



New Zealand Aluminium Smelters Limited

Interdepartmental

Committee

Report

1999

**REPORT TO THE INTERDEPARTMENTAL COMMITTEE
ON ENVIRONMENTAL EFFECTS OF THE TIWAI ALUMINIUM SMELTER
FOR THE YEAR ENDING 31 DECEMBER 1999**

**MEETING AT TIWAI
29 MARCH 2000**

**THE INFORMATION CONTAINED IN THIS REPORT IS CONFIDENTIAL TO
THE MEMBERS OF THE INTERDEPARTMENTAL COMMITTEE**

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Summary

Main stack discharges to air were within permit standards and generally stable during 1999. Total particulate and particulate fluoride discharges were higher than normal in November due to leaking seals in the dry scrubbing system. Improved sealant was used and the discharge returned to normal.

Potline roof louvre discharges were within permit standards during 1999 but were slightly higher than for 1998.

Wind speeds were generally lower and southerly winds more frequent during 1999 compared with 1998. Rainfall for 1999 was about average with the summer drier than normal, spring wetter than normal, and autumn and winter rainfall about normal.

Ambient air gaseous and particulate fluoride concentrations were similar to those reported for 1998 apart from one seven-day gaseous and particulate fluoride concentration measured at the 1 Km Hut site in October. The higher than normal concentrations measured at 1 Km Hut were most likely caused by the high frequency of westerly winds during the sampling period. Following approval from the Southland Regional Council monitoring at all sites apart from 1Km Hut were changed to a one-month sampling period at the end of November.

The fluoride concentrations of ungrazed grass and pinus radiata needles close to the smelter were higher during 1999 than during 1998. Fluoride concentrations further afield were similar to the fluoride concentrations reported for 1998.

The fluoride concentrations of grazed grass and cattle urine on GMF4 exceeded permit guidelines and some permit standards during 1999. These occurrences were due to topdressing with superphosphate followed by a prolonged period without significant rain.

The Tiwai Experimental Farm Project was closed in May. Monitoring reflected the decreased exposure to fluoride at the farms during the past three years.

Discharges from drains and of treated effluent and their effects on the environment were within permit standards and similar to previous years.

The faecal coliform concentration in groundwater down stream of the treated sewage disposal area increased during 1999 but is unlikely to significantly effect the receiving seawater in Foveaux Strait.

Monitoring of groundwater near the NZAS landfill during 1999 generally indicated similar results to 1998. Bore A24 had increased concentrations of nitrogen species and fluoride indicating the proximity of the bore to the MRP fines storage area. This increase is unlikely to significantly effect the receiving seawater in Foveaux Strait.

Monitoring of the cathode pad area groundwater contamination plume indicated that the contamination continued to decrease. Monitoring of total petroleum hydrocarbon concentrations in groundwater surrounding the diesel spill plume at the smelter site indicated there is no movement of the plume downstream or off-site. As a result the Southland Regional Council recommended that monitoring of both plumes be discontinued for three years.

Introduction

Operations at NZAS remained stable throughout 1999 apart from issues with air burn of anodes in the reduction cells. Initiatives to improve the smelter's efficiency continued throughout the year.

This report outlines NZAS' commitment to maintaining and where possible improving the smelter's environmental performance.

This report includes some of the annual reports forwarded to the Southland Regional Council (SRC) each year with additional sections including discharges to air, dispersion conditions, liquid discharges etc. included to cover NZAS' discharges to, and effects on, the environment.

The data is provided in summaries, maps and where appropriate as graphs. Analysis of trends and other comments are also included where appropriate.

Discharges to Air

Introduction

Discharges into air from the smelter and wharf are covered by Air Discharge Permit Number 93566. The Permit conditions were revised following NZAS' application to change or cancel some conditions, which was approved by the Southland Regional Council on 5 August 1998.

This chapter covers:

- Main Stack discharges,
- Potline roof louvre discharges,
- fluoride discharges into air,
- baghouse discharges,
- Main Stack plume opacity, and
- sulphur contents of raw materials and fuels used in the aluminium smelting process.

Main Stack Discharges

Monitoring results

The following table shows the average main stack monitoring results for 1999. The averages are equivalent to the 12 month running average for the period ending December 1999.

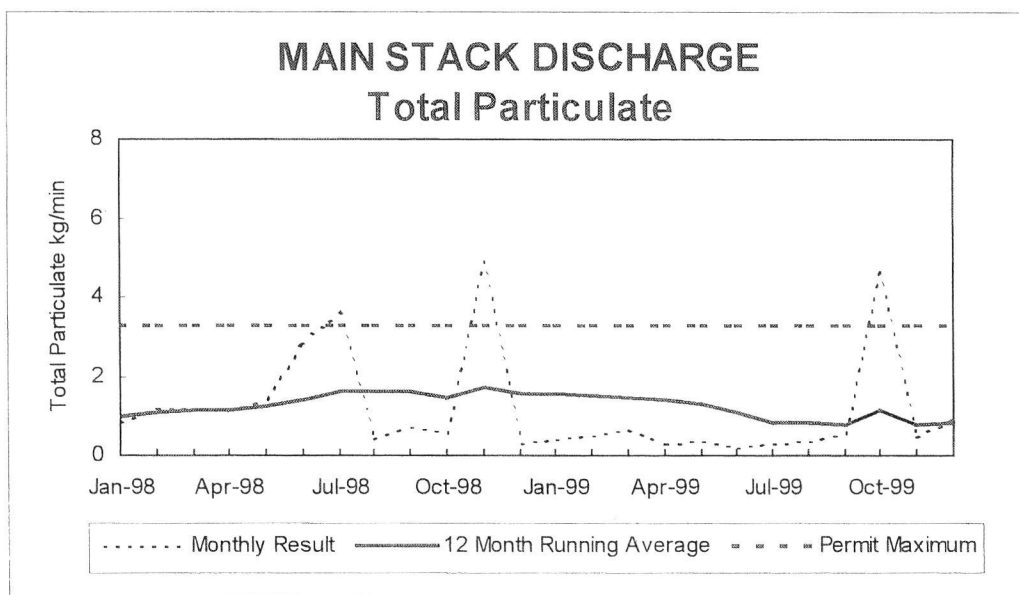
Parameter	Units	Running 12 month average		
		Standard	1999 result	Maximum for any month
Gas flow rate	Sm ³ /min	-	60,100	-
Total particulate	kg/min	3.25	0.82	1.55
Gaseous fluoride	kg/min	0.65	0.11	0.12
Particulate fluoride	kg/min	1.94	0.04	0.10
Sulphur dioxide	kg/min	-	13.0	13.3
Total condensable hydrocarbons	kg/min	-	0.31	-
Polycyclic aromatic hydrocarbons	kg/min	-	0.03	-

Main Stack Discharges, Continued

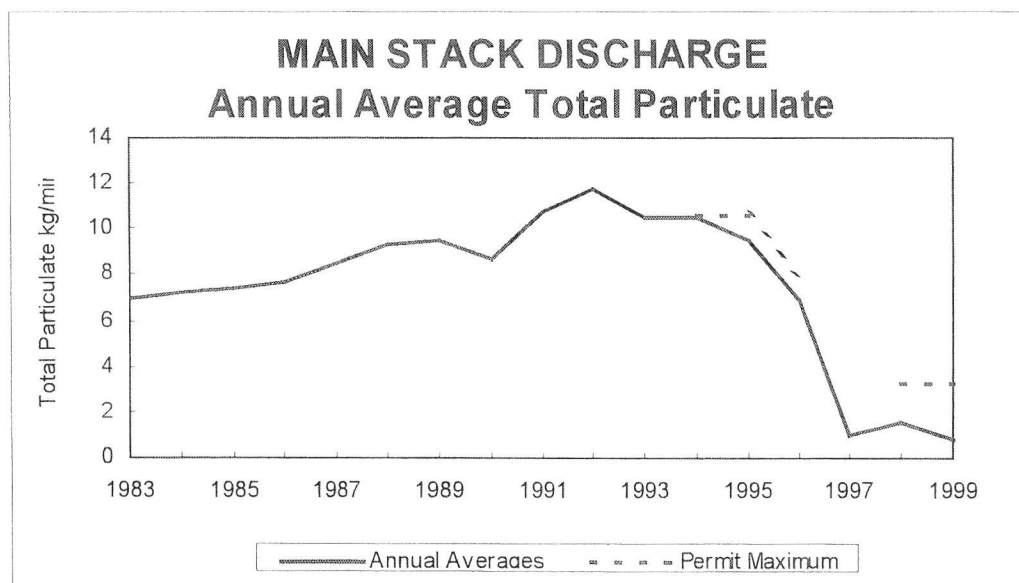
Total particulate

Standard: 12 month running average not to exceed 3.25 kg/min.

The following graph shows both the average monthly and 12 month running average main stack total particulate discharge during 1998 and 1999.



The following graph shows the annual average main stack total particulate discharge.

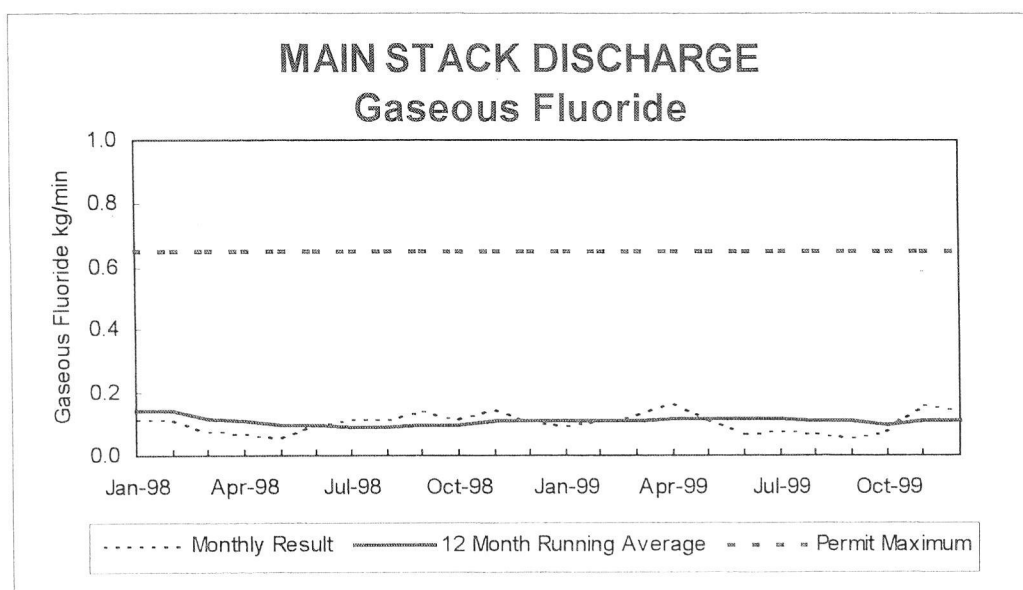


Main Stack Discharges, Continued

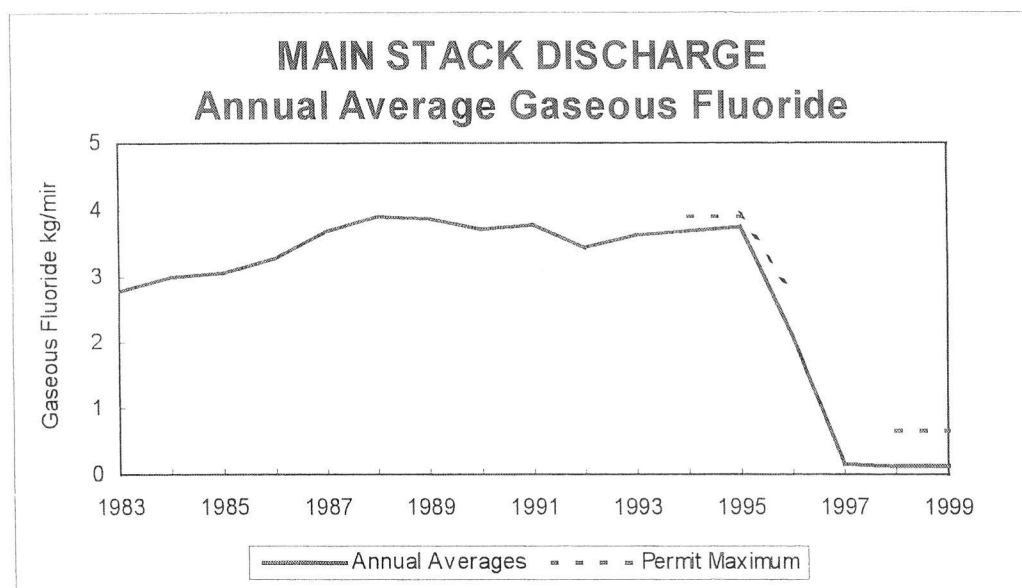
Gaseous fluoride

Standard: 12 month running average not to exceed 0.65 kg/min.

The following graph shows both the average monthly and 12 month running average main stack gaseous fluoride discharge during 1998 and 1999.



The following graph shows the annual average main stack gaseous fluoride discharge.

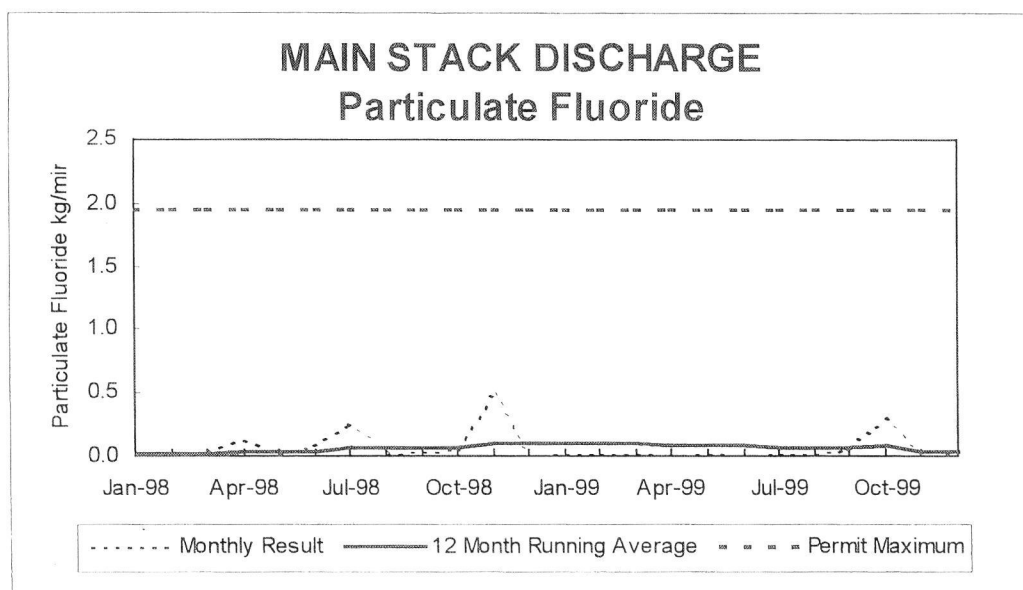


Main Stack Discharges, Continued

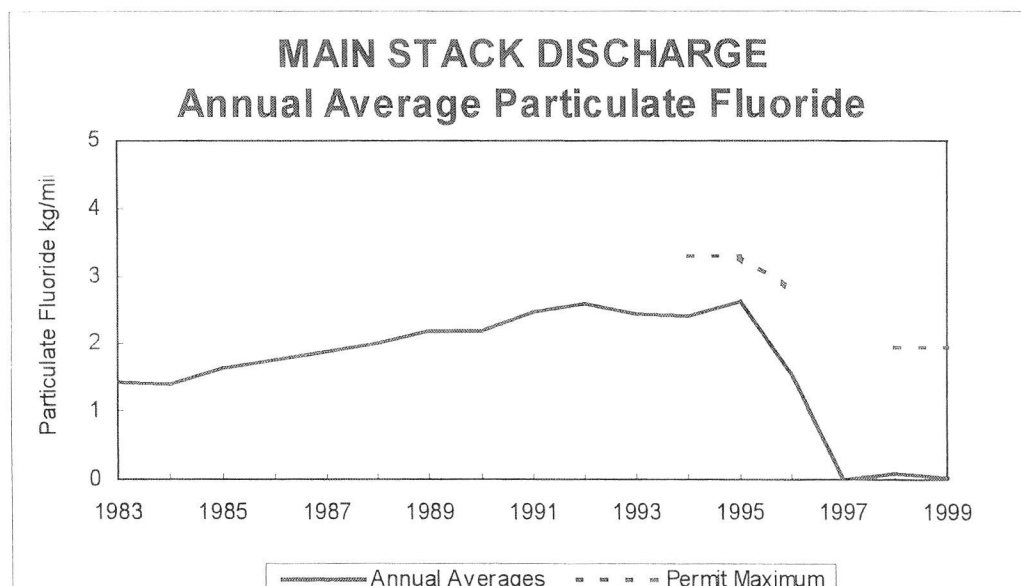
Particulate fluoride

Standard: 12 month running average not to exceed 1.94 kg/min.

The following graph shows both the average monthly and 12 month running average main stack particulate fluoride discharge during 1998 and 1999.



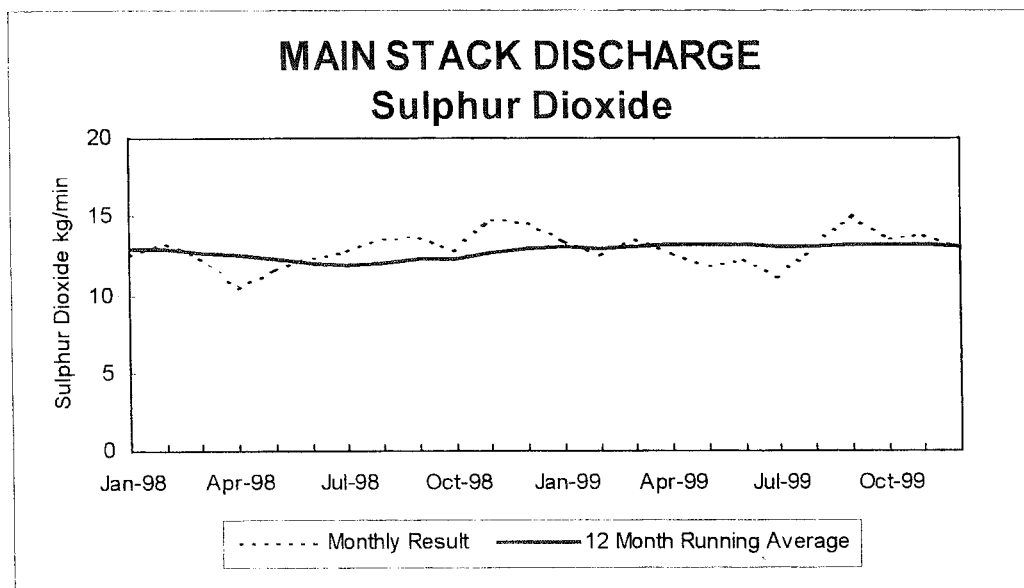
The following graph shows the annual average main stack particulate fluoride discharge.



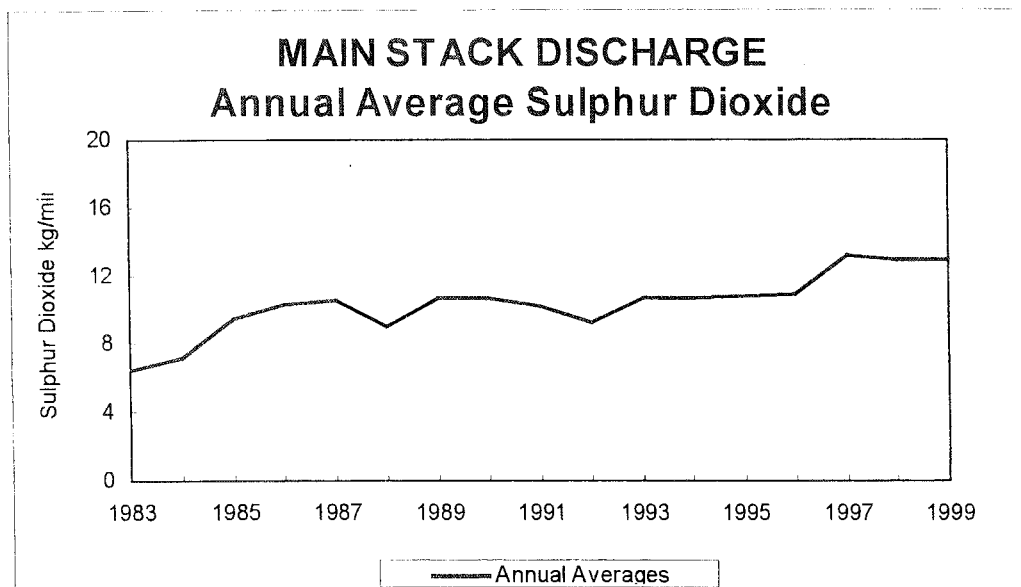
Main Stack Discharges, Continued

Sulphur dioxide

The following graph shows both the average monthly and 12 month running average main stack sulphur dioxide discharge during 1998 and 1999.



The following graph shows the annual average main stack sulphur dioxide discharge.



Main Stack Discharges, Continued

Comments

Discharges of total particulate, particulate fluoride and gaseous fluoride were within permit conditions throughout 1999.

Main stack discharge anomalies discussed at last years Interdepartmental Committee meeting (May 26, 1999) have been resolved. The main stack discharge rates and running 12 month averages since July 1996 included in this report have been calculated with the correct gas flow.

The higher than normal total particulate and particulate fluoride main stack discharge rates measured in October was due to leaks in dry scrubbing clean air plenum hatch seals. The plenum hatches had recently been opened in all reactors for improvement work but the sealant used was not effective although it had proven effective on previous occasions. The leaking seals allowed alumina to enter the discharge system. All the hatches were resealed during a two-day period with an improved sealant. A second October sample and subsequent main stack discharge monitoring has shown that the hatch seals are operating effectively. The improved sealant will be used for all future hatch sealing.

The average main stack sulphur dioxide discharge for 1999 was 13.0 kg/min which is similar to 1998.

The polycyclic hydrocarbon (PAH) discharge was measured on two occasions during 1999 and averaged 0.03 kg/min. The 1999 average discharge is lower than the 0.11 kg/min measured in 1998 but similar to those measured in 1994 and 1996.

The discharge of gaseous fluoride and total condensable hydrocarbons during 1999 was similar to those reported for 1998.

Potline Roof Louvre Discharges

Monitoring results

The following table shows the Potline roof louvre monitoring results for 1999. The permit standards are for 12 month running averages.

Parameter	Units	Running 12 month average		
		Standard	1999 result	Maximum for any month
Total particulate	kg/min	3.05	1.22	1.25
Gaseous fluoride	kg/min	0.38	0.13	0.13
Particulate fluoride	kg/min	0.38	0.20	0.20
Sulphur dioxide	kg/min	-	0.30	0.32

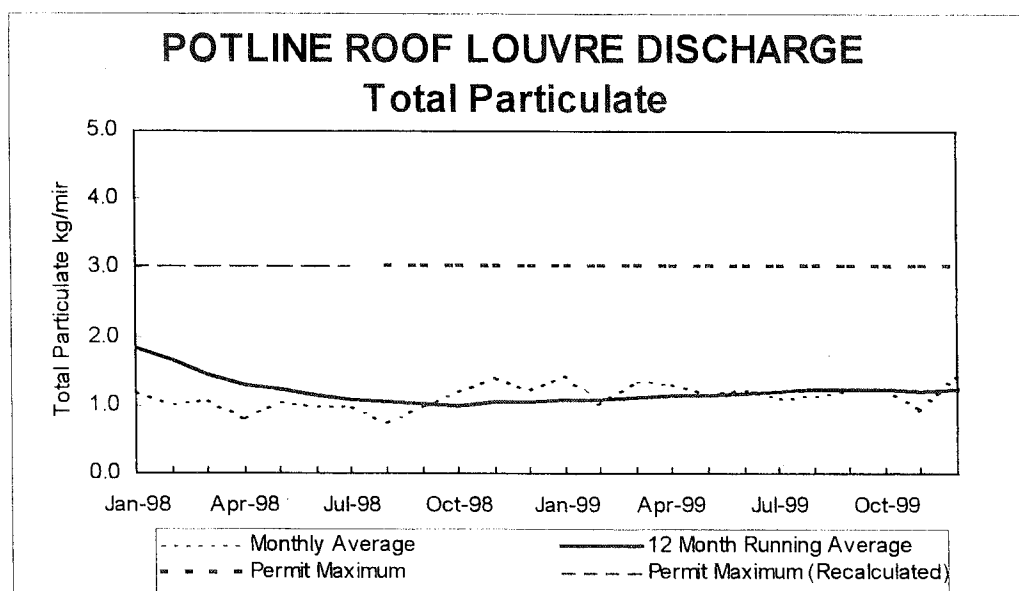
Potline Roof Louvre Discharges, Continued

Total particulate

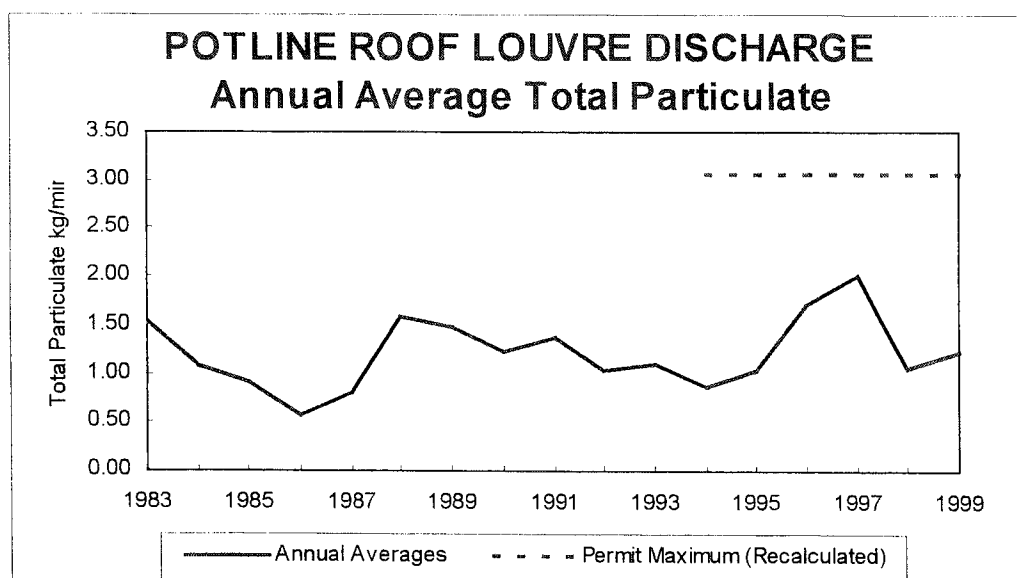
Standard: 12 month running average not to exceed 3.05 kg/min.

The permit maximum applying before the permit changes in August 1998 has been recalculated and included in the following two graphs. This allows comparison with the recalculated monthly and 12 month running averages prior to the permit changes.

The following graph shows both the average monthly and 12 month running average Potline roof louvre total particulate discharge during 1998 and 1999.



The following graph shows the annual average Potline roof louvre total particulate discharge.



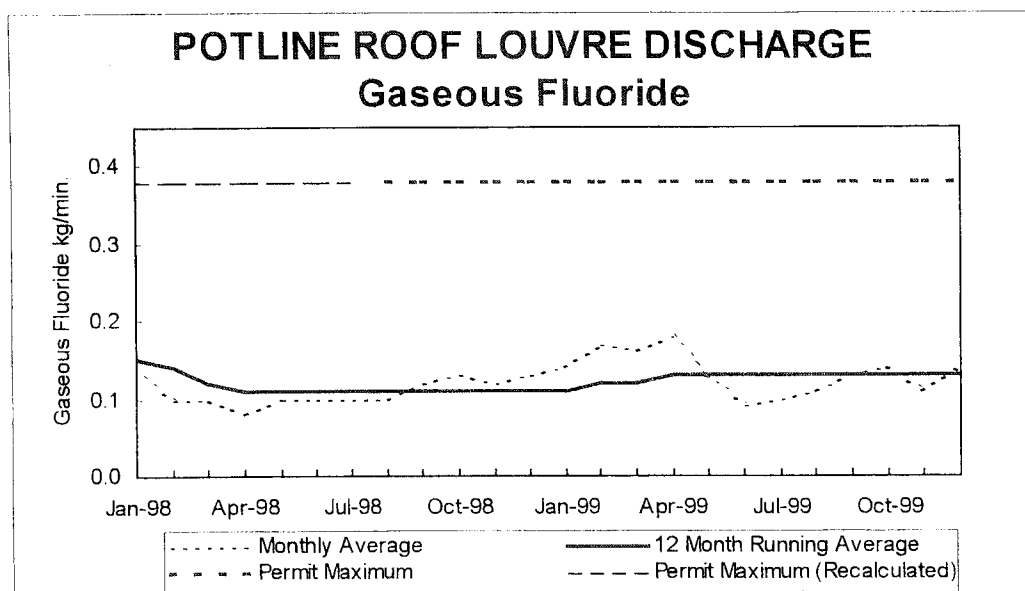
Potline Roof Louvre Discharges, Continued

Gaseous fluoride

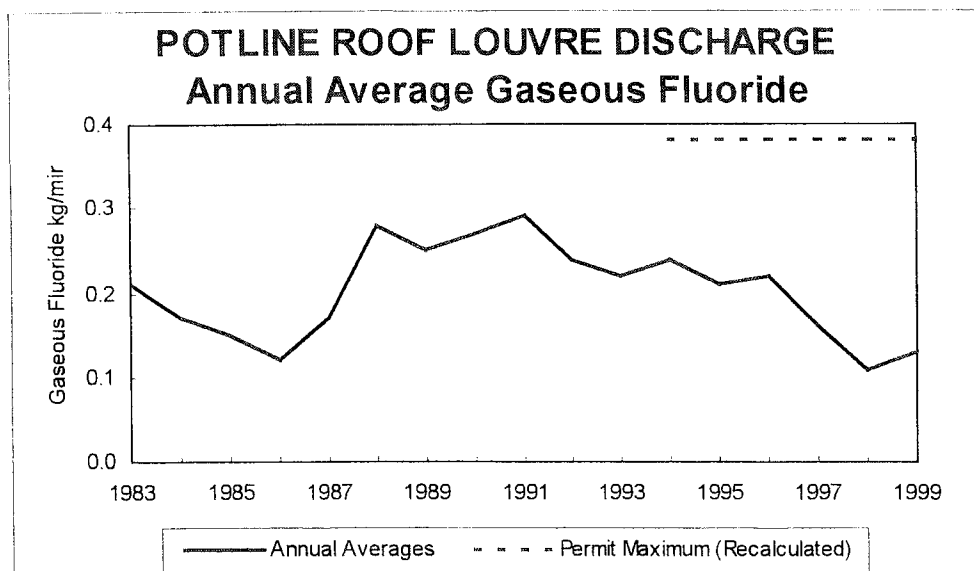
Standard: 12 month running average not to exceed 0.38 kg/min.

The permit maximum applying before the permit changes in August 1998 has been recalculated and included in the following two graphs. This allows comparison with the recalculated monthly and 12 month running averages prior to the permit changes.

The following graph shows both the average monthly and 12 month running average Potline roof louvre gaseous fluoride discharge during 1998 and 1999.



The following graph shows the annual average Potline roof louvre gaseous fluoride discharge.



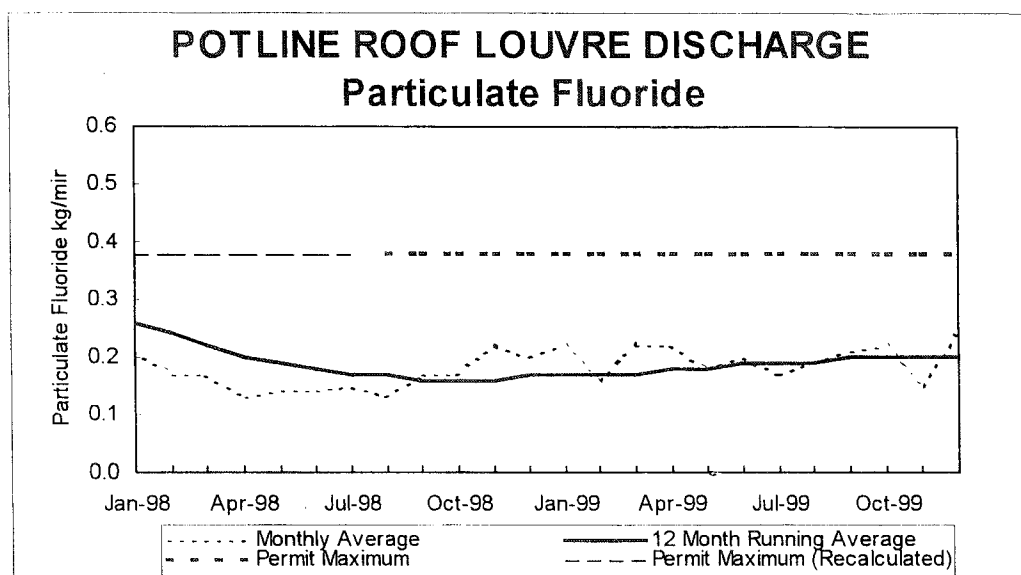
Potline Roof Louvre Discharges, Continued

Particulate fluoride

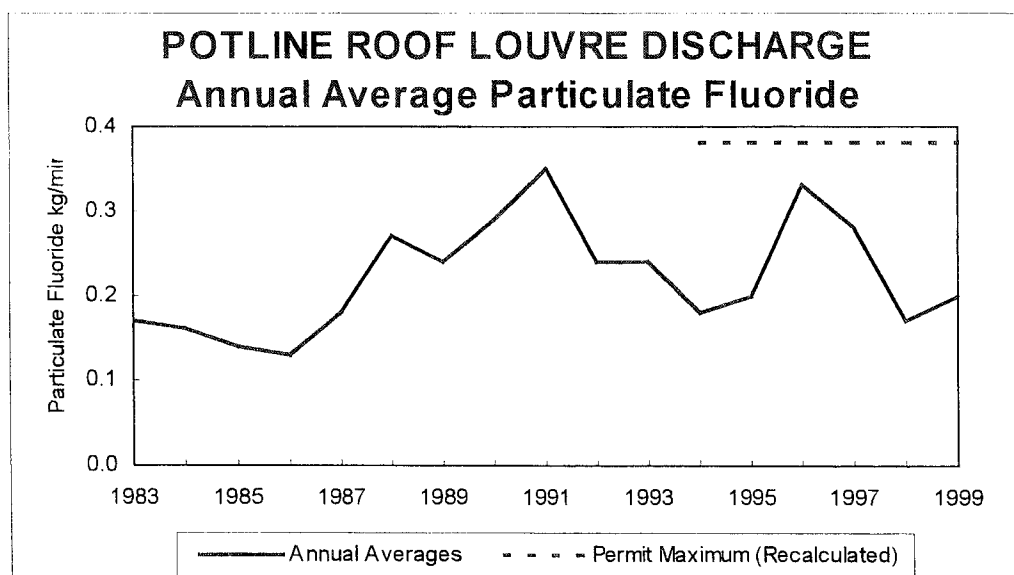
Standard: 12 month running average not to exceed 0.38 kg/min.

The permit maximum applying before the permit changes in August 1998 has been recalculated and included in the following two graphs. This allows comparison with the recalculated monthly and 12 month running averages prior to the permit changes.

The following graph shows both the average monthly and 12 month running average Potline roof louvre particulate fluoride discharge during 1998 and 1999.



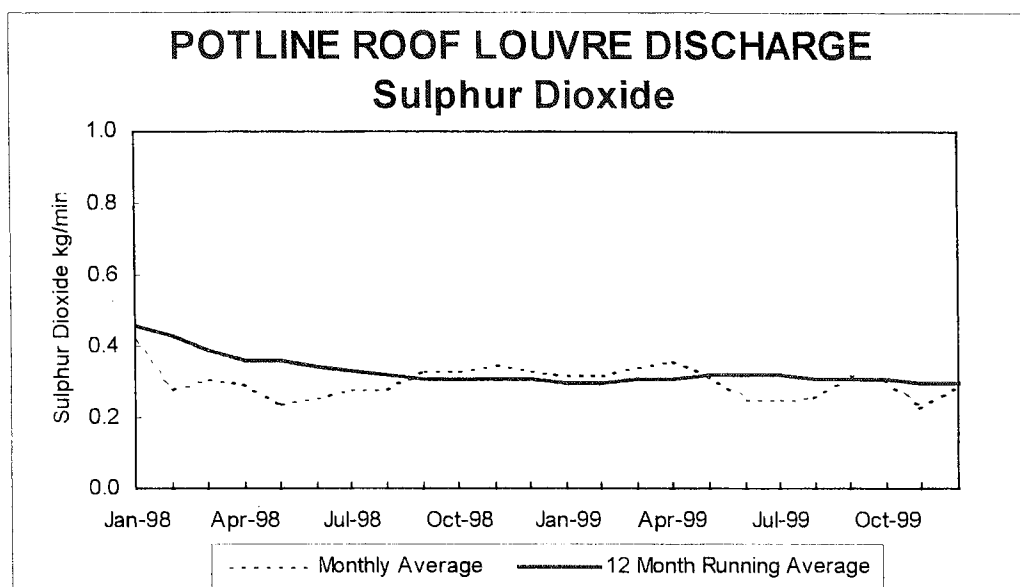
The following graph shows the annual average Potline roof louvre particulate fluoride discharge.



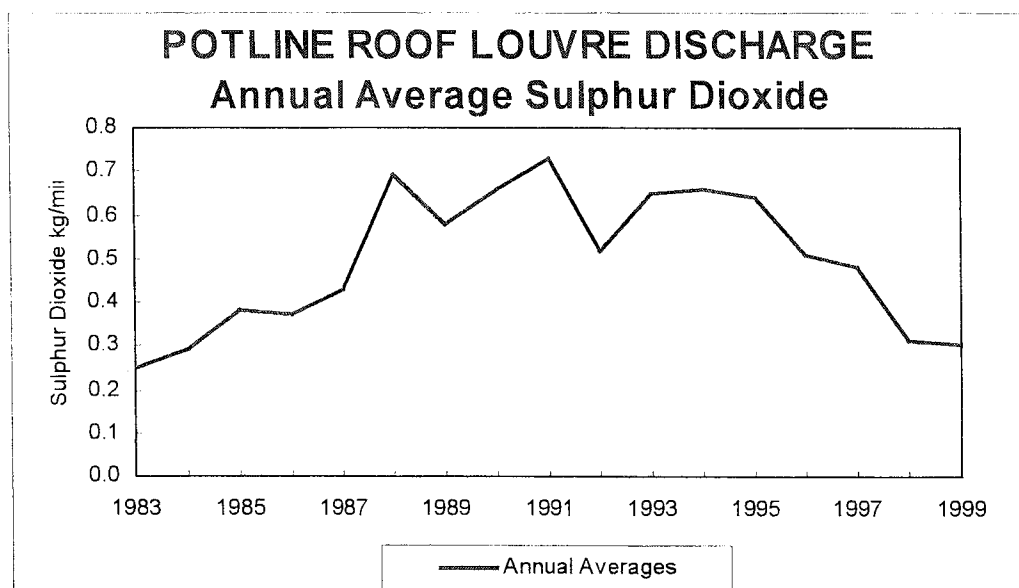
Potline Roof Louvre Discharges, Continued

Sulphur dioxide

The following graph shows both the average monthly and 12 month running average Potline roof louvre sulphur dioxide discharge during 1998 and 1999.



The following graph shows the annual average Potline roof louvre sulphur dioxide discharge.



Potline Roof Louvre Discharges, Continued

Comments

The roof louvre discharges during 1999 were within permit conditions.

The two yearly measurement of Potline roof louvre gas flow and verification of the Line 2A sampling manifold has commenced.

The measurements indicate that the flows through the roof louvres have increased by an average of 16% across all lines. These increases appear to be linked to several changes that were made to the operation of the Potlines during 1999. These included:

- operational changes to the cells to increase aluminium production with a small increase in the amount of heat being released into the Potlines' atmosphere, and
- side louvres of each Potline were raised to improve the work environment of staff.

Raising of side louvres appears to have been a major factor in the increase of the total flow through of the roof louvres. Work is underway to quantify the impact of these two factors on the increase in flow.

The roof louvre discharge survey is planned to be completed and reported in Quarter 2.

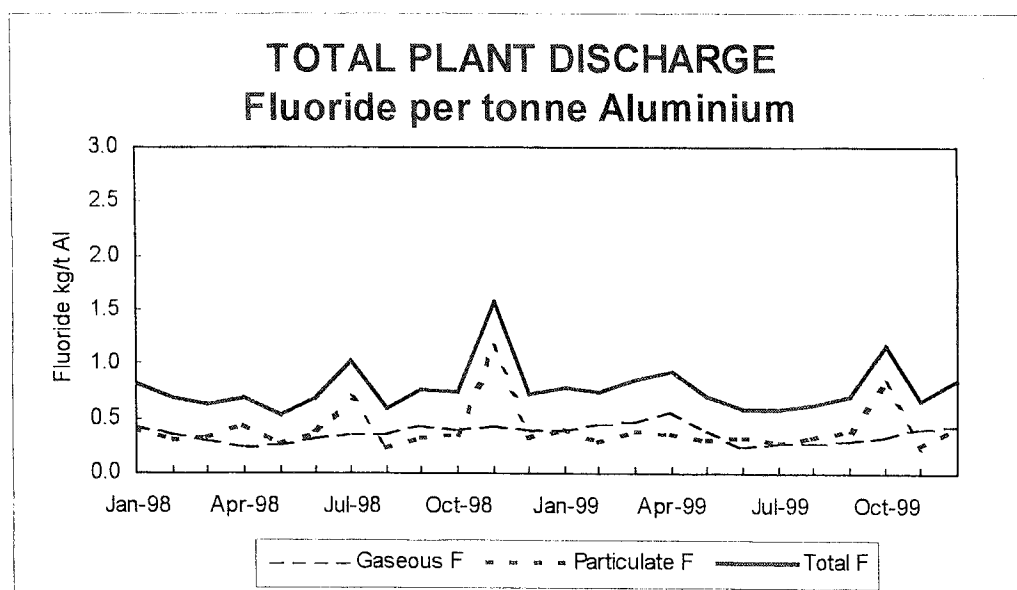
Fluoride Discharges

Performance data

The following table shows the fluoride discharges expressed as a ratio of hot aluminium metal production during 1999.

Parameter	Units	1999 result	Maximum for any month
Main Stack			
• Gaseous fluoride	kg/t Al	0.17	0.28
• Particulate fluoride	kg/t Al	0.06	0.47
• Total fluoride	kg/t Al	0.23	0.60
Reduction Line Roof Louvres			
• Gaseous fluoride	kg/t Al	0.21	0.29
• Particulate fluoride	kg/t Al	0.32	0.39
• Total fluoride	kg/t Al	0.53	0.65
Plant			
• Gaseous fluoride	kg/t Al	0.38	0.57
• Particulate fluoride	kg/t Al	0.38	0.82
• Total fluoride	kg/t Al	0.76	1.17

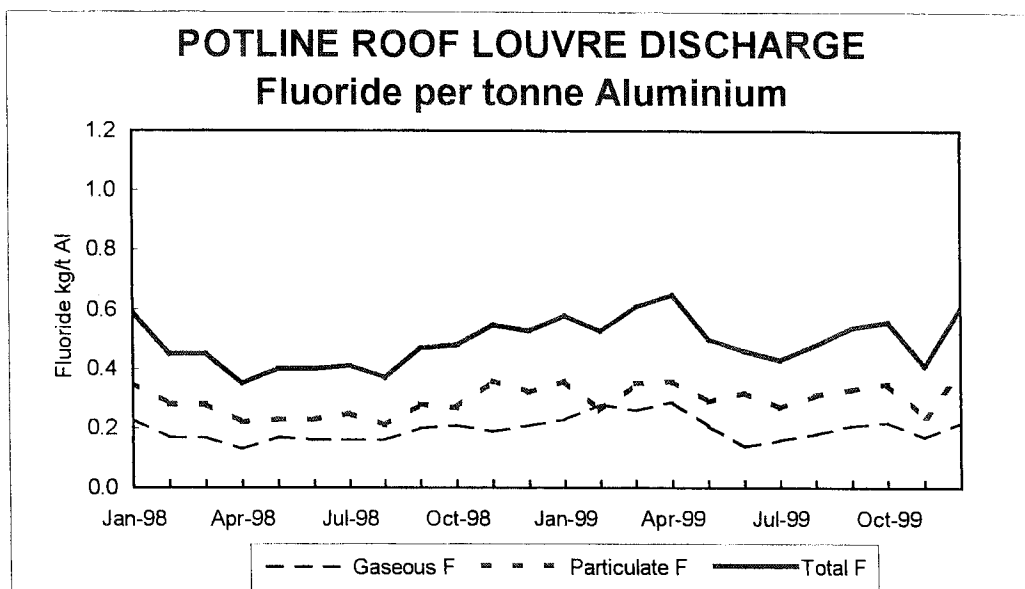
The following graph shows the average monthly main stack fluoride discharge during 1998 and 1999.



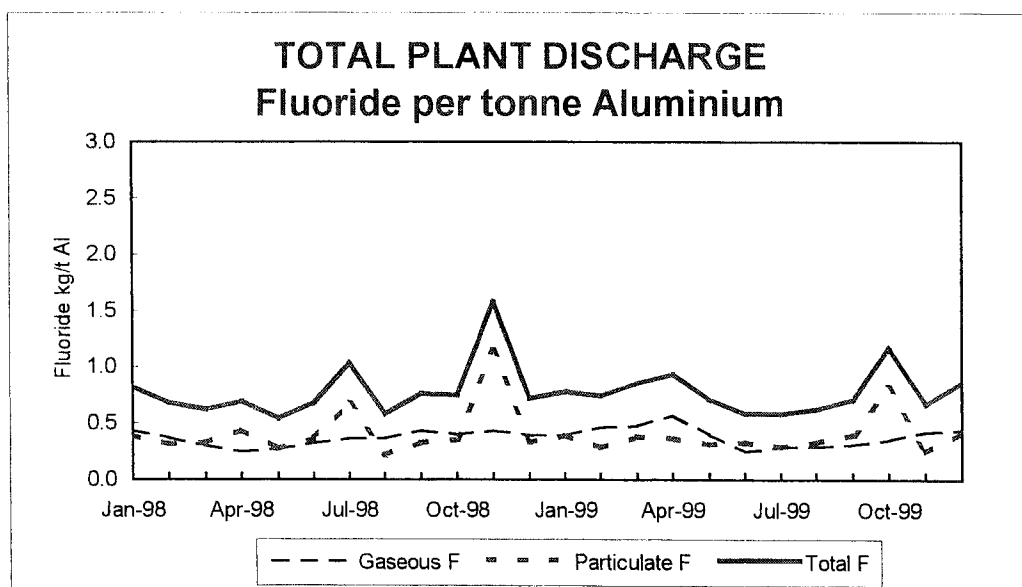
Fluoride Discharges, Continued

Performance data, continued

The following graph shows the average monthly Potline roof louvre fluoride discharge during 1998 and 1999.



The following graph shows the average monthly total plant fluoride discharge during 1998 and 1999.



Comments

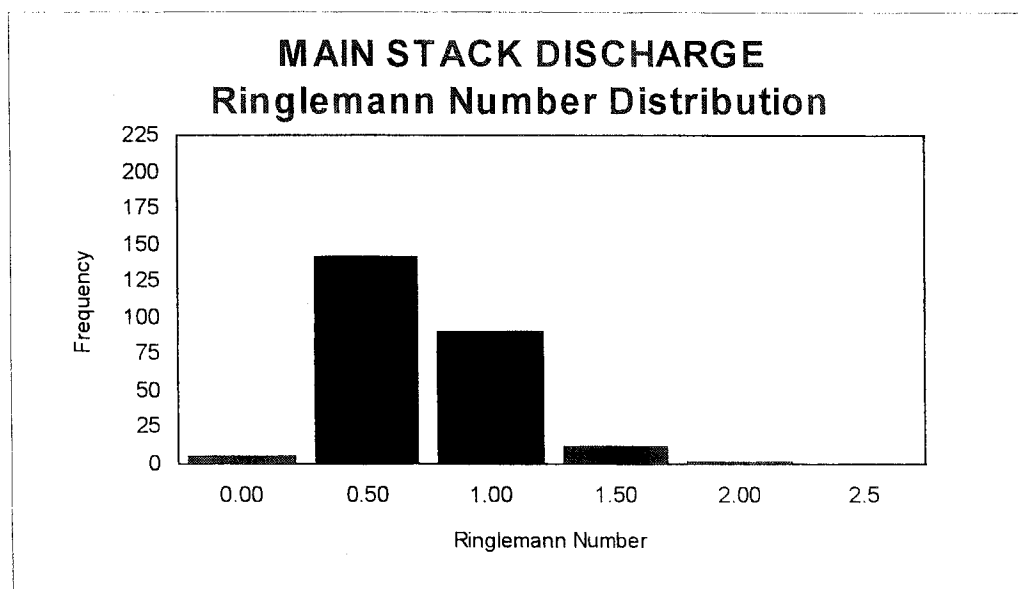
The fluoride discharge rate from the plant was generally stable during 1999. The increased particulate fluoride discharge in October is discussed in "Main Stack Discharges".

Baghouse Discharges

The regular inspection of the baghouse discharges continued during 1999. These inspections were in addition to the on-going operational surveillance of this equipment.

Main Stack Plume Opacity

Main stack plume opacity is determined by visual observations using the standard Ringlemann chart. The following graph summarises the observations recorded during 1999.



The visual observations indicate that the main stack plume was more opaque during 1999 than during 1998, but similar to 1997.

Sulphur Content of Raw Materials and Fuels

The following table shows the maximum, minimum, and average sulphur content of raw materials and fuels delivered to the smelter during 1999.

Material	Units	Permit Maximum	1999 Annual Average	1999 maximum	1999 minimum
Petroleum coke	%	3.0	2.79	2.87	2.70
Pitch	%	1.0	0.47	0.50	0.43
Heavy fuel oil	%	3.5	2.04	2.54	1.57

Comments

All shipments of raw materials and fuels during 1999 were within permit standards for sulphur content.

The average sulphur content of petroleum coke and pitch during 1999 was similar to that reported for 1998. The average sulphur content of heavy fuel oil during 1999 was lower than that reported for 1998.

Dispersion Conditions

Introduction

This chapter covers the monitoring of meteorological conditions at the Tiwai Point meteorological station. These conditions effect the dispersion of discharges into air from the smelter. The data includes

- the distribution of wind strength,
- the distribution of wind direction, and
- rainfall.

Meteorological Conditions

The mean wind frequency diagram on the following page shows that the 1999 wind pattern was dominated by westerly and north westerly winds.

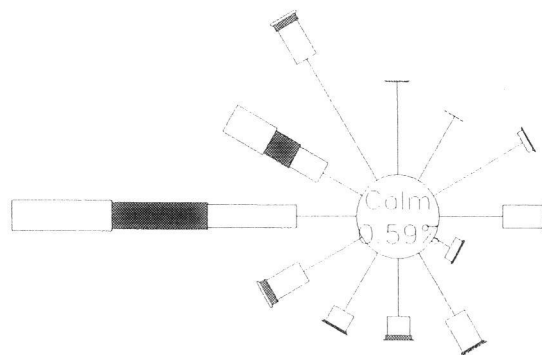
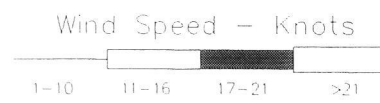
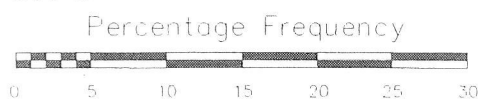
The following table shows the predominant winds and total rainfall recorded for each month during 1999.

Month	Predominant Wind Direction	Rainfall (mm)
January	West, south and south east	62
February	West	18
March	West, north west and south	92
April	West, north and north west	102
May	West and north west	101
June	North and north west	106
July	West, north west and east	81
August	West, north west and south west	83
September	West and north west	154
October	West	103
November	West, north west and south east	148
December	West and north west	54

Meteorological Conditions, Continued

NEW ZEALAND ALUMINIUM SMELTERS LIMITED – TIWAI POINT
WORKPLACE AND ENVIRONMENTAL MONITORING OUTPUT TEAM
MEAN WIND FREQUENCY (%) OF SURFACE WIND DIRECTIONS
PERIOD: SUMMARY 1999

Scale:



% Time at	
1-10 Knots	57.1
11-16 Knots	21.6
17-21 Knots	10.4
>21 Knots	10.4
Calm	0.59

Ambient Air

Introduction

This chapter covers the monitoring for gaseous and particulate fluorides in ambient air at six monitoring sites. Also covered are the changes to a one-month sampling period at most sites.

Permit Standards

The standards for ambient air gaseous fluoride covered by the air discharge permit are:

- 24 hour average $2.0 \mu\text{g}/\text{m}^3$
- 7 day average $1.0 \mu\text{g}/\text{m}^3$
- One month average $0.5 \mu\text{g}/\text{m}^3$

The 24-hour average is not to be exceeded on more than eight days in any twelve consecutive months.

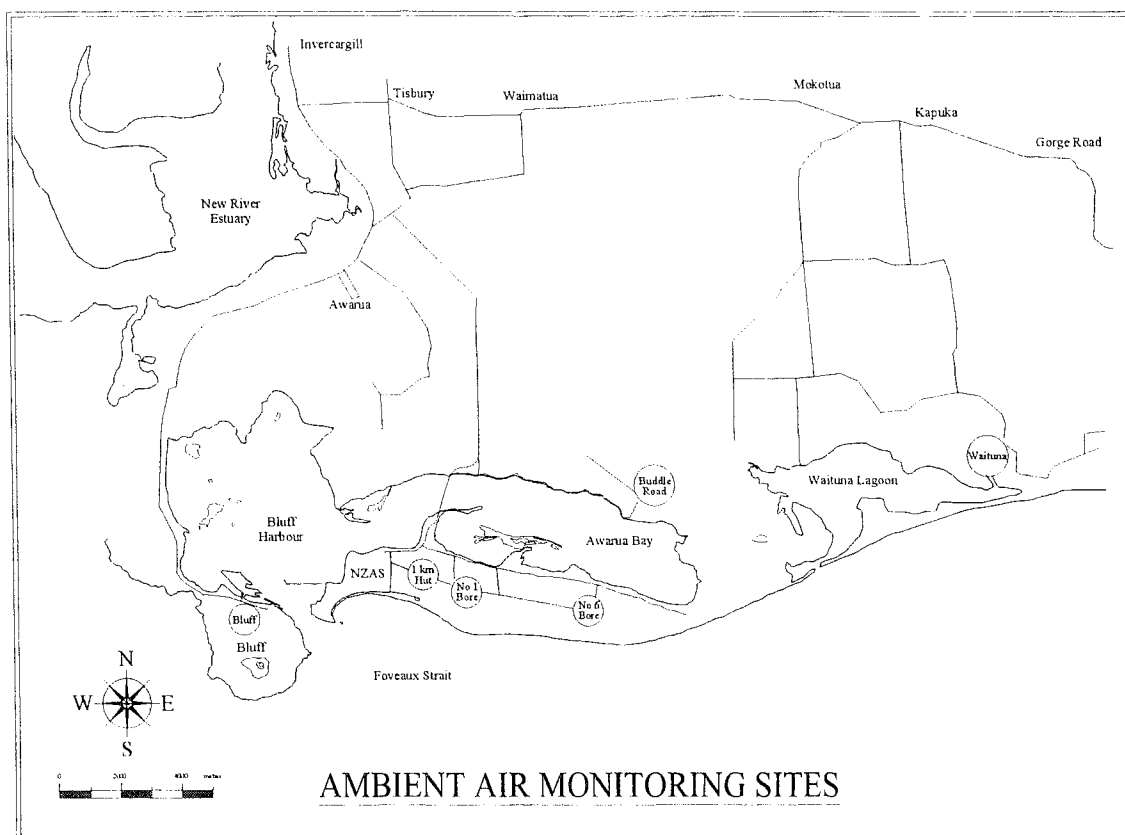
The standards apply to measurements on land off Tiwai Peninsula and on Tiwai Peninsula east of Comalco New Zealand Limited's freehold land.

Change to One Month Sampling Period

The Southland Regional Council approved the use of a one-month sampling period at No 1 Bore, No 6 Bore, Buddle Road, Waituna and Bluff sites. These sites were changed from seven-day sampling to monthly sampling on 27 November 1999. The first results for the monthly sampling period were reported in December 1999.

Site Locations

The locations of the monitoring sites are shown in following map.



Ambient Air at 1 Kilometre Hut

Monitoring results

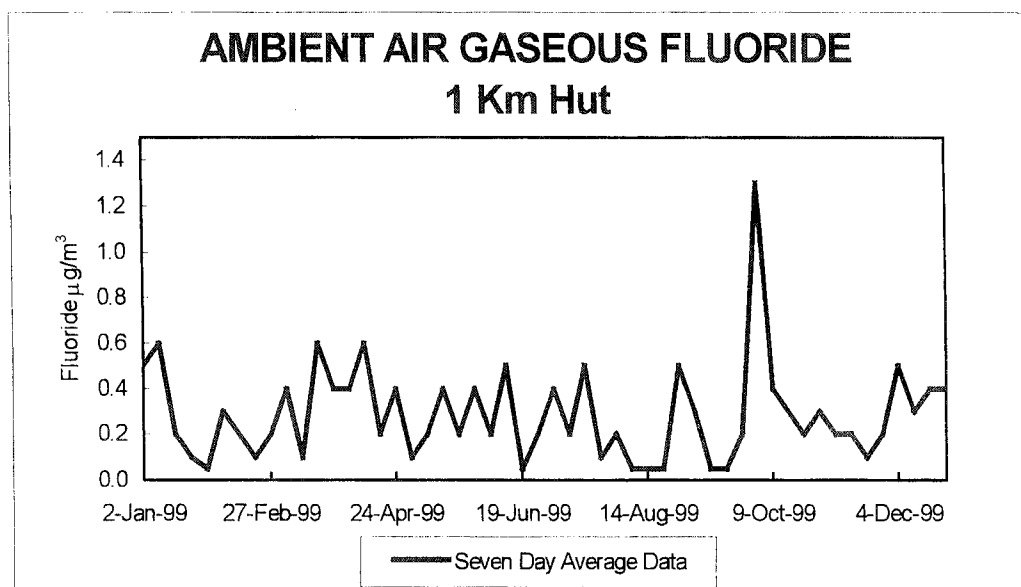
The following table summarises the monitoring results during 1998 and 1999. The sampling frequency for ambient air fluoride at this site is seven days.

Parameter	Units	Standard	1998	1999
Gaseous fluoride concentration				
• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	0.6	1.3
• Max monthly average	$\mu\text{g}/\text{m}^3$	-	0.5	0.5
• Annual Average	$\mu\text{g}/\text{m}^3$	-	N.D.	0.3
Particulate fluoride concentration				
• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	0.2	0.4
• Max monthly average	$\mu\text{g}/\text{m}^3$	-	0.1	0.2
• Annual Average	$\mu\text{g}/\text{m}^3$	-	N.D.	<0.1

Notes: N.D. means annual average not calculated as sampling method changed during the year.

Gaseous fluoride

The following graph shows the seven-day average gaseous fluoride results for this site.

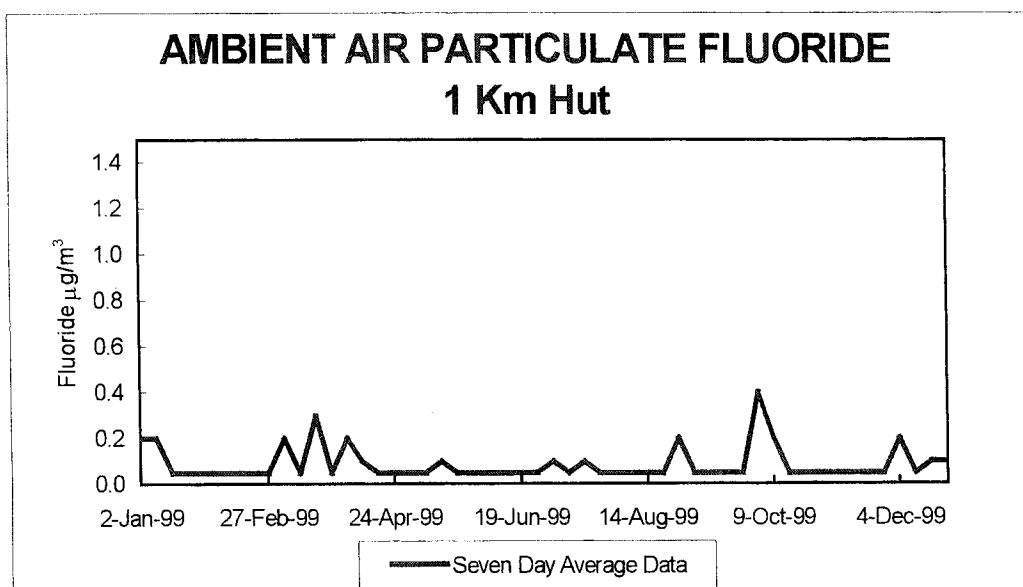


Note: Concentrations less than $0.1\mu\text{g}/\text{m}^3$ are plotted as $0.05\mu\text{g}/\text{m}^3$

Ambient Air at 1 Kilometre Hut, Continued

Particulate Fluoride

The following graph shows the seven-day average particulate fluoride results for this site.



Note: Concentrations less than $0.1 \mu\text{g}/\text{m}^3$ are plotted as $0.05 \mu\text{g}/\text{m}^3$

Comments

The $1.3 \mu\text{g}/\text{m}^3$ gaseous fluoride and $0.4 \mu\text{g}/\text{m}^3$ particulate fluoride maximum seven-day average concentrations measured in October are the highest measured at this site with the Australian Standard method AS3580. The most likely reason was the occurrence of westerly wind for 50% of the time during the sampling period.

All other results for this site are below the permit standards which apply to areas located at greater distances from the smelter.

Ambient Air at Other Sites on Tiwai Peninsula

Monitoring results

The following table summarises the monitoring results during 1998 and 1999 for the two other sites located on Tiwai Peninsula. The sampling frequency for ambient air fluoride at these sites changed from seven days to monthly on the 27 November 1999. The maximum seven-day averages reported for 1999 are for the period January to November.

Site	Parameter	Units	Standard	1998	1999
No.1 Bore	Gaseous fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	1.0	0.5	0.2
	• Max monthly average	$\mu\text{g}/\text{m}^3$	0.5	0.2	0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	0.1	0.2
No.6 Bore	• Max monthly average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	Gaseous fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	1.0	< 0.1	<0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	0.5	< 0.1	<0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	<0.1

Comments

Gaseous and particulate fluoride concentrations were close to or below the detection limit of the Australian standard method at these sites and were within the permit standards throughout 1999.

Ambient Air at Sites off Tiwai Peninsula

Monitoring results

The following table summarises the monitoring results during 1998 and 1999 for the three ambient air monitoring sites located off Tiwai Peninsula. The sampling frequency for ambient air fluoride at these sites changed from seven days to monthly on the 27 November 1999. The maximum seven-day averages reported for 1999 are for the period January to November.

Site	Parameter	Units	Standard	1998	1999
Buddle Road	Gaseous fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	1.0	< 0.1	< 0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
Waituna	• Max monthly average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	Gaseous fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	1.0	0.1	< 0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
Bluff	Particulate fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	Gaseous fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	1.0	0.1	< 0.1
	• Max monthly average	$\mu\text{g}/\text{m}^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu\text{g}/\text{m}^3$	-	0.4	0.2
	• Max monthly average	$\mu\text{g}/\text{m}^3$	-	0.1	< 0.1
	• Annual average	$\mu\text{g}/\text{m}^3$	-	< 0.1	< 0.1

Ambient Air at Sites off Tiwai Peninsula, Continued

Comments

All permit standards were met at the three sites off Tiwai Peninsula throughout 1999.

The maximum seven day particulate fluoride concentration measured at Bluff during 1999 was $0.2 \mu\text{g}/\text{m}^3$. This was unlikely to be related to activities at the smelter as winds were from north-west and west during the sampling period. A possible source of the high particulate fluoride concentration was the unloading of fertiliser material during the sampling period.

All other gaseous and particulate fluoride concentrations were at or below the detection limit of the Australian standard method at these sites during 1999.

Atmospheric Deposition

Introduction

This chapter covers the monitoring of atmospheric deposition at seven monitoring sites.

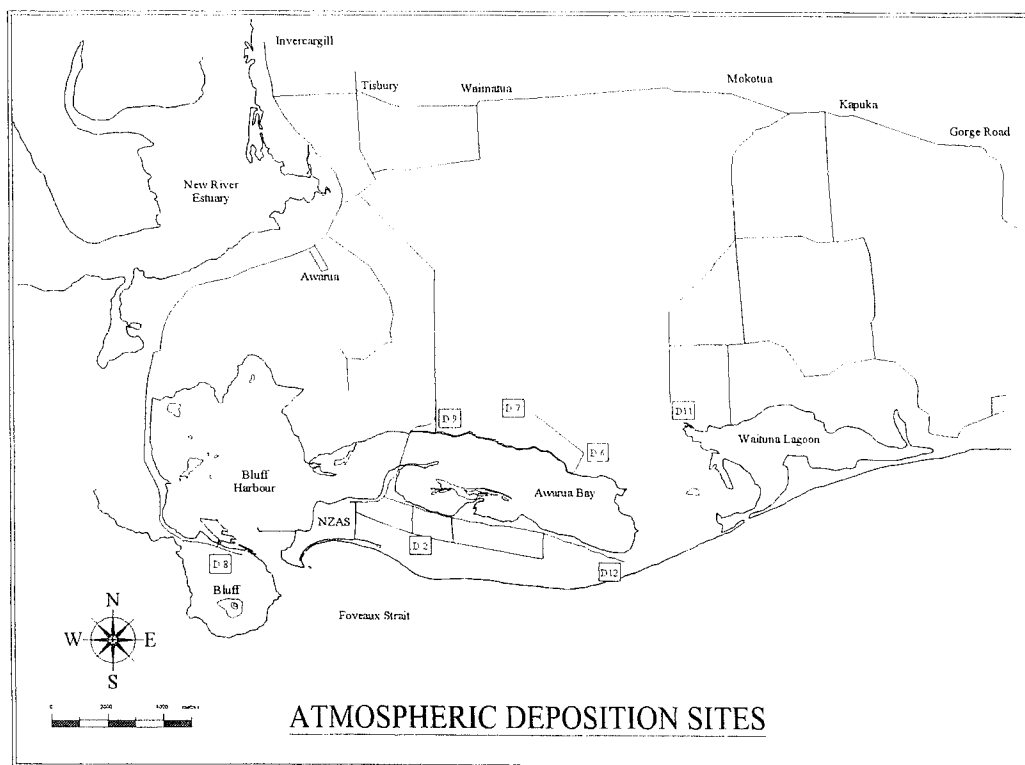
Permit Guidelines

The guidelines for atmospheric deposition apply to sites off Tiwai Peninsula and are shown in the table below.

Parameter	Unit	Guideline
Fluoride:	g.m^{-3}	0.9
Reactive Aluminium		
• Aesthetic highest desirable	g.m^{-3}	0.05
• Aesthetic excessive	g.m^{-3}	0.20

Site Locations

The locations of the monitoring sites are shown in the following map.



Atmospheric Deposition Monitoring Results

Fluoride Deposition

The fluoride atmospheric deposition during 1999 is summarised in the following table.

Site	Units	1999 average	Maximum for any month	Minimum for any month
D2. No.1 Bore ¹	g/m ³	0.17	0.33	0.10
D12 TEF2 ¹	g/m ³	<0.05	0.10	<0.05
D6 Buddle Road	g/m ³	<0.05	0.10	<0.05
D7 Gibson's Farm	g/m ³	0.05	0.13	<0.05
D8 Bluff	g/m ³	<0.05	0.12	<0.05
D9 Awarua Bay Road	g/m ³	0.05	0.12	<0.05
D11 Marshall Road	g/m ³	<0.05	0.11	<0.05

Note 1: Site located on Tiwai Peninsula and excluded from permit guideline.

Reactive Aluminium Deposition

The reactive aluminium atmospheric deposition during 1999 is summarised in the following table.

Site	Units	1999 average	Maximum for any month	Minimum for any month
D2. No.1 Bore ¹	g/m ³	0.04	0.14	<0.03
D12 TEF2 ¹	g/m ³	<0.03	<0.03	<0.03
D6 Buddle Road	g/m ³	<0.03	0.04	<0.03
D7 Gibson's Farm	g/m ³	<0.03	0.06	<0.03
D8 Bluff	g/m ³	<0.03	0.03	<0.03
D9 Awarua Bay Road	g/m ³	<0.03	0.05	<0.03
D11 Marshall Road	g/m ³	<0.03	0.03	<0.03

Note 1: Site located on Tiwai Peninsula and excluded from permit guideline.

Atmospheric Deposition Monitoring Results, Continued

Comments

All permit guidelines were met during 1999. Fluoride and reactive aluminium deposition during 1999 was generally within the normal range of results since the commissioning of the main stack dry scrubbing system in 1997.

The highest fluoride and reactive aluminium concentrations measured at most sites during 1999 were determined during February and May. This was most likely due to low rainfall, which resulted in low dilution of material deposited on the raingauge collection surface.

There is no known cause for the maximum fluoride concentration measured at No.1 Bore during March.

Fluoride in Ungrazed Grasses

Introduction

This chapter covers the monitoring of fluoride in ungrazed grasses at 23 monitoring sites located at Bluff, Green Hills, Awarua Plains, Waituna Wetlands and Tiwai Peninsula.

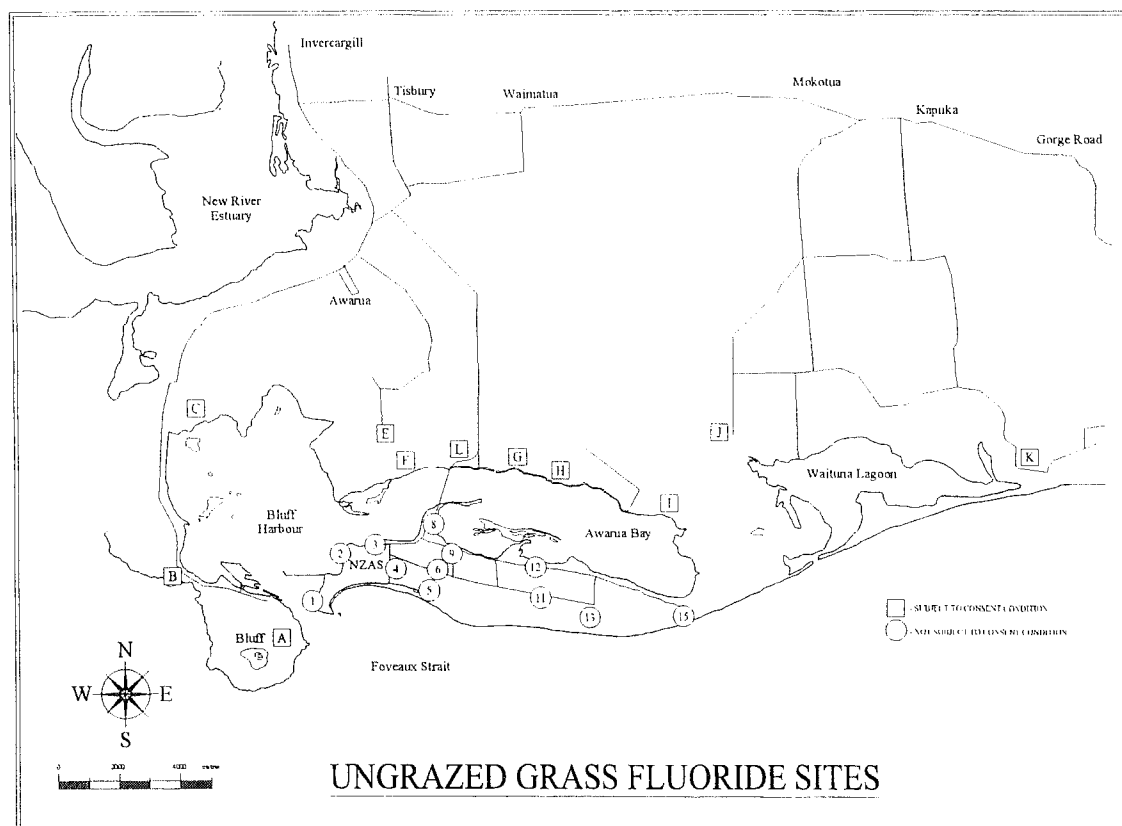
Permit Guidelines

The guidelines for fluoride in ungrazed grasses (on an unwashed, dry weight basis) on land off Tiwai Peninsula are detailed below. These guidelines came into effect in April 1994.

- Monthly sample shall not exceed 80 mg/kg more than once in any 12 consecutive months.
- Running average of any two consecutive months shall not exceed 60 mg/kg.
- Running average of any 12 consecutive months shall not exceed 40 mg/kg.

Site Locations

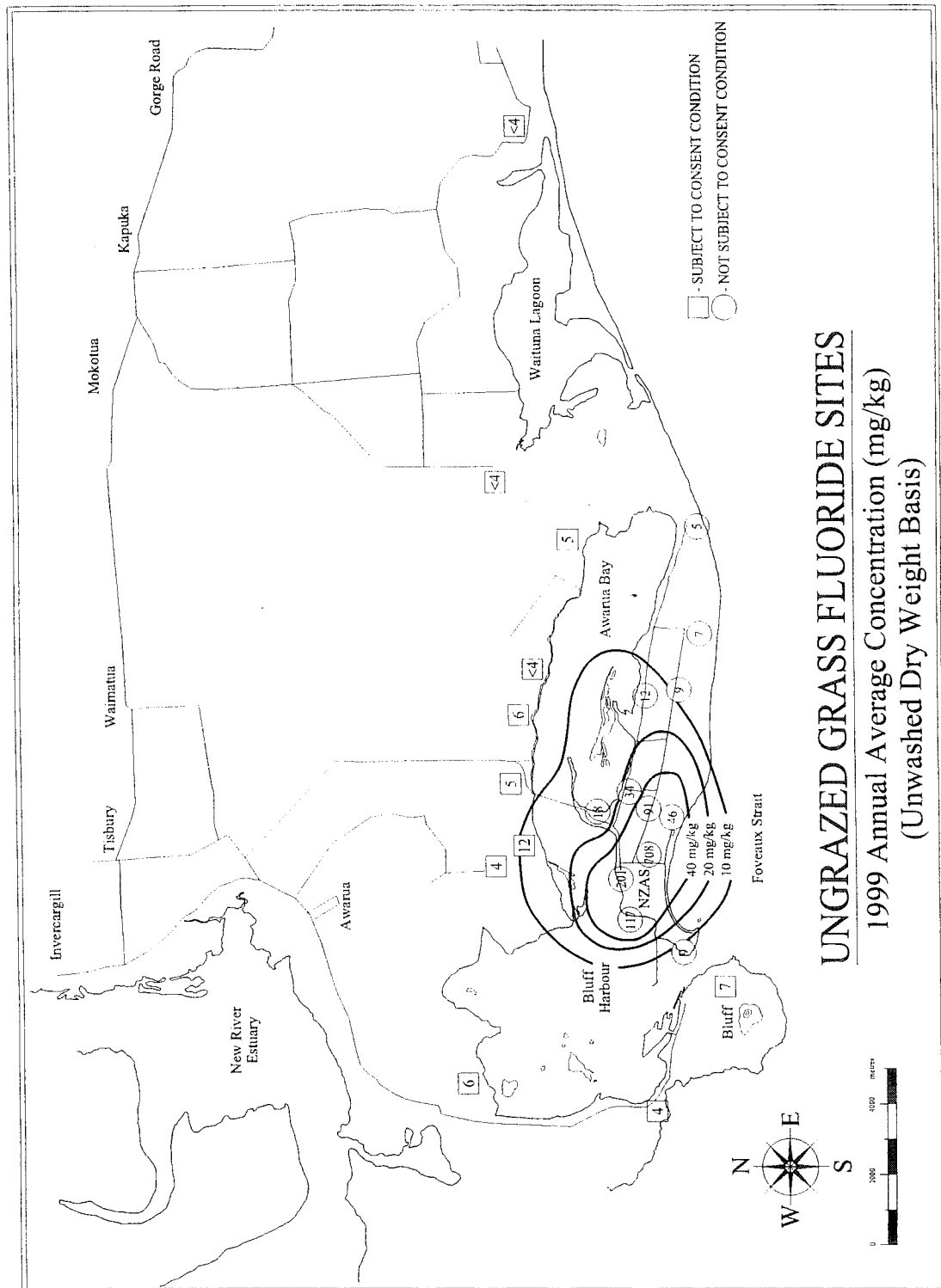
The ungrazed grass monitoring sites are shown on the following map.



Ungrazed Grass Monitoring Results

Annual average fluoride concentrations

The 1999 average ungrazed grass fluoride concentrations are shown in the following map.



Ungrazed Grass Monitoring Results, Continued

Monthly maximum concentration

The following table shows the maximum monthly fluoride concentrations for sites off Tiwai Peninsula during 1999.

Sites off Tiwai Peninsula	Permit Guideline not to be exceeded more than once in any 12 consecutive months mgF/kg	Maximum Monthly Result During 1999 mgF/kg
Ungrazed Grass Site A	80	15
Ungrazed Grass Site B	80	8
Ungrazed Grass Site C	80	11
Ungrazed Grass Site E	80	10
Ungrazed Grass Site F	80	25
Ungrazed Grass Site G	80	12
Ungrazed Grass Site H	80	6
Ungrazed Grass Site I	80	10
Ungrazed Grass Site J	80	7
Ungrazed Grass Site K	80	5
Ungrazed Grass Site L	80	17

The monthly fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1999.

Ungrazed Grass Monitoring Results, Continued

Two month average concentration

The following table shows the maximum two month running average fluoride concentrations for sites off Tiwai Peninsula during 1998.

Sites off Tiwai Peninsula	Permit Guideline mgF/kg	Maximum Two Month Running Average During 1999 mgF/kg
Ungrazed Grass Site A	60	10
Ungrazed Grass Site B	60	7
Ungrazed Grass Site C	60	9
Ungrazed Grass Site E	60	8
Ungrazed Grass Site F	60	20
Ungrazed Grass Site G	60	9
Ungrazed Grass Site H	60	5
Ungrazed Grass Site I	60	9
Ungrazed Grass Site J	60	6
Ungrazed Grass Site K	60	4
Ungrazed Grass Site L	60	10

The two month running average fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1999.

Fluoride in Ungrazed Grasses, Continued

Running 12 month average concentration

The following table shows the maximum 12 month running average fluoride concentrations for sites off Tiwai Peninsula.

Sites off Tiwai Peninsula	Permit Guideline mgF/kg	Maximum 12 Month Running Average During 1999 mgF/kg
Ungrazed Grass Site A	40	7
Ungrazed Grass Site B	40	7
Ungrazed Grass Site C	40	6
Ungrazed Grass Site E	40	5
Ungrazed Grass Site F	40	12
Ungrazed Grass Site G	40	6
Ungrazed Grass Site H	40	6
Ungrazed Grass Site I	40	7
Ungrazed Grass Site J	40	5
Ungrazed Grass Site K	40	< 4
Ungrazed Grass Site L	40	9

The 12 month running average fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1999.

Fluoride in Ungrazed Grasses, Continued

Comments

The annual average fluoride concentration in ungrazed grass at sites 2, 3, and 4 was higher during 1999 than during 1998. Sites 2, 3, and 4 are close to the smelter and are influenced by discharges from the Potline roof louvres.

The increased fluoride concentrations at these sites are most likely due to:

- increased frequency of winds below 10 knots reducing the dispersion of discharges from the Potlines roof louvres, and
- increased frequency of southerly winds able to transport discharges from the Potlines roof louvres towards site 3.

The fluoride concentrations at sites further from the smelter were similar to the concentrations reported for 1998.

Fluoride in Pinus Radiata

Introduction

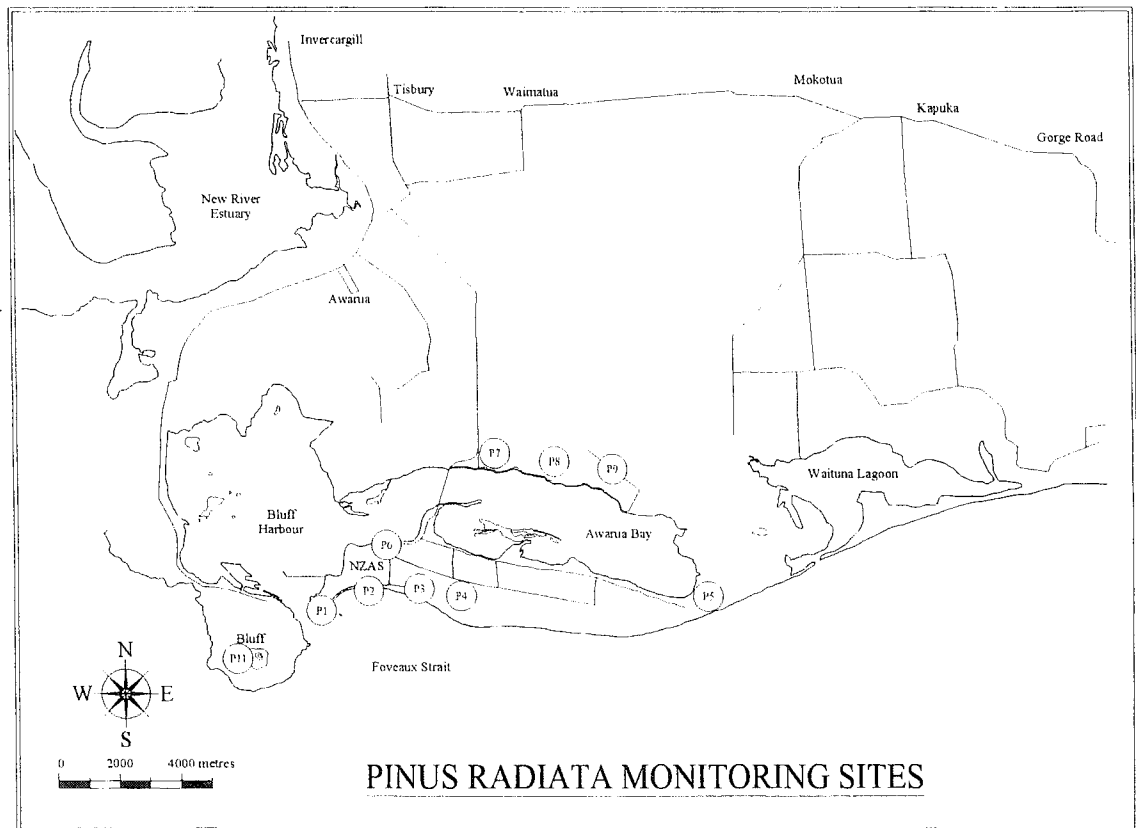
This chapter covers the monitoring of fluoride in pinus radiata at 10 monitoring sites located at Bluff, Awarua Plains, Waituna and Tiwai Peninsula.

Permit Guidelines

Pine needles between one and two years are sampled quarterly. The guideline for fluoride in washed pinus radiata needles on land off Tiwai Peninsula is 75 mg/kg.

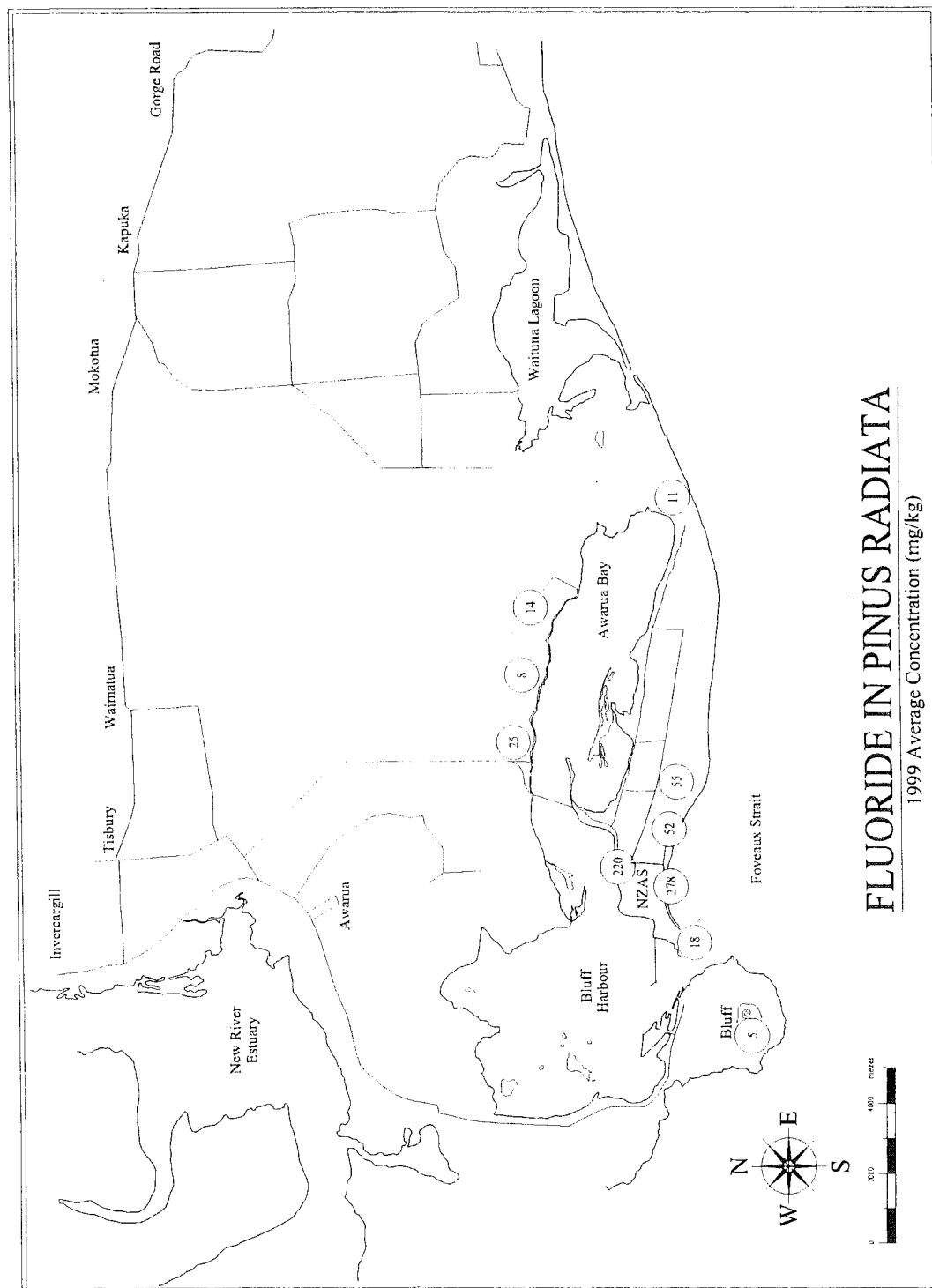
Site Locations

The locations of the monitoring sites are shown in the following map.



Pinus Radiata Monitoring Results

The 1999 annual average fluoride concentrations of pine needle samples collected from the monitoring sites are shown in the following map.



Pinus Radiata Monitoring Results, Continued

Comments

Fluoride concentrations in pinus radiata needles were within the permit guidelines during 1999.

Apart from sites P2 and P6, which are close to the smelter, fluoride concentrations of pine needles were similar to the 1998 concentrations.

The average fluoride concentration measured at site P2 during 1999 was 278 mg/kg compared with 210 mg/kg in 1998. The average fluoride concentration measured at site P6 during 1999 was 220 mg/kg compared with 123 mg/kg in 1998.

Site P2. This site is directly to the south of the smelter.

Site P6. This site is north east of the smelter near the water reservoir. There is a long term trend of increasing fluoride concentrations in pine needles at this site. There has also been a similar (but smaller) long term trending increase of fluoride at a nearby ungrazed grass (site 3).

No grass or pine needle samples from other locations appear to be displaying similar increases in fluoride concentration. More extensive environmental monitoring has been initiated at sites P2 and P6 to understand the reasons for the fluoride increase.

Results from this work are planned to be completed and reported in Quarter 4.

The increased fluoride concentrations at sites P2 and P6 are most likely due to the increased frequency of low wind speeds reducing the dispersion of discharges from the Potlines roof louvres.

Also, increased frequency of southerly winds during 1999 has most likely transported discharges from the Potlines roof louvres towards site P6.

The Health of Farm Livestock

Grazing Monitor Project

Summary

The fluoride concentration of grazed pasture and cattle urine sampled on GMF4 during 1999 exceeded permit guidelines and some permit standards. The fluoride concentration in grazed pasture on all other grazing monitor farms and in cattle bone on GMF4 were within permit standards and guidelines.

The average bi-monthly fluoride concentration on GMF4 exceeded the permit standard of 60 mg/kg during February and March. This was caused by the February sample having a fluoride concentration of 170 mg/kg. The higher February concentration was most likely caused by superphosphate remaining on the pasture for longer than normal following topdressing because of a prolonged period without significant rainfall.

Almost all cattle urine samples collected from GMF4 during the first quarter of 1999 contained fluoride concentrations in excess of the permit guideline of 10 mg/L. This was most likely due to the high grazed pasture fluoride concentration on GMF4 during the quarter.

Cattle bone fluoride concentrations on GMF4 were generally in the range of results determined on this farm over the past two years.

Decreased dental scores in cattle teeth formed on GMF4 since 1995 were lower than those formed in earlier years. The decrease reflects the decreased fluoride concentrations measured on this farm since the introduction of the dry scrubbing system at the smelter in 1996.

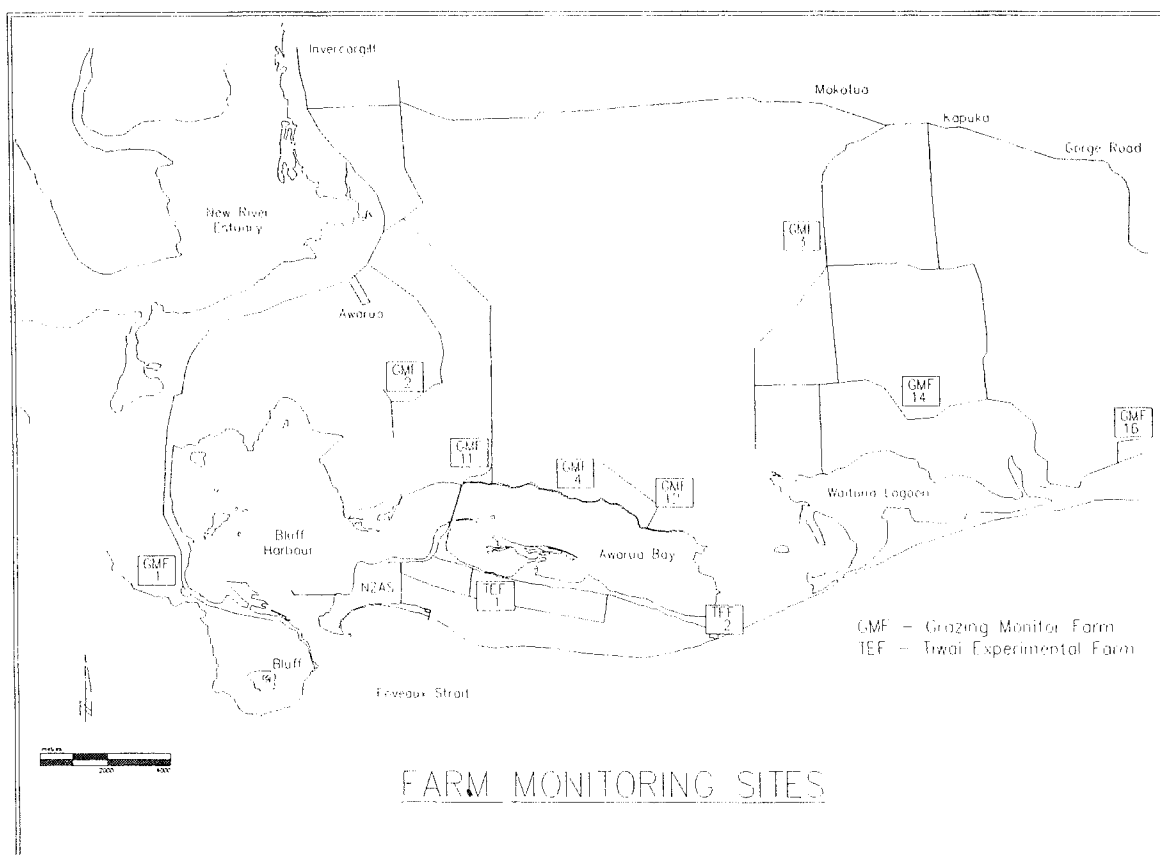
Introduction

Air Discharge and Coastal Permit Number 93566 requires NZAS to report on the health of farm livestock annually. The permit conditions were revised following NZAS' application to change or cancel some conditions, which was approved by the Southland Regional Council on 5 August 1998.

The Grazing Monitor Project was established in 1969 prior to the smelter being commissioned. The project has continued since then with modifications as part of NZAS' Environmental Monitoring Program.

Site Locations

The following map shows the location of the farms included in the Grazing Monitor Project. Also included in the map are the locations of the two Tiwai Experimental Farms.



Monitoring the Health of Farm Livestock

The health of farm livestock is monitored by:

- measuring the fluoride concentration of cattle urine,
- measuring the fluoride concentration of cattle tailbone, and
- assessing the dental condition of cattle.

Urinary Fluoride

The urinary fluoride concentrations are corrected to a specific gravity of 1.030.

Bone Fluoride

The bone samples collected for measuring fluoride concentrations are from tail bone biopsies. The tailbone fluoride concentrations are converted to a metacarpal/metatarsal bone fluoride concentration using the method developed by J. Suttie.

Fluoride (F) in dry fat free metacarpal/metatarsal bone = F in ashed tailbone * 0.5.

Dental Condition

The tooth scoring system follows the method of J. Suttie. As most effects on teeth occur prior to eruption, when the teeth are forming, the tooth scores are given in relation to the year during which the tooth was formed. There is over 1 year between formation and eruption so the dental condition cannot be assessed until 1 to 2 years after any effects have occurred.

The inspection results from past years are combined to provide a table summarising the dental condition of the cattle permanent incisor teeth for the years when the teeth are forming.

Permit Standards

The Air Discharge and Coastal Permit contains a number of standards. A standard is defined in the permit as a limit that is not to be breached.

The standards for fluoride in grazed pasture (on an unwashed, dry weight basis) on land off Tiwai Peninsula are:

- monthly sample shall not exceed 80 mg/kg more than once in any 12 consecutive months,
- the average of any two consecutive months samples shall not exceed 60 mg/kg,
- running averages of monthly samples for a period of twelve months shall not exceed 40 mg/kg.

Permit Guidelines

The Air Discharge and Coastal Permit also contains a number of guidelines. A guideline is defined in the permit as a level which is set on best current knowledge, the exceeding of which requires further investigation or other action.

The guidelines for animal health monitoring are:

- urinary fluoride in dairy and beef cattle should not exceed 10 mg/L corrected to S.G. 1.030,
- bone fluoride concentrations as measured in metacarpal/metatarsal bones are:
 - ◆ 1605 mg/kg for two year olds,
 - ◆ 2379 mg/kg for four year olds, and
 - ◆ 2794 mg/kg for six year olds.

Grazing Monitor Farm No.1

The following information is contained in this section:

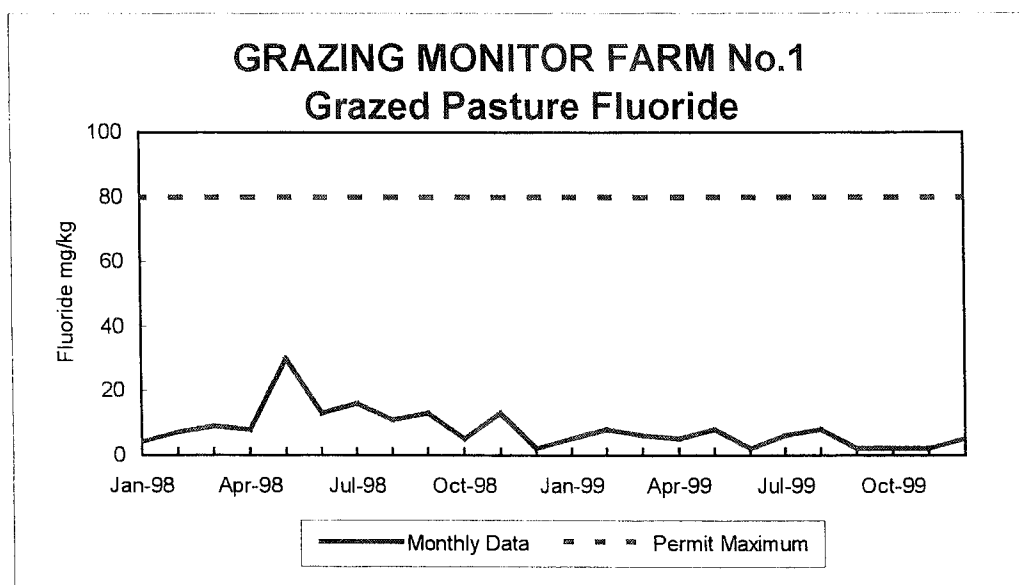
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	8
Two monthly average maximum	mg/kg	60	7
Twelve monthly running average maximum	mg/kg	40	11
Annual average	mg/kg		5

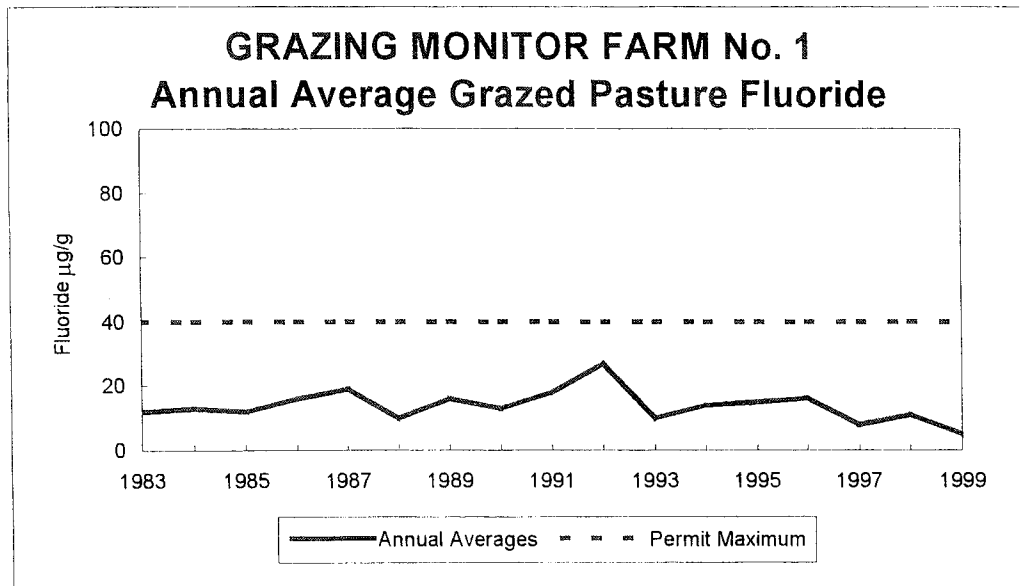
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No.1, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards. The 1999 average grazed pasture fluoride concentration of 5 mg/kg was lower than the average fluoride concentration measured during 1998.

Grazing Monitor Farm No. 2

Introduction

The following information is contained in this section:

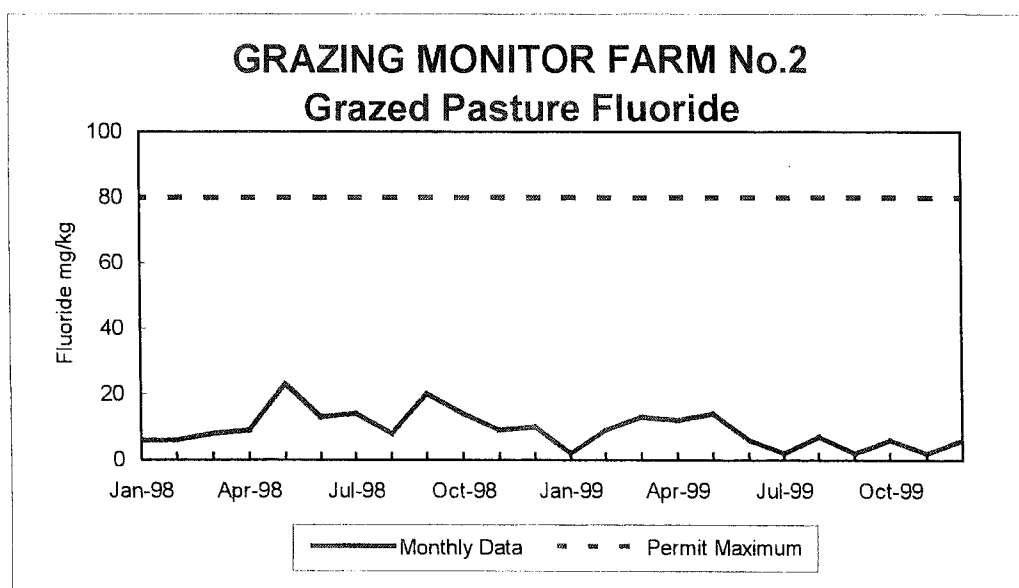
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	14
Two monthly average maximum	mg/kg	60	13
Twelve monthly running average maximum	mg/kg	40	12
Annual average	mg/kg		7

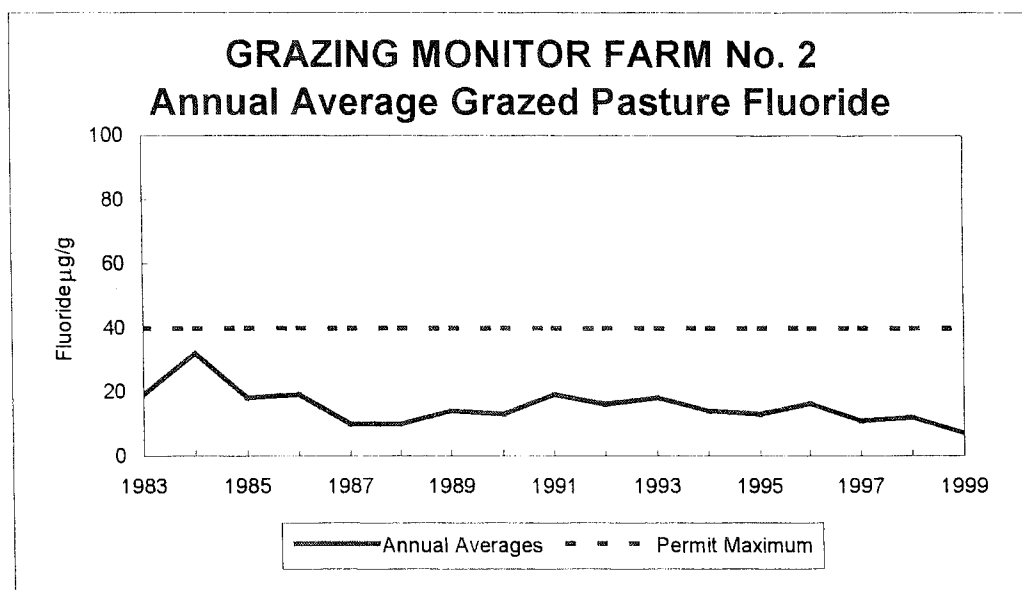
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 2, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards. The 1999 average grazed pasture fluoride concentration of 7 mg/kg was lower than the average fluoride concentration measured during 1998.

Grazing Monitor Farm No. 3

Introduction

The following information is contained in this section:

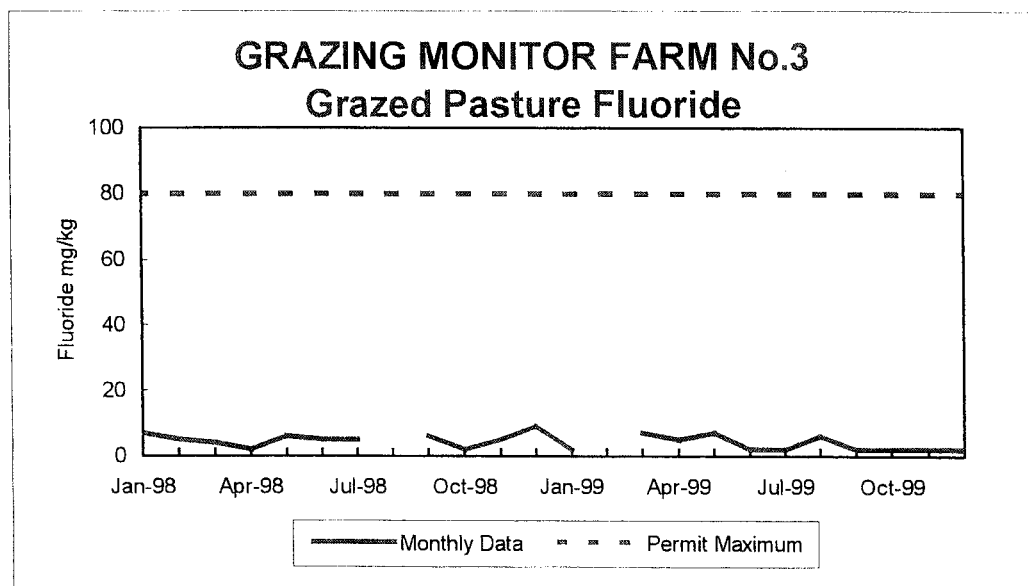
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	7
Two monthly average maximum	mg/kg	60	7
Twelve monthly running average maximum	mg/kg	40	5
Annual average	mg/kg		4

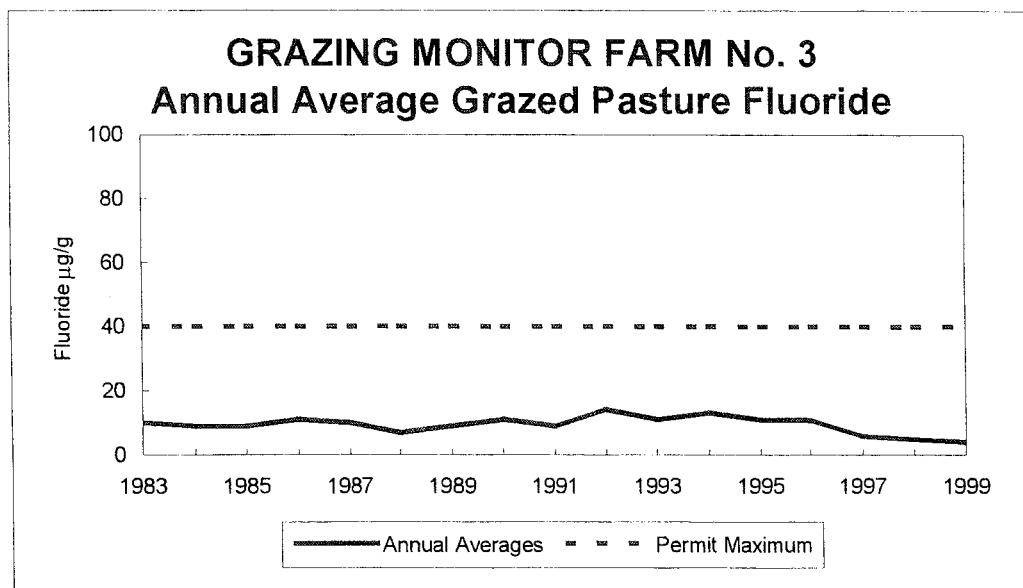
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 3, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards. The 1999 annual average grazed pasture fluoride concentration of 4 mg/kg was similar to the concentration measured during 1998.

No grazed pasture fluoride concentration was reported for February, as the site was topdressed about one week prior to sampling. Condition C2.2 of the Air Discharge Permit exempts samples collected within 28 days of topdressing from the permit standards.

Grazing Monitor Farm No. 4

Introduction

The following information is contained in this section:

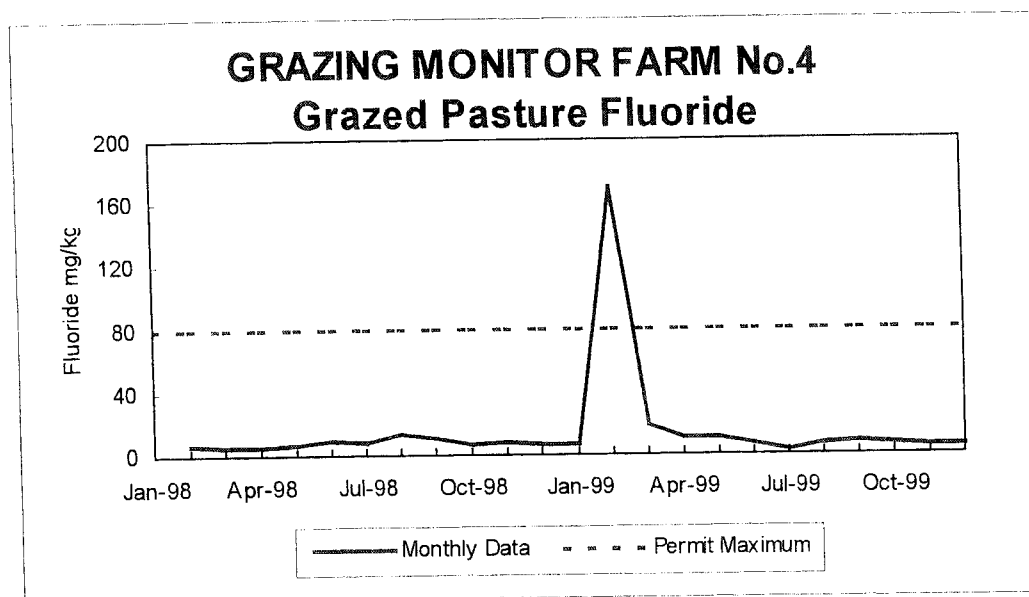
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	170
Two monthly average maximum	mg/kg	60	95
Twelve monthly running average maximum	mg/kg	40	23
Annual average	mg/kg		21

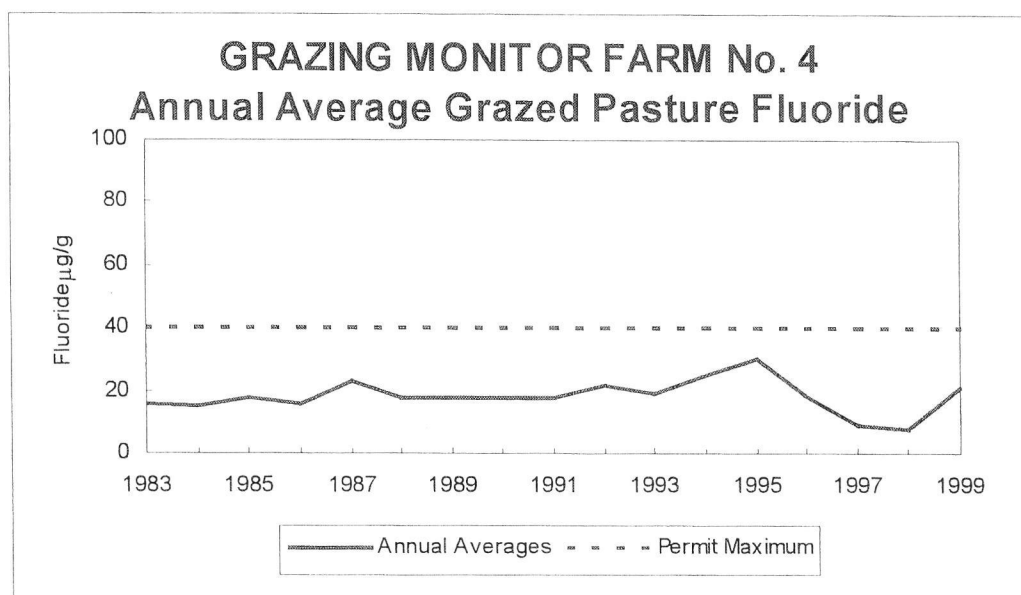
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 4, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Cattle urinary fluoride

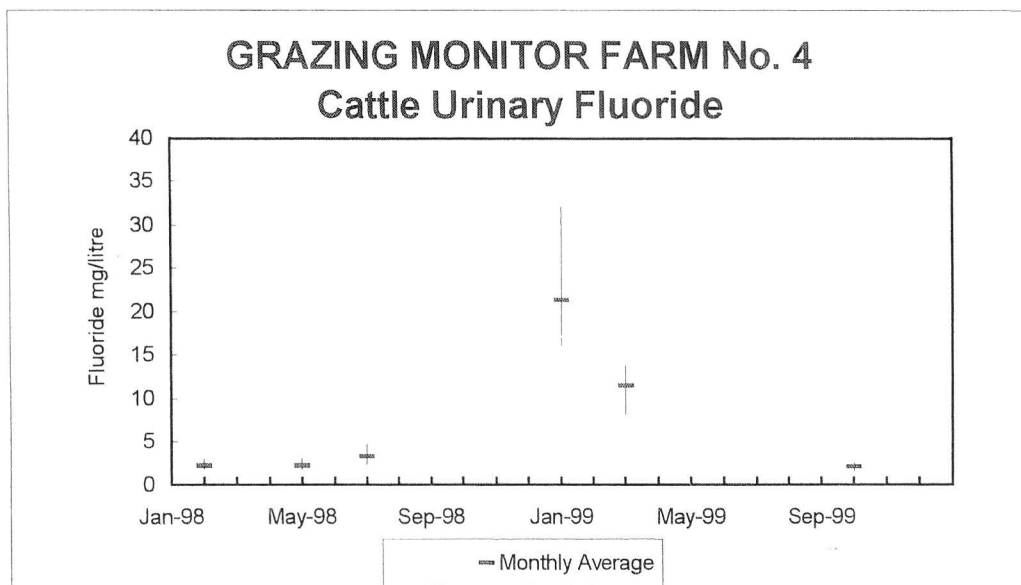
The following table summarises the results of cattle urinary fluoride monitoring during 1999.

	Units	Guideline	1999
Average fluoride concentration	mg/L	-	11.6
Maximum fluoride concentration	mg/L	10	32.2
Minimum fluoride concentration	mg/L	-	1.5
No. of samples	mg/L	-	14

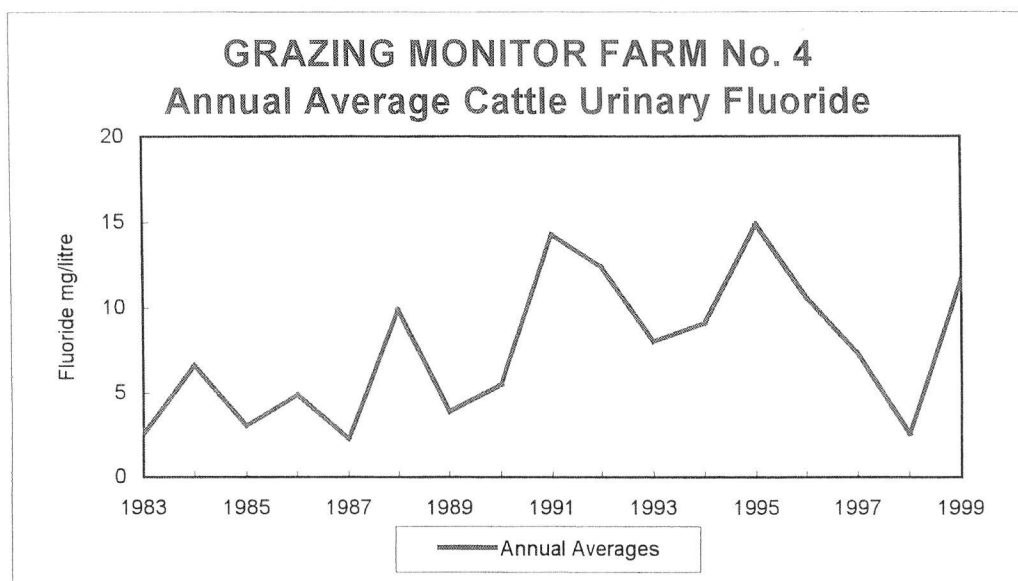
Grazing Monitor Farm No. 4, Continued

Cattle urinary fluoride, continued

The following graph shows the results of urinary fluoride monitoring of cattle during 1998 and 1999. The horizontal bars show the average concentration of the samples and the vertical bars show the range of concentrations.



The following graph shows the annual average fluoride concentration in cattle urine.



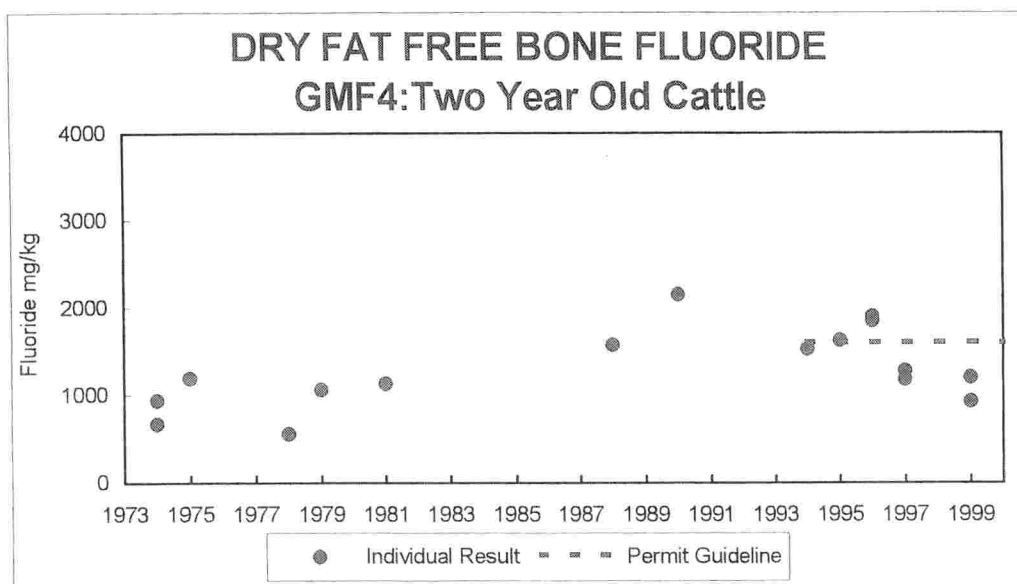
Grazing Monitor Farm No. 4, Continued

Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1999.

Identification	Age	Units	Guideline	1999
NZAS 98/1	2	mg/kg	1605	925
NZAS 98/2	2	mg/kg	1605	1200
Black	4	mg/kg	2,379	1775
72	6	mg/kg	2,794	1925

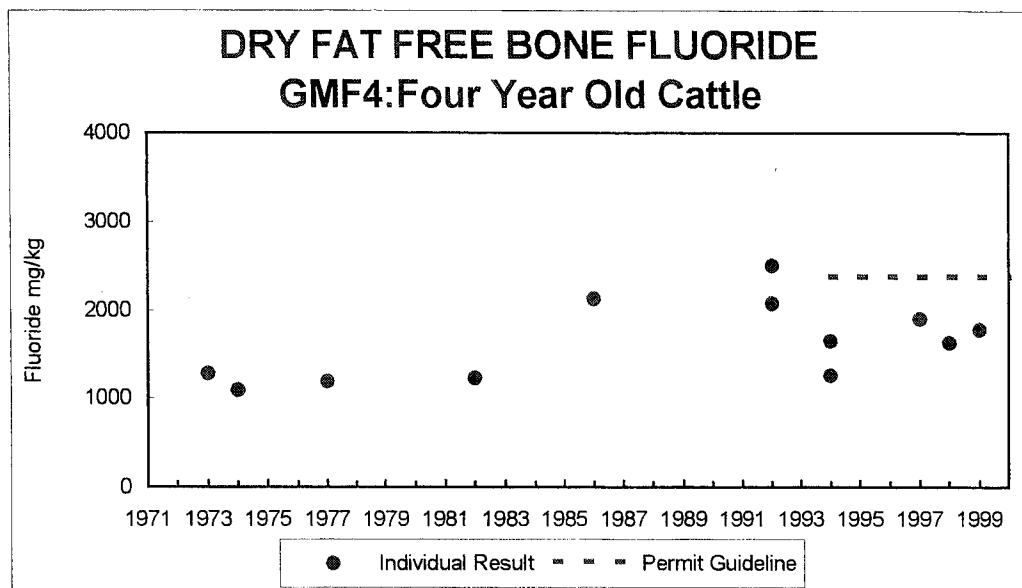
The following graph shows the bone fluoride concentration of individual biopsies collected from two year old cattle since the project began.



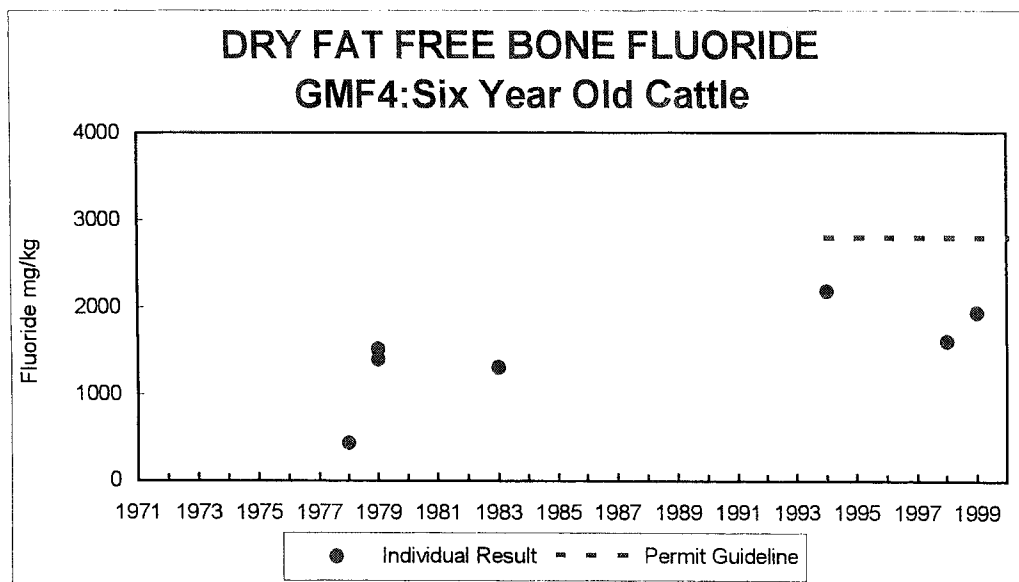
Grazing Monitor Farm No. 4, Continued

Cattle bone fluoride, continued

The following graph shows the bone fluoride concentration of individual biopsies collected from four year old cattle since the project began.



The following graph shows the bone fluoride concentration of individual biopsies collected from six year old cattle since the project began.



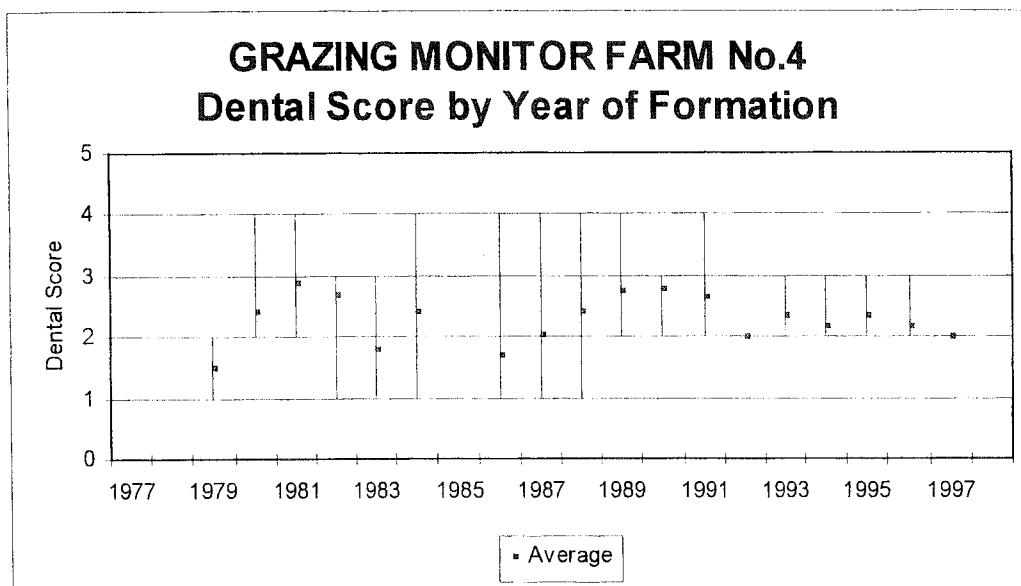
Grazing Monitor Farm No. 4, Continued

Cattle dental condition

The following table summarises combined results of the dental inspection of cattle.

Year of tooth formation	1995	1996	1997
Average tooth score	2.33	2.17	2
Maximum tooth score	3	3	2
Minimum tooth score	2	2	2
No. of cattle inspected	9	6	2

The following graph shows the average tooth score and range of tooth scores for the teeth of cattle formed since monitoring began.



Grazing Monitor Farm No. 4, Continued

Comments

The fluoride concentrations of cattle bone on GMF4 were within the permit guidelines during 1999. The fluoride concentrations of grazed pasture and cattle urine exceeded some permit conditions and guidelines during 1999.

The grazed pasture fluoride concentration determined during February was 170 mg/kg and resulted in bi-monthly average fluoride concentrations of 88 and 95 mg/kg during February and March. These bi-monthly average concentrations exceeded the permit standard of 60 mg/kg. The February monthly result was not a standard violation as it was the only occasion in 12 months that 80 mg/kg was exceeded.

The high February concentration was most likely the result of the site being topdressed with superphosphate on 14 January. The result is reported as the sample was collected on 13 February, two days outside the 28 day exemption for samples collected following topdressing. It is likely that a significant amount of superphosphate remained on the pasture at the time of sampling because few rain events were recorded at Tiwai Point between topdressing and sampling.

The 1999 annual average grazed pasture fluoride concentration of 21 mg/kg was about double that determined during 1998. If the February result was excluded, the 1999 average grazed pasture fluoride concentration would be 8 mg/kg, similar to that determined for 1998.

Eight of 14 urinary fluoride concentrations determined during 1999 exceeded the permit guideline of 10 mg/L. The high fluoride concentrations were in samples collected during the first quarter. The fluoride concentrations of other urine samples, collected during October, were all within the permit guideline. The annual average urinary fluoride concentration measured during 1999 was 11.6 mg/litre compared to 2.6 mg/litre measured during 1998. The maximum individual urinary fluoride concentration measured during 1999 was 32.2 mg/litre compared with a maximum of 4.7 mg/litre measured during 1998. The high fluoride concentrations during the first quarter were most likely related to:

- the superphosphate topdressing in January and
- the dry weather experienced in the area during January and February

discussed previously in this section regarding pasture fluoride concentrations.

Grazing Monitor Farm No. 4, Continued

Comments, continued

The average fluoride concentration of bones sampled from two year old cattle during 1999 was about 1050 mg/kg. This is lower than the 1225 mg/kg determined in the previous two year old bones sampled in 1997. The lower 1999 average concentrations do not necessarily indicate a decreasing trend in two year old bone fluoride concentrations. The decrease may only be indicating the lower end of the range of results that can be expected following the commissioning of the smelter's main stack dry scrubbing system. The bone fluoride concentration of a four year old cow was similar to that determined during 1997 and 1998. The 1,925 mg/kg bone fluoride concentration measured in a six year old cow was higher than that measured during 1998 but is most likely showing normal variation within the population.

The dental scores in cattle inspected during 1999 indicated decreasing fluoride effects on teeth formed since 1995. The decrease supports the decrease in fluoride concentrations measured on this farm since the progressive installation of the main stack dry scrubbing system started in 1996.

Grazing Monitor Farm No. 11

Introduction

The following information is contained in this section:

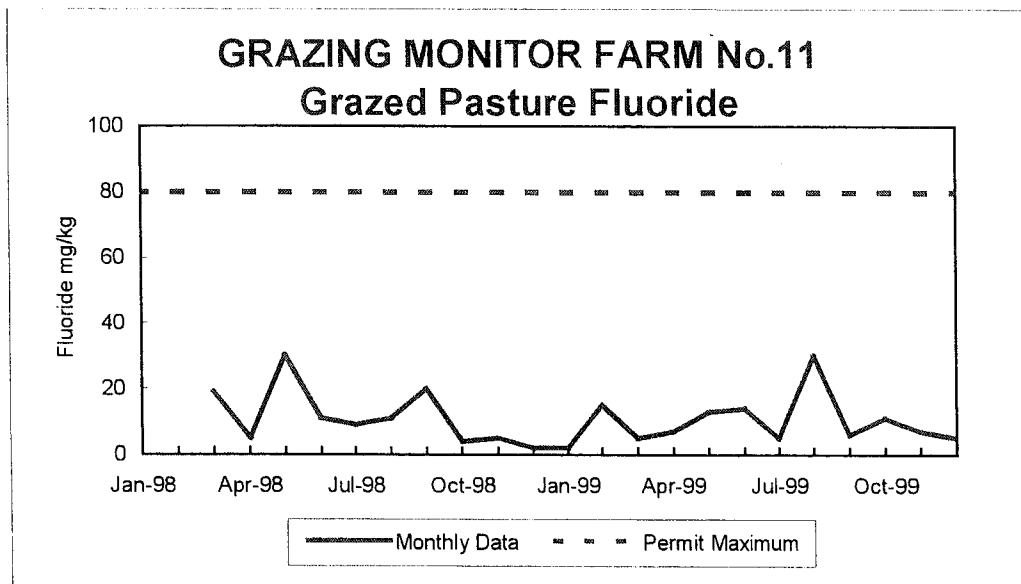
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	30
Two monthly average maximum	mg/kg	60	18
Twelve monthly running average maximum	mg/kg	40	11
Annual average	mg/kg		10

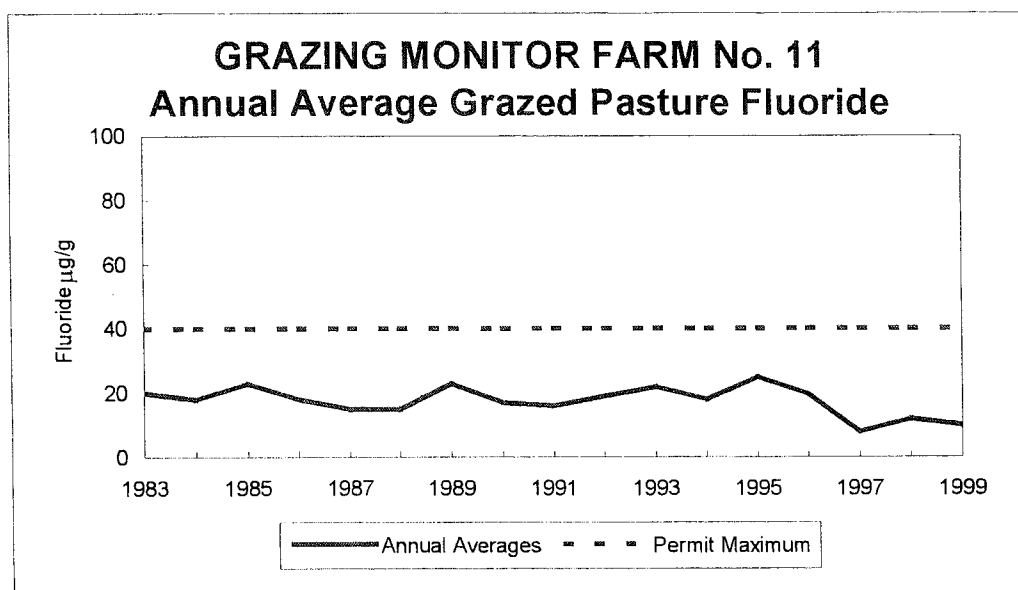
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 11, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards. The 1999 average grazed pasture fluoride concentration of 10 mg/kg was similar to the average fluoride concentration measured during 1998.

Grazing Monitor Farm No. 12

Introduction

The following information is contained in this section:

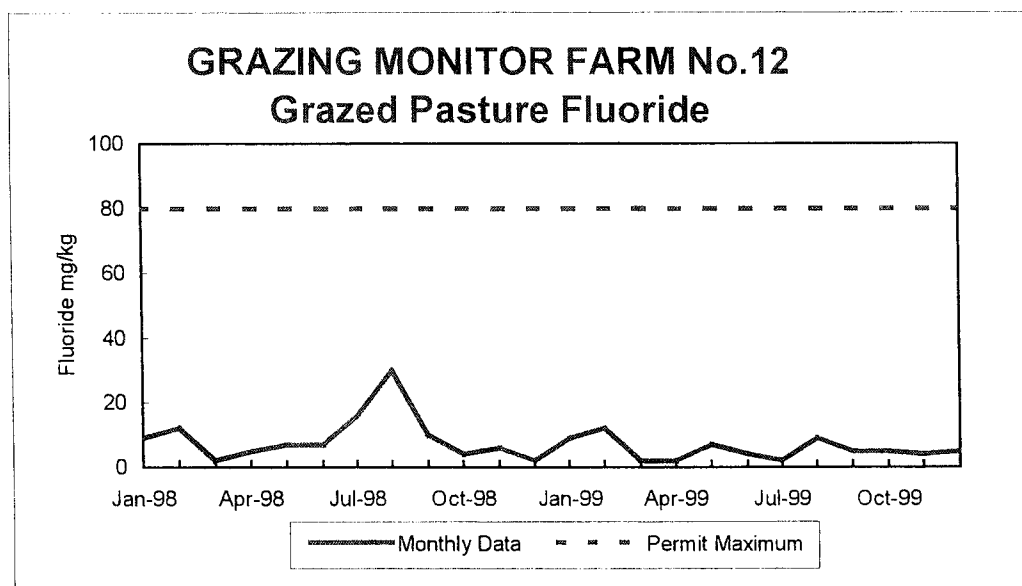
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	12
Two monthly average maximum	mg/kg	60	11
Twelve monthly running average maximum	mg/kg	40	9
Annual average	mg/kg		6

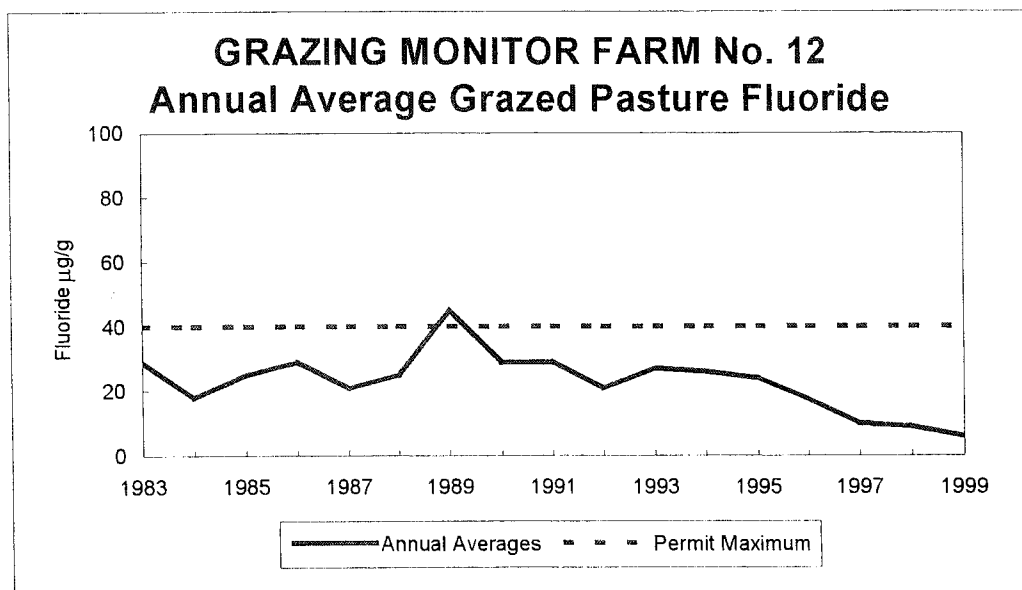
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 12, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride in grazed pasture was within the permit standards. The 1999 annual average grazed pasture fluoride concentration of 6 mg/kg was lower than the average concentration measured during 1998.

Grazing Monitor Farm No. 14

Introduction

The following information is contained in this section:

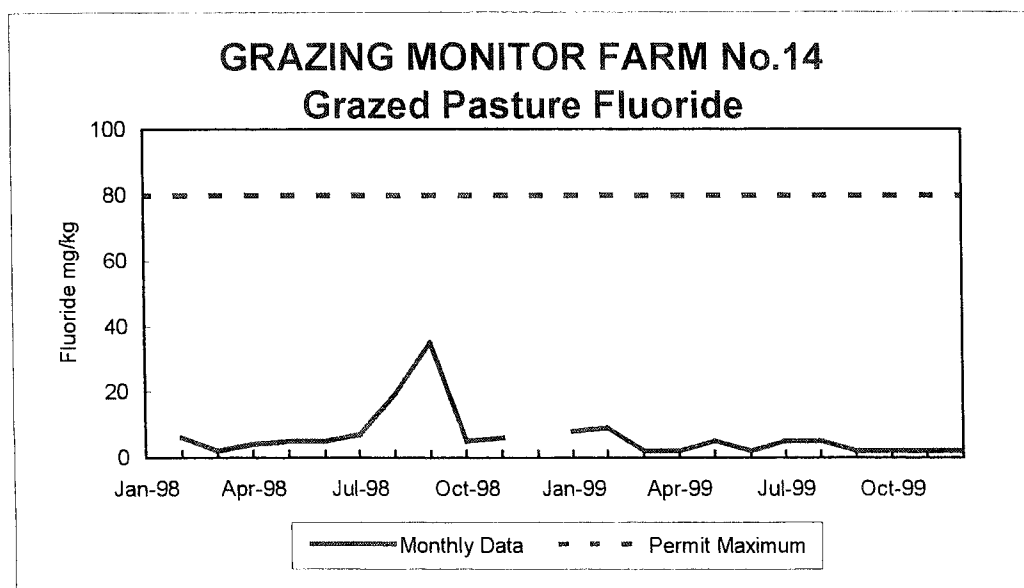
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	9
Two monthly average maximum	mg/kg	60	9
Twelve monthly running average maximum	mg/kg	40	10
Annual average	mg/kg		4

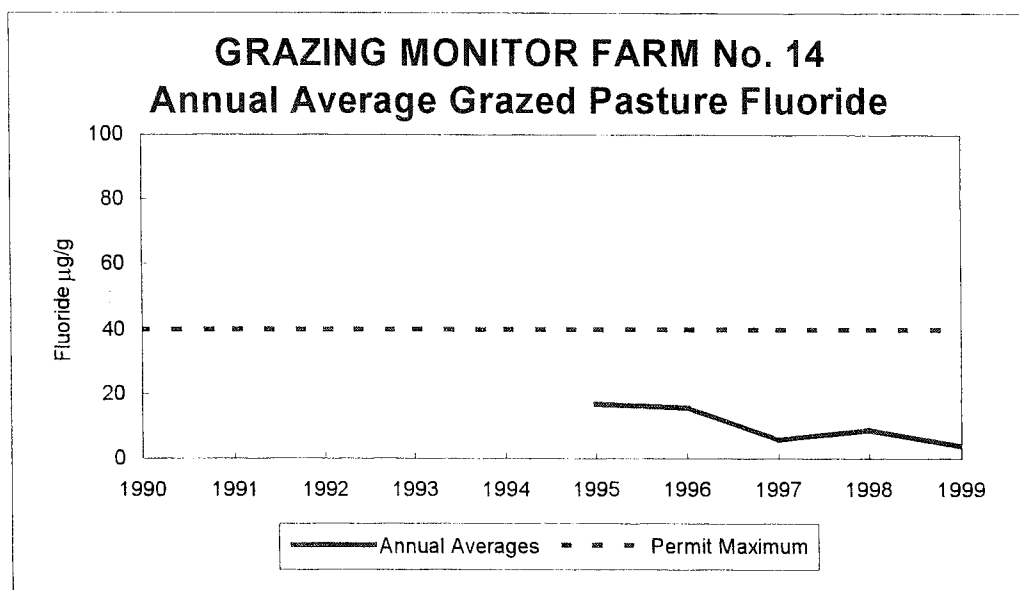
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 14, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Comments

The fluoride concentrations in grazed pasture were within the permit standards during 1999. The annual average grazed pasture fluoride concentration of 4 mg/kg was the lowest ever determined on this farm.

Grazing Monitor Farm No. 16

Introduction

The following information is contained in this section:

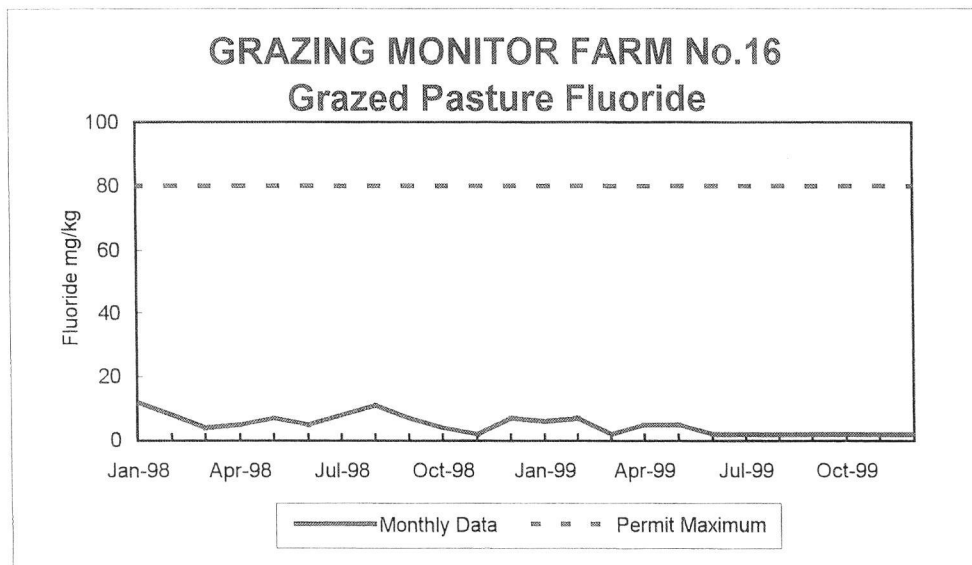
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1999.

	Units	Standard	1999
Monthly sample maximum	mg/kg	80	7
Two monthly average maximum	mg/kg	60	7
Twelve monthly running average maximum	mg/kg	40	6
Annual average	mg/kg		< 4

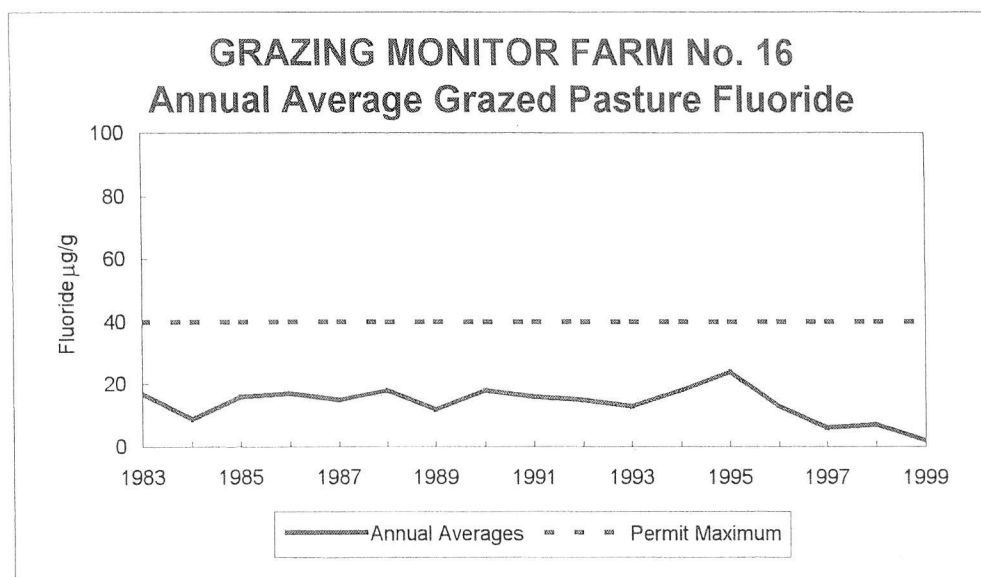
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Grazing Monitor Farm No. 16, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture. Although GMF 16 was only included in the monitoring program in August 1994 an annual pasture graph has been produced including pre 1994 data from the neighbouring GMF 10 site. GMF10 was removed from the program in February 1998 as it is in the same ownership as GMF16 and pasture samples from the two farms during the years 1994 to 1998 indicated similar results.



Comments

The fluoride concentrations in grazed pasture were within the permit standards during 1999. The 1999 annual average grazed pasture fluoride concentration of < 4 mg/kg was the lowest ever determined on this farm.

The Health of Farm Livestock

Tiwai Experimental Farms

Summary

The Tiwai Experimental Farm (TEF) Project was closed in May 1999 and all remaining livestock disposed of. The project has provided sufficient information on the effects of fluoride on sheep.

The 1999 annual average fluoride concentrations in grazed pasture on both farms were similar to the concentrations for the previous two years:

- 25 mg/kg on Tiwai Experimental Farm No.1 (TEF1) and
- 7 mg/kg on Tiwai Experimental Farm No.2 (TEF2).

The fluoride concentration of jawbone samples collected from sheep on both farms reflected the lower fluoride concentration of the pasture on both farms during the last three years. The fluoride concentration of jawbone sampled from sheep aged four to six years decreased due to the decreased exposure to fluoride.

Dental inspection of sheep on TEF1 showed that dental scores for teeth formed during 1997 and 1998 were lower than for earlier years. This is due to lower fluoride exposure since 1997. Dental scores for teeth formed during 1997 and 1998 on TEF2 were similar to previous results.

Introduction

The Tiwai Experimental Farm (TEF) Project was established to support the Grazing Monitor Farms Project. The aims of the TEF project were:

- to assess the condition of the smelter's discharges to air on sheep, and
- provide local veterinarians with experience in diagnosing fluorosis.

TEF1 is located on the Tiwai Peninsula, 3.5 kilometres east of the smelter. TEF1 was established in 1971.

TEF2 is at the east end of the Tiwai Peninsula, about ten kilometres east of the smelter. TEF2 was established in 1973.

The locations of the two Tiwai Experimental Farms are shown on the map in Grazing Monitor Project, Introduction.

Closure of the Tiwai Experimental Farm Project

As was discussed in last year's report NZAS closed the TEF Project in May 1999. The reasons for closing the project included:

- the fluoride discharge from the smelter has decreased significantly since the commissioning to the dry scrubbing equipment was completed in January 1997 and
- sufficient information on the effects of fluoride on sheep during increasing and decreasing exposure is available following 28 years of operating the TEF Project.

Tiwai Experimental Farm No.1

Introduction

The following information is contained in this section:

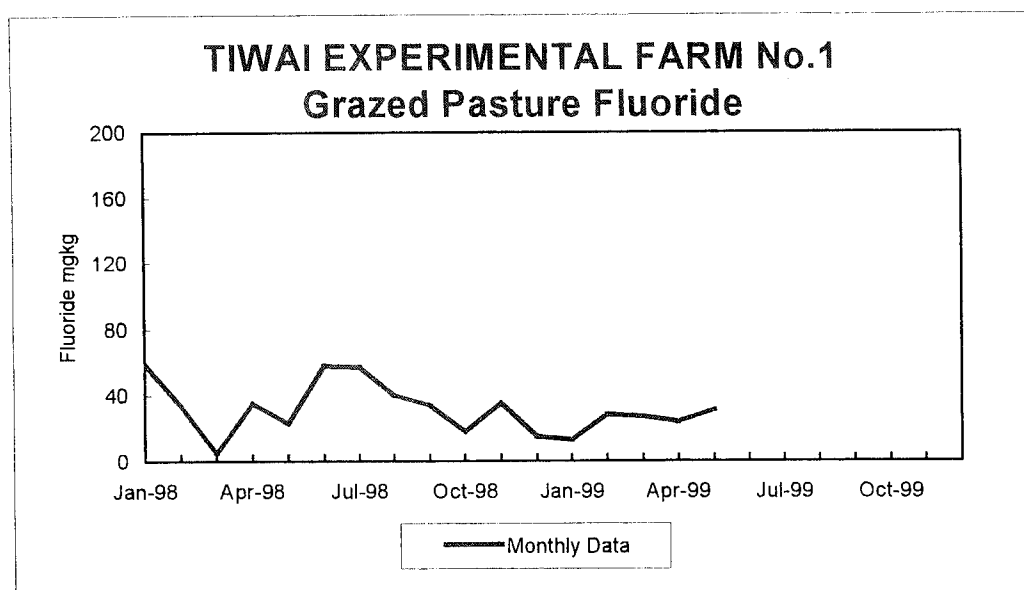
- fluoride in grazed pasture,
- sheep bone fluoride
- dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for January to May 1999.

	Units	1999
Monthly sample maximum	mg/kg	31
Two monthly average maximum	mg/kg	28
Twelve monthly running average maximum	mg/kg	32
Annual average	mg/kg	25

The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.

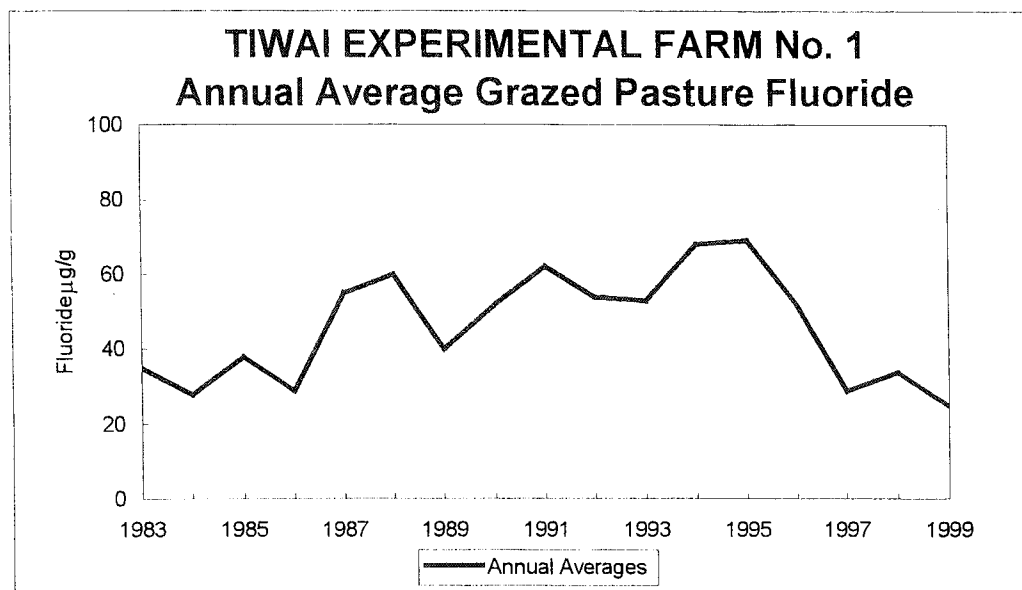


Note: No samples were collected after May as the TEF Project was closed.

Tiwai Experimental Farm No.1, Continued

Fluoride in grazed pasture, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Note: The 1999 average fluoride concentration includes samples collected from January to May only as the TEF Project was closed in May.

Tiwai Experimental Farm No.1, Continued

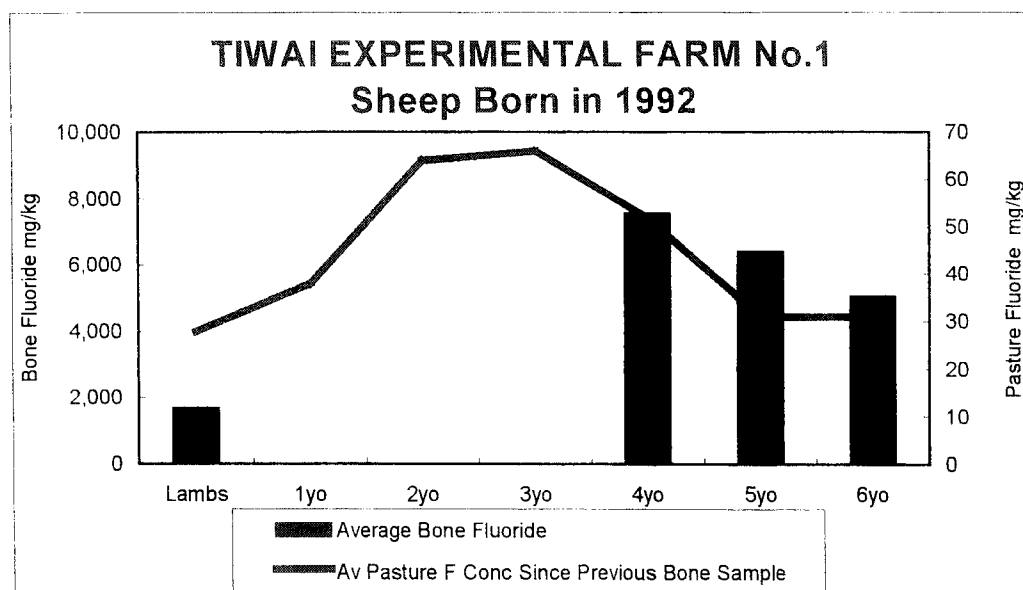
Sheep Bone Fluoride

From 1986 until 1993 sheep born on TEF1 were grazed on TEF2 from about four to 16 months of age and then returned to TEF1. Since 1994 sheep have remained on TEF1 since birth.

The following table shows the jawbone fluoride concentration as ashed bone for samples collected during 1999.

Age	No. of samples	Average Fluoride mg/kg	Maximum Fluoride mg/kg	Minimum Fluoride mg/kg
lambs	5	1,870	2,100	1,700
1	5	2,610	2,800	2,050
2	5	3,090	3550	2850
3	5	4,020	4,600	3,650
4	5	4,860	5,200	4,500
≥ 6	5	5,040	5,400	4,600

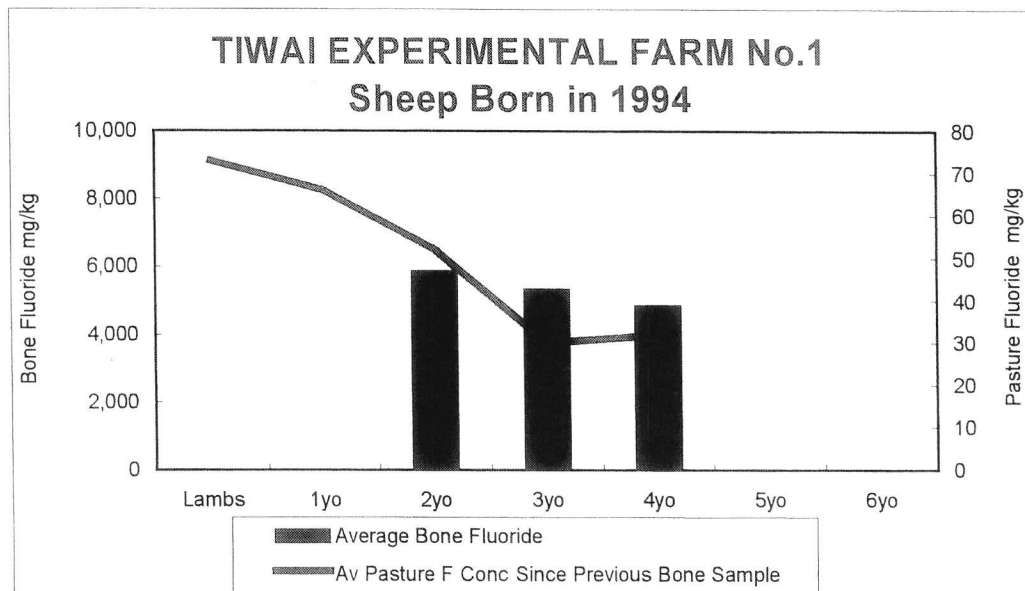
The following five graphs show average jawbone fluoride concentrations of sheep. The average fluoride concentration for each age group sampled is compared with the average grazed pasture fluoride concentration the sheep were exposed to between bone samples. Each graph combines the data for sheep born in the same year.



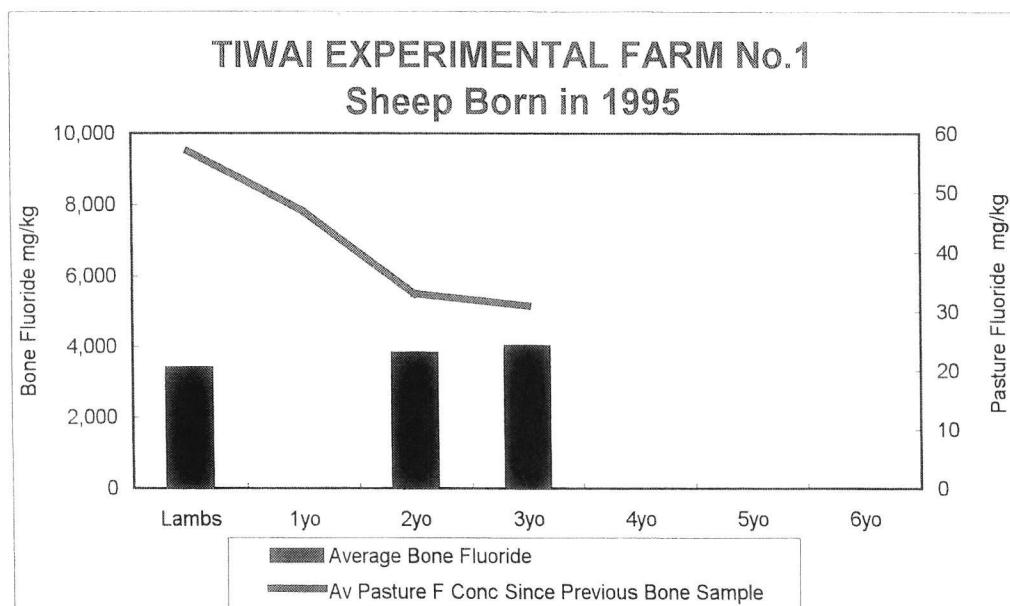
Note: six year old samples were collected in April 1999.

Tiwai Experimental Farm No.1, Continued

Sheep Bone Fluoride continued



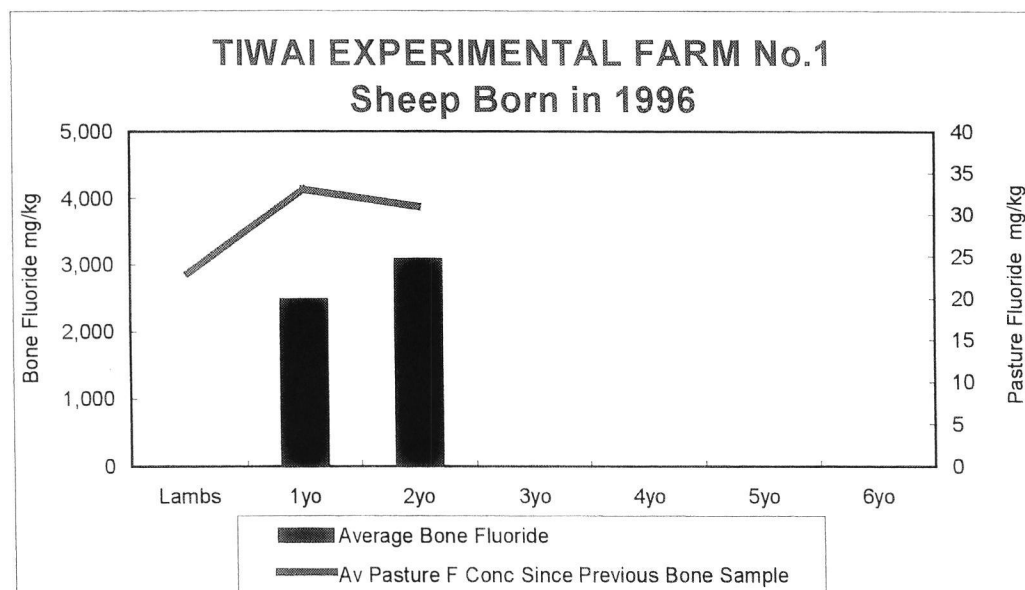
Note: four year old samples were collected in April 1999.



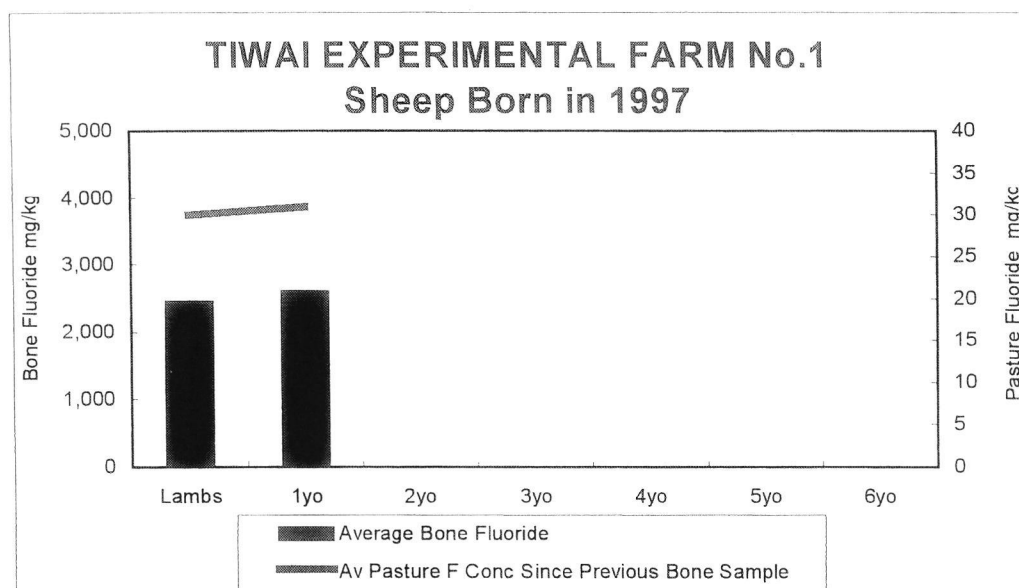
Note: three year old samples were collected in April 1999.

Tiwai Experimental Farm No.1, Continued

Sheep Bone Fluoride continued



Note: two year old samples were collected in April 1999.



Note: one year old samples were collected in April 1999.

Tiwai Experimental Farm No.1, Continued

Sheep dental condition

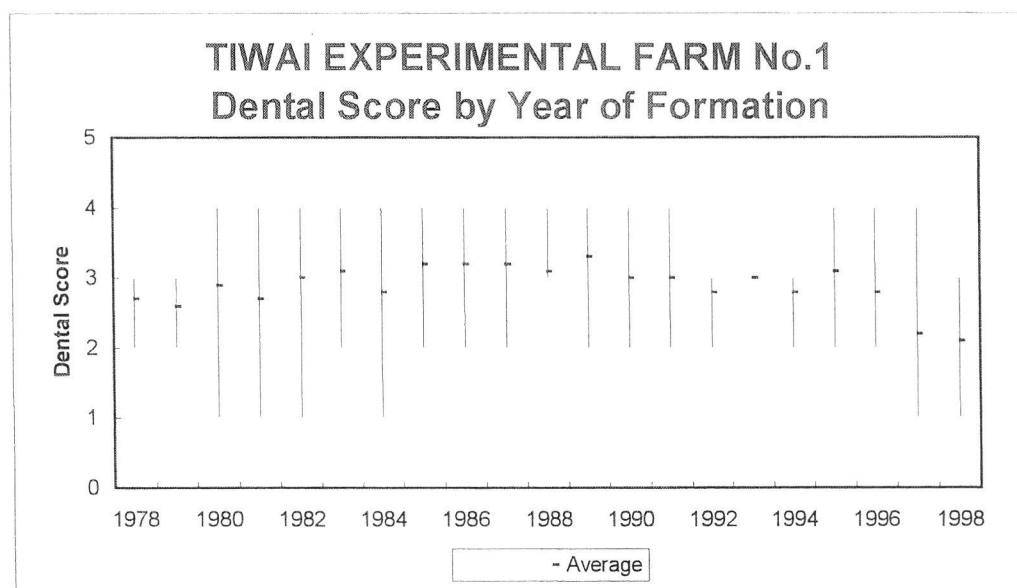
The dental inspection of sheep grazing on TEF1 was delayed from December 1998 until March 1999 to allow a greater number of recently erupted teeth to be available for the final inspection. The tooth scoring system follows the method of J Suttie. As most effects on teeth occur prior to eruption when the teeth are forming, the tooth scores are given in relation to the year during which they were formed. The results of previous inspections have been combined to provide a table summarising the dental condition of incisors formed during each year,

The following table summarises the results of the dental inspection of sheep on TEF1.

Year of tooth formation	1995	1996	1997	1998
Average tooth score	3.1	2.8	2.2	2.1
Maximum tooth score	4	4	4	3
Minimum tooth score	2	2	1	1
No. of pairs of teeth inspected	39	49	64	57

Sheep dental condition

The following graph shows the average and range of tooth scores on TEF1 since 1978.



Tiwai Experimental Farm No.1, Continued

Comments

TEF1 was closed in May 1999, as sufficient information on the response of sheep to elevated fluoride exposure is available.

The average grazed pasture fluoride concentration of 25 mg/kg for the period January to May was lower than the 35 mg/kg measured for all of 1998.

Jawbone fluoride concentrations were determined in sheep aged between eight months and six years of age during 1999. The fluoride concentrations were generally within the range of results expected. The graphs displaying the jawbone fluoride concentrations compared with grazed pasture fluoride concentrations show that the bone fluoride concentrations:

- increase with age if the pasture fluoride concentration increases or remains relatively constant, and
- decreases with age if the pasture fluoride concentration decreases.

Increasing and decreasing jawbone fluoride concentrations occurred in sheep born in 1992. The jawbone fluoride concentration increased from 1,680 mg/kg in lambs, sampled in 1993, to 7,560 mg/kg in four year old sheep, sampled in 1997. During this time the pasture fluoride concentration increased from about 30 mg/kg while the sheep grazed on TEF2 during 1993, to about 65 while the sheep grazed on TEF1 during 1994 and 1995.

The jawbone fluoride concentrations in sheep born in 1992 decreased from 7,560 mg/kg in the four year olds, sampled in 1997, to 5,040 mg/kg in six year old sheep sampled in 1999. During this time the pasture fluoride concentration decreased from 52 mg/kg during 1997 to about 30 mg/kg during 1998 and 1999.

The jawbone fluoride concentrations of sheep born in 1996 and 1997 increased with age. This increase was expected, as the pasture fluoride concentrations were generally stable at between 23 and 33 mg/kg.

Teeth inspected during 1999 were formed during 1997 and 1998. Dental scores averaged 2.2 for those formed during 1997 and 2.1 for those formed during 1998. Both years' results were significantly lower than for teeth formed during 1995 and 1996. The decrease reflects the lower pasture fluoride concentration, which averaged 30 to 35 mg/kg during 1997 and 1998, compared with 69 mg/kg during 1995 and 52 mg/kg during 1996.

Tiwai Experimental Farm No.2

Introduction

The following information is contained in this section:

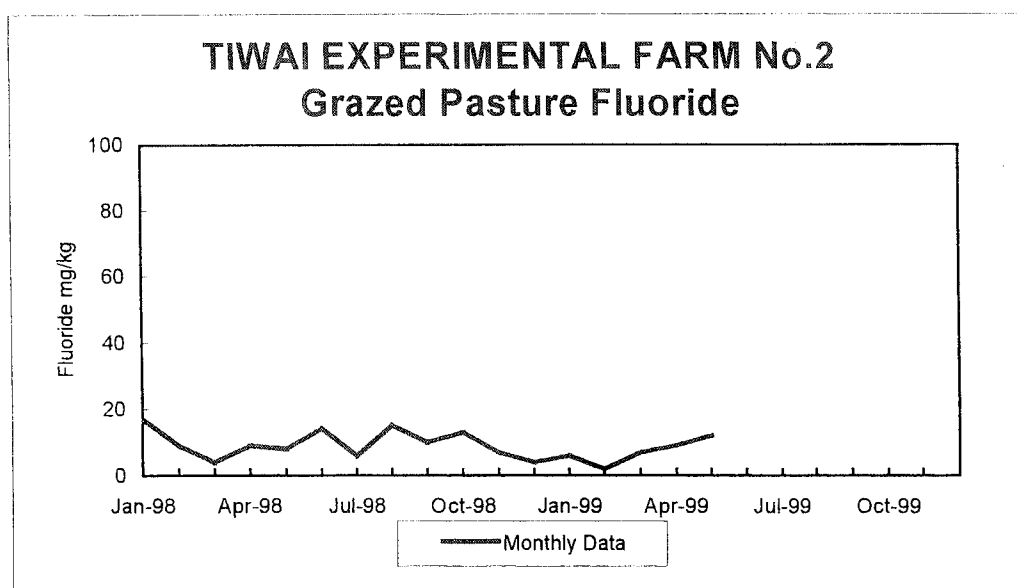
- fluoride in grazed pasture,
- sheep bone fluoride
- dental condition, and
- comments in the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for January to May 1999.

	Units	1999
Monthly sample maximum	mg/kg	12
Two monthly average maximum	mg/kg	11
Twelve monthly running average maximum	mg/kg	9
Annual average	mg/kg	7

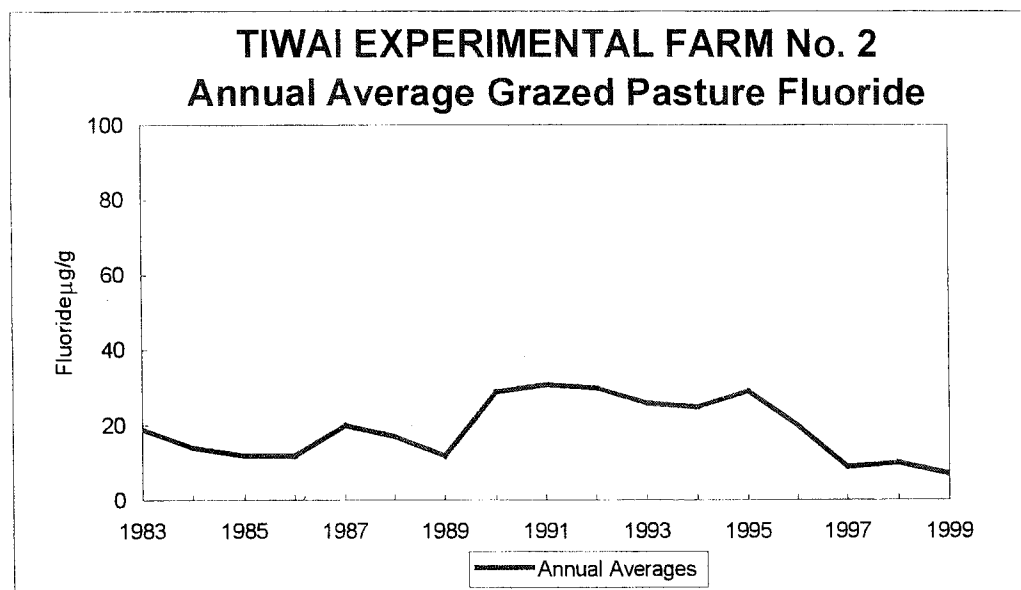
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1998 and 1999.



Tiwai Experimental Farm No.2, Continued

Fluoride in grazed pastures, continued

The following graph shows the annual average fluoride concentration in grazed pasture.



Sheep bone fluoride

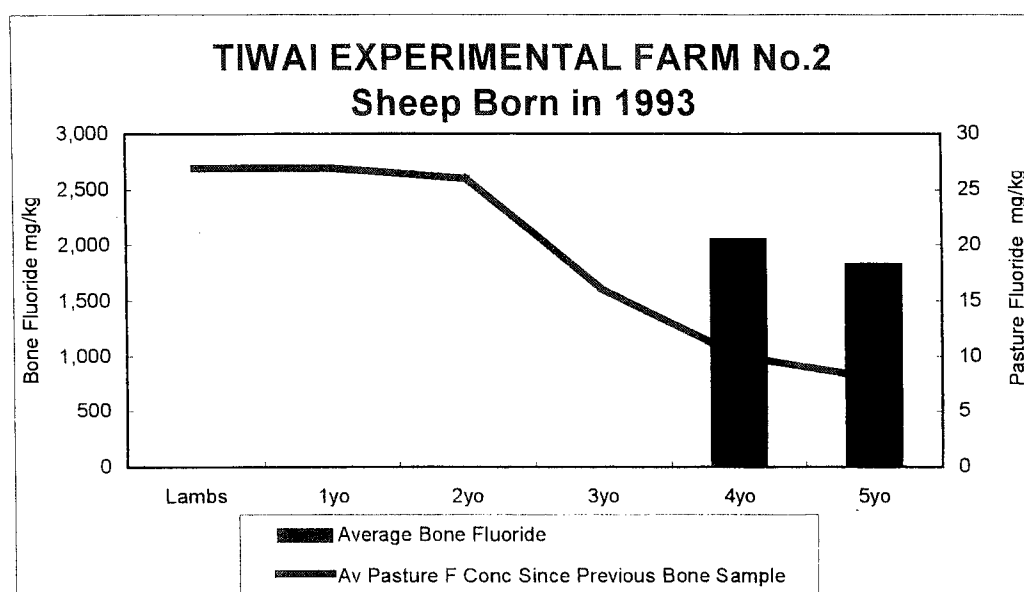
The following table shows the jawbone fluoride concentration as ashed bone on TEF2 in samples collected during 1999. The five year old sheep were born on TEF1 but were transferred to TEF2 after being weaned in December 1993. All other sheep have remained on TEF2 since birth.

Age	No. of samples	Average Fluoride mg/kg	Maximum Fluoride mg/kg	Minimum Fluoride mg/kg
Lambs	6	390	450	300
1	5	470	500	400
2	5	690	750	650
3	5	840	950	750
5	5	1,830	2,050	1,700

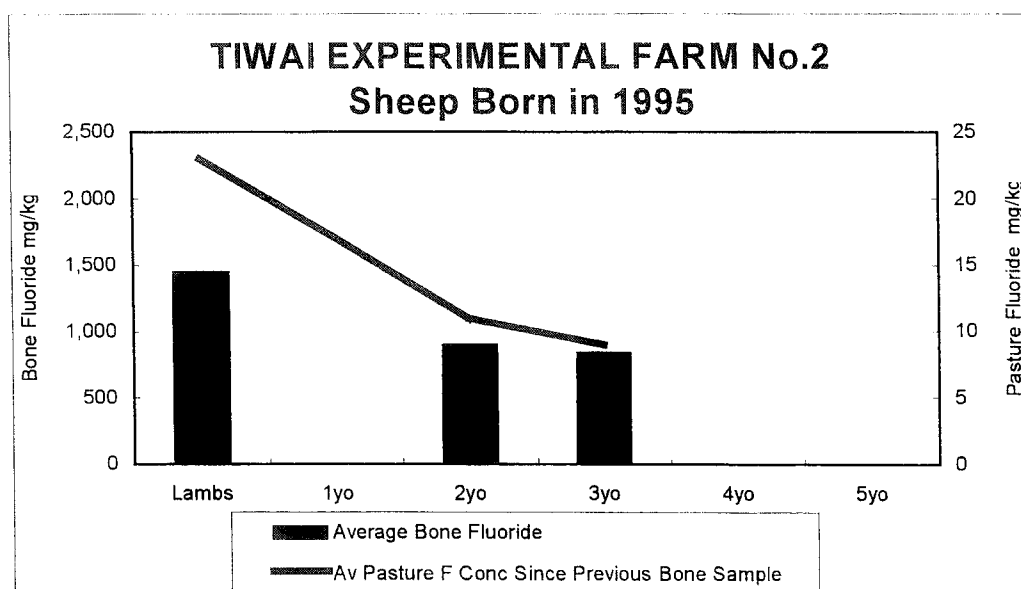
Tiwai Experimental Farm No.2, Continued

Sheep bone fluoride, continued

The following four graphs show average jawbone fluoride concentrations of sheep. The average fluoride concentration for each age group sampled is compared with the average grazed pasture fluoride concentration the sheep were exposed to between bone samples. Each graph combines the data for sheep born in the same year.



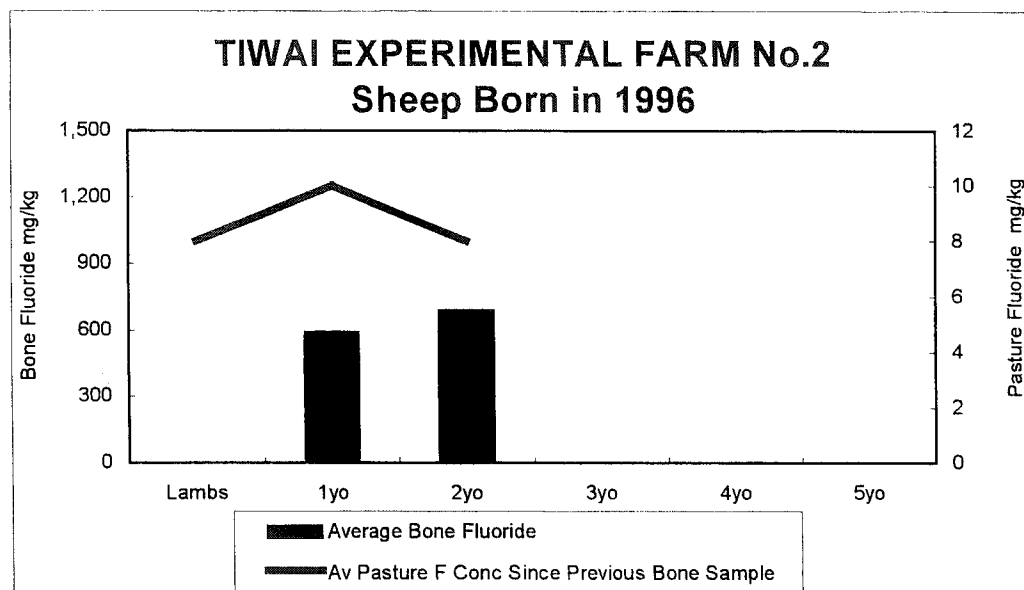
Note: five year old samples were collected in April 1999.



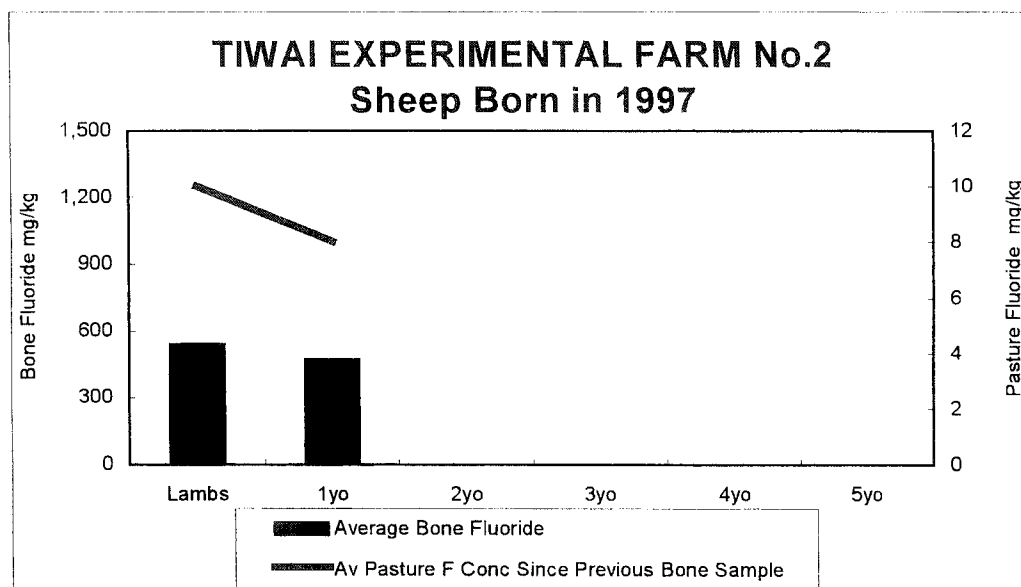
Note: three year old samples were collected in April 1999.

Tiwai Experimental Farm No.2, Continued

Sheep bone fluoride, continued



Note: two year old samples were collected in April 1999.



Note: one year old samples were collected in April 1999.

Tiwai Experimental Farm No.2, Continued

Sheep dental condition

The dental inspection of sheep grazing on TEF2 was delayed from December 1998 until March 1999 to allow a greater number of recently erupted teeth to be available for the final inspection. The tooth scoring system follows the method of J Suttie. As most effects on teeth occur prior to eruption when the teeth are forming, the tooth scores are given in relation to the year during which they were formed. The results of previous inspections have been combined to provide a table summarising the dental condition of incisors formed during each year,

The following table summarises the results of the dental inspection of sheep on TEF2.

Year of tooth formation	1995	1996	1997	1998
Average tooth score	1.9	2.1	1.9	1.9
Maximum tooth score	3	3	3	2
Minimum tooth score	1	1	1	1
No. of pairs of teeth inspected	12	26	30	27

Comments

TEF2 was closed in May 1999, as sufficient information on the response of sheep to elevated fluoride exposure is available.

The 1999 annual average grazed pasture fluoride concentration of 7 mg/kg for the period January to May was similar to the average concentration measured for all of 1998.

Similar to the discussion in Tiwai Experimental Farm No.1 "Comments" the jawbone fluoride concentrations of sheep grazing on TEF2 reflect the lower grazed pasture fluoride concentrations since 1997. Decreased jawbone fluoride concentrations have occurred with age for sheep born in 1993 and 1995. Sheep born since 1996 show either increasing or relatively stable jawbone fluoride concentrations with age.

The teeth inspected during 1999 were formed during 1997 and 1998. The average dental score for both years is 1.9 and is similar to dental scores for teeth formed during 1995 and 1996. The pasture fluoride concentration during 1997 and 1998 was about 10 mg/kg compared with about 30 mg/kg during 1995 and 1996. The stability of the dental scores suggests that pasture fluoride concentrations between 10 and 30 mg/kg have similar effects on sheep teeth.

Liquid Discharges and Their Effects

Introduction

Liquid discharges from the smelter are covered by six Coastal and Discharge Permits issued by the Southland Regional Council. These permits commenced in October 1996.

This chapter gives details of the monitoring results for each permit.

Permit Limits

The following table shows the permit limits applying to the discharges to water and onto land.

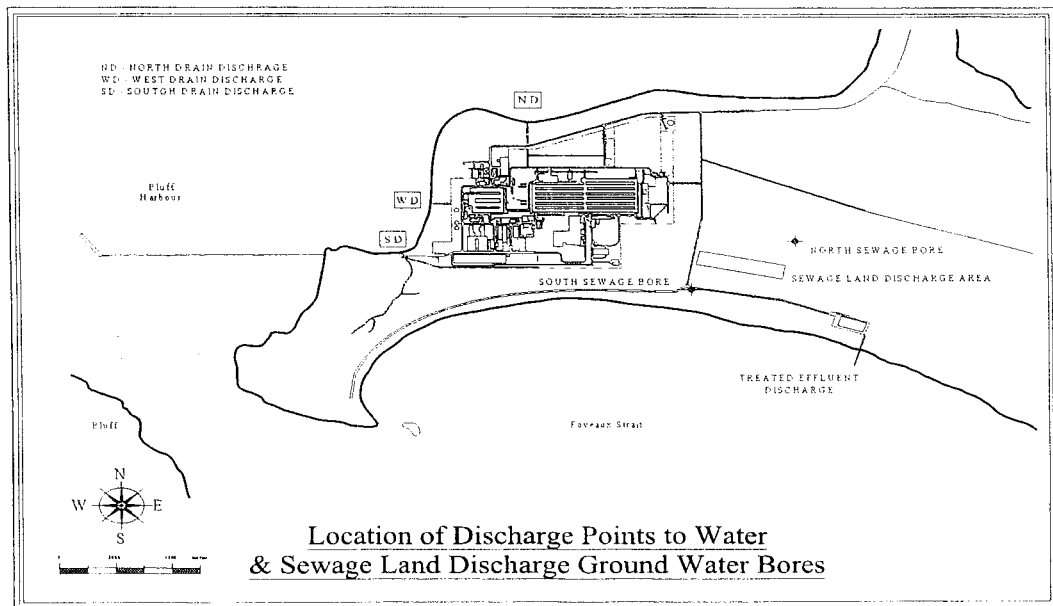
	Units	Limit
North, South, and West Drain <ul style="list-style-type: none">Quarterly average total suspended solids	g/m^3	30
Treated effluent <ul style="list-style-type: none">Maximum daily dischargeTotal suspended solidsFree cyanide	m^3/day g/m^3 g/m^3	140 100 20
Treated sewage <ul style="list-style-type: none">Maximum daily flowBiochemical oxygen demandTotal suspended solids	m^3/day g/m^3 g/m^3	295 18 8

The following permit limits apply to coastal water monitoring sites:

- the natural temperature shall not be changed by more than three degrees Celsius,
- the natural pH shall not be changed by more than 0.1 unit and at no time shall be less than 6.7 or greater than 8.5,
- there shall be no destruction of natural aquatic life by reason of a concentration of toxic substances nor shall the waters emit objectionable odours,
- the natural colour and clarity of the water shall not be changed to a conspicuous extent,
- the dissolved oxygen in solution in the waters shall not be reduced below 5 mg/litre,
- based on not fewer than five samples taken over not more than a 30 day period, the median value of the faecal coliform bacteria content of the waters shall not exceed 200/100 ml,
- there shall be no production of any conspicuous oil or grease films,
- the fluoride concentration of coastal water relating to drain discharges shall not exceed 5.0 g/m^3 , and
- the quarterly average fluoride concentration of coastal water relating to drain discharges shall not exceed 2.0 g/m^3 .

Site Locations

The locations of the liquid discharge and their effects monitoring sites are shown in the following map.



Discharge Monitoring

The discharges from the North, South and West Drains are sampled once each week. The temperature of each discharge is measured once each year as part of the annual seawater quality monitoring survey.

The discharge of treated sewage is sampled over a 24 hour period once each month.

The discharge of treated effluent is sampled once each discharge.

Coastal Water Monitoring

Coastal water quality is determined by comparing the results of monitoring at coastal water monitoring sites with the results at control sites where:

- coastal water monitoring sites are chosen to monitor the effects of discharges on coastal waters and
- control sites are chosen to best represent the background coastal water quality.

Some coastal water monitoring is undertaken each time a drain discharge is sampled. Additional coastal water monitoring for drain discharges is undertaken annually.

Annual coastal water monitoring is undertaken for the discharge of treated effluent.

Sewage Land Disposal Area Groundwater Monitoring

Groundwater near the sewage land disposal area is monitored by sampling from one bore north of the disposal area, upstream, and one bore south of the disposal area, downstream.

Monitoring is carried out at about six monthly intervals.

North Drain Discharges

Introduction

Discharges from the North Drain are covered by Coastal Permit 94501 which commenced on 8 October 1996.

Discharge monitoring results

The following table summarises the North Drain discharge monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Total suspended solids				
• Annual average	g/m ³	-	12.7	10.8
• Maximum quarterly average	g/m ³	30	17.4	15.0
• No. of times quarterly average > 30 g/m ³		0	0	0

Coastal water monitoring results

The following table summarises the North Drain weekly coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Fluoride				
• Annual average	g/m ³	-	1.3	1.3
• Maximum quarterly average	g/m ³	2.0	1.3	1.4
• No. of times quarterly average > 2.0 g/m ³		0	0	0
• Maximum individual sample	g/m ³	5.0	1.6	2.5
• No. of times individual sample > 5.0 g/m ³		0	0	0
pH				
• Maximum difference		0.1	0.1	0.2
• No. of times > 0.1		0	0	1
Visible oil				
• No. of times observed		0	0	0

The following table summarises the North Drain annual coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Difference in temperature	° C	3.0	0.0	0.1
Minimum dissolved oxygen concentration	mg/litre	5.0	7.8	8.1

North Drain Discharges, Continued

Comments

Discharges from the North Drain were within permit limits during 1999.

The maximum difference in pH of 0.2 between the coastal water and control samples occurred in November. It was not regarded as a violation of the permit limit because the coastal water sample was contaminated with what appeared to be sea lice. The pH of the drain discharge at the time was 8.0 and unlikely to affect the natural pH of the receiving seawater which is normally in the range 8.0 to 8.3.

South Drain Discharges

Introduction

Discharges from the South Drain are covered by Coastal Permit 94503 which commenced on 8 October 1996.

Discharge monitoring results

The following table summarises the South Drain discharge monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Total suspended solids				
• Annual average	g/m ³	-	3.4	3.1
• Maximum quarterly average	g/m ³	30	4.9	4.5
• No. of times quarterly average > 30 g/m ³		0	0	0

Coastal water monitoring results

The following table summarises the South Drain weekly coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Fluoride				
• Annual average	g/m ³	-	1.3	1.3
• Maximum quarterly average	g/m ³	2.0	1.3	1.3
• No. of times quarterly average > 2.0 g/m ³		0	0	0
• Maximum individual sample	g/m ³	5.0	1.5	1.5
• No. of times individual sample > 5.0 g/m ³		0	0	0
pH				
• Maximum difference		0.1	0.1	0.1
• No. of times > 0.1		0	0	0
Visible oil				
• No. of times observed		0	0	0

The following table summarises the South Drain annual coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Difference in temperature	° C	3.0	0.1	0.7
Minimum dissolved oxygen concentration	mg/litre	5.0	8.0	8.1

Comments

Discharges from the South Drain were within permit limits during 1999.

West Drain Discharges

Introduction

Discharges from the West Drain are covered by Coastal Permit 94502 which commenced on 8 October 1996.

Discharge monitoring results

The following table summarises the West Drain discharge monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Total suspended solids				
• Annual average	g/m ³	-	7.2	8.9
• Maximum quarterly average	g/m ³	30	10.9	15.4
• No. of times quarterly average > 30 g/m ³		0	0	0

Coastal water monitoring results

The following table summarises the West Drain weekly coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Fluoride				
• Annual average	g/m ³	-	1.3	1.3
• Maximum quarterly average	g/m ³	2.0	1.3	1.3
• No. of times quarterly average > 2.0 g/m ³		0	0	0
• Maximum individual sample	g/m ³	5.0	1.3	1.4
• No. of times individual sample > 5.0 g/m ³		0	0	0
pH				
• Maximum difference		0.1	0.1	0.2
• No. of times > 0.1		0	0	1
Visible oil				
• No. of times observed		0	0	0

The following table summarises the West Drain annual coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Difference in temperature	° C	3.0	0.0	0.1
Minimum dissolved oxygen concentration	mg/litre	5.0	7.9	8.0

West Drain Discharges, Continued

Comments

Discharges from the West Drain were within permit limits during 1999.

The maximum difference in pH of 0.2 between the coastal water and control samples occurred in January. It was not regarded as a violation of the permit limit as the pH of the drain discharge was the same as the control site. This indicates that the discharge was unlikely to affect the pH of the background coastal water represented by seawater at the control site.

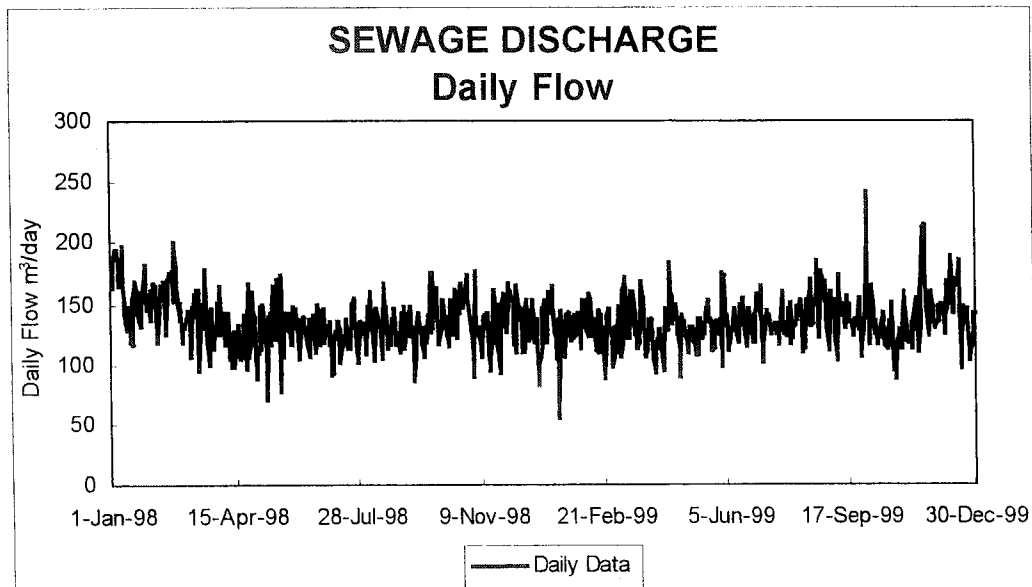
Treated Sewage Discharges

Introduction

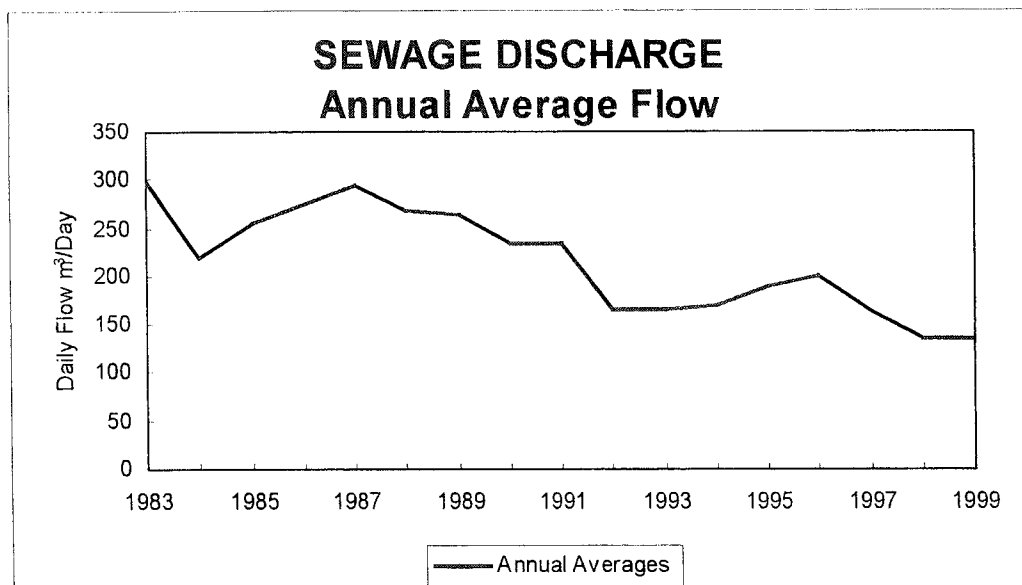
Discharges of treated sewage onto land are covered by Discharge Permit Number 96122, which was granted on 16 October 1996.

Discharge monitoring results

The following graph shows the daily sewage discharge flow during 1998 and 1999. The permit limit for daily flow is 295 m³/day.



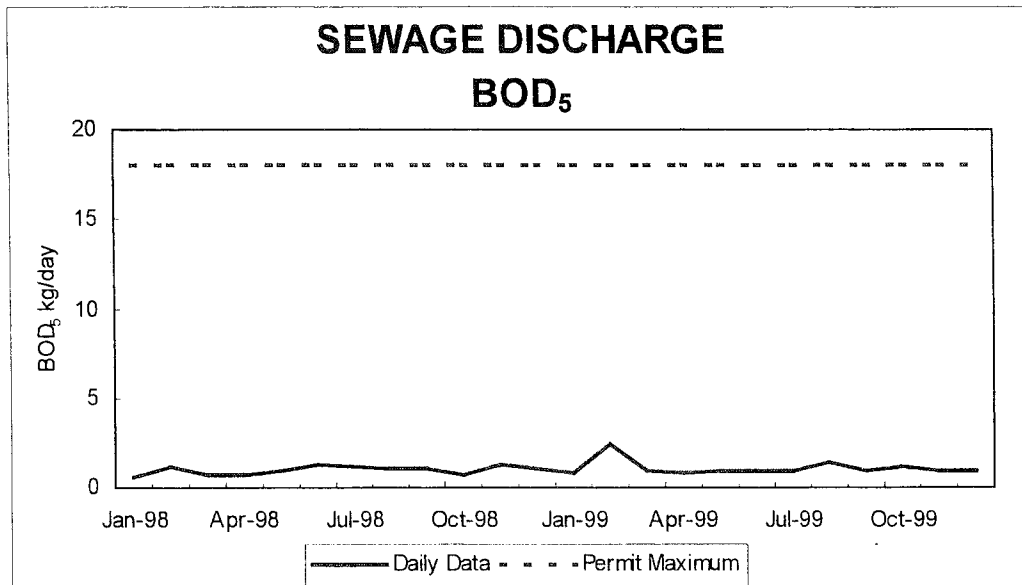
The following graph shows the annual average daily sewage discharge flow.



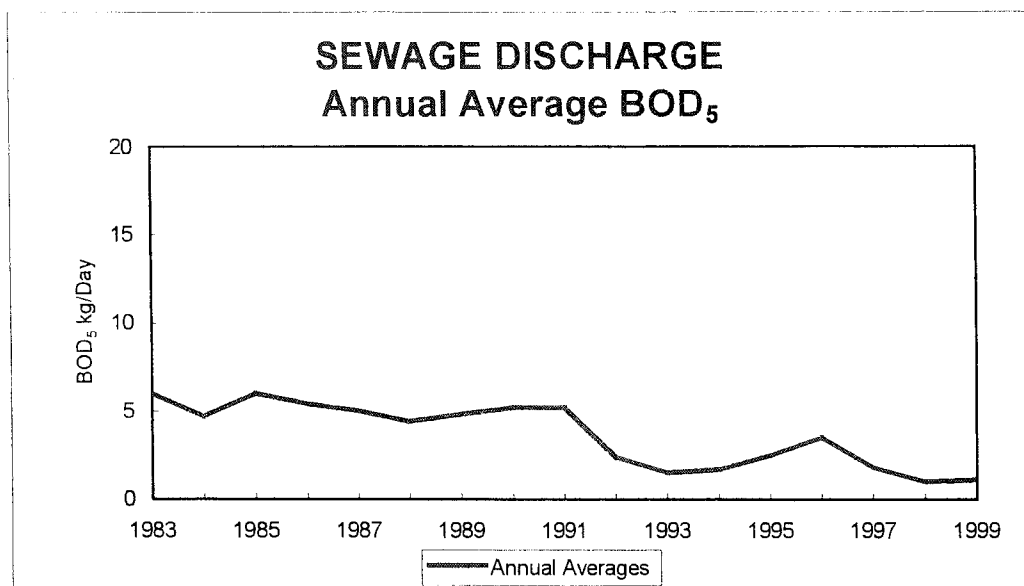
Treated Sewage Discharges, Continued

Discharge monitoring results, continued

The following graph shows the monthly biochemical oxygen demand (BOD₅) discharge from the sewage treatment plant during 1998 and 1999. The permit limit for BOD₅ is 18kg/day.



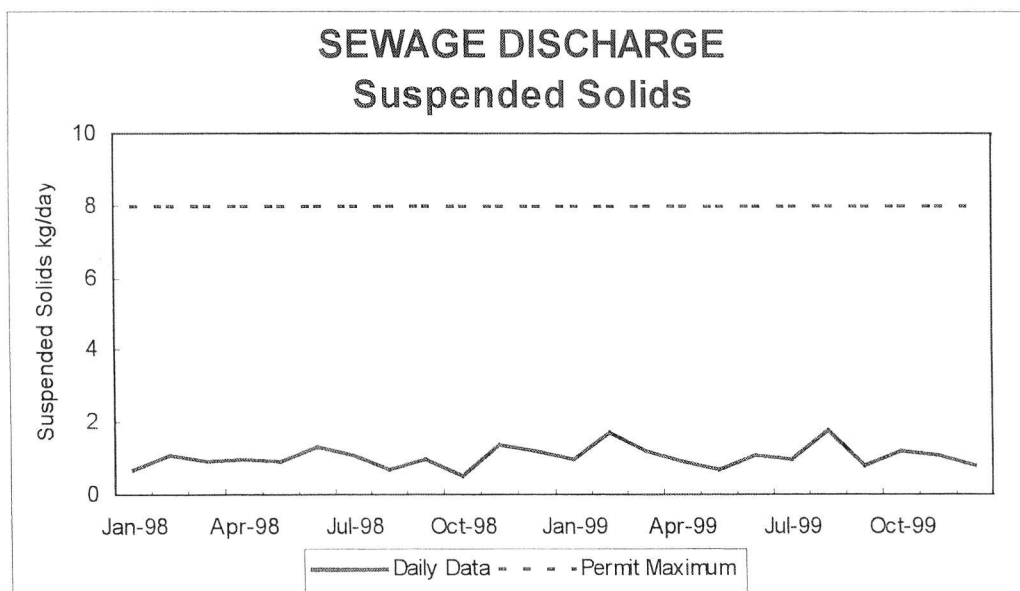
The following graph shows the annual average BOD₅ discharge from the sewage treatment plant.



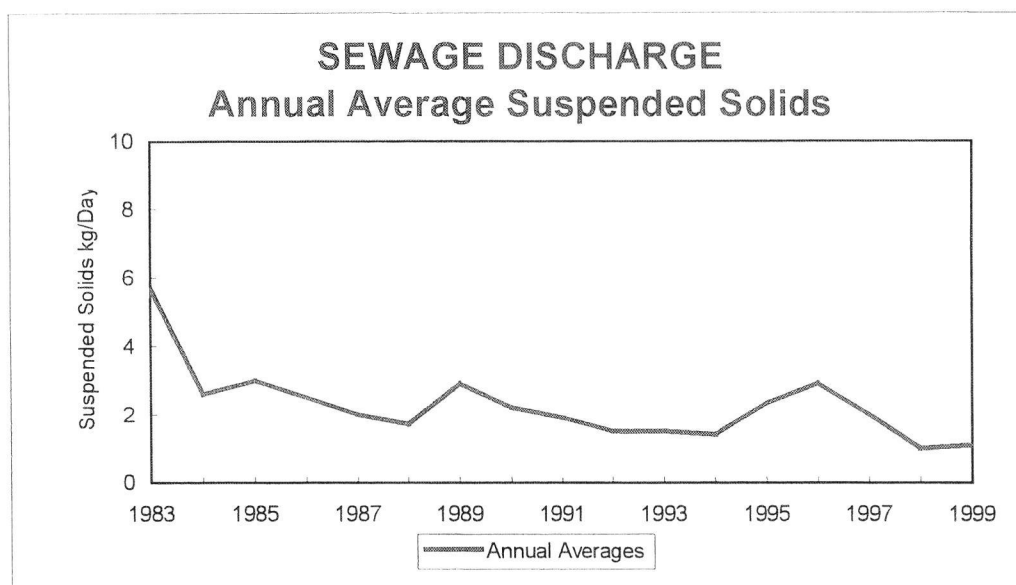
Treated Sewage Discharges, Continued

Discharge monitoring results, continued

The following graph shows the monthly suspended solids discharge from the sewage treatment plant during 1998 and 1999. The permit limit for suspended solids is 8 kg/day.



The following graph shows the annual average suspended solids discharge from the sewage treatment plant.



Treated Sewage Discharges, Continued

Land disposal area groundwater monitoring results

The following table summarises the results of groundwater monitoring near to the area where sewage is discharged to land. The location of the bores is shown in the map on page LD.2.

Parameter	Units	1998	1999	
		Average	Average	Range
North Bore (Upstream)				
Faecal coliforms	MPN/100 ml	< 2	< 2	< 2
Total phosphorus	g.m ⁻³	0.12	0.09	0.07 - 0.11
Total ammoniacal-N	g.m ⁻³	0.02	0.02	0.01 - 0.02
Nitrate-N	g.m ⁻³	0.03	0.028	0.020 – 0.035
Total nitrogen	g.m ⁻³	0.15	0.18	0.16 - 0.20
pH		8.0	7.9	7.9
Conductivity	μS.cm ⁻¹	318	313	312 –314
South Bore (Downstream)				
Faecal coliforms	MPN/100 ml	< 2	12	<2 – 23
Total phosphorus	g.m ⁻³	0.03	0.04	0.03 – 0.04
Total ammoniacal-N	g.m ⁻³	0.01	0.02	0.01 – 0.02
Nitrate-N	g.m ⁻³	0.17	0.28	0.20 – 0.35
Total nitrogen	g.m ⁻³	0.37	0.54	0.45 – 0.62
pH		7.9	7.6	7.4 – 7.7
Conductivity	μS.cm ⁻¹	397	319	252 - 386

Treated Sewage Discharges, Continued

Comments

The discharges of treated sewage onto land during 1999 were within permit limits.

The daily discharge flow was higher than normal on 1 October and 17 to 18 November. This may be due to stormwater entering the sewerage system during heavy rainfall events. Although investigated, the location of possible stormwater entry has not been determined.

The nitrate nitrogen and total nitrogen concentrations in the groundwater downstream of the sewage land disposal area are higher than previous results. The increase is minor and the concentrations are unlikely to cause any significant environmental effects.

The faecal coliform content of the ground water downstream of the sewage land disposal area during Quarter Four was 23 MPN/100 ml. Although higher than previously reported it is unlikely that the increased bacteria level in the groundwater will have a significant effect on the receiving seawater. It is expected that most, if not all, of the bacteria will die off during the time the ground water travels to the coast.

Treated Effluent Discharges

Introduction

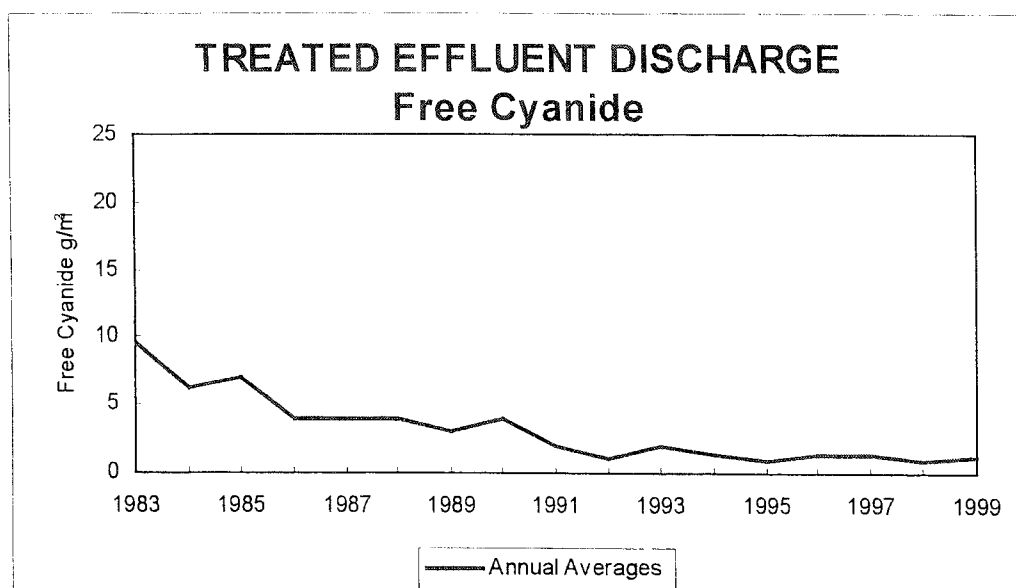
Discharges of treated effluent into Foveaux Strait are covered by Coastal Permit Number 94488 which commenced on 11 October 1996.

Discharge monitoring results

The following table summarises the results of treated effluent discharge monitoring during 1999 and shows a comparison with the 1998 results.

Parameter	Units	Limits	1998 Result	1999 Result
Maximum daily discharge	m ³ /day	140	85	80
Suspended solids				
Maximum concentration	g.m ⁻³	100	28.0	26.0
Average concentration	g.m ⁻³	-	5.9	7.3
No. of times > 100 g.m ⁻³		0	0	0
Free cyanide				
Maximum concentration	g.m ⁻³	20	2.6	5.8
Average concentration	g.m ⁻³	-	0.9	1.2
No. of times > 100 g.m ⁻³		0	0	0

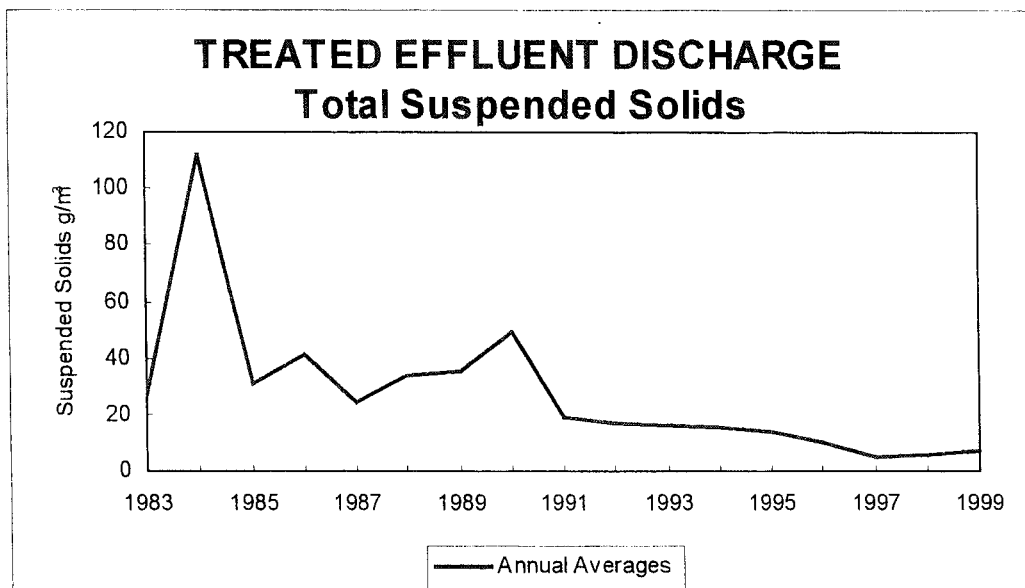
The following graph shows the annual average free cyanide concentration of treated effluent discharged.



Treated Effluent Discharges, Continued

Discharge monitoring results, continued

The following graph shows the annual average total suspended solids concentration of treated effluent discharged.



Coastal water monitoring results

The following table summarises the treated effluent annual coastal water monitoring results during 1999 and shows a comparison with 1998 results.

Parameter	Units	Limit	1998 Result	1999 Result
Difference in temperature	° C	3.0	0.0	0.0
Minimum dissolved oxygen concentration	mg/litre	5.0	8.0	7.8
Change to pH		0.1	0.0	0.0
No. of times visible oil observed		0	0	0

Comments

All discharges of treated effluent were within permit limits during 1999.

Landfill Operations

Introduction

Operation of the landfill on the smelter's Tiwai Point property is covered by Discharge Permit No. 94460 issued by the Southland Regional Council on 30 October 1995.

This report covers:

- proposed operation at the landfill for the next twelve months,
- the amount and type of materials deposited at the landfill, and
- groundwater monitoring.

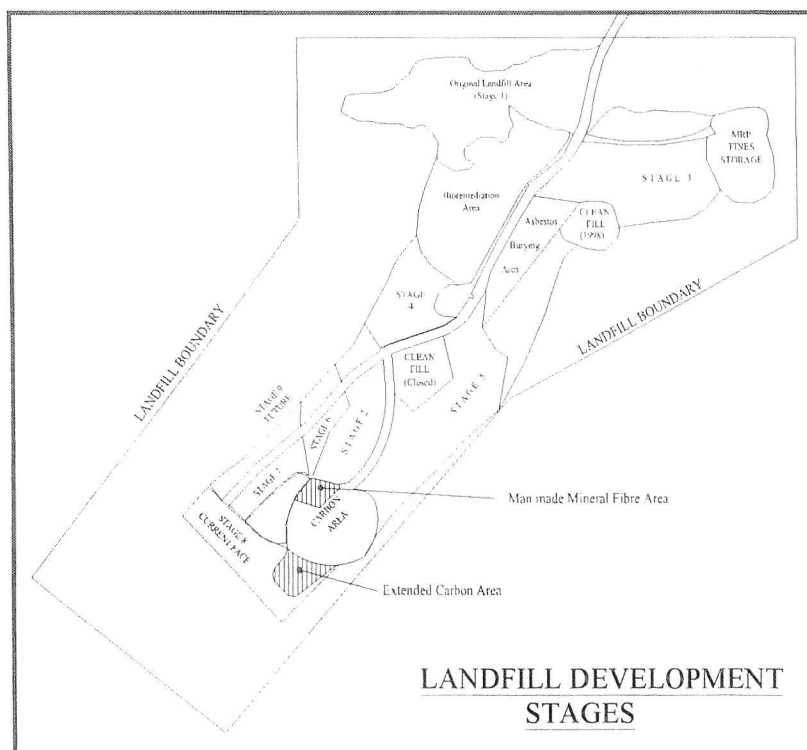
Proposed Operation For 2000

Introduction

The proposed operation of the landfill for 2000 as outlined in the NZAS Landfill Management Plan. Additional details on the proposed operations during 2000 are included in the following sections.

Landfill areas being developed or extended

The following map shows the current and previous landfill disposal and storage areas.



Proposed Operation For 2000, Continued

Landfill areas being developed or extended, continued

A number of new areas were developed or extended during 1999:

- the southern end of the MRP fines disposal area was utilised,
- the carbon disposal area was extended to the south,
- man made mineral fibres are disposed in the area previously used for carbon disposal, and
- the clean fill area east of the asbestos burial area is now in use and the old clean fill area is closed and covered.

Continued use of the current landfill face at stage 8 is proposed for the disposal of general waste.

Active landfill areas will be defined by concrete sleepers.

NZAS plans to continue the recovery of native flax bushes from the current landfill face (stage 8) for replanting elsewhere in the landfill.

Stormwater Control

NZAS plans to cover the following areas with a layer of pea gravel:

- the surface area up to the current face of the landfill, and
- new sections of the general waste disposal area, as they are completed.

After covering, NZAS plans to continue its practice of levelling and contouring these areas to maximise stormwater run-off and minimise the visual impact of the landfill.

Amount and Type of Materials Deposited

Introduction

Each year the smelter surveys the amount and type of material deposited at the Tiwai Point Landfill. The survey is usually conducted over a period of about four weeks during early summer.

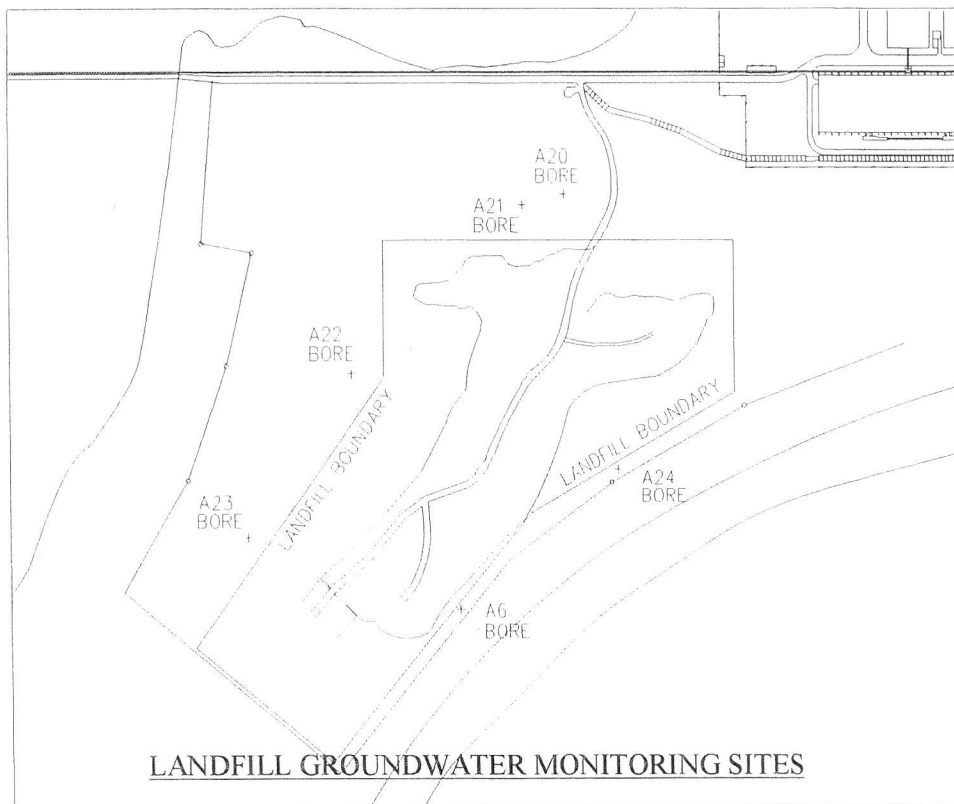
Survey procedure

The survey, normally conducted during Quarter Four each year, was delayed until Quarter One, 2000. The results of the 2000 survey are not available and will be reported in the 2000 report.

Landfill Groundwater Monitoring

Site locations

The locations of the groundwater monitoring bores are as shown in the following map. Two of the bores are north (upstream) of the landfill, and there are two bores south east and two bores west (downstream) of the landfill.



Landfill Groundwater Monitoring, Continued

Bore A20 monitoring results

The table below shows a summary of results from samples collected from bore A20 during 1998 and 1999. Bore A20 is located north of the landfill (upstream).

Parameter	Units	1998 Average	1999	
			Average	Range
PH	-	6.2	6.3	6.3
Total Nitrogen	g.m^{-3}	0.59	0.42	0.38 – 0.46
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	0.4	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	0.13	0.11	0.09 – 0.12
Nitrate Nitrogen	g.m^{-3}	N.D.	0.031	0.029 – 0.032
Nitrite Nitrogen	g.m^{-3}	N.D.	0.002	< 0.002 – 0.003
Alkalinity	g.m^{-3}	58	77	60 – 94
Carbonaceous BOD ₅	g.m^{-3}	2.5	2.3	1.0 – 3.5
Potassium	g.m^{-3}	N.D.	4.1	one sample only
Boron	g.m^{-3}	N.D.	0.044	one sample only
Fluoride	g.m^{-3}	0.13	0.13	0.09 – 0.16
Sulphate	g.m^{-3}	28	34	31 – 36
Temperature	°C	12.3	10.6	9.9 – 11.3
Conductivity	$\mu\text{S.cm}^{-1}$	738	753	722 – 783
Total Iron	g.m^{-3}	4.0	3.4	0.7 – 6.0
Manganese	g.m^{-3}	N.D.	0.31	one sample only
Vanadium	g.m^{-3}	N.D.	0.002	one sample only
Nickel	g.m^{-3}	N.D.	0.0025	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	< 0.001	one sample only

Landfill Groundwater Monitoring, Continued

Bore A21 monitoring results

The table below shows a summary of results from samples collected from bore A21 during 1998 and 1999. Bore A21 is located north of the landfill (upstream).

Parameter	Units	1998	1999	
		Average	Average	Range
PH	-	5.9	5.8	5.3 – 6.3
Total Nitrogen	g.m^{-3}	3.2	4.6	1.1 – 8.0
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	6.5	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	0.56	2.3	0.07 – 4.6
Nitrate Nitrogen	g.m^{-3}	N.D.	0.060	0.012 – 0.108
Nitrite Nitrogen	g.m^{-3}	N.D.	0.007	0.006 – 0.008
Alkalinity	g.m^{-3}	67	85	10 – 160
Carbonaceous BOD ₅	g.m^{-3}	3.9	8.5	1.0 – 16
Potassium	g.m^{-3}	N.D.	6.7	one sample only
Boron	g.m^{-3}	N.D.	0.077	one sample only
Fluoride	g.m^{-3}	0.34	0.46	0.19 – 0.73
Sulphate	g.m^{-3}	68	42	29 – 55
Temperature	°C	13.0	11.0	10.1 – 11.8
Conductivity	$\mu\text{S.cm}^{-1}$	1,085	1,180	1,010 – 1,350
Total Iron	g.m^{-3}	50.9	54.9	15.1 – 94.6
Manganese	g.m^{-3}	N.D.	0.47	one sample only
Vanadium	g.m^{-3}	N.D.	0.043	one sample only
Nickel	g.m^{-3}	N.D.	0.0041	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	< 0.001	one sample only
Naphthalene	mg.m^{-3}	0.011	< 0.05	< 0.005 - < 0.05
Anthracene	mg.m^{-3}	< 0.005	< 0.005	< 0.005
Phenanthrene	mg.m^{-3}	< 0.005	< 0.005	< 0.005
Fluoranthrene	mg.m^{-3}	< 0.005	< 0.005	< 0.005

Landfill Groundwater Monitoring, Continued

Bore A22 monitoring results

The table below shows the averages of results from samples collected from bore A22 during 1998 and 1999. Bore A22 is located west of the landfill.

Parameter	Units	1998 Average	1999	
			Average	Range
PH	-	5.2	5.6	5.3 – 5.9
Total Nitrogen	g.m^{-3}	1.85	0.85	0.80 – 0.89
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	0.9	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	0.29	0.22	0.08 – 0.35
Nitrate Nitrogen	g.m^{-3}	N.D.	0.015	0.013 – 0.016
Nitrite Nitrogen	g.m^{-3}	N.D.	0.006	0.006
Alkalinity	g.m^{-3}	11	18	9 – 26
Carbonaceous BOD ₅	g.m^{-3}	< 3	4	< 2 – 6
Potassium	g.m^{-3}	N.D.	2.9	one sample only
Boron	g.m^{-3}	N.D.	0.054	one sample only
Fluoride	g.m^{-3}	1.06	1.07	0.43 – 1.70
Sulphate	g.m^{-3}	13	12	10 – 13
Temperature	°C	12.1	10.2	10.0 – 10.3
Conductivity	$\mu\text{S.cm}^{-1}$	518	473	465 – 480
Total Iron	g.m^{-3}	2.1	1.74	1.65 – 1.83
Manganese	g.m^{-3}	N.D.	0.025	one sample only
Vanadium	g.m^{-3}	N.D.	0.007	one sample only
Nickel	g.m^{-3}	N.D.	0.0007	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	< 0.001	one sample only

Landfill Groundwater Monitoring, Continued

Bore A23 monitoring results

The table below shows a summary of results from samples collected from bore A23 during 1998 and 1999. Bore A23 is located west of the landfill.

Parameter	Units	1998	1999	
		Average	Average	Range
PH	-	5.7	5.9	5.8 – 5.9
Total Nitrogen	g.m^{-3}	2.5	2.2	2.0 – 2.3
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	1.8	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	1.13	1.3	1.2 – 1.4
Nitrate Nitrogen	g.m^{-3}	N.D.	0.014	0.013 – 0.015
Nitrite Nitrogen	g.m^{-3}	N.D.	0.008	0.004 – 0.011
Alkalinity	g.m^{-3}	46	48	47 – 48
Carbonaceous BOD ₅	g.m^{-3}	< 3	< 2	< 2
Potassium	g.m^{-3}	N.D.	5.0	one sample only
Boron	g.m^{-3}	N.D.	0.044	one sample only
Fluoride	g.m^{-3}	0.08	0.05	< 0.05 – 0.06
Sulphate	g.m^{-3}	< 1	< 1	< 1
Temperature	°C	12.5	10.3	10.1 – 10.5
Conductivity	$\mu\text{S.cm}^{-1}$	580	589	580 – 597
Total Iron	g.m^{-3}	8.3	6.4	5.2 – 7.6
Manganese	g.m^{-3}	N.D.	0.059	one sample only
Vanadium	g.m^{-3}	N.D.	0.013	one sample only
Nickel	g.m^{-3}	N.D.	0.0011	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	< 0.001	one sample only

Landfill Groundwater Monitoring, Continued

Bore A24 monitoring results

The table below shows a summary of results from samples collected from bore A24 during 1998 and 1999. Bore A24 is located south east of the landfill.

Parameter	Units	1998 Average	1999	
			Average	Range
PH	-	7.1	7.2	7.1 – 7.3
Total Nitrogen	g.m^{-3}	80	117	81 – 152
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	67	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	63	105	65 – 146
Nitrate Nitrogen	g.m^{-3}	N.D.	0.13	0.089 – 0.17
Nitrite Nitrogen	g.m^{-3}	N.D.	0.14	0.01 – 0.26
Alkalinity	g.m^{-3}	988	1,065	949 – 1,180
Carbonaceous BOD ₅	g.m^{-3}	7.6	10	2 – 17
Potassium	g.m^{-3}	N.D.	31.3	one sample only
Boron	g.m^{-3}	N.D.	5.48	one sample only
Fluoride	g.m^{-3}	0.61	3.04	0.56 – 5.52
Sulphate	g.m^{-3}	161	26	14 – 38
Temperature	°C	12.8	11.3	10.2 – 12.4
Conductivity	$\mu\text{S.cm}^{-1}$	3,125	3,650	2,890 – 4,410
Total Iron	g.m^{-3}	19.5	18.2	14.3 – 22.0
Manganese	g.m^{-3}	N.D.	0.125	one sample only
Vanadium	g.m^{-3}	N.D.	0.329	one sample only
Nickel	g.m^{-3}	N.D.	0.006	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	0.005	one sample only
Naphthalene	mg.m^{-3}	81	4.60	4.34 – 4.85
Anthracene	mg.m^{-3}	0.079	0.088	0.069 – 0.107
Phenanthrene	mg.m^{-3}	0.026	0.018	< 0.005 – 0.030
Fluoranthrene	mg.m^{-3}	0.008	0.022	0.007 – 0.036

Landfill Groundwater Monitoring, Continued

Bore A6 monitoring results

The table below shows a summary of results from samples collected from bore A6 during 1998 and 1999. Bore A6 is located south east of the landfill.

Parameter	Units	1998	1999	
		Average	Average	Range
PH	-	6.7	6.7	6.6 – 6.8
Total Nitrogen	g.m^{-3}	25	30	29 – 30
Total Kjeldahl Nitrogen	g.m^{-3}	N.D.	23.4	one sample only
Total Ammoniacal Nitrogen	g.m^{-3}	22.8	20.3	15.8 – 24.7
Nitrate Nitrogen	g.m^{-3}	N.D.	1.5	0.55 – 2.4
Nitrite Nitrogen	g.m^{-3}	N.D.	< 0.02	< 0.02
Alkalinity	g.m^{-3}	630	694	576 – 812
Carbonaceous BOD ₅	g.m^{-3}	< 3	3.2	3.0 – 3.3
Potassium	g.m^{-3}	N.D.	21.6	one sample only
Boron	g.m^{-3}	N.D.	1.45	one sample only
Fluoride	g.m^{-3}	7.3	10.0	9.3 – 10.7
Sulphate	g.m^{-3}	1,200	1,035	855 – 1,215
Temperature	°C	13.5	12.2	11.5 – 12.8
Conductivity	$\mu\text{S.cm}^{-1}$	3,815	3,745	3,150 – 4,340
Total Iron	g.m^{-3}	17.1	15.8	14.0 – 17.7
Manganese	g.m^{-3}	N.D.	1.85	one sample only
Vanadium	g.m^{-3}	N.D.	0.103	one sample only
Nickel	g.m^{-3}	N.D.	0.014	one sample only
Total Petroleum Hydrocarbons	g.m^{-3}	< 1	< 0.5	one sample only
Weak Acid Dissociable Cyanide	g.m^{-3}	N.D.	0.018	one sample only
Naphthalene	mg.m^{-3}	< 0.005	< 0.05	< 0.005 - < 0.05
Anthracene	mg.m^{-3}	0.21	0.16	0.08 – 0.25
Phenanthrene	mg.m^{-3}	0.018	0.020	0.017 – 0.022
Fluoranthrene	mg.m^{-3}	< 0.005	0.005	< 0.005 – 0.005

Landfill Groundwater Monitoring, Continued

Comments

Apart from Bore A24 the groundwater monitoring data from the bores near the landfill do not indicate any significant trends in the general groundwater quality during 1999.

Samples collected from Bore A24 in Quarter Four contained higher concentrations of nitrogen species, fluoride and fluoranthrene than previously measured at this bore. The increased concentrations are unlikely to have an impact on the receiving seawater in Foveaux Strait.

An additional sample collected from Bore A24 later in Quarter Four contained concentrations of nitrogen species and fluoranthrene within or only slightly higher than the previous range of results. Fluoride, at 4.4 g.m^{-3} , remained higher than the previous range of results.

The analyte concentrations at Bore A24 most likely indicate the proximity of the bore to the MRP fines storage area. It is likely that:

- variations in the analyte concentrations are related to variations in the amount of leachate entering the groundwater, and
- increased analyte concentrations represent periods when high rainfall produces larger volumes of leachate.

The hydraulic conductivity of groundwater east of the landfill was estimated at about 2.5 m/day in 1994 by consultants employed by NZAS. Bore A24 is about 200 metres south west of the MRP fines storage area. Variation of analyte concentrations in groundwater sampled at Bore A24 is likely to represent variation in leachate volume near the MRP fines storage area at least three months previously.

Groundwater

Spent Cathode Pad Leachate

The monitoring of the recovery, by natural dispersion, of the contaminated plume in the groundwater south of the spent cathode lining pad (SCL Pad) continued. An annual report on this monitoring was submitted to the Southland Regional Council (SRC) in July 1999.

A summary of the findings included in the report on the 1999 monitoring of the bores south of the SCL Pad is that the contaminant concentrations in:

- groundwater immediately south of the SCL Pad were close to the recommended 90% clean up criteria in both the pea gravel and fine sands layers,
- the midshore zone, between the SCL Pad and the coast, are close to or below the recommended 90% clean up criteria in the pea gravel layer and about 70% recovered in the fine sands layer,
- the coastal zone are about 70% recovered in both the pea gravel and fine sands layers, and
- the receiving seawater were within the range of results previously reported and are unlikely to be a threat to the environment.

As a result of the monitoring the SRC recommended cessation of monitoring for three years followed by a "snapshot" monitoring exercise. Future monitoring would be contingent on the "snapshot" results.

Bioremediation of Diesel Contamination

Annual monitoring to confirm that there is no potential for diesel to migrate off site was initiated during 1997. An annual report on this monitoring was submitted to the Southland Regional Council (SRC) in July 1999.

The report concluded that the levels of total petroleum hydrocarbons in the groundwater from four bores downstream of the diesel plume are

- close to or below the level of detection of the analytical method,
- similar to the concentrations determined in 1998, and
- confirm there is no movement of the plume downstream or off site.

As with the Spent Cathode Pad Leachate monitoring, the SRC recommended that monitoring cease for three years followed by "snapshot" monitoring with future monitoring contingent on the "snapshot" results.

Spent Cell Lining Storage Shed

Monitoring of the membranes under the Spent Cell Lining storage shed indicated minor leakage into the leak detection system. The volume of and the contaminant concentrations in the leaked liquid were both low and as there is no indication that the liquid was able to escape from the detection system it is unlikely to be a risk to the ground water.

Disposal of sludge from the treated effluent plant is suspected of contributing to the leak. Changed management of the sludge disposal has minimised the leak.