Water Quality
on New England wool properties

A technical guide

Introduction

During the Land, Water & Wool (LWW) Northern Tablelands Project (NSW), water quality in Monitor farm dams and creeks was measured to establish a baseline for the future.

This Fact Sheet reports the results of water chemistry testing, and the diversity of aquatic macro-invertebrates ('water bugs') on farms. (See Box for methods.)

Water bugs play a central role in aquatic food webs as food for fish and birds. As they are also sensitive to pollution or unnatural fluctuations in the physical and chemical environment, they are commonly used to indicate water quality and departure from natural conditions.

Monitor farm dams

The 27 farm dams varied from 0.03-1.92 ha in area of surface water (Table 1). Four larger dams contained islands; one contained 12 islands.

Most dam verges were well vegetated with an average of 95% pasture cover and an average of 2.7 tonnes of dry matter per hectare (range, 1.2-6.0 t DM/ha). Bare ground in dam verges varied up to 15%, and tree cover varied up to 20%.

The water chemistry of the farm dams was generally good to excellent in terms of stock water quality and ecosystem protection (Tables 1-5).

Electrical conductivity

Electrical conductivity of water (ECw) is a measure of total dissolved salts and a surrogate for salinity. The ECw of the dam water on LWW Monitor farms varied from 40-721 µS/cm (Table 1), which is good to excellent for livestock (Tables 2, 4 & 5). Stock do not suffer if the ECw of water is less than 1600 µS/cm.

Objectives have been set for the maintenance of healthy aquatic systems in the catchments where these dams are located (Table 3). A similar upper threshold for ECw (1500 µs/cm) to livestock is indicated.

The water chemistry in farm dams was strongly influenced by parent material (basalt, granite and metamorphosed sediment or 'trap'). The ECw in basalt dams was significantly higher than dams in granite and trap soils (Fig. 1). However, values did not give cause for concern on livestock health or environmental grounds.

Soluble reactive phosphorus

Soluble reactive phosphorus (SRP) measures the amount of phosphorus in water for use by plants. Too much phosphorus encourages potentially toxic build-up of blue-green algae, as well as other nuisance algae.

Values were generally good to excellent (Tables 1 & 5), with only one-fifth of values exceeding the level (0.05 mg/L) associated with blue-green algae outbreaks (Table 3). However, only one-third of values fell within the threshold (0.015 mg/L) identified as desirable for the conservation of aquatic ecosystems.

SRP increased with increasing available phosphorus in the soil surrounding dams and streams.

Nitrate-nitrite oxides

Oxides of nitrogen (NOx) measure the nitrogen available to plants in the water. High levels can indicate the potential for nuisance growth of green algae as well as pollution from external sources.

NOx in Monitor farm dams ranged from 0.001-0.807 mg/L. Almost all values were less than 0.015 mg/L which is excellent for both aquatic ecosystem conservation and stock drinking water (Table 2).

Turbidity

Turbidity is a measure of the amount of particulate matter and silt suspended in water. High values are generally caused by surface soil and streambank erosion. Values less than 25 NTU are associated with moderate or better water quality for aquatic ecosystem protection.

The values for Monitor farms ranged from 3-179 NTU, with most dams registering good or better water clarity (≤ 25 NTU; Table 5).

Dissolved oxygen

Dissolved oxygen indicates the ability of water to support aquatic animal life. The target for healthy aquatic ecosystems on the Northern Tablelands is 80-90% saturation (generally equivalent to > 6 mg/L at ambient temperature). Most Monitor farm dams had dissolved oxygen levels that were good or better (> 5.5 mg/L; Tables 2-5).

Above, top to bottom—Australasian grebe nest, eggs and chick on Monitor farm dams. Adult grebes deliberately cover their eggs with weed when they leave the nest. Photos—Stuart Green.

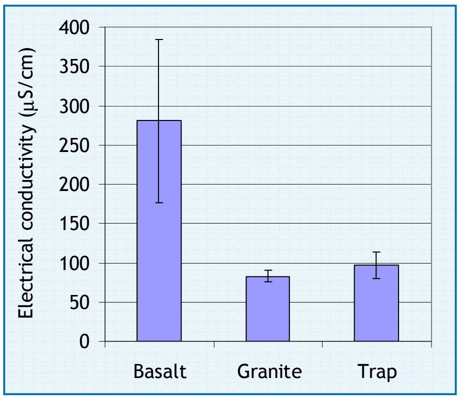

Figure 1. Electrical conductivity (mean ± s.e.m.) of water in farm dams in different parent materials. Sample sizes: basalt (n = 7), granite (n = 6) and trap (n = 14).

pH

The pH of water is a measure of acidity (pH < 7). Water should be neither too acid nor too alkaline (Tables 1-4) to support aquatic life. The desirable pH range for aquatic ecosystem protection on the Northern Tablelands is 6.5-9.0.

*Table 1. Water chemistry, vegetation, wetland size and opportunistic records of vertebrate fauna at Monitor farm dams (n = 27) and streams (n = 8). Significant differences between dams and streams for each variable (or its logarithmic transform) are indicated by * (ANOVA, P < 0.05) and ** (P < 0.1).*

	Dams		Streams	
	Average value (± s.e.m.)	Range	Average value (± s.e.m.)	Range
Water chemistry				
Electrical conductivity (μS/cm)	141 ± 31	40-721	222 ± 38	77-386
Soluble reactive phosphorus (mg/L)	0.069 ± 0.027	0.003-0.689	0.028 ± 0.009	0.009-0.083
Nitrate-nitrite oxides (mg/L)	0.036 ± 0.030	0.001-0.807	0.001	0.001-0.001
Turbidity (NTU)	22.0 ± 6.7	3-179	9.2 ± 1.8	3-18
Dissolved oxygen (mg/L)	7.6 ± 0.4	4.2-13.3	7.7 ± 0.6	5.2-10.6
pH	7.7 ± 0.2	6.7-9.9	7.9 ± 0.2	6.9-8.9
Vegetation				
Tree cover adjacent* (%)	2.0 ± 0.4	0.0-7.0	6.6 ± 2.7	0.0-5.0
Tree cover overhanging water* (%)	0.5 ± 0.2	0.0-5.0	12.2 ± 9.8	0.0-80.0
Pasture cover overhanging water* (%)	0.02 ± 0.02	0.0-0.5	26.1 ± 13.1	0.0-90.0
Emergent aquatic vegetation cover* (%)	9.9 ± 2.6	0.2-50.0	20.0 ± 5.4	0.5-43.0
Wetland size				
Surface area of water (m^2)*	4407 ± 879	280-19 100	1174 ± 190	65-2200
Vertebrate fauna				
No. of frog species*	1.07 ± 0.22	0-5	0.25 ± 0.16	0-1
No. of bird species*	2.56 ± 0.46	0-7	0.75 ± 0.37	0-3
No. of individual birds*	9.0 ± 1.7	0-33	2.4 ± 1.5	0-12
Aquatic macro-invertebrates				
No. of families**	12.7 ± 0.7	6.0-19.3	15.1 ± 1.0	9.3-19.3
SIGNAL2 index*	3.1 ± 0.1	2.4-3.6	3.3 ± 0.1	2.9-3.6

Table 2. Safe or 'trigger' levels of water quality indicators for slightly disturbed ecosystems (upland rivers) and livestock drinking water, in south-eastern Australia. After ANZECC & ARMCANZ (2000), Robson & Curran (2003) and SRC (2006).

	Trigger Levels	Livestock Drinking Water Quality—No Adverse Effect Expected
Dissolved oxygen (%)	90-110 a	
Electrical conductivity (μS/cm)	30-350	No serious burden to any livestock: <1600 No adverse effects on beef cattle: 6000 No adverse effects on sheep: 7500
Oxides of nitrogen (NOx, mg/L)	0.015	100
pH	6.5-8.0	6.5-8.5
Soluble reactive phosphorus (mg/L)	0.015	Insufficient data
Turbidity (NTU)	2-25	

[a] *Equivalent to approximately 8-10 mg/L (D. Ryder, pers. comm.).*

Below—Backswimmers like this notonectid were common on New England wool properties and are tolerant of pollution. Photo—Mark Dahm.

Below—Frog spawn in fringing aquatic vegetation on a Monitor farm dam. Photo—Stuart Green.

The desirable pH range for livestock drinking water is 6.5-8.5. Water with a pH below 6.5 or above 8.5 can cause digestive upsets in stock and depressed appetite.

The pH of dam water on most Monitor farms was good or better (6.5-9.0, Tables 1 & 5). pH was strongly affected by parent material, with dam water in basalt soils being significantly more alkaline than in granite and trap soils (Fig. 2). pH of dam water was a function of the pH of the soil surrounding each dam (Fig. 3).

Dams vs streams

Despite differences in the vegetative cover of trees surrounding dams and streams, the cover of overhanging trees and pastures, and of emergent vegetation in dams and streams, there were no consistent differences in water quality between the two (Table 1).

The average turbidity, phosphorus and nitrogen concentrations in streams were lower than those in dams, but the differences were not significant due to the large variation in measurements and

Sampling water quality

Twenty-seven farm dams and eight riparian sites were sampled on 17 Monitor farms in southern New England between 18 November 2005 and 13 January 2006. This period followed widespread rainfall totalling 150 mm in the preceding 33 days (Armidale climatic data). Local flooding and high flows in local streams were experienced prior to sampling. A further 217 mm fell during the sampling period.

Each site was delimited by a 1.2 ha circular area centred on small farm dams or an equivalent area towards the upstream end of larger dams to encompass both water and dam verges. A 1.2 ha area, 200 m long x 60 m wide, was sampled along water-ways, centred on the stream.

Each site was divided into three sections: the upstream, middle and downstream reaches in riparian sites, and three sides of each dam. Physico-chemical water measurements were made in the field in each section.

Water and water bug samples were collected for laboratory analysis and identification in each section. Water bugs were sampled for up to 5 minutes per section according to the method of Chessman *et al.* (1995). The median value of the three water chemistry measurements per site was recorded, and water bug scores (number of families and SIGNAL2, Chessman 2003) per section were averaged for each site.

the small number of riparian sites sampled.

Opportunistic recording of frogs and birds during the day revealed more frog and bird species and individual birds on farm dams than in riparian zones. This was probably due to the differences between the two in size of wetland habitat (area of water) (Table 1).

Although formal surveys were not conducted, waterbirds (Australasian grebe, grey teal, dusky moorhen, wood duck and black duck) were found breeding (nests or young) on 70% of farm dams, frogs were recorded at 67% of dams, and evidence of frog breeding (e.g. egg masses) was noted at 30% of dams.

Water bugs as indicators

A wide range of water bugs occurs in aquatic ecosystems, and they vary in their sensitivity to environmental conditions. The assemblage of water bugs in any particular wetland or stream indicates the extent to which aquatic conditions have been affected by catchment land and water use. Water bug assemblages are also sensitive to natural fluctuations in the environment (e.g. recent rainfall and river flows).

The number of water bug families varied from 6.0-19.3 and 9.3-19.3 for dams and streams, respectively, with an average of 12.7 and 15.1 families (good and excellent, respectively, Table 1). Every dam scored fair or better in terms of family diversity.

SIGNAL2 stands for the second iteration of the 'Stream Invertebrate Grade Number—Average Level.' It was developed by Chessman (1995, 2003) to help indicate departure in water quality from pristine or natural conditions.

Each water bug family is ranked in terms of sensitivity to pollution (from 1 = highly tolerant to 10 = highly sensitive), and a site SIGNAL is computed based on the average tolerance of the water bugs present. SIGNAL thus reflects pollution severity.

The SIGNAL2 index varied from 2.4-3.6 and 2.9-3.6 for dams and streams, respectively. Streams averaged significantly higher than dams (Table 1), but all SIGNAL2 scores were less than 4. This indicates severe pollution in stream water (Chessman 1995), which is at variance with the other water quality measurements.

A possible explanation for the discrepancy is that SIGNAL2 and water bug assemblages reflect aquatic conditions over a long period of time, whereas physico-chemical measurements are instantaneous.

Table 3. Water quality objectives for healthy aquatic systems in the upper Gwydir, Namoi and Macleay River catchments (EPA 2000a,b,c).

	Water Quality Objectives
Dissolved oxygen (mg/L)	> 6 (or 80-90% saturation)
Electrical conductivity (µS/cm)	< 1500
pH	6.5-9.0
Soluble reactive phosphorus (mg/L)	0.05 [a]
Total phosphorus (mg/L)	0.01-0.10 (rivers), 0.005-0.05 (lakes & reservoirs in Upper Namoi & Upper Macleay), 0.02-0.05 (lakes & reservoirs in Upper Gwydir)
Total nitrogen (mg/L)	0.10-0.75 (rivers), 0.10-0.50 (lakes & reservoirs)
Turbidity (NTU)	< 5 (low turbidity) 5-25 (medium turbidity) 26-50 (high turbidity) > 50 (very high turbidity) and < 10% change in seasonal mean NTU

[a] Values above this limit can be associated with blue-green algal blooms in streams and farm dams (A. Boulton, pers. comm.).

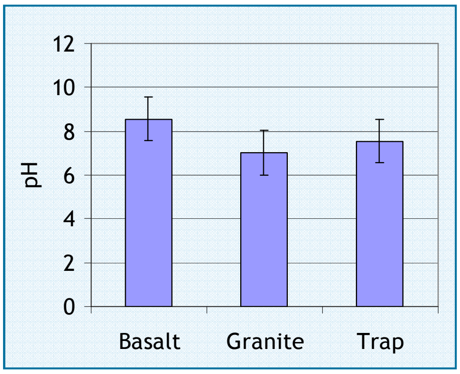

Figure 2. The pH (mean ± s.e.m.) of dam water in different parent materials. Sample sizes: basalt (n = 7), granite (n = 6) and trap (n = 14).

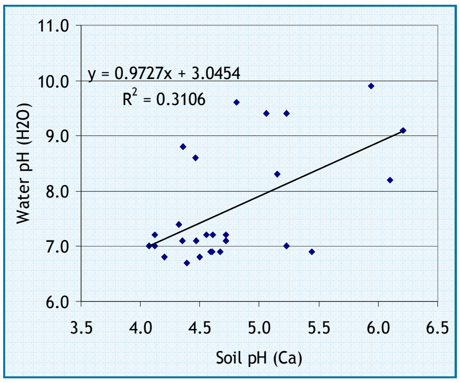

Figure 3. The linear relationship between dam water pH and the pHCa of the soil around each dam. The linear regression is statistically significant (P = 0.003).

See Fact Sheet 9 for information about the effects of grazing management on water quality.

Table 4. Critical values for water quality and macro-invertebrate variables on LWW Monitor farms.

	Very Poor	Poor	Fair	Good	Excellent	References
Water quality						
Dissolved oxygen (mg/L)	< 4.5	4.5-5.0	5.0-5.5	5.6-6.0	> 6	ANZECC & ARMCANZ (2000)
Electrical conductivity (µS/cm)	> 6000	1501-6000	751-1500	350-750	< 350	ANZECC & ARMCANZ (2000), EPA (2000a,b,c), Walter & Reuter (1996)
Oxides of nitrogen (NOx, mg/L)	> 1.0	0.5-1.0 (reservoirs) 0.75-1.0 (rivers)	0.1-0.5 (reservoirs) 0.1-0.75 (rivers)	0.015-0.10	< 0.015	ANZECC & ARMCANZ (2000)
pH	< 6.0 or > 9.5	6.0-6.2 or 9.3-9.5	6.2-6.4 or 9.1-9.3	6.4 or 8.6-9.0	6.5-8.5	EPA (2000a,b,c), Robson & Curran (2003)
Soluble reactive phosphorus (mg/L)	> 0.2	0.05-0.2 (reservoirs) 0.11-0.20 (rivers)	0.06-0.10 (rivers)	0.015-0.05	< 0.015	ANZECC & ARMCANZ (2000)
Turbidity (NTU)	> 100	51-100	26-50	5-25	< 5	EPA (2000a,b,c)
Macro-invertebrates						
Number of families	< 3	3-5	6-9	10-15	> 15	Walker & Reuter (1996)
SIGNAL2 index	< 4	4.0-4.9	5.0-5.9	6.0-6.5	> 6.5	Chessman (1995)

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Table 5. The percentage of Monitor farm dams (n = 27) with water chemistry readings and macro-invertebrate indicators from excellent to very poor. The values associated with each category of water quality variable are shown in Table 4.

	Percentage of Dams (%)				
	Very poor	Poor	Fair	Good	Excellent
Electrical conductivity	0	0	0	7	93
Soluble reactive phosphorus	7	11	4	41	37
Nitrate-nitrite oxides	0	4	0	11	85
Turbidity	4	7	7	74	7
Dissolved oxygen	4	11	0	11	74
pH	7	7	4	7	74
No. of families of waterbug	0	0	19	59	22
SIGNAL2 index	100	0	0	0	0

Grazed streams on the Tablelands today are thought to be very different to the wooded drainage plains and chains of ponds prior to European settlement.

(SIGNAL was developed for streams and is not normally applied to farm dams.)

Conclusions

The water chemistry measurements and the diversity of waterbugs in dams and streams indicated that water quality was generally good or excellent on LWW Monitor farms. Only a small minority of sites registered poor or very poor readings in some of these variables.

Water quality generally met the requirements for both livestock drinking, as specified by the NSW Department of Primary Industries, and water quality objectives for the Upper Namoi, Gwydir and Macleay catchments, as specified by the former NSW Environmental Protection Agency.

The generally good or excellent assessment of water quality on LWW Monitor farms was influenced by the good rainfall across the region preceding and during the 2-month sampling period. The measurements thus provide a good baseline for comparison in drier times.

More frogs and birds were recorded on farm dams than along streams. This was probably due to the larger expanse of water and wetland habitat at dams than streams. The dams provided breeding habitat for five waterbird species and up to seven species of frog.

The SIGNAL2 index based on water bug assemblages indicated severe pollution at all sites and differed from the other water quality indicators. While environmental conditions in grazed streams and farm are doubtless different to the pre-European situation, SIGNAL2 may be too blunt to discriminate between the catchment impacts of different grazing management.

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Below—A wooded, well vegetated stream on a Monitor farm. This stream is 'plan grazed' (high-intensity, short-duration grazing with long rest periods). Photo—Stuart Green.

Land, Water & Wool (LWW) is the most comprehensive natural resource management research and development program ever undertaken for the Australian wool industry. LWW is a partnership between Australian Wool Innovation Limited and Land & Water Australia, and has seven core sub-programs. The Native Vegetation and Biodiversity sub-program is working with woolgrowers and demonstrating that biodiversity has a range of values, can add wealth to the farm business and can be managed as part of a productive and profitable commercial wool enterprise.

The Land, Water & Wool Northern Tablelands Project is led by Associate Professor Nick Reid, University of New England, in collaboration with Southern New England Landcare Ltd, and the Centre for Agricultural and Regional Economics.

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