N015-020

New Zealand Aluminium Smelters Limited

Interdepartmental

Committee

Report

1998

REPORT TO THE INTERDEPARTMENTAL COMMITTEE ON ENVIRONMENTAL EFFECTS OF THE TIWAI ALUMINIUM SMELTER FOR THE YEAR ENDING 31 DECEMBER 1998

MEETING AT TIWAI
26 MAY 1999

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

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Summary

A number of conditions of Air Discharge and Coastal Permit Number 93566 were revised following NZAS' application to change or cancel some conditions which was approved by the Southland Regional Council on 5 August 1998. The changes included higher permit standards for Potline roof louvre discharges derived using the correct roof louvre gas flow and reduced environmental effects monitoring requirements.

Main stack discharges of fluoride and particulate were generally stable during 1998 although the particulate discharge was higher than normal in June, July, and November.

Potline roof louvre discharges were stable during 1998, as the cell operations within the reduction lines remained stable throughout the year.

Meteorological conditions were generally drier and more windy during 1998 with west and north-west winds predominating.

Ambient air gaseous fluoride concentrations measured at sites off Tiwai Peninsula were similar to those reported for 1997. Monitoring at 1Km Hut was changed to Australian Standard AS 3580 in August. The change coincided with a significant increase in the fluoride concentration measured. The increase at 1 Km Hut was most likely due to the method change.

Fluoride measured in pasture, cattle urine, and cattle bone on Grazing Monitor Farms and in ungrazed grass confirmed the lower exposure to fluoride at sites affected by the main stack discharge.

The fluoride concentrations of pinus radiata needles during 1998 were similar to or lower than the fluoride concentrations reported for 1997.

The smelter's discharges from drains and of treated effluent and their effects on the environment were similar to previous years.

Discharge of treated sewage into Awarua Bay ceased and onto land commenced on 25 September 1998. Monitoring of coastal water and groundwater likely to be effected by the treated sewage discharge indicated there was little or no effect on the environment.

Monitoring of groundwater near the landfill and near the new sewage land disposal area did not indicate any significant trends during 1998.

Monitoring of the cathode pad area groundwater contamination plume indicated that the contamination continued to decrease. As a result the Southland Regional Council agreed that NZAS could again reduce the monitoring program.

Summary

A number of conditions of Air Discharge and Coastal Permit Number 93566 were revised following NZAS' application to change or cancel some conditions which was approved by the Southland Regional Council on 5 August 1998. The changes included higher permit standards for Potline roof louvre discharges derived using the correct roof louvre gas flow and reduced environmental effects monitoring requirements.

Main stack discharges of fluoride and particulate were generally stable during 1998 although the particulate discharge was higher than normal in June, July, and November. Main stack sulphur dioxide discharges increased during 1998 but the increase was not supported by increased sulphur content or consumption rates of raw materials.

Potline roof louvre discharges were stable during 1998, as the cell operations within the reduction lines remained stable throughout the year.

Meteorological conditions were generally drier and more windy during 1998 with west and north-west winds predominating.

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Fluoride measured in pasture, cattle urine, and cattle bone on Grazing Monitor Farms and in ungrazed grass confirmed the lower exposure to fluoride at sites affected by the main stack discharge.

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Monitoring of groundwater near the landfill and near the new sewage land disposal area did not indicate any significant trends during 1998.

Monitoring of the cathode pad area groundwater contamination plume indicated that the contamination continued to decrease. As a result the Southland Regional Council agreed that NZAS could again reduce the monitoring program.

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.

Part A

Introduction

Introduction

Operations at NZAS remained stable throughout 1998 and initiatives to improve the smelter's efficiency continued.

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 format of the report has changed from that used last year. The changes are:

- separating the report into parts separated by coloured pages and
- changing the page numbering from a numerical only to an alpha-numerical system.

The changes allow the annual reports to the SRC to be directly included in the report to the Interdepartmental Committee without the cosmetic changes required in previous years.

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

A number of Air Discharge Permit conditions were revised following NZAS' application to change or cancel some conditions which was approved by the SRC in August 1998. Details of the changes are included in the appropriate sections of the report.

Disposal of treated sewage was changed from discharge to Awarua Bay to discharge to land on September 25.

Part B

Discharges to Air

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:

- permit changes regarding discharges to air,
- main stack discharges,
- Potline roof louvre discharges,
- fluoride discharges into air,
- baghouse discharges,
- Carbon Baking Furnace discharge to the main stack,
- Main Stack plume opacity, and
- sulphur contents of raw materials and fuels used in the aluminium smelting process.

Permit Changes Regarding Discharges to Air

The changes to the permit which effect the monitoring or reporting of source discharges to air are:

- Condition C1.6 – higher permit standards for Potline roof louvre discharges derived using the correct roof louvre gas flow,
- Condition D2.2 – annual monitoring of total condensable hydrocarbons and nominated polycyclic aromatic hydrocarbons from the main stack to replace quarterly monitoring of total condensable hydrocarbons, and
- Condition E3 – addition of reporting the toluene soluble content of each pitch shipment.

Main Stack Discharges

Permit changes

The changes which affects the monitoring or reporting of main stack discharges to air is annual reporting of total condensable hydrocarbons and nominated polycyclic aromatic hydrocarbons (PAHs) from the main stack instead of quarterly monitoring of total condensable hydrocarbons from the main stack.

Monitoring results

The following table shows the average main stack monitoring results for 1998. The averages are equivalent to the 12-month running average for the period ending December 1998.

Parameter	Units	Running 12 month average		
		Standard	1998 result	Maximum for any month
Gas flow rate	Sm^3/ min	-	68,800	-
Total particulate	kg/min	3.25	1.76	2.23
Gaseous fluoride	kg/min	0.65	0.12	0.15
Particulate fluoride	kg/min	1.94	0.09	0.10
Sulphur dioxide	kg/min	-	14.32	14.32
Total condensable hydrocarbons	kg/min	-	0.31	-
Polycyclic aromatic hydrocarbons	kg/min	-	0.11	-

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Monitoring results

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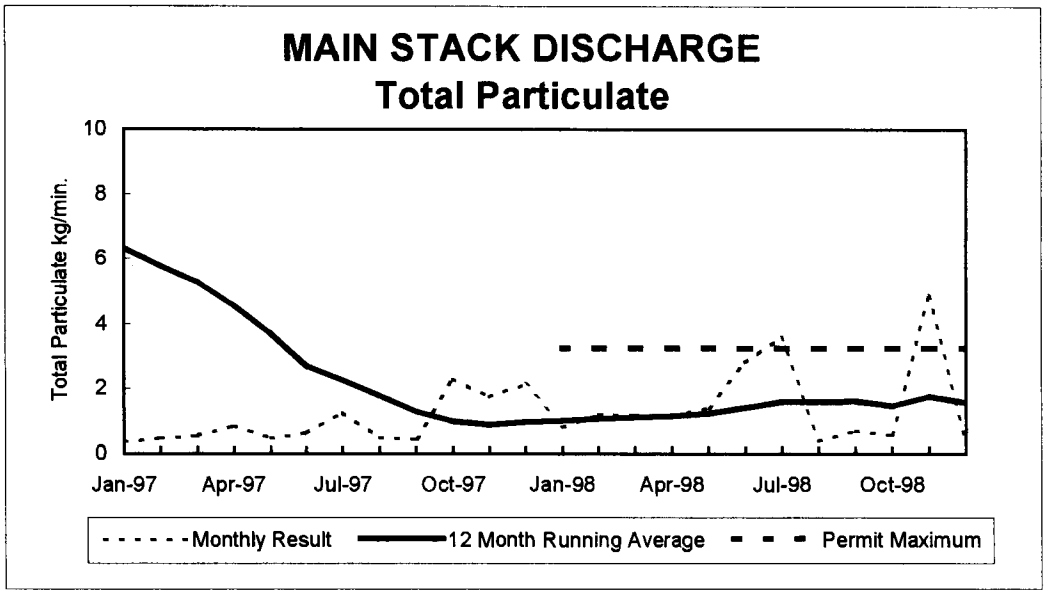
Parameter	Units	Running 12 month average		
		Standard	1998 result	Maximum for any month
Gas flow rate	Sm^3/ min	-	62,200	-
Total particulate	kg/min	3.25	1.58	1.74
Gaseous fluoride	kg/min	0.65	0.11	0.14
Particulate fluoride	kg/min	1.94	0.10	0.10
Sulphur dioxide	kg/min	-	12.9	13.0
Total condensable hydrocarbons	kg/min	-	0.31	-
Polycyclic aromatic hydrocarbons	kg/min	-	0.11	-

Main Stack Discharges, Continued

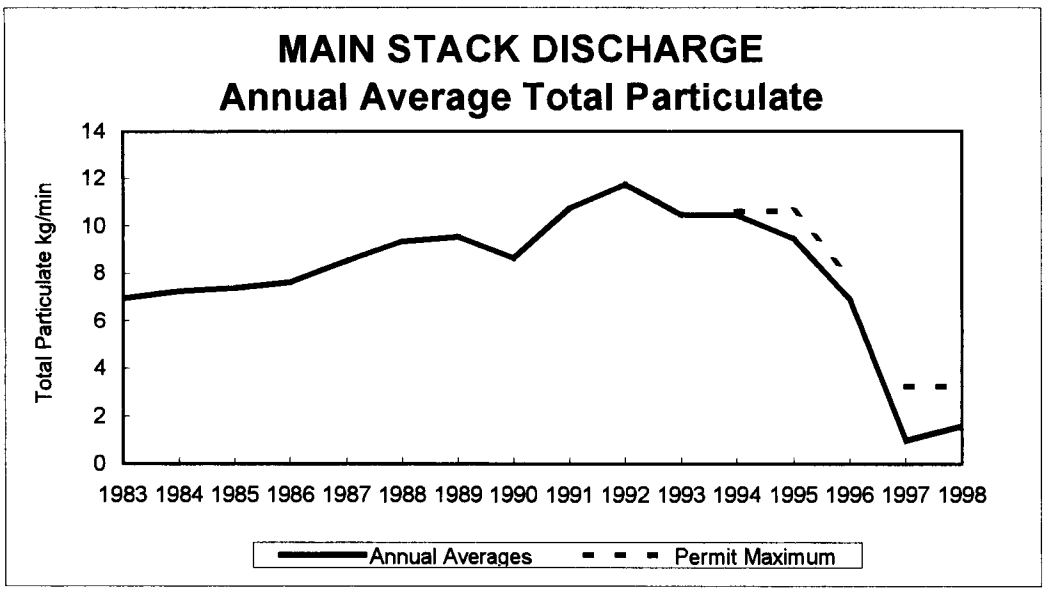
Total particulate

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 1997 and 1998.



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



Main Stack Discharges, Continued

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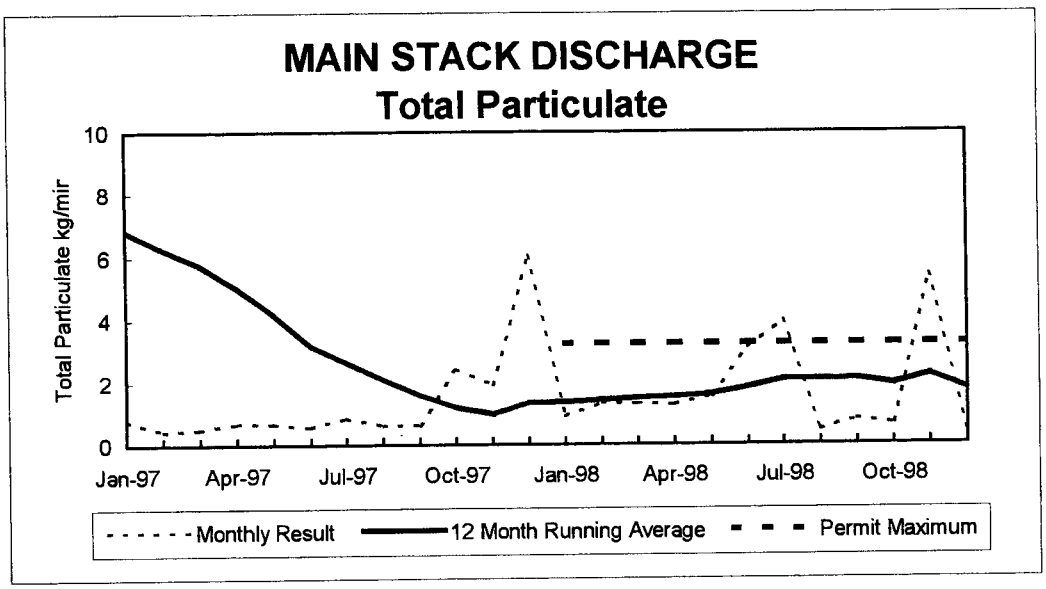
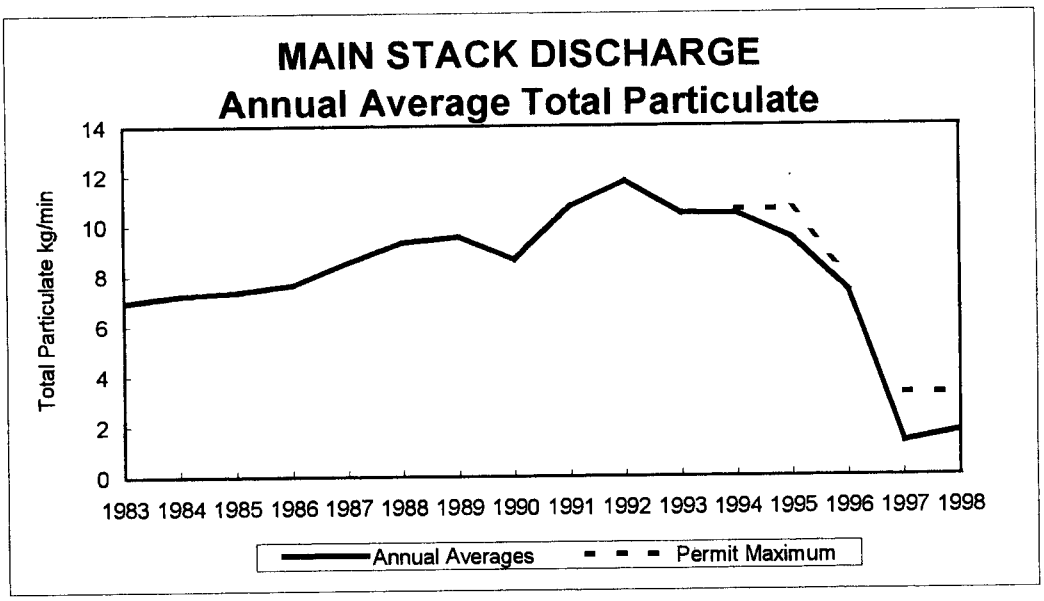


The following graph shows the annual average main stack total particulate discharge.

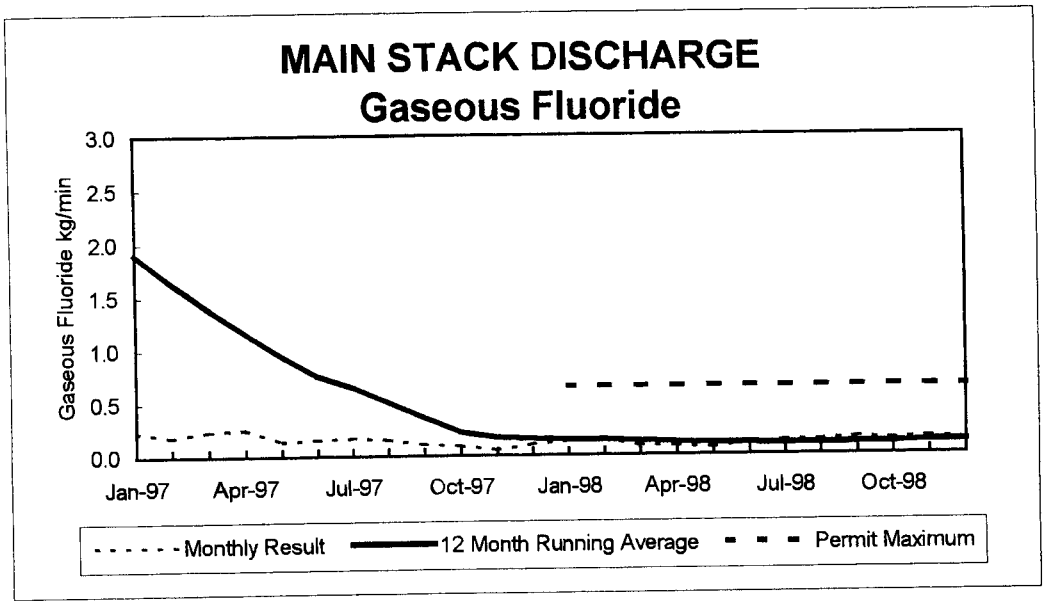


Main Stack Discharges, Continued

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 1997 and 1998.



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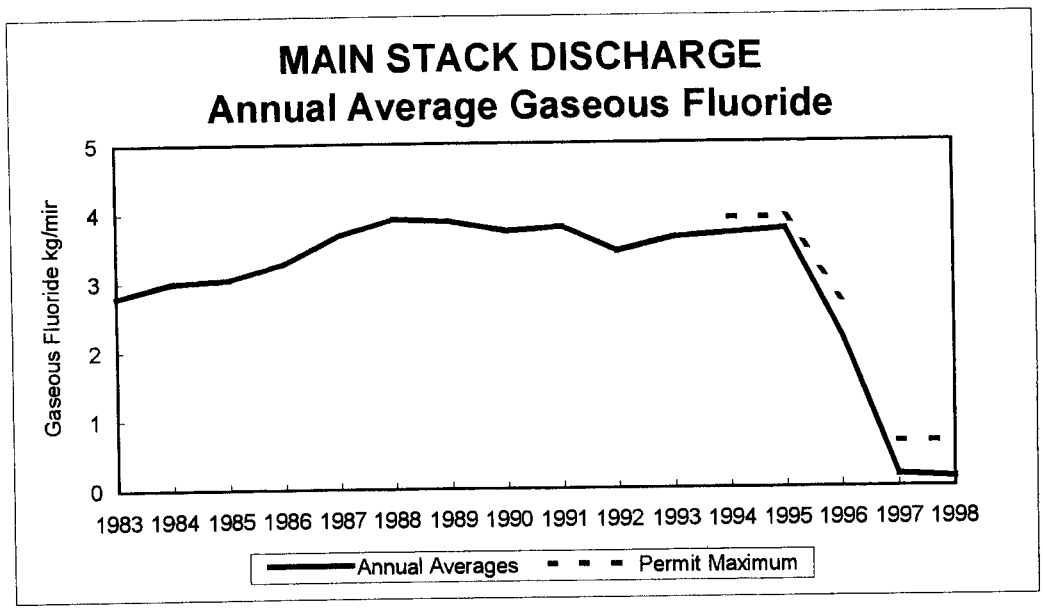

Main Stack Discharges, Continued

Gaseous fluoride

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

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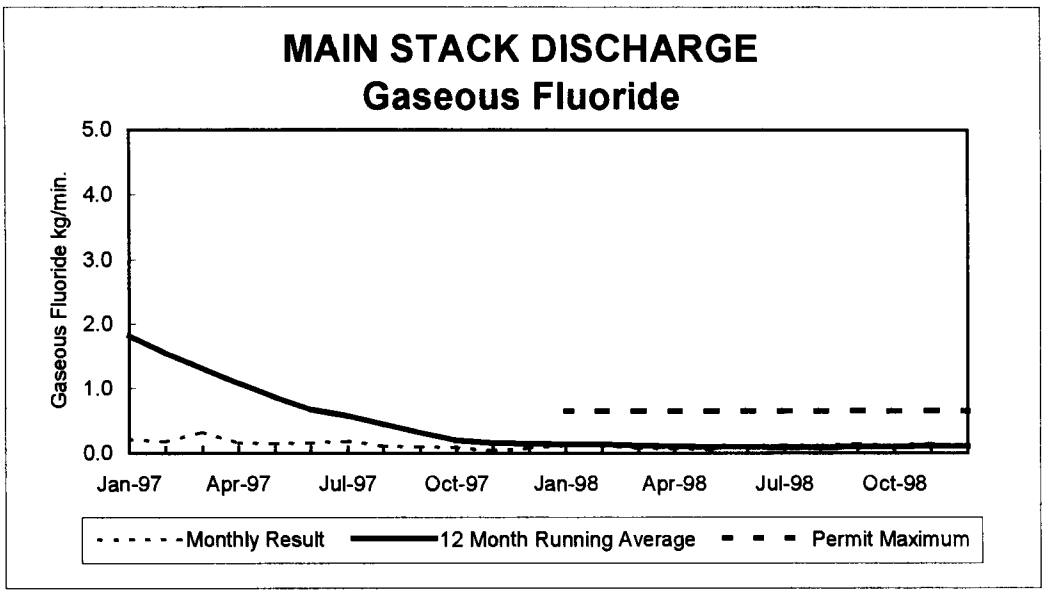
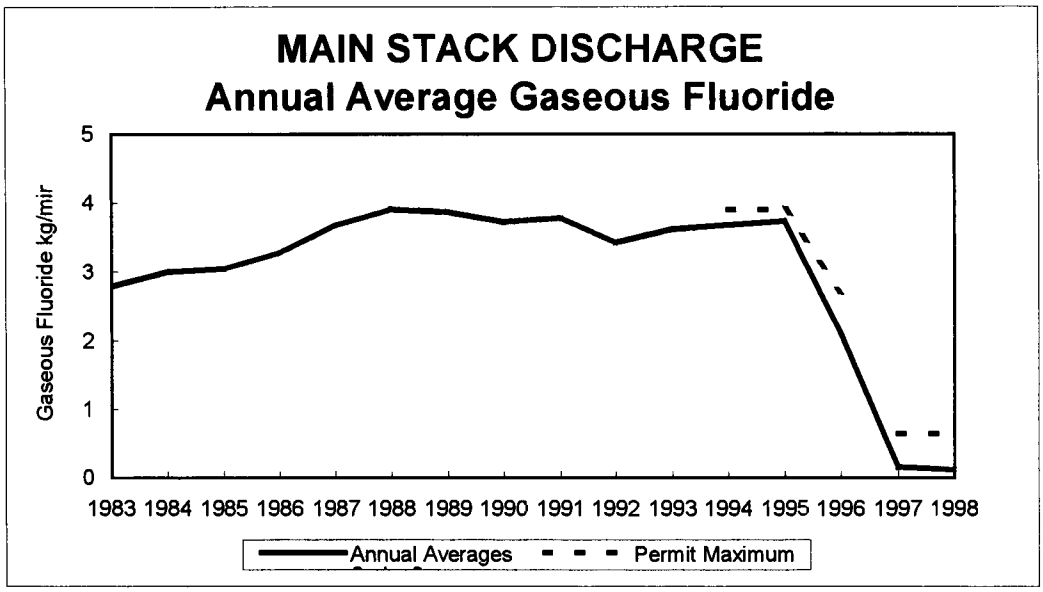


The following graph shows the annual average main stack gaseous fluoride discharge.

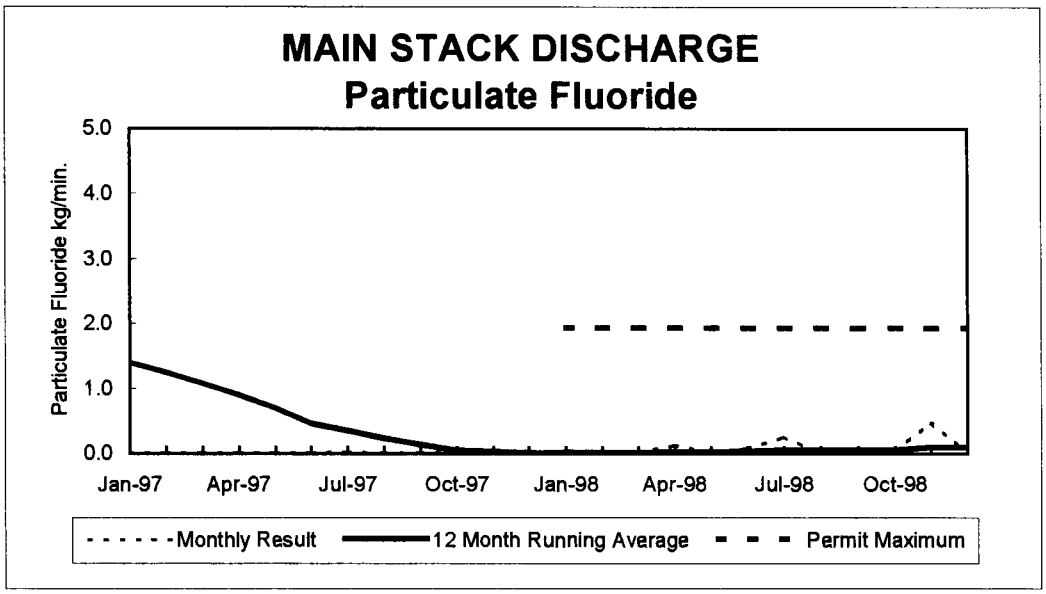


Main Stack Discharges, Continued

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 1997 and 1998.



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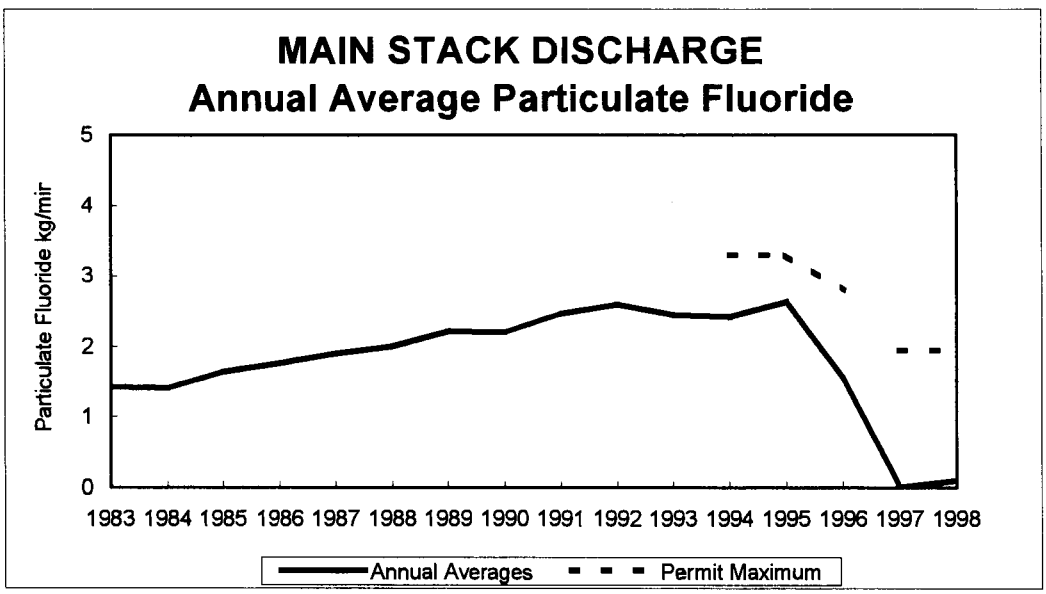

Main Stack Discharges, Continued

Particulate fluoride

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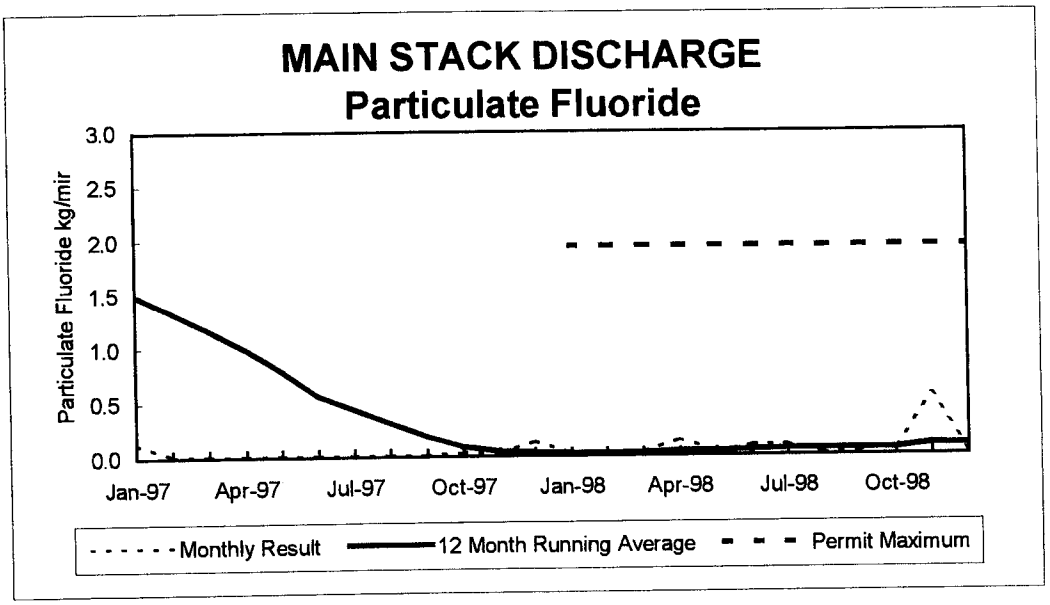

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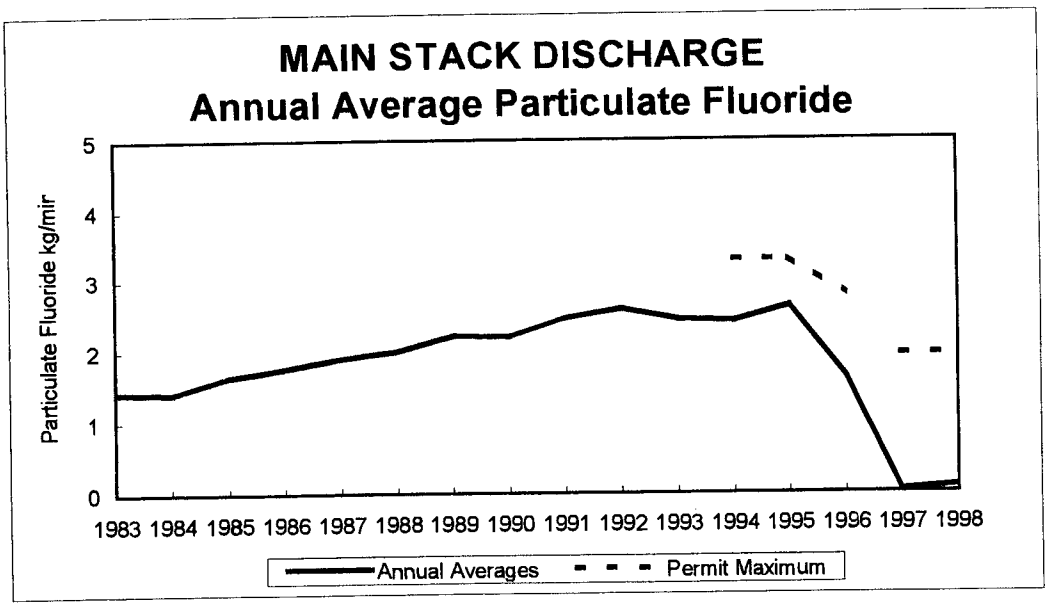
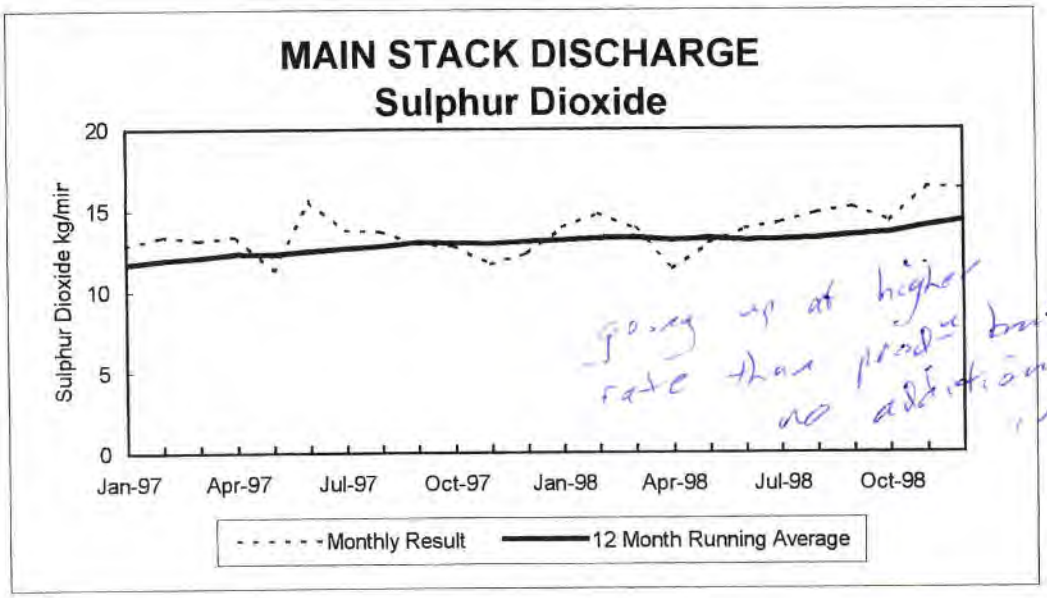


Main Stack Discharges, Continued

Sulphur dioxide

The following graph shows both the average monthly and 12-month running average main stack sulphur dioxide discharge during 1997 and 1998.



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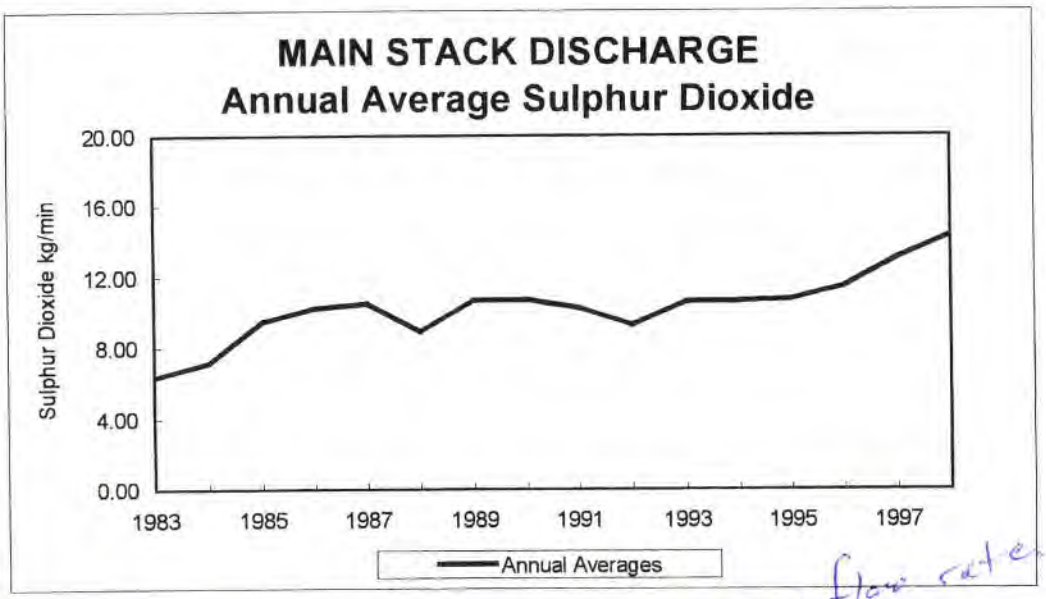

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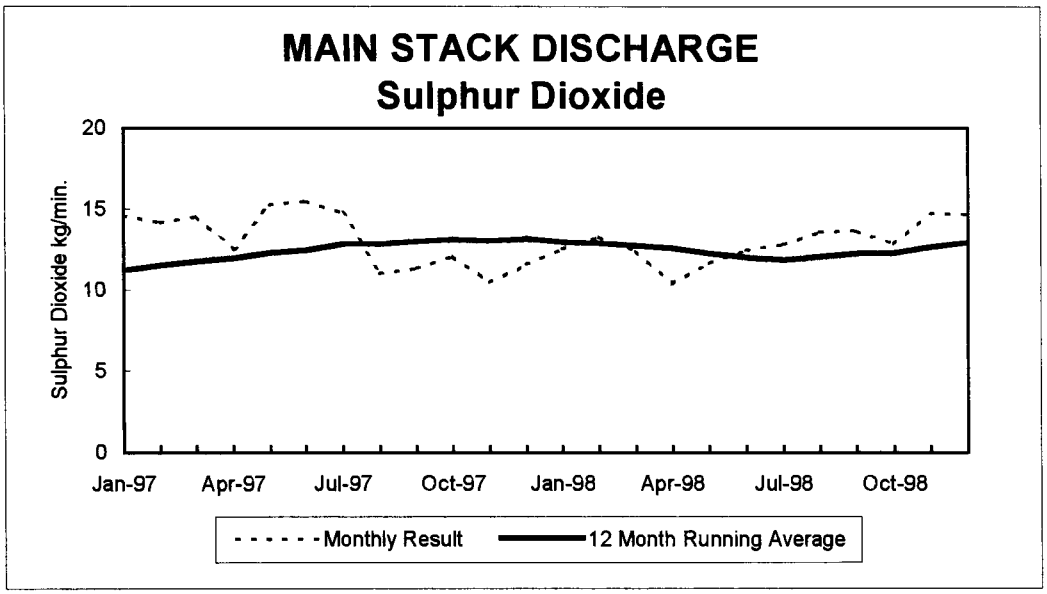

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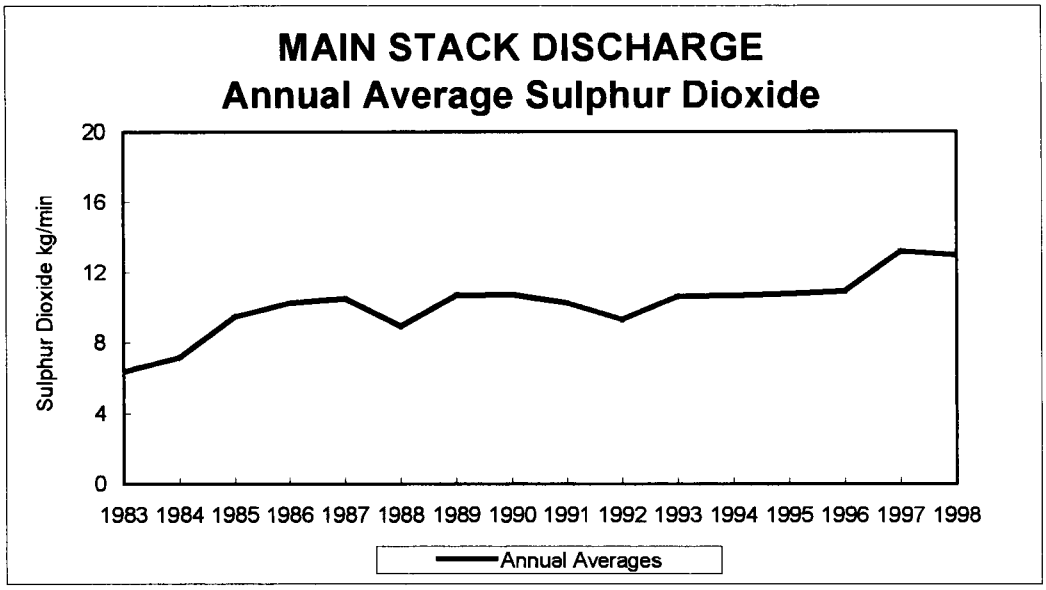

Main Stack Discharges, Continued

Comments

Discharges of total particulate, particulate fluoride and gaseous fluoride were within permit conditions throughout 1998.

The results of main stack discharge monitoring since July 1996 have been recalculated. The recalculated results are used in the graphs and tables included in this report. Previously a monthly average was reported. The monthly average was calculated by time weighting each month's test result using the time between tests and the previous month's test result. The change is to report each month's test result and to use the monthly test results to calculate the 12-month running averages.

Total particulate discharges were higher than normal during June, July and November. The higher result reported for June was most likely the result of broken bags in the dry scrubbing system's baghouses. The particulate in July contained about 60 % organic material suggesting that the main source of the increase was the carbon baking furnaces. However there was no occurrence in the carbon baking furnaces to explain the increase. The higher total particulate and particulate fluoride discharges reported for November may have been due to a power failure the day before sampling which most probably caused instability in the carbon baking furnaces and dry scrubbing system. Also, a small number of broken bags found during inspection of the dry scrubbing baghouses, and carbon material build up in the inner stack within the main stack, may have contributed to the November result. The bags were replaced and the carbon material removed from the inner stack.

The dry scrubbing system's baghouse operations are monitored with an electronic particulate detection system. To supplement the electronic system, lights were installed in the clean air plenum above each baghouse during the second half of 1998 and early 1999. Since the installation of the lights each clean air plenum is visually inspected daily.

The polycyclic hydrocarbon (PAH) discharge measured during 1998 was 0.11 kg/min. This is higher than expected based on measurements in 1994 and 1996. Additional sampling was undertaken in late March 1999 to help assess the stability of the PAH discharge.

The main stack gas flow decreased during 1998. The decrease coincided with changes implemented to optimise the exhaust rate from the reduction cells.

The discharge of gaseous fluoride, sulphur dioxide, and total condensable hydrocarbons during 1998 was similar to those reported for 1997.

Main Stack Discharges, Continued

Comments

Discharges of total particulate, particulate fluoride and gaseous fluoride were within permit conditions throughout 1998.

The results of main stack discharge monitoring since October 1997 have been recalculated. The recalculated results are used in the graphs and tables included in this report. Previously a monthly average was reported. The monthly average was calculated by time weighting each month's test result using the time between tests and the previous month's test result. The change is to report each month's test result and to use the monthly test results to calculate the 12-month running averages.

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The dry scrubbing system's baghouse operations are monitored with an electronic particulate detection system. To supplement the electronic system, lights were installed in the clean air plenum above each baghouse during the second half of 1998 and early 1999. Since the installation of the lights each clean air plenum is visually inspected daily.

The average main stack sulphur dioxide discharge for 1998 was 14.32 kg/min, which is higher than in 1997. Although the smelter's aluminium production has increased, the sulphur dioxide discharge has increased at a higher rate. This higher rate of sulphur dioxide discharge is not supported by identified changes to rates of inputs to and losses from the process. This issue is currently under investigation.

The polycyclic hydrocarbon (PAH) discharge measured during 1998 was 0.11 kg/min. This is higher than expected based on measurements in 1994 and 1996. Additional sampling was undertaken in late March 1999 to help assess the stability of the PAH discharge.

The main stack gas flow decreased during 1998. The decrease coincided with changes implemented to optimise the exhaust rate from the reduction cells.

The discharge of gaseous fluoride and total condensable hydrocarbons during 1998 was similar to those reported for 1997.

Potline Roof Louvre Discharges

Permit changes

The change which affects the monitoring or reporting of Potline roof louvre discharges to air is higher permit standards derived from using the correct roof louvre flow.

The following table shows the new permit standards for Potline roof louvre discharges compared with the original permit standards.

Parameter	Units	New	Original
Total particulate 12 month average	kg/min	3.05	1.87
Gaseous fluoride 12 month average	kg/min	0.38	0.233
Particulate fluoride 12 month average	kg/min	0.38	0.233

The original permit standards were derived using roof louvre gas flows for Lines 1, 2, and 3 measured in 1992. Subsequent investigation showed that the permit standards were derived from an underestimate of the flow. The new permit standards were derived using gas flows measured in 1996/97.

Potline Roof Louvre Discharges, Continued

Recalculated monitoring results

Previously reported results used in this report have been recalculated. The recalculated results are included in the tables and all graphs related to Potline roof louvre discharges to air. The recalculation:

- uses the correct Potline roof louvre gas flow of 761,300 Sm^3/min for Lines 1, 2, and 3 and 92,500 Sm^3/min for Line 4, and
- accounts for the change in monitoring method that recognises the discharges routinely measured from Line 2A East are higher than the total Potline roof louvre discharges.

The correct Potline roof louvre gas flow has been applied to all results since 1983. The correction factors applied to the Line 2A East sampling manifold results have been applied since the middle of 1996 when alumina from the dry scrubbing system was first used in the reduction cells. Alumina from the dry scrubbing system is used in Lines 1, 2, and 4 but not in Line 3 and this may be the cause of the variation between the Line 2A discharge and the total Potline roof louvre discharge.

The following table shows the correction factors applied to the Line 2A East sampling manifold results to obtain the total Potline roof louvre discharge rates.

Analyte	Factor
Total particulate	0.92
Gaseous fluoride	0.83
Particulate fluoride	0.83
Sulphur dioxide	0.80

will revalidate every 2 years
Due this year.

Potline Roof Louvre Discharges, Continued

Monitoring results

The following table shows the Potline roof louvre monitoring results for 1998. The permit standards are for 12-month running averages.

The standards shown in the table are the new permit standards approved on 5 August 1998.

Parameter	Units	Running 12 month average		
		Standard	1998 result	Maximum for any month
Total particulate	kg/min	3.05	1.06	1.84
Gaseous fluoride	kg/min	0.38	0.11	0.15
Particulate fluoride	kg/min	0.38	0.17	0.26
Sulphur dioxide	kg/min	-	0.31	0.46

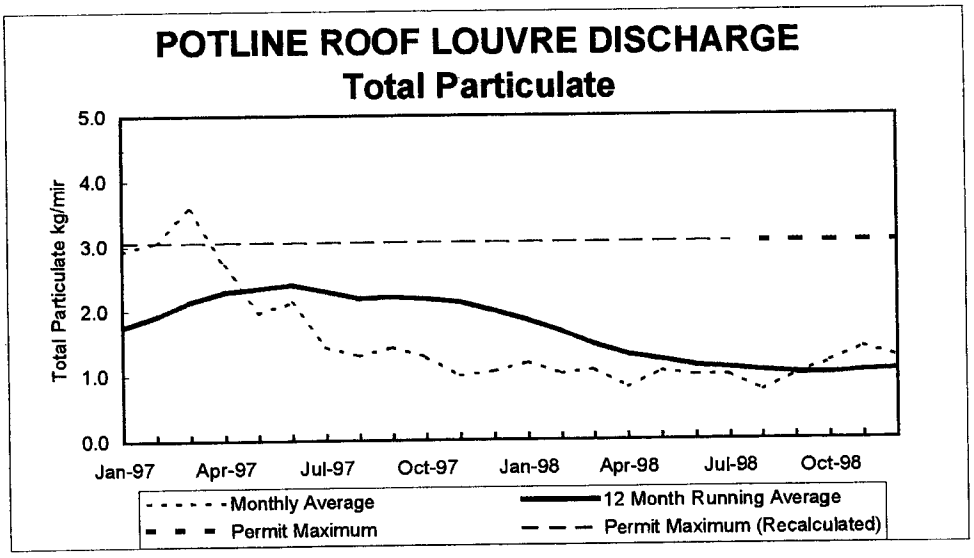
Potline Roof Louvre Discharges, Continued

Total particulate

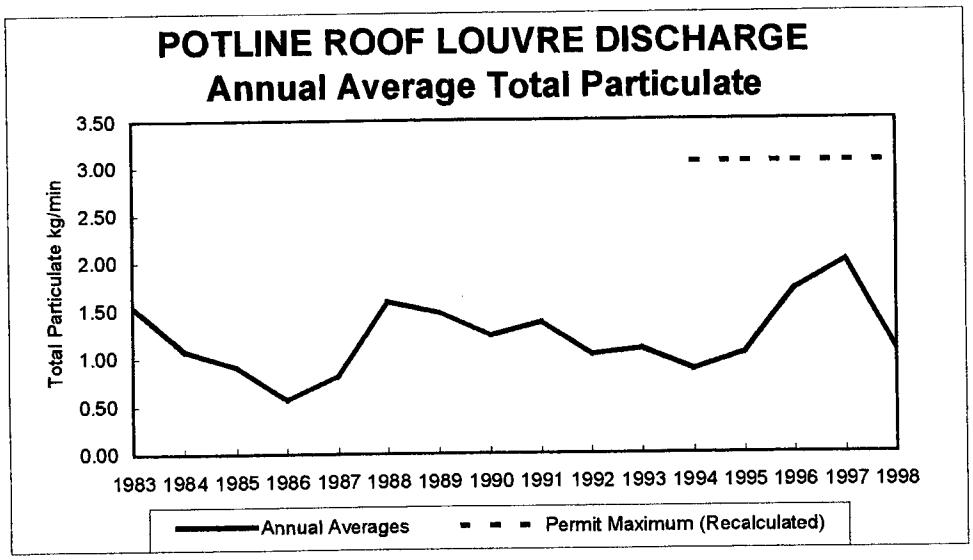
Standard: 12-month running average not to exceed 3.05 kg/min.

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 1997 and 1998.



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



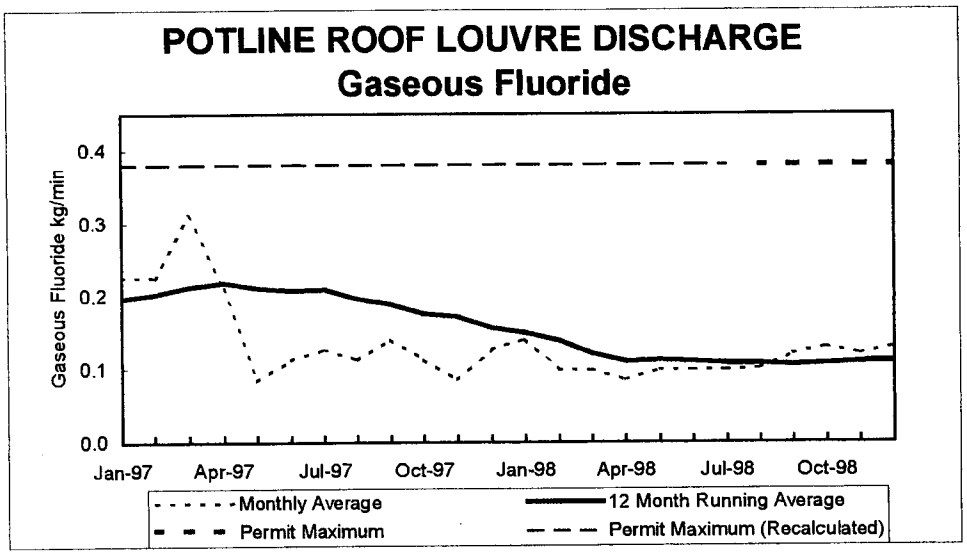
Potline Roof Louvre Discharges, Continued

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 1997 and 1998.



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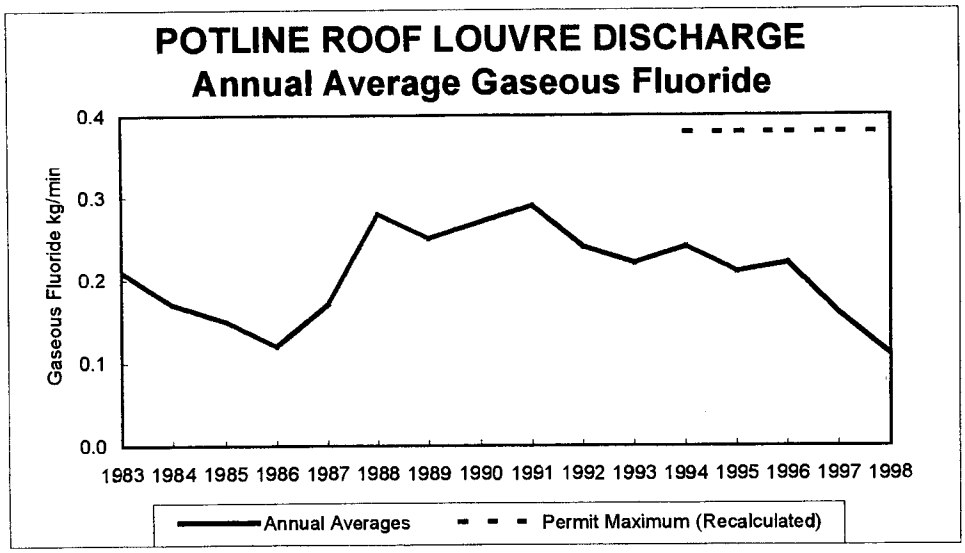

Potline Roof Louvre Discharges, Continued

Particulate fluoride

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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.

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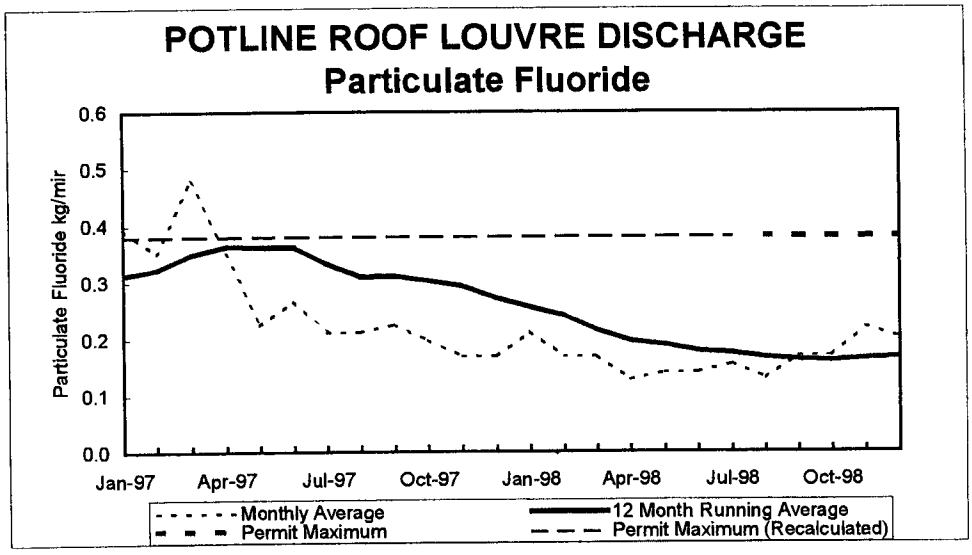

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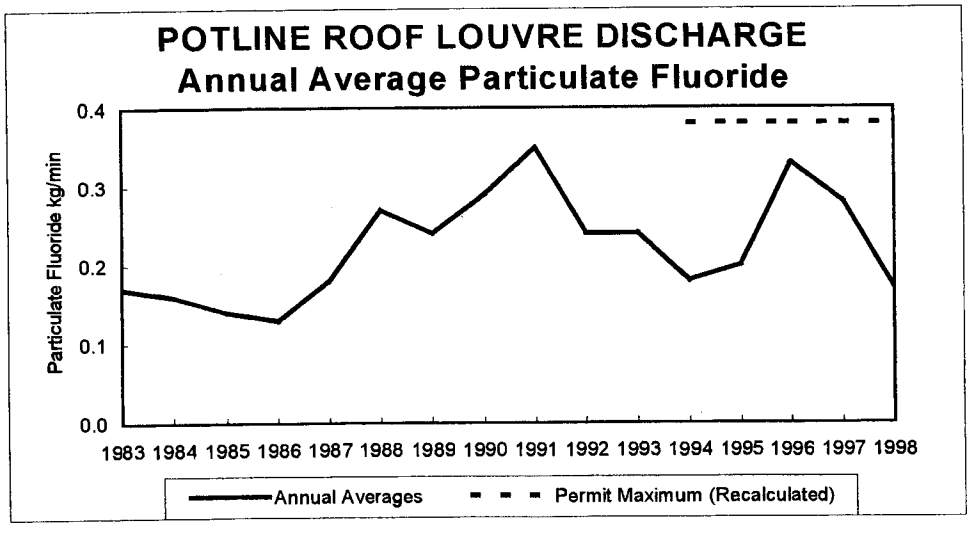

Potline Roof Louvre Discharges, Continued

Sulphur dioxide

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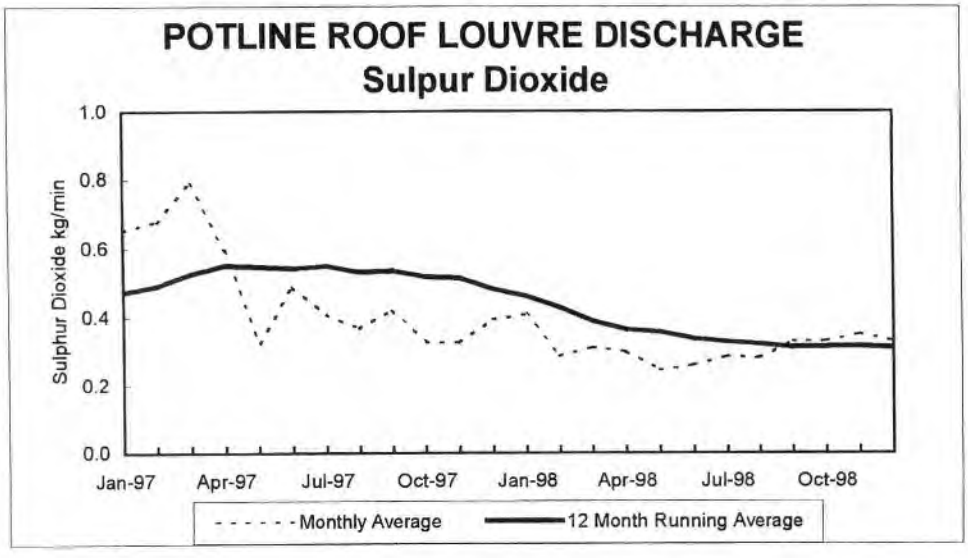
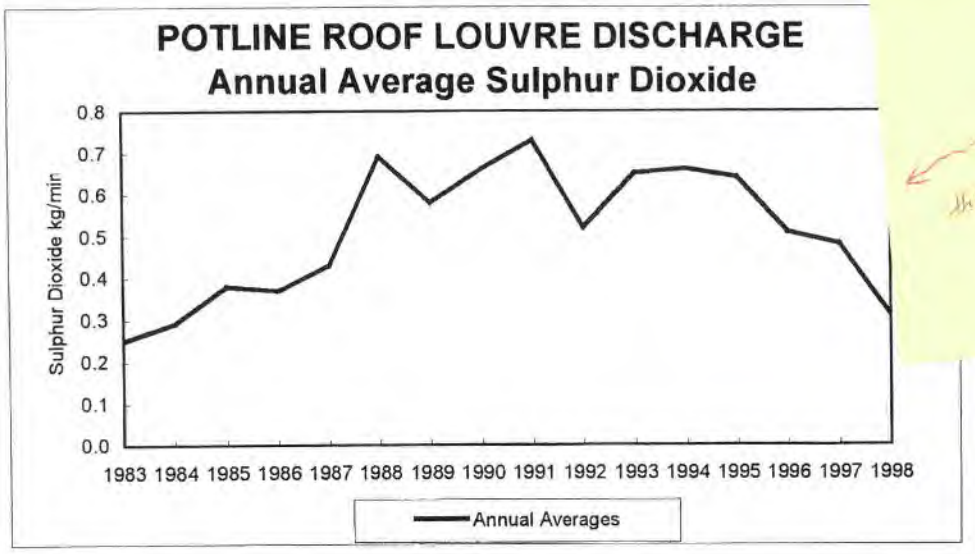


The following graph shows the annual average Potline roof louvre sulphur dioxide discharge.



Potline Roof Louvre Discharges, Continued

Comments

Potline roof louvre discharges during 1998 were within permit conditions and lower than during 1997. The lower discharge was due to maintaining the operating stability in the reduction cells discussed in last year's report.

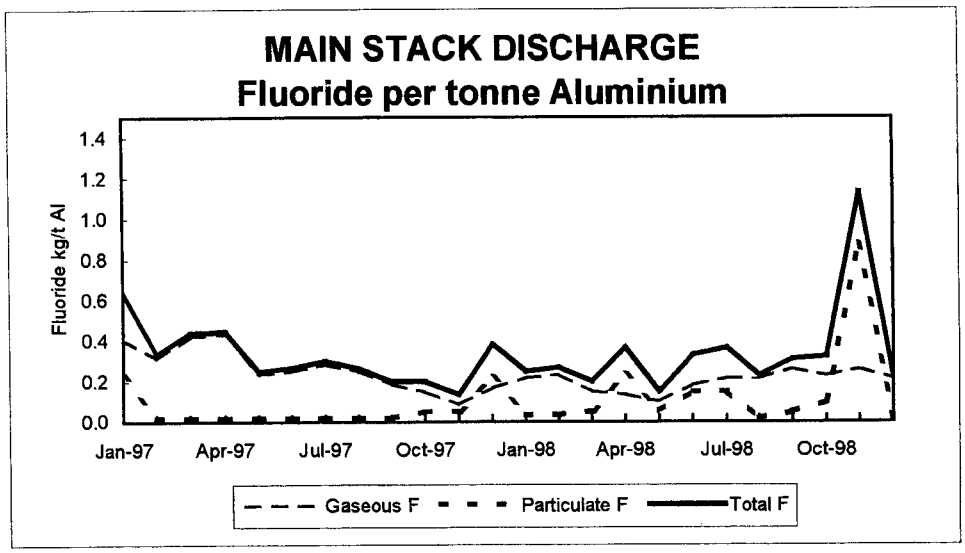
Fluoride Discharges

Performance data

The following table shows the fluoride discharges expressed as a ratio of hot aluminium metal production during 1998.

Parameter	Units	1998 average	Maximum for any month
Main Stack			
• Gaseous fluoride	kg/t Al	0.20	0.26
• Particulate fluoride	kg/t Al	0.15	0.87
• Total fluoride	kg/t Al	0.35	1.13
Reduction Line Roof Louvres			
• Gaseous fluoride	kg/t Al	0.18	0.24
• Particulate fluoride	kg/t Al	0.27	0.36
• Total fluoride	kg/t Al	0.45	0.59
Plant			
• Gaseous fluoride	kg/t Al	0.38	0.46
• Particulate fluoride	kg/t Al	0.42	1.23
• Total fluoride	kg/t Al	0.80	1.68

The following graph shows the average monthly main stack fluoride discharge during 1997 and 1998.



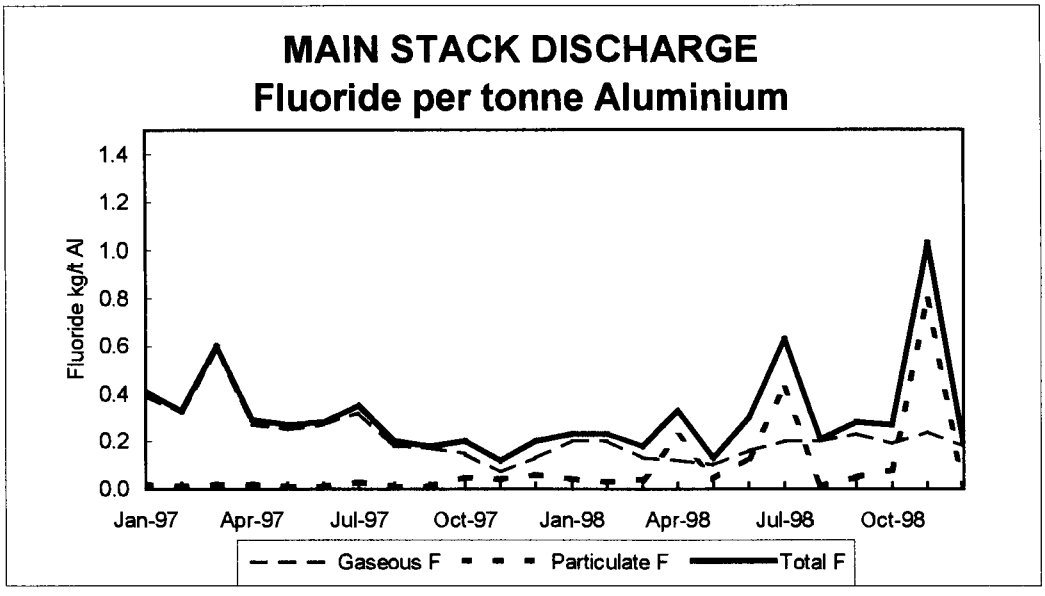
Fluoride Discharges

Performance data

The following table shows the fluoride discharges expressed as a ratio of hot aluminium metal production during 1998.

Parameter	Units	1998 result	Maximum for any month
Main Stack			
• Gaseous fluoride	kg/t Al	0.18	0.24
• Particulate fluoride	kg/t Al	0.16	0.79
• Total fluoride	kg/t Al	0.34	1.03
Reduction Line Roof Louvres			
• Gaseous fluoride	kg/t Al	0.18	0.23
• Particulate fluoride	kg/t Al	0.27	0.36
• Total fluoride	kg/t Al	0.45	0.59
Plant			
• Gaseous fluoride	kg/t Al	0.36	0.43
• Particulate fluoride	kg/t Al	0.43	1.15
• Total fluoride	kg/t Al	0.79	1.58

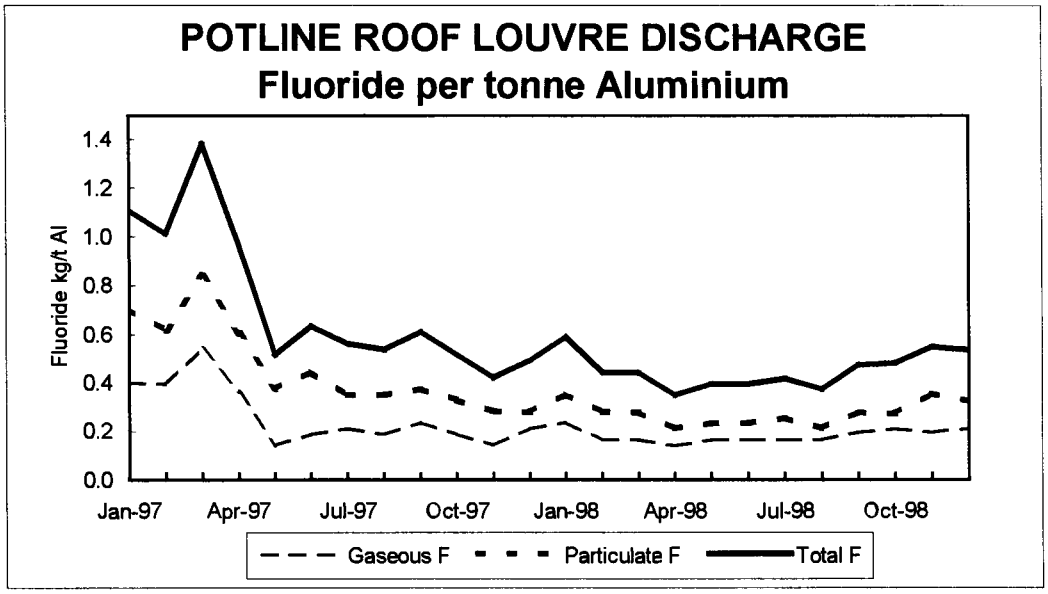
The following graph shows the average monthly main stack fluoride discharge during 1997 and 1998.



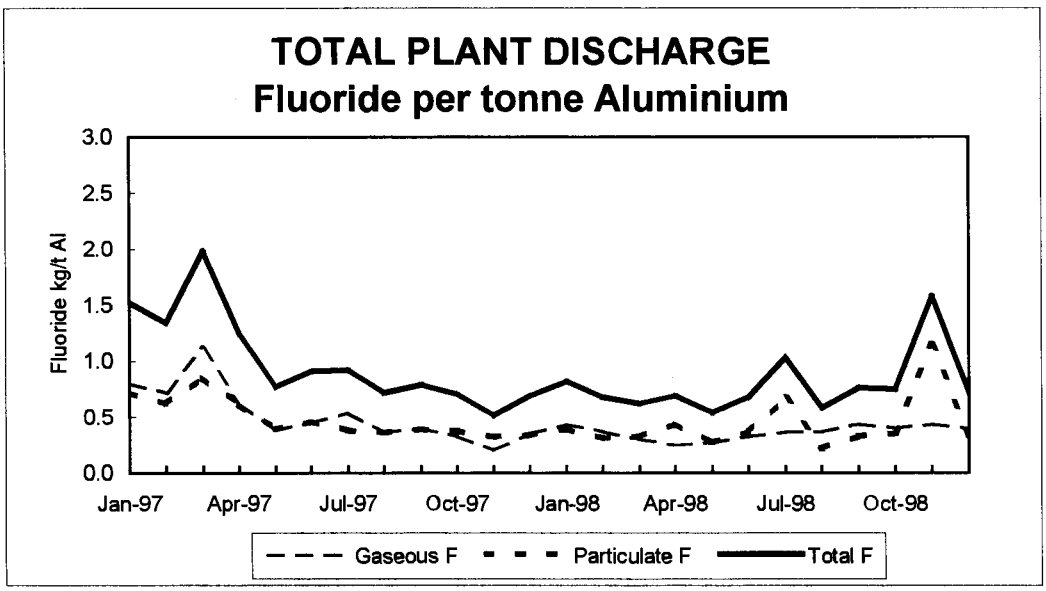
Fluoride Discharges, Continued

Performance data, continued

The following graph shows the average monthly Potline roof louvre fluoride discharge during 1997 and 1998.



The following graph shows the average monthly total plant fluoride discharge during 1997 and 1998.



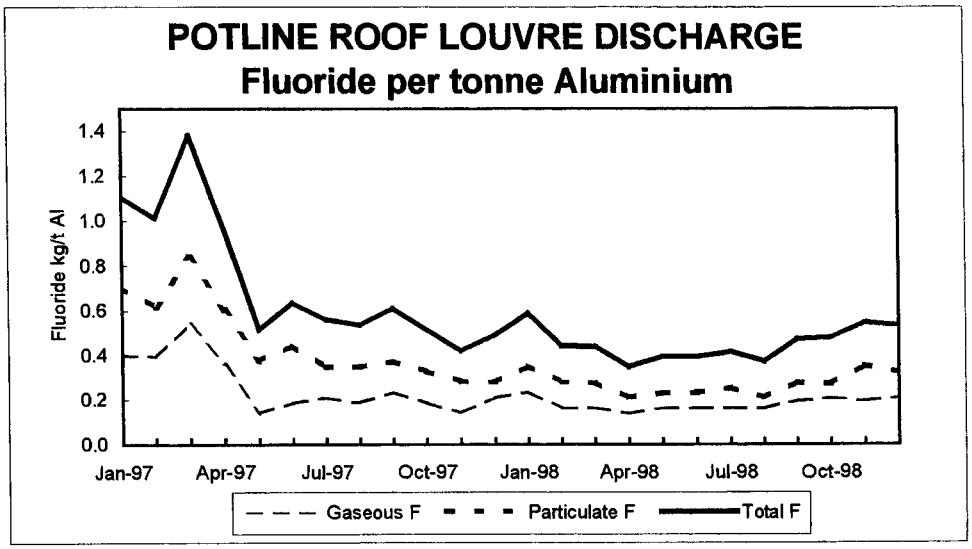
Comments

The fluoride discharge rate from the plant was generally stable during 1998 due to the main stack dry scrubbing equipment and operating stability of the reduction cells. The high particulate fluoride discharge in November is discussed in "Main Stack Discharges".

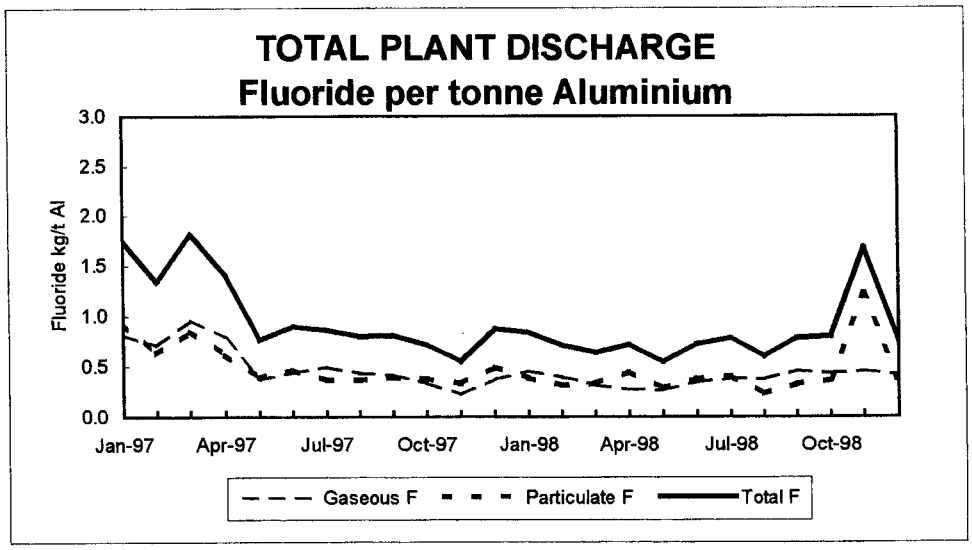
Fluoride Discharges, Continued

Performance data, continued

The following graph shows the average monthly Potline roof louvre fluoride discharge during 1997 and 1998.



The following graph shows the average monthly total plant fluoride discharge during 1997 and 1998.



Comments

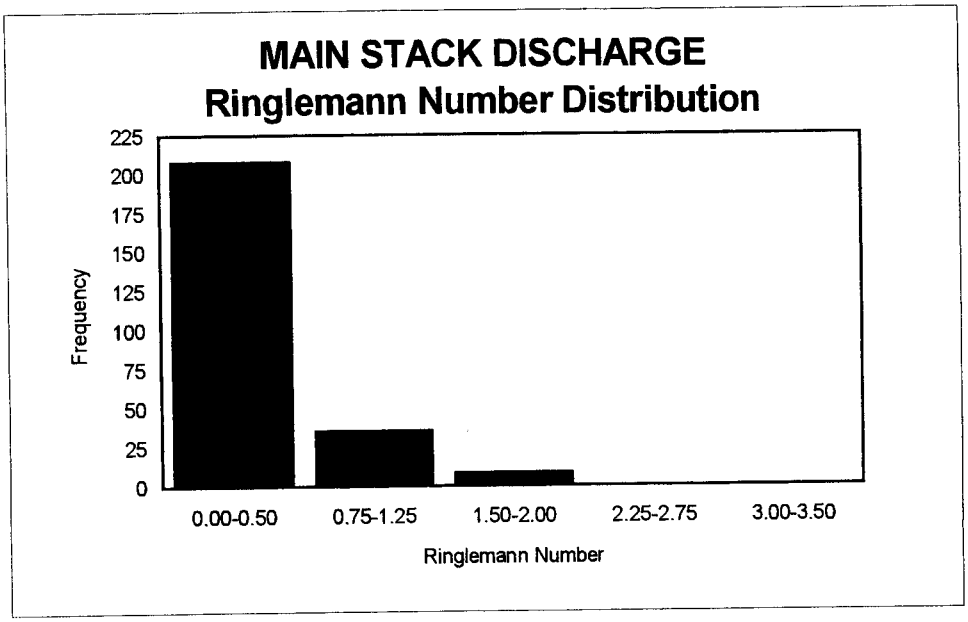
The fluoride discharge rate from the plant was generally stable during 1998 due to the main stack dry scrubbing equipment and operating stability of the reduction cells. The high particulate fluoride discharge in November is discussed in "Main Stack Discharges".

Baghouse Discharges

The regular inspection of the baghouse discharges continued during 1998. 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 1998.



The main stack Ringlemann numbers indicate that the plume was less opaque than last year.

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 1998.

Material	Units	Permit Maximum	1998 Annual Average	1998 maximum	1998 minimum
Petroleum coke	%	3.0	2.83	2.89	2.79
Pitch	%	1.0	0.47	0.49	0.46
Heavy fuel oil	%	3.5	2.32	2.73	1.92

Comments

All shipments of raw materials and fuels during 1998 were within permit standards for sulphur content.

The average sulphur content of petroleum coke and pitch during 1998 was similar to that reported for 1997. The average sulphur content of heavy fuel oil during 1998 was lower than that reported for 1997.

Part C

Dispersion Conditions

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.

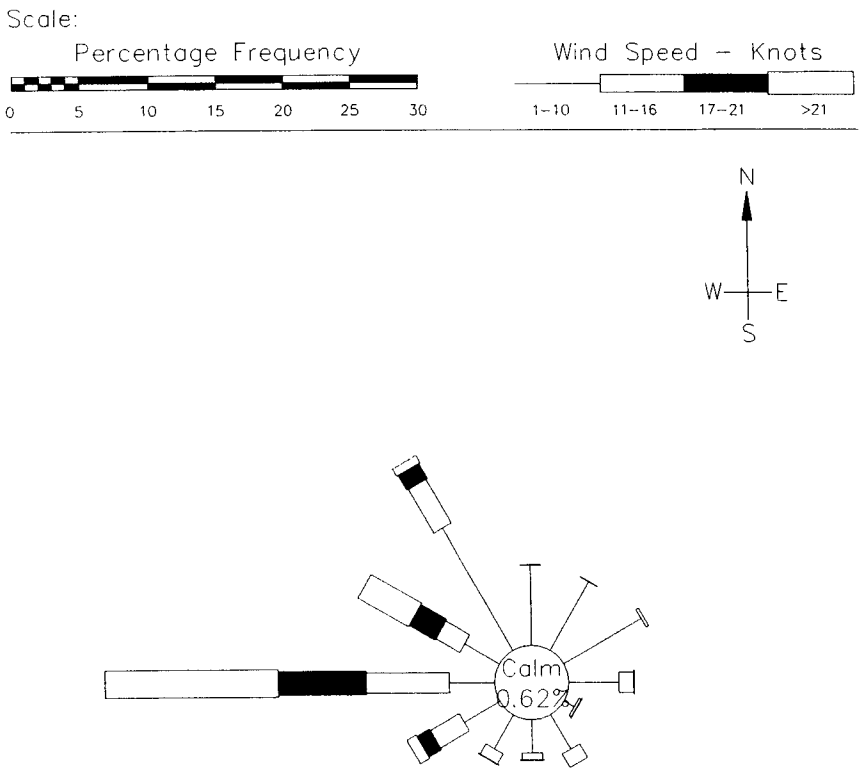
Meteorological Conditions

The mean wind frequency diagram on the following page shows that the 1998 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 1998.

Month	Predominant Wind Direction	Rainfall (mm)
January	West and north-west	36
February	West and north-west	111
March	West and north-west	202
April	West and north-west	96
May	West and north-west	61
June	North and west	94
July	West, north-west and north-east	70
August	West, north-west and south-west	93
September	West and north-west	148
October	West and north-west	112
November	West and south	41
December	West and south-east	77

NEW ZEALAND ALUMINIUM SMELTERS LIMITED – TIWAI POINT
WORKPLACE AND ENVIRONMENTAL MONITORING OUTPUT TEAM
MEAN WIND FREQUENCY (%) OF SURFACE WIND DIRECTIONS
PERIOD: SUMMARY 1998



% Time at	
1–10 Knots	51.1
11–16 Knots	18.6
17–21 Knots	11.2
>21 Knots	18.4
Calm	0.62

Part D

Ambient Air

Ambient Air

Introduction

This chapter covers the monitoring for gaseous and particulate fluorides in ambient air at six monitoring sites. Also covered are changes to the Air Discharge and Coastal Permit regarding ambient air monitoring.

Permit Changes Regarding Ambient Air

The changes to the permit:

- allow NZAS to monitor gaseous and particulate fluoride at five sites using a method based on up to a one month sampling period,
- require NZAS to monitor gaseous and particulate fluoride at a sixth site using a method based on a seven day sampling period, and
- require NZAS to revert to seven day sampling at any site where two monthly results exceed 0.3 $\mu gF.m^{-3}$ until two consecutive seven day results are each less than 0.3 $\mu gF.m^{-3}$.

Permit standards

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

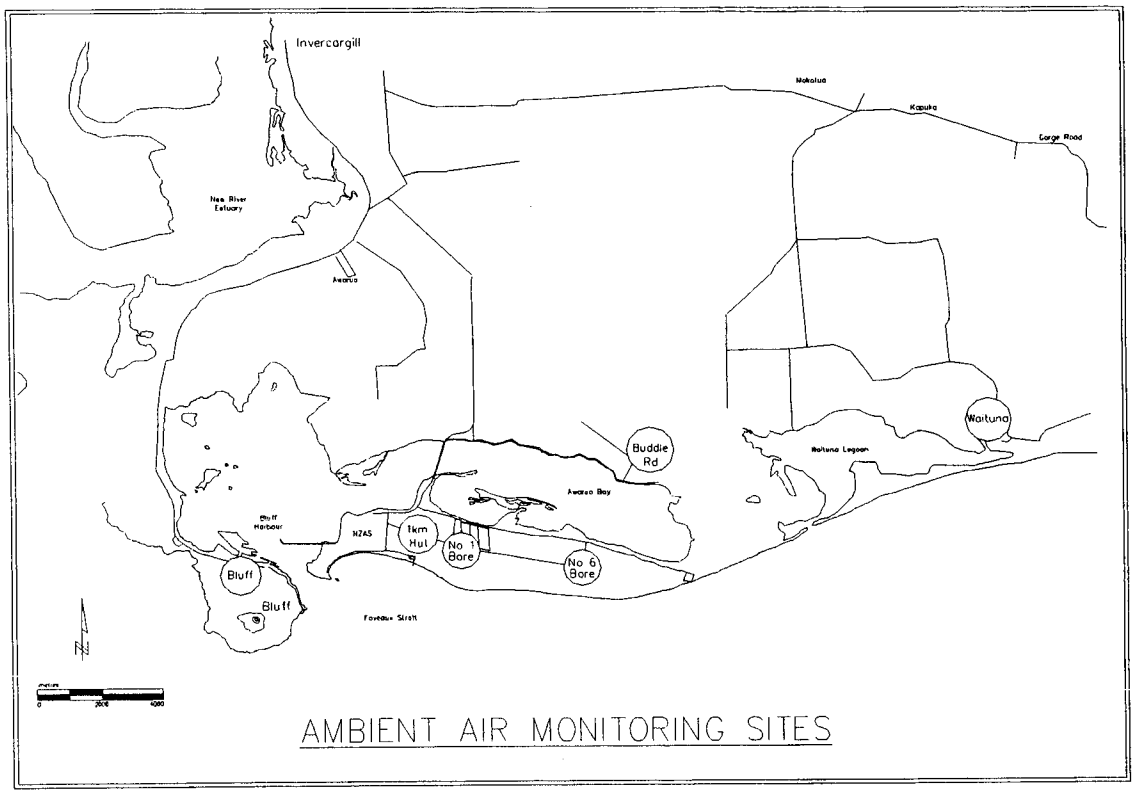
- 24 hour average 2.0 $\mu g/m^3$
- 7 day average 1.0 $\mu g/m^3$
- One month average 0.5 $\mu g/m^3$

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.

Site Locations

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



Ambient Air at 1 Kilometre Hut

Monitoring results

The sampling method at this site was changed to Australian Standard AS 3580.13.2 from the Merry-Go-Round (MGR) method on 26 August 1998. Since the change the sampling period is seven days compared to 12 hours used for the previous method and both gaseous and particulate fluoride are monitored.

The following table summarises the monitoring results using the Australian Standard method at this site during 1998. The sampling frequency for ambient air fluoride at this site is seven days. Annual averages were not calculated as the data is for four months only.

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

Notes: N.D. means annual average not calculated as sampling method changed during the year (see "Comments").

Ambient Air at 1 Kilometre Hut, Continued

Comments

The change to the Australian Standard method coincided with significantly higher gaseous fluoride concentrations being measured. Before the method change the monthly average gaseous fluoride concentration was generally less than 0.1 $\mu g/m^3$ but increased to 0.5 $\mu g/m^3$ after the change. The higher concentrations are most likely due to changing the sampling method as the increased fluoride concentrations were not supported by the fluoride monitoring at the nearby ungrazed grass monitoring Site 6. The fluoride concentration of ungrazed grass at site 6 was within the normal range throughout 1998.

Sealing problems with the MGR method were previously discussed with the Southland Regional Council as was the probability that fluoride concentrations measured using the Australian Standard method would be higher than those measured using the MGR method. Increased concentrations were also measured at No.1 Bore when the sampling method was changed to AS 3580.13.2 but the increase was not as significant as that observed at 1 Kilometre Hut.

The annual average gaseous fluoride concentration was not calculated because the results increased significantly when the sampling method was changed in August. As discussed previously the increase was most likely due to the method change. No annual average particulate fluoride concentration was calculated, as particulate fluoride monitoring only started when the sampling method changed in August.

The results are not graphed because the sampling method has changed. A graph for this site will be included in next year's report.

Ambient Air at Other Sites on Tiwai Peninsula

Monitoring results

The following table summarises the monitoring results during 1997 and 1998 for the two other sites located on Tiwai Peninsula. The sampling frequency for ambient air fluoride at these sites is seven days.

Site	Parameter	Units	Standard	1997	1998
No.1 Bore	Gaseous fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	1.0	0.2	0.5
	• Max monthly average	$\mu g/m^3$	0.5	0.1	0.2
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	-	0.2	0.1
	• Max monthly average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
No.6 Bore	Gaseous fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	1.0	< 0.1	< 0.1
	• Max monthly average	$\mu g/m^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Max monthly average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1

Comments

All permit standards were met at these sites throughout 1998.

The maximum seven day gaseous fluoride concentration measured at No.1 Bore was 0.5 $\mu g/m^3$. Although strong westerly winds predominated during the sampling period, results at 1 Kilometre Hut and No.6 Bore did not support the high result at No.1 Bore. No known reasons can be identified for the high No1. Bore result.

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

Ambient Air at Sites off Tiwai Peninsula

Monitoring results

The following table summarises the monitoring results during 1997 and 1998 for the three ambient air monitoring sites located off Tiwai Peninsula. The sampling frequency for ambient air fluoride at these sites is seven days.

Site	Parameter	Units	Standard	1997	1998
Buddle Road	Gaseous fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	1.0	< 0.1	< 0.1
	• Max monthly average	$\mu g/m^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Max monthly average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
Waituna	Gaseous fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	1.0	< 0.1	0.1
	• Max monthly average	$\mu g/m^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Max monthly average	$\mu g/m^3$	-	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
Bluff	Gaseous fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	1.0	< 0.1	0.1
	• Max monthly average	$\mu g/m^3$	0.5	< 0.1	< 0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1
	Particulate fluoride concentration				
	• Max 7 day average	$\mu g/m^3$	-	< 0.1	0.4
	• Max monthly average	$\mu g/m^3$	-	< 0.1	0.1
	• Annual average	$\mu g/m^3$	-	< 0.1	< 0.1

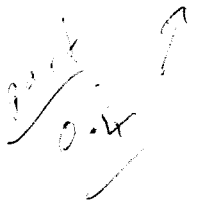
Ambient Air at Sites off Tiwai Peninsula, Continued

Comments

All permit standards were met at the three sites off Tiwai Peninsula throughout 1998.

The maximum seven day particulate fluoride concentration measured at Bluff during 1998 was 0.4 $\mu g/m^3$. This was unlikely to be related to activities at the smelter as winds were blowing towards the Bluff site for less than 5% of the time during sampling. A possible source of the high particulate fluoride concentration was the unloading of phosphate at Bluff during sampling. Winds at the time were predominantly northerly and may have transported phosphate dust towards the Bluff monitoring site.

All other gaseous and particulate fluoride concentrations were at or below the detection limit of the Australian standard method at these sites during 1998.



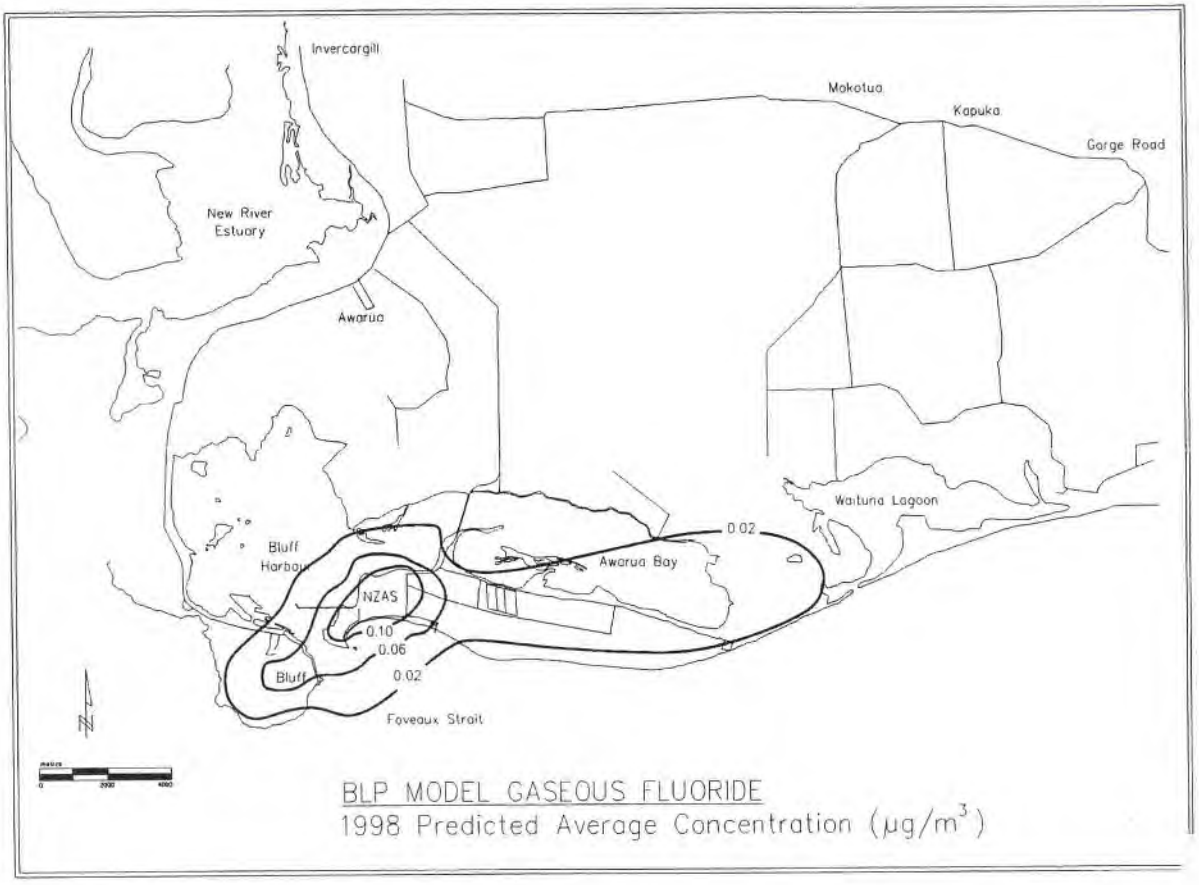
Ambient Air Model Prediction

Introduction

The BLP model was used to predict ambient air gaseous fluoride concentrations due to discharges from the smelter.

Predicted annual average concentrations

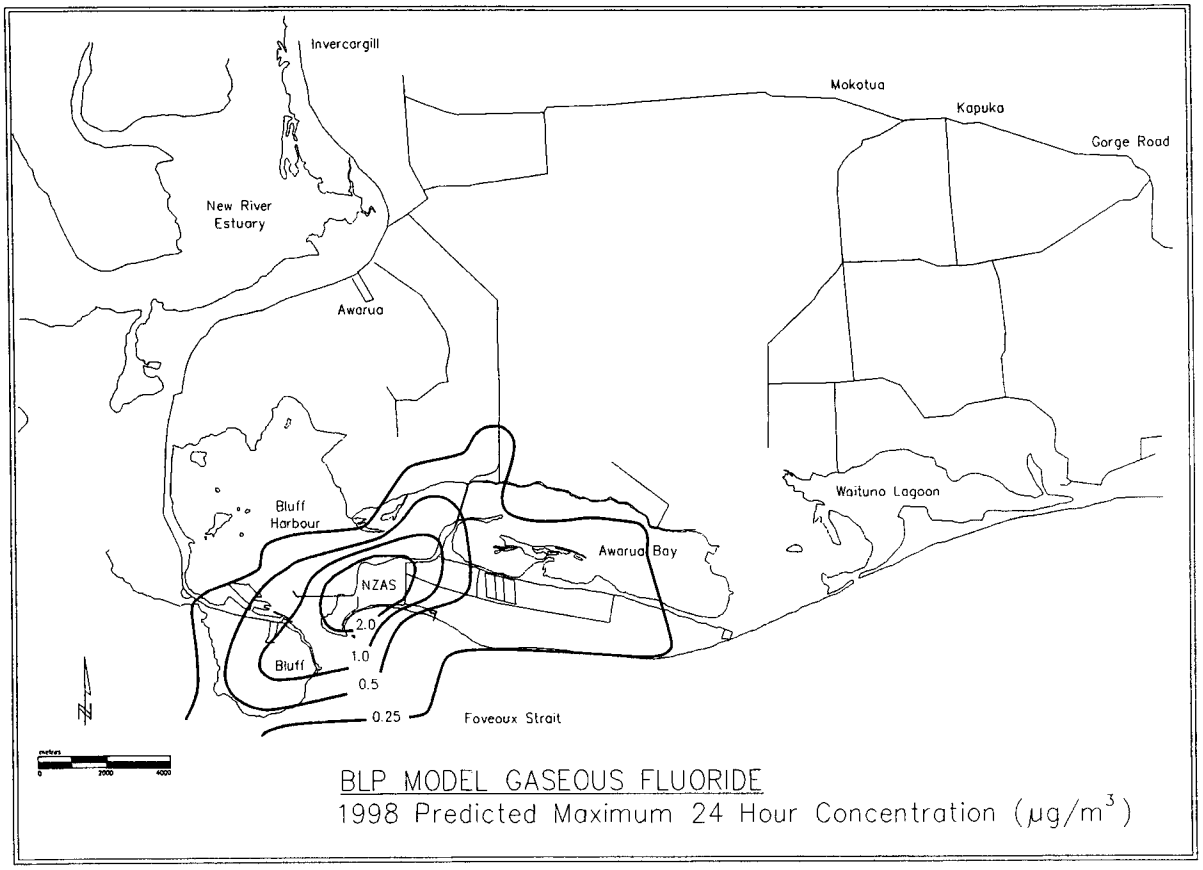
The predicted annual average ambient air gaseous fluoride concentrations due to the discharge from the smelter during 1998 are shown in the following map.



Ambient Air Model Prediction, Continued

Maximum 24 hour average concentrations

The predicted maximum 24-hour average ambient air gaseous fluoride concentrations due to the discharge from the smelter during 1998 are shown in the following map.



Comments

The predictions indicate that the 24-hour average ambient air gaseous fluoride concentrations in the area surrounding the smelter were unlikely to have exceeded the permit standard during 1998.

Part E

Atmospheric Deposition

Atmospheric Deposition

Introduction

This chapter covers the monitoring of atmospheric deposition at nine monitoring sites. Also covered are changes to the Air Discharge and Coastal Permit regarding the monitoring of atmospheric deposition.

Permit Changes Regarding Atmospheric Deposition

The changes to the permit that effect the monitoring of atmospheric deposition are:

- the number of sites required is reduced from nine to seven,
- the determination of pH and chloride concentration is no longer required, and
- the fluoride guideline is changed from 0.9 – 1.1 to 0.9 $g.m^{-3}$.

Permit Guidelines

The permit changes for fluoride in atmospheric deposition was changed from 0.9 $g.m^{-3}$ on 5 August 1998.

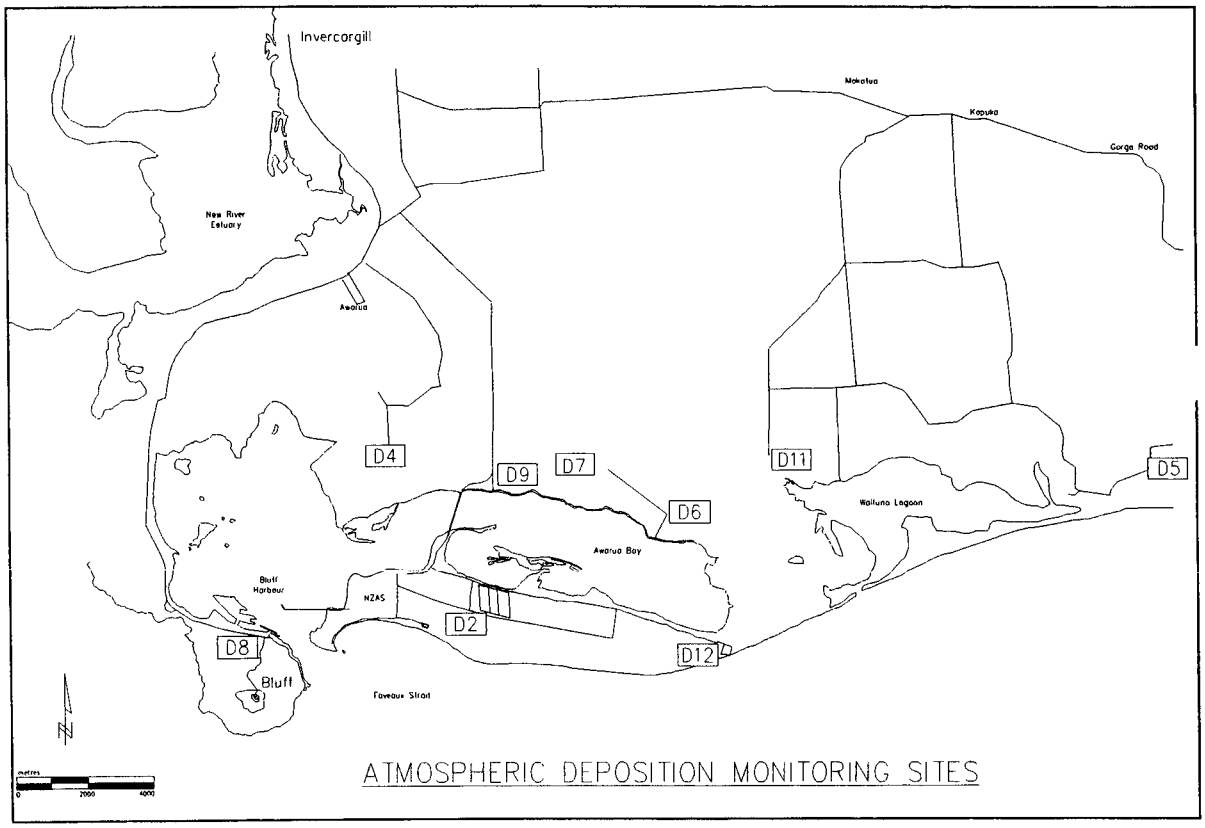
The guidelines for atmospheric deposition apply to sites off Tiwai Peninsula and are shown in the table below.

Parameter	Guideline	Unit
Fluoride: • From August • Before August	 0.9 0.9 – 1.1	 $g.m^{-3}$ $g.m^{-3}$
Reactive Aluminium • Aesthetic highest desirable • Aesthetic excessive	 0.05 0.20	 $g.m^{-3}$ $g.m^{-3}$

Site Locations

The sites removed due to the permit changes were D4, Duck Creek, and D5, Waituna. Samples were not collected from these locations after 21 August 1998.

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



Atmospheric Deposition Monitoring Results

Fluoride Deposition

The fluoride atmospheric deposition during 1998 is summarised in the following table.

Site	Units	1998 average	Maximum for any month	Minimum for any month
D2. No1 Bore[1]	g/m^3	0.17	0.30	0.08
D12 TEF2[1]	g/m^3	< 0.05	0.07	< 0.05
D4 Duck Creek	g/m^3	< 0.05	< 0.05	< 0.05
D5 Waituna	g/m^3	< 0.05	< 0.05	< 0.05
D6 Buddle Road	g/m^3	< 0.05	0.29	< 0.05
D7 Gibson's Farm	g/m^3	< 0.05	0.06	< 0.05
D8 Bluff	g/m^3	< 0.05	0.09	< 0.05
D9 Awarua Bay Road	g/m^3	< 0.05	0.18	< 0.05
D11 Marshall Road	g/m^3	< 0.05	0.09	< 0.05

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

Atmospheric Deposition Monitoring Results, Continued

Reactive Aluminium Deposition

The reactive aluminium atmospheric deposition during 1998 is summarised in the following table.

Site	Units	1998 average	Maximum for any month	Minimum for any month
D2. No1 Bore[1]	g/m^3	0.04	0.09	< 0.03
D12 TEF2[1]	g/m^3	< 0.03	< 0.03	< 0.03
D4 Duck Creek	g/m^3	< 0.03	< 0.03	< 0.03
D5 Waituna	g/m^3	< 0.03	< 0.03	< 0.03
D6 Buddle Road	g/m^3	< 0.03	< 0.03	< 0.03
D7 Gibson's Farm	g/m^3	< 0.03	< 0.03	< 0.03
D8 Bluff	g/m^3	< 0.03	< 0.03	< 0.03
D9 Awarua Bay Road	g/m^3	< 0.03	0.11	< 0.03
D11 Marshall Road	g/m^3	< 0.03	< 0.03	< 0.03

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

Comments

All permit guidelines were met during 1998.

Fluoride and reactive aluminium deposition during 1998 was similar to that reported for 1997.

Fluoride deposition at the Buddle Road and Awarua Bay Road sites and the reactive aluminium deposition at Awarua Bay Road were higher than normal during November. Although the main stack total particulate and particulate fluoride discharge was higher than normal during November it is unlikely to have caused the higher atmospheric deposition concentrations at Buddle Road and Awarua Bay Road. The frequency of winds able to transport smelter sourced discharges towards the two sites was about or less than normal during the sampling period and the results of monitoring at neighbouring sites were within the normal range at each site.

Part F

Fluoride in Ungrazed Grass

Fluoride in Ungrazed Grasses

Introduction

This chapter covers the monitoring of fluoride in ungrazed grasses at 25 monitoring sites located at Bluff, Green Hills, Awarua Plains, Waituna Wetlands and Tiwai Peninsula. Also covered are changes to the Air Discharge and Coastal Permit regarding monitoring of fluoride in ungrazed grasses.

Permit Changes Regarding Fluoride in Ungrazed Grass

The permit change that effects the monitoring of fluoride in ungrazed grass is the reduction in the number of sites from 25 to 23.

Permit Guidelines

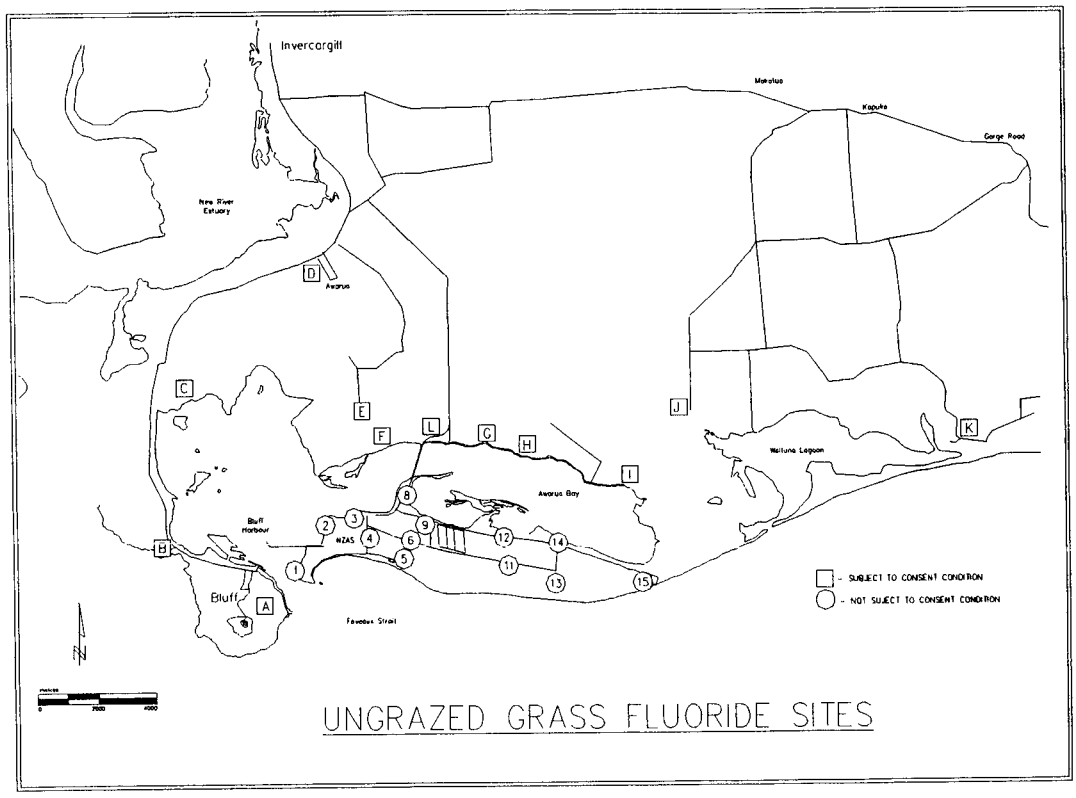
The guidelines in ungrazed grasses (on an unwashed, dry weight basis) on land off Tiwai Peninsula are detailed below. These guidelines came into effect in April 1994.

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

Site Locations

The sites removed due to the permit changes were Sites 14 and D. Samples were not collected from these sites after 21 August 1998.

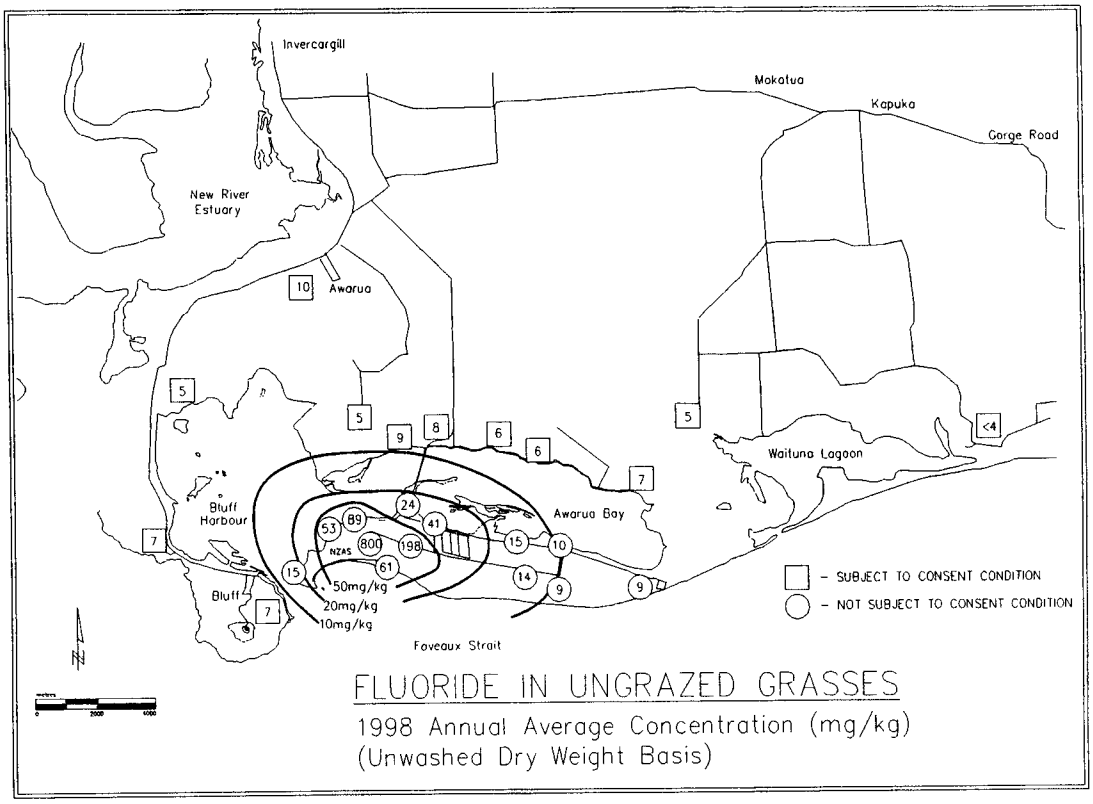
The ungrazed grass monitoring sites are shown on the following map.



Ungrazed Grass Monitoring Results

Annual average fluoride concentrations

The 1998 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 1998.

Sites off Tiwai Peninsula	Permit Guideline not to be exceeded more than once in any 12 consecutive months mgF/kg	Maximum Monthly Result During 1998 mgF/kg
Ungrazed Grass Site A	80	14
Ungrazed Grass Site B	80	20
Ungrazed Grass Site C	80	11
Ungrazed Grass Site D	80	16
Ungrazed Grass Site E	80	9
Ungrazed Grass Site F	80	14
Ungrazed Grass Site G	80	11
Ungrazed Grass Site H	80	9
Ungrazed Grass Site I	80	11
Ungrazed Grass Site J	80	9
Ungrazed Grass Site K	80	6
Ungrazed Grass Site L	80	20

The monthly fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1998.

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 1998 mgF/kg
Ungrazed Grass Site A	60	11
Ungrazed Grass Site B	60	14
Ungrazed Grass Site C	60	11
Ungrazed Grass Site D	60	13
Ungrazed Grass Site E	60	8
Ungrazed Grass Site F	60	12
Ungrazed Grass Site G	60	10
Ungrazed Grass Site H	60	8
Ungrazed Grass Site I	60	10
Ungrazed Grass Site J	60	8
Ungrazed Grass Site K	60	6
Ungrazed Grass Site L	60	15

The two-month running average fluoride concentration in ungrazed grass was within the permit guideline for all sites during 1998.

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 1998 mgF/kg
Ungrazed Grass Site A	40	8
Ungrazed Grass Site B	40	9
Ungrazed Grass Site C	40	8
Ungrazed Grass Site D	40	10
Ungrazed Grass Site E	40	7
Ungrazed Grass Site F	40	12
Ungrazed Grass Site G	40	7
Ungrazed Grass Site H	40	7
Ungrazed Grass Site I	40	8
Ungrazed Grass Site J	40	6
Ungrazed Grass Site K	40	6
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 1998.

Comments

The fluoride concentration in ungrazed grass was generally lower at sites within about two kilometres of the smelter. The decrease probably reflects the lower discharge from the Potlines roof louvres.

The fluoride concentrations at sites further from the smelter were similar to the concentrations reported for 1997.

Part G

Fluoride in Pinus Radiata

Fluoride in Pinus Radiata

Introduction

This chapter covers the monitoring of fluoride in pinus radiata at 15 monitoring sites located at Bluff, Awarua Plains, Waituna and Tiwai Peninsula. Also covered are changes in the Air Discharge and Coastal Permit regarding the monitoring of fluoride in pinus radiata

Permit Changes Regarding Fluoride in Pinus Radiata

The permit changes that effect the monitoring of fluoride in pinus radiata are:

- sampling at up to six sites on Tiwai Peninsula is required, instead of at six sites on Tiwai Peninsula, and
- the number of sites off Tiwai Peninsula is reduced from nine to four sites.

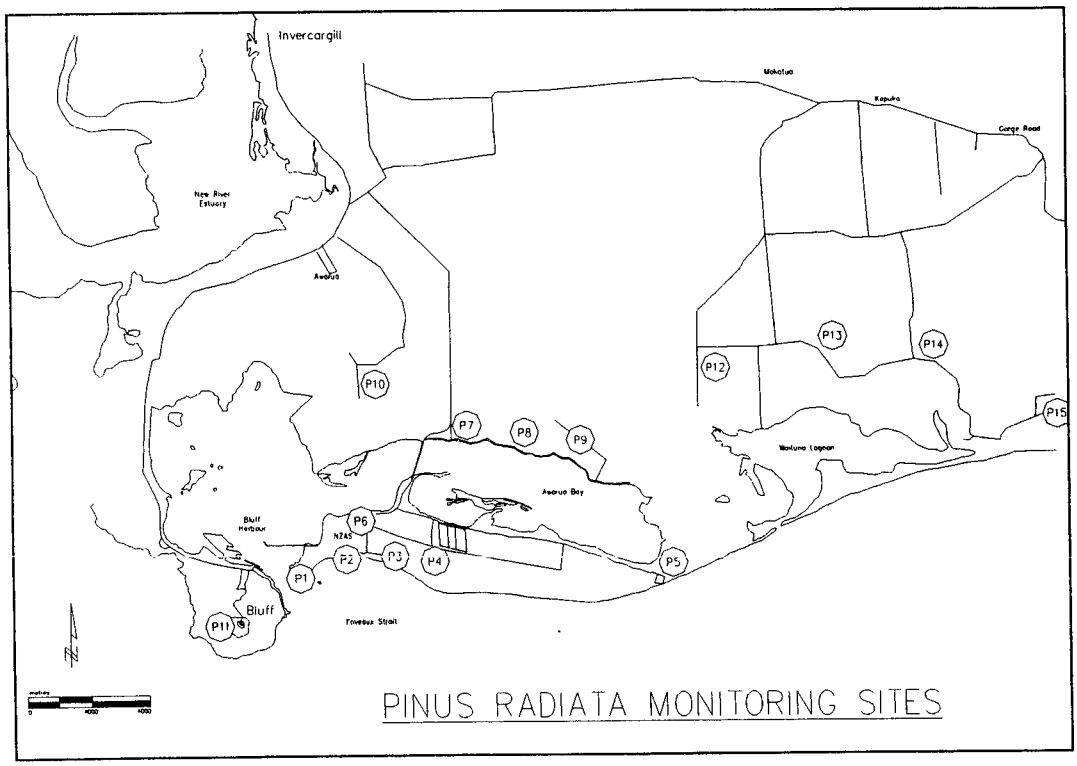
Permit Guidelines

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

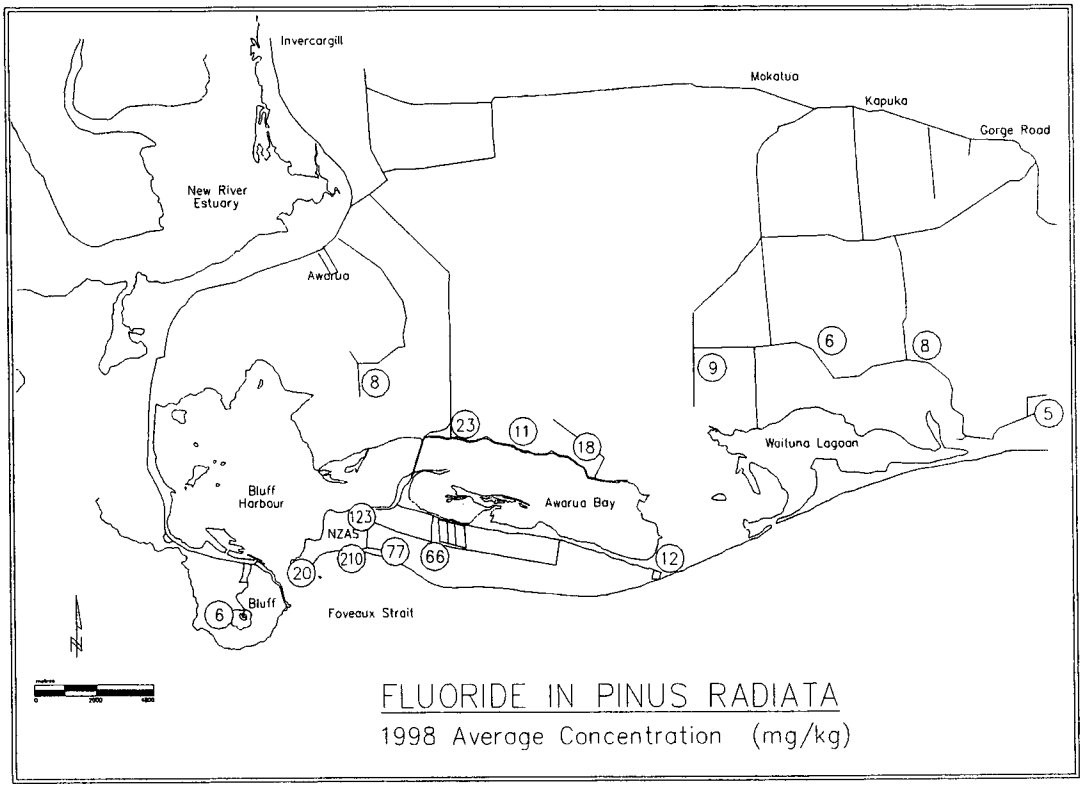
Five sites were removed from the monitoring program following the samples collected on 13 August 1998. The sites removed were P10, P12, P13, P14, and P15.

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



Pinus Radiata Monitoring Results

The 1998 annual average fluoride concentrations of pine needle samples collected from the monitoring sites are shown in the following map.



Comments

The fluoride concentrations in pinus radiata needles were within the permit guideline during 1998.

The fluoride concentrations of needles sampled within the influence of the Potline roof louvres discharge, within about two kilometres of the smelter, were similar to those reported for 1997. The concentrations at these sites does not reflect the decreased Potline roof louvre discharge most likely because the needles sampled during the first three quarters grew during Quarter Four 1996 and were exposed to the higher roof louvre discharges during 1996 and early 1997.

The fluoride concentrations of needles at two sites outside the influence of the Potlines roof louvre discharge, P7 and P8, were lower than those reported for 1997. The other sites outside the influence of the Potlines roof louvre discharge had similar concentrations to that reported for 1997.

Part H

The Health of Farm Livestock

Grazing Monitor Project

The Health of Farm Livestock

Grazing Monitor Project

Summary

The conditions of Air Discharge and Coastal Permit Number 93566 were revised following NZAS' application to change or cancel some conditions which was approved by the Southland Regional Council on 5 August 1998. Changes applying the Grazing Monitor Project include,

- reducing the number of farms for grazed pasture sampling from nine to eight and
- reducing the number of farms for monitoring the exposure of cattle to fluoride from four to one.

The monitoring of the fluoride concentration in grazed pasture, cattle urine, and cattle bone generally confirmed the lower exposure to fluoride on farms surrounding the smelter previously discussed in the 1997 report.

Fluoride concentrations in grazed pasture and cattle bone were within the permit standards and guidelines. Apart from the samples collected on GMF16 during February, cattle urinary fluoride concentrations were within the permit guideline. The cause of the high urinary fluoride concentrations measured at GMF16 during February was attributed to farm management.

Some of the grazed pasture and cattle urinary fluoride concentrations were higher in 1998 than in 1997 but these remained lower than in recent years prior to 1997.

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.

Permit Changes Regarding the Health of Farm Livestock

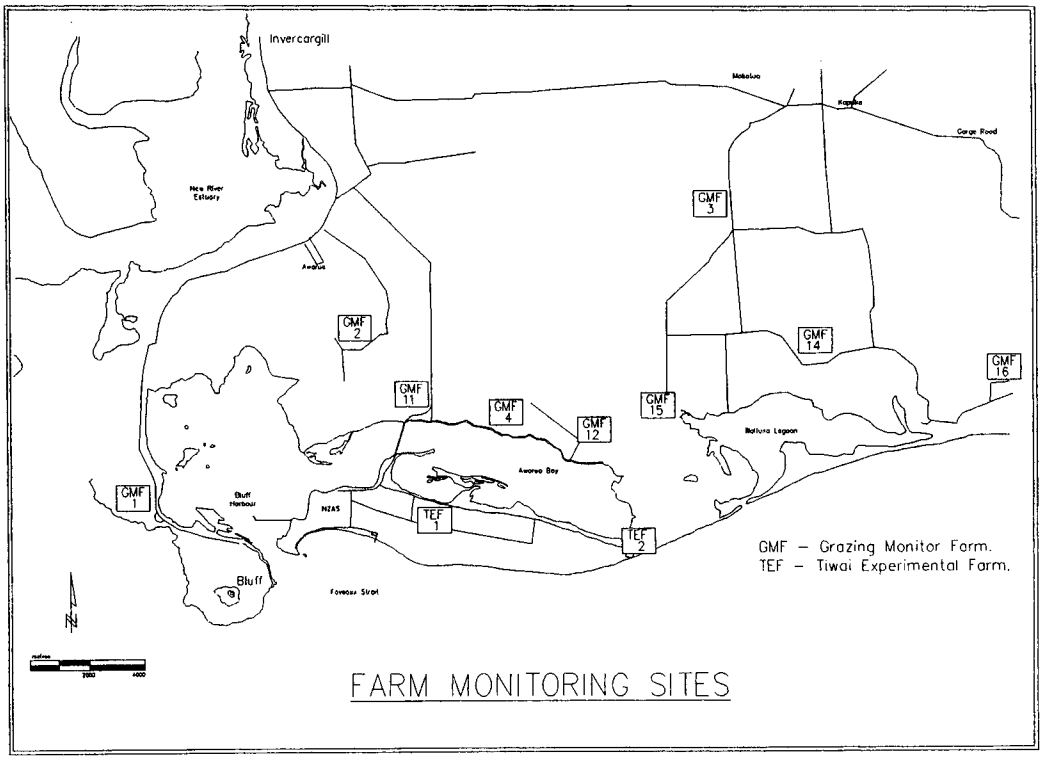
The changes to the permit that effect monitoring related to the health of farm livestock are shown in the following table.

What has changed	Amended to	Original
Grazed pasture, number of sampling locations.	Eight sites. Site removed: • GMF 15	Nine sites.
Dairy Cattle urine, number of sampling locations.	None. Sites removed: • GMF 14 • GMF 16	Two sites.
Beef Cattle urine, number of sampling locations.	One site: Site removed: • GMF 1	Two sites.
Cattle dental inspections, number of sampling locations.	One site: Sites removed: • GMF1 • GMF14 • GMF16	Four sites.
Cattle tail bone biopsies, number of sampling locations.	One site: Sites removed: • GMF1 • GMF14 • GMF16	Four sites.

The changes to the permit came into effect on 1 September 1998. GMF4 is the site chosen for monitoring the dental condition and fluoride content of bone and urine in cattle.

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.



Note: GMF15 was removed from the monitoring program on 1 September 1998.

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,
- assessing the dental condition of cattle,
- veterinary inspection during other sampling, and
- feedback from farmers.

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.

General Animal Condition

The livestock fluoride exposure from smelter discharges is well below accepted maximum levels. As expected, there is no evidence of animal health conditions related to the smelter discharges.

Permit Standards

The Air Discharge and Coastal Permit contains a number of standards. A standard is defined in the permit as a limit which 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:

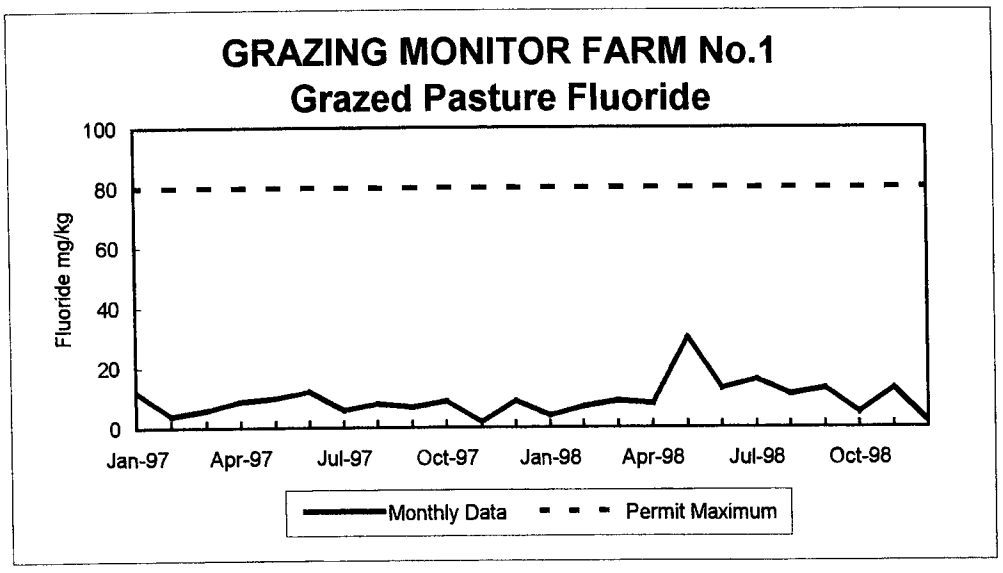
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	30
Two monthly average maximum	mg/kg	60	22
Twelve monthly running average maximum	mg/kg	40	12
Annual average	mg/kg		11

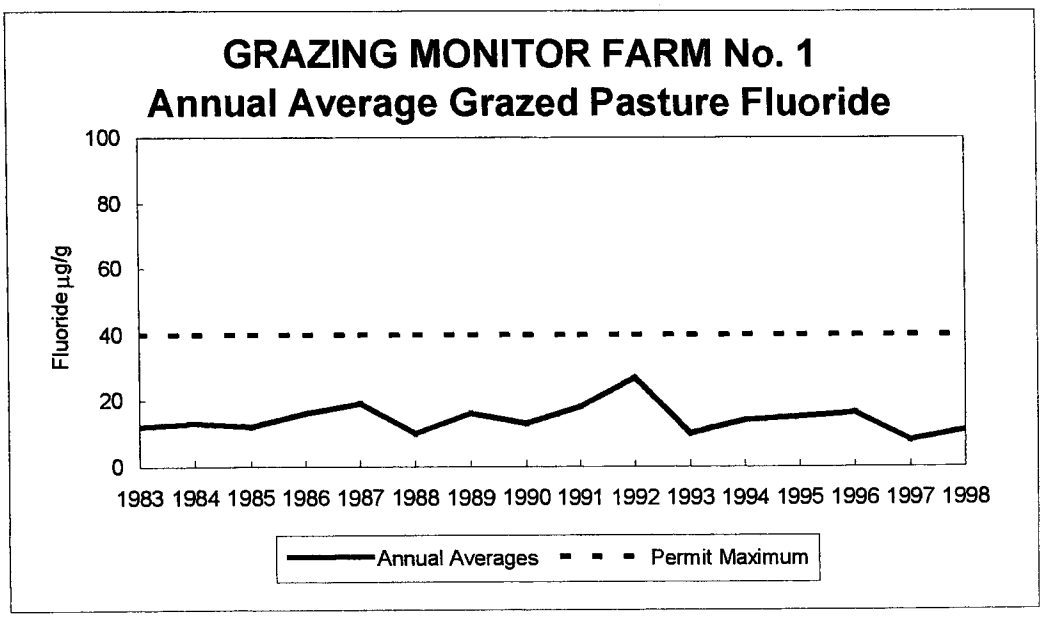
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



Grazing Monitor Farm No.1, Continued

Fluoride in grazed pasture, continued

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



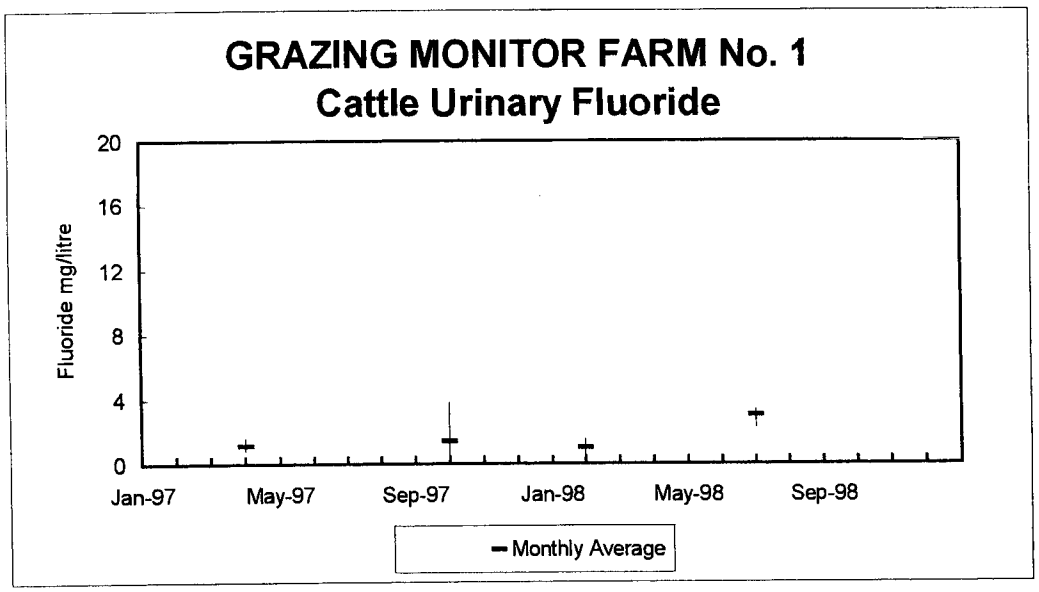
Grazing Monitor Farm No.1, Continued

Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1998.

	Units	Guideline	1998
Average fluoride concentration	mg/L	-	2.0
Maximum fluoride concentration	mg/L	10	3.4
Minimum fluoride concentration	mg/L	-	<1.0
No. of samples	mg/L	-	7

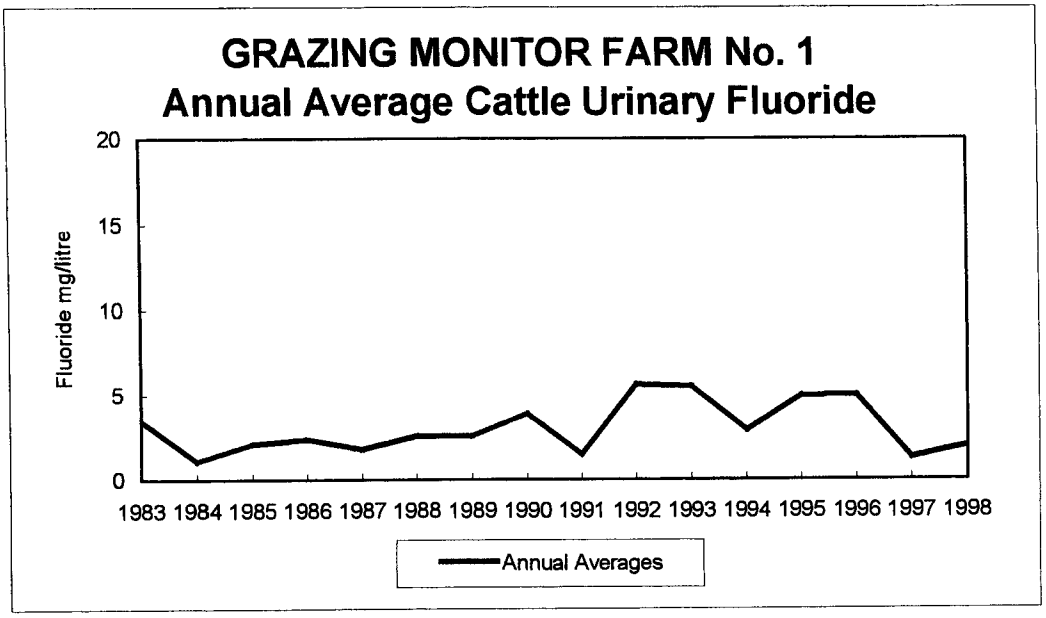
The following graph shows the results of urinary fluoride monitoring of cattle during 1997 and 1998. The horizontal bars show the average concentration of the samples and the vertical bars show the range of concentrations.



Grazing Monitor Farm No.1, Continued

Cattle urinary fluoride, continued

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



Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1998.

Identification	Age	Units	Guideline	1998
Heifer	2	mg/kg	1605	350
Bull	2	mg/kg	1605	425
9	5	mg/kg	-	1,100
103	5	mg/kg	-	1,050

Grazing Monitor Farm No.1, Continued

Cattle dental condition

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

Year of tooth formation	1996	1997
Average tooth score	2	2
Maximum tooth score	2	2
Minimum tooth score	2	2
No. of cattle inspected	2	1

No new teeth were inspected during 1998. All had been inspected and reported in previous reports.

Comments

The fluoride concentrations of grazed pasture, cattle urine and cattle bone on GMF 1 were within the permit standards and guidelines during 1998.

The 1998 annual average fluoride concentration in grazed pasture was 11 mg/kg and in urinary fluoride was 2.0 mg/L, both of which were about 50% higher than during 1997. The 1998 concentrations were lower than for recent years prior to 1997.

The fluoride concentration of bone samples from two year old cattle averaged 390 mg/kg which was about the same as was measured in 1997.

The teeth of four cattle were inspected on this farm during 1998. All teeth had previously been inspected and the results reported in previous reports.

Grazing Monitor Farm No. 2

Introduction

The following information is contained in this section:

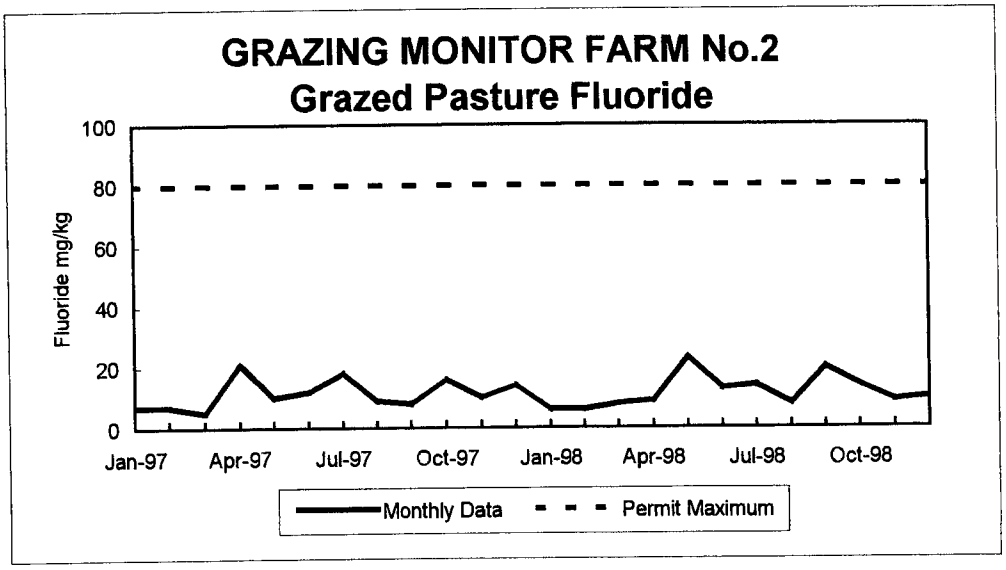
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	23
Two monthly average maximum	mg/kg	60	18
Twelve monthly running average maximum	mg/kg	40	12
Annual average	mg/kg		12

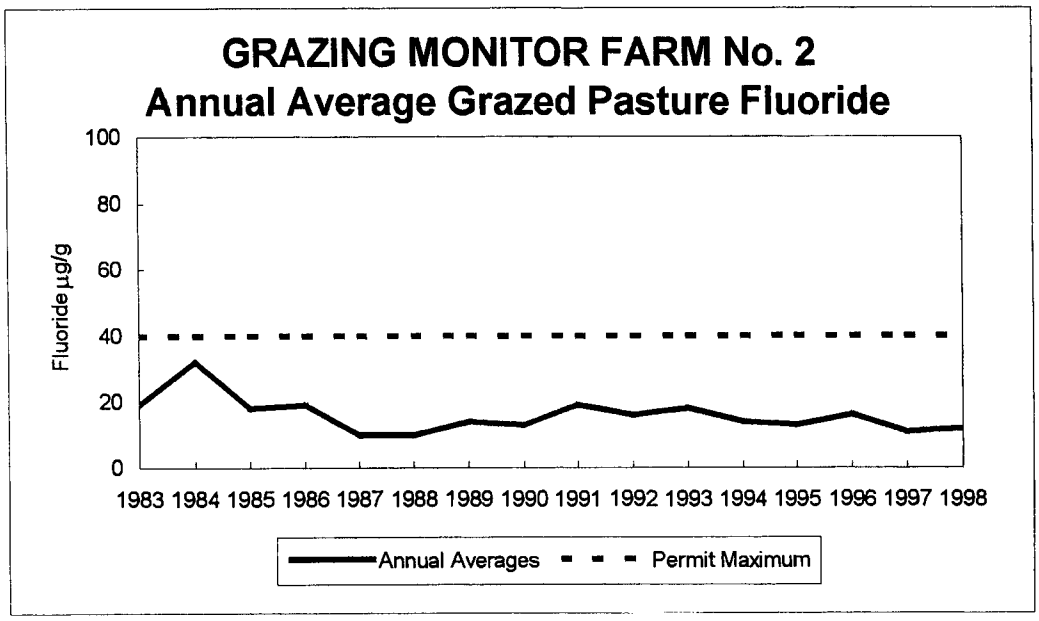
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 1998 average grazed pasture fluoride concentration of 12 mg/kg was similar to the average fluoride concentration measured during 1997.

Grazing Monitor Farm No. 3

Introduction

The following information is contained in this section:

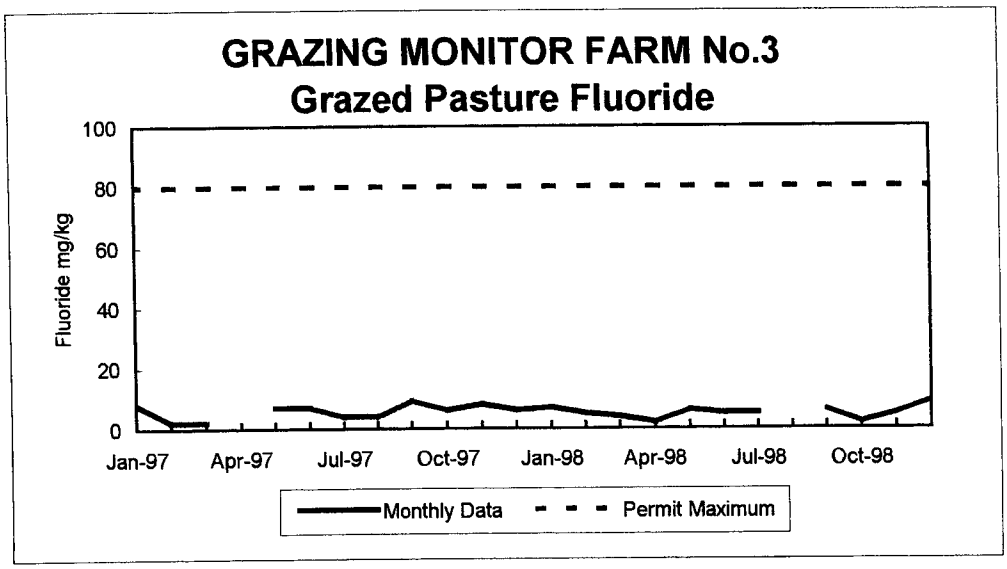
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	9
Two monthly average maximum	mg/kg	60	7
Twelve monthly running average maximum	mg/kg	40	6
Annual average	mg/kg		5

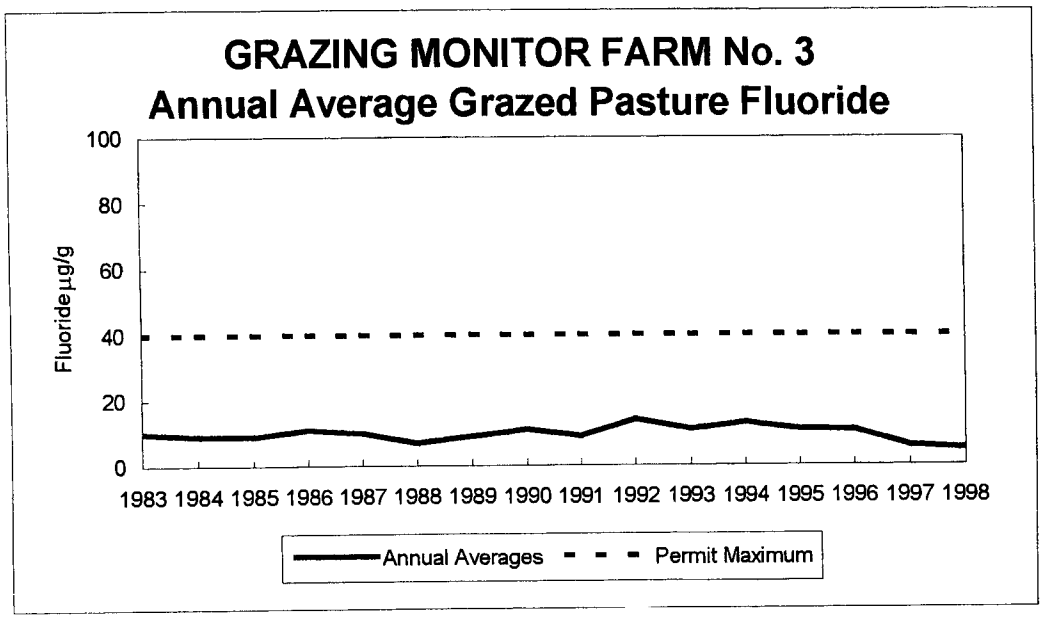
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 1998 annual average grazed pasture fluoride concentration of 5 mg/kg was similar to the concentration measured during 1997.

No grazed pasture fluoride concentration was reported for August as the site was topdressed just prior to sampling. Condition C2.2 of the Air Discharge Permit exempts samples collected within 28 day of topdressing from the permit standards.

Grazing Monitor Farm No. 4

Introduction

The following information is contained in this section:

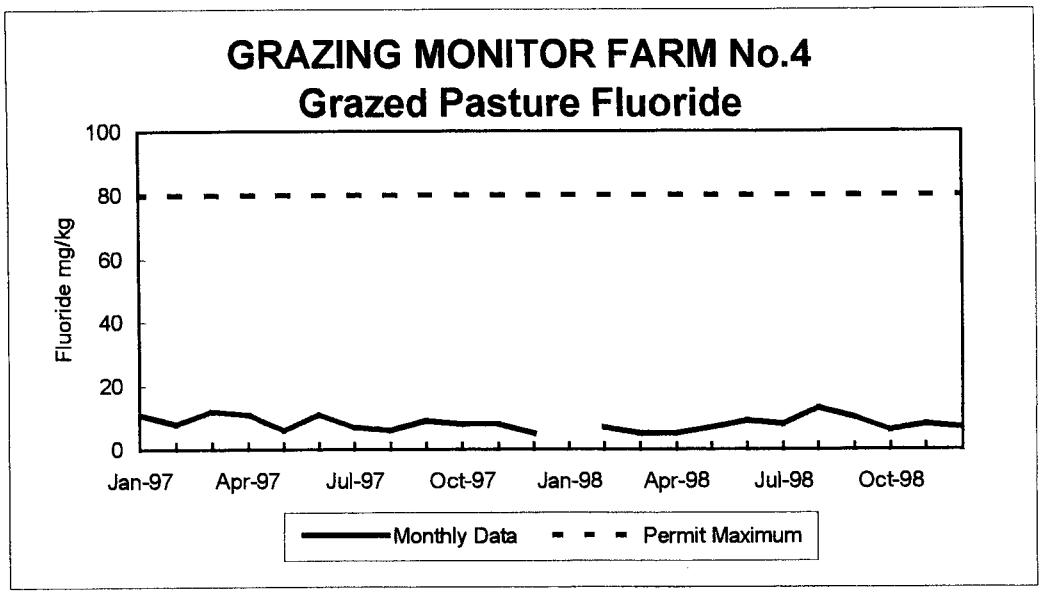
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	13
Two monthly average maximum	mg/kg	60	12
Twelve monthly running average maximum	mg/kg	40	8
Annual average	mg/kg		8

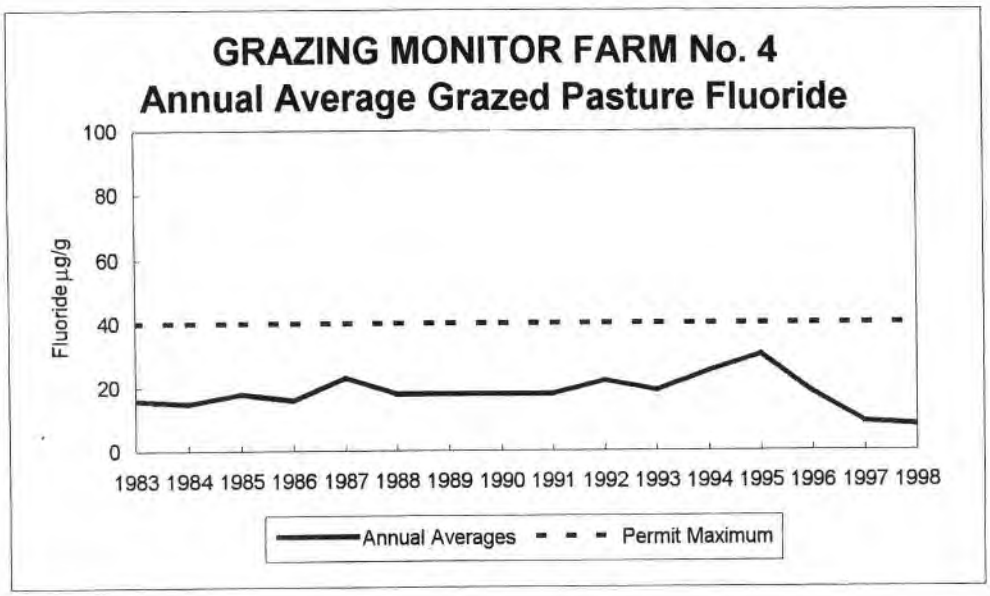
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 1998.

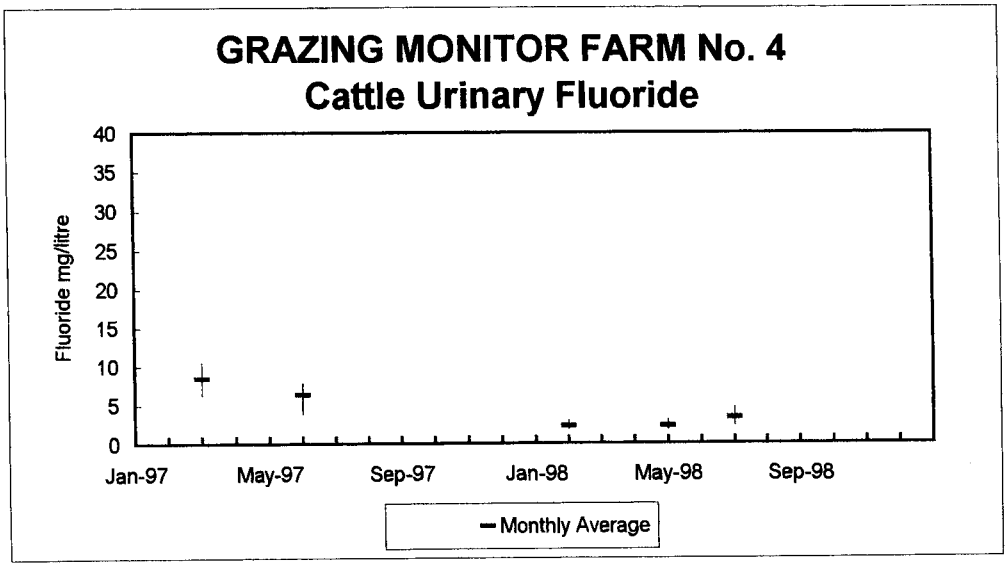
	Units	Guideline	1998
Average fluoride concentration	mg/L	-	2.6
Maximum fluoride concentration	mg/L	10	4.7
Minimum fluoride concentration	mg/L	-	1.7
No. of samples	mg/L	-	15

15 urinary F- samples

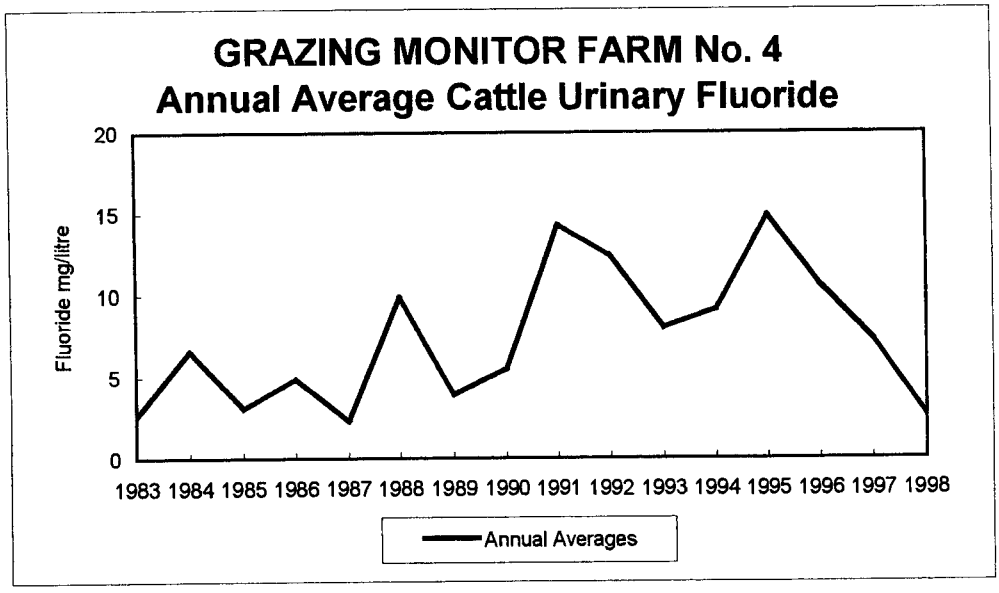
Grazing Monitor Farm No. 4, Continued

Cattle urinary fluoride, continued

The following graph shows the results of urinary fluoride monitoring of cattle during 1997 and 1998. 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.



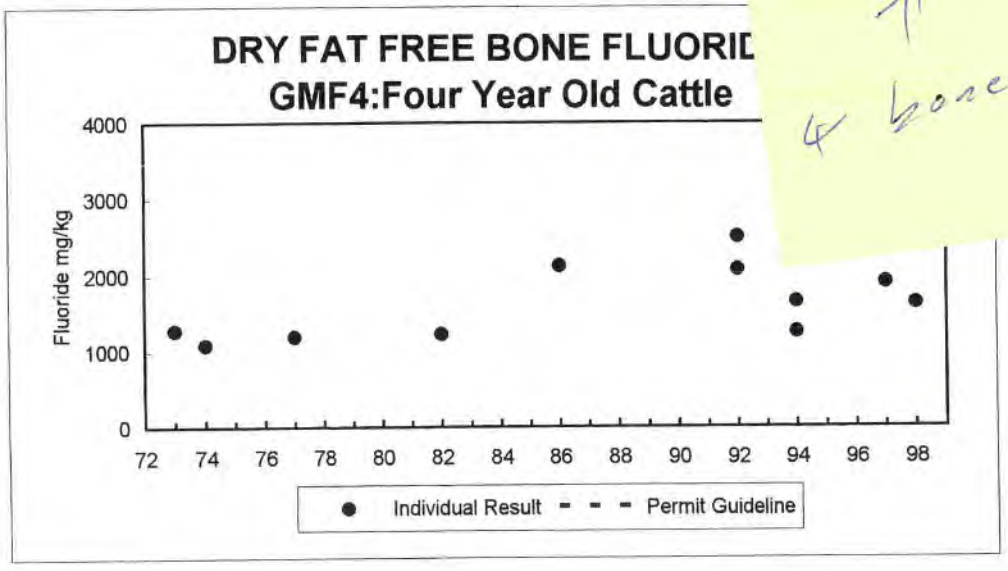
Grazing Monitor Farm No. 4, Continued

Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1998.

Identification	Age	Units	Guideline	1998
Black	3	mg/kg	-	1,325
Blue Black	3	mg/kg	-	1,100
Jersey	4	mg/kg	2,379	1,625
Brown	6	mg/kg	2,794	1,600

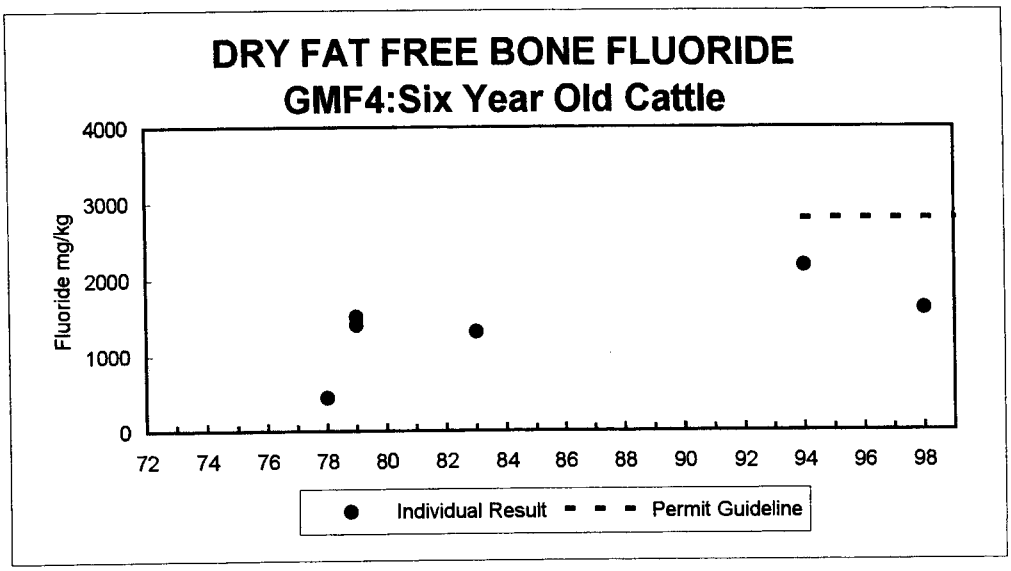
The following graph shows the bone fluoride concentration of individual biopsies collected from four-year-old cattle since the project began.



Grazing Monitor Farm No. 4, Continued

Cattle bone fluoride, continued

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



Grazing Monitor Farm No. 4, Continued

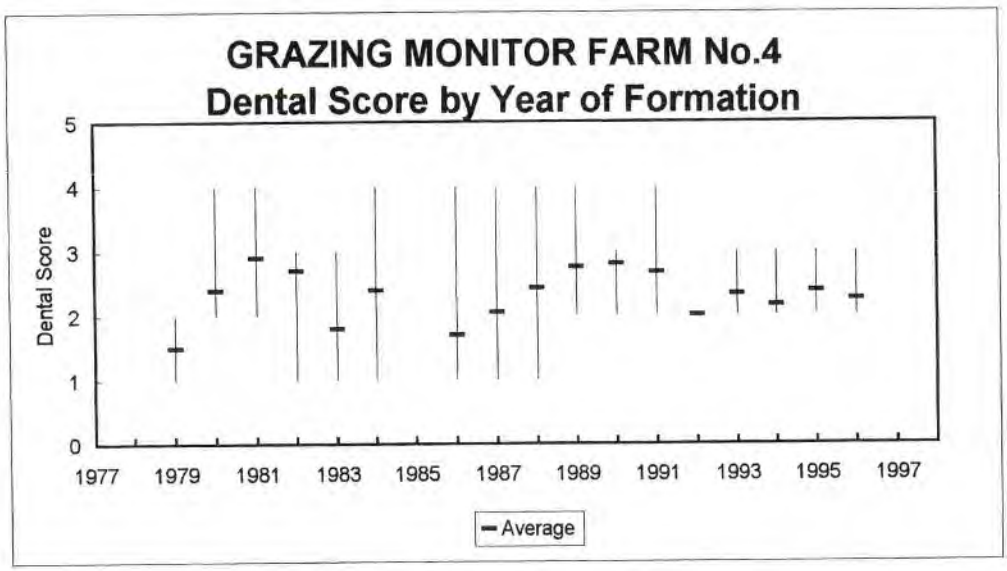
14 cattle inspected once teeth.

Cattle dental condition

The following table summarises combined results of the dental in

Year of tooth formation	1994	1995	1996
Average tooth score	2.2	2.4	2.3
Maximum tooth score	3	3	3
Minimum tooth score	2	2	2
No. of cattle inspected	5	7	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 grazed pasture, cattle urine and cattle bone on GMF4 were within the permit standards and guidelines during 1998.

The 1998 annual average grazed pasture fluoride concentration of 9 mg/kg was similar to the average concentration measured during 1997. No grazed pasture fluoride concentration was reported for January, as the site was topdressed within 28 days of sampling. Condition C2.2 of the Air Discharge Permit exempts samples collected within 28 day of topdressing from the permit standards.

The annual average urinary fluoride concentration measured during 1998 was 2.6 mg/litre, which was lower than the 7.3 mg/litre measured during 1997. The maximum individual urinary fluoride concentration measured during 1998 was 4.7 mg/litre compared with a maximum of 10.6 mg/litre measured during 1997.

The average fluoride concentration of bones sampled from three-year-old cattle during 1998 was about 1225 mg/kg, which is about 30% lower than for 1997. The lower bone fluoride concentrations measured in the three year old cattle during 1998 may be the result of the lower grazed pasture fluoride concentrations on this farm since the commissioning of all the dry scrubbing equipment in January 1997. Lower fluoride concentrations were also measured in bone sampled from a four-year-old cow and from a six-year-old cow.

The dental scores in cattle inspected during 1998 were generally lower than those inspected during 1997. New teeth inspected during 1998 were formed during 1994, 1995 and 1996 when fluoride concentrations measured on this farm were at a peak or had just started to decline.

The continued decrease in urinary fluoride and bone fluoride concentration, and the lower tooth scores are as expected for the years immediately after the commissioning of the dry scrubbing equipment.

Grazing Monitor Farm No. 11

Introduction

The following information is contained in this section:

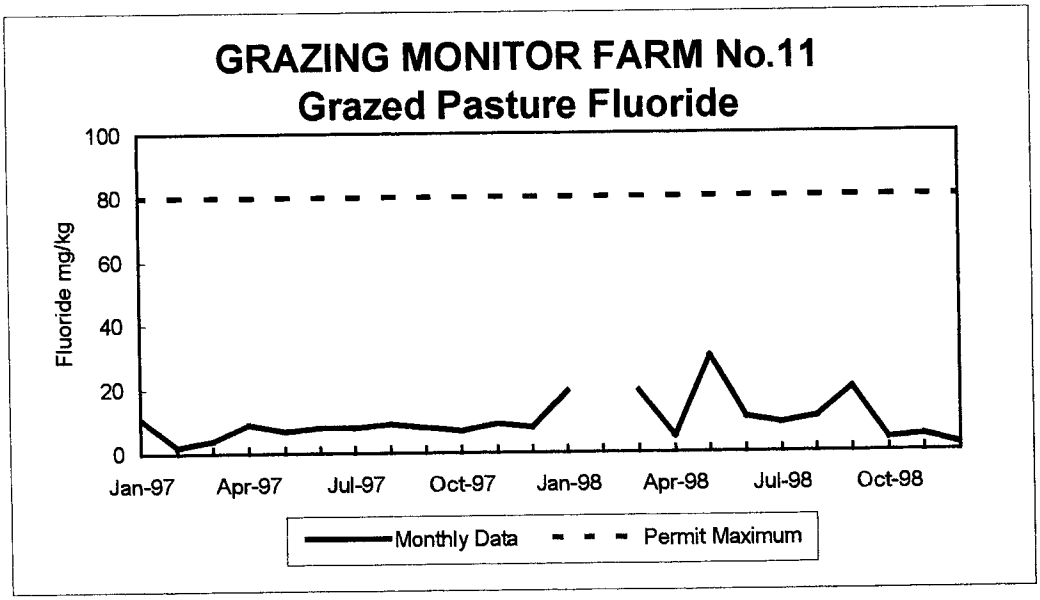
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	30
Two monthly average maximum	mg/kg	60	21
Twelve monthly running average maximum	mg/kg	40	13
Annual average	mg/kg		12

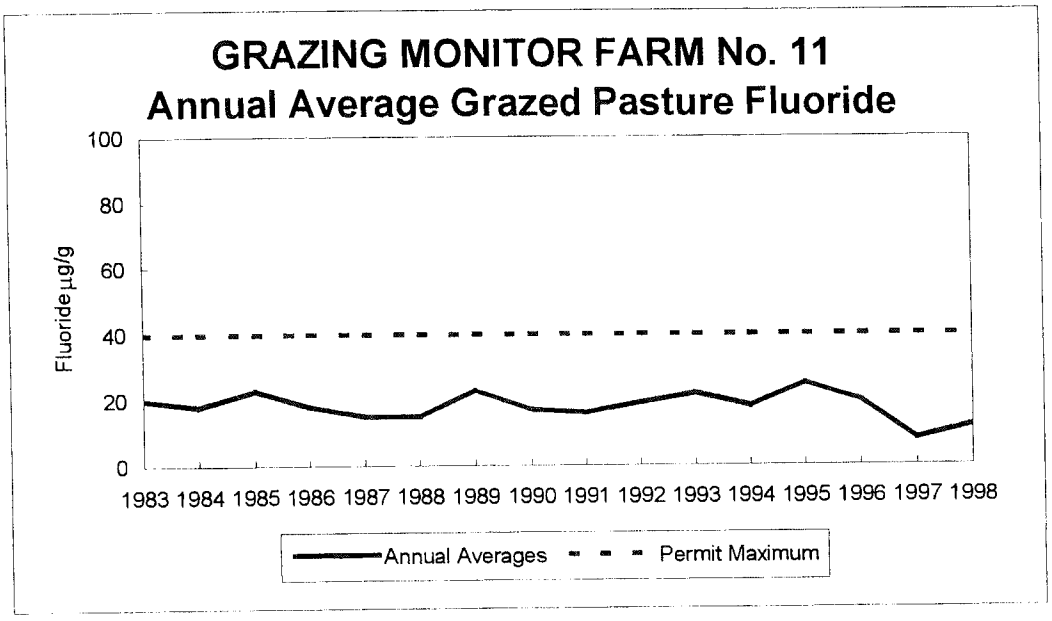
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 1998 annual average grazed pasture fluoride concentration of 12 mg/kg was higher than the 8 mg/kg recorded during 1997 but remained lower than for recent years prior to 1997. No grazed pasture fluoride concentration was reported for February as the site was topdressed within 28 days of sampling. Condition C2.2 of the Air Discharge Permit exempts samples collected within 28 day of topdressing from the permit standards.

Grazing Monitor Farm No. 12

Introduction

The following information is contained in this section:

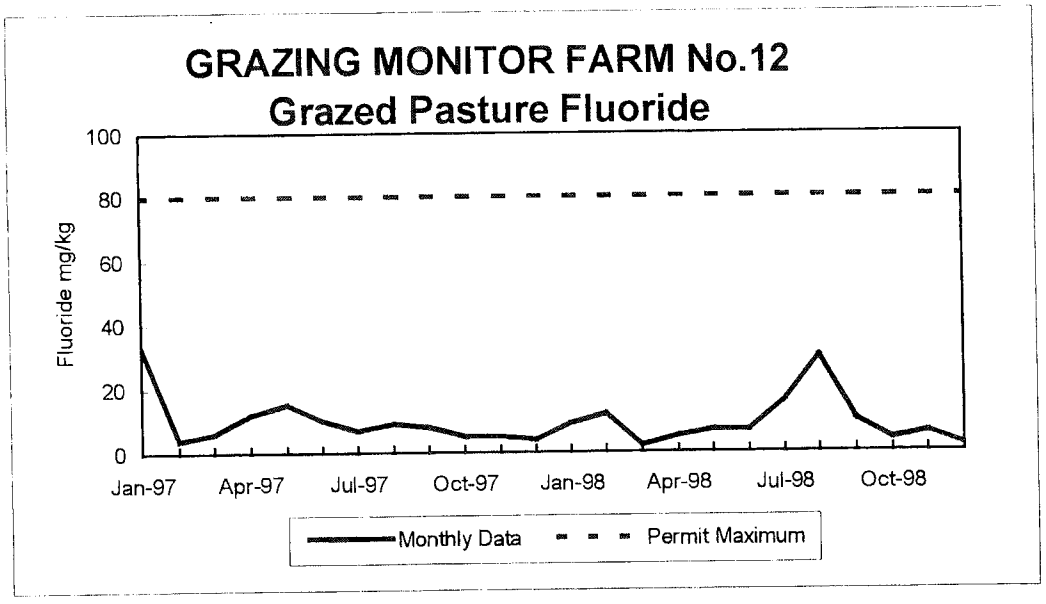
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the maximum grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	30
Two monthly average maximum	mg/kg	60	23
Twelve monthly running average maximum	mg/kg	40	9
Annual average	mg/kg		9

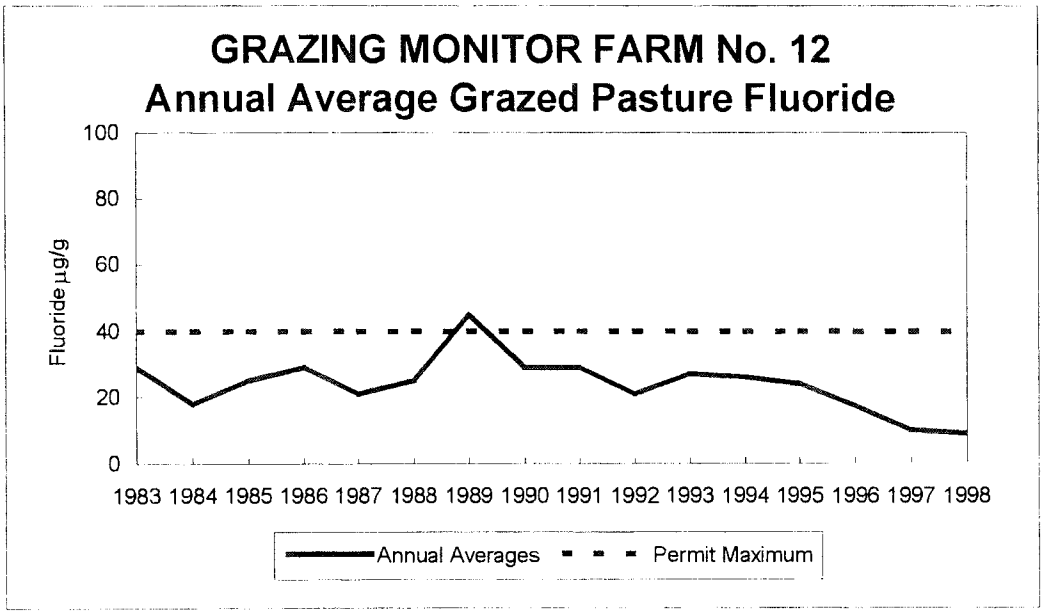
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 1998 annual average grazed pasture fluoride concentration of 9 mg/kg was similar to the average concentration measured during 1997.

Grazing Monitor Farm No. 14

Introduction

The following information is contained in this section:

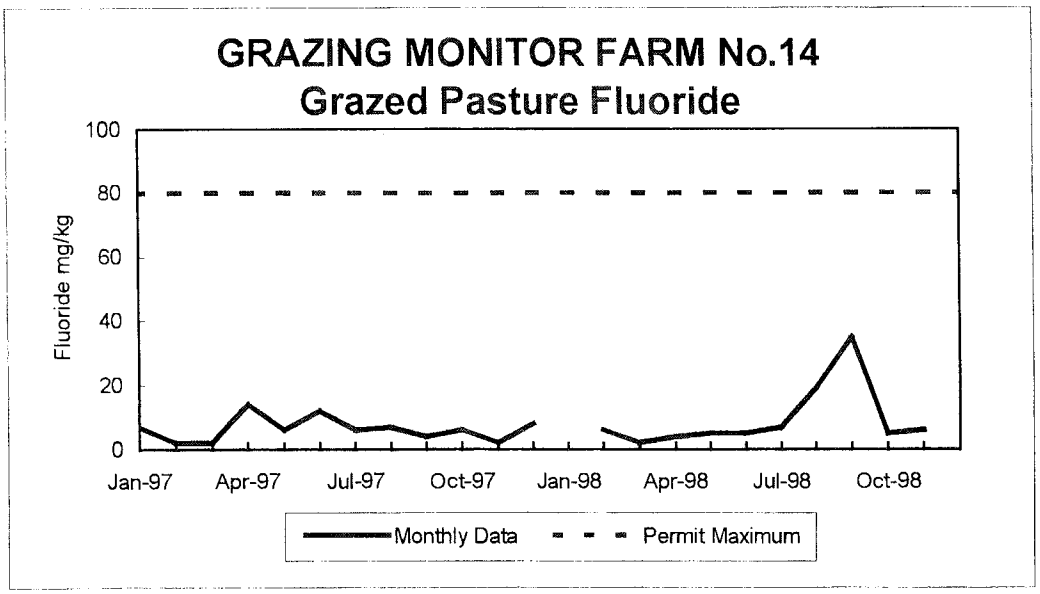
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	35
Two monthly average maximum	mg/kg	60	27
Twelve monthly running average maximum	mg/kg	40	9
Annual average	mg/kg		9

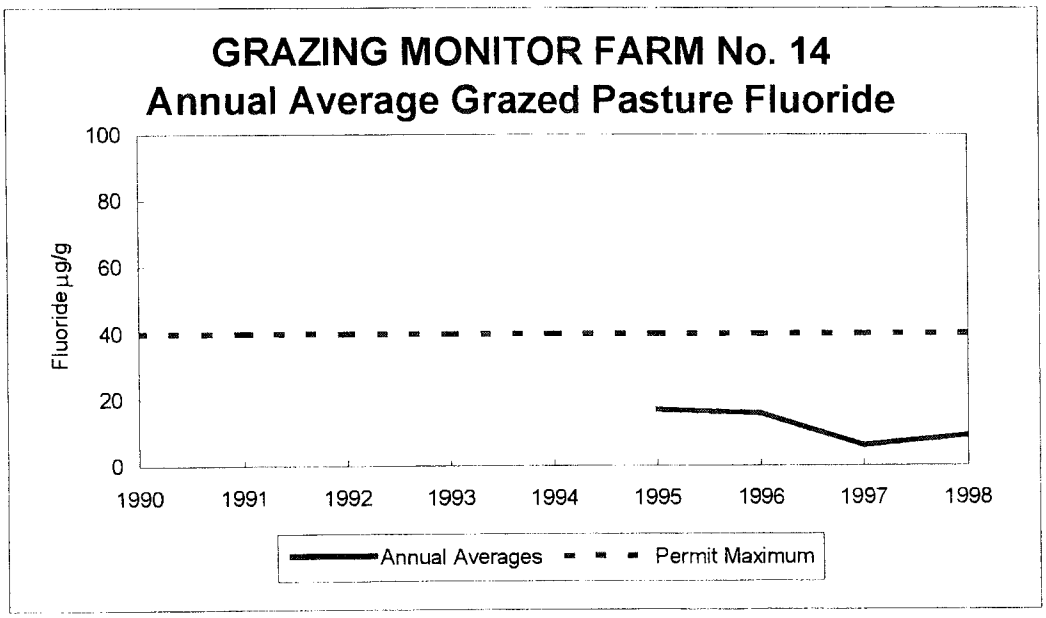
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



Grazing Monitor Farm No. 14, Continued

Fluoride in grazed pasture, continued

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



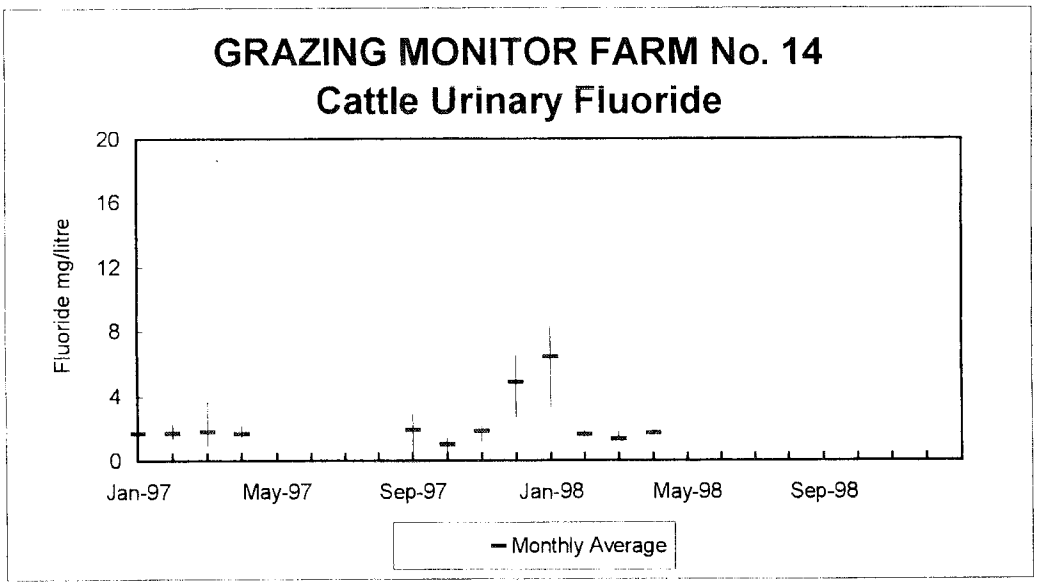
Grazing Monitor Farm No. 14, Continued

Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1998.

	Units	Guideline	1998
Average fluoride concentration	mg/L	-	2.8
Maximum fluoride concentration	mg/L	10	8.3
Minimum fluoride concentration	mg/L	-	1.2
No. of samples	mg/L	-	20

The following graph shows the results of urinary fluoride monitoring of cattle during 1997 and 1998. The horizontal bars show the average concentration of the samples and the vertical bars show the range of concentrations.

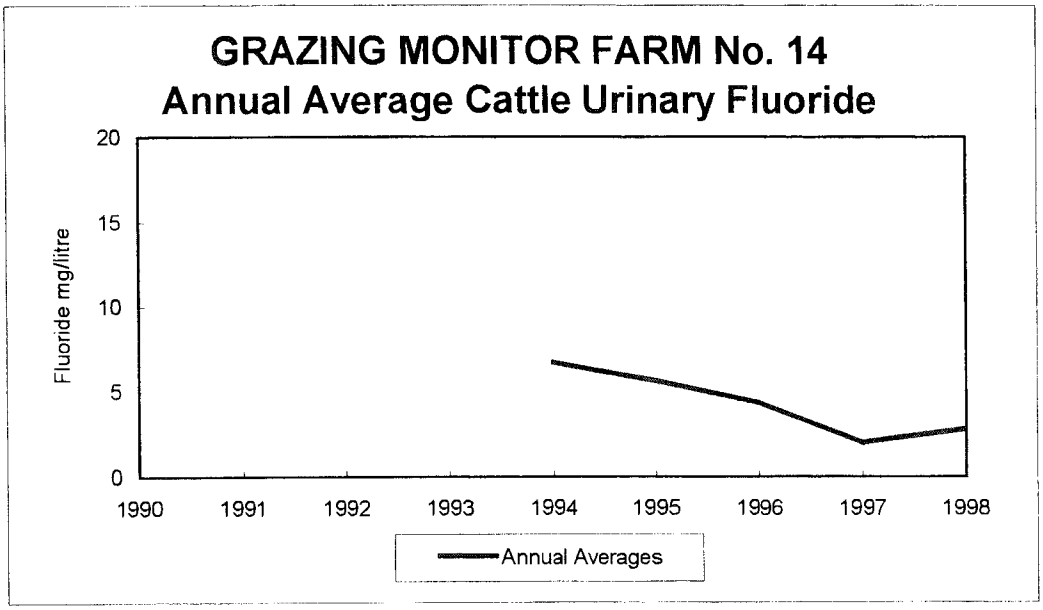


As is discussed in "Permit Changes Regarding Health of Farm Livestock" monitoring of urinary fluoride concentrations at GMF14 was removed from the program on 1 September 1998.

Grazing Monitor Farm No. 14, Continued

Cattle urinary fluoride, continued

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



Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1998.

Identification	Age	Units	Guideline	Fluoride
5	2	mg/kg	1605	625
433	2	mg/kg	1605	700
1284	4	mg/kg	2379	1225
1303	4	mg/kg	2379	1125

Grazing Monitor Farm No. 14, Continued

Cattle dental condition.

The following table summarises the results of the cattle dental inspections.

Year of tooth formation	1994	1995	1996
Average tooth score	1.9	1.9	2.0
Maximum tooth score	3	3	2
Minimum tooth score	1	1	2
No of cattle inspected	13	9	5

Comments

The fluoride concentrations in grazed pasture, cattle bone and cattle urine were within the permit standards and permit guidelines during 1998.

The 1998 annual average grazed pasture fluoride concentration of 9 mg/kg was higher than the 6 mg/kg measured during 1997 but remained lower than for the years before 1997. No grazed pasture fluoride concentrations were reported for January and December as the sites were topdressed within 28 days of sampling. Condition C2.2 of the Air Discharge Permit exempts samples collected within 28 day of topdressing from the permit standards.

The 1998 annual average urinary fluoride concentration of 2.8 mg/L was higher than the 2.0 mg/L measured during 1997 but remained lower than for the years before 1997. The average was affected by the higher than normal January result that was most likely affected by the application of fertiliser during the month. Urine samples were not collected after April as the cattle were not milked during the winter and farm livestock monitoring on this farm was removed from the program on 1 September as is discussed in "Permit Changes Regarding Health of Farm Livestock". Lack of samples during the latter part of 1998 may also have affected the annual average fluoride concentration.

The bone fluoride concentrations in samples collected from two-year-old cattle during 1998 averaged 665 mg/kg, which was lower than the 925 mg/kg measured during 1997. The bone fluoride concentration of samples collected from four year old cattle averaged 1175 mg/kg which is within the expected range for this farm.

Grazing Monitor Farm No. 14, Continued

Comments, continued

Tooth scores measured in cattle during 1998 were formed during 1994, 1995, and 1996. The results combined with the results of previous inspections show there is little change in the average score for teeth formed during the 1994 – 96 period. The 1995 average of 1.9 is lower than the average of 3 reported in the 1997 report. The average reported in the 1997 report was from the assessment of two cattle only. Assessing teeth from an additional seven cattle during 1998 has provided a more accurate assessment of the condition of teeth formed during 1995.

Grazing Monitor Farm No. 15

Introduction

The following information is contained in this section:

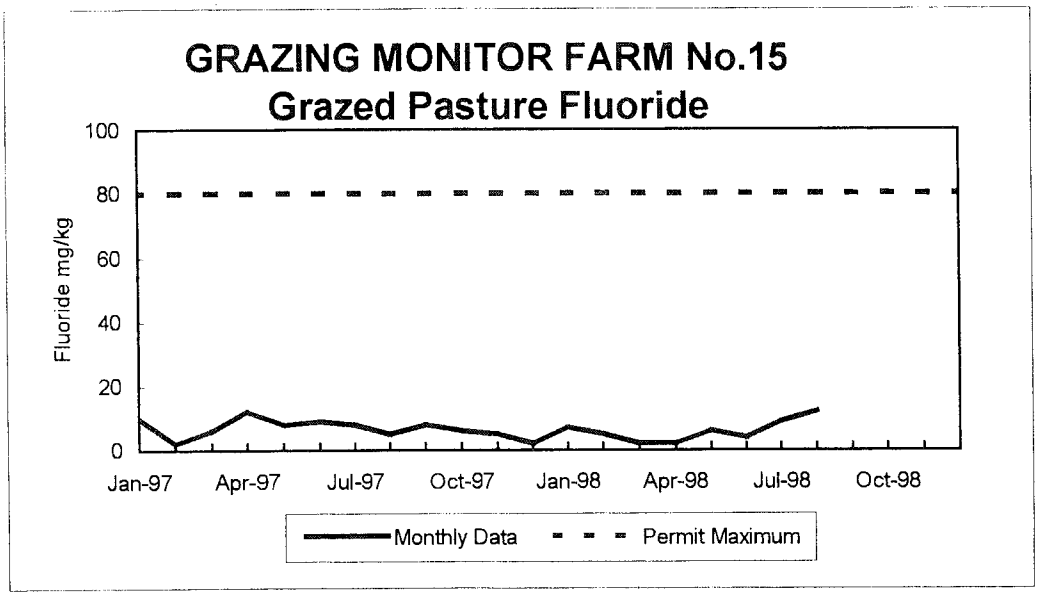
- fluoride in grazed pasture, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	12
Two monthly average maximum	mg/kg	60	11
Twelve monthly running average maximum	mg/kg	40	7
Annual average	mg/kg		6

The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.

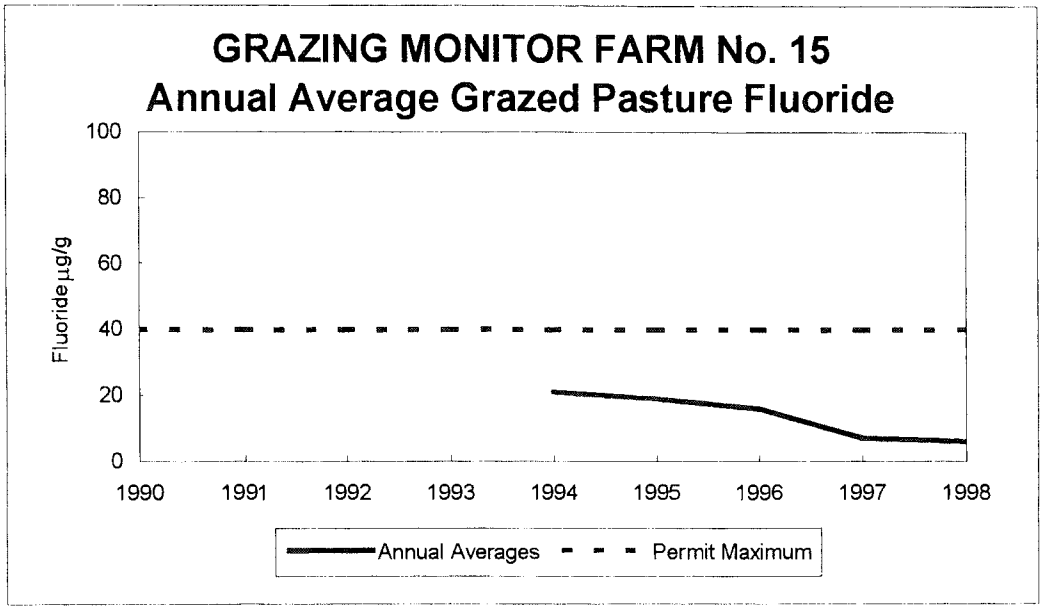


As is discussed in "Permit Changes Regarding Health of Farm Livestock" GMF15 was removed from the program on 1 September 1998.

Grazing Monitor Farm No. 15, 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. The 1998 annual average grazed pasture fluoride concentration of 6 mg/kg was similar to the average concentration measured during 1997.

Grazing Monitor Farm No. 16

Introduction

The following information is contained in this section:

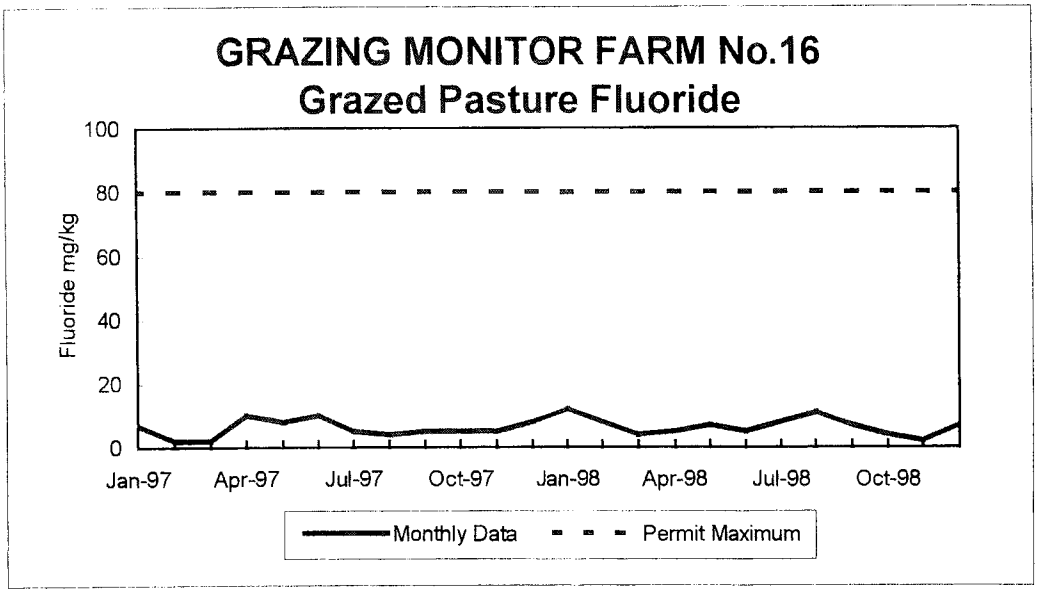
- fluoride in grazed pasture,
- cattle urinary fluoride,
- cattle bone fluoride,
- cattle dental condition, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	Standard	1998
Monthly sample maximum	mg/kg	80	12
Two monthly average maximum	mg/kg	60	10
Twelve monthly running average maximum	mg/kg	40	7
Annual average	mg/kg		7

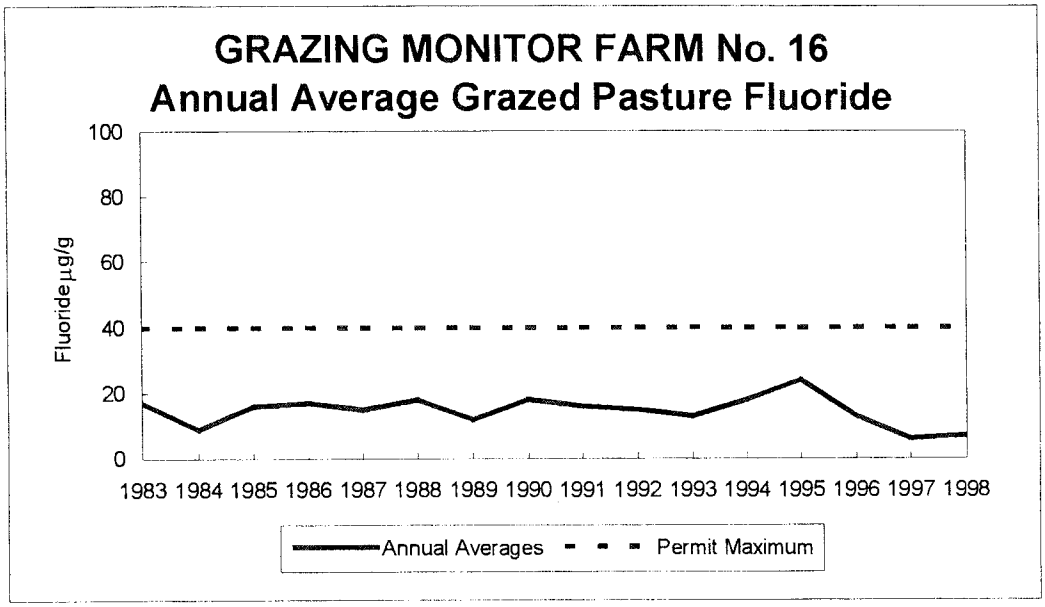
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



Grazing Monitor Farm No. 16

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 1997 as it is in the same ownership as GMF16 and pasture samples from the two farms during the years 1994 to 1997 indicated similar results.



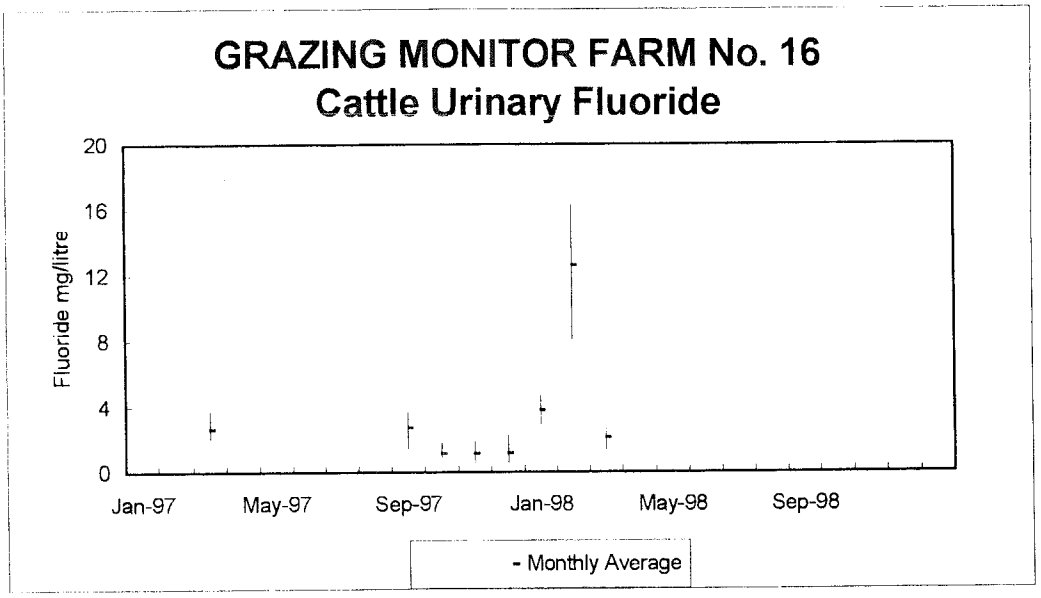
Grazing Monitor Farm No. 16, Continued

Cattle urinary fluoride

The following table summarises the results of cattle urinary fluoride monitoring during 1998.

	Units	Guideline	1998
Average fluoride concentration	mg/L	-	6.2
Maximum fluoride concentration	mg/L	10	16.3
Minimum fluoride concentration	mg/L	-	1.3
No. of samples	mg/L	-	14

The following graph shows the results of urinary fluoride monitoring of cattle during 1997 and 1998. The horizontal bars show the average concentration of the samples and the vertical bars show the range of concentrations.

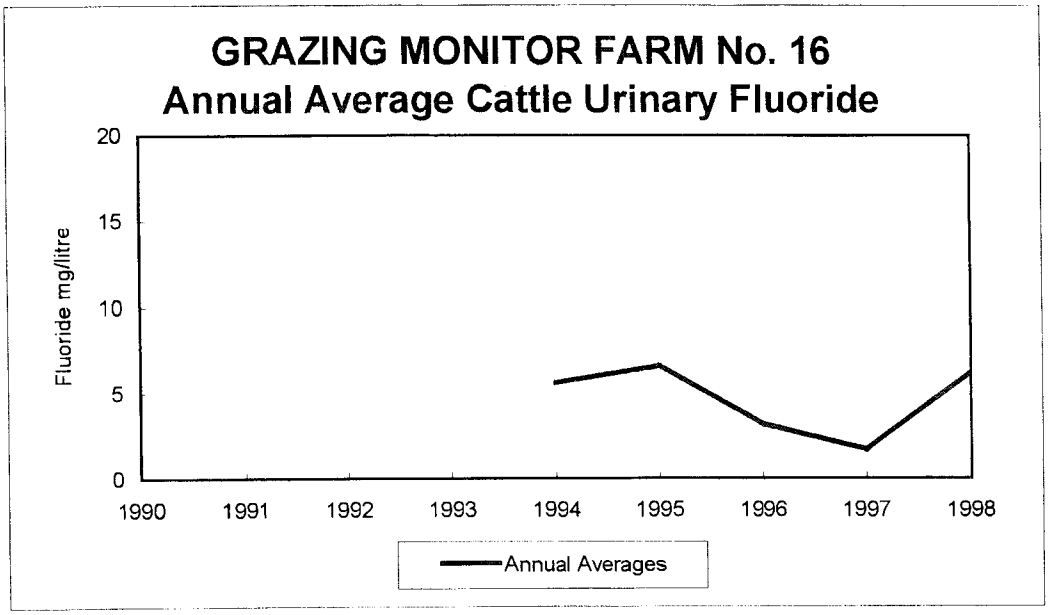


As is discussed in "Permit Changes Regarding Health of Farm Livestock" monitoring of urinary fluoride concentrations at GMF16 was removed from the program on 1 September 1998.

Grazing Monitor Farm No. 16, Continued

Cattle urinary fluoride, continued

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



Cattle bone fluoride

The following table shows the results of bone fluoride monitoring during 1998.

Identification	Age	Units	Guideline	Fluoride
Brown	2	mg/kg	1605	375
Black White Star	2	mg/kg	1605	500
147	4	mg/kg	2379	850
63	6	mg/kg	2794	900

Grazing Monitor Farm No. 16, Continued

Cattle dental condition

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

Year of tooth formation	1994	1995	1996
Average tooth score	2	1.7	2
Maximum tooth score	2	2	2
Minimum tooth score	2	1	2
No of cattle inspected	2	5	4

Comments

The fluoride concentrations in grazed pasture and cattle bone were within the permit standards and permit guidelines during 1998. Three of the four cattle urine samples collected during February were above the permit guideline.

The cause of the high cattle urinary fluoride concentrations measured during February was attributed to farm management because:

- the cattle were grazing on an area that was fertilised about a month prior to the urine sampling,
- routine monthly grazed pasture collected from a different part of the farm 12 days before the urine samples showed no evidence of elevated fluoride concentrations,
- analysis of the wind pattern during February indicated that the elevated fluoride was unlikely to be smelter related.

Other urine samples were within the normal range of results measured on this farm during the past 18 months.

Urine samples were not collected after March as the cattle were not milked during the winter and health of farm livestock monitoring was removed from the program on 1 September as is discussed in "Permit Changes Regarding Health of Farm Livestock".

The 1998 annual average grazed pasture fluoride concentration of 7 mg/kg was similar to the average concentration measured during 1997.

Grazing Monitor Farm No. 16, Continued

Comments, continued

The average fluoride concentration of bones sampled from two-year-old cattle during 1998 was about 450 mg/kg, which were about 50% lower than that measured during 1997. The fluoride concentration of bone sampled from a four-year-old cow was 850 mg/kg compared with 1275 mg/kg during 1997 and 950 mg/kg for a sample collected in 1995. The fluoride concentration of bone sampled from a six year old cow was 900 mg/kg which was lower than expected as younger cattle in previous years had bone fluoride concentrations of 1100 and 1200 mg/kg.

Tooth scores measured in cattle during 1998 were similar to the scores measured in previous years.

Part I

The Health of Farm Livestock

Tiwai Experimental Farms

The Health of Farm Livestock

Tiwai Experimental Farms

Summary

NZAS plans to close the Tiwai Experimental Farm (TEF) Project in May 1999 because a considerable amount of information on the effects of fluoride on sheep is available and little, if any, additional information would be gained if the project continued.

The 1998 annual average fluoride concentrations in grazed pasture on both farms were similar to the 1997 concentrations:

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

The fluoride concentration of jawbone samples collected from younger sheep reflected the lower fluoride concentration of the pasture on TEF1 during the last two years. The fluoride concentration of jawbone sampled from older sheep on TEF1 was within the normal range of results for recent years.

The dental inspection was postponed until March 1999 at both farms to allow more teeth to be available for the final inspection.

The hormone, zearalenone, was detected on both farms during 1998. Zearalenone can reduce the fertility of sheep and may have been present in previous years.

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

NZAS plans to close the TEF Project about May 1999. The reasons for closing the project include:

- the fluoride discharge from the smelter has decreased significantly since the commissioning to the dry scrubbing equipment was completed in January 1997 and
- a considerable amount of information on the effects of fluoride on sheep during increasing and decreasing exposure is available following 28 years of operating the TEF Project and little, if any, additional information would be gained if the project continued.

Tiwai Experimental Farm No.1

Introduction

The following information is contained in this section:

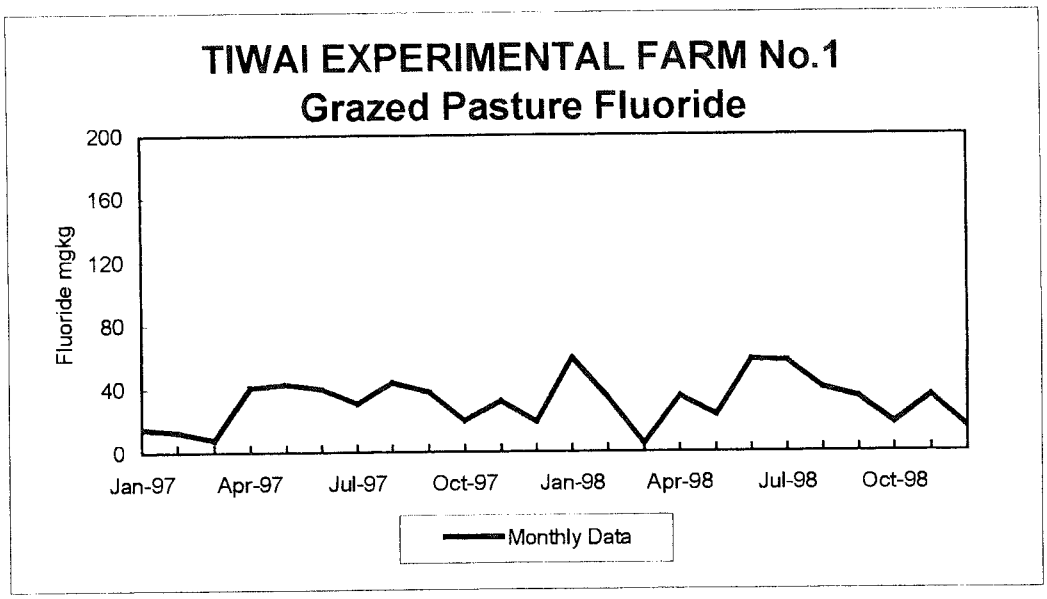
- fluoride in grazed pasture,
- sheep bone fluoride
- dental condition,
- lambing percentage,
- animal health monitoring, and
- comments on the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	1998
Monthly sample maximum	mg/kg	59
Two monthly average maximum	mg/kg	58
Twelve monthly running average maximum	mg/kg	35
Annual average	mg/kg	34

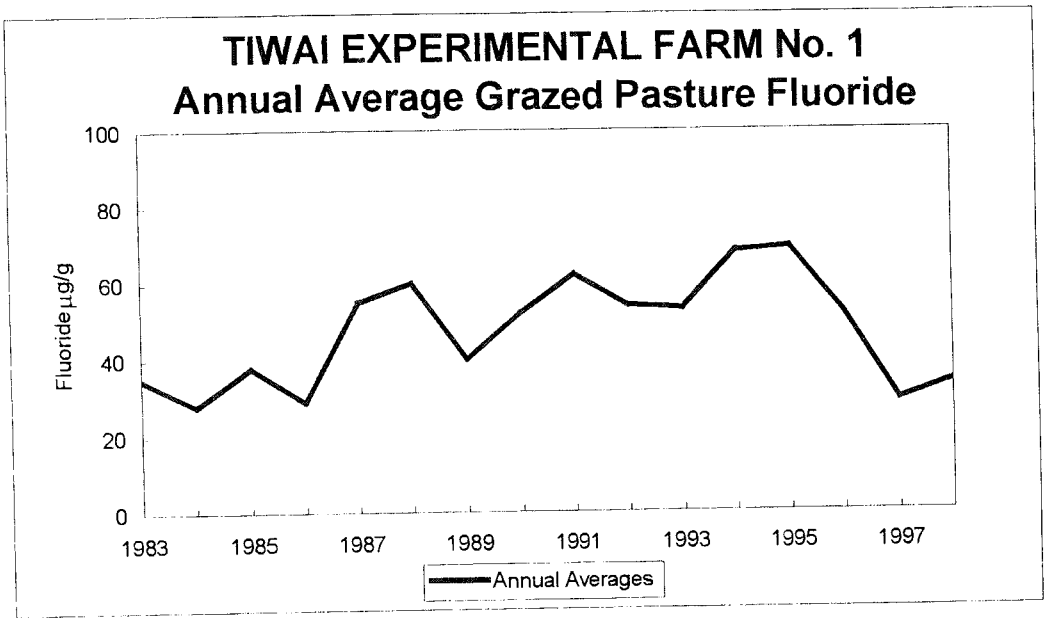
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



Tiwai Experimental Farm No.1, Continued

Fluoride in grazed pasture, continued

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



Tiwai Experimental Farm No.1, Continued

Sheep Bone Fluoride

Jawbone samples were collected from adult sheep in March 1998 and from lambs in May 1998.

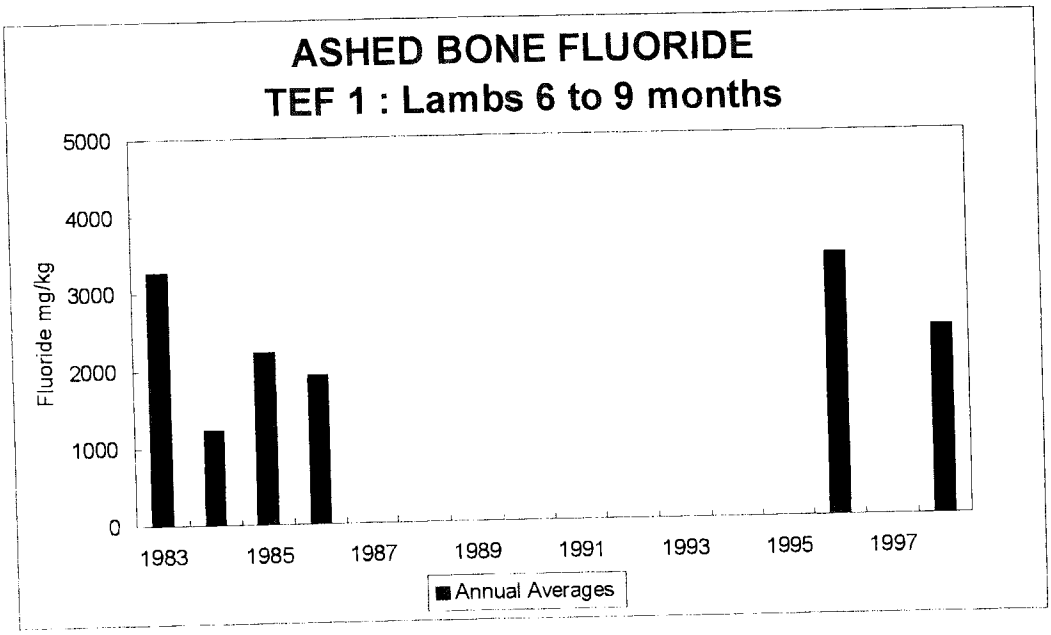
From 1986 until 1993 sheep born on TEF1 were grazed on TEF2 from about four to 16 months of age and then returned to TEF1. Since 1994 sheep have remained on TEF1 since birth.

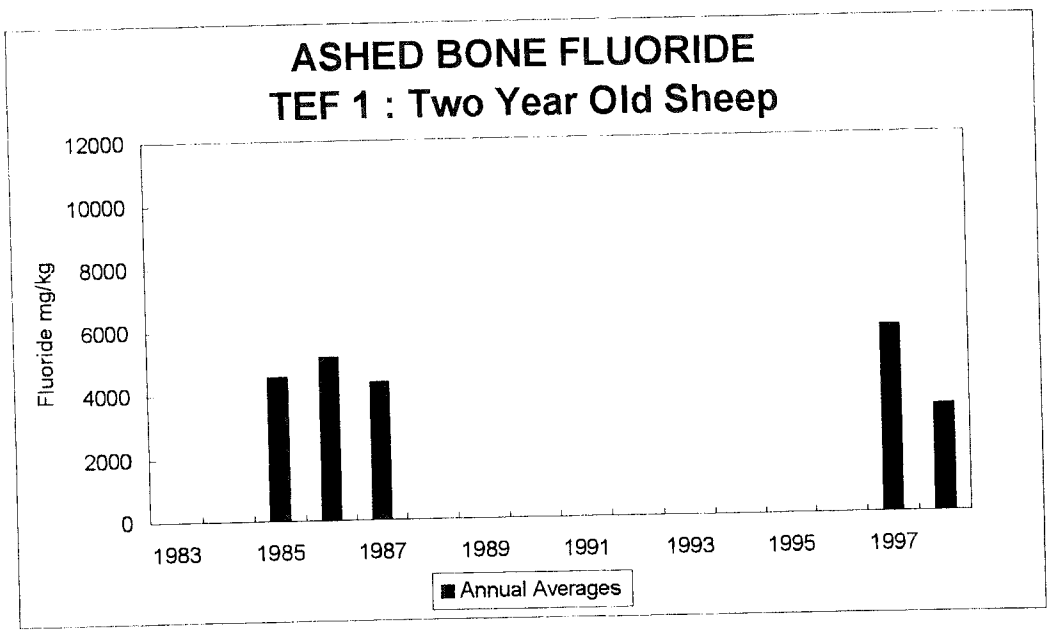
The following table shows the jawbone fluoride concentration as ashed bone for samples collected during 1998 and during September, October and December 1997. These 1997 samples are included with the 1998 samples as they are from sheep born in the same year as the 1998 samples and contain significantly different fluoride concentrations to those born in earlier years.

Age	No. of samples	Average Fluoride mg/kg	Maximum Fluoride mg/kg	Minimum Fluoride mg/kg
lambs	5	2450	2850	2200
1	9	2200	2650	1800
2	9	3390	4550	2000
3	2	5325	7300	3350
5	2	6400	6600	6200
≥ 6	6	8100	9250	7350

Sheep Bone Fluoride continued

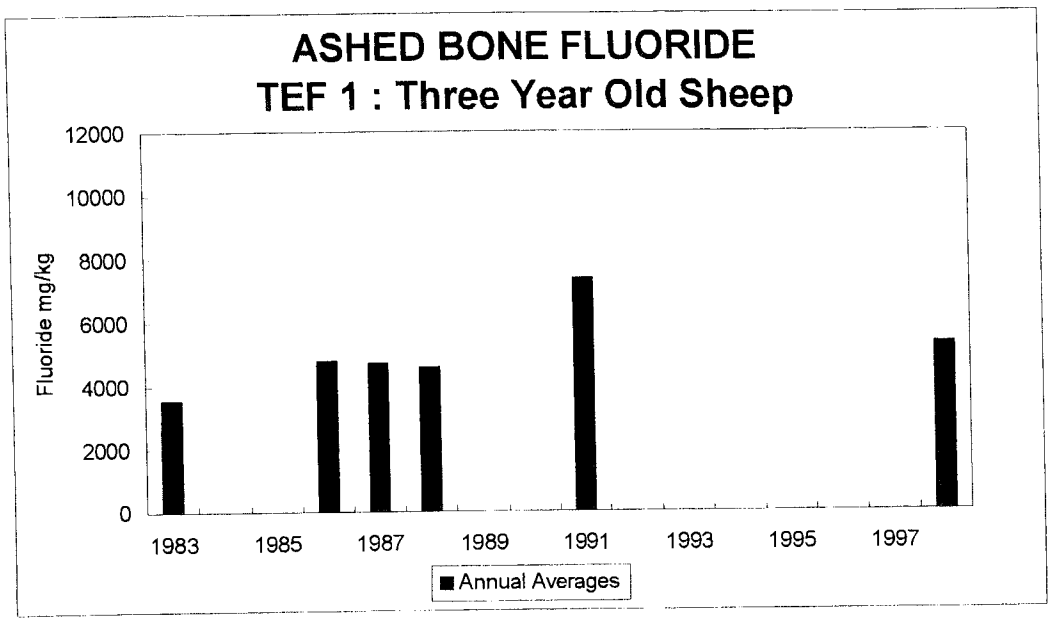
The following graphs show the annual average jawbone fluoride concentration of lambs, two, three, five, and six year old and older sheep grazing on TEF1 since 1983.

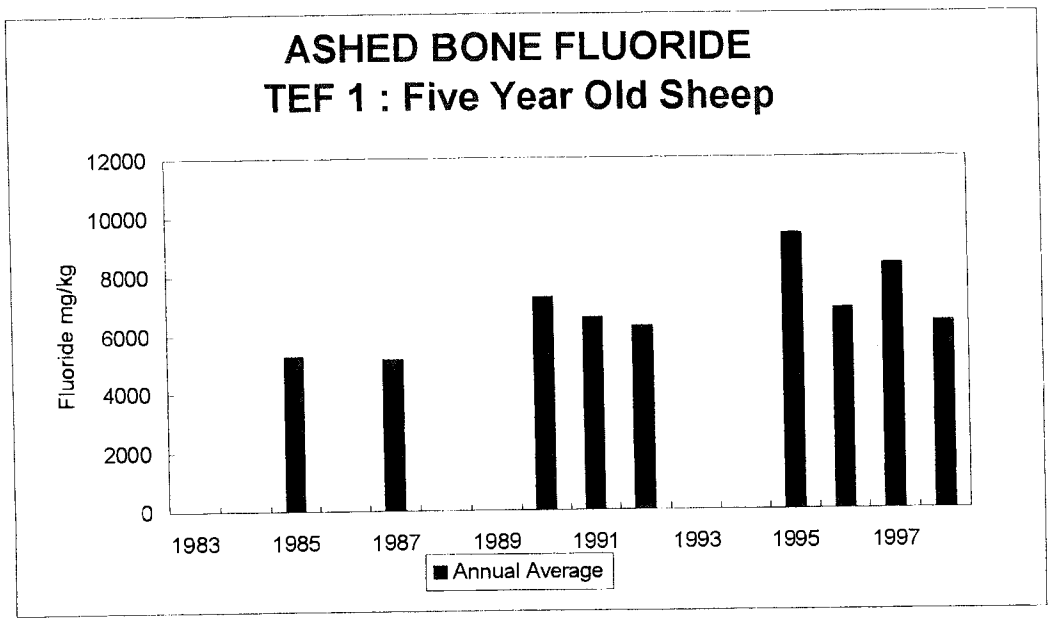




Tiwai Experimental Farm No.1, Continued

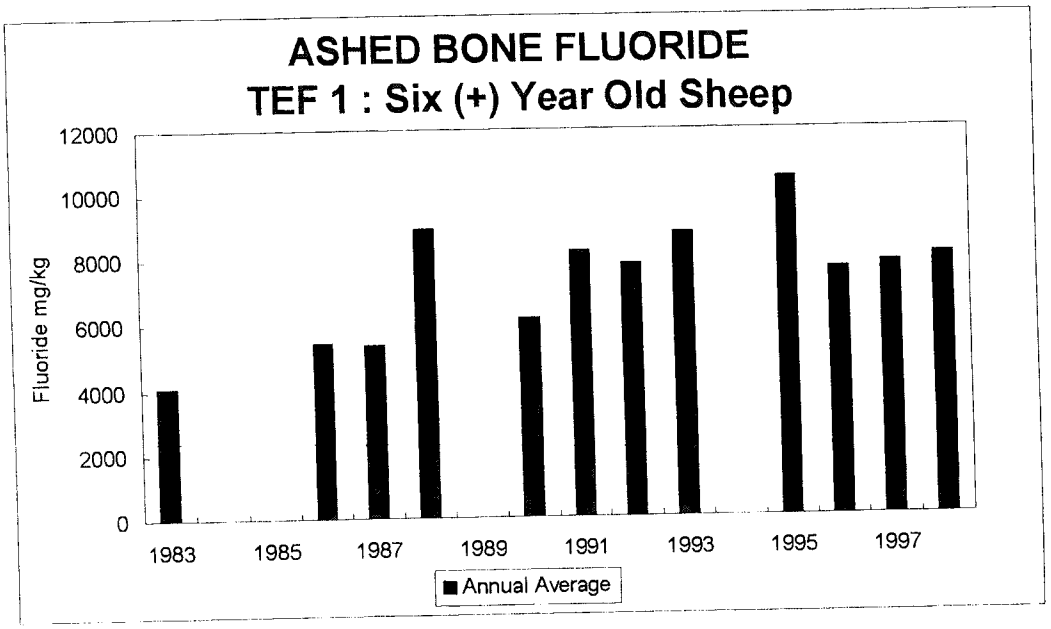
Sheep Bone Fluoride continued





Tiwai Experimental Farm No.1, Continued

Sheep Bone Fluoride, continued



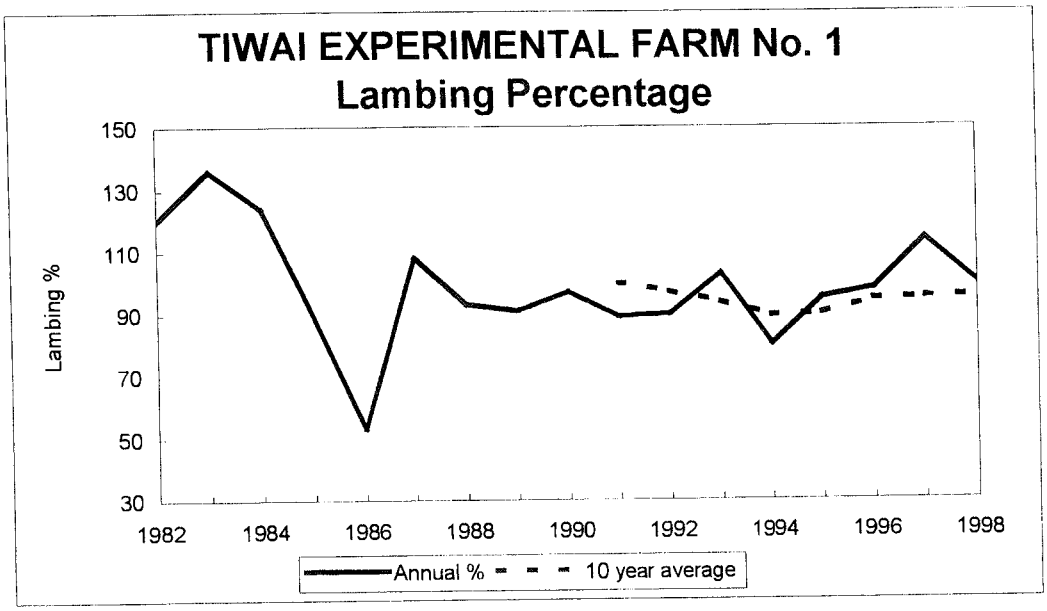
Sheep dental condition

There was no dental inspection of sheep grazing on TEF1 during 1998. The dental inspection was postponed until March 1999 to allow a greater number of recently erupted teeth to be available for the final inspection.

Tiwai Experimental Farm No.1, Continued

Lambing percentage

The following graph shows the lambing percentage recorded at TEF1 since 1982.



Animal health monitoring

Trace element analysis on liver samples collected from lambs grazed on TEF1 showed there were no issues indicative of health problems.

Comments

Closure of TEF1 is planned for May 1999, as a considerable amount of information on the response of sheep to elevated fluoride exposure is available. With the installation of the dry scrubbing system the fluoride exposure of animals grazing at TEF 1 has decreased by about 50% compared with 1994-95. As an example sheep aged three to six years have grazed on pasture averaging about 50 mgF/kg and lambs and one year old sheep have grazed on pasture averaging about 30 mgF/kg.

The 1998 annual average grazed pasture fluoride concentration of 35 mg/kg was similar to the 29 mg/kg measured during 1997.

Jawbone fluoride concentrations were determined in sheep aged between eight months and five years of age during 1998. The sheep sampled during September, October and December 1997 were included with the 1998 samples because the animals,

- particularly those less than three years of age, were exposed to less fluoride than those sampled earlier in 1997 and
- were the same age as those sampled in 1998.

This differentiation with the 1997 samples was discussed in the 1997 report.

Comments, continued

The fluoride concentration of jawbone samples was generally within the range of results expected for TEF1. The fluoride concentration for animals up to two years of age reflected the lower fluoride concentration of the pasture the sheep grazed on during the past two years.

The fluoride concentration in one-year-old sheep was similar to that in lambs. This was unexpected because:

- the fluoride concentration of bone generally increases with age and
- both groups were exposed to pasture with a fluoride concentration of about 30 mg/kg.

The similarity in the fluoride concentration for the two age groups is most likely due to normal variation. The fluoride concentration in the lambs appears to be at the high end, and in the one year old sheep at the low end, of the normal range for animals grazing at TEF1 on pasture with an average fluoride concentration of 30 mg/kg.

The fluoride concentration of jawbones from older sheep was within the normal range of results measured during recent years. No significant decrease in fluoride concentration was expected in the older sheep as fluoride is accumulated within the bone and generally increases with age.

The lambing percentage for TEF1 during 1998 was 100% compared with 111% during 1997. The sheep on TEF1 were tested for the hormone zearalenone for the first time during 1998 and significant concentrations were detected. Zearalenone is produced by red clover or fungi and can reduce the fertility of a flock. It is probable that zearalenone has been present at TEF1 in previous years.

Trace element analysis on liver samples indicated that the health of lambs on TEF1 was normal.

Tiwai Experimental Farm No.2

Introduction

The following information is contained in this section:

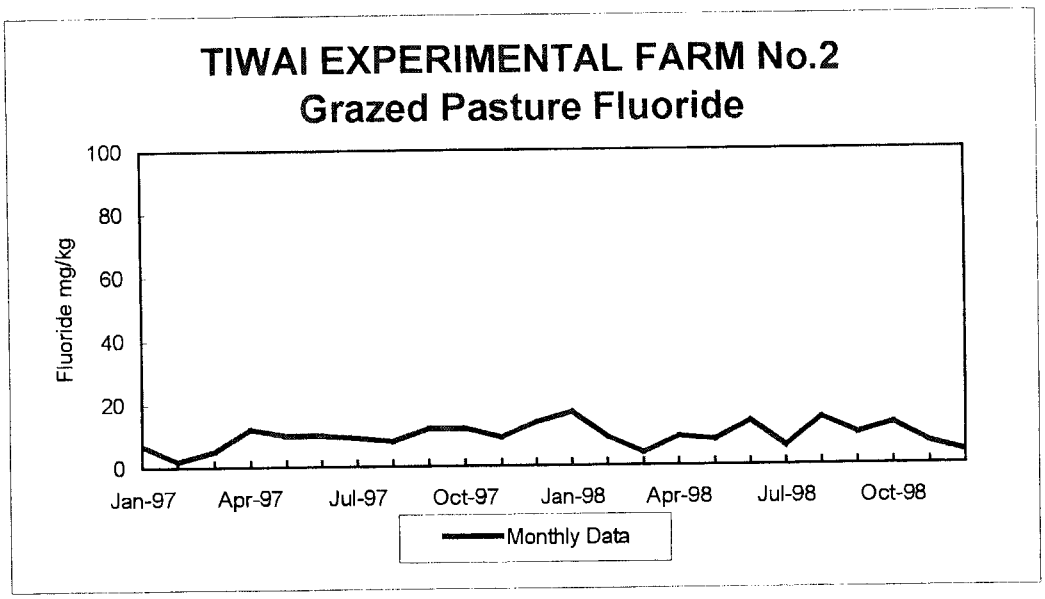
- fluoride in grazed pasture,
- sheep bone fluoride
- dental condition,
- lambing percentage, and
- comments in the monitoring.

Fluoride in grazed pasture

The following table shows the grazed pasture monitoring results for 1998.

	Units	1998
Monthly sample maximum	mg/kg	17
Two monthly average maximum	mg/kg	16
Twelve monthly running average maximum	mg/kg	11
Annual average	mg/kg	10

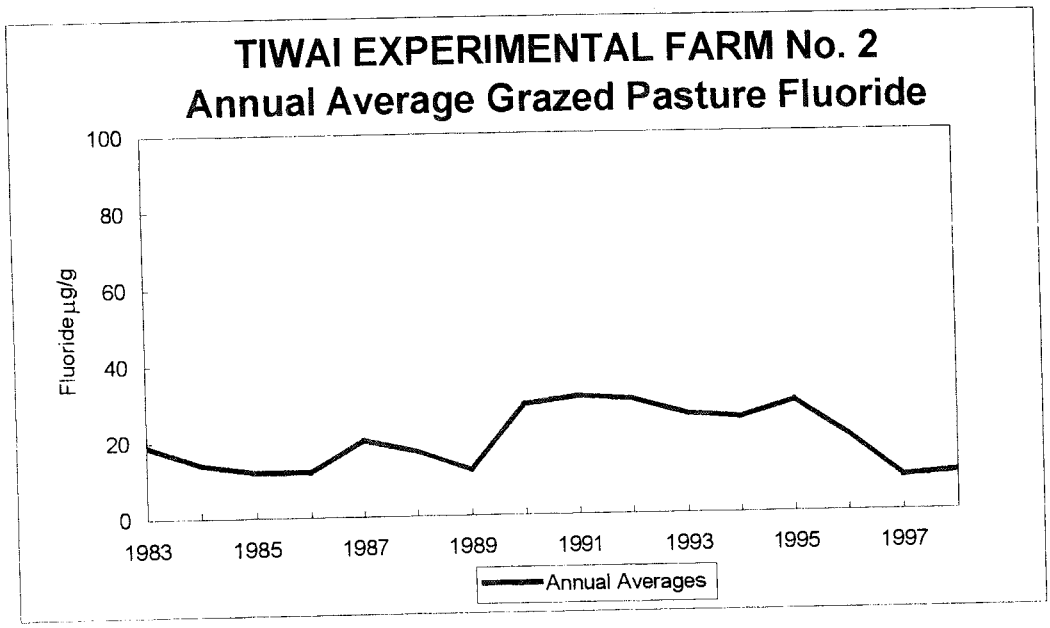
The following graph shows the results of monthly fluoride monitoring of grazed pasture during 1997 and 1998.



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 in December 1997 and during 1998. The 1997 samples are included with the 1998 samples as they are from sheep born in the same year. The four 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	540	600	450
1	7	530	700	400
2	4	900	1150	750
4	4	1990	2050	1850

Tiwai Experimental Farm No.2, Continued

Sheep dental condition

There was no dental inspection of sheep grazing on TEF2 during 1998. The dental inspection is planned for March to allow a greater number of recently erupted teeth to be inspected, particularly in one year old sheep

Lambing percentage

The lambing percentage recorded on TEF2 during 1998 was 82% compared with 91% in 1997.

Comments

Closure of TEF2 is planned for May 1999. The reasons for this are discussed in "Closure of the Tiwai Experimental Farm Project".

The 1998 annual average grazed pasture fluoride concentration of 10 mg/kg was similar to the average concentration measured during 1997.

The sheep jawbone samples collected in December 1997 have been included with the samples collected during March and May 1998 as the sheep were born in the same year. The average fluoride concentration of lamb jawbone samples was 540 mg/kg. The average fluoride concentration of the pasture the lambs grazed on was 10 mg/kg. This can be compared to the 730 mg/kg measured in jawbone samples from lambs grazing on pasture with a fluoride concentration of 15 mg/kg on TEF1 in 1983.

Similar to TEF1, the fluoride concentration in lamb jawbone samples was similar to that measured in one-year-old jawbones. As both age groups were grazing on pasture with a fluoride concentration of about 10 mgF/kg it was expected that the older sheep would have a higher bone fluoride concentration. The similarity in fluoride concentration for the two age groups may be due to normal variation.

The lambing percentage for TEF2 during 1998 was 82% compared with 91% during 1997. This was the lowest lambing percentage since lambing was started on TEF2 in 1995. As with TEF1 zearalenone was detected in urine sampled collected from sheep on TEF2 just prior to tupping. Zearalenone can reduce the fertility of a flock. The hormone may have been present in previous years as this is the first time that zearalenone has been tested for at TEF2.

Part J

Liquid Discharges and Their Effects

Liquid Discharges and Their Effects

Introduction

Seven Coastal and Discharge Permits issued by the Southland Regional Council cover liquid discharges from the smelter. 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.

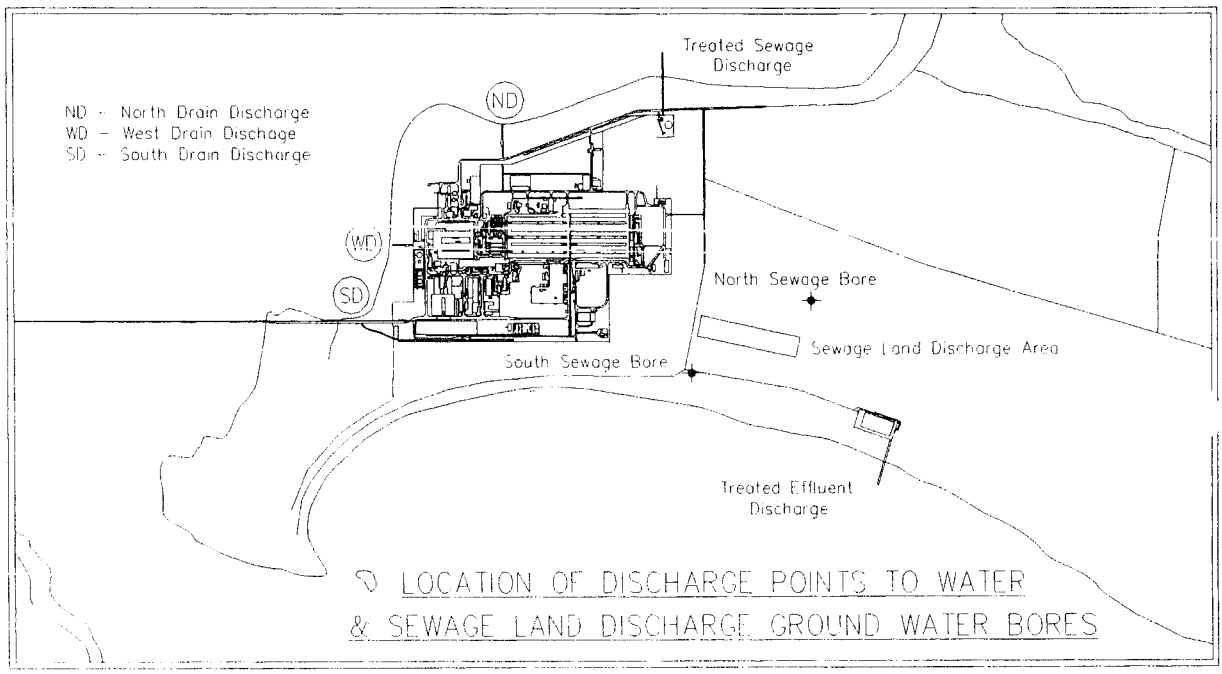
	Units	Limit
North, South, and West Drain		
• Quarterly average total suspended solids	g/m^3	30
Treated effluent		
• Maximum daily discharge	m^3/day	140
• Total suspended solids	g/m^3	100
• Free cyanide	g/m^3	20
Treated sewage		
• Maximum daily flow	m^3/day	295
• Biochemical oxygen demand	g/m^3	18
• Total suspended solids	g/m^3	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 that 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 and treated sewage.

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 was required for each of two months prior to commissioning the land disposal area and for three months after the commissioning.

In future monitoring is required 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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Total suspended solids				
• Annual average	g/m^3	-	17.2	12.7
• Maximum quarterly average	g/m^3	30	26.4	17.4
• 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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Fluoride				
• Annual average	g/m^3	-	1.4	1.3
• Maximum quarterly average	g/m^3	2.0	1.5	1.3
• No. of times quarterly average > 2.0 g/m^3		0	0	0
• Maximum individual sample	g/m^3	5.0	2.5	1.6
• No. of times individual sample > 5.0 g/m^3		0	0	0
pH				
• Maximum difference		0.1	0.3	0.1
• No. of times > 0.1		0	1	0
Visible oil				
• No. of times observed		0	0	0

The following table summarises the North Drain annual coastal water monitoring results during 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Difference in temperature	^{o}C	3.0	0.1	0.0
Minimum dissolved oxygen concentration	mg/litre	5.0	8.2	7.8

Comments

Discharges from the North Drain were within permit limits during 1998.

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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Total suspended solids				
• Annual average	g/m^3	-	4.5	3.4
• Maximum quarterly average	g/m^3	30	5.2	4.9
• 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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Fluoride				
• Annual average	g/m^3	-	1.4	1.3
• Maximum quarterly average	g/m^3	2.0	1.4	1.3
• No. of times quarterly average > 2.0 g/m^3		0	0	0
• Maximum individual sample	g/m^3	5.0	2.4	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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Difference in temperature	°C	3.0	0.1	0.1
Minimum dissolved oxygen concentration	mg/litre	5.0	7.9	8.0

Comments

Discharges from the South Drain were within permit limits during 1998.

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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Total suspended solids				
• Annual average	g/m^3	-	12.7	7.2
• Maximum quarterly average	g/m^3	30	29.5	10.9
• 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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Fluoride				
• Annual average	g/m^3	-	1.3	1.3
• Maximum quarterly average	g/m^3	2.0	1.4	1.3
• No. of times quarterly average > 2.0 g/m^3		0	0	0
• Maximum individual sample	g/m^3	5.0	1.6	1.3
• 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 West Drain annual coastal water monitoring results during 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Difference in temperature	°C	3.0	0.1	0.0
Minimum dissolved oxygen concentration	mg/litre	5.0	8.2	7.9

West Drain Discharges, Continued

Comments

Discharges from the West Drain were within permit limits during 1998.

A high suspended solids concentration of 70 g/m^3 was measured in a sample collected in December. This was probably caused as the result of work required to clean the drain. A sample collected the following day showed the suspended solids concentration had decreased to 4.5 g/m^3. The outlet to the drain was blocked by a gravel bar during most of December and the suspended solids material was most likely retained within the drain.

West Drain Discharges, Continued

Comments

Discharges from the West Drain were within permit limits during 1998.

A high suspended solids concentration of 70 g/m^3 was measured in a sample collected in December. This was probably caused as the result of work required to clean the drain. A sample collected the following day showed the suspended solids concentration had decreased to 4.5 g/m^3. The outlet to the drain was blocked by a gravel bar during most of December and the suspended solids material was most likely retained within the drain.

Treated Sewage Discharges

Introduction

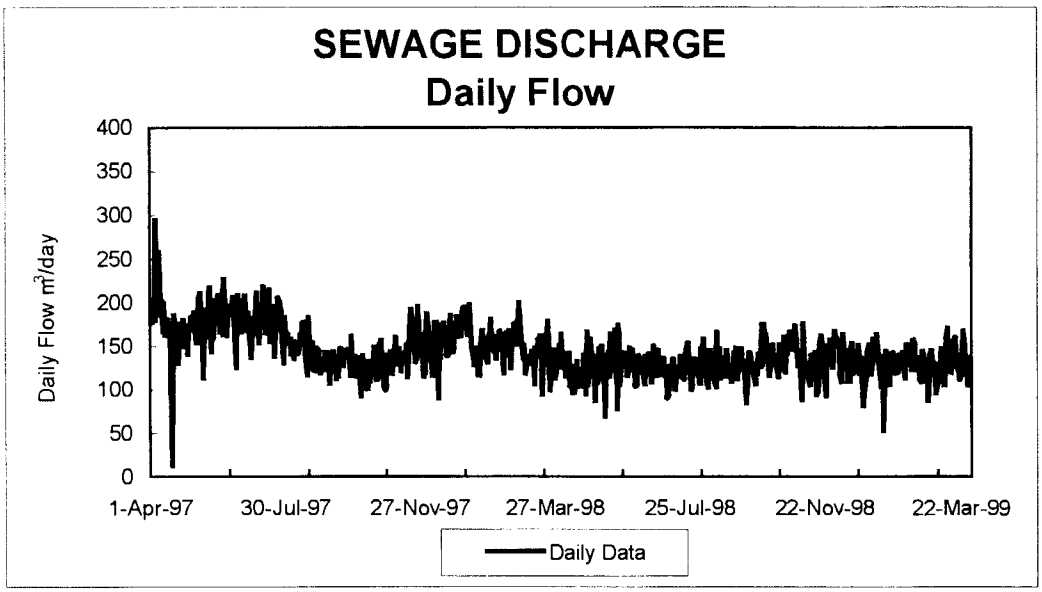
Discharges of treated sewage

- into Awarua Bay are covered by Coastal Permit Number 94487, which commenced on 15 October 1996, and
- onto land are covered by Discharge Permit Number 96122, which was granted on 16 October 1996.

Discharge of treated sewage into Awarua Bay ceased and onto land commenced on 25 September 1998.

Discharge monitoring results

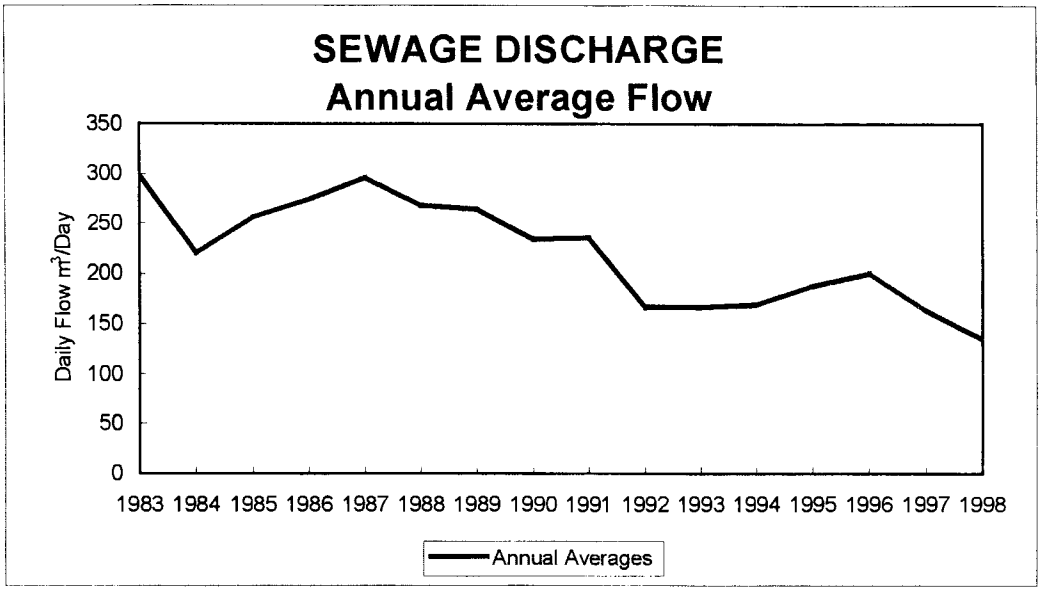
The following graph shows the daily sewage discharge flow during 1997 and 1998. The permit limit for daily flow is 295 m^3/day.



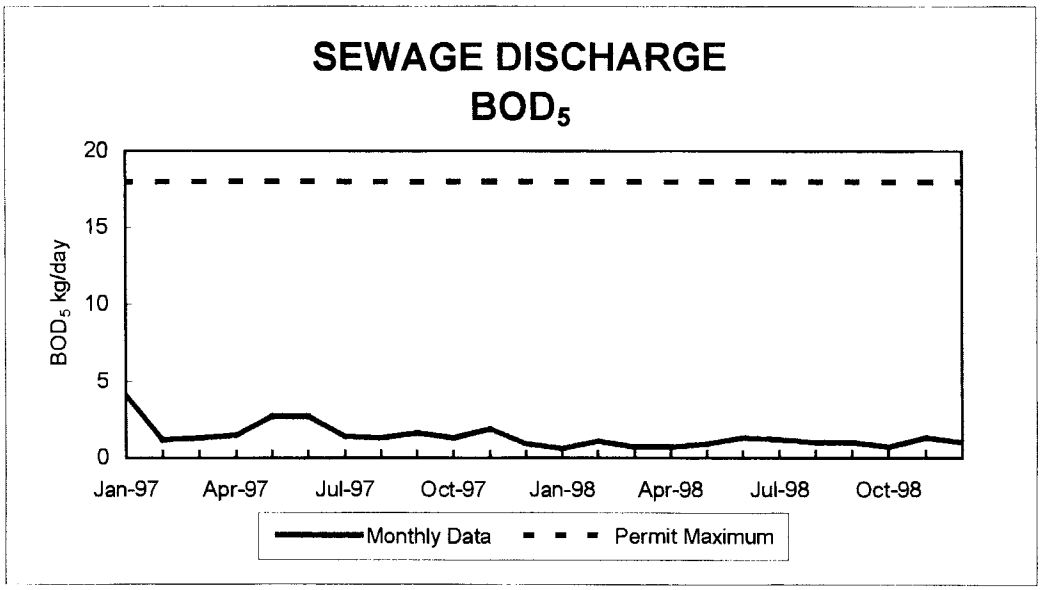
Treated Sewage Discharges

Discharge monitoring results, continued

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



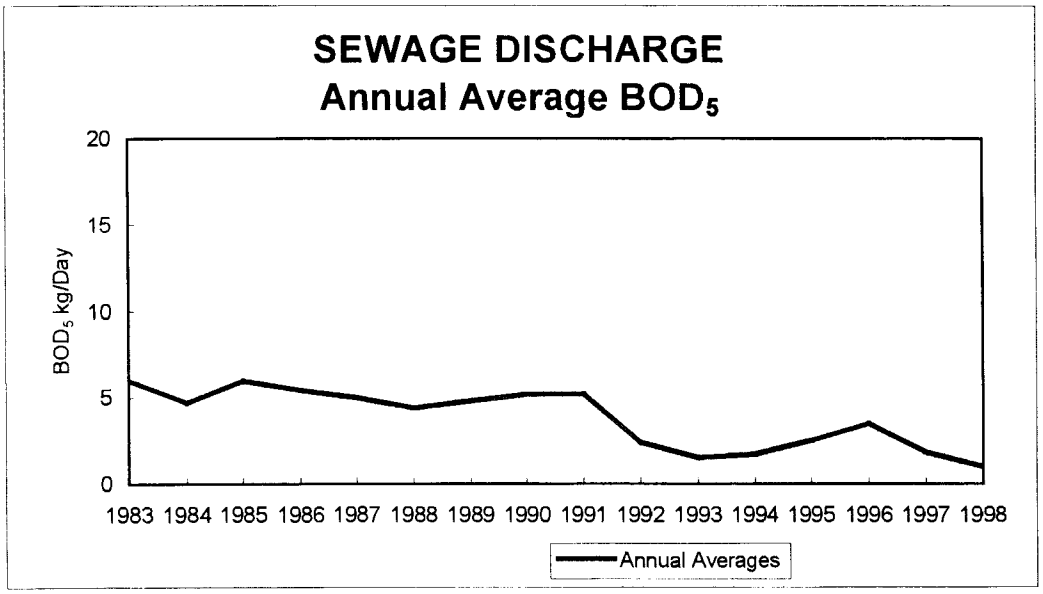
The following graph shows the monthly biochemical oxygen demand (BOD_5) discharge from the sewage treatment plant during 1997 and 1998.



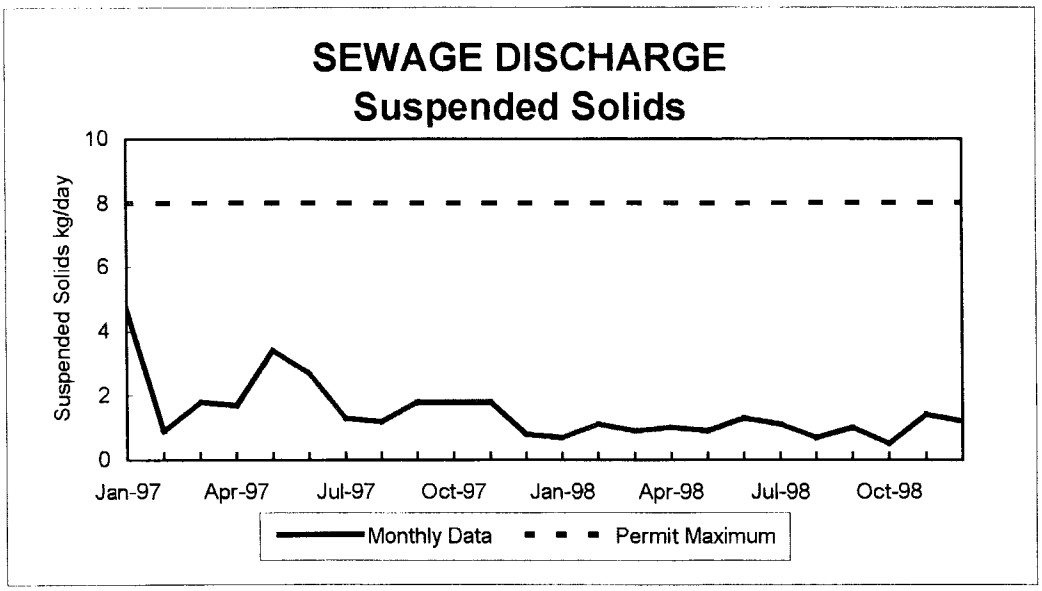
Treated Sewage Discharges, Continued

Discharge monitoring results, continued

The following graph shows the annual average BOD_5 discharge from the sewage treatment plant.



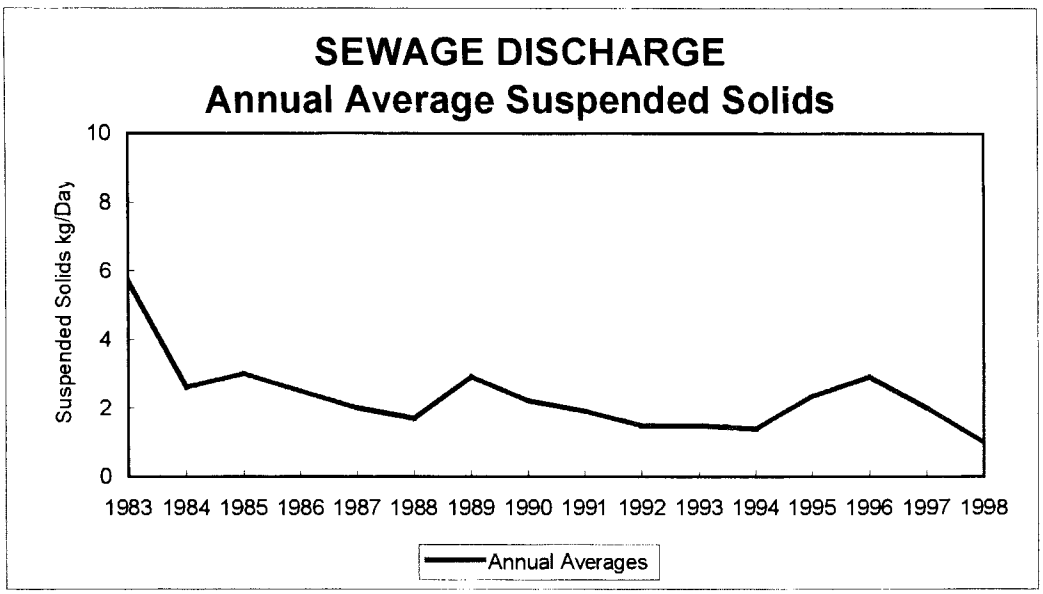
The following graph shows the monthly suspended solids discharge from the sewage treatment plant during 1997 and 1998.



Treated Sewage Discharges, Continued

Discharge monitoring results, continued

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



Treated Sewage Discharges, Continued

Coastal water monitoring results

The following table summarises the treated sewage annual coastal water monitoring results during 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Temperature				
• Maximum difference	^{0}C	3.0	0.3	1.1
• No. of times >3.0		0	0	0
PH				
• Maximum difference		0.1	0.1	0.1
• No. of times >0.1		0	0	0
Dissolved oxygen				
• Minimum concentration	mg/litre	5.0	8.8	7.6
• No. of times < 5.0		0	0	0
Visible oil				
• No. of times observed		0	0	0
Faecal coliforms Median concentration (highest of the two coastal water sites)	MPN/100ml	200	2	2

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. The pre-commissioning samples were collected during June and July and the post-commissioning samples were collected during October, November and December.

Parameter	Units	Pre-Commissioning		Post-Commissioning	
		Average	Range	Average	Range
North Bore (Upstream)					
Faecal coliforms	MPN/100 ml	< 2	< 2	< 2	< 2
Total phosphorus	$g.m^{-3}$	0.09	0.08 – 0.10	0.12	0.10 – 0.15
Total ammoniacal-N	$g.m^{-3}$	0.01	<0.01 – 0.01	0.02	0.01 – 0.03
Nitrate-N	$g.m^{-3}$	0.02	0.01– 0.03	0.03	0.02 - 0.06
Total nitrogen	$g.m^{-3}$	0.16	0.15 – 0.16	0.15	0.12 – 0.18
PH		8.0	7.9 – 8.0	8.0	7.8 – 8.1
Conductivity	$\mu S.cm^{-1}$	313	305 – 321	318	311 – 323
South Bore (Downstream)					
Faecal coliforms	MPN/100 ml	1	< 1 – 2	< 2	< 2
Total phosphorus	$g.m^{-3}$	0.02	0.02	0.03	0.03 – 0.04
Total ammoniacal-N	$g.m^{-3}$	0.01	<0.01 – 0.02	0.01	<0.01 – 0.02
Nitrate-N	$g.m^{-3}$	0.18	0.02 – 0.33	0.17	0.16 – 0.17
Total nitrogen	$g.m^{-3}$	0.47	0.37 – 0.56	0.37	0.36 – 0.38
PH		7.4	6.9 – 7.9	7.9	7.8 – 7.9
Conductivity	$\mu S.cm^{-1}$	322	227 – 417	397	374 – 413

Comments

The discharges of treated sewage to water and onto land during 1998 were within permit limits.

The results of the groundwater monitoring during 1998 are indicative of the background levels of the analytes measured. Total nitrogen and nitrate-nitrogen concentrations were higher downstream before and after the commissioning of the land disposal area. This may indicate a source of nutrients is located between the bores.

Treated Effluent Discharges

Introduction

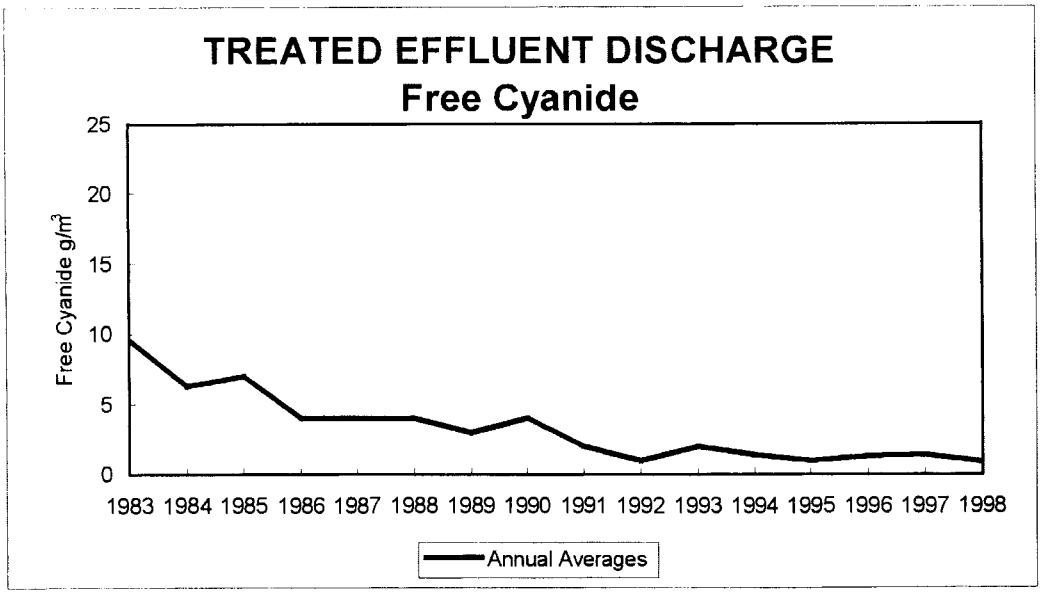
Discharges of treated effluent into Foveaux Strait are covered by Coastal Permit Number 94488 which commenced on 11 October 1996.

Discharge monitoring results

The following table summarises the results of treated effluent discharge monitoring during 1998 and shows a comparison with the 1997 results.

Parameter	Units	Limits	1997 Result	1998 Result
Maximum daily discharge	m^3/day	140	82	85
Suspended solids				
Maximum concentration	$g.m^{-3}$	100	35.0	28.0
Average concentration	$g.m^{-3}$	-	5.1	5.9
No. of times > 100 $g.m^{-3}$		0	0	0
Free cyanide				
Maximum concentration	$g.m^{-3}$	20	4.0	2.6
Average concentration	$g.m^{-3}$	-	1.4	0.9
No. of times > 100 $g.m^{-3}$		0	0	0

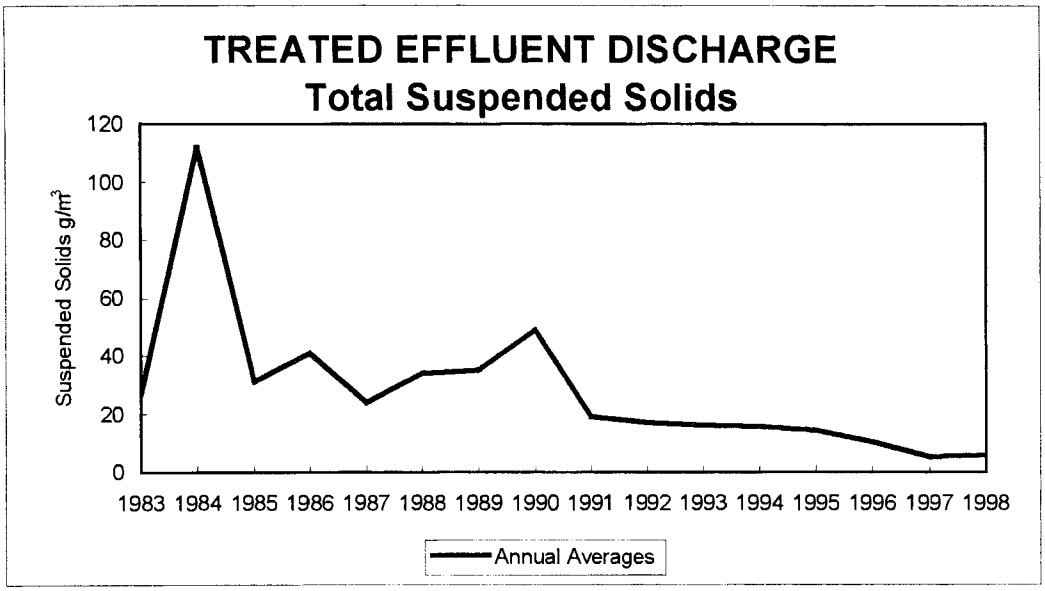
The following graph shows the annual average free cyanide concentration of treated effluent discharged.



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 1998 and shows a comparison with 1997 results.

Parameter	Units	Limit	1997 Result	1998 Result
Difference in temperature	°C	3.0	0.0	0.0
Minimum dissolved oxygen concentration	mg/litre	5.0	8.8	8.0
Change to pH		0.1	0.0	0.1
No. of times visible oil observed		0	0	0

Comments

All discharges of treated effluent were within permit limits during 1998.

Part K

Landfill

Landfill

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 and commenced 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.

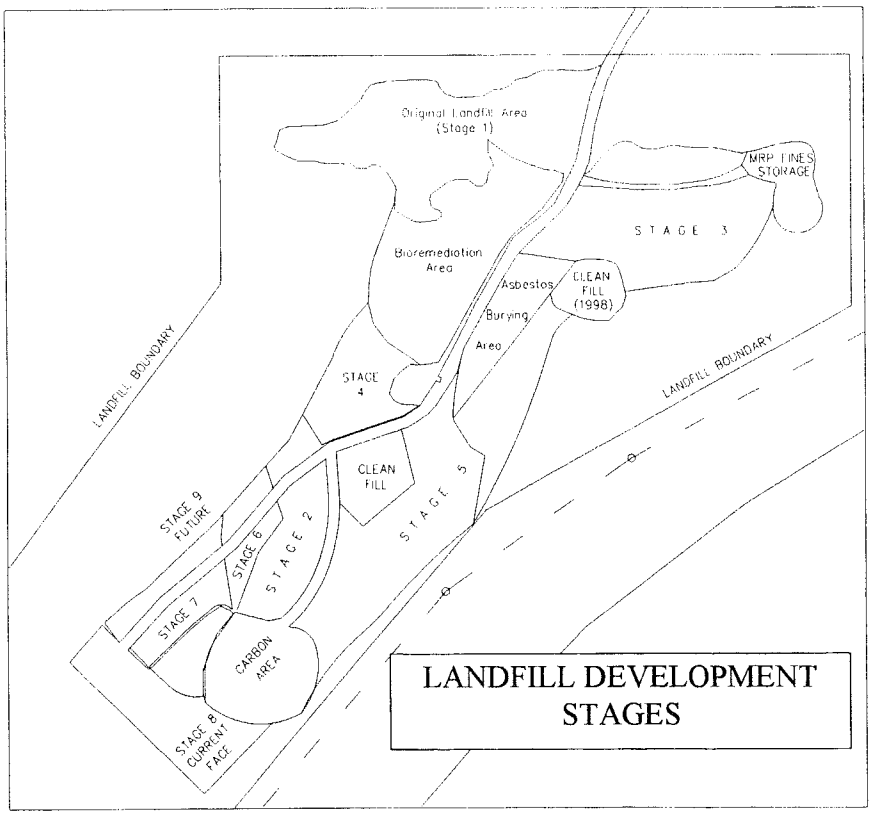
Proposed Operation For 1999

Introduction

The proposed operation of the landfill for 1999 is as outlined in the NZAS Landfill Management Plan. Additional details on the proposed operations during 1999 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 1999, Continued

Landfill areas being developed or extended, continued

No new areas were developed during 1998 and no development of new areas is proposed during 1999. The clean fill area, east of the defined asbestos burial area, that was developed in 1996 is scheduled for use in 1999.

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

Concrete sleepers will define active landfill areas.

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 generally follows the following procedure:

- taken over 28 days during November and December,
- each truck load of waste is weighed,
- the contents and source of each truck load is recorded, and
- the amount of waste measured during the survey is used to estimate the annual deposition.

The annual estimate calculated from the survey results may be corrected to account for special events that occur during the annual survey. Without the correction the special events may result in a significant over or under estimate of the annual deposition.

Results for 1997 and 1998

The following table shows the estimated amount of waste deposited at the Tiwai Point Landfill during 1997 and 1998.

Type of waste	1997 tonnes	1998 tonnes
Metal Reclaim Plant fines	1,827	2,160
Carbon fines	2,949	2,384
Bricks	1,029	361
General	1,039	782
Butt material	155	0
Furnace slag	242	220
Alumina	132	62
Coke	141	128
Plastic	94	62
Concrete	282	350
Man made mineral fibre	38	0
Other	345	212
Contaminated bath	0	149
Total	**8,273**	**6,870**

Amount and Type of Materials Deposited, Continued

Comments

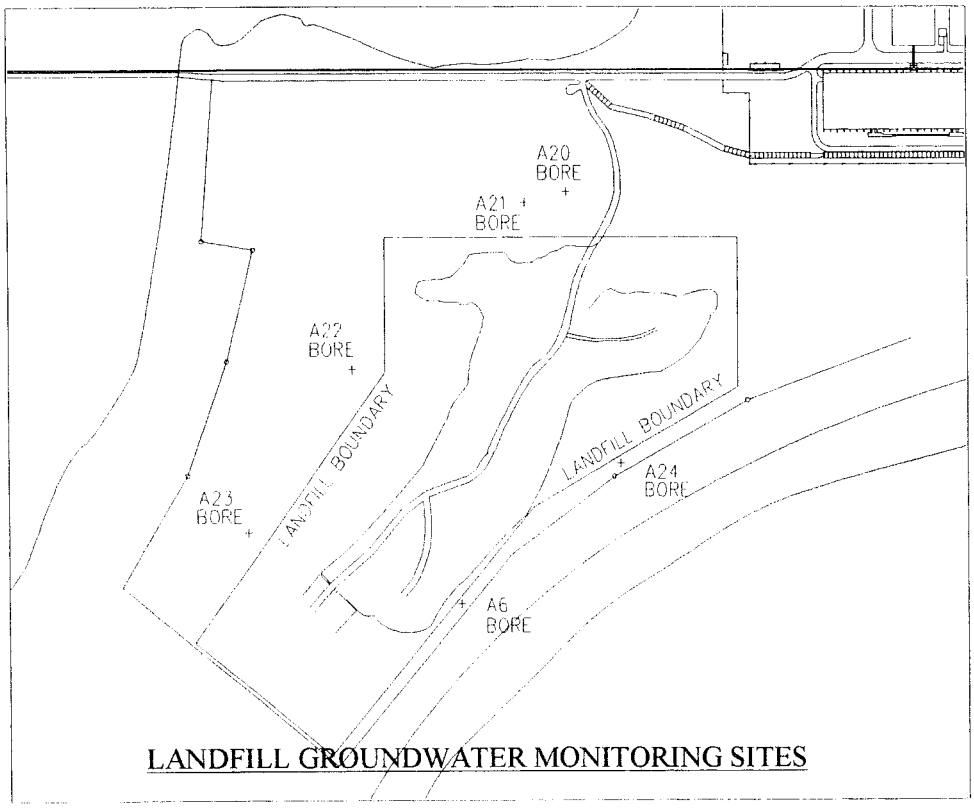
The estimated amount of concrete deposited at the landfill during 1998 is reported as 350 tonnes instead of the 1,286 tonnes calculated from the survey results. The 100 tonnes of concrete waste recorded during the 1998 survey was sourced from the demolition of floors from recently removed buildings and there was no evidence of unusually large amounts of concrete being deposited during the remainder of 1998.

The 1998 annual estimate for concrete was calculated by adding the amount of concrete recorded during the 1998 survey to the average annual amount of concrete estimated to have been deposited at the landfill during the years 1995 – 97.

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 southeast and two bores west (downstream) of the landfill.



LANDFILL GROUNDWATER MONITORING SITES

Landfill Groundwater Monitoring, Continued

Bore A20 monitoring results

The table below shows a summary of results from samples collected from bore A20 during 1997 and 1998. Bore A20 is located north of the landfill (upstream).

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	6.1	6.2	5.9 – 6.4
Total Nitrogen	$g.m^{-3}$	1.3	0.59	0.46 – 0.72
Total Ammoniacal Nitrogen	$g.m^{-3}$	<0.1	0.13	0.10 – 0.16
Alkalinity	$g.m^{-3}$	68	58	53 – 63
Carbonaceous BOD_5	$g.m^{-3}$	3	2.5	<2 – 4
Fluoride	$g.m^{-3}$	0.09	0.13	0.10 – 0.15
Sulphate	$g.m^{-3}$	33	28	27 – 28
Temperature	°C	10.2	12.3	One sample only
Conductivity	$\mu S.cm^{-1}$	747	738	737 – 739
Total Iron	$g.m^{-3}$	6.9	4.0	3.6 – 4.4
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	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 1997 and 1998. Bore A21 is located north of the landfill (upstream).

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	5.7	5.9	5.8 – 5.9
Total Nitrogen	$g.m^{-3}$	2.26	3.2	2.7 – 3.7
Total Ammoniacal Nitrogen	$g.m^{-3}$	0.51	0.56	0.21 – 0.91
Alkalinity	$g.m^{-3}$	37	67	43 – 90
Carbonaceous BOD_5	$g.m^{-3}$	3	3.9	2.8 – 5.0
Fluoride	$g.m^{-3}$	0.30	0.34	0.26 – 0.41
Sulphate	$g.m^{-3}$	77	68	67 – 68
Temperature	°C	10.7	13.0	One sample only
Conductivity	$\mu S.cm^{-1}$	1,056	1,085	1,050 – 1,120
Total Iron	$g.m^{-3}$	27.5	50.9	42.9 – 58.8
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	One sample only
Naphthalene	$mg.m^{-3}$	<0.01	0.011	<0.005 – 0.020
Anthracene	$mg.m^{-3}$	<0.01	<0.005	<0.005
Phenanthrene	$mg.m^{-3}$	<0.01	<0.005	<0.005
Fluoranthene	$mg.m^{-3}$	<0.01	<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 1997 and 1998. Bore A22 is located west of the landfill.

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	4.8	5.2	4.7 – 5.6
Total Nitrogen	$g.m^{-3}$	2.6	1.85	1.0 – 2.7
Total Ammoniacal Nitrogen	$g.m^{-3}$	0.28	0.29	0.20 – 0.38
Alkalinity	$g.m^{-3}$	9	11	4 – 17
Carbonaceous BOD_5	$g.m^{-3}$	3	<3	<3
Fluoride	$g.m^{-3}$	1.99	1.06	0.74 – 1.37
Sulphate	$g.m^{-3}$	27	13	10 – 15
Temperature	°C	9.8	12.1	One sample only
Conductivity	$\mu S.cm^{-1}$	711	518	450 – 585
Total Iron	$g.m^{-3}$	2.66	2.1	1.85 – 2.4
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	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 1997 and 1998. Bore A23 is located west of the landfill.

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	5.5	5.7	5.7
Total Nitrogen	$g.m^{-3}$	2.7	2.5	2.3 – 2.6
Total Ammoniacal Nitrogen	$g.m^{-3}$	0.63	1.13	1.10 – 1.15
Alkalinity	$g.m^{-3}$	39	46	44 – 48
Carbonaceous BOD_5	$g.m^{-3}$	<3	<3	<3
Fluoride	$g.m^{-3}$	0.07	0.08	0.07 – 0.08
Sulphate	$g.m^{-3}$	6	<1	<1
Temperature	°C	10.1	12.5	One sample only
Conductivity	$\mu S.cm^{-1}$	577	580	570 – 590
Total Iron	$g.m^{-3}$	8.5	8.3	6.7 – 9.8
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	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 1997 and 1998. Bore A24 is located south east of the landfill.

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	7.0	7.1	7.1
Total Nitrogen	$g.m^{-3}$	81.5	80	67 – 93
Total Ammoniacal Nitrogen	$g.m^{-3}$	49	63	47 – 78
Alkalinity	$g.m^{-3}$	1,034	988	936 – 1,040
Carbonaceous BOD_5	$g.m^{-3}$	7	7.6	7.2 – 8.0
Fluoride	$g.m^{-3}$	1.04	0.61	0.49 – 0.73
Sulphate	$g.m^{-3}$	38	161	5 – 317
Temperature	°C	10.9	12.8	One sample only
Conductivity	$\mu S.cm^{-1}$	2,901	3,125	2,790 – 3,460
Total Iron	$g.m^{-3}$	20.6	19.5	18.9 – 20.0
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	One sample only
Naphthalene	$mg.m^{-3}$	29.6	81	80 – 82
Anthracene	$mg.m^{-3}$	0.049	0.079	0.072 – 0.085
Phenanthrene	$mg.m^{-3}$	0.22	0.026	0.024 – 0.028
Fluoranthene	$mg.m^{-3}$	0.01	0.008	0.005 – 0.011

Landfill Groundwater Monitoring, Continued

Bore A6 monitoring results

The table below shows a summary of results from samples collected from bore A6 during 1997 and 1998. Bore A6 is located south east of the landfill.

Parameter	Units	1997	1998	
		Average	Average	Range
PH	-	6.5	6.7	6.7
Total Nitrogen	$g.m^{-3}$	44	25	20 – 29
Total Ammoniacal Nitrogen	$g.m^{-3}$	25.9	22.8	18.9 – 26.6
Alkalinity	$g.m^{-3}$	738	630	568 – 691
Carbonaceous BOD_5	$g.m^{-3}$	<3	<3	<3
Fluoride	$g.m^{-3}$	9.1	7.3	4.0 – 10.5
Sulphate	$g.m^{-3}$	1,725	1,200	1,160 – 1,240
Temperature	°C	11.6	13.5	One sample only
Conductivity	$\mu S.cm^{-1}$	4732	3,815	3,620 – 4,010
Total Iron	$g.m^{-3}$	17.5	17.1	15.7 – 18.4
Total Petroleum Hydrocarbons	$g.m^{-3}$	<1	<1	One sample only
Naphthalene	$mg.m^{-3}$	0.01	<0.005	<0.005
Anthracene	$mg.m^{-3}$	0.16	0.21	0.15 – 0.27
Phenanthrene	$mg.m^{-3}$	0.024	0.018	0.016 – 0.019
Fluoranthene	$mg.m^{-3}$	<0.01	<0.005	<0.005

Landfill Groundwater Monitoring, Continued

Comments

The groundwater monitoring data from the bores near the landfill do not indicate any significant trends in the general groundwater quality during 1998.

Part L

Groundwater

Groundwater

Spent Cathode Pad Leachate

The monitoring of the recovery, by natural dispersion, of the contaminated plume in the groundwater under the cathode pad has continued. An annual report on this monitoring was submitted to the Southland Regional Council (SRC) in July 1998.

A summary of the findings included in the report on the 1998 monitoring of the bores south of the cathode pad is:

- the analyte concentrations the groundwater had generally decreased during the previous 12 months and additional bores were below the clean up criteria,
- the analyte concentrations in the seawater were similar to those reported for 1997 and do not represent a threat to the receiving environment

As a result of the monitoring the SRC agreed with NZAS on a reduction to the monitoring program. The changes agreed were to:

- reduce the number of bores monitored from 17 to seven and
- reduce the frequency of seawater monitoring from monthly to quarterly.

The seven bores remaining in the monitoring program should continue to provide coverage over a suitable area and sufficient data to assess trends.

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 June 1998.

The report concluded that the levels of total petroleum hydrocarbons in the groundwater from four bores downstream of the diesel plume are all below the level of detection and indicate there is no movement of the plume downstream or off site.

Spent Cell Lining Storage Shed

Monitoring of the membranes under the Spent Cell Lining storage shed indicated there were no concerns during 1998.