Roles of Goulburn City in Managing Catchment Water Quality.

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SUMMARY: Goulburn City is a 54 km^2 urban area in the Southern highlands of NSW. The city lies at the confluence of the Wollondilly River and Mulwarree Ponds. It is the major urban centre in the area, containing some 24,000 people, and could have a significant effect on regional water quality.

The study described in this paper aimed to:
1. To establish the health of the river corridors within the urban area.
2. To develop an action plan to reduce the impact of Goulburn City on the streams
3. Improve the amenity of the streams for Goulburn's citizens.

The key findings of the study were:

1. Water reaching Goulburn City already has a high nutrient load due to upstream landuses.
2. Willows were choking up much of the streams, diverting flows and encouraging bank erosion. Earlier attempts at eradication have largely failed. Blackberry was the main groundcover weed.
3. There were virtually no native riparian trees and shrubs present.
4. Urban activities increased pollution loads to moderate values. The effects became less within 5 km downstream of the city.

Recommendations include:

1. Gradually replace exotic weeds such as willows and blackberry with local indigenous species.
2. Reduce the impact of sewage effluent through increasing irrigation area
3. Reduce stock access to streams.
4. Install Gross Pollutant Traps and treatment wetlands to improve stormwater quality exiting urban areas.
5. Develop Community and Construction Site Education Programs to reduce stormwater pollution.
6. Develop an urban vegetation management plan
7. Develop an integrated catchment management plan.

THE MAIN POINTS OF THIS PAPER

- Impacts of regional cities on river health are significant and can be similar to the cumulative effects of the surrounding agricultural areas.
- City impacts can be reduced by a combination of reduced stormwater pollution, effective sewage reuse schemes and vegetation management activities.

1. INTRODUCTION

Goulburn City is the oldest inland city in NSW. It lies in the southern portion of the Hawkesbury Nepean Catchment at the confluence of Mulwarree Ponds and the Wollondilly River. Since Goulburn's establishment in the early 1820s there have been major changes in the ecological, social and commercial values of the streams within the urban areas.

. Some of the changes include:

- Removal of forests to enable grazing and agriculture, leading to increased runoff, erosion, and nutrient contamination of rivers
- Increased stock access to streams, leading to track development and erosion.
- Installation of weirs and dams to regulate flow
- Increased roads, highway bypasses and housing, leading to increased runoff and changes in flood hydrology in the urban areas.
- Removal of native riparian vegetation and replacement with weeds such as blackberry
- Introduction of willows, which can markedly affect stream morphology
- Increased contaminant loads due to urban and industrial activities such as increased stormwater runoff, sewage treatment, abattoirs and wool scours.

Over the past few decades, Goulburn City Council has

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significantly reduced urban pollution through activities such as

- Park creation along the edges of the streams,
- Development of an effluent irrigation farm to utilise the city's sewage
- Community education programs aimed at reducing littering and stormwater contamination
- Supporting community environmental activities

An example of the reduction in impact is Faecal coliform population in waters below Goulburn City. These have fallen from 280/100 mL in 1970 to 26 /100 mL in 1996.

However there was a need to assess the current environmental status of the urban streams. This information could then be used to develop an action plan to rectify the major environmental problems.

2. METHODOLOGY

An integrated approach was taken. This involved investigation of catchment landuses (to determine the relative contribution of rural and urban activities on stream contaminant loads), and assessment of water quality, stream geomorphology, river health and riparian vegetation. An assessment of individual urban activities such as stormwater and sewage pollution and their effects on stream water quality was also made.

2.1 Catchment landuse and nutrient generation rates

Aerial photos were used to provide an estimate of catchment landuses. Bushland/forestry and urban landuses were easily identified. The difference between extensive grazing and intensive agriculture relied on evidence of cultivation, field crops or irrigation.

The area allocated to each landuse was multiplied by the nutrient generation rates for the Hawkesbury Nepean Catchment (Marston 1993).

2.2 Stream audit

The banks of the streams were walked from approximately 5 km below the city to 4 km above it. Information on stream characteristics such as width, depth, current, grade, substrate, and ponds, riffles, etc was recorded using standardised sheets developed by Woodlots & Wetlands. Bank stability and damage was noted, as were structures such as stormwater outlets, weirs, culverts etc.

The quality of stream habitat was assessed using a modification of a system designed to monitor the long term impacts (McCarron et al 1997). The assessment included features such as instream habitat variation, substrate smothering, channelisation and velocity.
Water quality data collected since 1990 was used to assess physical and chemical health of the ecosystem (ANZECC, 1992). The proportion of time the each section of the stream complied with the ANZECC guidelines was used to score the location as good, fair, poor or very poor. (>75% of time, 50-75%. 25-50% and <25% respectively). A similar approach was used to determine the suitability of the streams for primary (eg swimming) and secondary (eg fishing) recreation. Water sampling has occurred monthly since 1996. Data was therefore available from both flood and low flow periods.

The SIGNAL index (Chessman 1995) was applied to the macroinvertebrate data derived from field sampling (figure 3) to reveal trends in stream ecology. The SIGNAL index is a measure of water quality using the factors of indicator animals and abundance. The animals are identified to family level classification, with each family assigned a sensitivity grade between 1 and 10 depending on the tolerance to common pollutants (higher values represent lower levels of tolerance). Each species is then assessed for abundance on a 4 point scale. Scores for each type are calculated from the product of grade and abundance. The Index is derived from the sum of scores divided by the sum of abundances. This provides a comprehensive ecological indicator that takes into account the number and abundance of pollutant sensitive animals.

SIGNAL indices are classified into 4 levels:

Less than 4	probable severe pollution
4 to 5	probable moderate pollution
5 to 6	doubtful quality, possible mild pollution
More than 6	clean water

The riparian vegetation was assessed at 500m intervals along the streams (McCarron et al 1997). Information recorded at each site included:

- Location;
- Surrounding land uses;
- Topography;
- Point-source drainage;
- Vegetation – listing of native and introduced species.

General comments and a basic site description were also included.

2.3 Assessment of direct impacts of Goulburn

Data for stormwater runoff rates and contaminant concentrations were obtained from Council (O'Rourke, 1997). Additionally, Council staff were interviewed to determine 'hot' spots for contamination. Data from a recently completed Environmental Management Plan for the Council's effluent reuse scheme (Woodlots & Wetlands, 1997) was also used to determine the likely contribution of the city to the environmental impacts in the streams.

3. RESULTS

3.1 Catchment landuse and nutrient generation rates

The data in table 1 suggests Goulburn plays an important but not dominant role in nutrient generation rates. It contributes some 10 to 15% of the N and P generation. This figure would be far higher if the earlier system of sewage effluent discharge direct to streams were still being used. Goulburn generates some 5.9 ML/day of effluent containing 25 mg/L of N and 6 mg/L of P. The effluent reuse scheme reduces N and P addition to the river by 54 and 13 t/ year respectively. Provided the contaminants do not leach back to the river. The high contaminant concentrations in the water at Murrays Flats (adjacent to the effluent irrigation farm indicates leakage is occurring).

3.2 Stream audit results

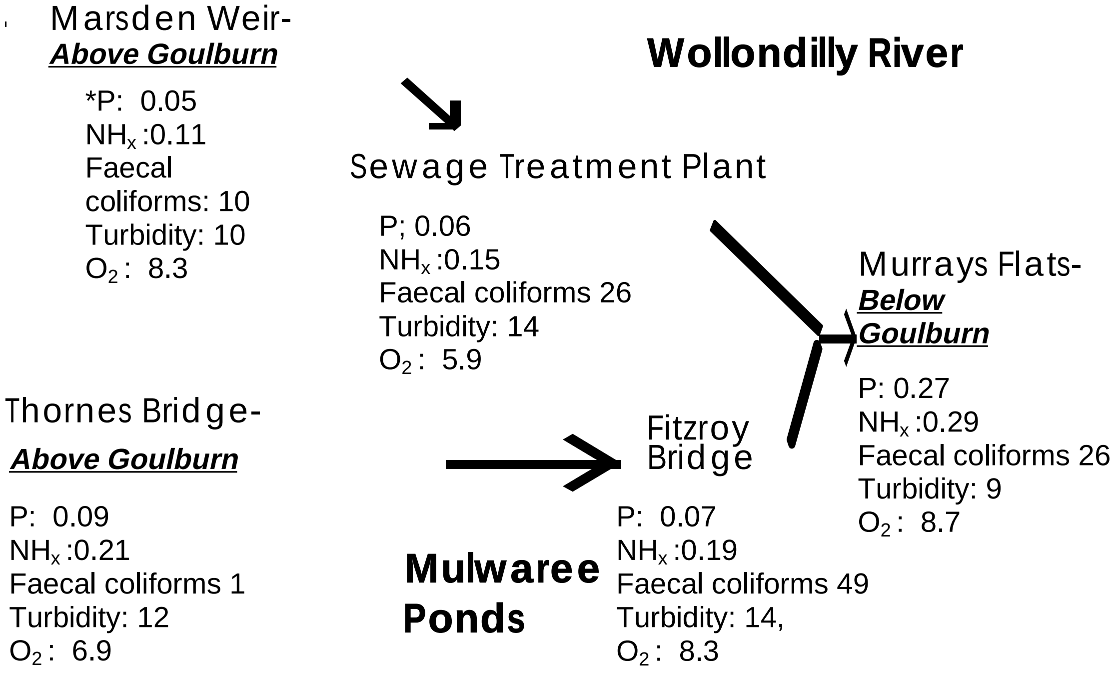
The assessment was undertaken immediately after a flood in September 1997. While there are some minor weirs and stormwater inflows, the river shape has not been greatly altered. There is however extensive infilling of waterholes along the Mulwarree Ponds. The base of the streams varied from thick sediment in Mulwarree Ponds to rocky riffle zones in shallow portions of the Wollondilly River.

Exotic plants such as willows and blackberry have almost completely replaced native plants such as Eucalypts and bottle brushes (*Callistemon spp*). However the aquatic vegetation is still largely native. *Phragmites* and *Bolboschoenus* are abundant in shallow water, while *Triglochin* was common in waters up to 1m deep. Dense stands of willows have shaded these species out in some areas. The presence of willows is the major anthropogenic change. In some places willows growing within the stream are significantly reducing flows and contributing to stream instability.

Table 1 Landuses and likely nutrient generation rates within the catchment (Based on data of Marston, 1993[5]).

LANDUSE	BUSHLAND/ FORESTRY	EXTENSIVE GRAZING	INTENSIVE GRAZING/ CROPPING	URBAN	TOTAL
Proportion of different landuses in the catchment above Goulburn	15%	72%	9%	4%	100%
Area (km^2)	224	1060	132	54	1470
N generation rate kg/ha/y (Marston, 1993)[1]	1.5	0.9	8	5	-
Contaminant load (t N/year)	34	95	106	27	262
P generation rate kg/ha/y (Marston, 1993)	0.1	0.25	1.25	1.3	-
Contaminant load (t P/year)	2	27	17	7	53

5 Frances Marston's study was based on the entire Hawkesbury Nepean catchment. This catchment is one of the most intensively researched in Australia (IEA, 1997).



*P as Total P concentration mg/L, NH_x as Total ammoniacal-N concentration mg/L
Faecal coliforms/100 mL, Turbidity as NTU. O_2 mg/L.

Figure 2. Mean contaminant concentrations in streams above and below Goulburn City since 1996.

Hobby farms and horse agistment paddocks are a common landuse on flood prone areas close to the city. These frequently contain high populations of animals with direct access to the streams. Damage to the river banks and water quality from livestock is apparent at virtually all stretches of the streams.

This damage results from several processes:

- Direct effects of animals excreting and defecating into the water
- Direct effects of animals stirring up sediment and pugging wet soil
- Damage to banks via development of tracks to the water
- Exposure of soil (and subsequent erosion) through heavy grazing near watering points
- Removal of preferred terrestrial vegetation via selective grazing and replacement with unpalatable species such as blackberry.
- Selective grazing of aquatic macrophytes such as Phragmites, leading to increased water velocity along banks.

The intense grazing effects of domestic stock are accentuated by the large population of rabbits in some portions of the river banks. Stock assess to the stream was therefore considered a major source of degradation in the agricultural and peri-urban zones that extended to within a km of the city centre.

The physical health of the water was fair upstream of the city. Increases in turbidity mean it was lower through the city, but water clarity had improved by the time the water reached Murrays Flats, some 5 km downstream. The results indicate the self purification processes such as sedimentation and re-oxygenation (Spellman, 1996) have been effective.

The chemical indicators of waterway health suggested waters entering the city were in fair to good condition. The condition of streams in the city was fair. The reduced grading was due to increased Phosphorous concentration. At Murrays Flats the health was very poor. This was almost totally due to high Phosphorous concentration. Council data since 1996 indicates the mean Phosphorous concentration in the Wollondilly increased from 0.05 to 0.27 mg/L between Wollondilly Ave, (immediately downstream of the city) and Murrays Flats (immediately downstream of the council's effluent irrigation farm). Data for other sites are shown in figure 2.

Increased turbidity was the main limitation to primary recreation. This was most obvious in the industrial areas, and reflects the effects of urban stormwater as well as point sources of pollution such as the saleyards.

The streams were almost always suitable for secondary contact recreation. This suggests that while there was significant pollution due to the city, it was not as great as found in some capital cites or in unsewered towns.
The suggestion that Goulburn does not have a dramatic effect on the river health is also supported by the results of the aquatic biodiversity study. The SIGNAL score (described above) incorporates species richness and species composition to provide an assessment of ecosystem health. The general assumption (ANZECC 1992) is that "high levels of diversity are desirable and equate with high levels of biological integrity." Marsden Weir (upstream of Goulburn) generally had the highest taxa diversity ranging from 24-44 taxa and the highest SIGNAL scores. This suggests that it is the least impacted site as it has a high diversity and abundance of pollution sensitive invertebrates. In comparison, the downstream site at Murrays Flats had a high diversity (20-42 taxa) but a low SIGNAL score. This indicates it was impacted. The diversity at Murrays Flats was largely due to abundant pollution tolerant invertebrates.

All other sites generally had a lower diversity and lower SIGNAL scores than the Marsden Weir site (figure 3). This indicates that the ecosystem health has been impacted to some degree ranging from probable severe pollution to possibly mild pollution (Chessman, 1995). Generally, the Mulwaree Ponds has lower stream health in comparison with Wollondilly River. This is obvious even at Marsden Weir and Thornes Bridge which are upstream of the city and suggests landuses along the Wollondilly are having less impact on stream health than landuses along Mulwarree Ponds. There is limited evidence that the fall in biodiversity within the urban area is greater along Mulwarree Ponds. This may be attributed to variable impacts from Goulburn as the Wollondilly river receives approximately 35% of urban discharge while Mulwaree Ponds receives 65% (O'Rouke, 1997). Therefore, pollution pulses received from stormwater discharge will have a greater impact on Mulwaree Ponds.

4. ACTION PLAN

This study was designed to assess the stream health and to use the results to provide Goulburn City with a series of prioritised actions designed to reduce the impacts of the city on stream health.

Following detailed discussion with Council and the Community, plus later field verification, it was decided that willow removal was the top priority. In many places they are choking the streams. Removal will be gradual to minimise bank instability. The bank side willows will be replaced with riparian natives such as *Eucalyptus viminalis.*

Native riparian vegetation will be replanted following an *effective* herbicide program to remove blackberry, and fencing off to prevent stock access.

Seepage from the Council's effluent reuse farm is a significant source of P contamination. Increased irrigation area is needed to reduce hydrological and nutrient overloading onto the site.

Removal of stock access to the riparian zone was considered essential to any revegetation program. A program of installation of off stream water supplies and fencing is needed. This program also recognises the probability of flood damage. Stream assessment and water analysis showed a combination of sediment, organic and chemical waste were entering the water within the urban areas. Therefore a multi target program was devised for the city. This included, in order of priority:

- Stricter soil and erosion management on building sites
- Design of new subdivisions to reduce both the volume and the contaminant loading of stormwater
- Encouragement of individual householders to reduce stormwater contamination via pet droppings, excess fertilization of lawns, car washing and dumping of garden waste into stormwater drainage lines.
- Reduction of faecal coliforms, phosphorous and suspended solid contamination from stormwater via installing inline detention basins in portions of the streams receiving intense pollution.
- Reduction in suspended solids and Gross Pollutant loads via Gross Pollutant Traps.

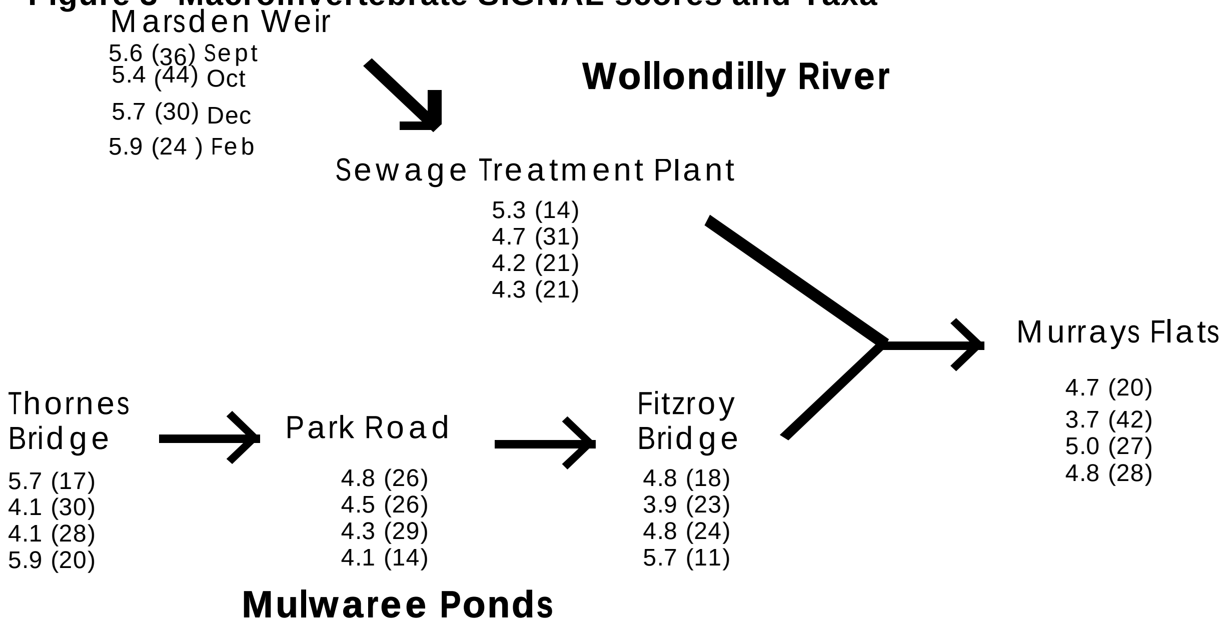
Setting remediation priorities

Funding limitations preclude intensive remediation simultaneously in all areas. Additionally some measures require cooperation and input from other parties. For example revegetation strategies for riparian zones require cooperation from land holders as well as agreement from DLWC to remove willows.

Several meetings were held with Council staff to formulate priorities. These considered such issues as Council funding, ability to attract external funding and community involvement. The prioritised plan was then presented to the community for input and acceptance.

This project aimed to provide Goulburn City with guidance on urban stream management. It demonstrated the need for an integrated approach based on chemical and biological criteria to reducing impacts of urban areas on waterways.

Figure 3 Macroinvertebrate SIGNAL scores and Taxa



*Numbers refer to SIGNAL scores, from Sept 97 (top number) to Feb 98 (bottom number).
Numbers in brackets refer to the number taxa recorded

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