

Copper and zinc levels in
Taranaki waterways
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Executive summary

In the *Regional Freshwater Plan for Taranaki*, the Council has given an undertaking to promote or undertake research into methods of water quality management. With discharges to water from dairy effluent ponds being the predominant category of discharge consents in the region (almost 1000 such consents are currently exercised), the potential effects of such discharges have been the subject of particular investigations undertaken by the Council over the past 8 years. Work to date has focused on the potential effects of the discharge from an individual source. In particular, the investigation reported as *Dairy shed oxidation pond discharges in Taranaki- a study and discussion of oxidation pond performance, management and environmental effects* (Volumes I and II), (Taranaki Regional Council, 2006), studied discharges from 10 pond systems located in the upper parts of catchments (ie low dilution capacity in the receiving waters) with regard to the quality of the discharges and the extent of effects upon the receiving environment (as indicated by both physicochemical and biological parameters).

During the implementation of this study, it was noted that elevated concentrations of copper or zinc were occasionally detected in pond discharges. The range of concentrations for copper was 0.0013-4.99 g m⁻³, while that for zinc was 0.01-4.98 g m⁻³. At very low dilution rates, these concentrations would exceed water quality guidelines within the receiving waters and may possibly cause adverse (toxic) effects. Accordingly, the Council undertook to conduct a more wide-ranging investigation of concentrations of copper and zinc in the waterways of the ring plain of Taranaki, to see whether this was a widespread problem and to evaluate the severity of it.

The study was conducted during the spring and summer of 2008-2009. The Council has in place a 'state of the environment' programme for monitoring the state of the surface waters in the region. The programme consists of determining water quality at 11 sites monthly throughout the year. Nine of these sites (all on the ring plain) were utilised for the survey of copper and zinc levels. In addition, another three sites were added for the purposes of the survey. Sampling began in November 2008 and concluded in April 2009.

The study found some elevated concentrations of dissolved copper, strongly associated (to the extent that could be determined within the limitations of this study) with periods of moderate to heavy rain in the region. Copper levels in the region's soils are known to be high naturally. There is thus a possible link between copper in the region's waterways, and copper occurring naturally in the region's soils, as well as the possible influence of isolated instances of high copper in individual dairy pond treatment systems. The results and findings of this study indicate that copper runoff or discharges from pastoral farming do not pose a present risk to the quality of the region's freshwater ecosystems, or water users, overall. While copper levels (from both natural and land use practices combined) may from time to time rise above the most stringent of criteria, the levels measured remained well below concentrations found to have effects upon stream benthic (bottom-dwelling) macroinvertebrates.

This study has not evaluated whether copper in the region's streams might have an actual effect at any time, although based on studies of toxicity effects this is highly unlikely. The Council monitors the ecological condition of the region's streams and rivers. Multiple factors determine ecological state. If copper levels are playing a part, then at most it is a very subtle

part given other factors such as flow levels, sunlight intensity, stream shading, periphyton substrate cover, and water temperature.

The results and findings of this study indicate that zinc runoff or discharges from pastoral farming do not pose a present risk to the quality of the region's freshwater ecosystems, or to water users.

The Council's current *Regional Fresh Water Plan for Taranaki* (due for review by October 2011) contains provisions addressing contaminants in surface waters. There is no indication from this study that urgent additional measures are required. Should the Council intend to address this issue further at the time of review of the Plan, this study has indicated that in part because of the high natural levels of copper in soils in the region, it may be prudent to raise awareness of the possibility of and options for reducing copper run-off from farms having potential adverse effects upon waterways, especially if the possibility of cumulative concentrations are considered (that is, land use management contributions on top of the baseload from natural sources).

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1. Introduction

1.1 Purpose

This report provides the results of an analysis of the levels of copper and zinc found within the surface water bodies of the ring plain in the Taranaki region. The report is one in a series of investigations exploring the potential environmental significance and options for appropriate management of discharges from dairy effluent ponds, as described further below. In this particular study, the focus is on identifying whether elevated levels of these two metals are present, and whether they are linked with the use of these elements as animal remedies on dairy farms. While copper and zinc and essential elements for animal growth, and are effective treatments for the prevention or remedy of various disorders, they are toxic to aquatic ecosystems in elevated concentrations. Their use on farms may lead to them passing from dairy pond systems into waterways.

1.2 Background

1.2.1 Proposed Regional Policy Statement for Taranaki

Section 5 of the Council's *Proposed Regional Policy Statement for Taranaki* (February 2009) includes Section 5.2, *Maintaining and enhancing the quality of water in our rivers, streams, lakes, and wetlands*. The section notes that point source discharges commonly occur from a wide range of activities, such as farming operations. Likewise, diffuse discharges such as agricultural wastes lead to reduced water quality in the region. Key issues that the PRPS identify are:

- *Managing adverse effects on water quality arising from point source discharges to water bodies*
- *Managing adverse effects on water quality arising from diffuse source discharges to water bodies*
- *Managing the cumulative effects on water quality arising from both multiple point source discharges and diffuse source discharges to water bodies*

The PRPS proposes policies that include encouraging *the careful application of the correct types and quantity of ... agrichemicals and other land management practices, including the discharge of contaminants to land...which avoid or reduce contamination of surface water.*

The methods of implementation to deliver these policies include a commitment to *apply regional rules to allow, regulate, and in some instances prohibit...point source agricultural discharge; providing advice and information...to generally promote awareness of water quality issues; advocating to..agricultural users to adopt waste minimisation or reduction practices and cleaner production technologies to reduce the quantity of contaminants being discharged to the environment; to monitor and gather information on the state of water quality, and to support research and investigations into water quality management including.. the cumulative effects of point source discharges on water quality.*

1.2.2 Regional Freshwater Plan for Taranaki

Issue 3.1 in the *Regional Freshwater Plan for Taranaki* addresses the protection and enhancement of the natural, ecological and amenity values of fresh water. Method 9 provides that the Council will *monitor and gather information on the state of the fresh water,*

rivers,, within the Taranaki region to enable assessment of the effectiveness of the objectives and policies of the Plan.

The environmental results anticipated include safeguarding the life-supporting capacity of Taranaki's rivers (ER 3).

Issue 6.2 in the *Regional Freshwater Plan for Taranaki* addresses adverse effects on surface water quality from the discharge of contaminants from point sources. Within this section, there is a general discussion of discharges both to land and to water:

- *Adverse effects on surface water quality from point-source discharges to land*
Point-source discharges to land in the region include ... discharges of agrichemicals...These discharges all have the potential to have adverse effects on surface water quality if they are not properly managed.
- *Adverse effects on surface water quality from point-source discharges to water*
Point-source discharges to water include... discharges from farm dairy oxidation ponds... for these discharges it is important that appropriate treatment and waste reduction techniques be used in order to minimise adverse effects on the quality of the receiving waters...

Policy 6.2.2 provides that:

Discharges of contaminants or water to land or water from point sources should:

- (a) be carried out in a way that voids, remedies or mitigates significant adverse effects on aquatic ecosystems;*
- (b) maintain or enhance ... aquatic ecosystems;*
- (c) be of a quality that ... does not have a significant adverse effect on ... the life supporting capacity of water and aquatic ecosystems*

Policy 6.2.3 provides that:

Waste reduction and treatment practices which avoid, remedy or mitigate the adverse environmental effects of the point-source discharge of contaminants into water or onto or into land will be required. In assessing applications for resource consents to discharge contaminants or water to land or water, the Taranaki Regional Council will consider:

- ...
- (c) the actual or potential risks to human and animal health from the discharge*
 - (d) the effect of the discharge on the natural state of the receiving environment*

....

- (i) measures to reduce the volume and toxicity of the contaminant;*

...

As one means of achieving these policies, the Council has given an undertaking to *promote or undertake research into methods of water quality management.* (Method of implementation 11).

Issue 6.3 in the *Regional Freshwater Plan for Taranaki* addresses adverse effects on surface water quality from the discharge of contaminants from diffuse sources. Similar policies and provisions as for discharges from point sources are set out in this section of the Plan.

1.2.3 Previous study¹

In October 2006 the Taranaki Regional Council released the findings of a study into the characteristics of dairy shed oxidation pond discharges in Taranaki. The Taranaki Regional Council's Regional Freshwater Plan for Taranaki specifies that if ponds satisfy certain criteria relating to pond sizing and dilution capacity in receiving waters (amongst other matters), then an application for a resource consent allowing discharge from those ponds may be assessed as a 'controlled' activity- that is, the consent must be granted by the Council (while the Council may still impose conditions upon the nature of the pond's operation and the level of environmental performance required). Given that by definition the Council has no option but to allow a 'controlled' activity to proceed, the purpose of the study was primarily to relate the actual performance of effluent ponds against conformance with the Council's criteria, to determine whether the criteria defining this category of activity give adequate protection against unacceptable adverse environmental effects.

The results demonstrated that a pond system designed and sized generally in accordance with the Council criteria, and consistently achieving a dilution ratio of 100:1 or greater, is unlikely to result in effects on the environment that are more than negligible, in either duration or degree of severity. Effects on in-stream biological quality reflected the variations between the pond systems in the study, in terms of their design and operation, and in dilution ratios. Biological effects ranged from undetectable to significant in nature.

It was noted that some data indicated that causes other than the degree of biological treatment were having an effect e.g. the presence of elevated copper in the discharge. During the implementation of this study, elevated concentrations of copper or zinc were occasionally detected in pond discharges (refer Table 3 of this report). The range of mean concentrations for copper was 0.0013-1.84 g m⁻³, while that for zinc was 0.023-3.29 g m⁻³. Maximum individual results were markedly higher than the mean concentration discharged from each pond system. For example, a pond identified as Pond 'D' had a copper concentration on one occasion of 4.99 g m⁻³, while Pond 'T' had a zinc concentration at 4.98 g m⁻³. Two other pond systems had a single maximum copper level of respectively 2.0 g m⁻³ and 0.73 g m⁻³, although the remaining pond systems were never found to exceed 0.07 g m⁻³ copper. Thus, one pond system on one occasion had a concentration of copper more than 70 times higher than the maximum measured for the majority of the other pond systems.

Likewise, for zinc, other than the value of 4.98 g m⁻³ discussed above, one system on one occasion was found to be discharging a concentration of 2.7 g m⁻³, but otherwise the maximum zinc concentration for any pond system was 0.22 g m⁻³. In this case, the highest value measured in the effluent from one pond system on one occasion had a concentration of zinc more than 20 times higher than the maximum measured for the majority of systems.

No pond system showed both an elevated copper level and elevated zinc level simultaneously, and no pond system had both a high copper and high zinc level during the season. The highest copper levels were all detected in sampling that

¹ *Dairy shed oxidation pond discharges in Taranaki: a study and discussion of oxidation pond performance, management and environmental effects*, Taranaki Regional Council, October 2006

occurred at the end of November-December, but the two highest zinc concentrations were found in October and in April, respectively.

There was no correlation of copper or zinc concentrations with other effluent characteristics that was apparent. It was noted that the dilution ratios that would have been required to bring copper contamination to within guideline levels were higher than the dilution ratio being achieved in some cases. No in-stream copper monitoring was undertaken as part of this study. There was evidence in this study (TRC, 2006) to suggest that copper may have impacted upon in-stream macroinvertebrate communities. At lower dilution rates, the higher of these potential concentrations would be above water quality guidelines and may be causing adverse (toxic) effects.

These results suggested that there should be more research undertaken into copper levels in the receiving environment to determine whether this is a matter over which the Council should be concerned.

The report recommended:-

'6. That the Taranaki Regional Council researches further the prevalence of levels of dissolved and total copper and zinc within the water column within and downstream of ponds.'

The report was received by the Council, and its recommendations adopted, on 12 October 2006.

1.3 Purpose of current study

Copper is a key component of many footbath systems used to treat cows' hooves, and there is a pathway via washdown or run-off from dairy shed holding yards to farm oxidation ponds to discharges to streams. Zinc is a widely-used remedy for facial eczema in animal husbandry, applied as a drench in sheds or via watering troughs. Given the possibility of the zinc applied to animals subsequently washing off or being deposited on dairy shed yards, there is a possible pathway to streams. While both elements have beneficial uses and are integral to animal health, and while both elements occur naturally (especially copper in volcanic soil), elevated levels of either can have toxic effects on components of ecosystems.

Given the findings and conclusions of the above study, it was considered worthwhile to ascertain whether there are indeed occasions during the dairy milking season when regional water quality could be adversely affected by discharges of copper and/or zinc (whether from ponds or from diffuse run-off from paddocks).

1.4 Study design

This study sets out to quantify in-stream levels of these metals, during a dairy milking season. The study ran from 1 November 2008 to 23 April 2009. Advice provided to Council staff from local vets is that farmers dose animals with copper sulphate via water troughs and milking shed foot troughs from November to April, and with zinc from February to May. The areas of highest use in the region are Tikorangi (north-east Taranaki ring plain), Inglewood (further south), Toko (central Taranaki), and the southern coast. Sites were therefore selected in this study to cover

those areas, as well as the catchments of discharges identified in the earlier study. The sites are shown in Figure 1, and described in Table 1.

Sampling was undertaken on a fortnightly basis as set out below. Samples were analysed for water soluble copper and zinc, being the form of the metals that is most readily available (ie most reactive) under all conditions.

- (a) Monthly at nine SEM freshwater sites (see attached map) at the time the sites were sampled for monthly SEM freshwater quality purposes, from the November 2008 run up to and including the April 2009 sampling run: MRK000420 (Mangaoraka Stream, Bell Block) representing the Tikorangi area; WKH000500 (Waiwhakaiho River, Inglewood) and MKW000300 (Maketawa Stream near Inglewood), representing the Inglewood area; PNH000200 (Punehu Stream near National Park boundary); PNH000900 (Punehu Stream near southern coast) and WGG000900 (Waingongoro River near southern coast), representing the southern coastal area; WGG000500 (Waingongoro River Eltham mid reaches); and PAT000200 (near the National Park boundary) and PAT000360 (Patea River near Stratford), representing the Toko area.
- (b) Monthly on the alternative fortnights, samples were collected at the same 9 sites and also at an additional 3 sites: MGN000195 (Manganui River, Midhirst; a mid-catchment site) and sites MWR000180 (Mangawhero Stream tributary to the south of the National Park boundary) and WTA000065 (Waitaha Stream tributary to the west of the National Park boundary), both upper catchment sites. The latter was immediately downstream of a dairy shed ponds system discharge monitored by the 2000-2001 investigative studies.

Analyses were initially undertaken in the Council's IANZ-accredited laboratory, with further analyses for low levels of copper and zinc undertaken by a contract laboratory [which enabled the detection of lower concentrations of these dissolved metals].

Table 1 Location of sites for dairy shed metals survey (November 2008 to April 2009)

Catchment Position	Site		Sampling Frequency	Number of consented dairy pond discharges upstream of site
	Location	Code		
Upper	Patea River @ Barclay Rd	PAT000200	fortnightly	0
	Punehu Stream @ Wiremu Rd	PNH000200	fortnightly	0
	Waitaha Stream trib. @ Wiremu Rd	WTA000065	monthly	1
	Mangawhero Stream trib. @ Opunake Rd	MWR000180	monthly	0
Middle	Maketawa Stream @ Tarata Rd	MKW000300	fortnightly	4
	Waiwhakaiho River @ SH 3	WKH000500	fortnightly	8
	Waingongoro River @ Eltham Rd	WGG000500	fortnightly	25
	Patea River @ Skinner Rd	PAT000360	fortnightly	20
	Manganui River @ SH 3	MGN000195	monthly	1
	Mangaoraka Stream @ Corbett Rd	MRK000420	fortnightly	8
Lower	Punehu Stream @ SH 45	PNH000900	fortnightly	15
	Waingongoro River @ SH 45	WGG000900	fortnightly	96

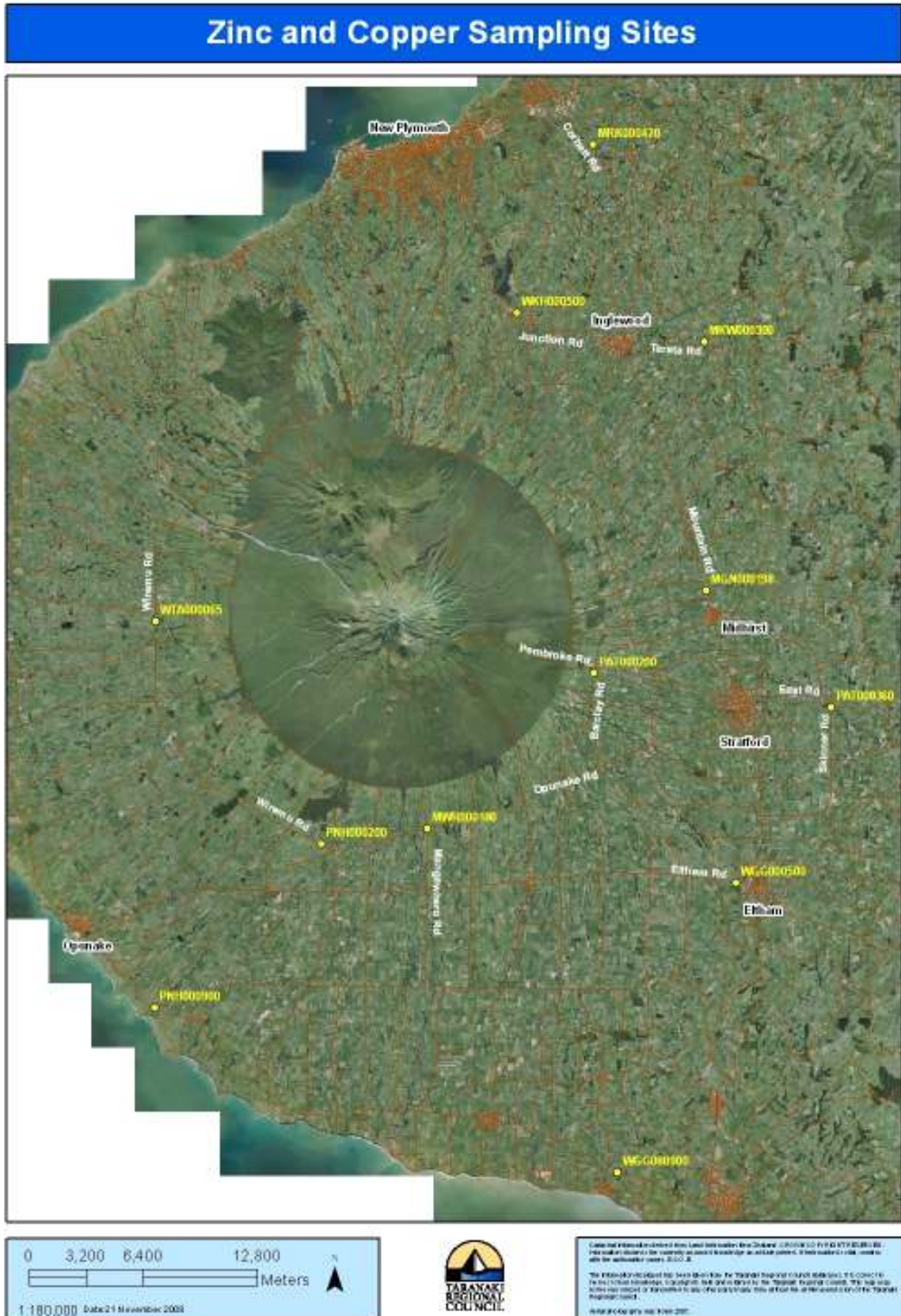


Figure 1 Sampling sites for determination of environmental levels of copper and zinc

2. Results

2.1 Copper

All samples were initially analysed through the Council's laboratory. Almost all results were below the limits of detection normally used. Given the very low levels of copper that were present (if any), samples were re-analysed by another laboratory with lower levels of detection. These results are presented in Table 2 and in Figure 2.

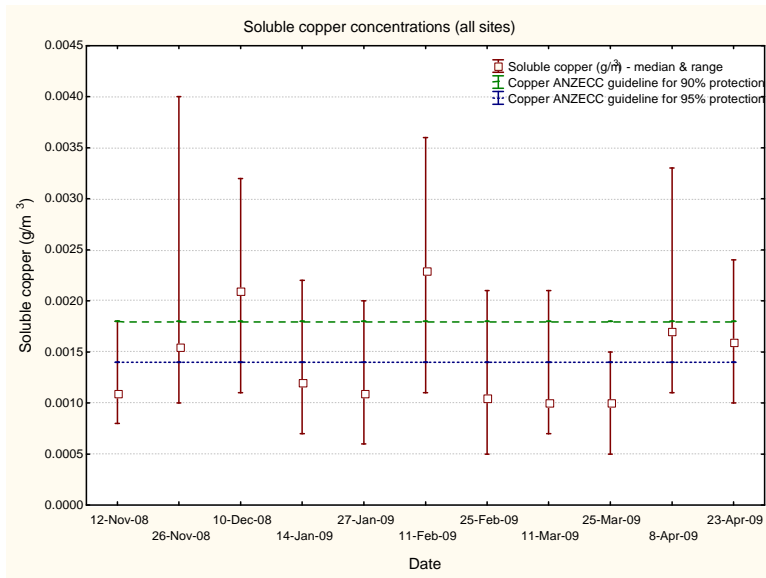


Figure 2 In-stream copper concentrations during the study

Four results (of a total of 110) had less than 0.0007 g m⁻³ copper, or less than half the ANZECC criterion for long-term protection of 95% of aquatic species (see section 3 for a discussion of criteria). Fifty-eight more results lay in the range from 0.0007 to 0.0014 g m⁻³. Thus, more than half (57%) of all samples satisfied the most stringent ANZECC long-term criterion.

Sixteen more results (another 15%) lay in the range from 0.0014 to 0.0018 g m⁻³, thus satisfying the ANZECC criterion for 90% protection level without meeting the 95% protection criterion. Thus, over 70% of all copper results met at least the 90% protection criterion. Another 26 results (24%) were below 0.0027 g m⁻³, or less than 50% above the 90% protection criterion.

Unlike zinc, there were no copper results that were significantly above the majority of other results. For example, the highest single copper result for any individual site was only three times the median copper result of all the medians for each site. The median of all individual site maxima was only double the median copper result of all the medians for each site. For zinc, the highest individual result was 14 times higher than the median zinc result of all the medians for each site, and the median of all individual site maxima was almost four times the median zinc result of all the medians for each site (refer Table 2).

Table 2 Results of analyses- copper (determined as water-soluble copper, all results in gm⁻³)

Position in catchment	Site	Dates											Median	Range	
		12 Nov 08	26 Nov 08	10 Dec 08	14 Jan 09	27 Jan 09	11 Feb 09	25 Feb 09	11 Mar 09	25 Mar 09	8 Apr 09	23 Apr 09		Min	Max
Upper	PAT000200	-	0.0010	0.0011	0.0007	0.0006	0.0011	0.0006	0.0007	0.0005	0.0011	-	0.0007	0.0005	0.0011
	PNH000200	0.0016	0.0019	0.0013	0.0013	0.0011	0.0019	0.0012	0.0021	0.0011	0.0021	0.0011	0.0013	0.0011	0.0021
	MWR000180	-	0.0013	-	-	0.0014	-	0.0005	-	0.0008	-	0.0019	0.0013	0.0005	0.0019
	WTA000065	-	0.0016	-	-	0.0017	-	0.0008	-	0.0013	-	0.0018	0.0016	0.0008	0.0018
	Median	-	0.0015	0.0012	0.0010	0.0013	0.0015	0.0007	0.0014	0.0010	0.0016	0.0018	-	-	-
Middle	PAT000360	0.0012	0.0013	0.0018	0.0012	0.0010	0.0025	0.0009	0.0010	0.0009	0.0033	-	0.0012	0.0009	0.0033
	MKW000300	0.0010	0.0021	0.0028	0.0013	0.0011	0.0031	0.0015	0.0014	0.0009	0.0026	0.0013	0.0014	0.0009	0.0031
	WKH000500	0.0008	0.0014	0.0018	0.0008	0.0009	0.0019	0.0009	0.0010	0.0009	0.0017	0.0013	0.0010	0.0008	0.0019
	WGG000500	0.0008	0.0015	0.0027	0.0012	0.0011	0.0022	0.0012	0.0010	0.0011	0.0014	-	0.0012	0.0008	0.0027
	MGN000195	-	0.0025	-	-	0.0014	-	0.0012	-	0.0012	-	0.0024	0.0014	0.0012	0.0025
	MRK000420	0.0009	0.0014	0.0021	0.0011	0.0010	0.0025	0.0009	0.0009	0.0008	0.0014	0.0010	0.0010	0.0008	0.0025
Median	0.0009	0.0015	0.0021	0.0012	0.0011	0.0025	0.0011	0.0010	0.0009	0.0017	0.0013	-	-	-	
Lower	PNH000900	0.0018	0.0027	0.0032	0.0020	0.0020	0.0036	0.0020	0.0020	0.0014	0.0024	0.0016	0.0020	0.0014	0.0036
	WGG000900	0.0018	0.0040	0.0021	0.0022	0.0017	0.0023	0.0021	0.0016	0.0015	0.0015	0.0023	0.0021	0.0015	0.0040
Median	0.0018	0.0034	0.0027	0.0021	0.0019	0.0030	0.0021	0.0018	0.0015	0.0020	0.0020	-	-	-	
	Regular sites														
Median		0.0011	0.0015	0.0021	0.0012	0.0011	0.0023	0.0012	0.0010	0.0009	0.0017	0.0013			
Minimum		0.0008	0.0010	0.0011	0.0007	0.0006	0.0011	0.0006	0.0007	0.0005	0.0011	0.0010			
Maximum		0.0018	0.0040	0.0032	0.0022	0.0020	0.0036	0.0021	0.0021	0.0015	0.0033	0.0023			
	All sites														
Median		0.0011	0.0016	0.0021	0.0012	0.0011	0.0023	0.0011	0.0010	0.0010	0.0017	0.0016			
Minimum		0.0008	0.0010	0.0011	0.0007	0.0006	0.0011	0.0005	0.0007	0.0005	0.0011	0.0010			
Maximum		0.0018	0.0040	0.0032	0.0022	0.0020	0.0036	0.0021	0.0021	0.0015	0.0033	0.0024			

The implication of this analysis is that copper levels are much more consistent throughout the season than zinc levels i.e. particular activities occurring at particular times do not significantly change copper levels in receiving waters above a 'background' level. This does not mean that there is no pattern to higher levels (see below), but rather when there are higher levels, they are not significantly above the overall general levels.

Spatial distribution

Figures 3 and 4 present an analysis of the median copper concentration for each grouping of sites according to their position within their respective catchment.

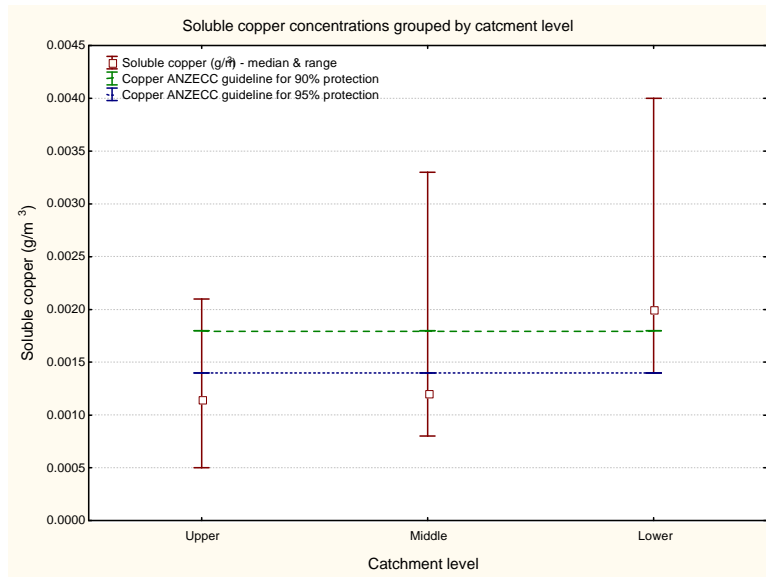


Figure 3 Copper concentrations grouped by catchment level (all results)

There is no clear spatial distribution of high or low results between catchments or along catchments with the exception that the two near-coastal sites were found to have the greatest number of high results (defined as above 0.0018 g m^{-3} , or exceeding the ANZECC guideline for protection of 90% of aquatic species, for the purposes of this study). This differentiation was further tested using statistical analysis, which confirmed a difference in median copper concentrations also, between the two lowest sites and the mid and upper catchment sites (significantly different [Kruskal-Wallis ANOVA, $H(2, N=110)=25.3851$, $P < 0.001$]. Significant differences were between the lower catchment and upper/middle catchments, identified using the Tukey post hoc test.)

While this might apparently indicate cumulative effects may occur, it must be qualified in that when upper and mid catchment sites are examined, there is no significant difference between the two groups, either in the number of occasions when higher concentrations were detected, or in the median copper concentrations. The maximum values found at mid-catchment sites were overall higher than at upper catchment sites, but on the other hand, of the two groups, the site with the highest median copper concentration was an upper catchment rather than mid-catchment site.

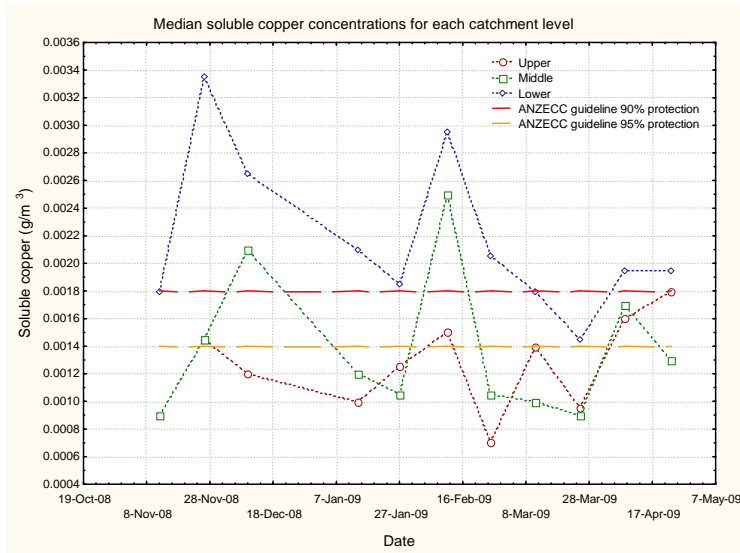


Figure 4 Median copper concentrations for each catchment category during the survey period

There were two occasions when no high results were found at any site, while on three occasions high concentrations were found in the lower catchment sites but not at mid-catchment or upper catchment sites.

The upper Punehu Stream (near National Park boundary) had the third-greatest number of high results, more than any mid-catchment site, yet equivalent sites in the nearby tributary of the Mangawhero Stream and the Waitaha Stream tributary had the lowest. Ten of the twelve sites had at least one copper result above 0.0018 g m^{-3} during the sampling period.

Temporal distribution

There was also no clear temporal distribution of results. The greatest number of high results occurred on 11 February, 2009, when 8 of the 9 sites sampled on that day exceeded 0.0018 g m^{-3} . However, the next highest number of high results had occurred three months previously, on 26 November 2008 and then again shortly afterwards on 10 December 2008. Subsequently, a comparatively high number of sites with high concentrations of copper was recorded again two months after the date of the greatest number of elevated results, on 8 April 2009. Between these three well-separated occurrences of elevated results were periods when there were few or no sites with elevated copper results.

To investigate this pattern further, reference was made to specific flow data for sites surveyed and associated rainfall records for the days preceding the detection of higher concentrations of copper in the region's streams. Interestingly, moderate to heavy rainfall fell on each of those days, with consequent increase in flows on the actual days of sampling (see Table 3 and Figures 5 and 6).

Table 3 Summary of flow statistics for the six sampling sites with adjacent hydrological recorders, (flow given as percentage of MALF) at time of sampling

Date	12 Nov 08	26 Nov 08	10 Dec 08	14 Jan 09	27 Jan 09	11 Feb 09	25 Feb 09	11 Mar 09	25 Mar 09	8 Apr 09	23 Apr 09
Median	340	734	340	196	141	250	188	289	156	315	105
Minimum	161	215	122	111	109	191	166	191	82	140	59
Maximum	548	795	552	257	184	270	524	361	175	607	113

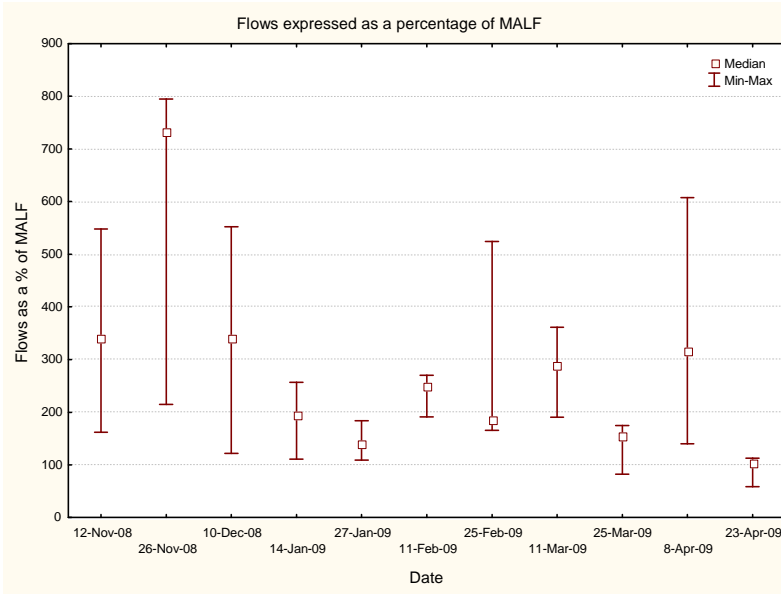


Figure 5 Relative flows on each sampling occasion

While there is generally increased flushing of diffuse pollution off pastures etc under such circumstances, many contaminants become more dilute in the receiving streams in wet weather, because of the flood conditions. However, notable exceptions are suspended sediment, turbidity and bacterial levels, which increase in concentration in wet weather flows.

The significance of the concentrations of copper found (comparison with guidelines) is discussed in section 3 of this report.

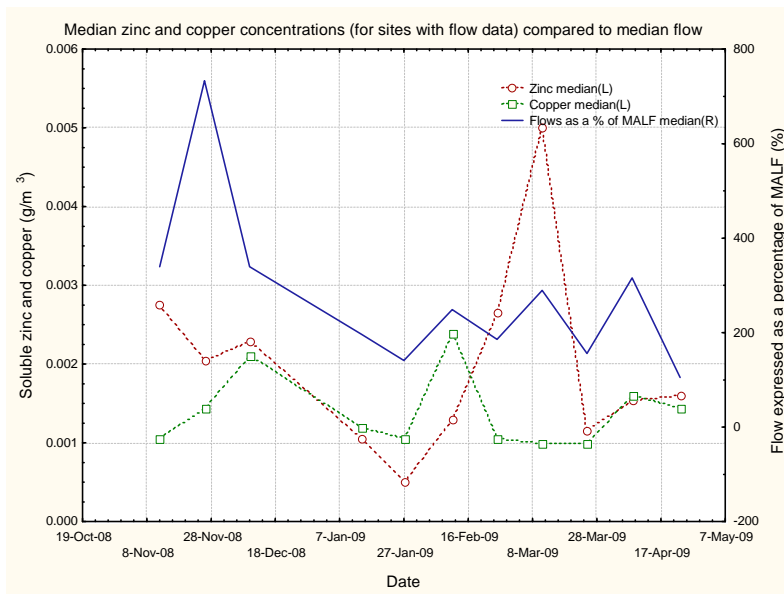


Figure 6 Variations in median copper and zinc concentrations compared with median flows (% of MALF for each site), by sampling occasion

2.2 Zinc

All samples were initially analysed in the Council's laboratory. Only one result was found to be above the normal laboratory limit of detection (0.005 g m^{-3} [5 parts per billion]). On six occasions the laboratory performed analyses using a lower limit of detection, recording zinc concentrations of 0.0013 to 0.0031 g m^{-3} .

Given the very low levels of zinc that were present (if any), samples were re-analysed by another laboratory using lower levels of detection. These results are presented in Table 4 and in Figure 7.

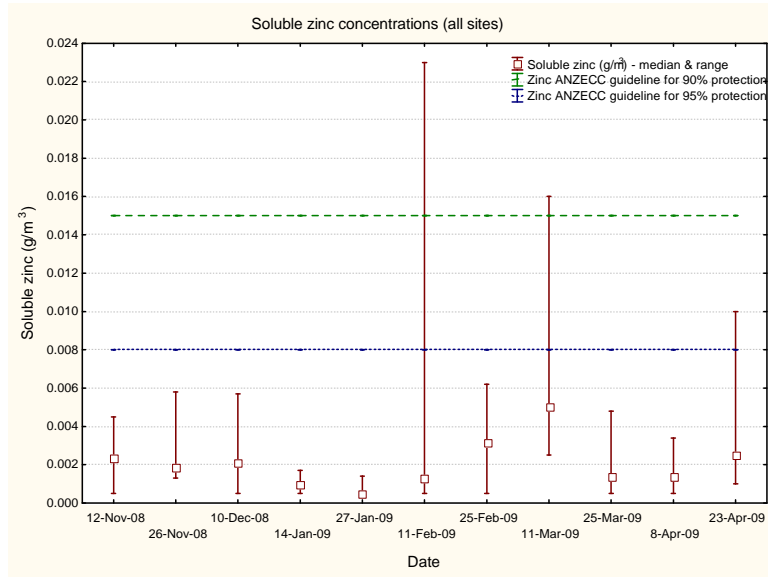


Figure 7 Zinc concentrations during the survey

The one comparatively elevated result (0.023 g m^{-3}) found by the second laboratory analytical run was identical with that result detected by the Council's laboratory, thus providing confidence in analytical accuracy and precision at this level of detection.

Twenty-eight results (of a total of 110) had no detectable zinc at a detection limit of 0.001 g m^{-3} . Thirty-seven results ranged from 0.001 to 0.002 g m^{-3} (thus, almost 60 % of all samples had less than 0.002 g m^{-3}); 16 results ranged from 0.002 to 0.003 g m^{-3} ; and 6 results ranged from 0.003 to 0.004 g m^{-3} . Thus, 79% of all samples had concentrations of zinc less than 0.004 g m^{-3} . The median of all values was 0.0016 g m^{-3} ; thus, more than 50% of all values lay below this concentration.

Of the samples with comparatively higher zinc concentrations, 16 had between 0.004 and 0.005 g m^{-3} (this includes 4 samples on the sampling run of 11 March where the results were provided as simply less than 0.005 g m^{-3}) and there was a total of 9 samples with concentrations higher than 0.005 g m^{-3} .

Spatial distribution

There was no discernible pattern of a spatial distribution of comparatively higher results for zinc (see Figures 8 and 9). The 9 highest results were found at 8 different

Table 4 Results of analyses- zinc (determined as water-soluble zinc, all results in gm⁻³)

Position in catchment	Site	Dates											Median	Range	
		12 Nov 08	26 Nov 08	10 Dec 08	14 Jan 09	27 Jan 09	11 Feb 09	25 Feb 09	11 Mar 09	25 Mar 09	8 Apr 09	23 Apr 09		Min	Max
Upper	PAT000200	-	0.0015	<0.0010	<0.0010	<0.0010	<0.0010	0.0027	<0.0050	0.0016	0.0010	-	<0.0010	<0.0010	0.0027
	PNH000200	0.0030	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	0.0044	<0.0050	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	0.0044
	MWR000180	-	0.0016	-	-	0.0010	-	0.0049	-	0.0048	-	0.0100	0.0048	0.0010	0.0100
	WTA000065	-	0.0055	-	-	0.0013	-	0.0024	-	0.0028	-	0.0046	0.0028	0.0013	0.0055
	Median	-	0.0016	<0.0010	<0.0010	<0.0010	<0.0010	0.0036	<0.0050	0.0022	<0.0010	0.0046	-	-	-
Middle	PAT000360	0.0040	0.0040	0.0057	0.0017	0.0014	0.0031	0.0024	0.0060	0.0013	0.0034	-	0.0033	0.0013	0.0060
	MKW000300	0.0017	0.0014	0.0025	0.0014	<0.0010	0.0021	0.0035	0.0160	<0.0010	0.0014	0.0025	0.0017	<0.0010	0.0160
	WKH000500	0.0011	0.0021	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0160	<0.0010	<0.0010	0.0010	<0.0010	<0.0010	0.0160
	WGG000500	<0.0010	0.0017	0.0025	<0.0010	<0.0010	0.0013	0.0029	0.0050	0.0015	0.0019	-	0.0016	<0.0010	0.0050
	MGN000195	-	0.0025	-	-	<0.0010	-	0.0062	-	0.0014	-	0.0048	0.0025	<0.0010	0.0062
	MRK000420	0.0043	0.0020	0.0027	0.0013	<0.0010	0.0013	0.0016	<0.0050	0.0010	0.0016	0.0013	0.0016	<0.0010	0.0043
Median	0.0017	0.0021	0.0025	0.0013	<0.0010	0.0013	0.0027	0.0060	0.0012	0.0016	0.0019	-	-	-	
Lower	PNH000900	0.0015	0.0014	0.0020	0.0010	<0.0010	0.0230	0.0044	0.0050	0.0010	0.0015	0.0019	0.0015	<0.0010	0.0230
	WGG000900	0.0045	0.0058	0.0021	0.0011	<0.0010	0.0010	0.0037	<0.0050	0.0029	0.0012	0.0030	0.0025	<0.0010	0.0058
	Median	0.0030	0.0036	0.0021	0.0011	<0.0010	0.0120	0.0041	<0.0050	0.0020	0.0014	0.0025	-	-	-
	Regular sites														
Median		0.0024	0.0017	0.0021	0.0010	<0.0010	0.0013	0.0027	0.0050	0.0010	0.0014	0.0016			
Minimum		<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	0.0010			
Maximum		0.0045	0.0058	0.0057	0.0017	0.0014	0.0230	0.0044	0.0160	0.0029	0.0034	0.0030			
	All sites														
Median		0.0024	0.0019	0.0021	0.0010	<0.0010	0.0013	0.0032	0.0050	0.0014	0.0014	0.0025			
Minimum		<0.0010	0.0013	<0.0010	0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	0.0010			
Maximum		0.0045	0.0058	0.0057	0.0017	0.0014	0.0230	0.0062	0.0160	0.0048	0.0034	0.0100			

sites, and were distributed evenly across upper catchment, mid-catchment, and lower catchment sites. Neither of the sites which had been selected as a result of elevated levels of zinc found during the earlier dairy effluent study [TRC, 2006], had significant zinc concentrations during this study. While the highest result was at a lower catchment site (lower Waingongoro River), the second highest was at an upper catchment site (Mangawhero Stream tributary).

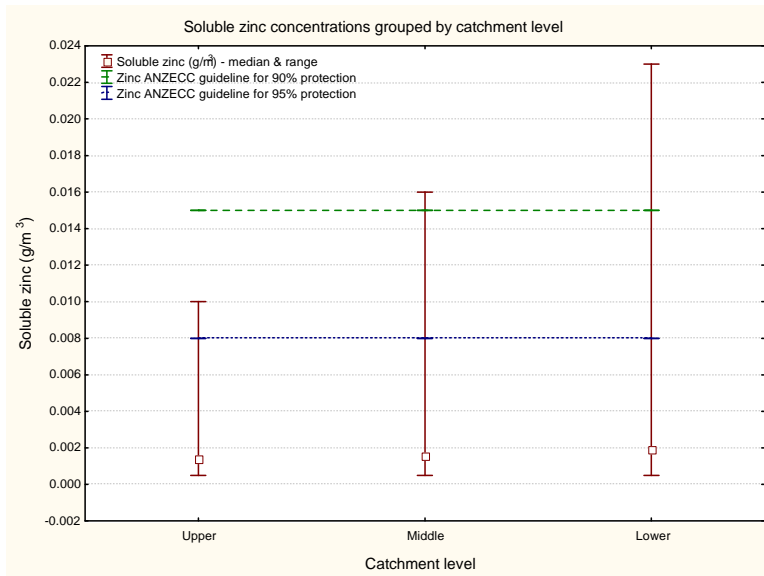


Figure 8 Zinc concentrations grouped by catchment level (all results)

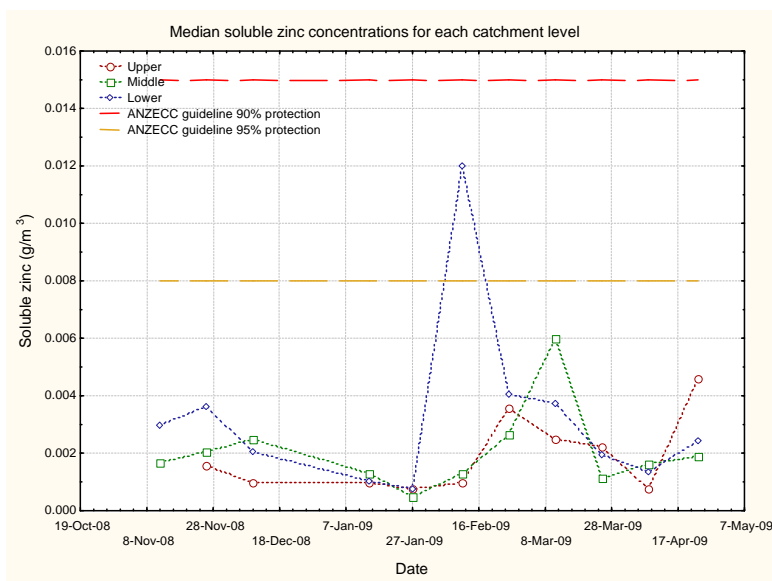


Figure 9 Median zinc concentration for each catchment level during the survey period

Likewise, the highest median zinc value of all site-specific samples was found at an upper catchment site (the Mangawhero Stream tributary), but 2 of the 3 lowest sites with lowest median concentrations were also upper catchment sites. One of the 2 low catchment sites had a median zinc value lower than almost all the mid catchment sites.

A statistical analysis to test for significant differences in median concentrations between catchment levels found median zinc concentrations between upper, middle and lower catchments were not significantly different (Kruskal-Wallis ANOVA, $H(2, N=110)=1.8054$, $P = 0.4055$).

Temporal distribution

There was no discernible pattern of a temporal distribution of comparatively higher results for zinc. The 9 highest results were spread across 6 separate sampling runs, across the entire dairying season. While veterinary advice was that zinc usage is highest from February to May, the results showed that 3 of the 9 highest results were detected in November-early December, and after a cluster in mid-February to mid-March results were comparatively low for the remainder of the sampling period.

Comparison of zinc results with river flows suggests a clear co-incidence of lower peak zinc concentrations with lower flows, and the highest zinc values with higher flows. The association of median zinc concentrations with median flows is shown in Figure 6, where a similar although somewhat weaker pattern emerges. The one sample where an unusually high zinc concentration was detected (0.023 g m^{-3}) was found in the lower reaches of the Punehu Stream, sampled in mid-February, 2009 coincidental with elevated absorbance and nutrient levels, typical of wet weather water quality.

The significance of the concentrations of zinc found (comparison with guidelines) is discussed in section 3 of this report.

3. Discussion

3.1 Discussion of significance of the results

3.1.1 Guideline values

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment and Conservation Council, October 2000) propose that for protection of 95% of species (the default value for ecological protection), copper in fresh water should be less than 0.0014 g m^{-3} , and zinc less than 0.008 g m^{-3} . For protection of 90% of species (a lower level of ecological protection), copper in fresh water should be less than 0.0018 g m^{-3} , and zinc less than 0.015 g m^{-3} . These numbers refer to chronic (on-going) exposure.

The Environmental Protection Agency of the United States has set a standard for chronic (longterm) exposure of 0.009 g m^{-3} for copper, and 0.120 g m^{-3} for zinc. The USEPA's standard for acute (short-term) exposure for copper is 0.013 g m^{-3} , and for zinc is 0.120 g m^{-3} .

It is obvious that there are major discrepancies between the ANZECC guidelines and the USEPA guidelines, with the former's chronic exposure guideline being more than 5 times more conservative (lower) for copper and 15 times more conservative for zinc, than the USEPA criteria.

Hickey and Vickers² reported on the sensitivity of the mayfly *Deleatidium* to copper and zinc. This mayfly taxon was tested because of its wide distribution and its typical abundance throughout New Zealand. They found that for copper, the EC_{50} (the concentration at which some effects of exposure could be observed in 50% of the exposed population) was 0.325 (range $0.182\text{-}0.535$) g m^{-3} for an exposure period of 24 hours, decreasing for longer periods of exposure to 0.034 (range $0.018\text{-}0.086$) g m^{-3} over 96 hours. The EC_{10} for 96 hours was found to be 0.015 g m^{-3} . They noted from a review of other toxicity data that *Deleatidium* appeared to be among the more sensitive species in regard to copper.

This data suggests that the ANZECC copper guideline for protection of 95% of aquatic species, of 0.0014 g m^{-3} , has a considerable margin of safety incorporated into it, being an order of magnitude lower than the lowest level at which effects were observed for an extended period of exposure in a sensitive aquatic species, even for a small proportion of the exposed population.

For zinc, the study reported that while *Deleatidium* spp were found to be relatively insensitive (EC_{10} of 1 g m^{-3}), other aquatic species studied elsewhere showed mortality at levels down to 0.09 g m^{-3} .

More recent work by Hickey and Golding³ studied the effects of mixed solutions of copper and zinc on Ephemeroptera, Plecoptera, and Tricoptera (mayflies, stoneflies, and caddisflies, respectively). This work used concentrations up to 10 times higher than the USEPA chronic criterion value. The study found that the majority of species studied had threshold effects or responses at concentrations more than 5 times the ANZECC criterion, with stimulus effects in this range; more significant effects occurred only above 21 times the ANZECC value. The authors concluded 'none of

² Comparison of the sensitivity to heavy metals and pentachlorophenol of the mayflies *Deleatidium* spp. and the cladoceran *Daphia magna*, Christopher Hickey and Maggie Vickers, New Zealand Journal of Marine and Freshwater research 1992, Vol 26:87-93

³ Response of macroinvertebrates to copper and zinc in a stream mesocosm, Christopher Hickey and Lisa Golding, Environmental Toxicology and Chemistry 2002, Vol 21 No 9:1854-1863

the individual species or indices had data threshold values below 1.4 [times the USEPA criterion], indicating that the **USEPA criteria would provide adequate community protection....** compliance with the ANZECC guidelines would provide a **considerable margin of protection** before effects would be observed on invertebrate communities....' (emphases added). The study found Ephemeroptera (mayflies) to be the most sensitive, which highlights the importance of the earlier work reported by Hickey and Vickers discussed above.

The Council's preferred minimum dilution for the discharge from a dairy pond system is 1:100; for almost all the ponds reported in the 2006 report, this level of dilution would ensure that downstream levels of copper and zinc always remain within ANZECC guideline values even at the maximum concentrations detected, but as noted there were exceptions where in-stream concentrations of copper or zinc would exceed the guideline values on occasion even at a 1:100 dilution rate.

Various other standards and guidelines are presented in Table 7, for comparative purposes.

3.1.2 Copper results and guidelines

No copper result breached the USEPA criterion for chronic (long-term) exposure or the USEPA acute (short-term) criterion. The highest value detected was less than half of the USEPA chronic criterion and less than one-third the acute criterion. All median results were less than one-quarter of the USEPA chronic exposure criterion.

32 of 110 results (29%) exceeded the ANZECC criterion for protection of 90% of aquatic species of 0.0018 g m^{-3} , and 44% exceeded the most stringent ANZECC protection criterion. Of the exceedances of the 90% protection criterion, almost all lay in the range $0.0019\text{-}0.0027 \text{ g m}^{-3}$, or within 50% higher than this long-term criterion. Only 6 were higher, lying in the range $0.0030\text{-}0.0040 \text{ g m}^{-3}$ with only 1 at the latter limit.

62 samples, or 56%, were lower than the ANZECC criterion for protection of 95% of aquatic species (0.0014 g m^{-3}). That is, the median value for all samples is lower than (ie satisfies) the 95% protection criterion. Thus, overall, even during the period of lowest flows (lowest dilution) and highest usage of copper on farms, the region's waterways satisfy the most stringent of protection criterion. Nevertheless, there are a significant proportion of results that exceed this particular criterion.

Care must be exercised in the interpretation of these results, especially in assigning the cause(s). Landcare reports (*Maps of total soil concentrations (background levels) of chromium, copper, lead, nickel, vanadium, and zinc in the Taranaki Region*, Landcare July 2002) that natural soil levels of copper are high in the region, ranging up to 120 g m^{-3} . Soil profile sampling work by the Council in 2008 found copper levels in soil ranging up to 100 g m^{-3} , and interestingly at most sites the concentration of copper increased with depth, the highest concentrations being found 400 mm deep. This indicates strongly that the copper was occurring naturally, rather than being the result of surface application.

The soil concentrations of copper mean that in conditions of elevated sediment loads in streams, such as in wet weather, total copper levels in the region's streams could easily exceed 0.06 g m^{-3} , or more than 30 times above the ANZECC criterion, due entirely to the load of suspended sediment being carried at such times. While this assessment relates to total rather than dissolved copper, and to short-term events

rather than long-term concentrations under base flow conditions, nevertheless it is clear that natural sources may contribute significant fractions of dissolved copper in the region's streams and must be taken into account as a baseline when considering if other sources such as treatment pond discharges are significant sources.

Comparing the number of dairy pond treatment systems above each sampling site with the occurrence of elevated concentrations of copper, there is simply no apparent correlation. The Punehu upper catchment site (PHN000200) and the Maketawa mid-catchment site (MKW000300) each had more high results than any of the other upper catchment or mid-catchment sites, yet have amongst the fewest dairy pond discharges above them of all such sites. The mid-catchment Waingongoro and Patea River sites (WGG000500 and PAT000360) have far more dairy pond discharge points above them than any of the other upper catchment or mid-catchment sites, yet had no more high results than sites with few or no pond discharges upstream.

On the other hand, the earlier study of dairy pond treatment systems did find that there were isolated instances of very high concentrations of copper in a few pond discharges, so some degree of association cannot be entirely discounted.

The study of dairy pond effluents noted the highest concentrations of copper occurred in November- December, yet this study of receiving stream concentrations has found the highest median environmental levels occurred in February, a generally drier time when it would normally be considered there was less on-farm use of copper for prevention of footrot. If the primary source of copper is farm pond systems, then it would be expected that highest in-stream concentrations would occur in dry conditions (less in-stream dilution) when ponds were discharging at their highest rate and copper was being used most liberally (November-December). In the study of dairy pond discharges, it was found that every pond had its peak copper concentration in early December, discharge concentrations falling rapidly thereafter.

Considering all copper results rather than just the highest, there was further analysis seeking to determine the extent of any correlation with either the number of dairy pond discharges above any site, or the total length of stream above any site. The two elements are obviously associated in any case- the longer the stretch of stream above a sample point, the more likely it is that there is a greater number of pond discharges. It should be noted that for reasons of accuracy and reproducibility, and because of the significance of the point of change of land use for effects upon water quality, the Council uses the National Park boundary as the point of reference for ring plain streams in GIS-based analysis.

The results of this correlation analysis are shown in Figure 10.

In Figure 10, the median 'loading' was calculated as the median of the copper concentration multiplied by the river flow, for each sampling occasion. Flows were measured at or in the vicinity of 6 of the 12 sites. The correlation analysis showed that there was only a weak association between copper loadings and the number of upstream dairy pond discharges, and an even weaker association with the length to Park boundary.

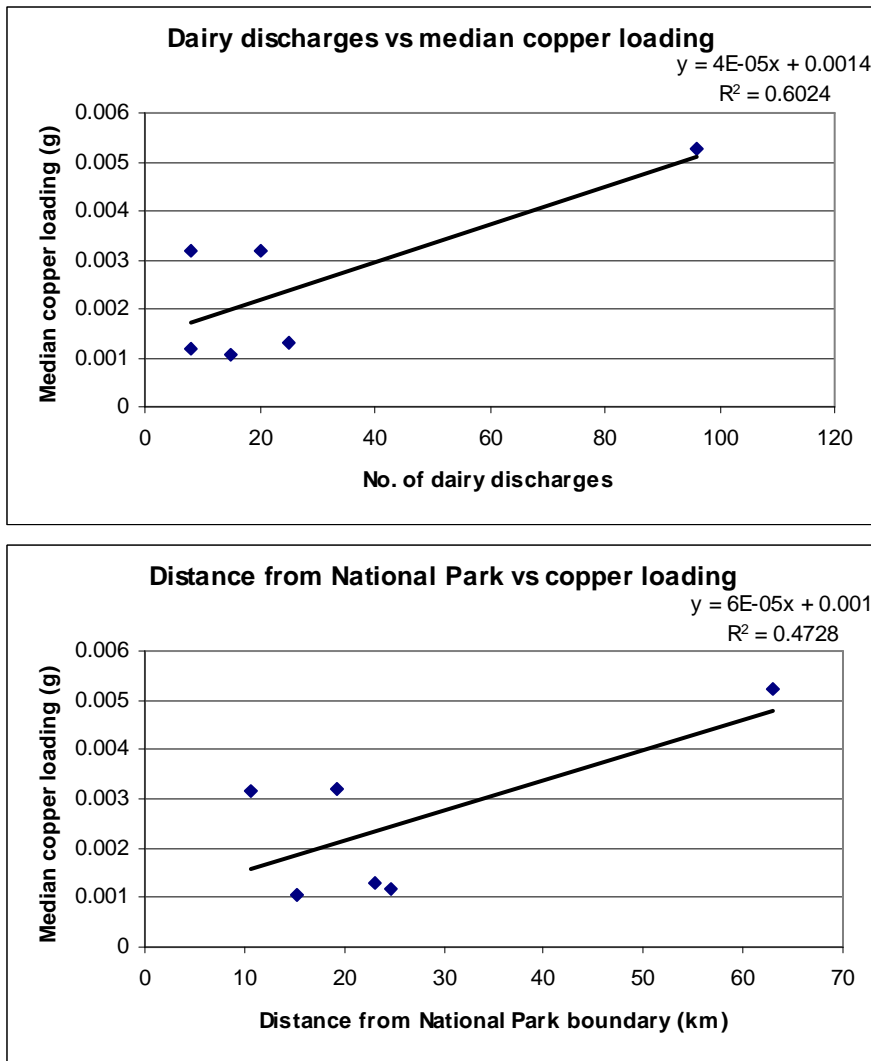


Figure 10 Correlation analysis for relationship between in-stream copper loadings and distance from source and upstream dairy pond discharges

As noted above, elevated concentrations of dissolved copper appear associated (to the extent that could be determined within the limitations of this study) with periods of moderate to heavy rain in the region. This observation, alongside the detection of elevated levels of copper at times when farmers are not known to be using copper to any great extent, and the indication that levels of copper are more consistent throughout the region and throughout the season than zinc (ie no sign of significant site-specific or time-specific elevation of copper concentrations) strengthens even further the possible link between copper in the region's waterways, and copper occurring naturally in the region's soils.

3.1.3 Zinc results and guidelines

As noted above, the highest single value of zinc found was 0.023 gm^{-3} .

This value exceeds the ANZECC guidelines for protection of aquatic ecosystems at the 95% protection and 90% protection levels, but it must be noted that the ANZECC guidelines relate to chronic (ongoing), and not intermittent or short-term, exposure patterns. Given that the occurrence of this concentration of zinc was a single event, it is not appropriate to compare against this guideline.

The two next highest values lay around 0.016 g m^{-3} , and one other at 0.010 g m^{-3} , (all four of these results occurred at separate sites) but otherwise all results were within the most stringent ANZECC chronic guideline.

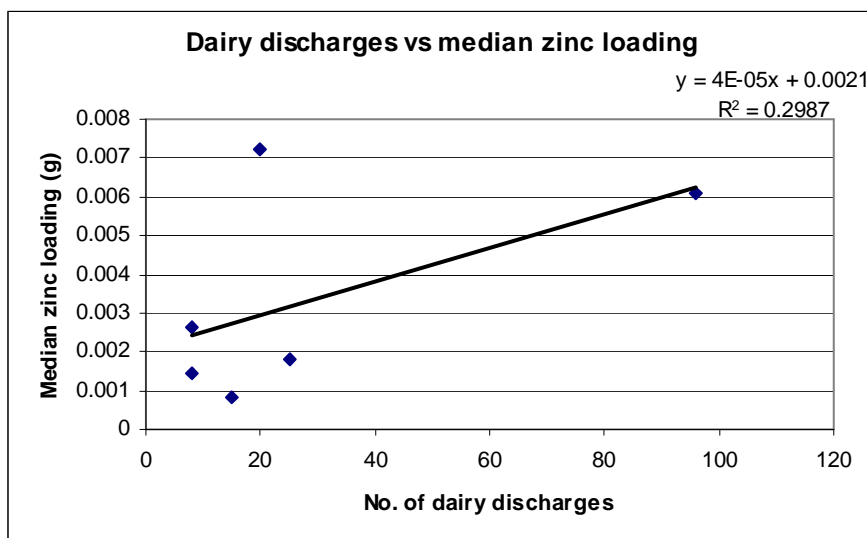
The study of dairy pond effluents noted there was no clear pattern as to when the highest concentrations of zinc were found in pond discharges. There was a spread from November to April. Yet this study of receiving stream concentrations has found the highest median and highest individual environmental levels to have a clear peak in March. This is co-incident with the advice from vets as to the use of zinc on pasture for the prevention of facial eczema, from February to May.

Looking at all zinc results rather than just the highest, there was further analysis seeking to determine the extent of any correlation with either the number of dairy pond discharges above any site, or the total length of stream above any site. The two elements are obviously associated in any case- the longer the stretch of stream above a sample point, the more likely it is that there is a greater number of pond discharges. It should be noted that for reasons of accuracy and reproducibility, and because of the significance of the point of change of land use for effects upon water quality, the Council uses the National Park boundary as the point of origin for ring plain streams in GIS-based analysis.

The results of this analysis are shown in Figure 11.

In Figure 11, the median 'loading' was calculated as the median of the zinc concentration multiplied by the river flow, for each sampling occasion. Flows were measured at or in the vicinity of 6 of the 12 sites. The correlation analysis showed that there was no association between zinc loadings and either the number of upstream dairy pond discharges, or the length to Park boundary. The apparent slope in Figure 11 was driven by a single sample result at a single site. The US Environmental Protection Agency standard for short-term exposure to zinc is 0.12 gm^{-3} . The highest level of zinc found in this study was less than 20% of this standard, and all other results were less than 5% of this standard.

It is therefore concluded that, based on the results of this survey, the agricultural use of zinc does not pose a risk for aquatic communities in Taranaki.



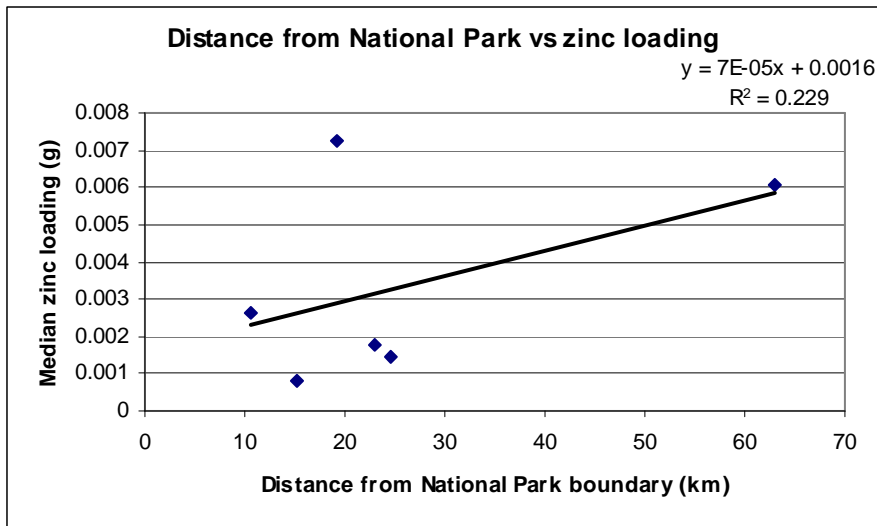


Figure 11 Correlation analysis for relationship between in-stream zinc loadings and distance from source and upstream dairy pond discharges

3.2 Discussion of significance of the issue of metals in surface freshwaters in Taranaki

3.2.1 Implications of this study

The results and findings of this study indicate that copper runoff or discharges from pastoral farming do not pose a present risk to the quality of the region's freshwater ecosystems, or water users, overall. Copper levels (from both natural and land use practices combined) may from time to time rise above the most stringent of criteria, but New Zealand studies of macroinvertebrate sensitivity to metals indicates that these criteria provide a substantial margin of protection, and the measured levels of copper in the region's streams remained well below the thresholds at which effects have been observed in the laboratory studies.

Levels of copper in the region's waterways show a pattern of highs and lows that reflects wet weather influences, but the degree of variation in the levels of copper between the highs and lows is not as pronounced for copper as it is for zinc. The period of known peaks in concentrations of copper in pond discharges had no correlation with peak copper concentrations observed in the region's waterways. This is consistent with a model of a baseline level of copper in the region's waterways, that is influenced only to a minor degree if at all, by land use activities. When peaks of zinc occur, they are comparatively more pronounced when compared with the baseline concentrations than is the case for copper. The random pattern of comparatively greater peak zinc values suggests a stronger link with site-specific and time-specific events than for copper.

This study has not evaluated whether copper in the region's streams might have an actual effect at any time. The Council monitors the ecological condition of the region's streams and rivers. Multiple factors determine ecological state. If copper levels play a part, then at most it is a very subtle part given other factors such as flow levels, sunlight intensity, stream shading, the extent of substrate periphyton cover, and water temperature.

The results and findings of this study indicate that zinc runoff or discharges from pastoral farming do not pose a present risk to the quality of the region's freshwater ecosystems, or to water users.

Table 5 Summary of mean discharge characteristics- 2006 report

Parameter	Farm A	Farm B	Farm C	Farm D	Farm E	Farm F	Farm G	Farm H	Farm I	Farm J	MEAN Of means	MEDIAN Of means	RANGE Of means
Copper gm ⁻³	1.2	0.0013	1.838	0.025	0.025	0.418	0.03	0.0075	0.05	0.0275	0.36	0.03	0.0013-1.838
Zinc gm ⁻³	0.084	1.2	0.141	0.064	-	0.11	0.127	0.023	3.295	0.083	0.57	0.11	0.023-3.295
Dilution ratios											>340:1	180:1	3:1->1600:1

Table 6 Water quality guidelines

Parameter	Guideline	Application of guideline
Copper gm ⁻³	0.0014	ANZECC (2000) Protection of aquatic ecosystems [95% species protection and 90% species protection respectively]
	0.0018	
	1	ANZECC (2000) low risk livestock drinking water – cattle
	0.4	ANZECC (2000) low risk livestock drinking water – sheep
	0.009	USEPA 2005- Protection of aquatic ecosystems chronic (long-term) exposure- http://www.epa.gov/waterscience/criteria/wqctable/ Actual value depends on prevailing water chemistry. Value is indicative for waters similar to Taranaki
	0.013	USEPA 2005- Protection of aquatic ecosystems acute (short-term) exposure- http://www.epa.gov/waterscience/criteria/wqctable/ Actual value depends on prevailing water chemistry. Value is indicative for waters similar to Taranaki
Zinc gm ⁻³	0.008	ANZECC (2000) protection of aquatic ecosystems [95% species protection and 90% species protection respectively]
	0.015	
	20	ANZECC (2000) low risk livestock drinking water
	0.120	USEPA 2005- Protection of aquatic ecosystems chronic (long-term) exposure- http://www.epa.gov/waterscience/criteria/wqctable/
	0.120	USEPA 2005- Protection of aquatic ecosystems acute (short-term) exposure- http://www.epa.gov/waterscience/criteria/wqctable/

3.2.2 Implications for the Regional Fresh Water Plan

When considering whether a regional plan should contain particular or specific provisions to deal with an environmental issue above the general provisions set out in the Resource Management Act, it is appropriate to take into account whether the proposed measure is efficient (is it justified to put resources into developing measures that are applied universally, or instead can the situation be adequately dealt with on a case by case basis?), and whether the measure is effective (what is achieved as an outcome?).

With a review of the Council's RFWP due in 2011, the Council is able to consider whether additional or alternative measures are necessary.

The Council's RFWP already contains provisions related to the management of runoff from farming activities such as the application of animal remedies. These provisions include both the application of rules to discharges (Methods 1 and 2 of Section 6.2 RFWP), and the encouragement of adoption/implementation of codes of practice and guidelines (Methods 4, 6, and 8).

It appears that this is an issue that affects very few stretches of streams, on very few occasions. That goes to the *efficiency* of any measure in a plan. In other words, if the Council were to implement additional measures, these measures would result in improvements in a few stretches of the water courses on the ring plain, on very few occasions, when compared with the current situation.

It is also noted that the Council already promotes the upgrading of dairy pond treatment systems and a minimum level of dilution within receiving waters, and that the Council and the Clean Stream Accord together promote riparian fencing and planting, which reduce runoff from pasture and thus enhances water quality and mitigates potential effects. Thus, any new measures to address the cumulative effects from copper and zinc discharges will be incremental and marginal beyond the benefits of these improvements, rather than stand-alone. This goes to the question of the *effectiveness* of any such measures.

If the Council were minded to introduce additional measures, these measures (whether voluntary or compulsory) could be targeted at research into identifying preferred management of farming activities involving copper and zinc, improving the on-farm management of animal dosing practices and the disposal practices of residues, and increasing farmer awareness of the potential for in-stream effects due to discharges.

In particular this study has indicated that in part because of the high natural levels of copper in soils in the region, it may be prudent to raise awareness of the possibility of copper run-off from farms having a potential for adverse effects upon waterways, especially if the possibility of cumulative concentrations are considered (that is, land use management contributions on top of the baseload from natural sources), as a precautionary approach. Advocacy of good practice may revolve around consideration of avenues for reducing the likelihood or extent of direct discharge of copper solutions to surface water.

It should be noted that this survey has not investigated on-farm practices to ascertain options that reduce discharges of copper and zinc to streams.

4. Recommendations

It is recommended that the Taranaki Regional Council:-

1. receives this report on copper and zinc in surface waters in the region;
2. notes that the study finds that concentrations of zinc remain below levels of concern in surface waters in the region,;
3. notes that the study finds that concentrations of copper may reach levels comparable to some guideline values in some surface waters in the region, although such levels are well below those known to cause adverse effects;
4. notes that natural copper from soils appears to be the source of the greater part of copper found in the region's waterways, with elevated concentrations associated with wet weather flows rather than land use activities;
5. notes that the Resource Management Act and the Council's current *Regional Freshwater Plan for Taranaki* contain requirements, policies, and methods of implementation that require potential effects of discharges of copper or zinc from pastoral activities to be managed by land owners/occupiers;
6. notes that the need for and nature of any additional or alternative measures (policies, objectives, rules, or other methods of implementation) can be considered by the Council in 2011 at the time of review of the *Regional Freshwater Plan for Taranaki*; and
7. distributes this report to interested parties.

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