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THE HEALTH OF STREAMS IN THE CAMPASPE, LODDON AND AVOCA CATCHMENTS

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Introduction

Careful management of our waterways and catchments is crucial to maintain and improve river health. Good decision making requires detailed information on the environmental condition of our rivers.

The Monitoring River Health Initiative (MRHI) – a biological monitoring program across Australia – was introduced as part of the National River Health Program funded by the Commonwealth. The main aim of the MRHI was to develop a standardised biological assessment scheme for evaluating river health. This was to be achieved by sampling reference sites and using the information collected to build models to predict which macroinvertebrate families would be expected to occur under specified environmental conditions. In Victoria the program was conducted by the Environment Protection Authority (EPA) and AWT Victoria (formerly Water EcoScience). In urban areas, this is also complemented by Melbourne Water's Healthy Waterways program.

Currently, an Australia-wide Assessment of River Health (AWARH) is being conducted under the National Rivercare Program to assess the health of Australia's rivers. EPA is sampling approximately 600 test sites in Victoria and evaluating these against the MRHI models.

Having undertaken biological monitoring in Victoria since 1983, EPA has a great deal of experience in the field. The results of previous studies will be combined with those of the current program, providing a solid background of data. This will be used to determine long term trends in the health of our rivers and will help the protection of water quality and the beneficial uses of our water courses.

Monitoring water quality

Traditional water quality monitoring involves measuring physical and chemical aspects of the water. Common measurements include pH, salinity, turbidity, nutrient levels, toxic substances and the amount of oxygen dissolved in the water. These measures provide a 'snapshot' of environmental conditions at the moment samples are taken. Water quality conditions are variable, so such monitoring can fail to detect occasional changes or intermittent pulses of pollution.

In contrast, the biological monitoring program involves sampling aquatic animals, which gives an indication of the health of the river as a whole. Because they live at the site for some time, animals reflect the build-up of impacts of environmental change on the river ecosystem – such as the influence of surrounding land use or the effects of pollution.

Biological monitoring techniques

Aquatic macroinvertebrates (such as insects, snails and worms) are very useful indicators in biological monitoring. They are visible to the naked eye and are commonly found in rivers and streams. They are an important source of food for fish and many are well known to anglers – such as yabbies, mudeyes, stoneflies and mayflies. They are widespread, easy to collect, relatively immobile and provide good information about the environment.

The presence or absence of specific species provides information about water quality. Some species are known to have particular tolerances to environmental factors such as temperature or levels of dissolved oxygen. Other information can be obtained from the number of species found at a site (biological diversity), the number of animals found at a site (abundance) and the relationship between all animals present (community structure).

Sites with a high level of species diversity generally have good water quality. Sites which have low diversity are less healthy – often due to the impacts of pollution. In polluted habitats, sensitive species are eliminated and less sensitive species show an increase in numbers.

Study site selection and assessment

Sites are selected to include a variety believed to be representative of the river basin's waterways – including sites that are relatively unimpacted (reference) and sites which are subject to the impact of pollution (test), although most of these are situated away from any obvious point source of pollution.

Sites are sampled twice a year (autumn and spring) using the rapid bioassessment technique. This involves collecting two types of biological samples where possible.

◆ ***Kick samples for riffle habitat***

To conduct kick samples, the stream bed is disturbed by the sampler's feet to dislodge animals which are swept into a net by the current. Samples are taken from shallow areas with stony or rocky substrates in medium to fast currents. This type of habitat is called a riffle and is usually associated with upland streams. In sandy streams, shallow fast flowing sandy areas are sampled.

◆ ***Sweep samples for edge habitat***

Sweep samples are collected by sweeping a net along banks and around snags in backwaters and pools which have slow currents or no flow. Aquatic plants (macrophytes) – which provide additional habitat for aquatic animals – are often found in these edge habitats and are included in the sweep sample. These habitats can be found in both the upland and lowland reaches of rivers.

Water quality measurements – including dissolved oxygen, pH, temperature and electrical conductivity – are made at each site and water samples are taken for laboratory analysis of nitrogen and phosphorus levels and turbidity. The vegetation along the river banks (the riparian zone) and the aquatic habitat are also assessed. The aquatic habitat is those parts of the river environment which animals use to make a home. It can be strongly affected by the streamside vegetation as well as the environment and land use of surrounding and upstream regions. The water quality and habitat measurements, taken at the same time as the biological samples, are also used in modelling and other data analyses.

For example, if fertiliser runoff is causing an excess of nutrient to enter the river, there may be excess growth of algae attached to rocks and snags in the river, affecting these important habitats. It can also result in blooms of toxic blue-green algae which are potentially hazardous to humans, animals and birds contacting or consuming the water. Thus different factors can influence many parts of the river environment. Biological monitoring can be a valuable tool to measure the overall effect of all these influences.

Invertebrate analysis techniques

Biological data can be analysed in a number of ways – from using simple biotic indices through to more complex statistical and modelling procedures.

A combination of analytical and interpretative measures gives far more reliable results than any measure on its own.

Number of families

The number of invertebrate families found in streams can give a reasonable representation of the health of a stream, though it is too great a simplification of data to be adequate on its own. Lack of suitable habitat or the presence of various pollutants can cause a reduction in the number of families present. This assessment method complements SIGNAL (see below) which tends to underestimate toxic effects.

SIGNAL

This biotic index uses families of aquatic invertebrates that have been awarded sensitivity scores according to their tolerance or intolerance to various pollutants. The index is calculated by totalling these scores and dividing by the number of families present. A single value between one and 10 is produced, reflecting the degree of water pollution – high quality sites have high SIGNAL scores (Chessman 1995) (table 1). While SIGNAL is particularly good for assessing water quality problems such as salinisation and organic pollution, its usefulness for toxic impacts and other types of disturbance is uncertain.

Table 1: Key to SIGNAL scores

SIGNAL score	*Water quality*
>7	Excellent
6-7	Clean water
5-6	Doubtful, mild pollution
4-5	Moderate pollution
<4	Severe pollution

AUSRIVAS

One of the main aims of the National River Health Program was the development of predictive models which could be used to assess river health. As a result, the Co-operative Research Centre for Freshwater Ecology has developed the Australian Rivers Assessment System (AUSRIVAS) which consists of several mathematical models. These models are being refined in 2000.

Each model uses reference data collected under the MRHI from a single aquatic habitat from either a single season (autumn or spring) or from the two seasons combined (Coysh *et al.* 2000).

AUSRIVAS predicts the macroinvertebrates which should be present in specific stream habitats under reference conditions. It does this by comparing a test site with a group of reference sites which are as free as possible of environmental impacts but have similar physical and chemical characteristics to those found at the test site.

One of the products of AUSRIVAS is a list of the aquatic macroinvertebrate families and the probability of each family being found at a test site if there were no environmental impacts. By comparing the totalled probabilities of predicted families and the number of families actually found, a ratio can be calculated for each test site. This ratio is expressed as the observed number of families/expected number of families (the O/E index).

The value of the O/E index can range from a minimum of zero (none of the expected families were found at the site) to around one (all of the families which were expected were found). It is also possible to derive a score of greater than one, if more families were found at the site than were predicted by the model. A site with a score greater than one might be an unexpectedly diverse location, or the score may indicate mild nutrient enrichment by organic pollution, allowing additional macroinvertebrates to colonise.

The O/E scores derived from the model can then be compared to bands representing different levels of biological condition, as recommended under the MRHI (table 2). This allows an assessment of the level of impact on the site to be made and characterisation of the general health of the part of the river that was sampled.

At this stage of its development, it appears that AUSRIVAS is more sensitive to changes in habitat than to changes in water quality.

Reporting results

With the end of the initial three-year biological monitoring program, a base of assessment has been completed for all the major river basins in Victoria. Currently, a wide range of test sites subject to the impact of pollution are being sampled and assessed against the MRHI models.

The River Health Bulletin series and River Health condition maps provide a summary of the health of streams in each basin as it becomes available. Direct access to the information collected under this program is expected to be available in September 2000 via the world-wide web.

Table 2: Example of AUSRIVAS O/E family score categories, for combined seasons edge data

Band label	*O/E scores*	*Band name*	*Comments*
X	>1.14	richer than reference	◆ more families found than expected ◆ potential biodiversity 'hot spot' ◆ possible mild organic enrichment
A	0.85–1.14	reference	◆ index value within range of the central 80% of reference sites
B	0.56–0.84	below reference	◆ fewer families than expected ◆ potential mild impact on water quality, habitat or both, resulting in loss of families
C	0.27–0.55	well below reference	◆ many fewer families than expected ◆ loss of families due to moderate to severe impact on water and/or habitat quality
D	<0.27	impoverished	◆ very few families collected ◆ highly degraded ◆ very poor water and/or habitat quality

THE HEALTH OF STREAMS IN THE CAMPASPE, LODDON AND AVOCA CATCHMENTS

The Campaspe, Loddon and Avoca catchments have their headwaters at moderate to low altitudes in the gently undulating hills of the Great Dividing Range in central western Victoria. The three catchments cover an area of a little over three million hectares. The major rivers flow northwards, leaving the foothills and meandering across the broad Murray riverine plain to eventually flow into the River Murray, or in the case of the Avoca River into Lake Bael Bael.

The region is characterised by a dry climate, with relatively low and irregular rainfall. Annual rainfall ranges from about 300 mm on the northern plains to 1200 mm in the southern highlands. Surface run-off is very low over the greater part of each catchment, with only the southern uplands having an average run-off greater than 25 mm per year. All streams in the catchments have natural flows which are extremely variable, often with long periods of very low flows broken by periods of above average flows following heavy or extended rainfall. The variability of stream flow increases from east to west across the three catchments. In the north of the catchments, the lack of habitat diversity in the slow flowing riverine plain streams and the natural environmental stresses imposed by the extreme variability of stream flow have historically influenced river invertebrate communities.

Prior to European settlement the Campaspe, Loddon and Avoca catchments were almost completely covered by native forests and open woodlands. Much of the land has since been cleared for agriculture, and 80–90 per cent of the catchment is now grassland or planted to crops. The small pockets of remaining native forest are predominantly at higher elevations in the south of the catchments.

It has long been recognised that the removal of native vegetation, including much of the riparian vegetation, and the almost complete allocation of available water to meet irrigation, local agricultural and urban needs has resulted in reduced stream flows and considerably degraded instream environments (Anon. 1988). Flows are strongly regulated, and approximately 270,000 hectares of land in the lower Campaspe and Loddon catchments are irrigated. Reservoirs located on the major rivers harvest water in winter and spring, and store it for irrigation release in summer and autumn, thus reversing the natural seasonality of downstream flow regimes.

Major water quality problems which have been recognised in the region include elevated stream salinities and high nutrient concentrations. The extensive clearing of trees and their replacement with shallow-rooted pasture and crop plants is the main cause of increased stream salinities, while poor land management practices and the disposal of waste products and sewage effluent from population centres such as Bendigo, Kyneton, Castlemaine and Maryborough have contributed to high concentrations of nitrogen and phosphorus.

Biological Assessment

Biological data are available for 47 sites from the three catchments. Although samples were collected from edge habitats at all sites, only 43 sites were sampled in both autumn and spring, while four sites were dry in autumn and were sampled in spring only. Riffles were absent from most sites, and kick samples were collected from only 18 of the 47 sites. Sixteen of these were sampled in both seasons, while two were sampled in spring only. The location of sites is presented in figure 1.

Ordination and classification of sites based on biological communities highlighted the strong influence of altitude. In general, upstream sites in the foothills and at higher elevations supported invertebrate communities that differed from communities at downstream sites on the plains. For presentation of results and discussion, the sites have been grouped into: 1) foothill or broad valley sites at altitudes greater than 250 metres, 2) broad valley or upper plains sites at altitudes of 150–250 metres and 3) sites on the northern plains at altitudes of less than 150 metres.

Results of biological assessments are presented in table 3 (Edge habitat) and table 4 (Riffle habitat). Within the altitudinal groupings, sites are listed in order of increasing SIGNAL scores.

Also presented are nutrient and conductivity data obtained at the time of biological sampling. Figures presented are median values for a small number of samples (usually less than four), and therefore of limited value in characterising general water quality. They do, however, provide a snapshot of water quality at the time of sampling. For some sites, more extensive water quality data are available in Anon. (1998). Concentrations of phosphorus and nitrogen are compared with *Preliminary Nutrient Guidelines for Victorian Inland Streams* (EPA 1995), and electrical conductivities are compared with the recommended maximum for Australian freshwaters of 1500 μScm^{-1} (ANZECC 1992).

AUSRIVAS and SIGNAL

1. Foothills and Higher Elevation Sites

Edge samples were collected from all 15 sites in this group, and riffle samples were collected from 10 of the sites. The SIGNAL index rated most of the edge communities as fair, while AUSRIVAS rated most as reference or above (table 3). Riffle communities yielded similar results (table 4). Nutrient guideline maxima for nitrogen were exceeded at all 15 sites and for phosphorus at eight sites. Conductivities were below 1500 µS/cm at all sites.

One of the lower rating sites was the Campaspe River at Carlsruhe (FFJ), where edge communities were rated by SIGNAL as poor and by AUSRIVAS as below reference. At this site the stream has high, unprotected, eroding banks and flows through grazing land. At the time of biological sampling the water was high in nutrients, low in dissolved oxygen and the sediments were anaerobic.

Three of the more impacted Group 1 sites were small tributary streams with very little surface flow. Middle Creek at Puntons Road (HGV) had a riffle community which was rated by SIGNAL as poor and by AUSRIVAS as well below reference, while the edge community was rated as fair and below reference, respectively. The site was located in grazing land, nutrient concentrations were high, and when sampled in autumn the stream was barely flowing. Dissolved oxygen concentrations were low and the water had a decidedly black appearance. The stream is perhaps intermittent, and the riffle is marginal in terms of habitat quality. Organic loading (either from livestock or from riparian leaves and bark) probably exceeds the capacity of the stream to process the material without deterioration in water quality.

Cochranes Creek at McIntyre Road (HGO) is also a small stream located in grazing land, with extremely high nitrogen and phosphorus concentrations. The stream was not flowing when sampled in autumn, and although there was some flow in spring the dissolved oxygen concentration was less than 10 per cent saturation. Again, the volume of water is probably inadequate to cope with organic loading.

Rutherford Creek at Curtis Road (HGU) was similar to the previous two sites, with no surface flow when sampled both in autumn and spring, high nutrient concentrations and low dissolved oxygen concentrations.

The four sites discussed above were ranked by SIGNAL as the worst of the higher elevation sites. This indicates that invertebrate communities at these sites include a greater proportion of pollution tolerant families than do communities at other higher elevation sites. The actual numbers of families recorded from these sites were also very low, again indicating that the sites are less healthy than other sites.

2. Broad Valley–Upper Plains Sites

Riffles were present at seven of the 19 sites in this group, while edge samples were collected at all sites. The SIGNAL index rated edge communities as fair at most sites, while AUSRIVAS rated seven sites as below or well below reference and the remainder as reference or above. Riffle communities were rated by SIGNAL as fair at most sites, and by AUSRIVAS as below reference at three sites and reference at four sites. Nutrient guideline maxima for total nitrogen and total phosphorus were exceeded at 18 sites and 14 sites, respectively. Conductivity exceeded 1500 µS/cm at 12 of the 19 sites.

In the Campaspe River downstream of Lake Eppalock (FFA), riffle and edge communities were both rated as poor by SIGNAL, and riffle communities as below reference by AUSRIVAS. Nutrient concentrations and conductivity readings at the site were not excessive. Below Lake Eppalock 'the Campaspe has moderate instream habitat conditions, with adequate riparian vegetation and no major erosion problems' (Anon. 1988). Flow variations imposed by release from Lake Eppalock to ensure adequate seasonal irrigation flow would appear to be the primary cause of the unhealthy invertebrate communities. Sudden reductions in flow, for example, will strand riffle invertebrates, and if severe could eliminate species from the site.

Bendigo Creek at Lyons Road (GGL) and Bendigo Creek at Neilborough Road (GGM) are located downstream from urban Bendigo and downstream of the Bendigo Sewage Treatment Plant, respectively. At Lyons Road, the edge community was rated poor by SIGNAL and below reference by AUSRIVAS. High nutrients and anaerobic sediments were noted, which are typical of many urban streams and indicative of organic enrichment. At Neilborough Road, the riffle community was rated fair and below reference by SIGNAL and AUSRIVAS while the edge community was rated poor and below reference, respectively. Phosphorus and nitrogen concentrations were extremely high. Clearly, the Sewage Treatment Plant is contributing significant organic enrichment to the stream.

Edge communities at Number 2 Creek (HGJ) and Campbell Creek (HGQ) were assessed as poor by SIGNAL and below reference by AUSRIVAS. The sites supported low numbers of invertebrate families. Nutrient concentrations were high at Campbell Creek, but were not excessively so at Number 2 Creek. Both streams are relatively small tributaries in grazing land, and impact on invertebrate communities is probably mostly attributable to environmental stress during periods of low or zero flow.

The edge community at Homebush Creek (HGW) was rated fair by SIGNAL but as well below reference by AUSRIVAS. The stream is small and exposed, with grass extending to the side of the channel and shrubs and trees absent from most of the riparian zone. Banks are steep and eroding, and the bottom substrate is predominantly clay with some sand. The habitat diversity is extremely low, which explains the low number of invertebrate families collected and the low AUSRIVAS rating. A similar explanation can be advanced for the low AUSRIVAS rating of the Avoca River at Charlton (HGZ). This site also featured a predominantly clay substrate and low family richness, as well as moderately-high conductivity measurements.

3. Lower Plains Sites

A single reference site from the lower plains of these catchments was used in the building of the AUSRIVAS model, which perhaps compromises the model outputs. Edge samples were collected from all 13 sites in this group, while riffle habitat was present at one site only. Edge communities were rated by SIGNAL as fair at most sites, while AUSRIVAS rated five sites as reference and the remainder as below or well below reference. One site was outside the experience of the model. The single riffle community was rated by SIGNAL as poor and by AUSRIVAS as below reference. Nutrient guideline maxima for nitrogen and phosphorus were exceeded at nine and 10 sites, respectively. Conductivity exceeded 1500 µS/cm at five of the sites.

Yeungoon Creek at Nine Mile Road (HGL) was a shallow, earthen ditch in cropped land, with riparian vegetation consisting of short grass only. The stream substrate was silt and clay, and this lack of habitat diversity explains the low number of families present and the poor SIGNAL and AUSRIVAS ratings. The site was dry in autumn, and probably holds water for a limited period each year. Nutrient concentrations were quite low, although the concentration of total phosphorus was a little above the nutrient guideline maximum.

Both edge and riffle habitats were available at Mt Hope/Bendigo Creek at Mitiamo (GGI). The SIGNAL index ratings were poor for communities in

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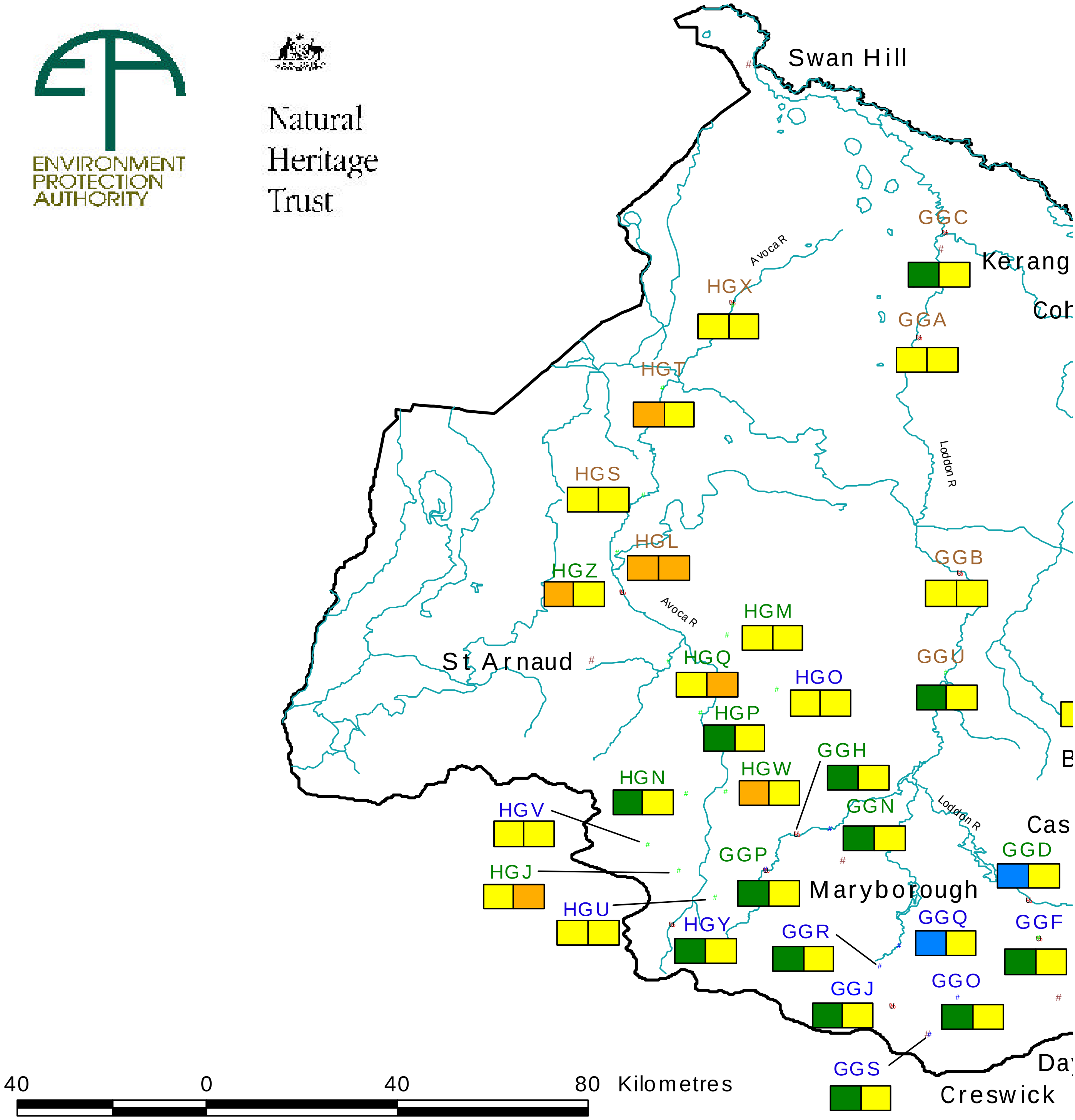
Figure 1: AUSRIVAS O/E and SIGNAL fam
for the Campaspe, Avoc



bands (edge habitat, combined seasons)
nd Loddon Catchments

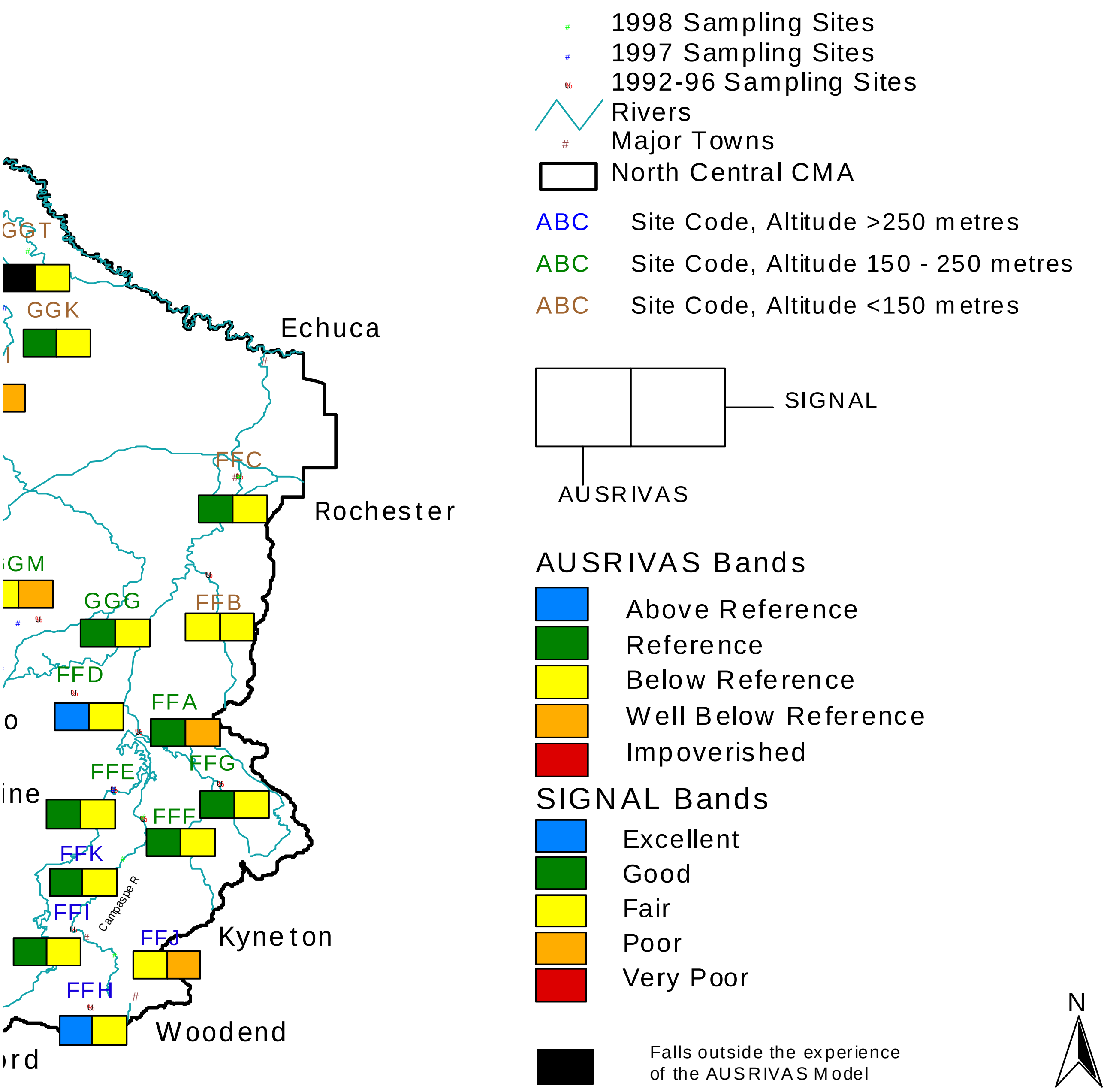


Table 3: AUSRIVAS O/E and SIGNAL scores for combined season edge samples from sites in the Campaspe, Loddon and Avoca catchments (grouped by altitude)

Within each group sites are arranged in order of increasing SIGNAL score. Family numbers fewer than 20 are highlighted, as are values of Total Phosphorus and Total Nitrogen which exceed nutrient guideline maxima and conductivities exceeding 1500 µS/cm.

		CombEdge SIGNAL	CombEdge AUSRIVAS	No. of Families	Total P (mg/L)	Total N (mg/L)	EC@25°C (µS/cm
Group 1 Foothill sites, Altitude >250 metres							
FFJ	Campaspe R @ Carlsruhe	4.65	0.8	18	0.088	1.16	726
HGO	Cochranes Ck @ McIntyre Rd	5.07	0.61	16	0.21	2.5	150
HGV	Middle Ck @ Puntons Rd	5.08	0.57	15	0.065	1.46	937
HGU	Rutherford Ck @ Curtis Rd	5.11	0.58	19	0.124	1.552	357
GGJ	Creswick Creek, Mac Rae Road Ford	5.19	1.02	28	0.043	0.834	522
FFI	Campaspe R @ Kyneton	5.25	1.1	30	0.022	0.402	348
GGF	Jim Crow Ck, Yandoit-Dalesford Rd	5.33	1.1	31	0.025	0.62	356
FFK	Campaspe R, Kyneton-Heathcote Rd	5.33	1.08	28	0.179	0.898	818
HGY	Avoca River, Amphitheatre	5.34	1.04	35	0.019	0.691	917
GGS	Creswick Ck, Creswick	5.37	0.9	29	0.031	0.992	644
GGR	Birch Ck (Bullarook Ck), N of Clunes	5.38	1.07	34	0.015	0.92	1147
GGO	Birch Ck, Smeaton	5.46	0.94	28	0.022	1.71	216
GGE	Loddon R @ Vaughn	5.53	1.17	32	0.032	0.638	243
GGQ	Tullaroop Ck	5.6	1.19	31	0.014	0.668	1163
FFH	Campaspe R @ Ashborne	5.69	1.41	31	0.015	0.306	111
Group 2 Broad valley-plains sites, Altitude 150–250 metres							
GGM	Bendigo Ck, Neilborough Rd	4.56	0.79	18	2.655	3.3	1351
HGJ	Number 2 Ck @ Robinson-Percyville Rd	4.67*	0.56*	15	0.034	0.47	212
GGL	Bendigo Ck, Lyons Rd	4.9	0.81	22	0.29	0.915	3800
HGQ	Campbell Ck @ Stockham Bridge Rd	4.94	0.76	16	0.149	1.915	2117
FFA	Campaspe R d/s Eppalock	4.95	0.89	23	0.017	1.22	417
GGG	Bendigo Creek, Huntly	5	1.13	32	0.645	1.436	1843
HGM	Fentons Ck @ Fentons Creek Rd	5.05*	0.65*	19	0.04	0.955	2160
HGZ	Avoca River, Charlton, Coonooer Bridge	5.2	0.54	13	0.032	0.861	8928
GGP	Bet Bet Ck, Gordons Bridge	5.21	1.1	35	0.036	0.734	3025

		CombEdge SIGNAL	CombEdge AUSRIVAS	No. of Families	Total P (mg/L)	Total N (mg/L)	EC@25°C (µS/cm)
HGP	Avoca R near Emu, St Arnaud Dunolly Rd	5.24	0.97	25	0.072	1.215	5830
GGH	Bet Bet Creek, Norwood	5.28	0.88	26	0.069	0.856	3506
GGD	Loddon River, Newstead	5.37	1.22	33	0.38	0.639	630
FFE	Coliban R, Lyal Bridge	5.39	1.05	34	0.022	0.799	942
HGW	Homebush Ck @ Dunluce-Nate Yallock Rd	5.44	0.39	9	0.078	2.4	3682
HGN	Cherrytree Ck, St Arnaud-Maryborough Rd	5.48	0.89	22	0.147	1.8	932
FFF	Campaspe R @ Redesdale	5.48	1.11	34	0.061	1.1	870
FFD	Axe Ck @ Longlea	5.5	1.19	33	0.024	0.441	2105
GGN	Bet Bet Ck, Timor	5.52	1.08	28	0.068	1.157	2996
FFG	Wild Duck Ck, Kyneton-Heathcote Rd	5.6	1.09	32	0.033	0.69	1753
Group 3 Plains sites, Altitude <150 metres							
HGL	Yeungoon Ck @ Nine Mile Rd	4.82*	0.52*	12	0.054	0.797	821
GGI	Mt Hope/Bendigo Creek, Mitiamo	4.89	0.94	21	0.98	3.311	1209
GGT	Gunbower Ck @ Shelley's Rd	5.07	Outside model	15	0.077	0.596	236
FFC	Campaspe R @ Rochester	5.18	0.99	29	0.036	0.905	1473
HGS	Avoca R d/s Charlton, Arundell St Bdge	5.22	0.83	18	0.063	0.743	4783
GGA	Loddon River, Appin South	5.24	0.69	17	0.11	1.403	1382
GGK	Mt Hope Ck	5.27	0.99	23	0.28	2.532	1525
FFB	Mt Pleasant Ck @ Runnymead	5.28*	0.79*	22	0.017	0.303	1440
GGC	Loddon River, d/s Kerang	5.35	0.91	23	0.141	1.204	428
GGU	Loddon R @ Browns Rd	5.36	0.89	25	0.051	0.728	1877
HGX	Avoca R @ Quambatook (Meering Rd)	5.43	0.74	22	0.107	1.952	6587
GGB	Loddon River, Serpentine Weir	5.54	0.65	14	0.025	0.804	1052
HGT	Avoca R d/s Ninyeunook Rd	5.94	0.54	18	0.121	1.43	5615

SIGNAL	AUSRIVAS O/E
Excellent	Above reference
Clean water	Reference
Mild pollution	Below reference
Moderate pollution	Well below reference
Severe pollution	Impoverished

* Spring sample only

Reference site, used for AUSRIVAS model building

Outside model – characteristics of the site are outside the experience of the model

Table 4: AUSRIVAS O/E and SIGNAL scores for combined season riffle samples from sites in the Campaspe, Loddon and Avoca catchments (grouped by altitude)

Within each group sites are arranged in order of increasing SIGNAL score. Family numbers fewer than 20 are highlighted, as are values of Total Phosphorus and Total Nitrogen which exceed nutrient guideline maxima and conductivities exceeding 1500 uS/cm

		CombRiffle SIGNAL	CombRiffle AUSRIVAS	No. of Families	Total P (mg/L)	Total N (mg/L)	EC@25°C (µS/cm)
Group 1 Foothill sites, Altitude >250 metres							
HGV	Middle Ck @ Puntons Rd	4.47	0.48	18	0.065	1.46	937
FFI	Campaspe R @ Kyneton	5.48	0.81	23	0.022	0.402	348
HGY	Avoca River, Amphitheatre	5.48	1.11	30	0.019	0.691	917
GGF	Jim Crow Ck, Yandoit-Dalesford Rd	5.59	0.92	23	0.025	0.62	356
GGE	Loddon R @ Vaughn	5.62	1	28	0.032	0.638	243
GGQ	Tullaroop Ck	5.62	1.11	30	0.014	0.668	1163
FFH	Campaspe R @ Ashborne	5.64	0.57	28	0.015	0.306	111
GGJ	Creswick Creek, Mac Rae Road Ford	5.75*	0.91*	17	0.043	0.834	522
GGR	Birch Ck (Bullarook Ck), N of Clunes	5.86	1.05	30	0.015	0.92	1147
GGO	Birch Ck, Smeaton	6.19	0.91	23	0.022	1.71	216
Group 2 Broad valley-plains sites, Altitude 150-250 metres							
FFA	Campaspe R d/s Eppalock	4.75*	0.56*	17	0.017	1.22	417
GGM	Bendigo Ck, Neilborough Rd	5	0.72	19	2.655	3.3	1351
GGH	Bet Bet Creek, Norwood	5.41	0.83	24	0.069	0.856	3506
GGD	Loddon River, Newstead	5.44	1.11	30	0.38	0.639	630
FFG	Wild Duck Ck, Kyneton-Heathcote Rd	5.61	0.94	25	0.033	0.69	1753
FFE	Coliban R, Lyal Bridge	5.68	1	27	0.022	0.799	942
FFF	Campaspe R @ Redesdale	5.89	1	30	0.061	1.1	870
Group 3 Plains sites, Altitude <150 metres							
GGI	Mt Hope/Bendigo Creek, Mitiamo	4.93	0.67	17	0.98	3.311	1209

SIGNAL	AUSRIVAS O/E
Excellent	Above reference
Clean water	Reference
Mild pollution	Below reference
Moderate pollution	Well below reference
Severe pollution	Impoverished

* Spring sample only

Reference site, used for AUSRIVAS model building

Outside model – characteristics of the site are outside the experience of the model both habitats. The edge community was rated by AUSRIVAS as reference. As previously mentioned, the SIGNAL biotic index is a particularly good indicator of water quality, while AUSRIVAS is more sensitive to habitat quality. Water quality at the site was poor, with very high nutrient concentrations. However, habitat diversity was fairly good.

The Avoca River downstream of Ninyeunook Road (HGT) was rated fair by SIGNAL, but the actual score was not far below good. However, the site was rated as well below reference by AUSRIVAS. Nutrients and conductivity were high at the site, the banks were steep and eroding and the substrate predominantly clay. The low AUSRIVAS rating is probably attributable to the absence of good quality habitat.

Summary

Macroinvertebrate communities at the majority of sites in the three catchments show evidence of being impacted. Assessment using the SIGNAL biotic index rated all but a single riffle community as fair or poor, while assessment using AUSRIVAS rated communities at approximately half the sites as either below reference or well below reference.

One difficulty with the AUSRIVAS approach to assessment is that many of the reference sites, particularly in the lower catchments, are themselves impacted. Unfortunately, the absence of pristine sites has meant that the least impacted sites have had to be used for model building. If a test site is rated as 'reference' it is strictly being assessed as comparable to reference sites, and since these are impacted sites then so too is the test site. This partly explains why assessment using AUSRIVAS has rated the biological health of most sites higher than has assessment using the SIGNAL score. Another reason for the difference in ratings is that AUSRIVAS appears to be more sensitive to changes in habitat than to changes in water quality, while SIGNAL is more sensitive to changes in water quality.

Most streams in the three catchments are subject to natural stresses imposed by low and often irregular rainfall. Hydrologically the streams are less predictable than streams in eastern and southern Victoria, and historically this has imposed restraints on macroinvertebrate communities. In the absence of pristine reference sites it is not possible to make a direct comparison between present day macroinvertebrate communities and communities prior to European settlement. Nevertheless, it is clear that natural stresses have been greatly exacerbated by activities since European settlement, and that this would have been accompanied by a deterioration of biological river health.

In the period since European settlement, native forests and woodlands have been cleared from 90 per cent of the catchment areas. Exotic pasture grasses have been planted, and riparian trees and shrubs have been extensively removed. Cattle and sheep have been introduced and allowed direct access to many streams. Water has been extracted from rivers and streams for agricultural and urban needs. Soil erosion and siltation of water courses has been enhanced by roadworks and other activities, and waste products of urban and rural communities have been introduced to the waterways.

Some of the consequences of these activities have been:

- reduction in the amount of water in streams and in the duration of surface flow (perhaps changing some permanent streams to intermittent ones);
- reduction in the amount of leaves and coarse organic material which enters streams and forms the basis of the food chain for many river invertebrate species;
- increase in the amount of clay and silt entering streams (changing the nature of the substrate and reducing habitat diversity);
- changes to water quality such as increased nutrient concentrations, increased salinity and reduced dissolved oxygen.

Recommendations

The major problems associated with reduced river health in the three catchments can be attributed to increased nutrient concentrations, increased water salinity, flow modifications and changes in streamside and instream habitat.

Remedial measures which should be undertaken to reduce nutrient inputs to streams include:

- revegetation of riparian zones and land surfaces which are subject to storm runoff, thereby reducing soil erosion and transport of associated nutrients.
- restriction of stock access to waterways, thus minimising bank erosion and preventing livestock excretory products from entering the stream.
- reduction of nutrient export from urban areas, which can be achieved by reuse of effluent from sewage treatment plants and the upgrade of treatment facilities from secondary to tertiary, and by the passing of stormwater runoff through artificial wetlands to remove nutrients.

The Government's water reform initiative aims to ensure that municipal sewage management is upgraded. All water authorities are currently implementing either major upgrades to their sewage treatment plants to reduce nutrient loads or are implementing new effluent reuse schemes. When completed, these measures should result in an improved level of river health in areas currently affected by nutrient rich discharges.

Salinity management plans for the North Central region have been developed, and implementation has already demonstrated the benefits of these plans (North Central Catchment and Land Protection Board, 1997). A continued commitment to the management plans is essential.

Remedial action to overcome the environmental impacts of flow modifications will be difficult. Available surface water in the three catchments is almost completely allocated for agricultural and domestic use, and redirection of water for environmental flows will have social and economic consequences. Nonetheless, it is essential that water audits be undertaken with a view to increasing river flows and establishing more natural flow regimes downstream of reservoirs.

The development of a catchment management strategy and associated implementation programs for the North Central region represents a very positive step for protection of the environment. It is essential, however, that the success of programs be evaluated. Monitoring of river macroinvertebrate communities is recommended as a measure of future environmental changes.

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Further Information

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