Air Quality Monitoring: Highland

Report to The Highland Council

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Executive Summary

The Highland Council has contracted netcen to carry out measurements of air quality at three locations in the region, for a period of six months. This report summarises the results from this study, and provides a comparison with the National Air Quality Objectives as set out by defra and the Scottish Executive.

The programme involved the following monitoring sites:

Fort William	Sulphur dioxide, SO_2	Wind speed and direction
Inverness	Nitrogen dioxide, NO_2	
Castletown, Caithness	Sulphur dioxide, SO_2	

None of the relevant air quality objectives for the measured pollutants were exceeded at any at the three sites. There were no significant pollution events detected at any of the sites. The concentrations of NO_2 measured at Inverness were similar to those at the defra AURN monitoring site in Inverness; SO_2 concentrations at Castletown and Fort William were comparable to those at the Glasgow Centre AURN site, although the 6-month average was lowest at Glasgow.

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1 Introduction

Netcen has been contracted by The Highland Council to carry out a 6-month survey of air quality in the region. The study of air quality in the area is required as part of the local authority review and assessment process as required by the UK's Air Quality Strategy[1]. Monitoring was carried out at three locations-Fort William, Inverness and Castletown. Full details of the site locations are given in section 2 of this report. The air quality monitoring sites were operational from 15 December 2004 until 30 June 2005 (4 June for Inverness). The pollutants measured were sulphur dioxide (SO_2-Fort William and Castletown), and nitrogen dioxide (NO_2-Inverness); wind speed and direction were also measured at Fort William to provide local meteorological information in the event of a significant pollution episode.

Sulphur dioxide is a corrosive acid gas, which combines with water vapour in the atmosphere to produce acid rain. Both wet and dry deposition have been implicated in the damage and destruction of vegetation and in the degradation of soils, building materials and watercourses. SO_2 in ambient air is also associated with asthma and chronic bronchitis. The burning of fossil fuels (eg coal) is a significant source of this pollutant, and many households in rural areas of the UK rely on coal fires for domestic heating purposes.

Oxides of nitrogen are produced mainly by combustion sources, particularly motor vehicles. NO is not recognised as harmful to health, but is readily oxidised in the atmosphere to form NO_2. There is evidence that NO_2 in high concentrations causes inflammation of the airways in humans, and may affect lung function

The data from the Highland Council monitoring sites are compared to those from similar sites in the defra automatic monitoring network (AURN).

2 Location of Monitoring Sites

Maps showing the site locations are given in Appendix 1.

2.1 FORT WILLIAM

The monitoring site was located in the grounds of the British Alcan Social Club, close to Inverlochy Castle. The aluminium smelting works are located approximately 500m south-east of the site.

For security reasons, the meteorological station could not be located at the Social Club. This was located at the Highland Council roads depot approximately 1km north-east of the social club. For the purposes of apportioning any pollution episodes to a particular wind direction, this may be considered an acceptable location.

Figure 1: Fort William site

2.2 INVERNESS

The Inverness site was located in the front courtyard of a commercial property in Academy Street. This street is a busy urban thoroughfare, and queueing traffic was frequently observed at this location.

Figure 2: Inverness site

2.3 CASTLETOWN

The site was located adjacent to the Police Station in Churchill Road, at the south-eastern end of the village.

Figure 3: Castletown site

3 Site operation

3.1 MEASUREMENT METHODS

The measurement methods used were as described in Table 1:

Table 1: Measurement Methods and estimated uncertainty

Species	Measurement Method	Estimated Uncertainty
NO_x (=NO+NO_2)	Chemiluminescence	±10% ± 5 μgm^{-3}
SO_2	UV Fluorescence	±10% ± 3 μgm^{-3}

These are identical methods to those used at the UK's national air quality monitoring stations in the defra Automatic Urban and Rural Network (AURN). The gas analysers were calibrated approximately fortnightly by netcen staff, using ISO17025 accredited compressed gas mixtures. These are certified in our Gas Standards Calibration Laboratory at Harwell (UKAS calibration laboratory no. 0401), which ensures traceability to both national standards and to the Defra monitoring networks through netcen's involvement in the AURN. The data from the analysers are collected on a datalogger and transferred to netcen's central computer by telemetry.

The sites were operated by netcen staff using procedures compliant with defra's Technical Guidance[2].

The meteorological equipment was a Casella Nomad portable solar-powered station. The wind speed and direction sensors were at a height of approximately 2m above the ground.

3.2 DATA CAPTURE

The hourly-average data capture figures are given in Table 2.

Table 2: Data Capture: 9 December 2004-30 June 2005

Site	Fort William	Inverness*	Castletown
Data Capture	72%	98%	90%

Due to a communications fault at Inverness, the monitoring ceased on 4 June at this site.

The SO2 analyser at Fort William suffered damage through water ingress during a spell of very wet weather at the beginning of January 2005. The analyser was returned to the UK service agent for repair. Following re-installation in February, the parts fitted during the repair failed, necessitating a return to the agent again.

The meteorological station suffered data losses during the winter as a result of poor weather causing the battery to discharge. The battery was recharged manually until the solar gain was sufficient to power the equipment reliably.

The Castletown site suffered from communications problems as a result of low mobile telephone signal strength. As a result of the lack of data transmission, a period of data from January to February was lost.

4 Results

The results from the three monitoring stations are given in Tables 3, 4 and 5:

Table 3: Summary of results-Fort William

POLLUTANT	SO_2
Number Very High	0
Number High	0
Number Moderate	0
Number Low	13696
Maximum 15-minute mean	77 µg m^{-3}
Maximum hourly mean	43 µg m^{-3}
Maximum running 8-hour mean	19 µg m^{-3}
Maximum running 24-hour mean	12 µg m^{-3}
Maximum daily mean	10 µg m^{-3}
Average	4 µg m^{-3}
Data capture	72.3 %

Table 4: Summary of results-Inverness

POLLUTANT	NO_X	NO_2
Number Very High	-	0
Number High	-	0
Number Moderate	-	0
Number Low	-	4206
Maximum 15-minute mean	546 µg m^{-3}	220 µg m^{-3}
Maximum hourly mean	466 µg m^{-3}	162 µg m^{-3}
Maximum running 8-hour mean	325 µg m^{-3}	102 µg m^{-3}
Maximum running 24-hour mean	164 µg m^{-3}	72 µg m^{-3}
Maximum daily mean	163 µg m^{-3}	68 µg m^{-3}
Average	47 µg m^{-3}	26 µg m^{-3}
Data capture	97.9 %	97.9 %

Table 5: Summary of results-Castletown

POLLUTANT	SO_2
Number Very High	0
Number High	0
Number Moderate	0
Number Low	17081
Maximum 15-minute mean	72 µg m^{-3}
Maximum hourly mean	43 µg m^{-3}
Maximum running 8-hour mean	29 µg m^{-3}
Maximum running 24-hour mean	16 µg m^{-3}
Maximum daily mean	16 µg m^{-3}
Average	6 µg m^{-3}
Data capture	90.3 %

Plots of the hourly averaged measured concentrations at each site are shown in Figures 4, 5 and 6

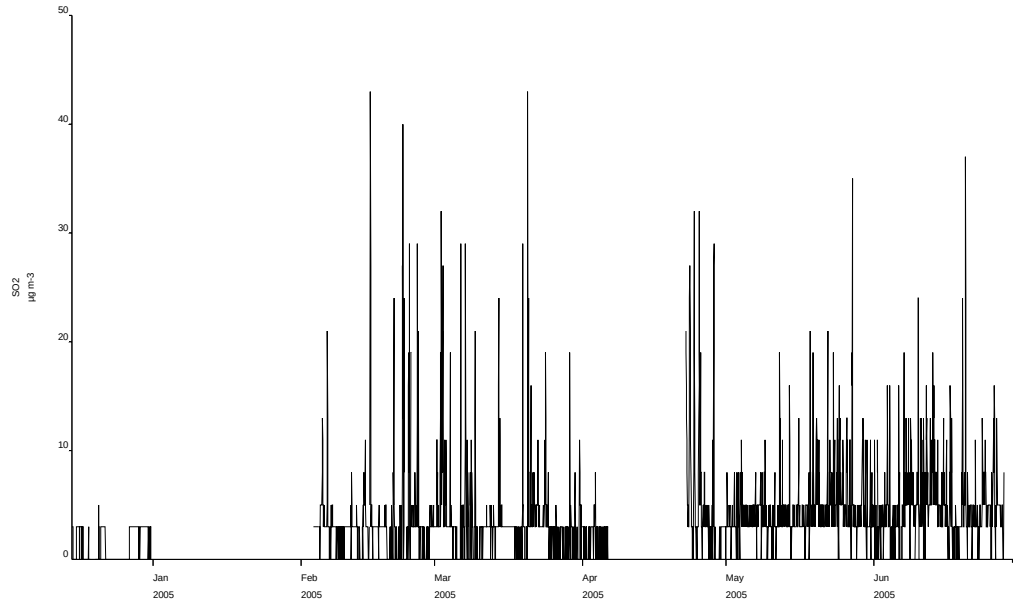

Figure 4: Fort William SO_2 Timeseries Plot

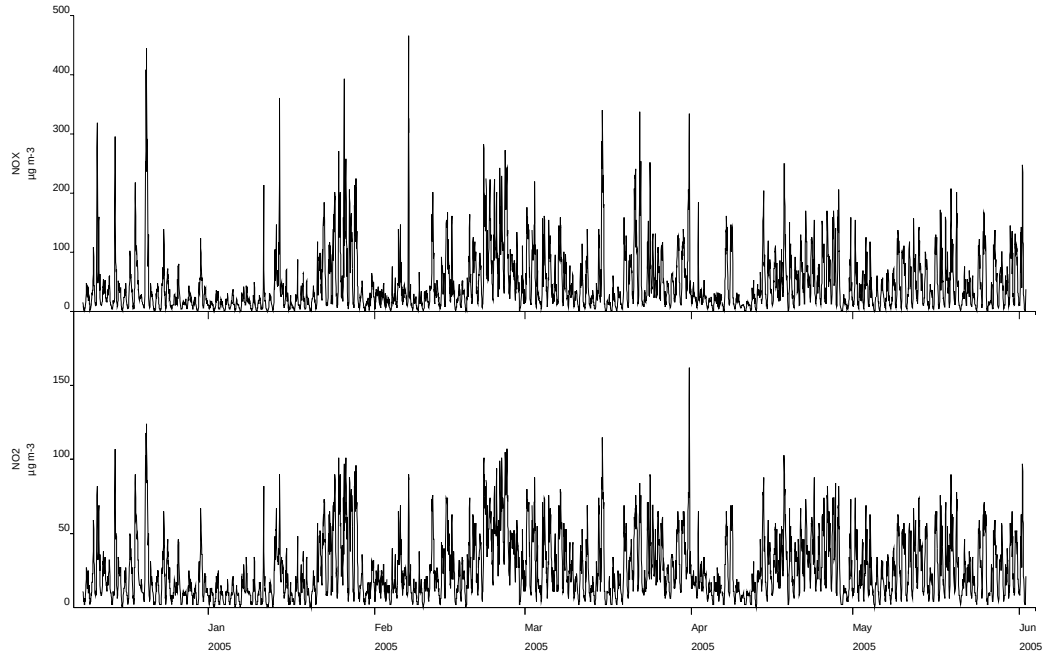

Figure 5: Inverness NOx and NO2 Timeseries Plots

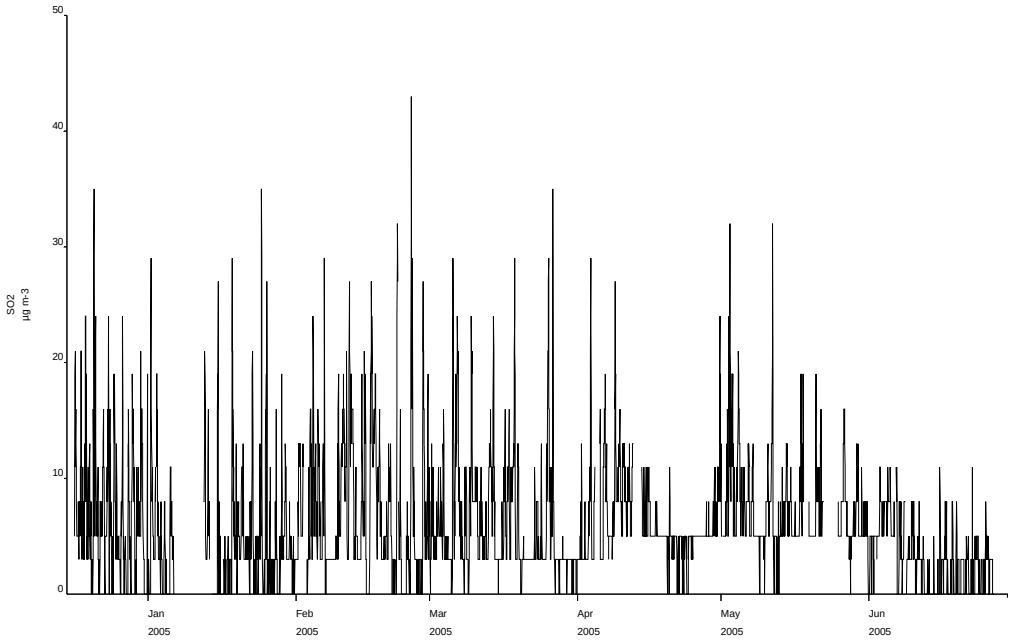

Figure 6: Castletown SO_2 Timeseries Plot

A discussion of the results is given in Section 6 of this report.

5 Meteorological Data

Measurements of wind speed and direction were made at Fort William. A portable weather station was installed at the Council roads maintenance depot close to the A82 just north of Fort William. Plots of wind speed and direction are given in Figures 7 and 8.

The recorded wind speed and direction values are 5-minute averages. The solar-powered instruments stopped working in January due to low ambient light levels producing insufficient power to charge the battery.

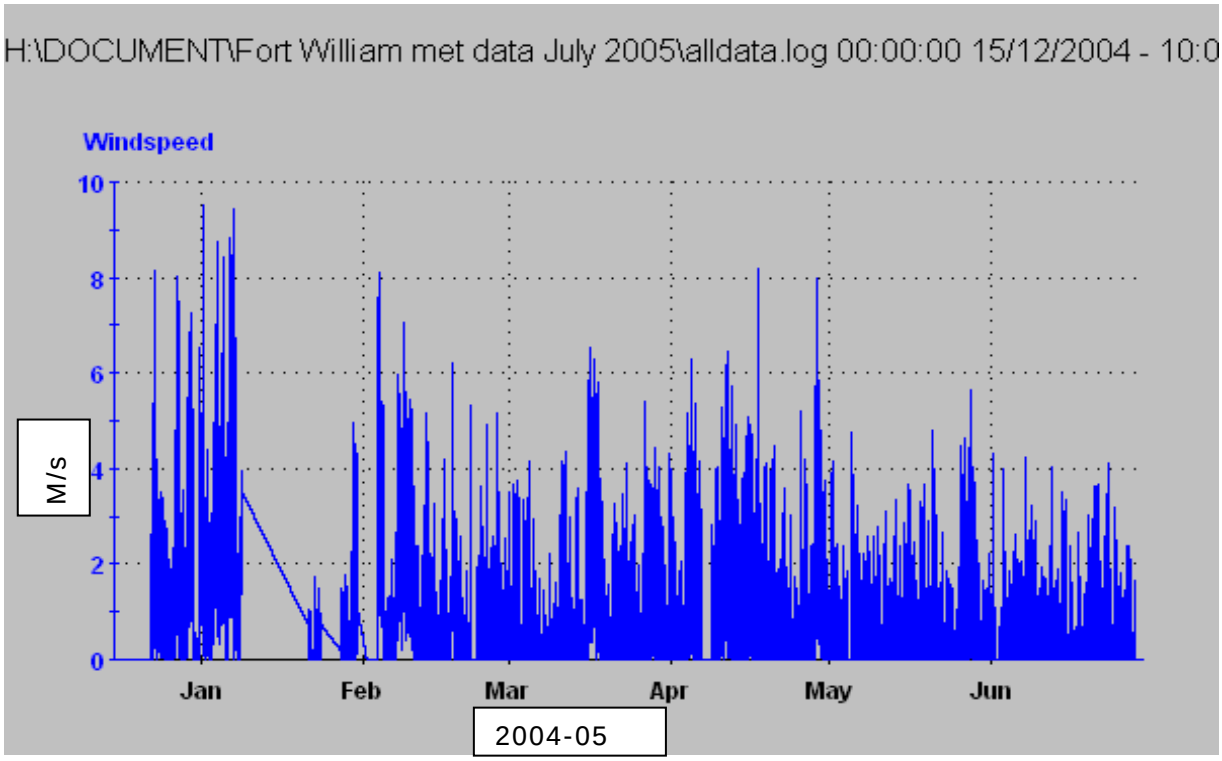

Figure 7: Wind speed at Fort William

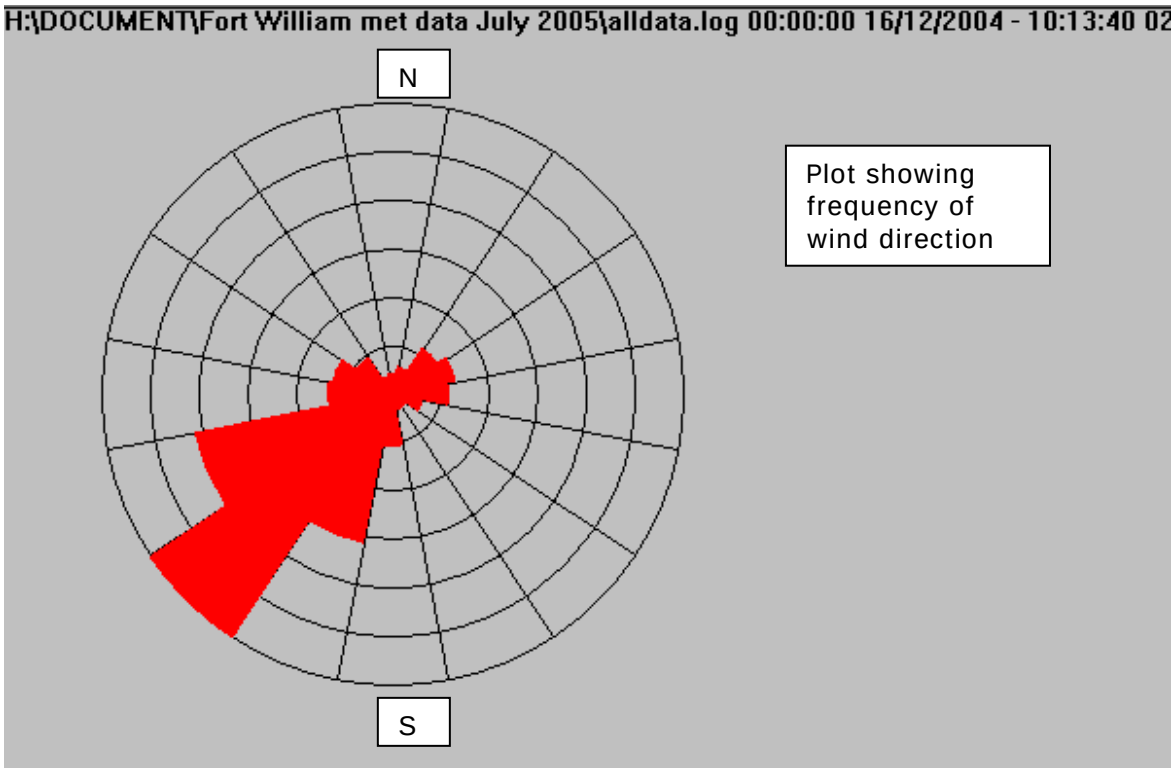

Figure 8: Wind Rose: Fort William, 16 Dec 2004-2 June 2005

As can be seen, the predominant wind direction during the period was from the south-west. This is likely to bring relatively unpolluted air to this location, although some minor contribution from the town itself may be expected.

The wind speed and direction data can be used to identify potential sources of significant pollution events; however, there were no such events at Fort William during the monitoring period.

6 Discussion of Results

6.1 COMPARISON WITH AIR QUALITY STANDARDS

The current UK Air Quality Strategy objectives, EC Directive limit values and defra air quality bandings for the pollutants covered by this study are given in Appendix 2.

Standards for air pollution are concentrations over a given time period that are considered to be acceptable in the light of what is known about the effects of each pollutant on health and on the environment. They can also be used as a bench mark to see if air pollution is getting better or worse.

An exceedence of a standard is a period of time (which is defined in each standard) where the concentration is higher than that set down by the standard. In order to make useful comparisons between pollutants, for which the standards may be expressed in terms of different averaging times, the number of days on which an exceedence has been recorded is often reported.

An objective is the target date on which the number of exceedences of a standard must not exceed a specified number. The objectives adopted in the UK are based on the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purpose of Local Air Quality Management. These Air Quality Regulations have adopted into UK law the limit values required by EU Daughter Directives on Air Quality.

On a day-to-day basis UK automatic air quality monitoring data are reported to the public using a health-effects based system of four bands and a 1-10 index. This provides detail about air pollution levels in a simple way, similar to the sun (UV) index or pollen index. This is described in Table 6. .

Table 6: Health Effects Banding System for Air Quality

Banding	Index	Health Descriptor
Low	1	Effects are unlikely to be noticed even by individuals who know they are sensitive to air pollutants
	2	
	3	
Moderate	4	Mild effects, unlikely to require action, may be noticed amongst sensitive individuals.
	5	
	6	
High	7	Significant effects may be noticed by sensitive individuals and action to avoid or reduce these effects may be needed (e.g. reducing exposure by spending less time in polluted areas outdoors). Asthmatics will find that their 'reliever' inhaler is likely to reverse the effects on the lung.
	8	
	9	
Very High	10	The effects on sensitive individuals described for 'High' levels of pollution may worsen.

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[1] sets out health-based standards for eight main air pollutants and objectives for their achievement throughout the UK by 31 December 2005, and/or other dates. It identifies the action that needs to be taken at international, national and local level, and provides a framework which allows relevant parties, such as industry, business and local government to identify the contributions they can make to ensuring that its objectives are met.

Since 1997 local authorities in the UK have been carrying out a review and assessment of air quality in their areas. The aim of the review is to make sure that the national air quality objectives will be achieved. If a local authority identifies a location where the objectives are not likely to be achieved, it must declare an Air Quality Management Area. The air quality objectives for SO_2 are given in Appendix 2.

Note that different objectives have been set for Northern Ireland, but these are omitted here for clarity.

A summary of the SO_2 and NO_2 data compared to the Air Quality Strategy Objectives is given in Table 7. Concentrations are generally expected to be higher during the winter months (October-March) when emissions are highest and atmospheric dispersion conditions poorest.

Table 7: Comparison with Air Quality Strategy Objectives

Pollutant	Air Quality Regulations (2000) and (Amendment) Regulations 2002	Site	Exceedences	Days	Max. concentration
Sulphur dioxide	266 µg/m^3 as 15-minute mean Not to be exceeded more than 35 times per year	Fort William	0	0	77 µg m^{-3}
		Castletown	0	0	72 µg m^{-3}
	350 µg/m^3 as 1-hour mean Not to be exceeded more than 24 times per year	Fort William	0	0	43 µg m^{-3}
		Castletown	0	0	43 µg m^{-3}
	125 µg/m^3 as 24-hour mean Not to be exceeded more than 3 times per year	Fort William	0	0	10 µg m^{-3}
		Castletown	0	0	16 µg m^{-3}
Nitrogen Dioxide	Annual mean > 40 µg m^{-3}	Inverness	-	-	26 µg m^{-3} (6-month)
	Hourly mean > 200 µg m^{-3}		0	0	162 µg m^{-3}

The EC have set limit values for SO_2 under the 1st Air Quality Daughter Directive. These are the same as the hourly and daily objectives listed in Table 3. Further objectives for protection of ecosystems are based on whole winter (1 October-31 March) or annual statistics; there are insufficient data at this site to compare against these standards. The EC alert threshold of 500 µg m^{-3} as a 3-hour mean was not exceeded at Fort William or Castletown during the monitoring period.

The results from the three monitoring stations have been compared to the Air Quality Strategy Objectives. A full list of these for the relevant pollutants is given in Appendix 2. A summary of exceedences is given in Table 8.

Table 8: Exceedence Statistics for Fort William, Inverness and Castletown

NO_X mass units are NO_X as NO_2

Pollutant	Air Quality Regulations (2000) and Air Quality (Scotland) Amendment Regulations 2002	Exceedences	Days
Fort William			
Sulphur Dioxide (SO_2)	15-minute mean > 266 µg m^{-3}	0	0
	Hourly mean > 350 µg m^{-3}	0	0
	Daily mean > 125 µg m^{-3}	0	0
	Annual mean > 20 µg m^{-3}	No (6-month)	-
Inverness			
Nitrogen Oxides (NO_2)	Annual mean > 30 µg m^{-3}	No (6-month)	-
	Annual mean > 40 µg m^{-3}	No (6-month)	-
	Hourly mean > 200 µg m^{-3}	0	0
Castletown			
Sulphur Dioxide (SO_2)	15-minute mean > 266 µg m^{-3}	0	0
	Hourly mean > 350 µg m^{-3}	0	0
	Daily mean > 125 µg m^{-3}	0	0
	Annual mean > 20 µg m^{-3}	No (6-month)	-

The monitoring was started during the winter, when pollutant concentrations may be expected to be highest. Burning of fossil fuels such as coal may contribute to local air pollution in rural areas, particularly for SO_2.

7 Comparisons with other Monitoring Sites

There is an AURN monitoring station in Inverness, monitoring NO_2 and CO. The site is close to Telford street, and is classed as a Roadside site. The NO_2 data for the same period as the Inverness ad-hoc site is given in Table 9.

Table 9: Summary of NO_2 data from Inverness AURN site, 8 December 2004-4 June 2005 compared to Inverness Academy Street

POLLUTANT	Inverness AURN NO_2	Inverness Academy St NO_2
Number Very High	0	0
Number High	0	0
Number Moderate	0	0
Number Low	4253	4206
Maximum 15-minute mean	193 µg m^{-3}	220 µg m^{-3}
Maximum hourly mean	157 µg m^{-3}	162 µg m^{-3}
Maximum running 8-hour mean	121 µg m^{-3}	102 µg m^{-3}
Maximum running 24-hour mean	70 µg m^{-3}	72 µg m^{-3}
Maximum daily mean	70 µg m^{-3}	68 µg m^{-3}
Average	22 µg m^{-3}	26 µg m^{-3}
Data capture	99.0 %	97.9 %

The concentrations at Academy Street over this period are generally similar to but slightly higher than those measured at the AURN site. NO SO_2 measurements are made at the Telford Street site. The nearest AURN site where SO_2 is measured is at Glasgow Centre. A comparison with the data from Glasgow Centre, Fort William and Castletown is given in Table 10.

Table 10: Summary of SO_2 data from Glasgow Centre AURN site, 8 December 2004-30 June 2005, compared to Fort William and Castletown

POLLUTANT	Glasgow Centre SO_2	Fort William SO_2	Castletown SO_2
Number Very High	0	0	0
Number High	0	0	0
Number Moderate	0	0	0
Number Low	16458	13696	17081
Maximum 15-minute mean	59 µg m^{-3}	77 µg m^{-3}	72 µg m^{-3}
Maximum hourly mean	35 µg m^{-3}	43 µg m^{-3}	43 µg m^{-3}
Maximum running 8-hour mean	24 µg m^{-3}	19 µg m^{-3}	29 µg m^{-3}
Maximum running 24-hour mean	14 µg m^{-3}	12 µg m^{-3}	16 µg m^{-3}
Maximum daily mean	13 µg m^{-3}	10 µg m^{-3}	16 µg m^{-3}
Average	1 µg m^{-3}	4 µg m^{-3}	6 µg m^{-3}
Data capture	96.6 %	72.3 %	90.3 %

The concentrations at Fort William and Castletown are similar to those at Glasgow; however, the 6-month average at Glasgow is actually less than for these two sites. The peak 15-minute and 1-hour averages at Castletown and Fort William are also higher than Glasgow Centre. This may be due to specific local sources nearby. However, long-term averages at all three sites are very low. The most stringent Objective for SO_2 is the 15-minute mean; the maximum 15-minute mean concentrations at all three sites were significantly lower than the Objective of 266 µgm^{-3}.

8 Conclusions

The results from the three sites site show that no relevant air quality standards for SO_2 or NO_2 were exceeded during the period 8 December 2004 to 30 June 2005.

Concentrations of SO_2 at Fort William and Castletown were similar to or slightly higher than those measured at the Glasgow Centre AURN site. NO_2 concentrations at Inverness Academy Street were similar to or slightly higher than those at the Inverness AURN site.

There were no days of "Moderate" or higher SO_2 or NO_2 air pollution as defined by defra's air pollution index, at any of the three monitoring sites during this monitoring period.

It is likely that the main sources of SO_2 in the rural areas are local combustion sources (eg domestic heating); lower concentrations may therefore be expected in the summer months. Higher SO_2 concentrations are often observed at many AURN monitoring sites during the winter. The main source of NO_2 is likely to be road traffic at the Inverness site, which was in a roadside location.

There were no significant periods of elevated air pollutant concentrations observed at any of the sites during the monitoring period.

9 References

1. The Air Quality Strategy.for England, Scotland, Wales and Northern Ireland. January 2000. ISBN 0-10-145482 and Addendum 2003, defra product code PB7874

2. Local Air Quality Management Guidance, LAQM.TG(3) February 2003

Appendices

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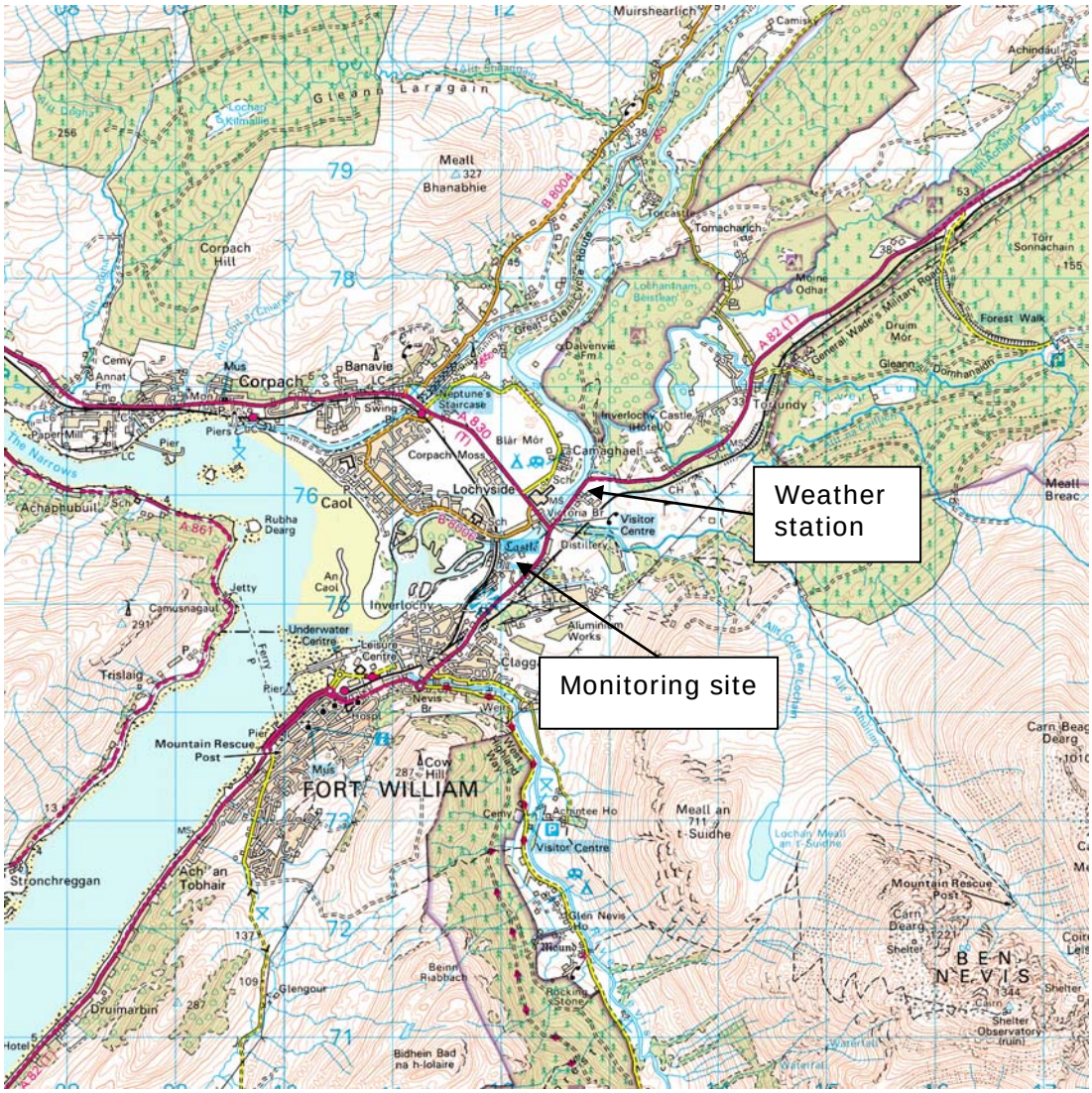
Appendix 1

Locations of monitoring sites

Fort William




Monitoring site
INVERNESS
Charlestown
North Kessock
Craigton
Kessock Bridge
Longman Point
Craigton Point
Dolphin Centre
Kilmuir
Viewbank
Craigbreck
Drumsmittal
Croftnacriech
Balguntoune
Craigrory
Lettoch
Bellfield
Orienteering Course
Ord Hill
Croft Downie
Slack of Kessock
Wildlife Park
Ashleyd
Dut Circles
Ploverfield
Antafellie
Goldwells
Loch Lundie
Church (ruins of)
Alturlie
Milton
Longman Industrial Estate
Refuse Tip
Seafield
Hotel
Stratton
Retail Park
Ashton
Resaurie
Beechwood
Culcabock
Castlehill
Westhi
Dell of Inshes
Inshes
Lower Muckovie
Balvonie of Inshes
Raigmore
Merkinch
Clachnaharry
Scorguie
Craig Phadrig
Blackpark
Forest Park
Kinmylies
Leachkin
Dalneigh
Bught Park
Sports Centre
Floral Hall
Drummond
Torvean
Charleston
Dunain Hill
Dunain Park (Hotel)
Balnagaig Fm
Ness-side
Dunaincroy
Ness Castle
Drumdevan
Torbreck
Knocknagael
Balmore of Leys
Oldtown of Leys
Lower Slackbuie
Upper Slackbuie
Druidtemple
Milton of Leys
Welltown of Easter Leys
Leys Castle
Boghain
Lagnalean
Weir
CALEDONIAN CANAL
A82(T)
A9(T)
B865
B8062
B862
B861
Chambered Cairn
Cairn
Mill
Hilton
Harbour
South Kessock
Merkinch Basin
Muirtown Basin
Castle
Sch
Hospl
Cemy
Crem
Ho
Wks
LC
PC
PH
MS
CH
Infmy
Ballifeary
Tce
Pk
Sq
Rd
Ave
Gdns
Cres
Dr
Ln
Pl
Ct
Hill
Fm
Mkt
Bldg
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Ind Est
Retail Pk
Sports Cen
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PC
PH
MS
CH
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Ballifeary
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Sq
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Ave
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Dr
Ln
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Ct
Hill
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Ind Est
Retail Pk
Sports Cen

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Appendix 2
Air Quality Standards

Nitrogen Dioxide

Set By	Description	Criteria Based On	Value (μgm^{-3})
UK Government - Air Pollution Bandings	LOW Air Pollution	1-hour mean	< 287
	MODERATE Air Pollution		287 - 572
	HIGH Air Pollution		573 - 763
	V HIGH Air Pollution		>=764
- The Air Quality Strategy(1)	Objective for Dec. 31st 2005 (protection of health)	1-hour mean	200 not to be exceeded more than 18 times per calendar year
	Objective for Dec. 31st 2005 (protection of health)	Annual mean	40
	Objective for Dec. 31st 2000 (protection of vegetation)	Annual mean *	30

* Objectives for protection of vegetation only apply in rural areas and are not set in regulations.

Sulphur Dioxide

Guideline Set By	Description	Criteria Based On	Value / ppb (μgm^{-3})
UK Government - Air Pollution Bandings	LOW Air Pollution	15-minute mean	< 266
	MODERATE Air Pollution		266 - 531
	HIGH Air Pollution		532 - 1063
	V HIGH Air Pollution		>=1064
- The Air Quality Strategy(1)	Objective for Dec. 31st 2005 (protection of health)	15-minute mean	266 not to be exceeded more than 35 times per calendar year
	Objective for Dec. 31st 2004 (protection of health)	1 hour mean	350 not to be exceeded more than 24 times per calendar year
	Objective for Dec. 31st 2004 (protection of health)	24 hours (daily mean)	125 not to be exceeded more than 3 times per calendar year
	Objective for Dec. 31st 2004	Annual and winter (Oct-Mar) mean *	20

	(protection of vegetation)		

* Objectives for protection of vegetation only apply in rural areas and are not set in regulations.

Appendix 3
Title

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