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Water quality in the Wingecarribee Shire, NSW

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Abstract

This paper reports on a water quality monitoring program carried out for Wingecarribee Shire Council between March 2002 and July 2004 by University of Wollongong staff and students. Initially 40 sites were sampled on four occasions over three months in a pilot program leading to the selection of sites and parameters for a two year program of monthly monitoring. A range of chemical, physical and biological parameters was measured including nutrients and faecal coliform bacteria on samples collected over the 26 approximately monthly sampling trips. Chlorophyll a, phaeophyton and blue-green algae were also determined over a shorter period. The sampling period included the particularly hot and dry spell September 2002 - January 2003 and a return to less extreme conditions after February 2003. The range of nutrient and coliform data is reported with discussion of the effects of rainfall patterns on nutrients and on faecal coliform counts at the various sites. Small creek sites showed significant changes to nutrient regimes in the long dry spell, whereas the same effect was not apparent in larger river sites. Very wide ranges of faecal coliform counts were found, especially at small creek sites in farmland. Excepting extreme results, generally elevated coliform counts were found when rainfall occurred 0-3 days immediately prior to sampling. Generally lower counts were found in drier weather. The Shire has already implemented some measures to improve water quality in response to this program.

Keywords

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WATER QUALITY IN THE WINGECARRIBEE SHIRE, NSW

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ABSTRACT

This paper reports on a water quality monitoring program carried out for Wingecarribee Shire Council between March 2002 and July 2004 by University of Wollongong staff and students. Initially 40 sites were sampled on four occasions over three months in a pilot program leading to the selection of sites and parameters for a two year program of monthly monitoring. A range of chemical, physical and biological parameters was measured including nutrients and faecal coliform bacteria on samples collected over the 26 approximately monthly sampling trips. Chlorophyll a, phaeophyton and blue-green algae were also determined over a shorter period. The sampling period included the particularly hot and dry spell September 2002 – January 2003 and a return to less extreme conditions after February 2003.

The range of nutrient and coliform data is reported with discussion of the effects of rainfall patterns on nutrients and on faecal coliform counts at the various sites. Small creek sites showed significant changes to nutrient regimes in the long dry spell, whereas the same effect was not apparent in larger river sites. Very wide ranges of faecal coliform counts were found, especially at small creek sites in farmland. Excepting extreme results, generally elevated coliform counts were found when rainfall occurred 0-3 days immediately prior to sampling. Generally lower counts were found in drier weather. The Shire has already implemented some measures to improve water quality in response to this program.

BACKGROUND

Wingecarribee Shire is located 110 to 200 km southwest of Sydney (about latitude 34°30'S and longitude 150°30'E). The majority of the shire is above 630 m in elevation and is part of the Southern Highlands. The shire covers approximately 2700 km^2 of rural NSW and includes the semicontinuous belt of urbanised occupation including Bargo (north), Mittagong, Bowral and Moss Vale (south). Robertson in the east is also within the shire. Outside of the urban areas, various agricultural activities are found on land adjacent to undeveloped land, which includes the headwaters of several regionally significant rivers that drain into the Sydney Catchment Authority (SCA) dams, including Wingecarribee and Fitzroy Falls Reservoirs.

Almost all of local rivers are impounded in water storage reservoirs for use in Sydney and locally, with some released for environmental flows. In addition, local rivers are used currently to transfer significant amounts of water northwards into the Sydney metropolitan water supply. Such water transfers can impact stream biota. Good water quality is therefore important for the local and wider community, as well as for the ecological health of the waterways.

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Geologically, much of the shire is underlain by Permo-Triassic sedimentary rocks, predominantly the quartz-rich Hawkesbury Sandstone with lesser areas of Wiannamatta Shale and lithic Narrabeen Group sandstone. The underlying Permian sedimentary rocks are exposed in the deep gorges and at the margins of the shire. To the west, regionally metamorphosed sedimentary rocks of the Lachlan Fold Belt crop out and to the east around Robertson, basalts are found. The surface geology of the region is dominated by the Wianamatta Shale, the Tertiary volcanics and the Hawkesbury Sandstone. The fertility of the soils reflects the parent rocks with the Hawkesbury Sandstone and Lachlan Fold Belt rocks producing very poor sandy soils and the basalts very rich red soils sought after for agricultural use.

Major waterways include the Nepean, Wollondilly, Wingecarribee, Shoalhaven and Paddys Rivers. Several of these rivers have cut deep gorges through the Hawkesbury Sandstone and upper Narrabeen group rocks. Water quality is strongly affected by geology, soil and land use. Water quality is lower on the shale and volcanic derived soils in agricultural and urban areas and higher on the undeveloped sandstone country.

Land use includes urban (4 % of the shire), agriculture, grazing and cropping (44 % combined) state forest, water catchment and national parks (52 % combined). There is limited manufacturing (WSC, 2004).

The local climate is generally cooler than neighbouring coastal areas due to elevation and distance from the moderating effect of the sea. Rainfall is highest in the east, with an average of 1600 mm per annum, due to orographic effects, but decreases to 850 mm per year in the west. Precipitation is generally evenly spread throughout the year.

THE WATER SAMPLING PROGRAMME

The Wingecarribee Shire Council initiated the Environmental Water Quality Monitoring Program (EWQMP) as part of the Shire Environmental Water Quality Management System (WSC, 2004) in collaboration with the (then) Environmental Science Unit, University of Wollongong (UOW). The program began in 2002 with an initial pilot study screening 42 sampling sites spread across the Shire from which 14 sites were chosen to be monitored for the whole two year program of monthly sampling. Sampling was carried out over the period March 2002 – July 2004. Within that time the fourteen sites were sampled on 26 occasions (site 14, 22 sampling occasions). The sampling days were chosen to be more or less one month apart, with a three month gap between the end of the pilot program and the initiation of the longer term program. Sampling days were not chosen to follow a particular weather or flow condition. Sampling consisted of a once a month site visit with some measurements made on site as well as samples taken for various off site determinations. The methods, monitored parameters, sampling procedures and quality control system are described elsewhere (O'Donnell et al, 2006).

THE SAMPLING SITES

The sampling site details are listed in Table 1, along with an indication of the type of site.

Figure 1. Wingecarribee Shire EWQMP sampling sites and waterways.

Table 1. EWQMP Sampling Sites.

Site	Name	Site Type	Site Description / Notes
1	Medway Rivulet at Hume Freeway	small, rural	small rural creek in pasture, rural catchment, catchment includes part of Mossvale and STP discharge.
2	Wells Cr at Hume Freeway	small, rural	small rural creek in pasture, rural catchment
3	Whites Cr at Oldfield Rd	STP	small rural creek, rural / urban catchment and catchment includes part of Mossvale, STP discharge within 1 km of sampling site. Ducks frequently there.
4	Wingecarribee R at Bongbong	large rural	larger river site, under Bowral – Mossvale Road bridge. Catchment urban / rural and reservoir.
5	Mittagong Cr at Burradoo	STP	small rural creek in pasture, catchment rural, semi-rural, urban (Bowral) and Bowral STP.
6	Mittagong Cr at Victoria St	small urban	small urban creek in public park walking area.
7	Kellys Cr, at Illawarra Hway	small, rural	small rural creek in pasture, rural catchment. Dries up when rainfall very low..
8	Caalang Cr at Caalang Rd	small, rural	small rural / urban creek in Robertson.
9	Nepean R at Tourist Rd	small, rural	small rural creek in pasture, rural / bush catchment.
10	Paddys R at Quarry Rd, Bundanoon	STP	small rural creek in pasture bush, rural catchment, urban catchment, Bundanoon STP.
11	Paddys R at Inverary Rd, Canyonleigh	large rural	larger river site, rural, bush catchments
12	Bundanoon Cr at Yallawa Rd	small, rural	small rural creek in pasture, rural catchment. Dries up when rainfall very low.
13	L Alexandra, Mittagong	small lake	urban, in public parkland, much birdlife always present.
14	Sheepwash Cr at Drapers Rd	small, rural/urban	small rural / urban / bush creek in north Mittagong.

A wide variety of water quality parameters were measured in the program, including water chemistry, nutrient condition and microbiological quality. Particular issues which stood out in the data and have been considered by Council are highlighted in the State of the Environment (SOE) report of the Shire Council (WSC, 2006). These include nutrient levels and associated eutrophication, elevated faecal coliform counts, turbidity in some smaller creeks, riparian management and the effects of discharges from sewage treatment plants (STPs). Actions initiated already in response are also outlined in the SOE report.

This paper reports particularly the response of nutrients and faecal coliforms to weather patterns. The two year period can be characterised as the driest portion of several dry years (SCA dam inflow data, SCA 2006). Within the study period March 2002 – July 2004, the months September 2002 – January 2003 were notably lacking in rainfall. This is exemplified by the six monthly summed rainfall data (recorded at Bongbong) summed for the six months prior to each sampling event. Over these five months the 6 months summed rainfall prior to each sample day ranged between 85 and 156 mm. Then, rainfall in February 2003 was 118 mm. Thus this dry spell had a distinct end point from the point of view of our sampling schedule. Generally the six month summed rainfall throughout the rest of the program ranged between 200 and 450 mm at the Bongbong rainfall station.

NITROGEN AND PHOSPHORUS RESPONDING TO LONG TERM RAINFALL

Total phosphorus and total nitrogen data are presented in Figure 2 and Figure 3 respectively. There was high variability in the total phosphorus data, but a few sites only satisfied the ANZECC 0.02 mg/L guideline on some occasions.

Four sites have median values for total phosphorus below the guideline; these were Caalang Cr (8), Nepean R (9), Paddys R at Inverary Rd (11) and Sheepwash Cr (14). The character of these sites is varied but they are notably areas of relatively low development impact – top of catchment, bushland catchment, lower impact farming, little or no suburban development. These sites also generally have relatively higher flow and were not reduced to seepages in the very dry periods. As the data show, the maximum concentrations found at these sites can still be high, for example, the highest reading at Paddys R was ten times the guideline value.

Most other sites showed medians between 0.038 and 0.051 mg/L TP. However the median value at site 5 (d/s Bowral STP) was 0.455 mg/L TP and the median measured in site 13 (Lake Alexandra) was 0.12 mg/L TP. The greatest values by far were found immediately downstream of sewage treatment plants (STPs) discharges, in Lake Alexandra or in low flow streams in paddocks with stock activity in the immediate vicinity.

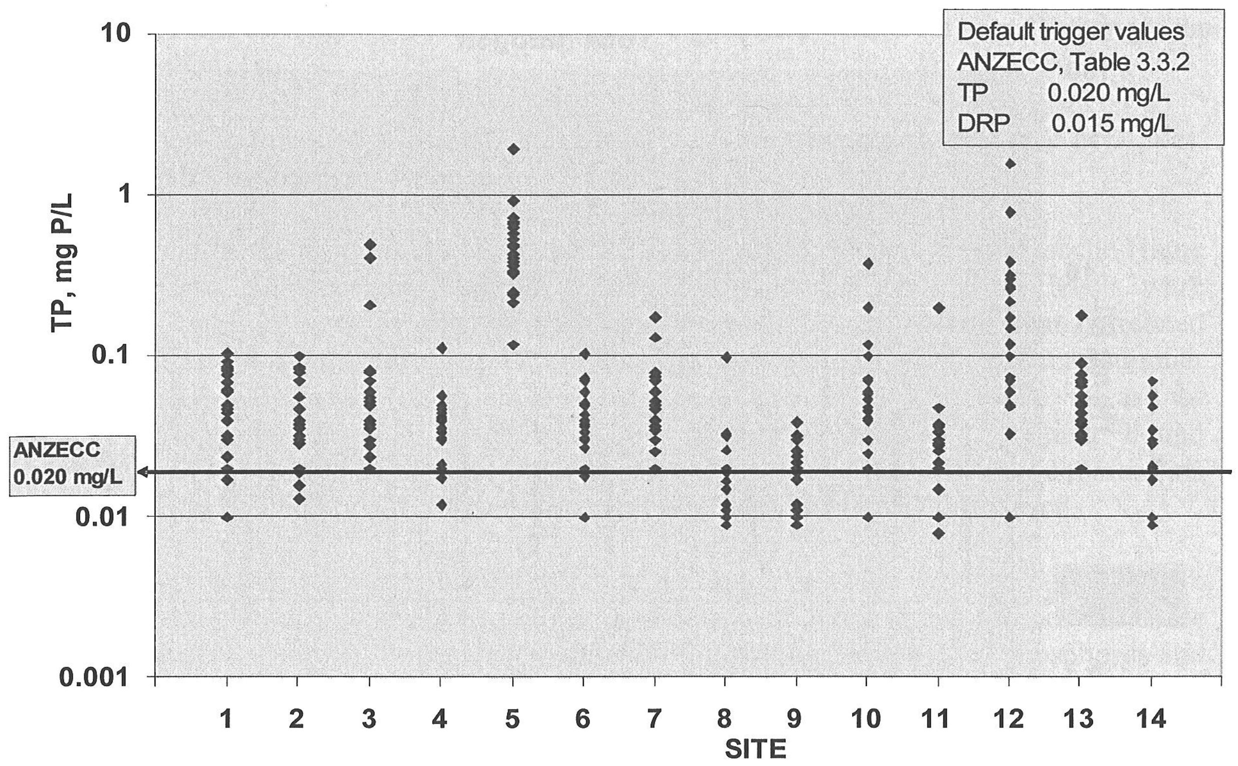

Figure 2. Total Phosphorus at all sites. NB log scale. ANZECC guideline for Total Phosphorus indicated.

The concentration of dissolved reactive phosphorus (DRP, equivalent to ortho-P) was usually found to be very low or at the detection limit. Of approximately 350 measurements, less than 25% exceeded the ANZEEC guideline value. Thus phosphorus is carried mostly in particulates rather than in the more readily available soluble form.

Total nitrogen values (Figure 3) were well in excess of ANZECC 0.250 mg N /L value in 95% of all samples. Some extremely high values were found, associated either with STPs or low flow farmland streams with stock immediately present.

Speciation of nitrogen was highly varied between sites and in response to season and / or rainfall. Although organic nitrogen did constitute a substantial portion of the total nitrogen, quite often a high proportion of the nitrogen was present as nitrate or ammoniacal nitrogen. Commonly at sites downstream of STPs or small creeks in farmland the levels of these forms of nitrogen are an order of magnitude or more in excess of the guideline values. These species exceeded guideline values in 80-85% of all samples.

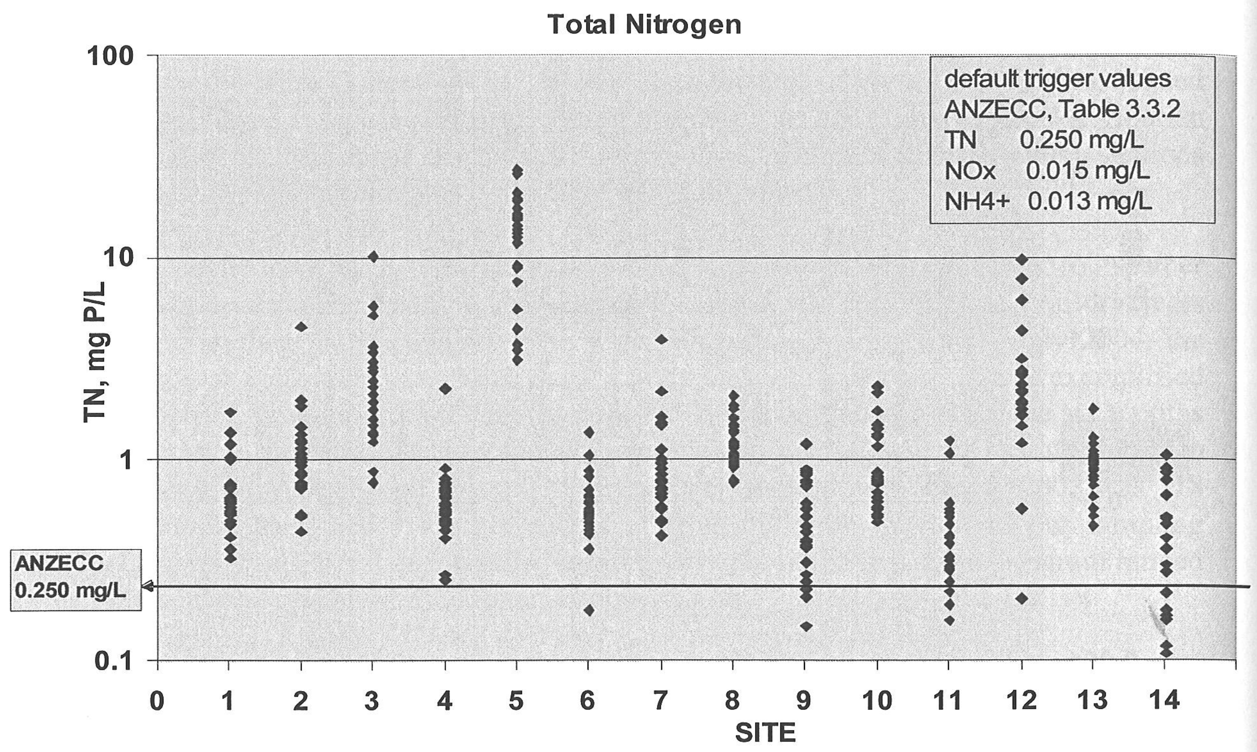

Figure 3. Total Nitrogen data for all sites. NB log scale. ANZECC guideline for Total Nitrogen is indicated.

The nutrient results of the Sept 02 – Jan 03 dry period have been compared to the results for the whole 2 yr program and also to the results for the same period twelve months later. Thus differences on the basis of long term low rainfall are sorted from seasonal differences. The comparison has been made on the basis of means being significantly different (application of t-test at 95% confidence level or better).

The response of nutrients to the dry spell varied from site to site, but some patterns stood out:

Total Phosphorus (TP)

- Small rural(/urban) creeks (8 sites, refer Table 1): TP significantly (99% level) higher during dry spell
- Larger rivers (Site 4): TP not significantly different, this site less affected by dry spell extremes.
- Sites downstream of STPs: TP significantly higher during dry spell at 2 of 3 sites

Total Nitrogen (TN)

- Small rural creeks: TN levels not significantly different in dry spell, but speciation changed.

- Larger Rivers (site 4, 11) TN levels not significantly different, small changes in speciation.
- Sites downstream of STPs, TN significantly higher during dry spell at 2 of 3 sites. Speciation of nitrogen changed.

The situation in the small rural creeks is exemplified by site 1, Medway rivulet at the Hume Freeway. During the very dry Sept 02 – Jan 03 period, the phosphorus levels were significantly higher relative to other periods, and the phosphorus concentration correlated strongly with that of organic nitrogen. During this low flow period with the onset of summer warmth, biomass increased (chlorophyll a increased concurrently). Possible release of sediment phosphorus may have added to the phosphorus loading. Sediment bound phosphorus can be released as pools of water become stagnant and the sediments anoxic. This is consistent with low dissolved oxygen concentrations measured during this period.

This low flow situation was significantly different from the rest of the two year period, where phosphorus is not strongly correlated with organic nitrogen, and a larger component of the nitrogen is present as nitrate. In the same period the following year, levels of phosphorus and nitrogen were not so high, dissolved oxygen did not decrease below 85% saturation and chlorophyll a levels were found to be about half. It appears the extreme dry conditions did significantly impact the stream, by allowing increased concentrations of phosphorus to develop, with the consequent increase in biomass over and above what would occur seasonally.

Generally the nutrient concentrations in larger rivers were not so significantly affected by the long dry spell. Changes in nutrient concentration were not significant in the Wingecarribee R, although increased phosphorus levels were observed in Paddys R at Inverary Rd. At the time large algal mats were noted developing on the stony surfaces at the Inverary Rd sampling site. Under the very low flow conditions, Paddys River appeared to behave like the smaller creeks.

Downstream of Bowral and Bundanoon STPs, nutrient levels were significantly increased in the dry period relative to the rest of the program. The dominant nitrogen forms were found to be organic and ammoniacal nitrogen. This speciation was significantly different from the predominance of nitrate nitrogen found to occur in wetter periods.

MICROBIOLOGICAL QUALITY AS DETERMINED BY FAECAL COLIFORM BACTERIA

A variety of parameters can be used to determine the microbiological suitability of water for drinking, recreation and stock watering. In this study only faecal coliform bacteria (FC) were monitored (O'Donnell, 2006). FC results varied widely between sites. Elevated FC counts were not found on the same sampling occasion at all sites or even at the majority of sites or even at 'similar' sites.

Statistical measures of the data are reported in Table 2 and all data for each site are displayed in Figure 4. Median and quartiles are reported in Table 2 because the data are not normally distributed. Counts above 10 000 cfu / 100 mL (4 sites) are not shown in Figure 4 as the four results >10 000 cfu / 100 mL are maximum results for four of the sites (all are listed in Table 2).

Table 2. Faecal Coliform data for all sites.

Site	Name	Number of Sampl es	Minimum cfu / 100 mL	25% cfu / 100 mL	Median cfu / 100 mL	75% cfu / 100 mL	Maximum Recorded cfu / 100 mL
1	Medway R	25	20	42	100	280	4000
2	Wells Cr	24	1	20	69	247.5	670
3	Whites Cr	25	30	111	250	460	2100
4	Wingecarribee R	25	2	13	20	50	2700
5	Mittagong Cr	25	68	132.5	370	805	3700
6	Mittagong Cr	24	6	47	177.5	557.5	24000
7	Kellys Creek	20	2	90.5	570	1075	12000
8	Caalang Cr	24	1	9.5	35.5	52.75	950
9	Nepean R	25	5	26	62	145	5800
10	Paddys R	25	1	4	24	46	2480
11	Paddys R	25	2	11	54	88.5	340
12	Bundanoon Cr	19	1	210	550	3000	36000
13	L Alexandra	25	15	625	1100	2650	27000
14	Sheepwash Cr	20	1	7	36	89.5	7500

Rural sites, on smaller creeks with limited flow and greater stock access showed the highest levels of coliforms (especially sites 7 and 12) and failed to meet various water quality criteria most often.

A number of observations can be made.

1. The minimum counts ranged from 1 cfu / 100 mL of sample, at four localities to 68 cfu / 100 mL of sample. The maximum counts ranged from 340 to of sample to 36000 cfu / 100 mL.
2. The data clearly show the concentrations of faecal coliform bacteria in Wingecarribee Shire streams vary considerably both at each site monitored and between sites. For example, the maximum count of 36000 cfu / 100 mL of sample was observed in Bundanoon Creek where it crosses Yallah Road. This site also recorded a minimum count of 1 cfu / 100 mL on another occasion. At Mittagong Creek at Burradoo, the minimum number of counts was 68 cfu / 100 mL, the highest minimum recorded, but the maximum recorded at this site was only 3700 cfu / 100 mL which is an order of magnitude less that the highest maximum recorded at any of the sites during the program.

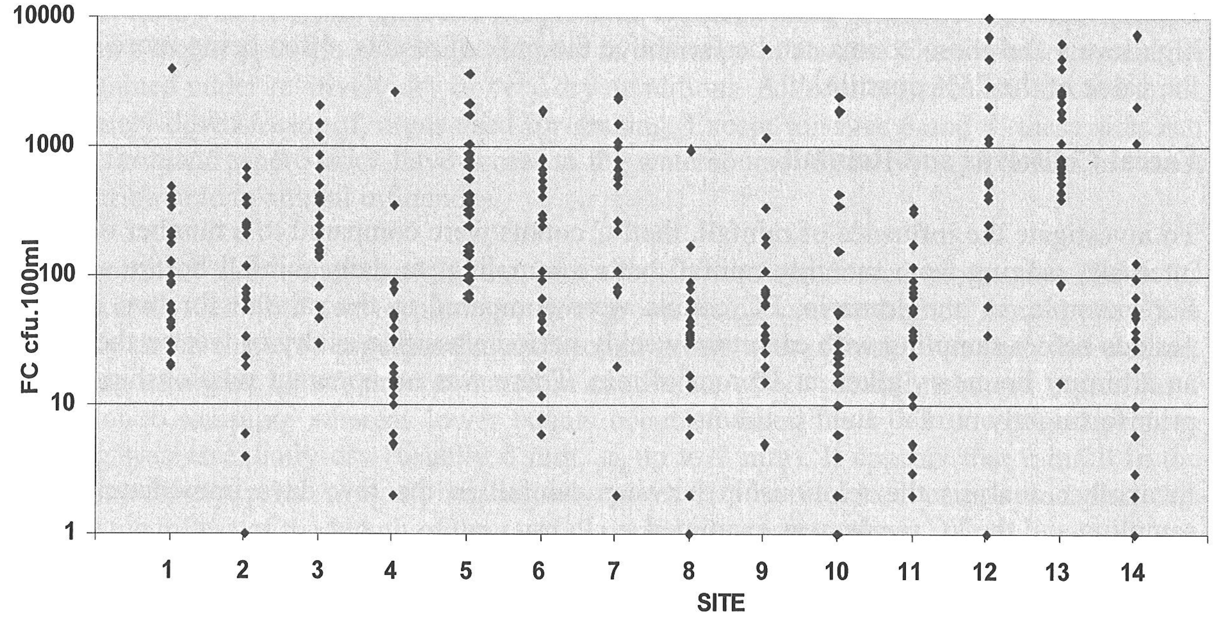

Figure 4. Faecal Coliform Data, all sites. NB Log scale.

3. Virtually all sites have occasional very high counts but not necessarily during the same sampling survey. For example the highest count in Mittagong Creek at Burradoo occurred in December 2003 whereas the highest count in Bundanoon Creek occurred in June 2002, during the pilot study. The highest count in Lake Alexandra, 27000 cfu / 100 mL, occurred in January 2004.
4. There is no apparent clear correlation between rainfall amount and faecal coliform data although there is some suggestion that concentrations in most streams respond dramatically to rain events with increases of several orders of magnitude normal after rain on the day before or on the day of sampling not being unusual. It is likely that high concentrations are also a function of other variables, such as the number of animals upstream of the sample site and hydrological factors. Dry weather sources are probably direct faecal contamination of the water by unfenced stock such as one very high dry weather result at the Nepean River site (site 9) when cattle were observed in the creek during sampling, and high counts in Lake Alexandra which has a large population of ducks and other birdlife. The relationship of FC data to rainfall is discussed further below.

Comparison with Guideline Limits

Two relevant guidelines were considered:

1. Primary human contact guideline level (ANZECC, 2000): 150 faecal coliform organisms / 100 mL median value.
2. Livestock drinking water (ANZECC, 2000): 100 faecal coliforms / 100 mL median value (based on a number of readings generated over time from a regular monitoring programme), investigations are warranted when 20% of results exceed 4 times the median guideline value, i.e., 400 cfu / 100 mL.

Clearly few sites meet both guidelines. As noted above virtually all sites have occasional very high levels and these counts can be far above the bulk of results, often being more than 10x the value of the 75% quartile.

Faecal Coliforms and Rainfall

To investigate the influence of rainfall, the FC counts were compared to a number of rainfall intervals, ranging from monthly rainfall before sampling, to daily rainfall before sampling. For example, in one scenario, FC counts were compared to the rainfall for two 2-weekly periods before sampling with each two-weekly period classified as dry or wet on the basis of an arbitrary boundary taken at 10 mm of rain. There was no apparent relationship between prior fortnightly rainfall and FC counts.

In another analysis the relationship between rainfall in the few days immediately before sampling and the FC results was examined.

The data for small rural (rural / urban) creek sites are reported in Table 3 and discussed.

Table 3. Rainfall and FC results for Small Rural (rural /urban) Sites.

Site	Name	Max cfu/100 mL	Rainfall 0, 1,2,3,.day before sampling of max result / mm	Rainfall condition of grouped higher FC results compared to lower FC results.	Max value used in comparisons
1	Medway at Hume Fway	4000	0, 0, 0, 0	Higher FC values generally had rainfall in 0 – 3 days before sampling. Lower FC generally dry weather prior or rain more than 3 days before sampling	max result 8 x next value, not used.
2	Wells at Hume Fway	670	5.5, 2, 0, 0,	Higher FC generally had rainfall in 0-3 days prior to sampling. Lower results generally drier periods or rain more than 3 days before sampling.	max value used
6	Mittagong Cr at Victoria St, Bowral	24000	0, 1.5, 2.5, 0	Lower FC results (≤ 100 cfu/100 mL) generally weather dry prior or rainfall 5 days or more prior to sampling. Higher FC results came under all weathers.	max result 10 x next value, not used.
7	Kellys Creek at Illawarra Hway	12000	3.0, 0, 0, 0	Low FC results (≤ 110 cfu/100 mL) generally weather dry prior or rainfall 5 days or more prior. Higher FC results came with rainfall in the 0-5 days before sampling.	max result 5 x next value, not used.
8	Caalang Cr at Caalang Rd	950	3.0, 0, 0, 0	Low FC results (≤ 20 cfu/100 mL) generally weather dry prior or rainfall 5 days or more prior. Higher FC results came under all weathers.	max result 5 x next value, not used.
9	Nepean R at Tourist Rd	5800	0, 0.5, 0, 0	Low FC results (≤ 42 cfu/100 mL) generally weather dry prior or rainfall 5 days or more prior. Higher FC results came under all weathers and 2 very high results under very dry conditions.	max 5800, next 1190, then ≤ 340. Two extreme results not used.
12	Bundanoon Cr at Yallawa Rd	36000	3.0, 0, 0, 0	Low FC results (≤ 100 cfu/100 mL) generally weather dry prior or rainfall 3 days or more prior. Higher FC results came under all weathers.	max result 3.5 x next value, not used.
14	Sheepwash Cr at Drapers Rd	7500	0, 2, 2.5, 2	Next two highest values, 2100, 1100, very different from remainder, these were on two days of 'first flush' event – see discussion. Other samples (n=17, FC 1-130 cfu / 100mL) taken mostly under the prevailing dry conditions.	max result not used

For small rural / semi urban sites, the maximum FC counts were generally very high being 5 to 10 times higher than the next highest count in the range of results. These maximum counts were obtained under relatively dry or very dry conditions. All of these sites are located in, or immediately downstream of, areas used for grazing. Except for sites 6 and 8, these sites run through farmland where stock have access to the watercourse. The very high counts are most likely attributable to animal influences.

Faecal coliform data, other than the extreme events, were considered separately. These FC data were divided into two groupings, one group being counts higher than the median especially those clustered together and the second group with counts lower than the median. The group of higher counts predominated in conditions where rainfall occurred in the 0 – 3 days prior to sampling whereas lower counts occurred when the 0 - 3 day period prior to sampling was essentially dry (usually 0 mm, or up to 2 mm). It appears that rainfall in the days immediately prior to sampling usually gives rise to elevated counts and that this operates regardless of the length of the rainfall period prior to sampling.

Site 14, Sheepwash Creek at Drapers Rd, displayed a significantly different response to rainfall compared to other small creek sites. Two particular sampling days (sample day 13, 27 May 2003 and sample day 22, 8 Mar 2004) were the only two times in all of the sampling days which could be characterised as a "first flush" event. Rainfall of 21 – 23 mm fell the day before sampling, 4-7 mm fell the day of sampling and the week prior had been essentially dry. Of all the small creek sites, only at this site were FC results much elevated (2100, 1100 cfu / 100 mL) on these occasions relative to the median (36 cfu / 100 mL) for the site.

The effect of rainfall on FC counts at sites downstream of STPs was mixed. Maximum counts occurred under a variety of rainfall conditions. Lower counts were found when no rainfall was recorded over the 0 – 3 days prior to sampling. All three sites responded with faecal coliforms counts at or well above median values for the two "first flush" events.

The larger river sites show a smaller range of FC counts and a less clear cut rainfall response, although there is a possible elevated response to "First Flush" events. These sites are somewhat buffered against high values because of the volume of water and in the case of Wingecarribee River, inputs of relatively sterile dam water.

Lake Alexandra, in popular parkland within the Mittagong urban area, showed consistently high levels of faecal coliform bacteria on most occasions. This small water body carries a sizable resident population of ducks and other birds. The results are not unexpected given large concentration of water birds.

Sydney Catchment Authority regularly monitors a variety of parameters in the streams and storage reservoirs under its authority. Data published in the Annual Water Quality Monitoring Report 2005-2006 show that generally low counts of selected indicator bacteria such as *E. Coli* and *Enterococci*, are recorded in the storage dams in the Southern Highlands. Thus whilst high counts were recorded at all sites on some occasions or even frequently in Wingecarribee monitoring program, these are probably local and even if faecal coliforms do reach the storage dams before die-off, the large volume of water has a strong diluting influence. Notwithstanding the dilution and die-off effects, it is necessary to recognise where risks lie and act accordingly, particularly with regard more persistent and dangerous micro organisms. Some measures already outlined by the Shire in the 2005-2006 *State of the Environment Report*, may reduce the occurrence of these very high results.

The faecal coliform data presented above was collected during one of the driest periods of European occupation of the Southern Highlands. It is not possible to state whether the data collected are typical for the Wingecarribee Shire over the long term or whether these data are an aberration because of the dry period. There is a need for monitoring programs to be carried out over a longer time interval or alternatively to be carried out when rainfall returns to a more normal pattern.

CONCLUSION

The effect of long term dry weather and the resultant low (no) flow in small creeks has been shown to result in elevated levels of particulate phosphorus in association with organic nitrogen. Towards the end of the dry spell significantly higher levels of chlorophyll a were also measured. This elevation of nutrients during the very dry September 2002 – January 2003 period was significantly greater than the seasonally elevated levels measured the following year. The smaller water bodies were significantly impacted, whereas the larger water bodies were not. Responses of nutrient concentrations to rainfall patterns over shorter time intervals (1-2 weeks) were mixed and showed no straight forward pattern. Overall it appears that when flow is very low, nutrients have the chance to build up in what are effectively unchanging pools of water, which later get flushed with the next rainfall event.

The response of faecal coliform counts to rainfall patterns was, not unexpectedly, quite different to the response found in nutrient concentrations. The data vary considerably, with very high results occurring commonly during dry spells and appearing to be unrelated to other parameters. Except for the very high results, the dominant pattern is elevated levels of coliforms when there is rain in the 0-3 days immediately before sampling.

Sampling programs carried out by Sydney Catchment Authority at specific monitoring sites in the Shire are primarily focussed on larger water volume sites, whereas this program has a predominance of sites at the small creek level. Thus this study has captured effects occurring in small waterways. These effects can be damped or obscured in larger water volumes.

The results obtained in this program have been used by the Wingecarribee Shire Council to formulate various management responses; upgrade of sewage treatment plants and management of riparian zones have been initiated.

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REFERENCES

ANZECC. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000).* Australia and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Hamilton, C. (2002). *The Development of an Environmental Water Quality Monitoring Program in the Wingecarribee Shire.* BEnvSc Honours Thesis, University of Wollongong, 97p + Appendices.

O'Donnell M., O'Brien G. and Hutton A. (2006). *Factors affecting water quality in the Wingecarribee Shire Council Local Government Area.* Proceedings of the Sydney Basin Symposium 2006

SCA. (2006). *Annual Water Quality Monitoring Report 2005 – 2006*, Sydney Catchment Authority.

WSC. (2004). *State of the Environment Report 2002-2003.* Wingecarribee Shire Council.

WSC. (2006). *State of the Environment Report 2005-2006.* Wingecarribee Shire Council.