WATER QUALITY MANAGEMENT —
A TOTAL CATCHMENT
MANAGEMENT APPROACH

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ABSTRACT

Water quality standards set in the past have not helped resource managers in the
decisions that they face in seeking sustainable development. Resource managers
are looking for meaningful information on water quality so as to evaluate the
resource, set priorities for action, and to monitor progress. Resource managers
need to know how water quality affects, and is affected by, catchment uses and
activities. Examples of three wild and scenic rivers, the Nymboida, Murrumbidgee,
and Hawkesbury/Nepean River systems, demonstrate how a 'Total Catchment
Management' approach to resource use and resource protection has advantages for
water quality management.

KEYWORDS

Water resource management; wild and scenic rivers; total catchment management;
water quality criteria; Nymboida River; Murrumbidgee River; Hawkesbury/Nepean
River; land use management.

PREAMBLE

Australians, both traditional and European, have always had close ties to this
country's rivers. Rivers have been a means of transport, a source of food and
water, and an attractive place to live and play.

Our ties with rivers are no less significant today. Not only are our crops
irrigated and stock watered from rivers, but we swim and fish in them, boat on
them, walk, picnic or camp beside them. They feature in Australian art and
provide vital flora and fauna habitats in a land of irregular rainfall. The
activities mentioned above indicate the wide range of activities that influence,
and are influenced by, the quality of a river.

One indicator of river health is water quality. To achieve water quality
objectives, two approaches have generally been adopted. The first has been to
determine the sources of pollutants and determine acceptable standards for dis­
charges, applying penalties when the standards are not met. The other approach
has been to license discharges up to a prescribed total level of pollution for
a given waterbody.

Both approaches are very restrictive because they consider only a narrow
portion of the total water resource management picture. They ignore the nature
of activities in the catchment, have little hope of controlling dispersed
sources of pollution, take no account of localised interactions of pollutants
with the ecology, and provide no insight into the social and economic aspects of catchment use. Besides, pollution control agencies seldom have the resources to enforce the standards set.

With the water economy entering a mature phase, characterised by greater demands on a limited resource by competing and conflicting uses, it is no longer feasible to treat issues like water quality in isolation.

It is our contention that the science of water chemistry has the potential to contribute significantly to our understanding of the interaction between catchment uses and the resource and to how to manage the ecosystems of catchments for sustained productivity.

The impacts of recreational use of rivers with wild and scenic values will illustrate how water quality information, in its current form, seems to be an end in itself rather than a tool for resource managers to achieve the Total Catchment Management objectives mentioned above.

WATER QUALITY MANAGEMENT AND TOTAL CATCHMENT MANAGEMENT

All human activity in a catchment, including recreation and tourism, has an implication for water quality. Any aims or standards for water quality must affect catchment area activities if the standard is to be achieved. It follows then that water quality management needs to have a Total Catchment Management (TCM) perspective.

Total Catchment Management is about co-ordinating and integrating activities of resource managers and users, on a catchment-wide basis, to achieve a balance between resource use and resource protection. Water quality is but one attribute to manage for.

Water quality standards set in the past have not helped resource managers in the decisions that they face in seeking sustainable development. Resource managers are looking for meaningful information on water quality so as to evaluate the resource, set priorities for action, and monitor the progress of actions. To do this, resource managers need to know how water quality affects, and is affected by, catchment uses and activities. For instance, the implications of different levels of water quality for ecological health, recreation, or other water uses. This communication of needs and information can only occur if water chemists work closely with their market, the resource manager.

WILD AND SCENIC RIVER MANAGEMENT

The use made of rivers indicates their value. From all the rivers in New South Wales, some river reaches can be identified as having special value because of their recreational use, scenic, aesthetic, scientific, cultural, or historic qualities, environmental protection, or some other special attributes.

Such rivers and river reaches can attract the label 'Wild and Scenic River'. The 'Wild and Scenic River' label not only applies to the rushing white water of the Nymboida River, for example, but also the lazy meanderings of the wide Murrumbidgee, or even a dry river bed of the Channel Country where the only trees for miles around are found.

The river resources used for recreation spaces and consumptive uses often compete and conflict with environmental protection, and this can contribute to the degradation of the river and its associated land resources. The resource manager's task of resolving the conflicts is made more difficult by the fact that perfect knowledge of these dynamic river systems is not available. In the case of water quality issues, the lack of knowledge of the ecological responses to changes in the levels of nutrients, sediments, and so on, make absolute and comprehensive environmental standards impossible to set, at least for the present.

In a dynamic catchment ecosystem the management system must also be dynamic. A process that takes such dynamics into account is called 'Limits of Acceptable
A total catchment management approach

Change' (LAC), originally developed by George Stankey et al. (1985) in the USA. The process was first applied to the management of wilderness areas because the concept of carrying capacity was recognised as being inadequate and inappropriate. In addition, developments were changing the nature of wilderness areas.

Further, LAC recognises that ecosystems are continually changing due to climatic variation, vegetation dynamics or natural catastrophes such as floods or bushfires, as well as the impacts of human activities.

An important feature of LAC is the use of a set of indicator values of the key resources in the catchment to monitor and guide management of the catchment’s biophysical and social attributes with the aim of maintaining or achieving the desired condition of the resource or environmental quality.

The result of blending the TCM approach with the LAC process is a process that is issue-driven and performance oriented. In practice, this links the co-ordination of policies and activities of government agencies, local government, and individuals with the sustained productivity of agriculture and other resource uses and the protection of the environment. Fundamental is the description of appropriate and acceptable resource conditions, and the establishing of criteria for evaluating alternative resource allocations and management strategies.

Water quality criteria as indicators for evaluating alternatives would need to communicate the effects of various levels of suspended salts, nitrates, and phosphorus on crops and riparian native vegetation, turbidity, as it influences aesthetic appreciation, and acceptable levels of Escherichia coli with respect to domestic or urban consumption. Consequently, the important information will not be the quality of effluent as much as the quality of raw water at each point of use.

Monitoring management progress by measuring water quality requires knowledge of the critical value of each criterion and the degree to which activities contribute to a decline in quality. This is so that as each critical level is approached, the activity can be curtailed or measures to reduce the impact can be applied.

The application of LAC to the management of wild and scenic rivers would possibly involve four steps:

1. Identification and Classification.
2. Identify Issues.

IDENTIFICATION AND CLASSIFICATION

Through a consultant’s study, carried out by Cameron-McNamara, we have been developing a system of classifying coastal river reaches which we believe will be suitable for New South Wales. River reaches can be classified into three broad geomorphic forms: incised valley; mid-valley; and, floodplain.

The incised valley has a typical V-shaped valley profile with significant relief. Mid-valley settings have a well-defined valley floor with a U-shape or asymmetrical profile. Floodplain settings are broad river valleys with the river taking a sinuous, meandering form.

The classification will help define physical zones of management, grouping together reaches according to their geomorphic form, which often face similar pressures.

The social, use, and environmental attributes of wild and scenic rivers are incorporated using five criteria to give a management and social class within a geomorphic setting. The criteria are: land use; scenic value; access; hydrological modification; and, water quality.

Table 1 outlines the criteria for incised valley settings.
TABLE 1  River Setting: Incised Valley*  

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Class 1</th>
<th>Class 2</th>
<th>Class 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>95% tree cover in sub-catchment; no settlement evidence or other built intrusions.</td>
<td>80% tree cover in sub-catchment; occasional grazing, clearing or logging; minor built intrusions.</td>
<td>60% tree cover; clearing for agriculture or forestry operations; scattered settlement, in a sub-dominant role.</td>
</tr>
<tr>
<td>Scenic value</td>
<td>Outstanding; typically includes deeply incised gorges and waterfalls.</td>
<td>High; including rock outcrops and rapids.</td>
<td>Moderate; no precipitous slopes; occasional rapids.</td>
</tr>
<tr>
<td>Access</td>
<td>No vehicular access within river corridor except for occasional 4-wheel drive point sources.</td>
<td>Four-wheel drive access but limited primarily to point sources.</td>
<td>Occasional tracks or minor roads; possible lookouts on valley rim.</td>
</tr>
<tr>
<td>Hydrological modification</td>
<td>Essentially free-flowing with no regulation or modification.</td>
<td>Occasional minor regulation or water extraction.</td>
<td>Minor modifications including regulation and extraction principally for agricultural uses.</td>
</tr>
<tr>
<td>Water quality</td>
<td>Unmodified; no permanent increase in base load sediment or nutrients.</td>
<td>Partially modified; occasional minor deterioration (typically sediments &gt; 5 NTU for part of year and PO₄ and NO₃ levels around 1 and 6 mg/l respectively).</td>
<td>Modified; minor permanent deterioration (typically sediments &gt; 25 NTU for short periods and phosphate and nitrate levels generally exceed 1 mg/l and 6 mg/l respectively).</td>
</tr>
</tbody>
</table>

*Similar tables of criteria have been developed for mid-valley and floodplain settings.

An apparent correlation exists between geomorphic setting, land use, and wild and scenic river value, but not necessarily between settings. Accordingly, the standard of each criterion for each class varies with the geomorphic setting.

The most difficult criteria to establish are for water quality. We have had great difficulty obtaining sensible and meaningful values for water quality to use as indicators of wild and scenic river values. Water chemists consulted have been reluctant to offer any suggestions. The water quality values presented are for your consideration. In doing so, we would ask, as we did of our water chemists:

Is it appropriate to set state-wide or even regional standards for water quality, given the peculiarities of each catchment?

What might have been the water quality pre-European settlement?

Should the pre-European quality be the standard, given that some streams and rivers are naturally highly turbid and phosphate and nitrate levels have been radically altered as a result of changes in catchment conditions?

What is an achievable economic water quality standard?

What are the relationships between the various components that are measured to evaluate water quality?

In terms of classifying estuarine river reaches, their different geomorphic form and the different set of management problems has meant a classification is yet to be attempted.

The wild and scenic river values of western plains rivers have been determined and some rivers or areas with these values identified. The scales of aerial photographs and maps are too large and knowledge of the rivers too fragmented for a detailed classification at present.
ISSUES AND MANAGEMENT STRATEGIES

Three examples will highlight water quality as an issue and the benefits of managing on a TCM basis.

Nymboida River, New South Wales

The Nymboida River, in the north eastern region of NSW, rises in the Dorrigo Plateau and flows north-west before joining the Clarence/Mann River system.

The river is a popular rafting trip due to its spectacular incised gorges and white water reaches. The immediate river corridor is relatively undisturbed and the catchment mostly under the control of the National Parks and Wildlife Service or the Forestry Commission.

Overuse by commercial rafting operations and individual canoeists threatens water quality for continuing recreational use. In addition, the eastern freshwater cod is under threat. The Nymboida is the only remaining habitat and breeding area for the cod. The Nymboida is also the source of Grafton’s water supply, which is taken from the river below the reaches used heavily for recreation. Table 2 summarises the issues for the Nymboida and the state agency or local authority that has prime responsibility.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Prime responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational use</td>
<td>Forestry, Nat. Pk., Water Res., N. Shire, Lands</td>
</tr>
<tr>
<td>Access (vehicular, river, walking)</td>
<td>Forestry, N. Shire</td>
</tr>
<tr>
<td>Soil erosion/sedimentation</td>
<td>Soil Con., Ag.</td>
</tr>
<tr>
<td>Eastern freshwater cod/habitat protection</td>
<td>Ag. (Fisheries)</td>
</tr>
<tr>
<td>Land use and riparian vegetation</td>
<td>Soil Con., Water Res., Lands, Ag.</td>
</tr>
<tr>
<td>Development control/scenic protection</td>
<td>N. Shire, B. Shire, Nat. Pk.</td>
</tr>
<tr>
<td>Safety/search/rescue</td>
<td>Police, Emergency Ser.</td>
</tr>
<tr>
<td>Bushfire control</td>
<td>Forestry, Bush Fire Council, Lands</td>
</tr>
<tr>
<td>Water quality (turbidity)</td>
<td>Water Res., Pollution Cont., Grafton C.C.</td>
</tr>
<tr>
<td>Creation of natural tourism areas</td>
<td>Tourism, Planning, Lands</td>
</tr>
<tr>
<td>Communications and interpretation</td>
<td>Forestry, Nat. Pk., Lands</td>
</tr>
</tbody>
</table>

Managing the river resource and land use of the upper catchment to protect water quality for town water supply, habitat protection, and sustainable recreational use shifts the emphasis of management away from pollution standards to managing the whole resource-producing ecosystem. Table 3 presents a guide to the type of management strategy which could be developed to achieve this new emphasis.

Murrumbidgee River - Burrinjuck Dam to Wagga Wagga

The Murrumbidgee River rises in the Snowy Mountains in south-eastern New South Wales. The Tangarara Dam diverts water into the Snowy Mountains Scheme before the river flows south-east towards Cooma. Here it turns abruptly north across the Monaro Tableland and the Australian Capital Territory before turning west. Burrinjuck Dam, near Yass, regulates water primarily for the Murrumbidgee Irrigation Area further downstream. A short section of deeply incised valley broadens into a typically mid valley setting as far as Gundagai, where it is joined by the Tumut River. Downstream of the town, the valley broadens and the river meanders across the floodplain as it flows west across the plains, passing through the towns of Wagga Wagga, Narrandera, and Hay. The Lachlan joins the Murrumbidgee from the north as it turns southward through Balranald to join the Murray.

Between Burrinjuck Dam and Wagga Wagga, the wild and scenic river values include: recreation (rafting, camping, fishing) and the aesthetics of a large flowing river. However, several elements have an impact on water quality and threaten the wild and scenic river values.
TABLE 3 Nymboida River - Water Quality

**Objective:** That the water quality of the Nymboida study area remains of a standard that does not affect the recreational, scenic, or town water consumption potential of the resource.

**Desired condition:** That water quality be of a standard in its untreated form to conform with the NSW Department of Health urban water supply criteria, during all flow conditions. As well, turbidity should not exceed 5 NTU, phosphates 1 mg/l, and nitrates 5 mg/l.

**Inconsistency:** Grafton has been experiencing turbidity and micro-biological problems during high flow conditions. Sediments and nutrients enter the system from Dorrigo Plateau and near the town water supply off-take at Nymboida village. Forestry operations may increase sediment loads at times.

**Management options:**
- The Soil Conservation Service (Coffs Harbour) be asked to investigate the soil erodibility and sediment movement associated with agricultural practices (particularly potato growing, dairying and pasture improvement) within the Upper Nymboida catchment and recommend a strategy to overcome any identified problems.
- The Department of Water Resources re-schedule monitoring at gauging stations in the upper Nymboida catchment to specifically investigate any water quality problems.
- The Forestry Commission to develop operational procedures for logging adjacent to the Wild and Scenic River corridor to ensure a minimum sediment load reaching the river.
- The State Pollution Control Commission to monitor water quality indices, particularly pesticide levels, within the study area.
- The Nymboida Shire to develop standards relating to waste disposal options within the Wild and Scenic River corridor and advise landholders accordingly.

**Performance review:** Grafton City Council advise the management committee regularly (approximately every 6 months) of improvements or otherwise to water quality, using the monitoring information collected from Grafton’s town water supply.

The storage has altered in-stream water temperatures, oxygen levels, sediment movement and the frequency of river flushes. Gravel extraction has altered river cross sections and profile, increasing sedimentation and river bank instability resulting in increased turbidity. Agricultural activities have reduced riparian vegetation while pesticides, herbicides, and fertilisers have entered the river.

Ultimately, the decline in wild and scenic river values and water quality will have an impact on agricultural production of both private diverters and in the irrigation areas and districts. Even now, impacts affect the tourist potential of the area and reduce the value of the major recreational focus for Wagga Wagga's large population. Table 4 identifies the issues and the state agencies and local authorities who have prime responsibility for action.

TABLE 4 Murrumbidgee River - Major Management Issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Prime responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riparian vegetation</td>
<td>Soil Con., Water Res., Lands, Ag.</td>
</tr>
<tr>
<td>Water allocation and use</td>
<td>Water Res.</td>
</tr>
<tr>
<td>Development control - scenic protection</td>
<td>Y. Shire, H. Shire, G. Shire, Wagga C.C., Planning</td>
</tr>
<tr>
<td>Recreation use</td>
<td>Lands, Water Res.</td>
</tr>
<tr>
<td>Protection of inland fisheries</td>
<td>Ag. (Fisheries), Water Res.</td>
</tr>
<tr>
<td>Communications and interpretation</td>
<td>Water Res., Lands</td>
</tr>
<tr>
<td>Extractive industries</td>
<td>Water Res., Pollution Cont.</td>
</tr>
</tbody>
</table>
Table 5 further illustrates possible management strategies in this case.

**TABLE 5 Murrumbidgee River - Water Quality**

| Objective: | That the water quality of the Murrumbidgee study area remains at a standard that does not affect the recreational, scenic, agricultural, or town water consumption potential of the resource. |
| Desired condition: | That water management policies be introduced that minimise water quality issues downstream of the study area, recognising: the specific spawning requirements of native fish, particularly Murray Cod, the large evapotranspiration rates in summer which cause some salinity and nutrient problems, and the sediment loads, particularly emanating from the study area. |
| Inconsistency: | Currently there are few major water quality problems in the study area, apart from: high sediment movement during high flow from Adelong and Tarcutta Creeks (due to erodible soils in the catchment); high salt content emanating from Jugiong and Muttama Creeks (due to increased water table and geological conditions); and, low water temperatures from Burrinjuck Dam and more particularly from the high altitude catchment and bottom release Blowering Dam. The major water quality problems in the Murrumbidgee River manifest themselves further downstream predominantly below the Murrumbidgee Irrigation Area. However, the water release management of the two major storages feeding the Murrumbidgee, namely Burrinjuck and Blowering Dams, is critically important to the Wild and Scenic River values of the whole system. |
| Management options: | The Department of Water Resources and State Pollution Control Commission produce a statement on water quality issues within the study area, concentrating on point source issues and recommending policies for overcoming problems. The Soil Conservation Service representative advises the committee on options for reducing the salinity levels and sediment load in the previously defined creeks. |
| Performance review: | The Department of Water Resources reports annually (in its Annual Report) on trends in water quality indicators such as turbidity, temperature, and salinity. The trends should be linked with the specific management practices implemented in the previous period. |

The Department of Water Resources, being responsible for the licensing of gravel extraction and dam operations, will need to identify the practices contributing to turbidity and modify its policies to possibly exclude gravel extraction from the beds and banks and confine it to the floodplain.

The Department also needs to examine the timing and quantity of releases in terms of velocities, water level fluctuations, and water temperature, as well as the option of flushing releases and releases for recreation.

Other agencies should have the opportunity to advise on options to reduce salinity levels and sediment loads.

**Hawkesbury/Nepean River**

The Hawkesbury/Nepean drains the Southern Highlands from near Goulburn, the Woronora Plateau, the eastern side of the Great Dividing Range including the Blue Mountains and most of the Cumberland Plain.

The land uses in this catchment are equally as extensive: agriculture, water supply, urban, industrial, recreation. Most alter water quality to some extent or other. Further, the catchment will accommodate much of Sydney's population growth placing increasing and often conflicting demands on the river. The river and its tributaries frequently experience low flows which only partly dilute wastewaters discharged from the catchment.
Major tributaries of the Nepean are dammed for Sydney's water supplies and are therefore not operated to make releases generally. The weirs on the main river down to the tidal limit for regulating flow for agriculture and gravel extraction have altered the river profile. Together they have created greater lengths of shallow pools. The accumulative result is lowering of the river's assimilative capacity, compounding the existing problems of excessive nutrient concentrations and associated algal and weed growths.

Despite declining water quality, the Hawkesbury/Nepean is a major water-based recreation resource in a region bereft of such resources. Power boating and house boating add to the sources of sewage, oil, etc., entering the river.

Water quality problems can be solved partially by upgrading water treatment plants to remove nutrients. However, the ultimate solution lies in a combination of controls of sand and gravel extraction, urban run-off, and possibly releasing flushing flows from the dams as well as considering planning controls on future development.

Consideration also needs to be given to defining water quality requirements in terms of the desired condition of the estuarine ecosystem and the types of recreation to be encouraged in and along different river reaches.

CONCLUSIONS

Pollution agencies alone do not have the resources to enforce standards nor the perspective to set regional strategies. Water quality benefits can only be achieved by harnessing the wider resources of all relevant government agencies, by having consistent planning controls, and by educating and seeking the cooperation of river users - this is Total Catchment Management.

Issues such as sustainable recreation use, habitat protection, and water quality for agricultural use or town water supply place water quality standards in a management context. Water quality becomes a means to an end, not an end in itself.

A win in co-ordinating and managing activities on a catchment-wide basis, to obtain a balance between resource use and resource protection, can only mean a win for water quality objectives. The advantage is that the objectives are achieved by a process with a focus on issues and benefits, an approach that non-water chemist resource managers, politicians, and the community can understand.

Water chemists need to focus on the standards of receiving water, not just discharges. These standards then need to be communicated to resource managers who will use them in setting management objectives and measuring performance. If this focus and communication does not occur, it is doubtful if water quality problems can be effectively resolved.

REFERENCES

Cameron-McNamara. Wild and Scenic River - consultants' reports.