaching from septic tanks in and around the town (Cygnet has only recently been sewered). Furthermore, at both these sites the nitrite form of nitrogen was also found. This form is usually only detected (above 0.005 mg/L) when there is some industrial or domestic pollution entering the waterway.

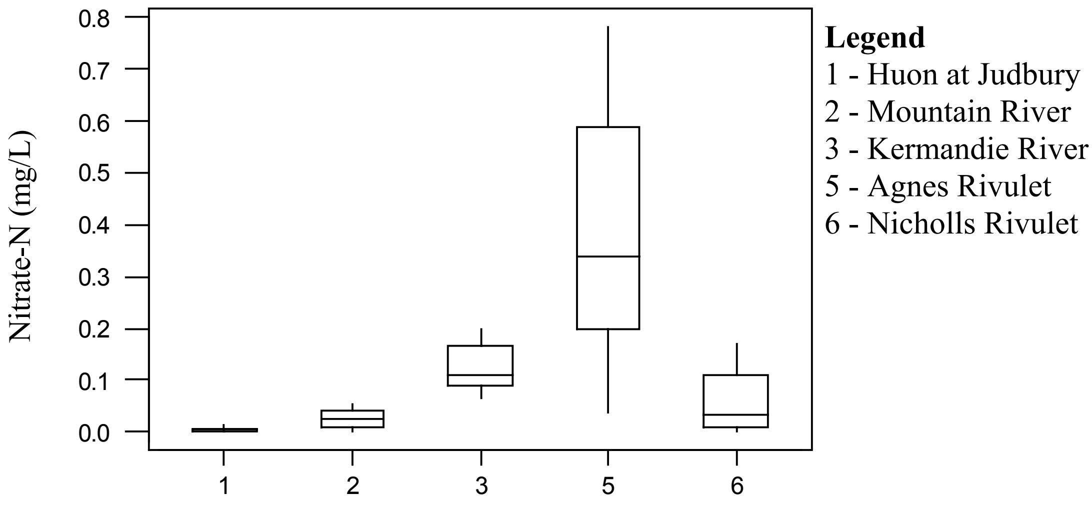

Figure 12 Statistics of monthly Nitrate-N (NO_3/N) concentrations at monitoring sites in the Huon catchment.

3.2.3 Total Nitrogen

Total nitrogen concentration in water is made up of several forms of nitrogen, the main contributors being the oxidised forms (nitrate and nitrite) and the organic forms and their components (proteins, peptides, urea, etc.). In most cases the forms of most interest are nitrate, nitrite, ammonia and organic nitrogen, all of which are the main components of the nitrogen cycle (APHA, 1992).

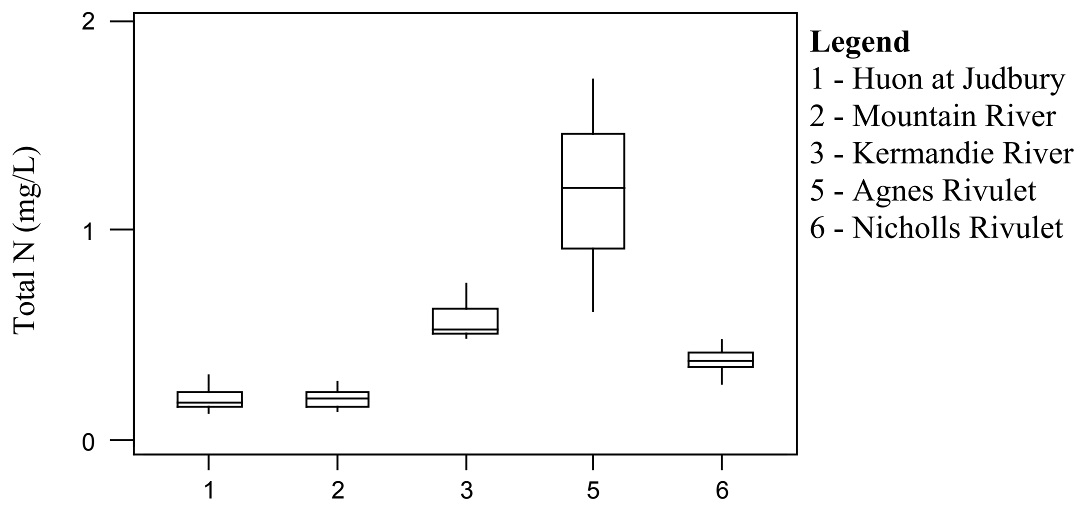

Figure 13 Statistics of monthly Total N concentrations at monitoring sites in the Huon catchment.

The ANZECC (1992) water quality guidelines do not set specific guidelines for freshwaters other than to state that ‘concentrations at or above which problems have been known to occur ... are: Total-N 0.1 - 0.75 mg/L'. The guidelines also state that limits should only be set after sites specific studies.

Of the five monitoring sites in the Huon, it is evident that Agnes Rivulet is most degraded, with a median TN concentration which is much higher than all other sites (Figure 13). The highest concentration recorded at this site was 1.71 mg/L. The only other rivers having slightly elevated TN concentrations are the Kermandie River (median of 0.53 mg/L) and Nicholls Rivulet (median of 0.38 mg/L).

Mountain River and the Huon at Judbury both showed the lowest TN concentrations (median TN concentrations of 0.20 mg/L and 0.19 mg/L respectively). In the Huon catchment, these rivers might therefore be used to set the standard or target level for TN concentrations in freshwaters.

3.2.4 Dissolved Phosphorus

The analysis of Total phosphorus (TP) includes all phosphorus both bound to particulate material and dissolved in the water. The dissolved fraction, measured as dissolved reactive phosphorus (DRP) is generally considered as free and available to aquatic plants and algae. In natural waters DRP normally makes up only a small fraction of TP. Higher concentrations of DRP are usually characteristic of areas where there is nutrient pollution of some kind (fertiliser run-off, sewage effluent discharge or septic leaching).

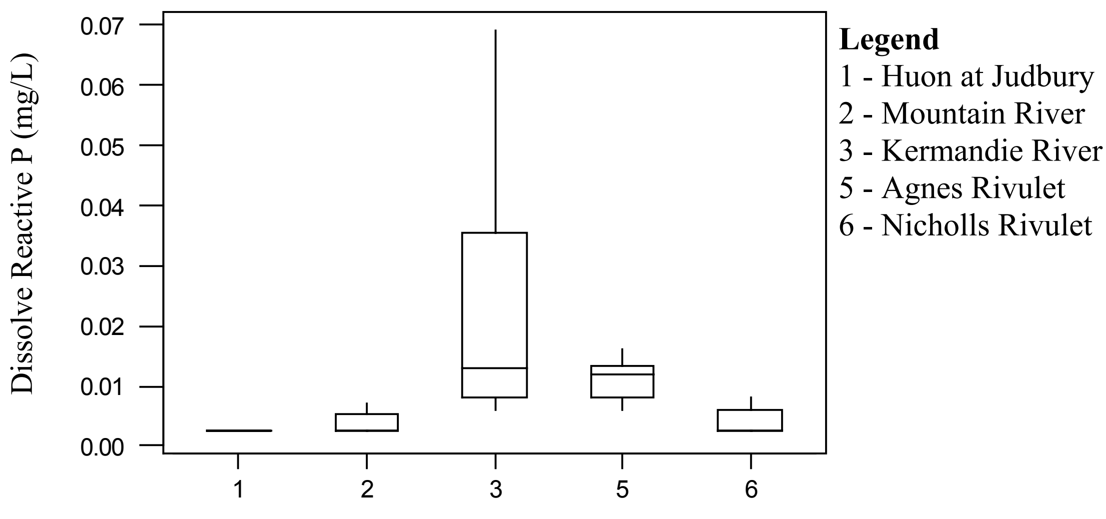

Figure 14 Statistics of monthly Dissolved Reactive phosphorus concentrations at monitoring sites in the Huon catchment.

Significant levels of DRP were found at two of the monitoring sites in the Huon (Figure 14). The median concentration at the Kermandie River was 0.013 mg/L with concentrations occasionally very high (0.069 mg/L), probably due to fluctuations in effluent output from the sewage treatment facility upstream. At Agnes Rivulet the median concentration of DRP was almost the same as in the Kermandie River (0.012 mg/L), though the range of concentrations was much less. At this site the proportion of DRP contributing to TP concentration was also much less (about 17%) compared to the Kermandie River (around 30%).

3.2.5 Total Phosphorus

Despite the high values of DRP found in the Kermandie River, it did not have highest TP concentrations (Figure 15). Agnes Rivulet, which was consistently more turbid, had the highest median TP concentration (0.07 mg/L). Turbidity is often a strong determinant of TP concentrations in water as phosphorus quickly attaches to particulate material if it is present. Water with higher turbidity often has most of its phosphorus bound up in this way, which explains why Agnes Rivulet had a lower proportion of DRP than the Kermandie River which is less turbid.

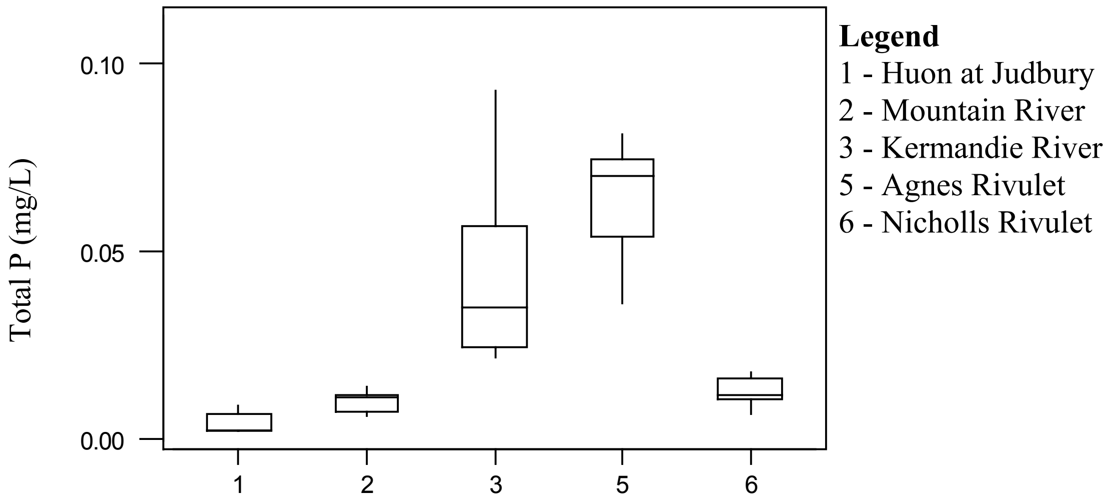

Figure 15 Statistics of monthly Total P concentrations at monitoring sites in the Huon catchment.

Total phosphorus concentrations at the three other monitoring sites were significantly lower than either Agnes Rivulet or the Kermandie River. The range of TP concentrations at each of these sites is also much smaller, indicating that any point sources which may be discharging into these rivers upstream of the sites are having relatively small impacts on stream TP levels. As stated for the TN results, TP concentrations in the Huon River, Mountain River and Nicholls Rivulet might be used to set target concentrations for other rivers in the catchment.

3.3 Quarterly Sampling of Ions

Sampling to examine the ionic character of water at each of the five monitoring sites was carried out every three months. In broad terms the conductivity of water is governed by its ionic content (its dissolved salts), which is generally a reflection of the geology and vegetation through which the river flows. In areas close to the sea, ocean aerosols will also have some effect on the ionic content of rivers. Human related activities may also impact on the amount and make-up of dissolved salts of rivers, though distinguishing these from more natural influences is difficult. The following sections present plots which show the variation in waters across the catchment.

3.3.1 Apparent Colour

The visible colour of water is essentially a reflection of the amount and type of dissolved and fine particulate material present. Natural occurring minerals such as iron hydroxides and complex organic compounds such as humic material give water what is called its 'true colour'. Apparent colour includes not only colour derived from these sources but also colour caused by fine suspended matter. It is measured in Hazen units.

Natural waters can vary from <5 Hazen units in clear mountain streams, to over 300 in dark, peaty water. Rivers in the Huon vary widely in colour, from moderately dark in the Huon and Kermandie rivers, to quite clear in Mountain River (median of 40 Hazen units).

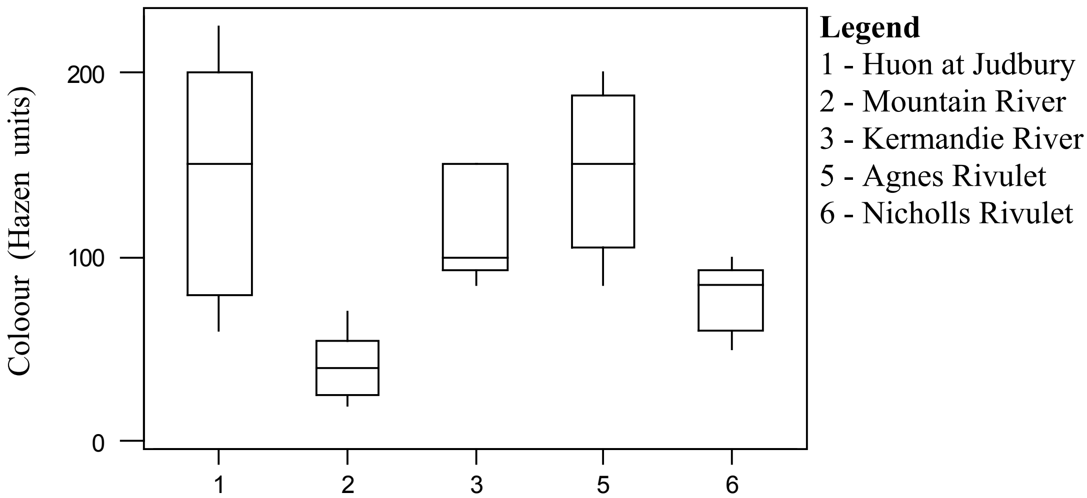

Figure 16 Variation in colour (in Hazen Units) at monitoring sites.

3.3.2 Ionic Constituents

The rivers flowing into the Huon estuary are generally dilute, with low levels of dissolved salts. Of the tributaries sampled during this study, Agnes Rivulet showed the highest level of all dissolved ionic components (Figures 17 to 20). Calcium, sulphate and chloride concentrations at Agnes Rivulet were all found to be substantially higher than in any other river, explaining the higher conductivity of this site (Figure 5). Nevertheless, concentrations at all sites were well below the freshwater environmental and water use guidelines where they have been determined (ANZECC, 1992).

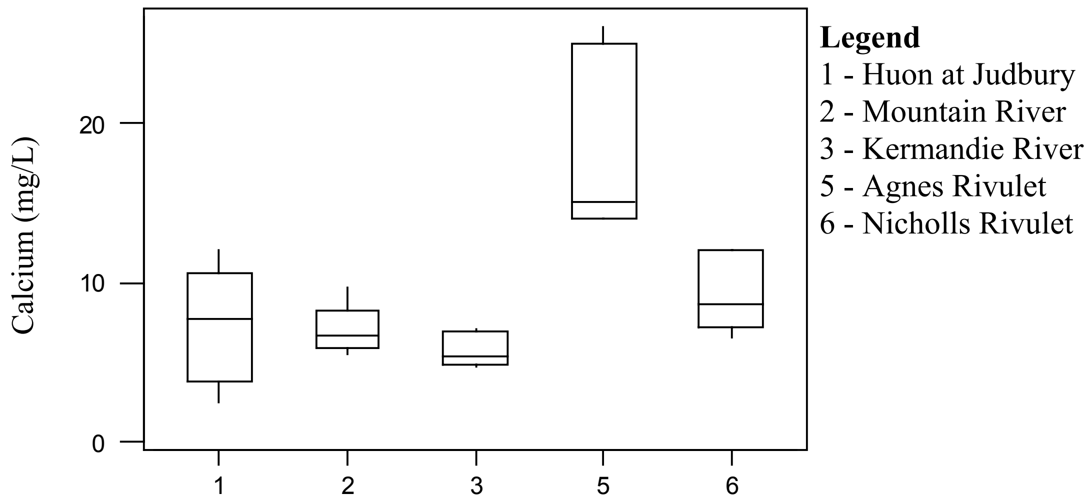

Figure 17 Calcium concentrations at monitoring sites in the Huon catchment.

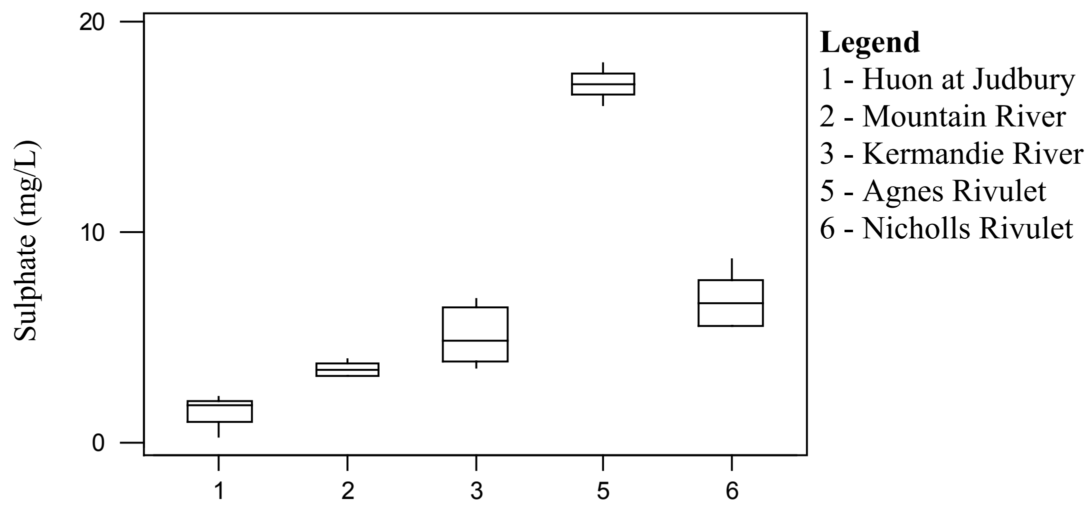

Figure 18 Sulphate concentrations at monitoring sites in the Huon catchment.

Sulphate concentrations in particular, were much higher in Agnes Rivulet than Nicholls Rivulet, which is a bordering catchment (Figure 18) and which would be expected to have similar chemical characteristics. This difference might be an indication of excessive use of gypsum (hydrated calcium sulphate) in the catchment, although the concentrations in Agnes Rivulet are still within the range found to occur naturally (2 - 60 mg/L).

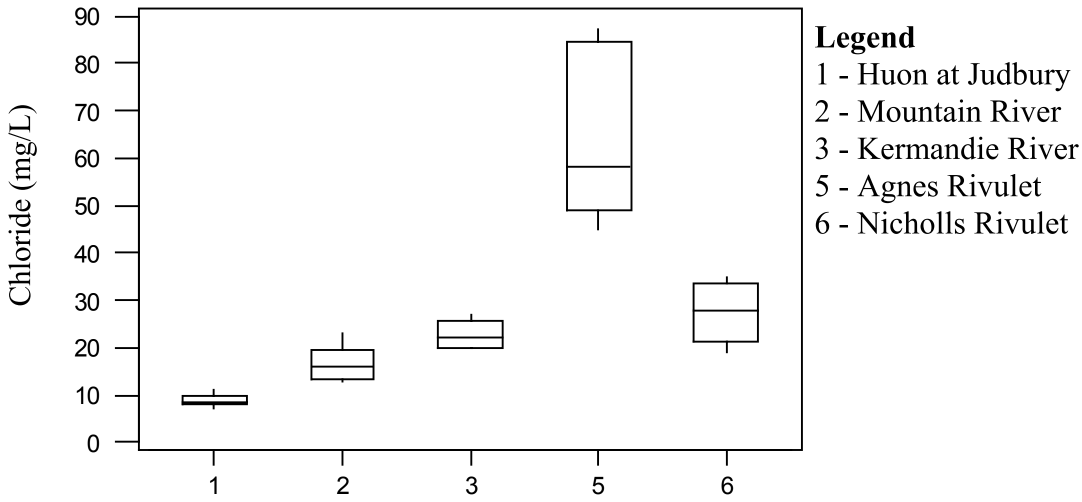

Figure 19 Chloride concentrations at monitoring sites in the Huon catchment.

The other significant feature of the ionic data is that silica levels in the Huon River are lower than in the smaller tributaries of the estuary (Figure 20) further highlighting the dilute nature of the Huon River. The main reason for highlighting this is that silica is an essential element for the growth of many forms of algae (diatoms) and may be important in sustaining growth of algae in the Huon estuary.

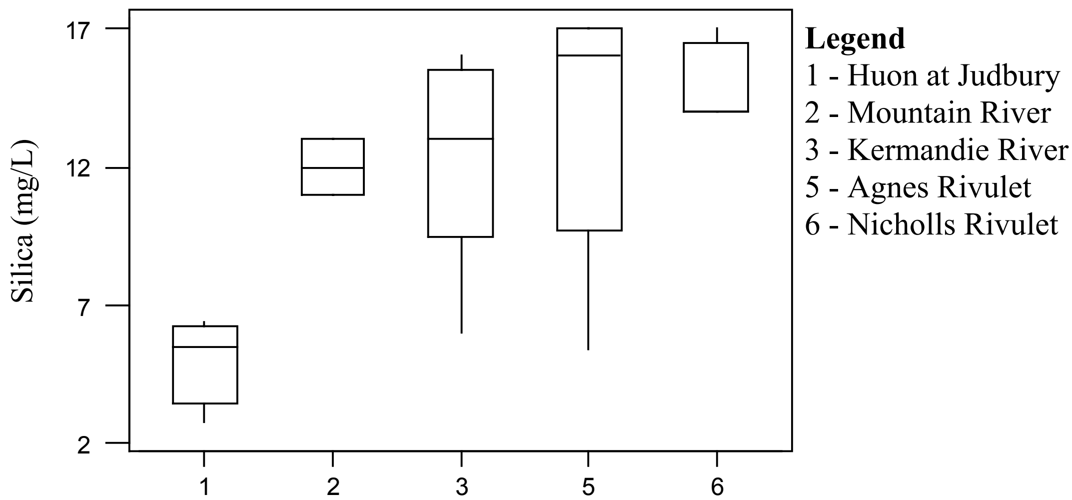

Figure 20 Silica concentrations at monitoring sites in the Huon catchment.

4.0 Nutrient Load Estimates

4.1 Huon River at Judbury

Turbidity was monitored in the Huon River at Judbury using an 'in situ' BTG sensor which includes a wiping mechanism, ensuring that data collected remains free of interference from algal growth. Regular checking against a portable meter was performed, both during flooding and during low flows. Some example plots of turbidity changes during flow events are given in the following figures and demonstrate both the pattern and magnitude of change in turbidity during events of different sizes. Flows are given in cumecs (m^3s^{-1}). Both plots show that during floods the turbidity increases to a maximum slightly before flood waters reach their peak. It is during this time that rivers are carrying their greatest sediment and nutrient load.

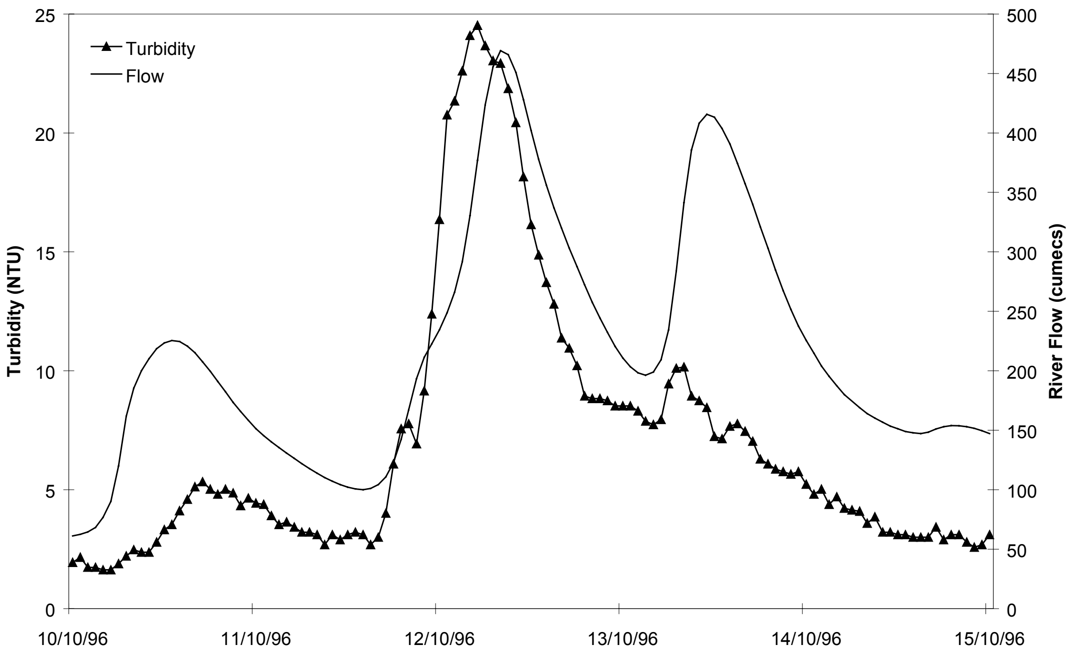

Figure 21 Changes in turbidity with river flow during a high flow event in the Huon River between 10 - 15 October, 1996 (Corresponding rainfall at Geeveston, Grove and Strathgordon was 21mm, 26mm and 18mm respectively).

Turbidity was monitored at Judbury from 20/6/96 through to 31/10/97. For part of this period extreme low flows occurred, when the probe was not able to monitor turbidity levels (25/1/97 to 3/4/97) as it was out of the water. Routine sampling in this period showed turbidity was very low (<3 NTU) so during periods when the probe was out of the water an artificial level of 2.5 NTU was adopted.

To make some estimate of nutrient loads being exported from the catchment upstream of Judbury, it was proposed to develop relationships between turbidity and the major nutrients of P and N for this site. In addition to the monthly sampling, nutrient samples for Total P and Total N concentrations were taken during higher flows and the data plotted against turbidity at the time of collection. The following figures show the relationships derived in this manner (Figures 23 and 24).

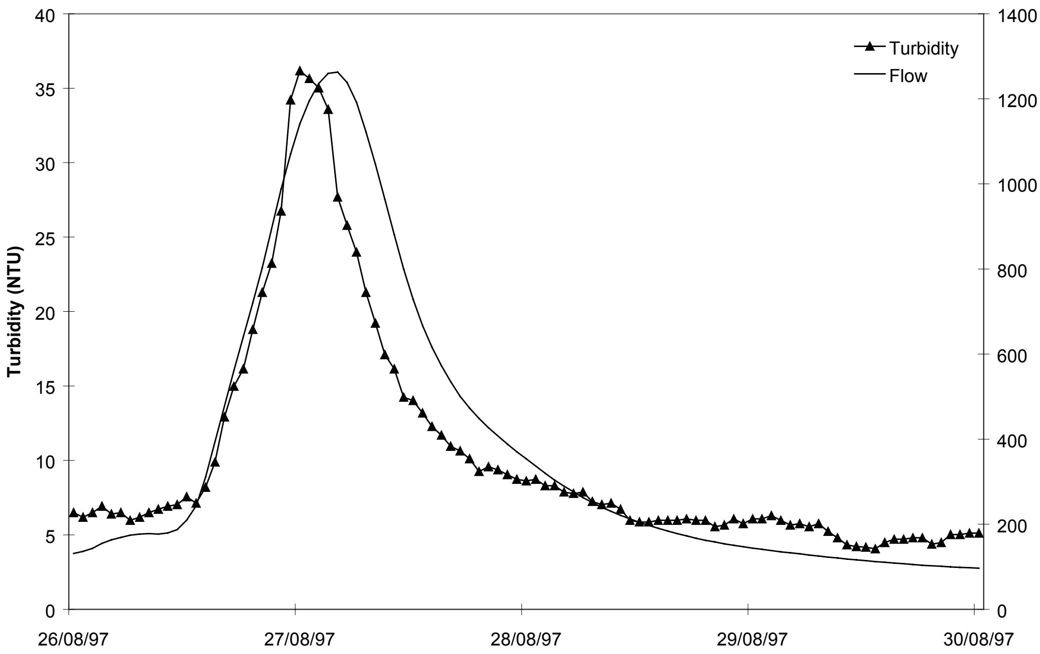

Figure 22 Changes in turbidity with river flow during flooding in the Huon River between 26 - 30 August, 1997 (Corresponding rainfall for the period at Strathgordon was 33mm).

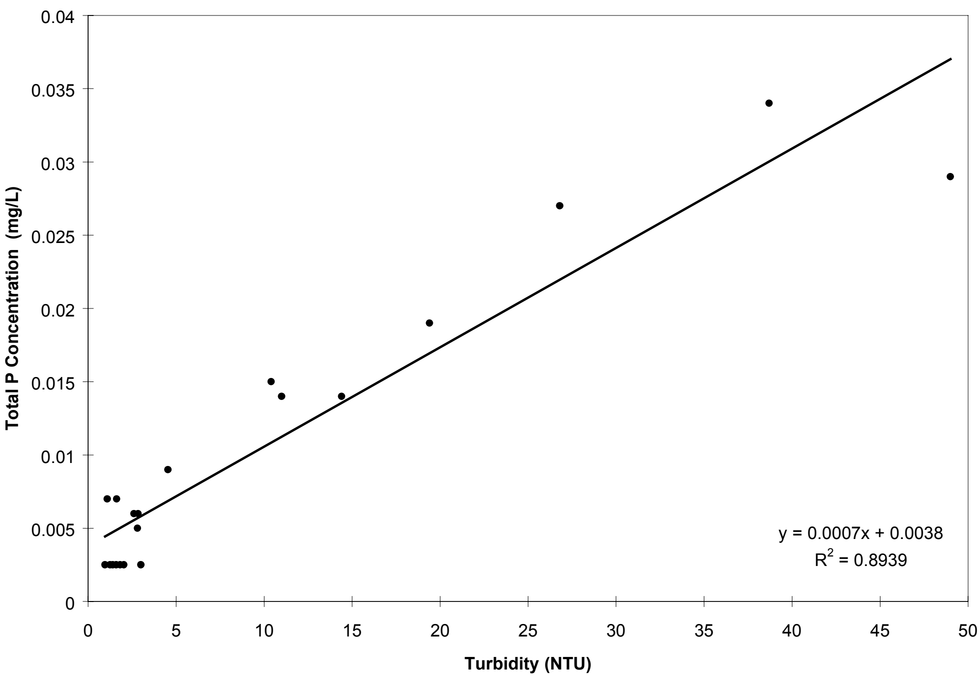

Figure 23 Relationship between turbidity and Total P concentration in the Huon River at Judbury (Significant at the 0.001 level).

The relationship for in-stream turbidity and Total P concentration is best defined by a linear regression (which is significant at the 0.001 level). For Total N, the relationship is more complex (Figure 24), but appears to be adequately described by a logarithmic regression (also significant at the 0.001 level).

Having established the relationship between Turbidity and TP & TN, they were then used to convert the turbidity time series record from Judbury to a synthetic time series of TP and TN concentration for the same period. Using the flow record from the Huon River upstream of Fryingpan Creek, the load of P and N was then calculated.

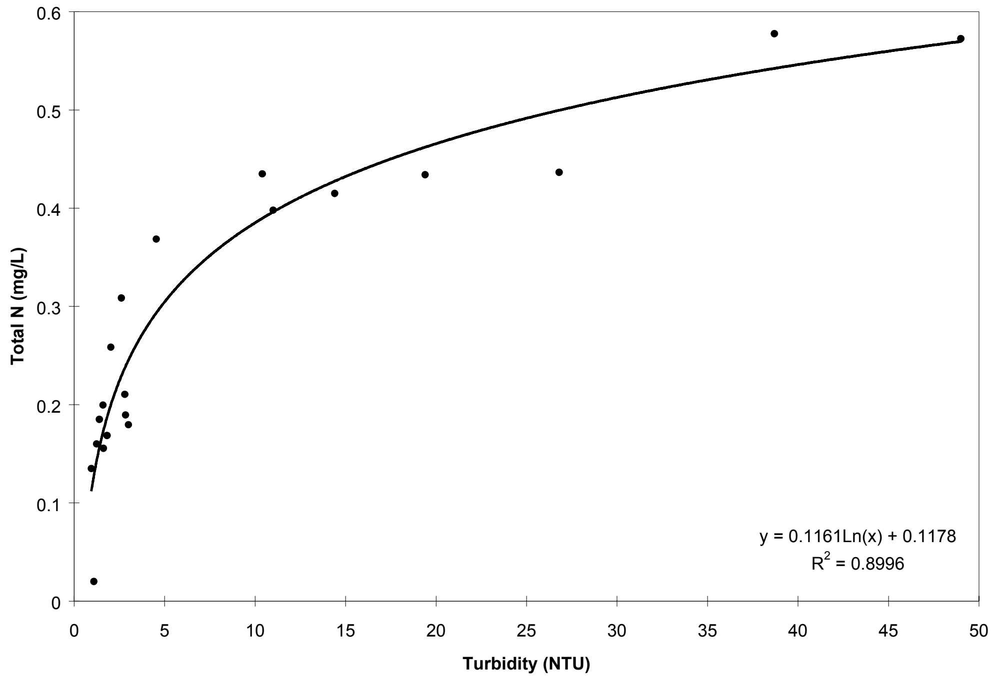

Figure 24 Relationship between turbidity and Total N concentration in the Huon River at Judbury (Significant at the 0.001 level).

There are some inherent 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.

The calculations for export loads from Judbury have also used flows measured in the Huon River upstream of Fryingpan Creek which is more than 5 km upstream from Judbury. In the intervening stretch of river, there is inflow from the Little Denison River, the Russell River and Judds Creek, all of which would have increased flow in the river to some degree, depending on the distribution of rainfall. In cases such as that presented in Figure 22 (August '97 event), where most of the river flow was due to rain in the upper catchment, the load estimate is more accurate than other events where the rainfall lower in the catchment may have resulted in a greater contribution from Judds Creek and the Russel River.

Bearing these assumptions in mind, Table 1 gives the estimated export load of phosphorus and nitrogen for the Huon River at Judbury for the entire 16 months of turbidity record. Also included is the total discharge for the river in megalitres (10^6

litres).

Table 1. River discharge volume and estimated export load of phosphorus and nitrogen from the Huon River upstream of Judbury

Period	Total Discharge (Megalitres)	Total P Load (tonnes)	Total N Load (tonnes)
20/6/96 to 31/10/97	4,206,005	38.52	1,355.14

The data is separated into monthly figures in Table 2. It shows that highest river discharge and concurrent nutrient export, occurred in August of both '96 and '97. Months of low discharge and nutrient export appears to be less predictable although the driest month was February, '97.

Table 2. Monthly discharge and estimated nutrient load for the Huon River at Judbury between July 1996 and October 1997.

MONTH	River Discharge (ML)	TP Load (kg)	TN Load (kg)
July '96	141,588	902	34,775
August '96	422,873	3,700	129,722
September '96	388,759	3,445	125,539
October '96	345,044	2,590	96,905
November '96	326,188	2,529	96,004
December '96	269,191	1,804	70,657
January '97	129,966	1,434	44,137
February '97	56,953	353	13,640
March '97	163,130	1,558	49,985
April '97	367,622	4,226	132,665
May '97	174,075	1,478	58,273
June '97	131,778	996	40,842
July '97	322,620	3,254	116,042
August '97	515,037	6,253	197,476
September '97	91,191	633	26,266
October '97	334,784	3,246	118,403

The average monthly export of phosphorus and nitrogen from the Huon upstream of Judbury is 1,014 kg and 11,841 kg respectively.

4.2 Kermandie River

The estimates of nutrient export from the Kermandie River are much less accurate than those for the Huon River. In the Huon at Judbury, the 'in situ' measurement of turbidity results in fairly accurate estimates of export loads if adequate calibration and validation of the turbidity record is carried out and relationships between turbidity and nutrient concentrations are significant. However, load estimates made in this way require considerable capital expenditure (cost of technology and maintenance) and is not feasible in many cases.

At the Kermandie River site, a less accurate method for export load estimates was used. It involved sampling nutrients in the river during the rising and falling stages of the floods and then deriving relationships between the nutrient concentrations and rising and falling flows. This technique is based on the fact that during rising flood waters the river is carrying more particulate material and hence more nutrients (which are bound to particles). Later in the flood, most of the easily dislodged material has already been washed away and flows are more diluted and carry lower nutrient loads. This technique has been used to estimate export loads in other catchments in Tasmania (Bobbi, *et. al*., 1996).

Due to the absence of a gauging station at the site, flows for the site were modelled from records collected at Rileys Creek upstream of Rileys Dam using a scaling method. The gauging station at Rileys Creek is only about 5 km upstream of the Kermandie River monitoring site. To estimate flows in the Kermandie River, the flow record from Rileys Creek is simply scaled up on the basis of catchment area. As the catchment area above the Rileys Creek station is 20 km^2 and the total catchment above the Kermandie River monitoring site is 130 km^2, the flow at Rileys Creek was simply multiplied by 6.5. During the study several flow gaugings were carried out at the Kermandie site as calibration checks for this model. The average of these measurements showed an increase in flow at the Kermandie site of 7.1 times the flow at Rileys Creek indicating that output from the model was reasonable.

This modelled flow record was then used in the development of relationships between flow and nutrient concentration. Figure 25 shows the relationship for TP concentration during rising and receding river flow.

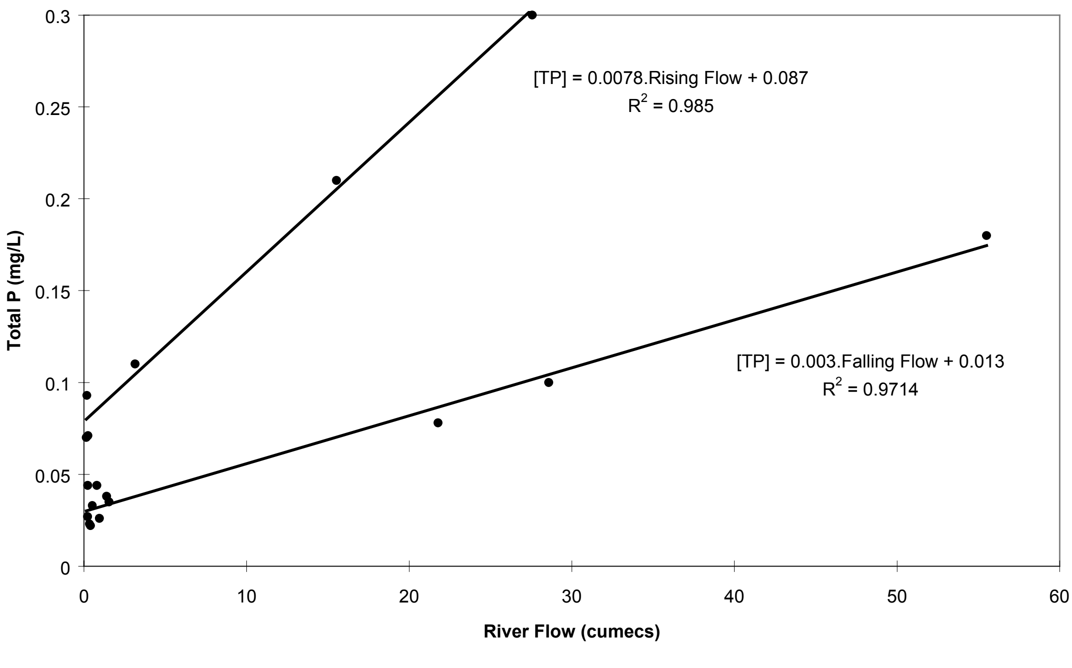

Figure 25 Relationships developed between Total P concentrations and rising and falling river flows in the Kermandie River (Both are significant at the 0.005 level).

In a similar manner, relationships between Total N concentrations and river flows were developed and applied to the flow record to generate a 'synthetic' Total N concentration time series. The following relationships were used;

1) [TN] = 0.0635*Rising Flow + 0.9874
2) [TN] = 0.0202*Falling Flow + 0.8334

Both relationships have R^2 values greater than 0.95 and are significant at the 0.005 level.

This method has been employed for load estimates in other rivers (Bobbi *et al*., 1996) and was found to give best results where nutrient concentration records are adequate. However it has been noted that some inaccuracy is inherent with the method in the area where flows change from rising to falling flows. At this nexus, there is a significant jump in nutrient concentration when crossing from the rising relationship to the falling relationship.

Using these relationships to convert the flow record into nutrient concentrations, loads were then simply calculated by multiplying the flow and nutrient concentration records. Table 3 shows the resulting estimates of phosphorus and nitrogen export from the Kermandie River. The results show that about 12 times more nitrogen than phosphorus was exported in a total volume of just under 50,000 megalitres. This compares with a 35:1 ratio of N:P export for the Huon River at Judbury. It indicates that nutrient export from the Kermandie catchment is more phosphorus enriched than the upper Huon, which is probably a consequence of the higher level of agricultural activity in the Kermandie catchment compared with the upper Huon catchment which is primarily natural with some logging.

Table 3. River discharge volume and estimated export load of phosphorus and nitrogen from the Kermandie River upstream of the Huon Highway.

Period	Total Discharge (Megalitres)	Total P Load (kilograms)	Total N Load (kilograms)
1/11/96 to 1/10/97	49,987	6,081	71,046

A monthly analysis of export loads from the Kermandie catchment is given in Table 4. It shows that lowest export loads occurred in June, 1997 when discharge for the month was only 741 megalitres. Highest export loads were in August, 1997 when discharge was very high due to widespread flooding in the greater Huon region (compare with Table 2).

Table 4. Monthly discharge and estimated nutrient load from the Kermandie River at between November 1996 and October 1997.

MONTH	River Discharge (ML)	TP Load (kg)	TN Load (kg)
November ’96	4,470	383	4,891
December ’96	2,236	113	1,698
January ’97	5,130	785	8,765
February ’97	3,323	433	5,047
March ’97	4,465	731	8,045
April ’97	4,024	223	3,505
May ’97	1,744	78	1,181
June ’97	741	33	437
July ’97	3,623	175	2,847
August ’97	16,449	2,934	31,665
September ’97	3,784	192	2,966

4.3 Conclusions from Load Estimates

While the accuracy of these export load estimates is difficult to assess, they do provide some indication of the differences in nutrient export between a large and relatively un-impacted catchment (upper Huon) and a smaller, more intensively used catchment (Kermandie). The following table presents a comparison between export coefficients for phosphorus and nitrogen from the Kermandie and the upper Huon catchments. These coefficients correct for catchment area and discharge volume (ie catchment runoff) and allow catchments of different sizes and rainfall patterns to be compared. When figures are adjusted to compensate for these differences, it is clear that the Kermandie catchment exports a proportionately greater load of both phosphorus and nitrogen (Table 5).

TABLE 5 Export coefficients for the upper Huon River and the Kermandie River for the period November '96 to October '97.

Catchment	P Export (kg)	N Export (kg)	Discharge (ML)	Total P (kg/mm/km^{-2})	Total N (kg/mm/km^{-2})
Upper Huon River	24,517	845,987	2,547,751	0.010	0.332
Kermandie River	6,081	71,046	49,987	0.122	1.421

Upper Huon catchment area = 2097 km^{-2}; Kermandie catchment area = 130 km^{-2}.

These coefficients can be compared to others which have been calculated for rivers elsewhere in Tasmania (Table 6 - adapted from Bobbi, *et. al.*, 1996). The figures in Table 6 are averages calculated over several years, as the amount of rainfall received in a catchment will determine the amount of nutrient exported, and hence the export coefficient for that catchment. The Kermandie coefficients for both phosphorus and nitrogen are at the upper end of those for other agricultural catchments in Tasmania, while those for the upper Huon catchment are below almost all other calculated values for Tasmanian Rivers. It should be pointed out that these coefficients were calculated using data from only a single year of data and wetter or drier years will yield correspondingly higher or lower coefficients.

TABLE 6 Export coefficients for other catchments in Tasmania (South Esk Basin 'State of Rivers Report', 1996). Figures are averages calculated over several years between 1992 and 1995.

Catchment	Catchment Area (km^2)	Mean Annual Discharge (ML)	Total P (kg/mm/km^{-2})	Total N (kg/mm/km^{-2})
Meander River u/s Strath Bridge	1,012	368,733	0.058	0.670
Liffey River	224	61,186	0.052	0.779
South Esk at Perth	3,280	335,425	0.034	0.657
Break O'Day River	240	32,548	0.065	0.942

5.0 Catchment Snapshot Surveys

Although the two snapshot surveys were carried out at different times of the year (January and June), the results from both were quite similar and reflect the very similar hydrological conditions prevailing at the time. The winter of 1997 was quite dry, with river flows very comparable to those which normally occur in summer.

5.1 Survey Results

The following section is designed to graphically indicate sites in the catchment where degraded water quality was found, relative to the rest of the catchment. Plots from both the summer and winter surveys will be presented together for comparison, though in several cases they will be very similar.

5.1.1 Conductivity

Electrical conductivity showed a very similar pattern during both surveys, with sites of higher conductivity consistent on both occasions (Figure 26a and 26b). Highest conductivity occurred in the Agnes Rivulet sub-catchment (400-550 μS/cm), Dover Rivulet (380-390 μS/cm) and the smaller creeks around Huonville (Watson’s and Dickensons creeks at Glen Huon and Fourteen Turn Creek at Grove) where conductivity ranged was 360-640 μS/cm. Streams with conductivity of between 280 - 800 μS/cm are classed as having medium salinity water under the ANZECC (1992) guidelines. Most other locations displayed typically low conductivity levels of 100-150 μS/cm.

5.1.2 Turbidity

The snapshots of turbidity highlighted the significant degradation occurring in the Agnes Rivulet sub-catchment, especially in the smaller tributaries of Supplices Creek and Golden Valley Creek (Figure 27a and 27b). Both sites on these smaller tributaries are within the fringe of Cygnet township and probably reflect the level of impact of human activities in that area (lack of riparian vegetation, weed infestation and road drainage).

During low flows, high turbidity readings are much more indicative of the impacts of local activities on water quality in the stream at that site as suspended material is not likely to be carried for any distance downstream. This was particularly relevant in the Kermandie River sub-catchment during the summer survey as higher turbidity was recorded at upper catchment sites (Scotts Rivulet and Rileys Creek). The higher turbidity in Scotts Rivulet appeared to be caused by higher silt levels in the stream from the gravel road which runs up the valley.

A similar situation appears to impact on water quality in the upper reaches of Kellaways Creek, where elevated turbidity in the upper sites (relative to turbidity at the lower site) seems to be caused by increased silt levels in the stream due to runoff from the gravel road which travels up the valley. In the lower section of the valley the road is further from the stream and silt appears not to have reached the stream. Turbidity at both the upper Kellaways Creek sites is still relatively low in comparison to other sites in the Huon Catchment.

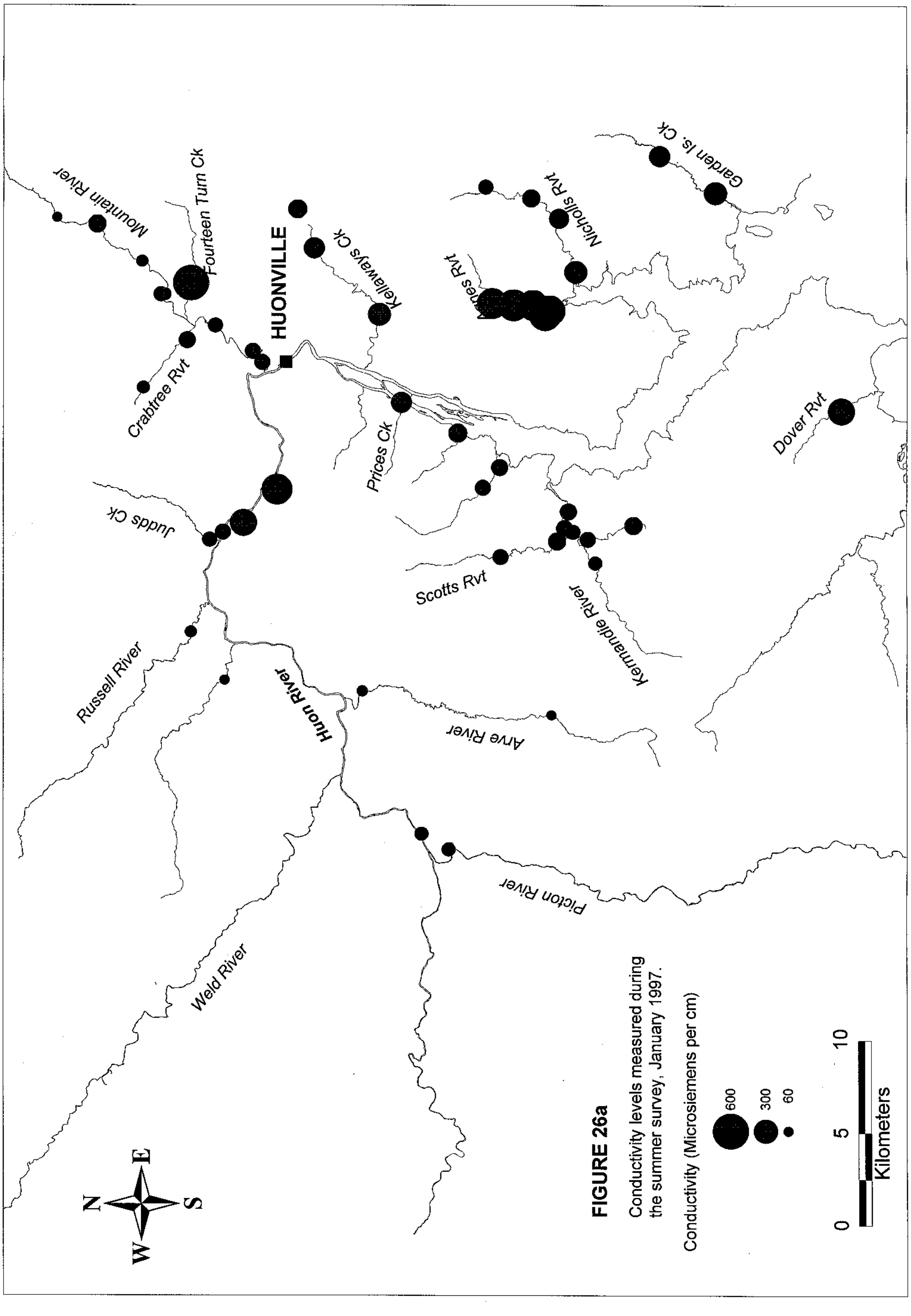

FIGURE 26a

Conductivity levels measured during the summer survey, January 1997.

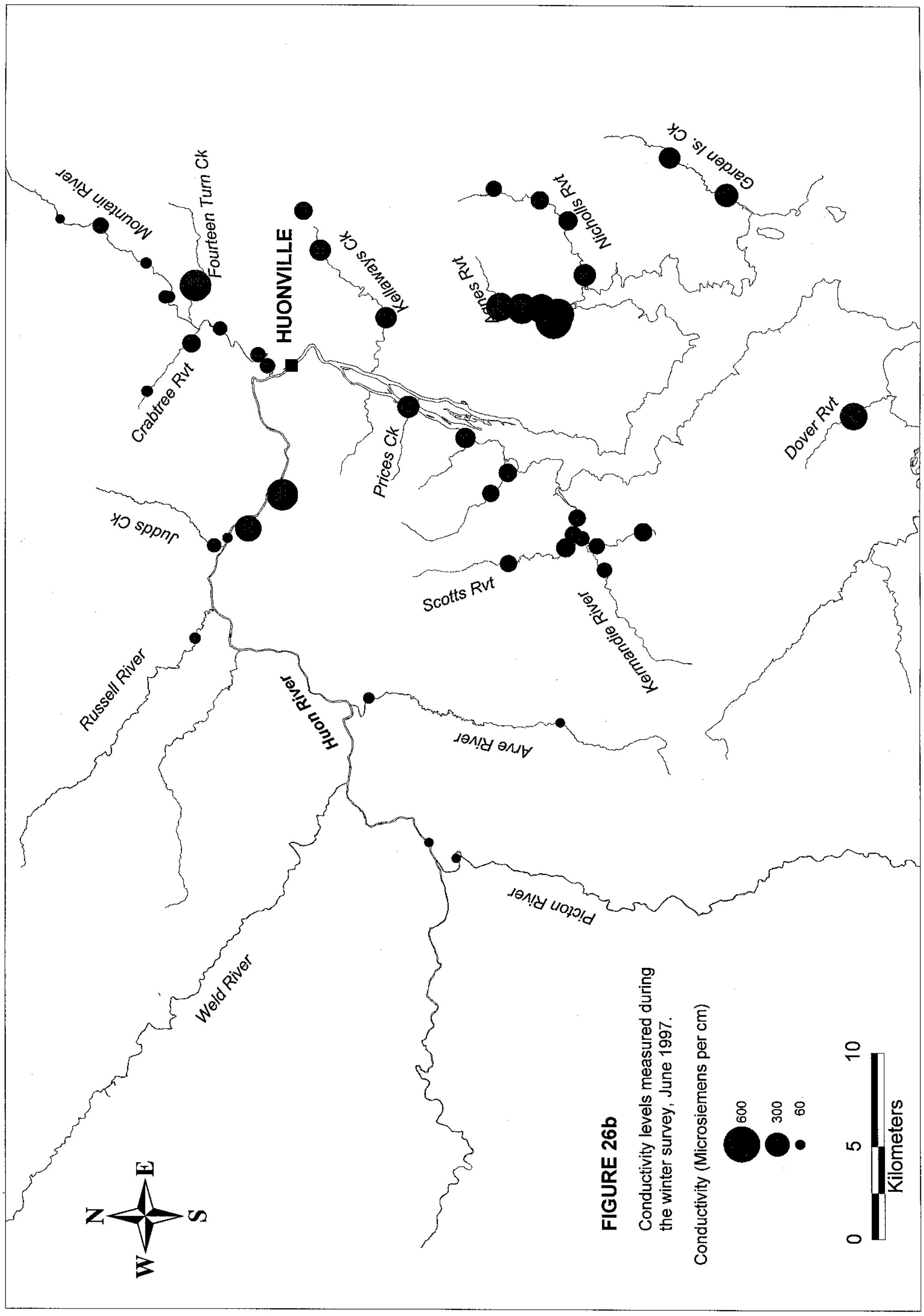

FIGURE 26b

Conductivity levels measured during the winter survey, June 1997.

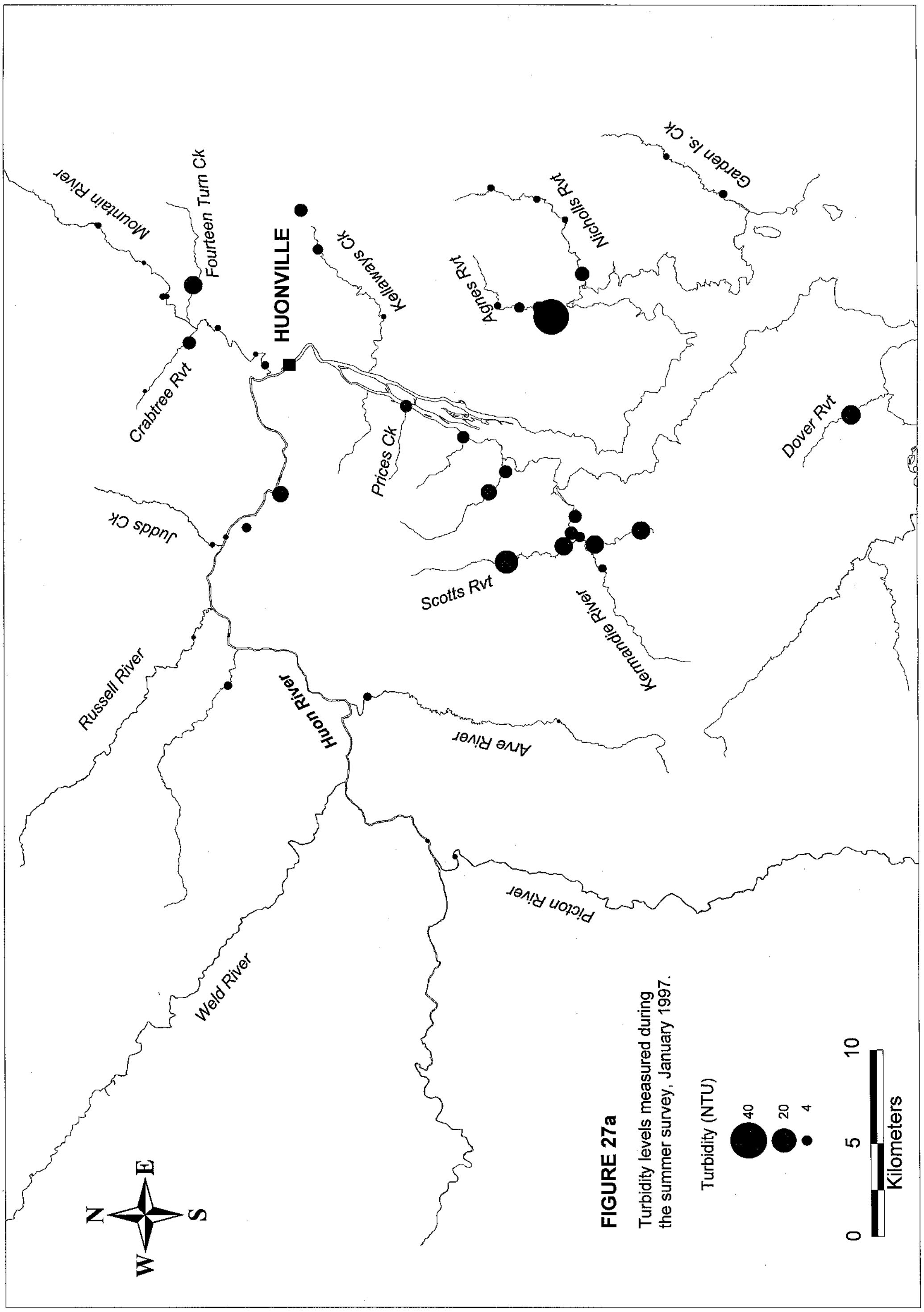

FIGURE 27a

Turbidity levels measured during the summer survey, January 1997.

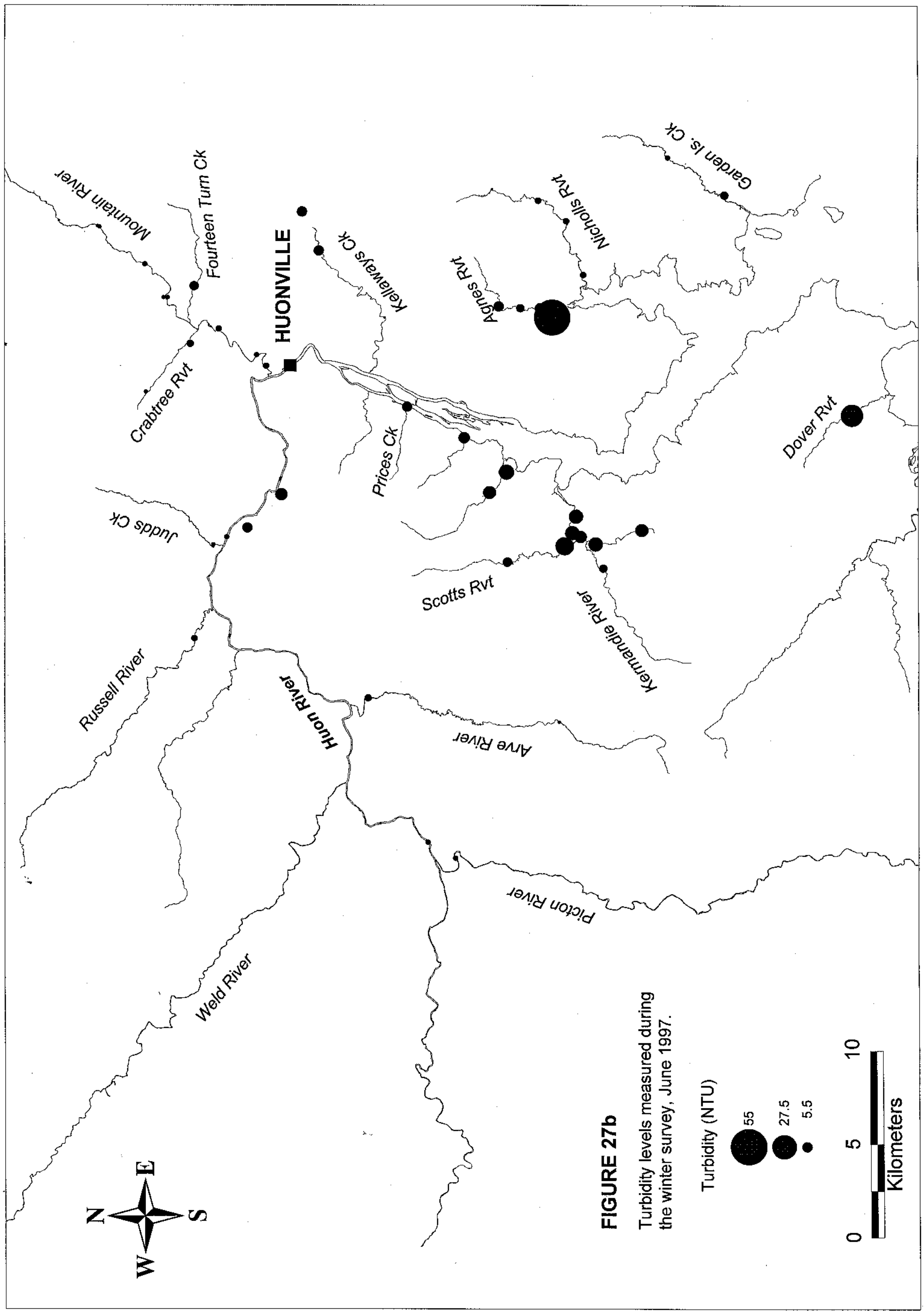

FIGURE 27b

Turbidity levels measured during the winter survey, June 1997.

Moderately high turbidity (>10 NTU) was recorded at several sites in the Kermandie River sub-catchment, Dover Rivulet and Fourteen Turn Creek (at Grove). Turbidity at Castle Forbes Rivulet and Watsons Creek (at Glen Huon) were only marginally less then 10 NTU.

Sites where very low turbidity (< 2 NTU) was measured during both surveys were in the upper Huon River, the upper Arve and Picton rivers, Judds Creek, Crabtree Rivulet and most of Mountain River.

5.1.3 Faecal Coliforms

The coliform indicator, *Escherichia coli*, was measured as an indicator of faecal pollution. *E. coli* is a bacteria which is present in faeces from warm blooded animals and its presence in water indicates that pollution is relatively recent as it cannot survive long outside the warmer environment of the intestine. This bacteria is usually used to assess the quality of water for human consumption or contact. Where water is used for human consumption, no *E. coli* should be detected (NHMRC & ARMCANZ, 1996). Where water is to be used for swimming or bathing (primary contact activities) the ANZECC (1992) guidelines state that the median concentration from 5 or more samples should not be greater than 150 counts per 100mL and that four out of the five samples should have less than 600 per 100 mL. It might therefore be safe to assume that while sites where coliform counts are greater than 150 per mL pose some risk to those in direct contact, sites where counts are over 600 per 100mL are more indicative of sites of significant risk and may need further monitoring to properly assess that risk.

The data from both surveys clearly show that faecal pollution is more prevalent during the summer than winter. It is noteworthy that of the 49 sites sampled during the surveys, only one showed undetectable levels of *E. coli* on both occasions. Of the 49 sites sampled during the summer survey (Figure 28a), 15 showed coliform counts less than 100 per mL, an additional 7 sites were between 100 and 200 per mL and 11 sites showed levels over 600 per mL. Seven of these eleven sites showed coliform concentrations well over 1000 per 100mL.

Sites which stand out in Figure 28 as having highest *E. coli* levels are;

- Mountain River at Ranelagh
- Fourteen Turn Creek at Grove
- Crabtree Rivulet upstream of Mountain River
- Judds Creek
- Prices Creek at Franklin
- upper Agnes Rivulet
- Kermandie River downstream of the township

In some cases the high coliform counts can be linked to activities at the site, such as the presence of a flock of geese in the area of lower Crabtree Rivulet or cattle access to the lower Kermandie River and upper Agnes Rivulet. Prices Creek, which flows through Franklin township may reflect input from domestic effluent. At many of the other sites the causes are less visibly obvious.

During the winter survey (Figure 28b) 'hotspots' are still apparent at Agnes Rivulet, Scotts Rivulet and Mountain River at Ranelagh, but faecal pollution generally is much lower (Of the 49 sites sampled in the winter survey, 29 showed faecal coliform counts below 100 per mL). During the cooler winter conditions, faecal coliforms would not persist for long outside the intestine (The temperature of rivers at the time of the winter survey was about 5-6 ^{o}C).

5.1.4 Ammonia-N

Higher concentrations of ammonia nitrogen were found at several sites during both the summer (Figure 29a) and winter (Figure 29b) surveys. Sites which showed higher concentrations on both occasions were;

Kermandie River downstream of the Geeveston sewage treatment plant
Rileys Creek upstream of Rileys Creek Dam
Supplices Creek at Cygnet
and Dover Rivulet

which indicates that these sites may carry a sustained organic load or be persistently polluted by human or animal waste. The upstream site on Rileys Creek carries a high organic and silt load which makes this site prone to stagnation and consequently to the production of ammonia. There is also some grazing by stock around this site.

The site at Dover Rivulet is also similar in that the stream has a moderate silt load, which is further impacted by willows which add substantial organic matter to the stream. There is also widespread access to the rivulet by stock upstream of the site.

5.1.5 Nitrate-N

Nitrate concentrations through the rivers of the Huon were generally higher during the winter survey (Figure 30b). At many of the upper and middle catchment sites (Arve, Picton, Russel, Little Denison and Mountain rivers) concentrations were very low (below about 0.05 mg/L) on both occasions. Highest concentrations were found at sites in the Agnes Rivulet sub-catchment, particularly in the two smaller tributaries of Supplices Creek and Golden Valley Creek. On the winter survey, nitrate nitrogen concentration in Supplices Creek was measured at 1.9 mg/L. These high readings, when interpreted in association with the other nutrient data, indicate significant pollution to streams of this system.

High levels of nitrate were also measured at Prices Creek in Franklin (0.23 mg/L and 0.43 mg/L in summer and winter respectively). Sites in the Kermandie catchment were between 0.05-0.18 mg/L during the summer survey and increased during the winter (0.1-0.25 mg/L). These higher levels during the winter survey are probably best explained by increased groundwater infiltration and subsequent leaching of nitrate from the catchment into the Agnes Rivulet drainage system.

5.1.6 Total Nitrogen

As was found for both previous forms of nitrogen, concentrations of Total N were highest in the Agnes Rivulet area (Figures 31a and 31b), with concentrations between 1-3.5 mg/L occurring in Supplices and Golden Valley creeks.

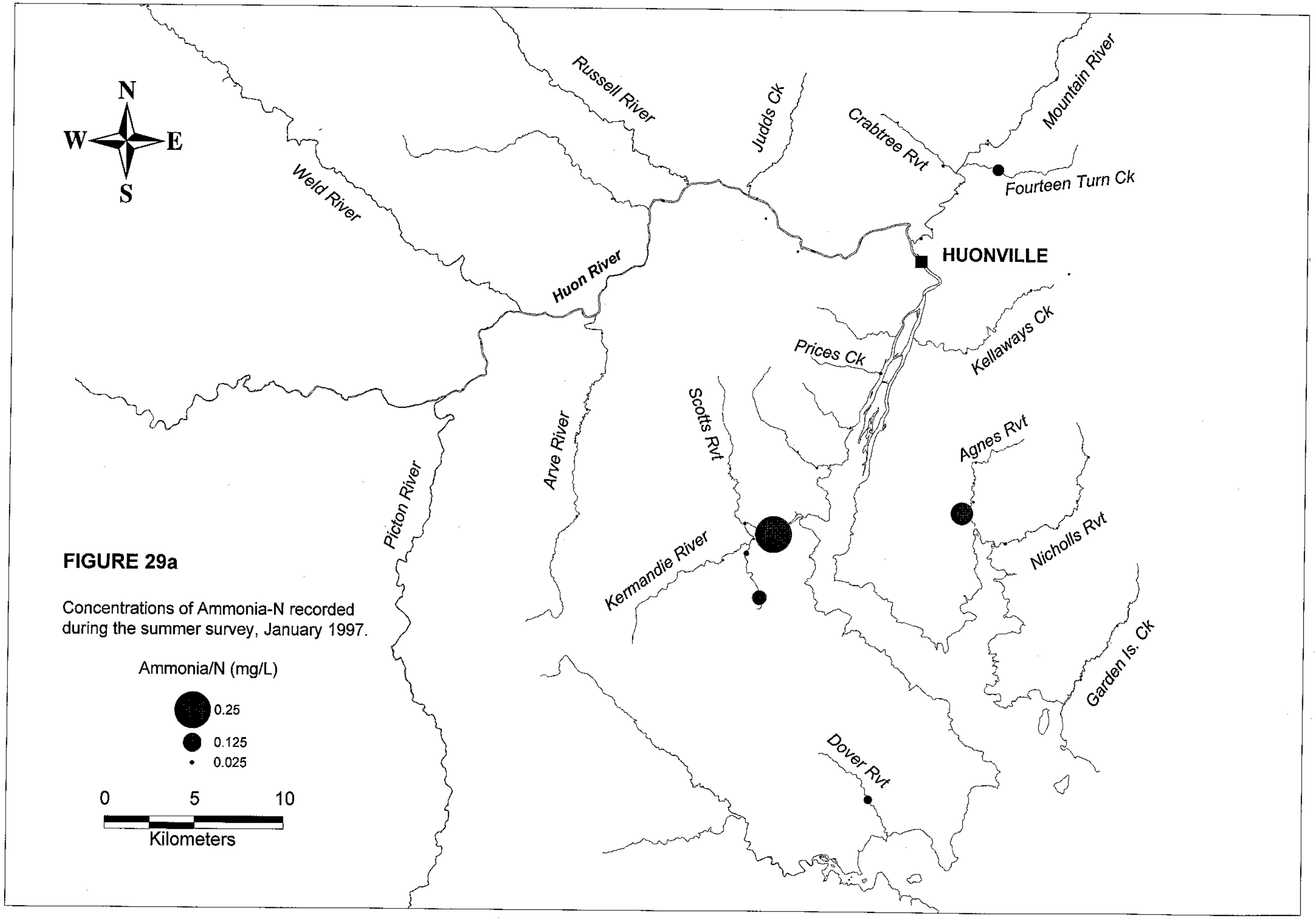

FIGURE 29a

Concentrations of Ammonia-N recorded during the summer survey, January 1997.

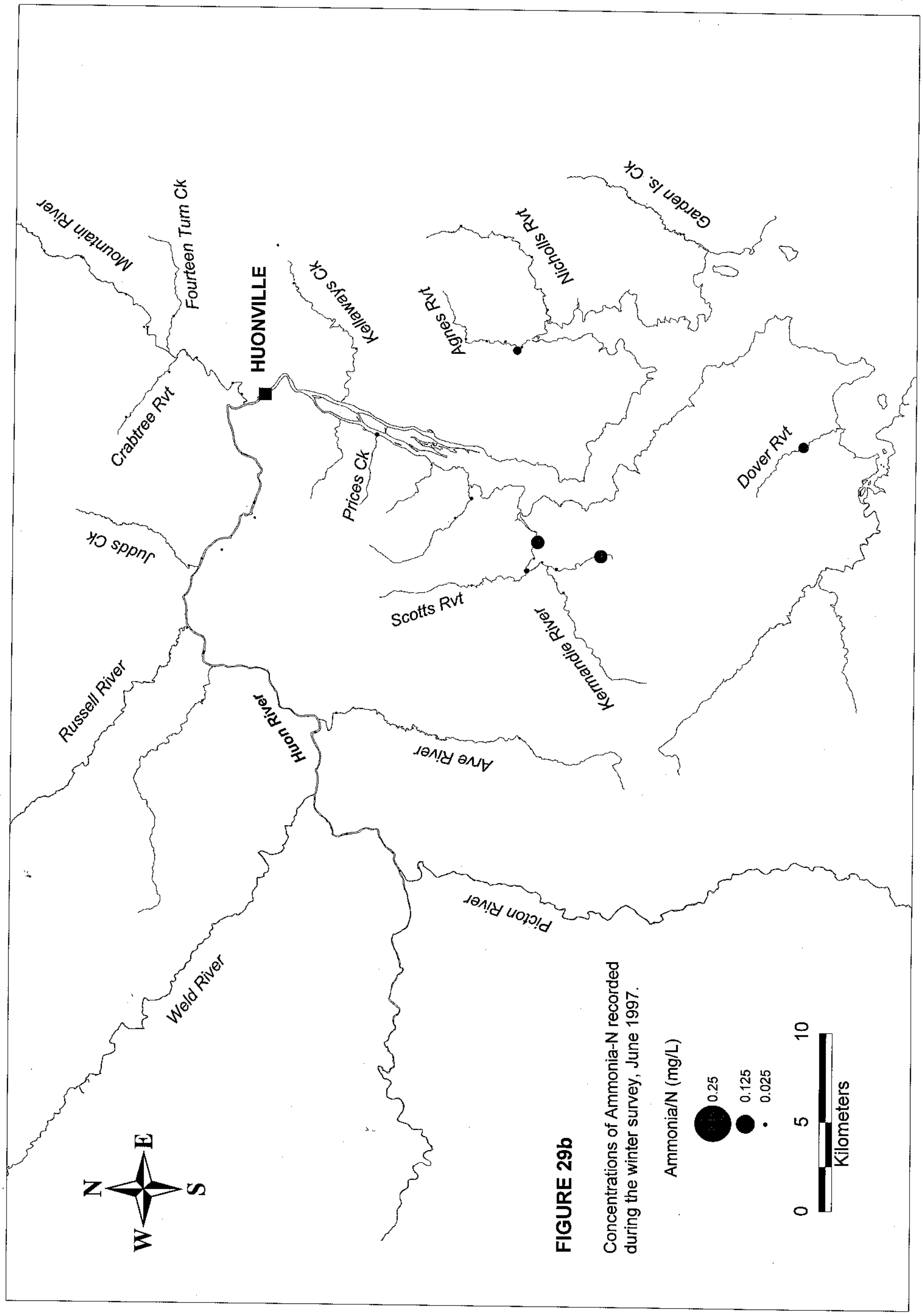

FIGURE 29b

Concentrations of Ammonia-N recorded during the winter survey, June 1997.

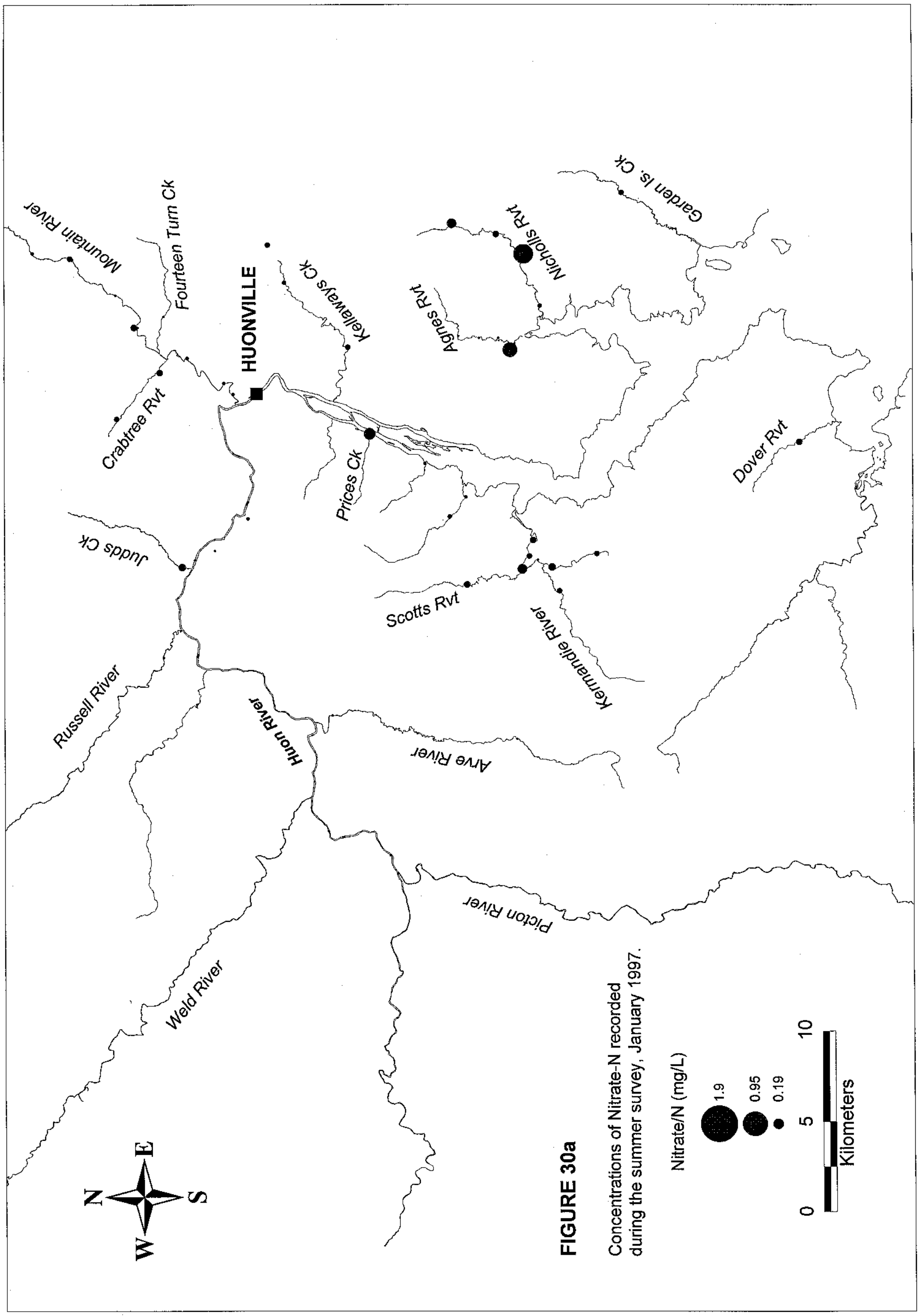

FIGURE 30a

Concentrations of Nitrate-N recorded during the summer survey, January 1997.

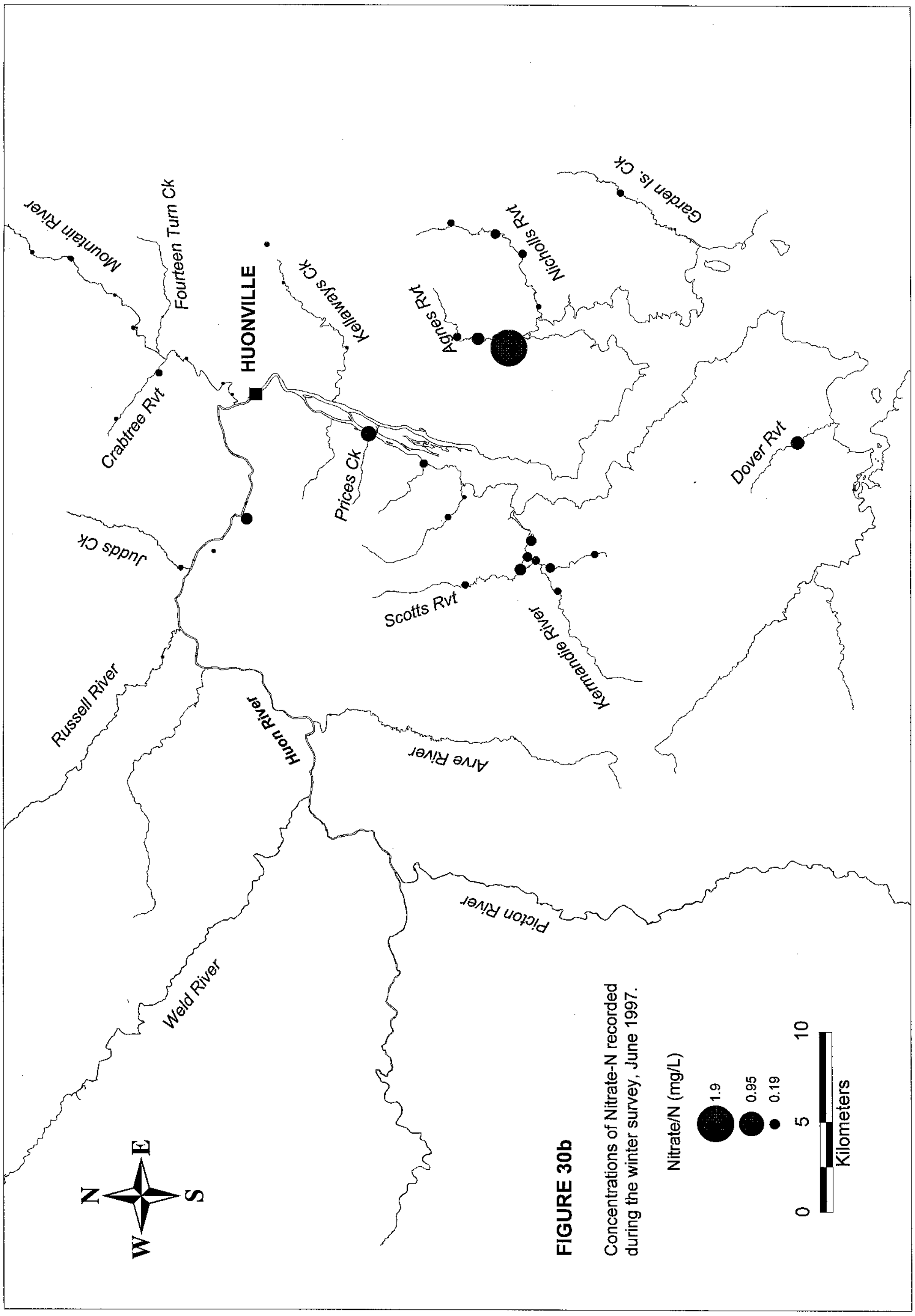

FIGURE 30b

Concentrations of Nitrate-N recorded during the winter survey, June 1997.

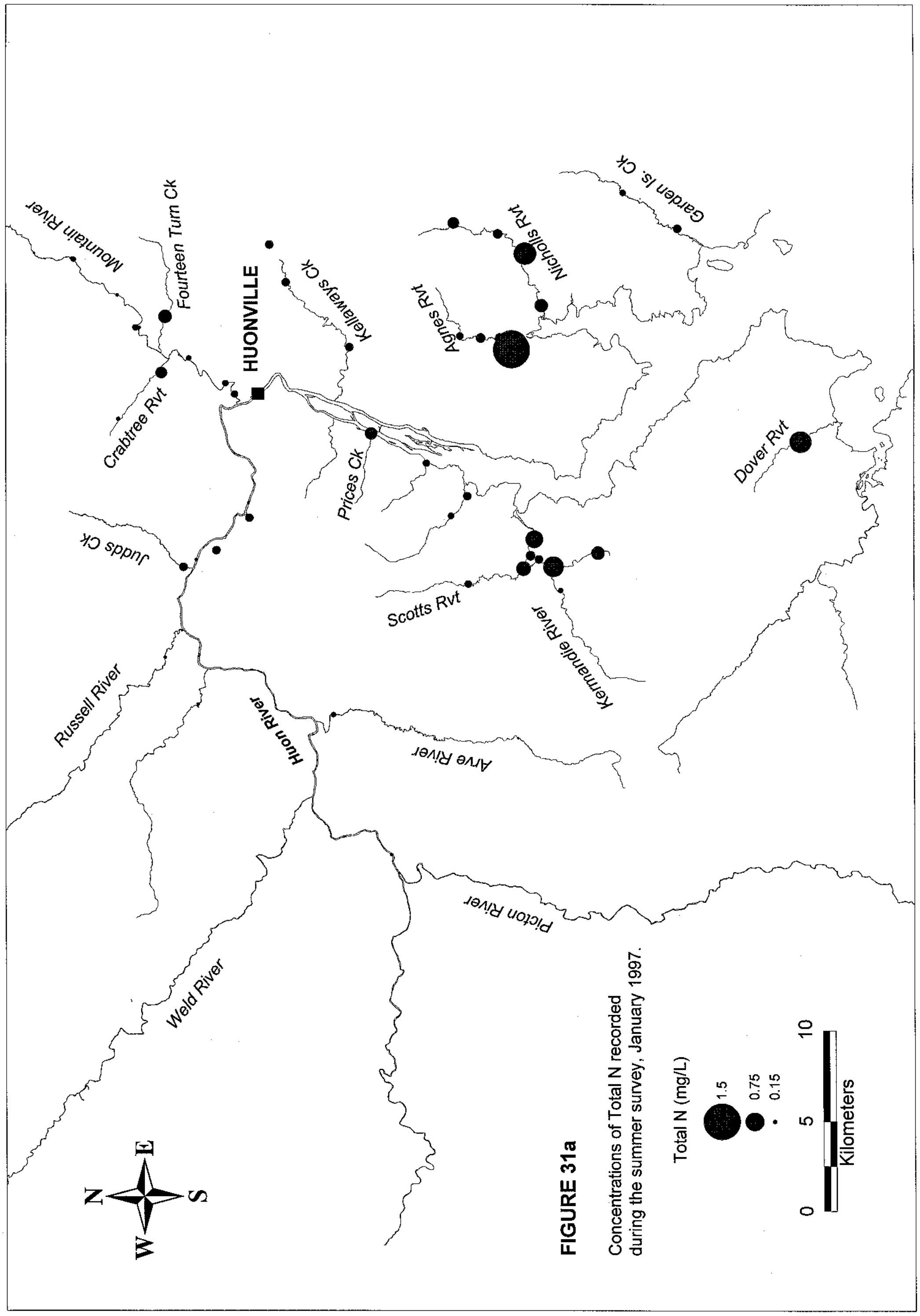

FIGURE 31a

Concentrations of Total N recorded during the summer survey, January 1997.

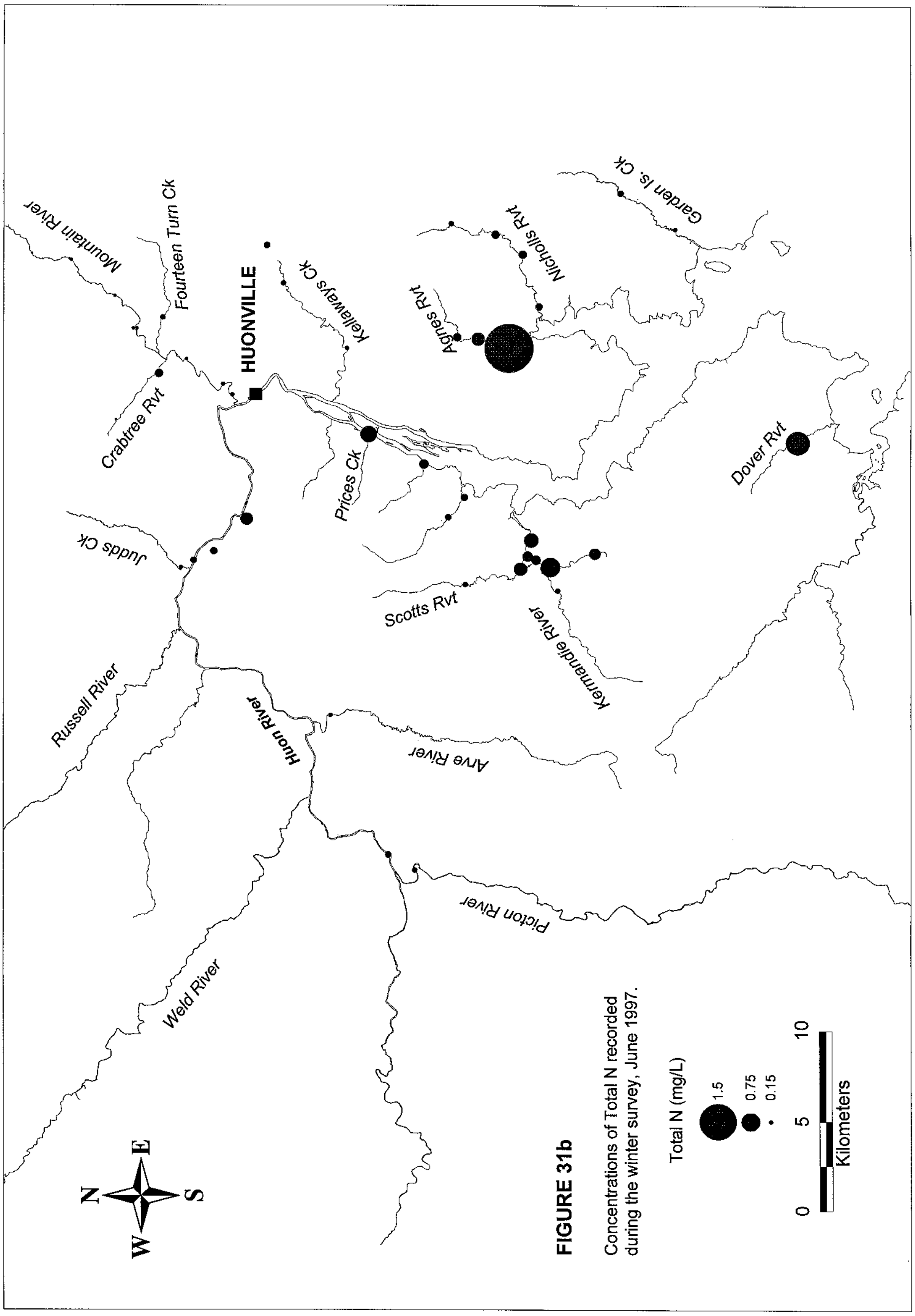

FIGURE 31b

Concentrations of Total N recorded during the winter survey, June 1997.

Relatively high levels were measured elsewhere in the catchment at Dover Rivulet

(0.84 & 0.95 mg/L), lower Rileys Creek (0.8 & 0.77 mg/L), lower Kermandie River (0.68 & 0.57 mg/L) and Prices Creek (0.5 & 0.65 mg/L). Although most sites in Nicholls Rivulet were about 0.35 - 0.55 mg/L during the summer survey, a concentration of 0.9 mg/L was recorded at the site at Joes Road.

When considered in terms of the ANZECC (1992) guidelines for the protection of aquatic ecosystem (outlined in Section 3.2.3), between 10 and 13 sites show levels of Total N which are in the upper range of concentrations at which algal problems have been found to occur. Most of these are sites in and around the areas of Cygnet and Geeveston.

5.1.7 Total Phosphorus

Phosphorus concentrations at sites throughout the Huon were generally below 0.02 mg/L during both surveys (Figure 32a and 32b). During the summer survey, 17 sites showed TP concentrations below 0.01 mg/L. During the winter survey, the number of sites with concentrations less than 0.01 mg/L increased to 26, most of which were upper catchment sites. Concentrations of phosphorus below 0.01 mg/L can be considered low for an agricultural catchment in Tasmania, while levels between 0.01 and 0.02 mg/L are more typical of waterways draining areas of intensive agriculture (Bobbi *et al*., 1996; Bobbi, 1997). Where concentrations above 0.02 mg/L are measured during base flow conditions, it could be stated that nutrient enrichment is occurring.

In the summer survey carried out in the Huon, 13 sites were found to have phosphorus concentrations above 0.02 mg/L (Figure 32a). Most of these sites were within the Kermandie River and Agnes Rivulet sub-catchments. Several of these showed concentrations well over 0.1 mg/L (Supplices Creek, Golden Valley Creek and lower Kermandie River).

During winter, fewer sites had phosphorus concentrations above 0.02 mg/L. The most enriched sites during the winter survey were Supplices Creek (0.24 mg/L), Golden Valley Creek (0.093 mg/L) and lower Agnes Rivulet (0.073 mg/L), further highlighting the level of degradation of this area.

5.1.8 Dissolved Phosphorus

As has been pointed out in an earlier section, dissolved phosphorus in water is a fraction of the total phosphorus present and this fraction is usually considered as free and available for algal and plant growth. The following two figures showing the results from analysis of samples for dissolved phosphorus (Figures 33a & 33b) are simply intended to highlight sites where higher levels of dissolved phosphorus were found.

During the summer survey it was clear that the lower site on the Kermandie River showed very high levels of dissolved phosphorus, which indicates that effluent from the Geeveston sewage treatment plant is rich in free phosphorus. During the winter survey (Figure 33b) this was no as obvious. While levels at many site were generally slightly higher during the winter survey, they appear to be more uniform across the

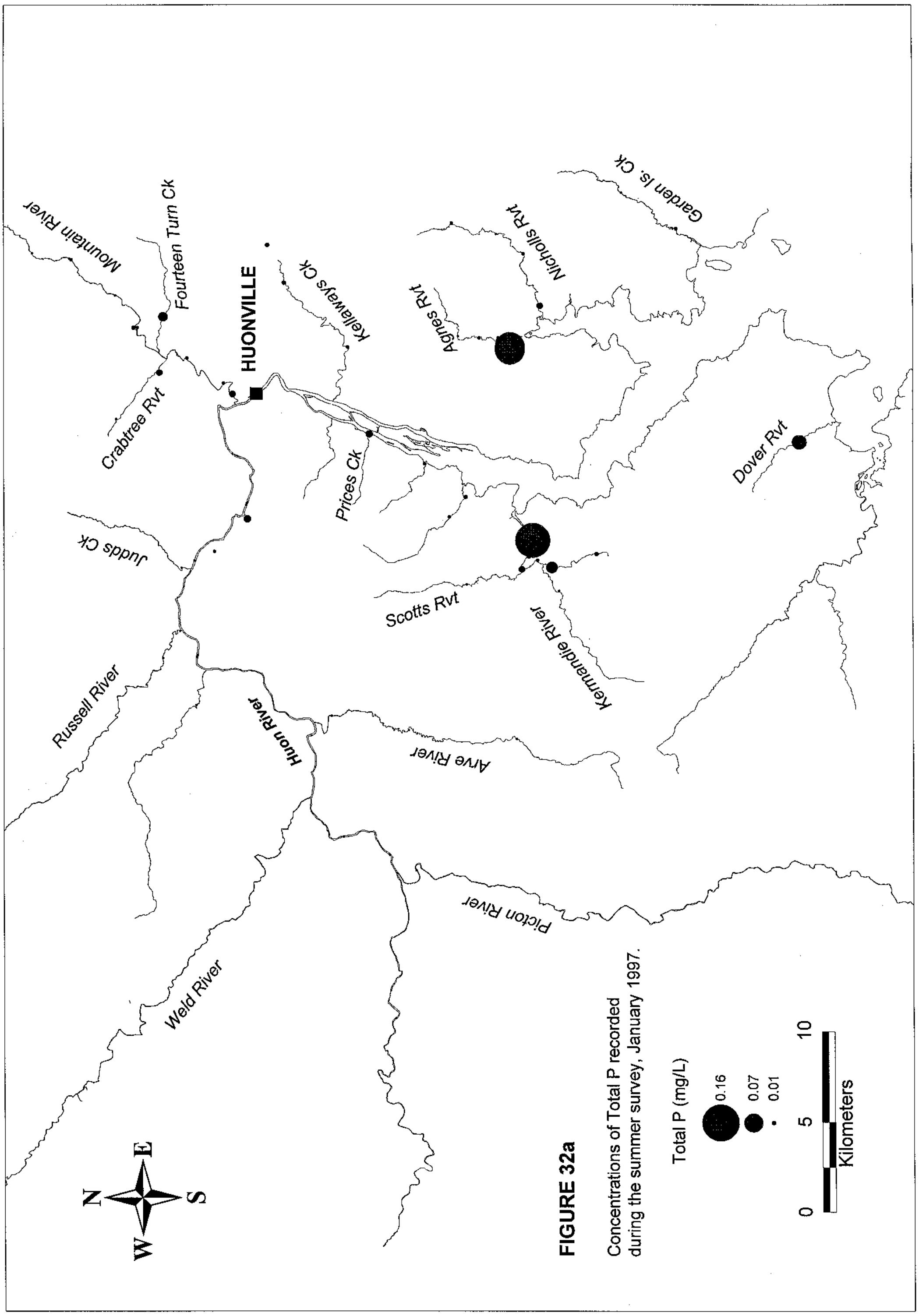

FIGURE 32a

Concentrations of Total P recorded during the summer survey, January 1997.

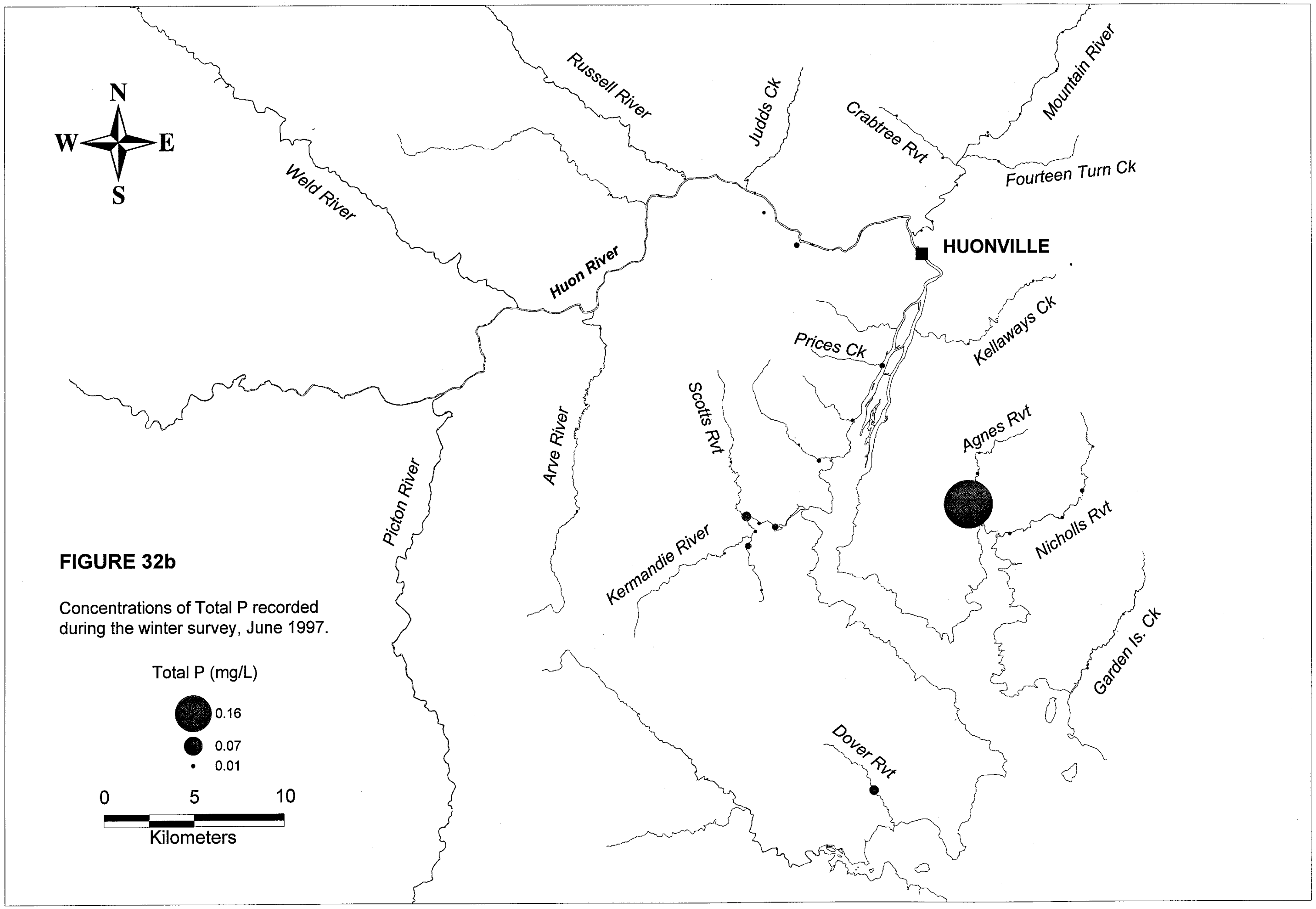

FIGURE 32b

Concentrations of Total P recorded during the winter survey, June 1997.

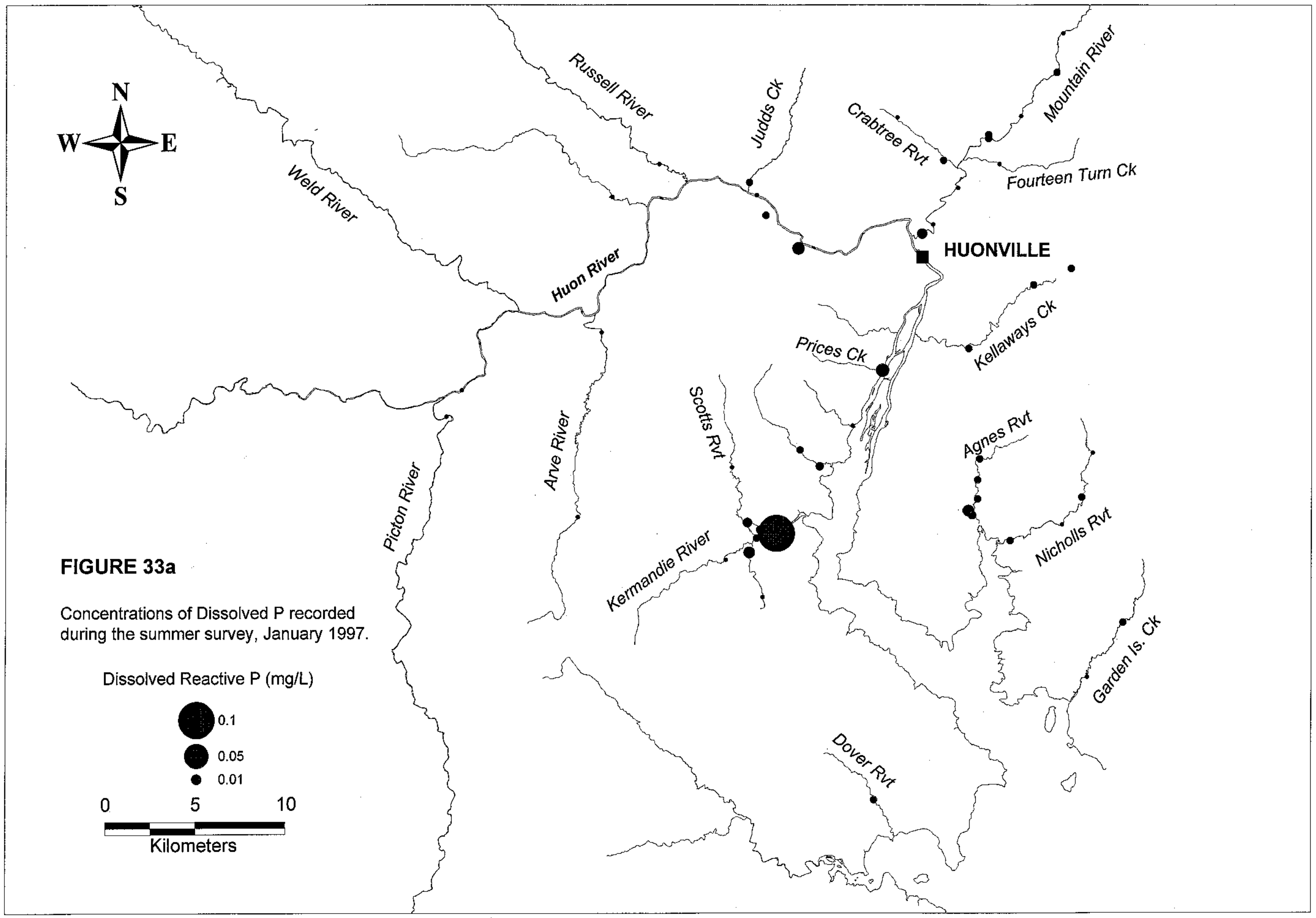

FIGURE 33a

Concentrations of Dissolved P recorded during the summer survey, January 1997.

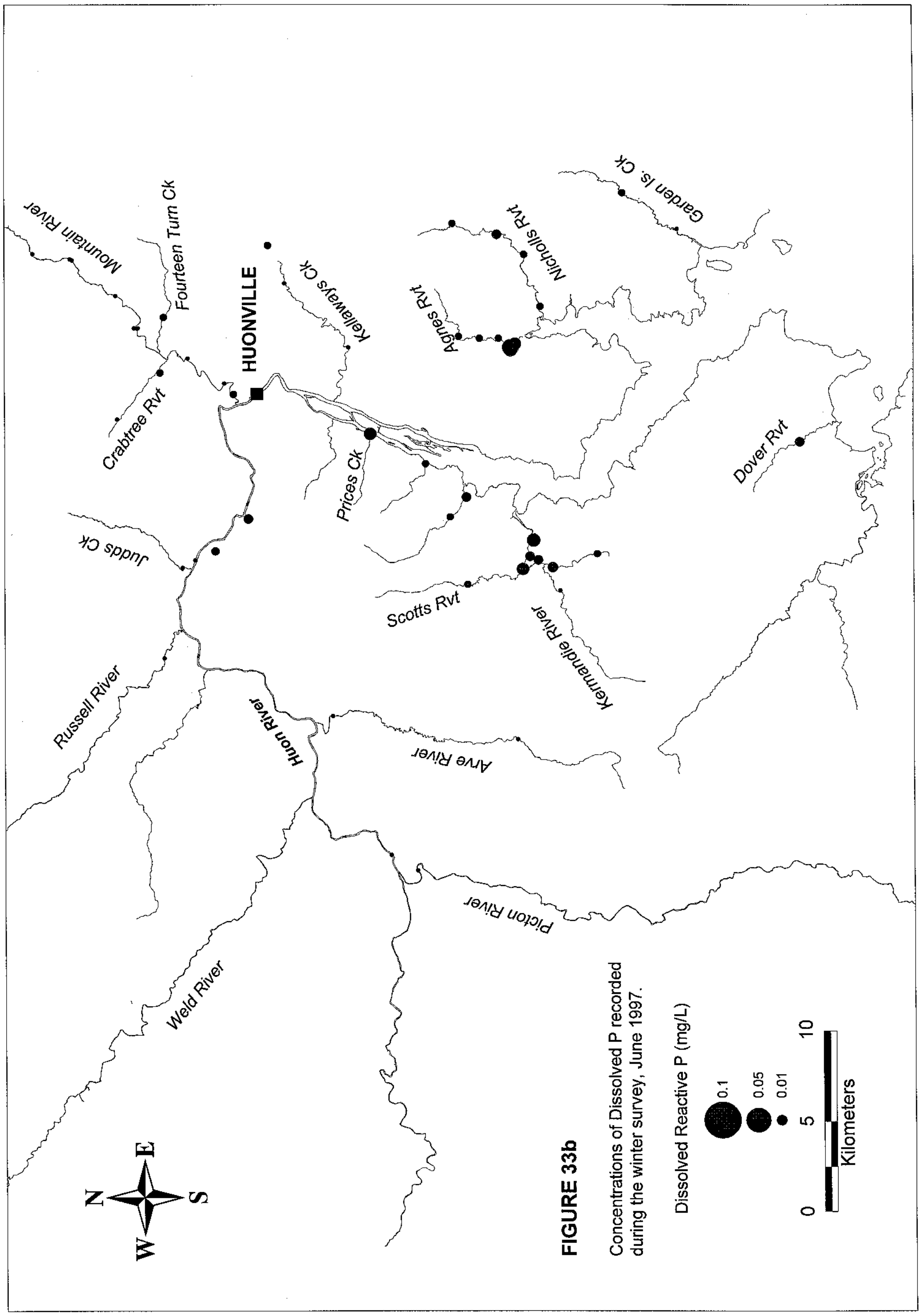

FIGURE 33b

Concentrations of Dissolved P recorded during the winter survey, June 1997.

lower catchment. During both surveys, concentrations in the upper catchment were at or below detection limits.

5.2 Conclusions from the Catchment Surveys

While it is difficult to draw too many conclusions from only two such 'snapshot' surveys of the catchment, some sites have been highlighted as having significantly worse water quality than others in the region. It is clear that streams draining the Cygnet area are impacted by activities in the area, some quite heavily. Golden Valley and Supplices creeks are both very nutrient enriched and show evidence of faecal pollution. While conductivity levels in this sub-catchment are of medium salinity, during prolonged dry periods care may be needed when using this water for irrigation purposes (VIRASC, 1980).

Another area where there is some degradation in water quality is in the rivers draining the Kermandie catchment. While a large component of the nutrient load leaving the catchment under normal flows is due to the discharge of treated effluent from the Geeveston sewage treatment plant, both surveys showed some deterioration in water quality in Rileys Creek and Scotts Rivulet. The tributaries showed elevated nutrient and turbidity levels, while faecal coliform levels in Scotts Rivulet and lower in the Kermandie River were also high.

Runoff from the gravel road which closely follows Scotts Rivulet down the valley appears to cause higher turbidity in this stream and the silt load has visibly affected the stream bed. Sampling in the Kermandie catchment during rain events in March 1997 showed that turbidity in Scotts Rivulet was substantially higher than any of the other tributaries (Table 7) in the sub-catchment.

TABLE 7 Turbidity readings in the Kermandie catchment during a rain event in March 17, 1997.

Location	Turbidity (NTU)
Kermandie River u/s Rileys Creek	104
Rileys Creek u/s Rileys Dam	160
Rileys Creek d/s Dam	21
Scotts Rivulet u/s Kermandie River	634
Kermandie River @ Hwy	186

This sampling also showed the dramatic effect the Rileys Creek Dam has on reducing turbidity in Rileys Creek. During the event, water flowing out of the dam showed an 8-fold decrease in turbidity, as suspended material settles out of the water during its passage through the dam.

Other sites where water quality shows some deterioration are sites on Dover Rivulet and Prices Creek and Fourteen Turn Creek, where the levels of most parameters which were measured were moderate to very high. Concentrations of nitrogen and phosphorus at Dover Rivulet were noteworthy in this respect, as was faecal coliform levels at Prices and Fourteen Turn creeks.

While the data for faecal coliforms should be viewed with caution, it also appears that the lowest site on Mountain River may also be receiving faecal pollution of some form. Most other parameters at this site indicated good quality water.

Water in most rivers of the upper catchment appears to be of high quality during low flow conditions, particularly upstream of Judbury. This is expected as land use in these areas is restricted mainly to recreational and forestry activities.

6.0 References

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