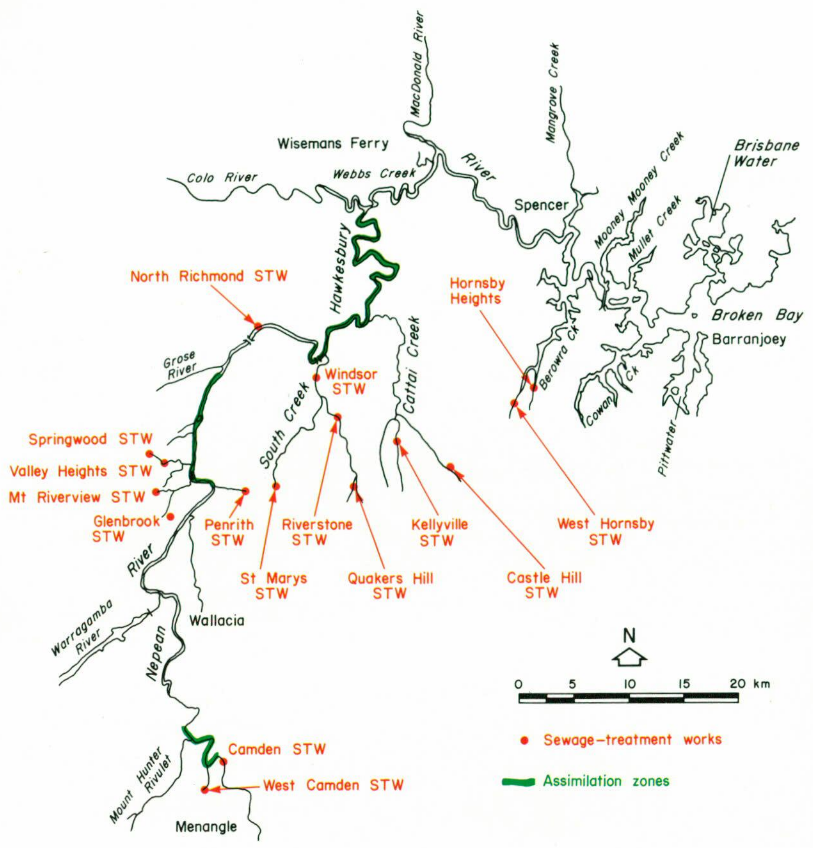


Predicted nutrient assimilation zones in the river in the year 2000, assuming the control strategy recommended by the SPCC is implemented.

areas and in the normally nitrogen-limited saline estuary, and also to keep nitrate concentrations in waters used for drinking purposes within acceptable health limits and to maintain the performance of treatment works.

A reduction in nutrient levels in effluents discharged to the tributaries is unlikely to improve the tributaries' water quality in the long term. For this reason, the details of the SPCC's recommended strategy are based primarily on the predicted effects of various control options on the water quality of the river itself.

By the year 2000, in order simply to maintain water quality and aquatic plant growths in the river at even their present (in some areas unsatisfactory) levels:

- "Nitrification" (ammonia-oxidation) facilities will be required at most of the sewage-treatment works discharging into the river and its tributaries.
- Nutrient-removal facilities will be required at the major sewage-treatment works discharging into the river between Penrith and North Richmond. Phosphorus should be made the nutrient limiting plant growth by installing phosphorus-removal facilities at all these sewage-treatment works.
- Phosphorus removal and limited nitrogen removal will be required at the sewage-treatment works discharging into South and Cattai Creeks.

In the case of the smaller sewage-treatment works at Windsor and West Camden and the proposed Menangle and Picton works, the irrigation of treated sewage effluents is a desirable strategy as an alternative to nutrient removal from effluent discharges to the river. This strategy may also be feasible at Riverstone. Planning authorities should ensure sufficient land is reserved for this purpose. At most of the large treatment works, however, it is unlikely that sufficient land will be available.

In addition to these controls on point sources of pollution, urban stormwater runoff should be detained in settling ponds or recreational lakes where practicable, to reduce pollutant loads to tributaries and the mainstream during wet weather.

Planning controls will be needed to minimise these and other diffuse inputs of nutrients to the river and its tributaries. Diffuse inputs will become increasingly significant as the sewage-effluent discharges – currently the dominant influence on river-water quality under normal flows – are progressively controlled and as the urbanisation of the catchment increases.

Priorities

The recommended priorities for improving the quality of effluents from sewage-treatment works are:

1. Nitrification of the effluents, to reduce ammonia toxicity effects, to reduce oxygen demands in receiving waters and to increase the extent of nutrient assimilation in the tributaries.

Algal bloom at Windsor

Duckweed, Azolla and Hydrodictyon growths at Penrith

2. Phosphorus removal, to 1 mg/L under dry-weather conditions. This would make phosphorus the limiting nutrient for aquatic plant growth, and would decrease the extent of plant growths between now and the year 2000.

   The major existing sewage-treatment works, Penrith, St Marys and Quakers Hill, should be the first to be equipped for phosphorus removal.

   Elsewhere, in those parts of the catchment below the water-storage reservoirs, phosphorus removal should also be provided at the smaller sewage-treatment works close to the river, such as Glenbrook, as soon as practicable.

3. Limited nitrogen removal under dry-weather conditions, to enable balanced aquatic plant growth to occur, to control nitrate concentrations in waters currently used for potable supplies and to maintain the performance of treatment works.

   A design effluent concentration of 5 mg/L total nitrogen has already been specified for the augmentation of the Penrith sewage-treatment works, and nitrogen removal is being considered for the older sections as well.

   Works discharging to or downstream of South Creek should treat their effluents so that they contain, as a weighted mean for all tributary works, 15 mg/L total nitrogen under dry-weather conditions.

   Because of the relatively high costs and more extensive plant modifications needed for nitrogen removal, this goal will have to be achieved on a progressive basis.

   New plants and augmentations of existing plants should, however, be designed taking nitrogen-removal requirements into account. The opportunity should be taken by sewerage authorities to remove larger proportions of nitrogen at new or augmented sewage-treatment works, where nitrogen removal will be more economical than at older works.

Greater degrees of phosphorus removal may be necessary further into the future, as the works continue to expand and as the nutrient loads discharged to the river again approach current levels towards the year 2000.

The responses of the river to progressive nutrient removal and the development of removal technology will both be factors in determining the ultimate optimum nitrogen and phosphorus levels at individual sewage-treatment works.

Future investigations

A number of specific aspects of the river are still being studied by the SPCC. One example is the impact of increased instream sandmining on the assimilation of nutrients entering the river.

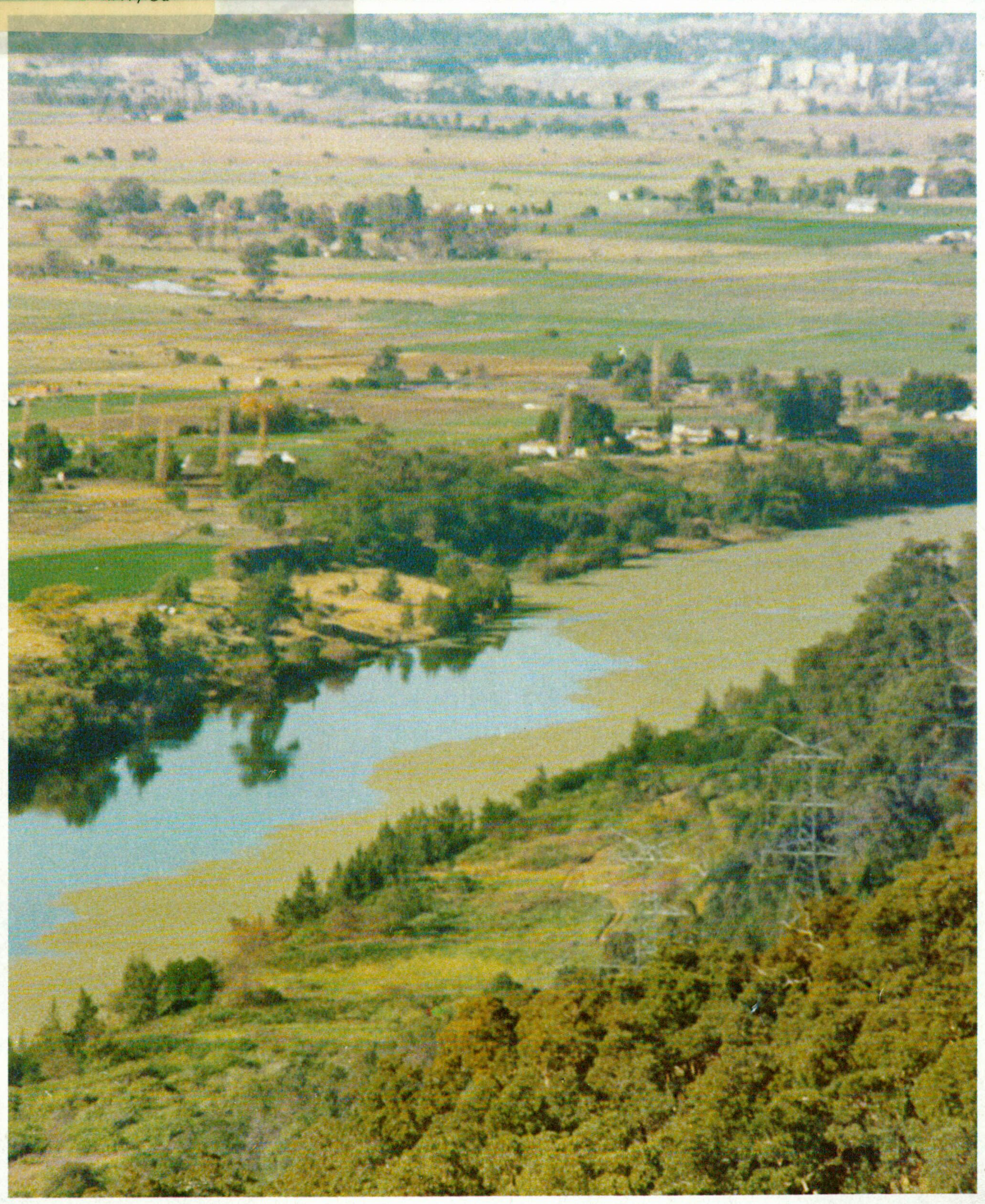
More generally, the implementation of the SPCC's recommended priorities will necessarily be progressive, and an ongoing evaluation of population-growth distributions, engineering practicalities, the responses of the river to changed nutrient loads and the options available for pollution control will be carried out to determine the most cost-effective expenditure of public funds.

This evaluation will be able to be used to review the above priorities in the light of practical experience, and to decide whether further pollution controls are needed as the catchment's population continues to increase.

Further information

For further information, please contact:

State Pollution Control Commission
157 Liverpool Street, Sydney 2000.
Telephone (02) 266 0661



Water Quality in the Hawkesbury-Nepean River

A Study and Recommendations

State Pollution Control Commission

Introduction

The population of the Hawkesbury-Nepean River catchment is increasing rapidly as a result of the northward and westward expansion of Sydney's urban areas.

This expansion increases the value of the river for recreation and amenity, but poses increasing water-pollution problems.

Treated sewage effluents from the urban areas in the river's catchment, including Blacktown, St Marys, Penrith, Liverpool, Campbelltown, Camden, Richmond, Windsor and Baulkham Hills, are predominantly disposed of by discharge to the river, often via short tributaries.

These effluent discharges are already placing the river under stress – and they are predicted to double by 1990 and treble by the year 2000.

The State Pollution Control Commission (SPCC) commenced studies in 1978 to:

- Identify current water-pollution problems in the river
- Predict future impacts
- Develop water-pollution control policies.

A detailed scientific report on these studies has been published and may be obtained from the SPCC. The major findings and recommendations are summarised in this leaflet.

Study methods

Water quality in the river and the quality of effluents from sewage-treatment works discharging to the river between Camden and Broken Bay were monitored between 1978 and 1981.

Measurements of flows enabled the quantities of pollutants being transported in the river and its tributaries to be calculated, and the data were then analysed, taking into account the effects of varying river flows.

Biological tests with algae were used to assist in assessing the potential effects of increased pollutant loads and to indicate which plant nutrient was limiting aquatic plant growth (that is, whether it was the availability of nitrogen, phosphorus or some other nutrient that determined the extent of plant growth in the river).

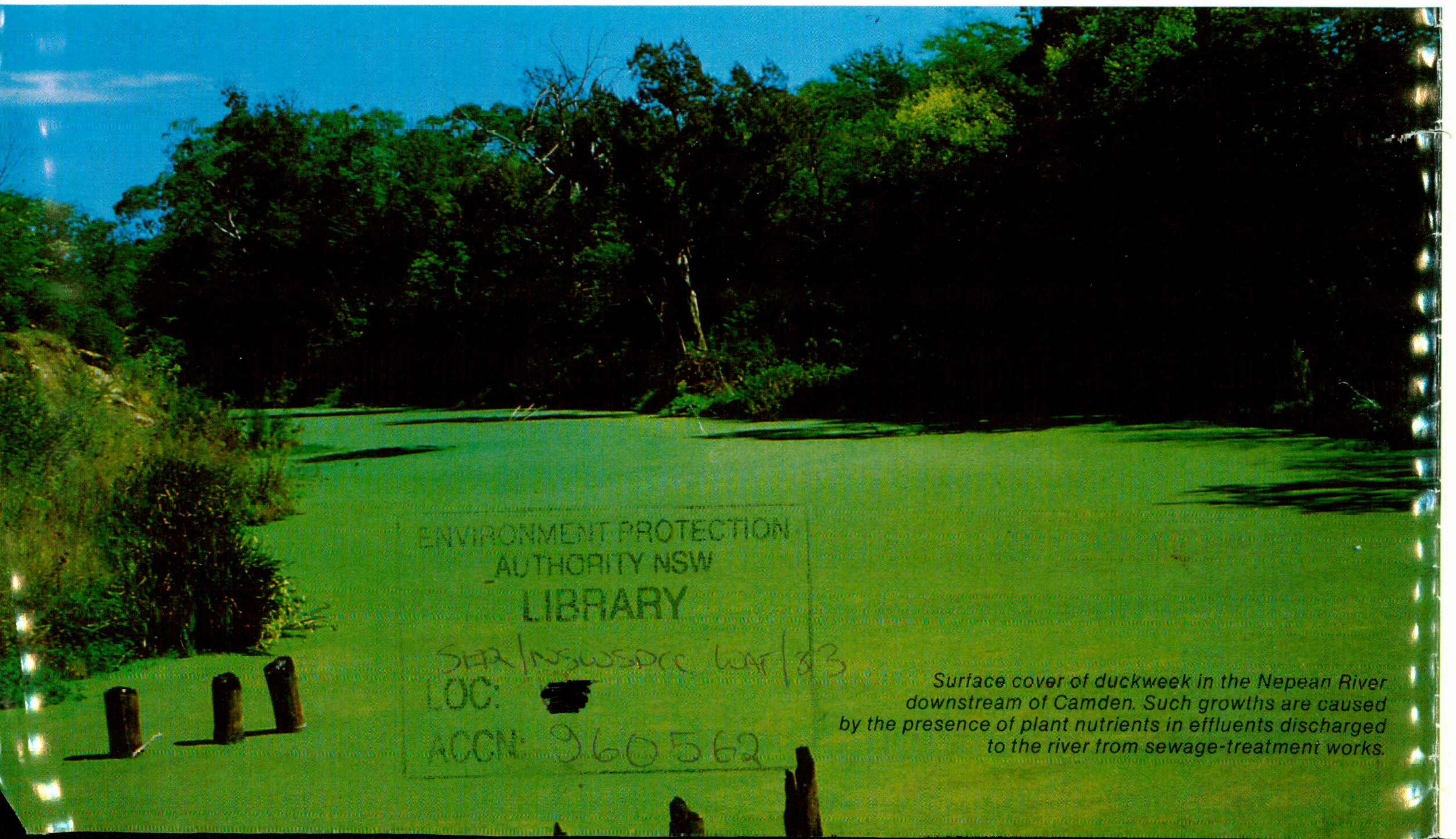
Mathematical "models" were prepared to simulate the "assimilation" of nutrients in the river under low-flow conditions and to enable predictions to be made of future pollution levels in the river for a variety of possible control strategies.

Existing water quality

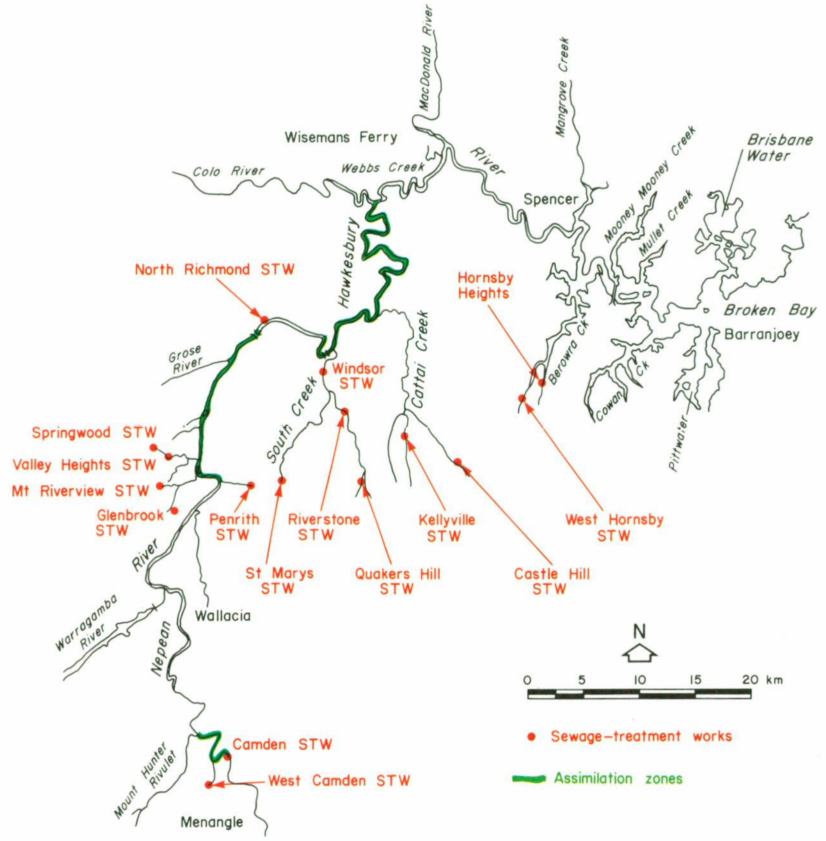
Under low to medium flow conditions, which occur at least 70 per cent of the time, the water quality of substantial sections of the Hawkesbury-Nepean River is affected primarily by point-source discharges from sewage-treatment works.

Diffuse sources of pollution, such as urban and rural runoff, generally have a significant effect on water quality only during wet weather and a short time afterwards.

The quantities of plant nutrients (especially nitrogen and phosphorus) in the effluents discharged from the sewage-treatment works are significantly greater than those normally transported by the river and its tributaries. For example, even the small Camden works, which have now been replaced by the larger



Surface cover of duckweek in the Nepean River downstream of Camden. Such growths are caused by the presence of plant nutrients in effluents discharged to the river from sewage-treatment works.



Nutrient-assimilation zones in the river in 1979-80. Excessive plant growths and degraded water quality occur in these zones under normal river-flow conditions. (The effects of treated sewage discharges to Berowra Creek are the subject of a separate SPCC study, and are not shown on these maps.)

West Camden works, used to discharge more phosphorus into the river than the Colo River did, even though its flow was only 1/200th of the flow of that tributary.

As a result, instream concentrations of nitrogen and phosphorus are markedly elevated downstream of the sewage-treatment works at Camden and Penrith and downstream of South Creek. South Creek transports treated sewage from the St Marys, Riverstone, Quakers Hill, HMAS Nirimba and Windsor sewage-treatment works.

The elevated nutrient concentrations in the river result in the growth of surface coverings (eg, duckweed and Azolla) and attached and suspended aquatic plants, the degree of impact depending on the proximity of the sewage-treatment works.

These growths incorporate nitrogen and phosphorus into plant biomass; ie, the nutrients are gradually "assimilated". Nitrogen is usually the nutrient limiting the amount of plant growth in the river (ie, nitrogen is usually the least available plant nutrient, and when the nitrogen is assimilated plant growth ceases even if phosphorus levels are still high).

Excessive aquatic plant growths decrease the aesthetic appeal of waters, diminish recreational use, change water quality so that river sections may be unsuitable for desired aquatic flora and fauna, and pose irrigation and potable water-treatment problems.

Other deleterious effects on tributary and mainstream waters caused by discharges of sewage effluents are increased oxygen demands, which reduce oxygen levels in the water, ammonia toxicity problems for aquatic fauna, and, where dilutions are low, malodours.

During low river-flow periods extensive saline intrusion can occur in normally freshwater sections of the estuary. In 1980 and 1981, for example, salinity was experienced more than 9 km upstream of the Colo River confluence, causing problems for irrigators with citrus crops.

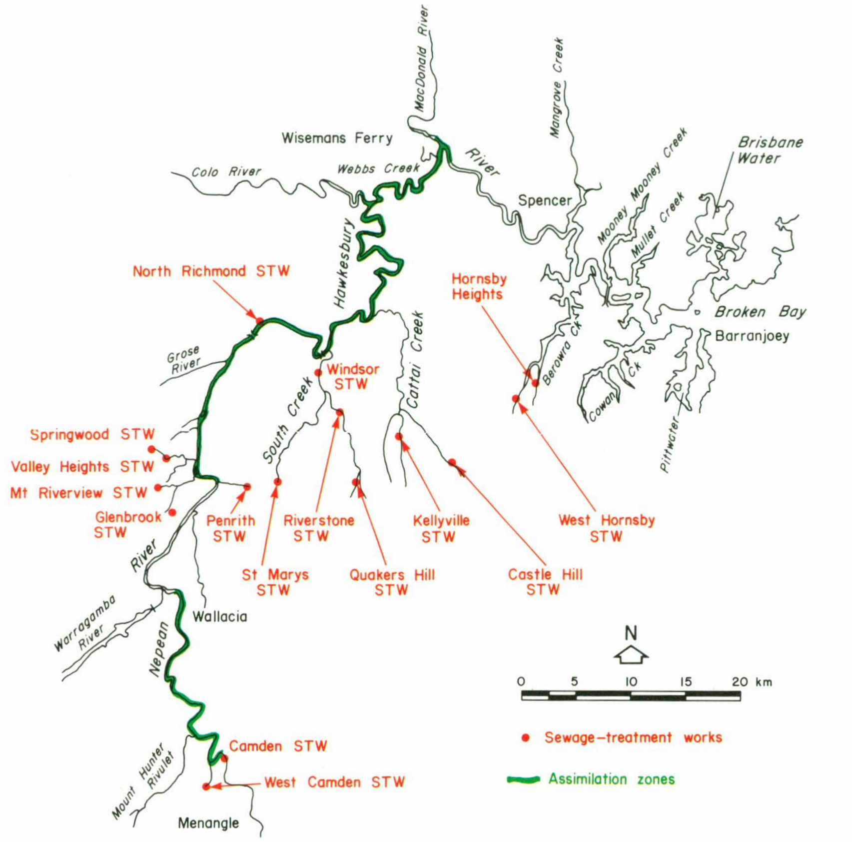
The flows in South, Eastern, Lapstone, Fitzgeralds and Cattai Creeks are predominantly treated sewage effluents. Nutrients are poorly assimilated in South and Eastern Creeks, probably because elevated ammonia concentrations inhibit plant growth, and water quality in these creeks is extremely poor.

Future water quality

Treated sewage-effluent discharges to the river are predicted to treble by the year 2000.

If control actions of the types recommended below are not implemented, the SPCC's studies predict that:

- The dilution of these effluents by the river will be considerably decreased, and instream concentrations will increase to levels 2 to 10 times those experienced today
- The length of the river adversely affected by aquatic plant growths



Predicted nutrient assimilation zones in the river in the year 2000, assuming no additional controls on the quality of treated sewage discharges are reduced.

during normal river flows will increase, with more than half the length of the river between Camden and Broken Bay being affected in this way
- Treated sewage effluents will make up more than 90 per cent of the flows in South, Eastern, Lapstone, Fitzgeralds and Cattai Creek, and there will be little assimilation of nutrients in these tributaries.

Control strategies

Ocean disposal of treated sewage effluents from the region is not recommended as a strategy to reduce the nutrient loads discharged to the river system. It is doubtful whether ocean disposal would be economically feasible, and increasing effluent flows in the river will increasingly help to prevent the problem of saline intrusion during low river-flow periods.

Banning or limiting the phosphate content of detergents would not overcome current or future water-quality problems. Even a complete ban would not reduce plant growths, and the environmental effects of the available substitutes for phosphates are uncertain.

The first recommended way in which the water quality of the tributaries and the mainstream can be improved is by reducing the ammonia concentrations in treated sewage effluents, by providing "nitrification" (ammonia-oxidation) facilities at the treatment works. This would prevent ammonia toxicity to aquatic fauna, facilitate more rapid assimilation of nutrients and reduce the de-oxygenating effects of the sewage discharges.

Steps to introduce such facilities at some of the major sewage-treatment works are already well advanced.

The remaining elements of the SPCC's recommended strategy to control the effects of point-source discharges incorporate varying degrees of both phosphorus and nitrogen removal from sewage effluents. In the case of some sewage-treatment works, irrigation of effluents rather than discharge to the river is recommended as a desirable alternative.

Because nitrogen is currently the nutrient limiting plant growth in the river, it might initially be thought that a reduction in the amount of nitrogen in sewage-effluent discharges would reduce the length of the river affected by plant growths. The removal of nitrogen **alone** could, however, actually encourage the growth of the less desirable species of algae, and is thus not a recommended control strategy.

On the other hand, a reduction in the amount of phosphorus in sewage effluents, so as to make phosphorus the nutrient limiting plant growth in most parts of the river, would definitely reduce plant growths, at least in the short term. Phosphorus removal is thus recommended as the primary control strategy.

Some degree of nitrogen removal would also be required, however, to enable balanced aquatic plant growth to occur, especially in shallow