NUTRIENT EXPORT FROM RURAL LAND IN THE HAWKESBURY-NEPEAN CATCHMENT

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Abstract

Nutrient runoff from land leads to eutrophication of surface water, which is a major problem in the Hawkesbury-Nepean.? Agriculture is a potentially significant contributor. Runoff and its nutrient concentration were measured over a 30 month period from three market gardens, two dairies and semi-improved pasture (mostly hobby farms). Eleven locations were monitored, seven of which were in a nested arrangement in a major subcatchment (Currency Creek). Nutrient export rates were very high for market gardens (200, 15 kg/ha/yr for N and P, respectively) and an intensive dairy (6N, 6P kg/ha/yr), whilst unimproved pasture had the lowest rates of 2 (N) and 0.3 (P) kg/ha/yr. At another location, a less intensive dairy had lower export rates (4N, 2P kg/ha/yr).? These values for agriculture are at the high end of the ranges suggested for use in the Catchment Management Support System program (CMSS). For the whole of the Currency Creek. subcatchment, the estimated long-term exports of N and P were high at 19.3 and 3.3 kg/ha/yr, respectively, suggesting that assimilation of nutrients was relatively low and action to reduce exports was urgently needed.

Key words: Agriculture, nutrient runoff, nitrogen, phosphorus, eutrophication.

Increasing frequency and severity of outbreaks of blue-green algae in the Hawkesbury-Nepean river system have focused attention on the contributors to eutrophication. In 1992, CSIRO released a report in which the Catchment Management Support System (CMSS) program was used to estimate contributions of various land uses to annual loads of nitrogen (N) and phosphorus (P) added to the Hawkesbury-Nepean (R. Davis, *pers. comm*.). Locally-derived data were used to estimate exports from urban areas and sewage treatment plants, whilst estimates of agricultural runoff were based on interstate and overseas data. Although no local data for rural lands were available for use in the study, the report showed that agriculture might account for as much as half of the annual nutrient load.

Given the paucity of data on nutrient runoff from rural land in the Hawkesbury-Nepean, and given the likely contribution of agriculture to poor water quality, it was important to obtain reliable information for use in CMSS. Moreover, the data provided to CMSS would also provide a baseline for erosion and nutrient export rates for major rural land uses in the catchment. This baseline could then be used to target remedial measures, and evaluate progress, in future programs which aimed to reduce land and water degradation in the catchment.

The overall objective of the project was to enable better management of nutrient inputs to the river system from agricultural land. The specific aims of the part of the project reported here were to:

• provide quantitative data on nutrient runoff andsoil loss for agriculture in the Hawkesbury-Nepean;

• provide baseline data to assess changes in the environmental impact of agriculture;

• provide estimates of nutrient generation rate to users of CMSS.

Methods

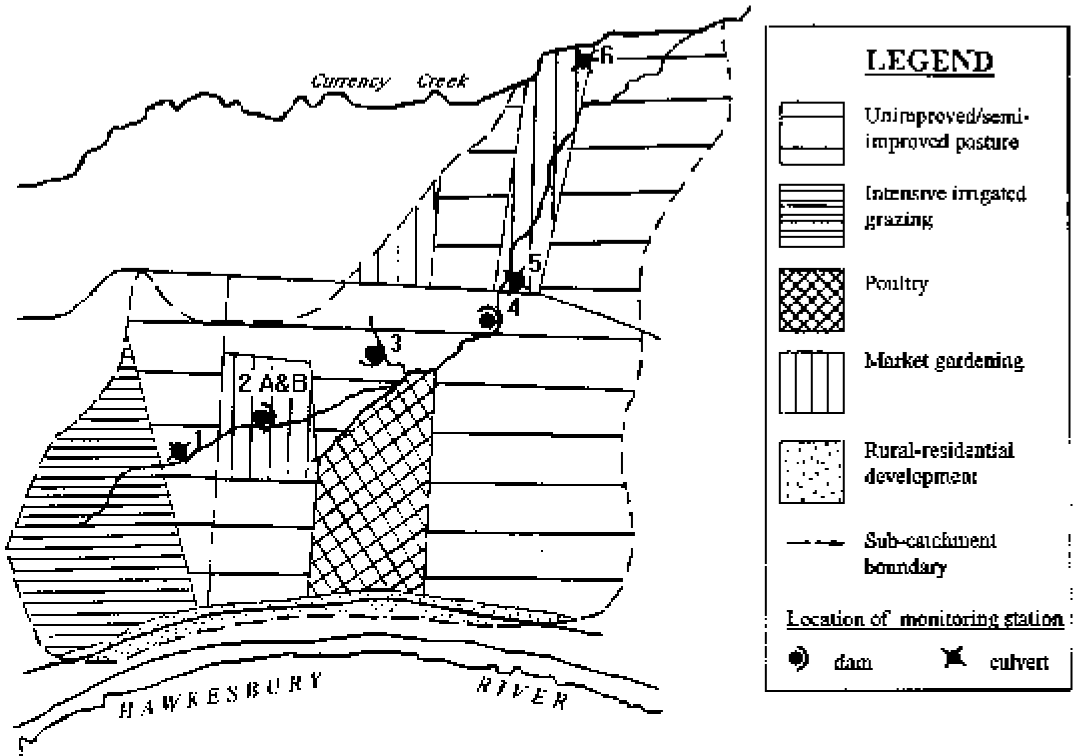

Figure 1

Eleven automatic monitoring stations were established at three locations in the catchment, commencing in 1995: a subcatchment of Currency Creek (near Richmond), Mangrove Mountain and near Camden (1). At the first two of these locations, stations were "nested" so that nutrient export from individual land uses could be measured, as well as the 'assimilat-ion' of nutrients beyond the farm. This paper focuses only on nutrient export. 'Nesting' made the paddock scale measurements relevant at the catchment scale. At Camden, a single dairy farm was monitored. Soils in Richmond and Camden were heavy in texture, derived from sedimentary material, while in Mangrove Mount-ain the soils were light-textured, being derived from sandstone.

The installation of equipment was staged so that monitoring periods varied from about 18-30 months. The longest sampling period and most intensive data collection were in the Currency Creek catchment. This subcatchment of 225 ha is typical of intensively used areas in Western Sydney, comprising 44 ha of intensive dairy pasture, 16 ha market garden, 165 ha semi- or unimproved pasture including several hobby farms, and a large intensive poultry establishment (Fig. 1). The subcatchment discharged to Currency Creek several kilometres from the confluence with the Hawkesbury River near Sackville.

Careful observations were made of farm management to explain the results and to relate land management to environmental impact.

At each monitoring station, measurements included:? rainfall; runoff (and the hydrograph); concentrations of soluble, particulate and total nitrogen (N) and phosphorus (P) during runoff; calculated nutrient export for each runoff event; and the pollutograph.

As the monitoring period was quite short, computer modelling was used to estimate annual generation rates averaged over much longer periods (1881-1993).

To measure discharge and water quality, existing landscape features were used where possible as control structures for gauging discharge. These included cul-verts and farm dams. Automatic water samplers were controlled by programmable loggers to take water samples using a variable-discharge-increment approach. In this way, we had the best chance of obtaining samples throughout runoff events, regardless of the magnitude of the event. After each runoff event, and often during events, water samples were recovered from the field and returned to the laboratory for storage and later analysis.

For each runoff event, and for each monitoring station, we obtained a record of rainfall and nutrient concentration through the event. From these results, total export of sediment and the different forms of N and P could be calculated for each location. Results were then converted to erosion and nutrient generation rates per hectare of land use.

Nutrient generation rate was calculated by summing total N and P exports over the sampling period, dividing by the number of months and multiplying by 12. This is a standard procedure, but for relatively short monitoring periods (like ours) results in estimates which may be heavily biased by hydrological events during the monitoring period. This is quite likely, as runoff and especially erosion are highly episodic events. To overcome this problem, relationships between runoff and nutrient load were developed for selected sites where data were adequate. Long-term rainfall records were then entered into a simple water balance model to estimate runoff. From this and the runoff-load relation-ship, the long-term nutrient runoff could be calculated.

Results and discussion

Typical results for monitoring station 5 in a single runoff event are given in Fig. 2.

Water quality attributes of runoff water.

The forms in which nutrients occurred varied with land use and to some extent management. This was particularly so for phosphorus (P), which had important implications for management. The total P concentration in runoff from market gardens was very high (2-80 mg/L) and mainly in the particulate form. Particulate P is associated with high rates of erosion, calculated to be about 20 t/ha/yr. Particulate P was partially removed from runoff water in farm dams and flowlines (data not presented). The oldest market garden with longest fertiliser history had very high soil P and the highest exports of soluble P (up to 2 mg/L), which is more "bioavailable" and more readily transported than particulate P.

Runoff water from the intensive dairy (approximate stocking rate 4 cows/ha) was surprisingly high in total P (up to 5 mg/L), considering the very low erosion rate.? Most of this P was in the soluble reactive form. The runoff from unimproved or semi-improved pasture was low in both soluble and particulate P (total P typically .6 mg/L).

Subcatchment exports from Currency Creek.

The estimate for the whole of the Currency Creek subcatchment is 19.3 and 3.3 kg/ha/yr for N and P respectively, based on a 30-month monitoring period with adjustment to provide a long-term value. This was surprisingly high, when it is considered that:

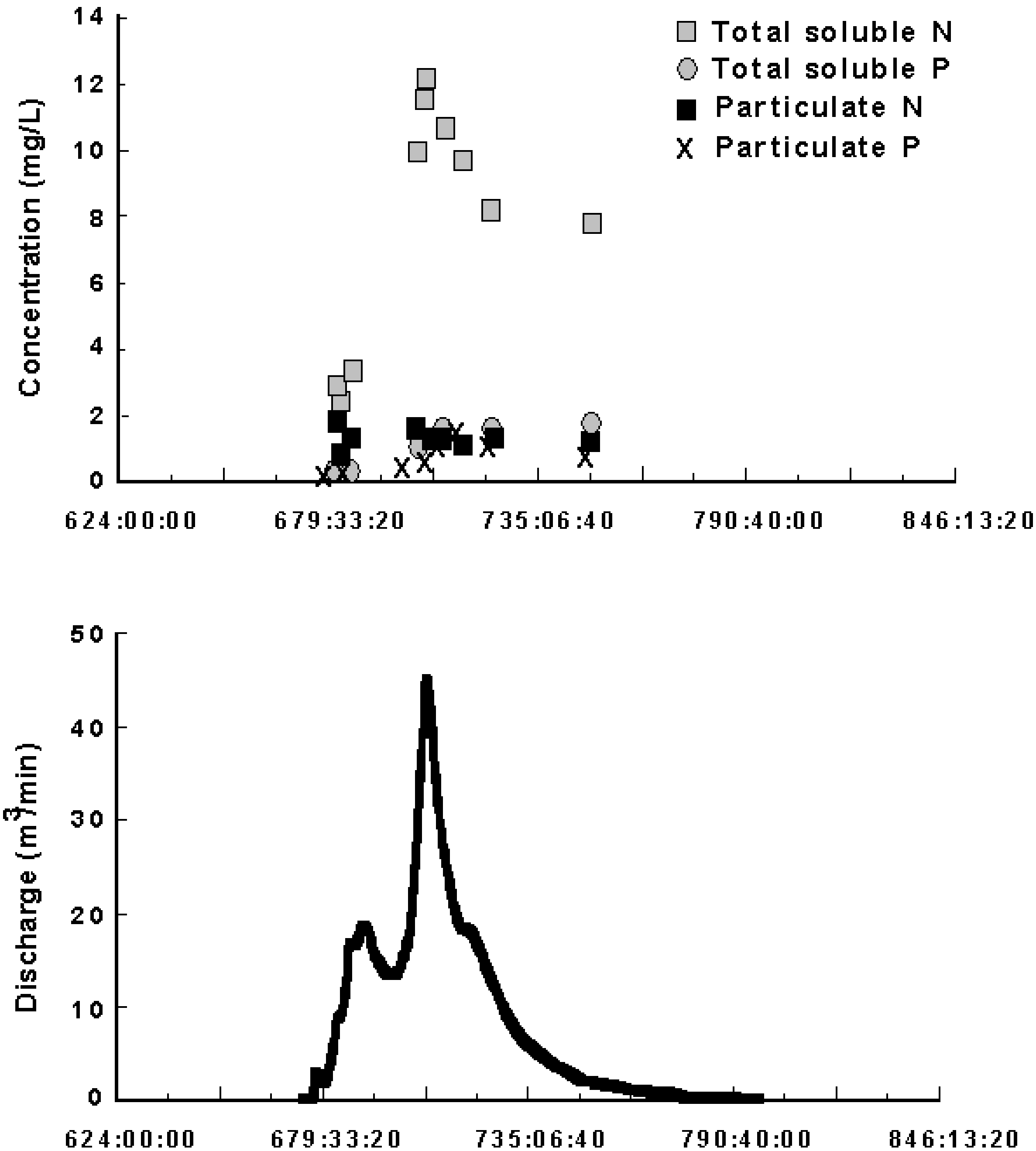

Figure 2

• 3.3 kg/ha/yr is within the range that interstate and overseas studies suggest for market gardens which characteristically exhibit high export rates, yet market gardens comprised only 7% of the subcatchment; and,

• that whole catchment studies usually reveal a reduction in loads between the point of generation and their exit from the catchment (assimilation).

The high export could be due to either very high generation rates from some or all of the component land-uses, and/or lower than expected assimilation. Results not presented here suggest that, whilst some of the land uses did generate very high nutrient runoff, assimilation was also low. The export of 3.3 kg/ha/yr P can be compared with the much lower value of 0.3 kg/ha/yr found in the nearby but less intensively developed catchment of Monkey Creek (2).

Nutrient generation rate for major land uses.

Table 1 lists the P generation rate for land uses at Currency Creek and Camden. Insufficient data were obtained from Mangrove Mountain to provide reliable results, in part because the highly permeable soil resulted in significant runoff on only two occasions.

Table 1: Nutrient generation rates

Land use	P (kg/ha/yr)
market garden[1]	15.3
dairy (intensive: high stocking rate)[1]	6.4
dairy (extensive: low stocking rate)	1.9 - 2.5[2]
semi-improved pasture / hobby	0.8
unimproved	0.3[3]

[1] modelled long-term estimates
[2] Camden data, few runoff events (value in range depended on farm area sampled)
[3] published data for the Nepean-Hawkesbury (1)

The generation rate for market gardens is at the highest end of the range suggested in CMSS, whereas the value for intensive dairy pasture greatly exceeds any value for pasture in CMSS. However, there is mounting evidence from other Australian studies (3) that intensively used dairy pasture can generate very high exports of soluble P. While the values for semi-improved past-ure are low, this land-use is still a major contributor to nutrient exports because of the large areas of pasture in this catchment and elsewhere in the Hawkesbury-Nepean.

<u>Conclusions</u>

Nutrient exports from intensive land uses were high.? Export from market gardens was dominated by particulate P, as expected from the tillage practices used and high erosion rates measured. Dairy pasture runoff was dominated by soluble forms of P. Although only 40% of the Currency Creek sub-catchment was used for in- tensive agriculture, nutrient exports from the catchment were high. This resulted from both the high export rate of the component land uses and apparently from relatively low assimilation of nutrients between the paddock and the receiving water. Hence, control of export at source is imperative, which will involve substantial changes in land management.

Acknowledgments

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