Presented to: Technical Committee on 23/11/16
Decision:
1. That the report be received, and
2. That the state of air quality in Otago be noted.

Otago Regional Council

REPORT

Document Id: A940687

Report Number: 2016/1075
Prepared For: Technical Committee
Prepared By: Deborah Mills, Environmental Scientist
Date: 15 November 2016

Subject: **2016 Air Quality Results**

---

1. Précis

Ambient air quality monitoring of PM_{10}[1] continued this year at eight sites across Otago. Continuous year-round monitoring was performed at four sites: Alexandra, Arrowtown, Mosgiel and Central Dunedin. Monitoring was performed from April-September at the remaining four sites – Balclutha, Milton, Clyde and Cromwell. This report presents Otago's ambient air quality monitoring results for 2016 and examines the long-term trends in PM_{10}.

Monitoring and associated reporting fulfils requirements of the Otago Regional Council Annual Plan target A1 – Ambient Air Quality Monitoring and Reporting.

Ambient (outdoor) air quality is regulated by the National Environmental Standards for Air Quality (NESAQ), effective in 2004 and amended in 2011. The NESAQ sets an ambient PM_{10} concentration limit of 50 micrograms per cubic metre of air ($\mu g/m^3$) as a 24-hour average; one exceedance of that limit is allowed in a 12-month period.

The NESAQ set a final compliance date of 1 September 2020, with an interim target of no more than three days per year over the limit from 1 September 2016. Days with average PM_{10} greater than the 50 $\mu g/m^3$ limit are referred to as exceedances, or high-pollution days.

Table 1 shows the number of exceedances (days with average PM_{10} values exceeding 50 $\mu g/m^3$) this calendar year at monitored sites around Otago.

Table 1. Number of exceedances recorded at Otago PM_{10} monitoring sites.

Location	Number of exceedance days
Alexandra	39
Arrowtown	30
Balclutha	11
Clyde	17
Cromwell	33
Dunedin	0
Milton	35
Mosgiel	8

[1] Particulate matter with an aerodynamic diameter of less than 10 micrometres

Central Dunedin is on track to meet the NESAQ this year; no exceedances have been recorded to date for this calendar year or within the past 12 months. The remainder of the monitored centres have all had multiple exceedances. Alexandra had the greatest number (39 days).

2. Introduction to the NESAQ and the Otago context

In 2004, the Ministry for the Environment (MfE) introduced national environmental standards for air quality which regulate, among other things, five outdoor air pollutants. These include carbon monoxide (CO), particulate matter less than 10 micrometres in diameter (PM_{10}), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and ozone (O_3). Of these pollutants, only PM_{10} is of concern in the Otago region.

The regulations were amended in 2011 to re-define and extend compliance deadlines, make provision for exceptional events that cause high-pollution days, require the use of emission 'offsets' for significant industrial discharges, and to add further restrictions on open fires in polluted areas.

The standard for PM_{10} is based on a short-term exposure; an average 24-hour concentration threshold is set at 50 micrograms per cubic metre of air ($\mu g/m^3$). One exceedance per annum of that limit is allowed. This set of standards is to be met by 2020; in the interim, only three exceedances per annum are allowed from 1 September 2016 until 1 September 2020.

Currently, the NESAQ is under review by the MfE with an outcome projected for 2017. The review was prompted, in part, by the report produced by the Parliamentary Commissioner for the Environment in March 2015[2] which highlighted the international thinking about health-related effects of exposure to $PM_{2.5}$. These smaller particles are a subset of PM_{10} and are capable of travelling deep into the respiratory system where they are responsible for most of the more significant adverse health effects related to particulate pollution.

In accordance with the regulations, in 2005 the Otago Regional Council (ORC) gazetted 22 towns and areas into 4 airsheds; those same 22 towns were then simplified into two Air Zones for the purpose of regional air quality management through the ORC's Regional Plan: Air (Air Plan). Table 1 lists the designations of towns into both airsheds (for reporting purposes to the Ministry for the Environment) and Air Zones (for air quality management by the ORC). The Air Plan sets a goal value of no more than 35 $\mu g/m^3$ over a 24-hour period.

ORC maintains a network of continuous PM_{10} monitors in eight towns. Four of these run year-round and are used to report to MfE for regulatory purposes; these are located in Alexandra, Arrowtown, Central Dunedin and Mosgiel. Four other monitors, located in Balclutha, Milton, Clyde, and Cromwell run during colder, winter months. In all areas, the major source of PM_{10} emissions is solid-fuel burners used for domestic heating.

This report presents ambient air quality monitoring results for 2016 (to 15 October). Monitoring results are presented in Section 3 and trends are discussed in Section 4.

[2] Parliamentary Commissioner for the Environment, *The state of air quality in New Zealand: Commentary by the Parliamentary Commissioner for the Environment on the 2014 Air Domain Report,* Wellington, March 2015

Currently, Central Dunedin is complying with the PM_{10} limits set in the NESAQ. All other monitored towns are not compliant and are unlikely to achieve compliance from 1 September 2016. An explanation of the Otago air quality context can be found in the report titled, *Air quality in Otago – Issues and Consideration*[3].

Table 2. Designation of Otago towns and areas by airshed and Air Zone

Airshed 1- MfE	Air Zone 1 – ORC
Alexandra Arrowtown Clyde Cromwell Naseby Ranfurly Roxburgh	Alexandra Arrowtown Clyde Cromwell
Airshed 2 - MfE	Air Zone 2 – ORC
Palmerston Mosgiel South Dunedin Green Island Milton	Balclutha North Dunedin Central Dunedin South Dunedin Green Island Hawea Kingston Milton Mosgiel Naseby Oamaru Palmerston Port Chalmers Queenstown Ranfurly Roxburgh Waikouaiti Wanaka
Airshed 3 - MfE	Air Zone 3 – ORC
Balclutha North Dunedin Central Dunedin Oamaru Port Chalmers Waikouaiti	Rest of Otago
Airshed 4 - MfE	
Hawea Kingston Queenstown Wanaka	

[3] ORC, Report Number 2014/0983, *Air quality in Otago – Issues and Considerations*, Presented to Technical Committee 24/7/2014.

3. Winter Summary

3.1. PM_{10} Statistics

Air quality monitors operated in Alexandra, Arrowtown, Clyde, Cromwell, Balclutha, Central Dunedin, Milton and Mosgiel this year.

The key indicators in Table 2 show that the numbers of exceedances range from zero in Central Dunedin to 39 days in Alexandra. The table also lists the maximum and second highest one-day values along with the winter (May – August) average for each site. A spreadsheet with a wider range of descriptive statistics for each site is attached as Appendix 1.

Table 3. Annual summary statistics for daily PM_{10} in 2016. The highest value in each category is marked in bold. (Unless noted, all units are µg/m^3).

Location	Number of exceedances (days)	Maximum daily value	Second highest PM_{10} daily value	Winter average (May-Aug)	NESAQ threshold concentration
Alexandra	**39**	116	116	42	50
Arrowtown	30	113	111	37	50
Balclutha	11	64	62	28	50
Clyde	17	91	86	29	50
Cromwell	33	104	103	36	50
Dunedin	0	41	38	18	50
Milton	35	**203**	**157**	**44**	50
Mosgiel	8	116	71	24	50

4. Comparison to typical winter PM_{10} air quality

The typical air quality situation is described by aggregating statistics for the previous three years; in this case, an averaged dataset was created from data collected from 2013 through 2015. Using three years minimises the influence of annual climatic differences from year to year on air quality.

The number of exceedances and winter averages for 2016 are compared to the aggregate dataset (Figures 1 and 2) to indicate whether this year's air quality was better or worse than usual. In general, it appears that air quality this winter was characteristic of a typical year. One notable exception is Balclutha where the number of exceedances was more than double the usual number. The reason for this is unknown.

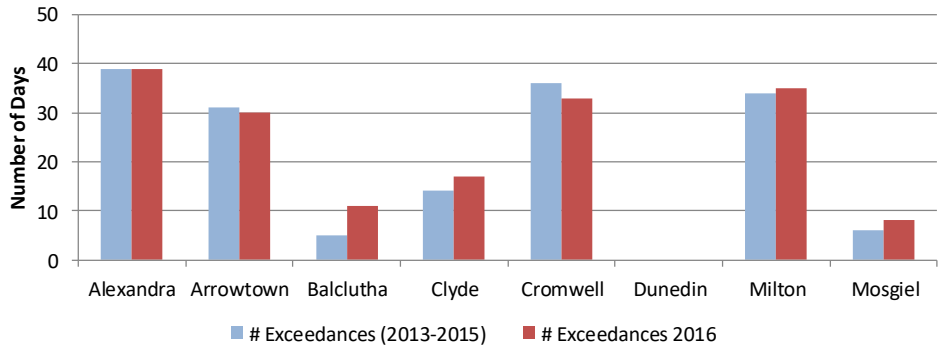

Figure 1. Number of exceedances in 2016 (red) compared to the typical number (blue).

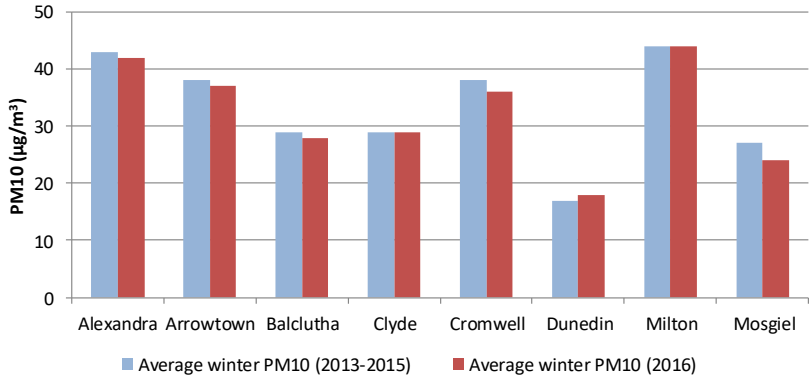

Figure 2. Average winter PM_{10} values in 2016 (red) compared the typical number (blue).

PM_{10} concentrations are a result of emission rates and amounts, in combination with the weather. This winter was declared the 8th warmest winter according to NIWA's seven station indicator network.[4] Mean monthly temperatures in Cromwell this year as compared to 30-year climate normals (1980-2010) appear to bear that out (Table 3).

Table 4. Monthly mean air temperatures in Cromwell compared to 30-year normals (1980-2010). All temperatures are given in degrees C.

	May	June	July	August
2016	9.6	5.7	5.1	5.5
Normal (1980-2010)	7.2	4.1	3.2	5.6
Departure from Normal	+2.4	+1.6	+1.9	-0.1

The unusually 'warm' winter, however, does not necessarily translate to better air quality due to fewer emissions and/or enhanced dispersion. Despite warmer mean temperatures, minimum temperatures in Central Otago towns still reached below zero on 54 days this winter, going down as low as -8 degrees. There is no reason to believe that burners were used less than usual this winter for domestic heating.

Other weather factors play a role in the potential for particulates to accumulate, most notably when temperature inversions occur. The synergistic effect of cold temperatures, clear skies, and calm winds provide the conditions for inversions to form and persist through the night; this serves to trap discharges from domestic burners in the lowest 50-100 metres of air. This combination of conditions typically exists anywhere from 30-50 days each winter in Central Otago.

Large-scale weather patterns also influence the daily weather patterns which affect air quality. For example, last winter's (2015) strong El Nino created a pattern of much more frequent westerlies, resulting in enhanced dispersion. This situation led to lower PM concentrations and improved air quality around the country. The El Nino pattern weakened early this year, leading to neutral conditions this winter; this has led to normal westerly flows across New Zealand.

[4] NIWA National Climate Centre, *Seasonal climate Summary: Winter 2016*, 5 September 2016

5. Long-term trends

As of this year, the four year-round monitoring sites – Alexandra, Arrowtown, Dunedin, and Mosgiel – all have 10 years of continuous data. Long-term trends in both daily PM_{10} values and exceedance values were examined using a smoothed-trend technique[5]. This technique uses monthly mean values of the 50th and 95th percentile values and fits a smooth line to the dataset. The 95% confidence interval is shown around the line to highlight important features and real variation in the data without including excessive 'noise' found in the dataset.

5.1. Alexandra

Overall, year-round PM_{10} values do not demonstrate any significant trend over the past 10 years (Figure 3). However, examining the values of PM_{10} on days that exceed that NESAQ (>50 µg/m^3), there appears to be a slight, but steady, decrease in those highest values (Figure 4). It is expected that the reason for this is that the replacement of older, inefficient wood burners with newer, more efficient models is having an effect on concentrations.

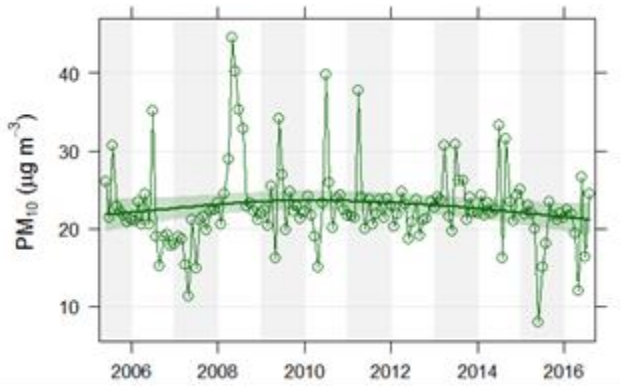

Figure 3. Trend in daily PM_{10}

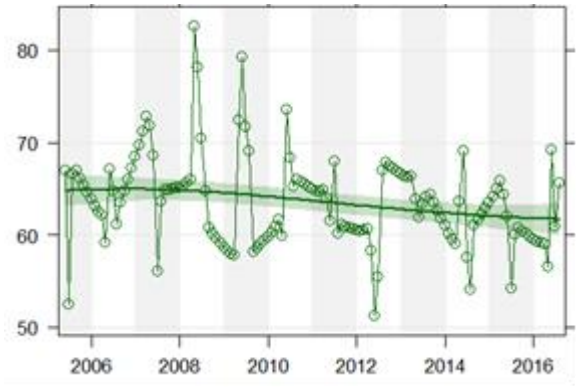

Figure 4. Trend in PM_{10} exceedance values

5.2. Arrowtown

PM_{10} values have been much more variable year-to-year in Arrowtown (Figures 5 and 6) but with a significant decrease in PM_{10} from 2007 to 2011. In 2013, the monitor was moved to an alternate location in Arrowtown. PM_{10} levels are generally higher at the second site, but have also shown improvement over the past three years.

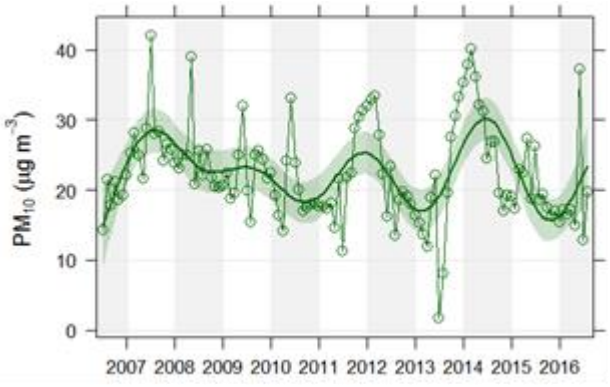

Figure 5. Trend in daily PM_{10}

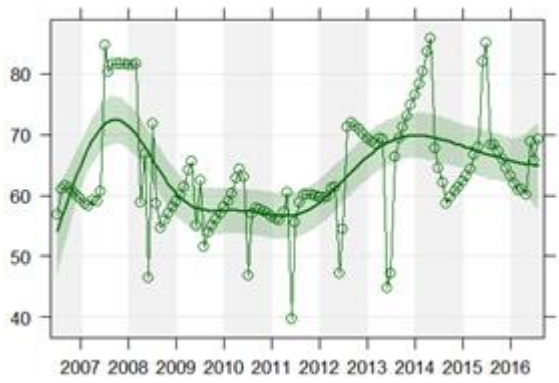

Figure 6. Trend in PM_{10} exceedance values

[5] Carslaw, D.C., Ropkins, K., 2012. Openair — an R package for air quality data analysis. Environmental Modelling & Software, Volume 27-28

5.3. Mosgiel and Dunedin

PM_{10} levels increased in Mosgiel from 2007 through 2011, but have since started to decline with this year having some of the best year-round air quality over the past 10 years (Figure 7). This year, 86% of winter days met the Otago Goal Level (<35 µg/m^3) and only 7% exceeded the NESAQ level (>50 µg/m^3).

In Dunedin, PM_{10} levels dropped significantly after 2011 and have remained low since that time (Figure 8). Improvements to industrial discharges-to-air and natural attrition of older, inefficient solid-fuel burners are the likely reasons for the improvement. This is the 5th consecutive year that the Central Dunedin airshed has been compliant with the NESAQ.

Neither Mosgiel nor Dunedin has had enough exceedances to perform a meaningful trend analysis on those figures.

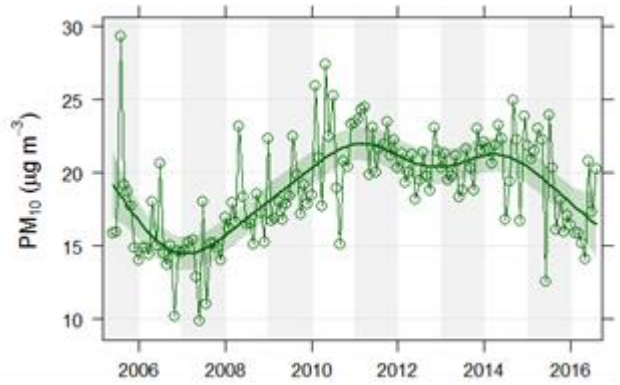

Figure 7. Trend in daily PM_{10} - Mosgiel

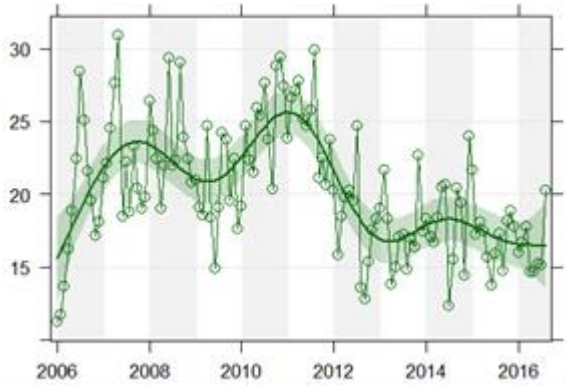

Figure 8. Trend in daily PM_{10} - Dunedin

6. Recommendations

1. That this report be received.

1. **That the state of air quality in Otago be noted.**

Gavin Palmer
Director Engineering, Hazards and Science

2016	Alexandra	Arrowtown	Balclutha	Clyde	Cromwell	Dunedin	Milton	Mosgiel
Summary								
Winter average PM_{10} (May-Aug)	42	37	28	29	36	18	44	24
Number Exceedances (days)	39	30	11	17	33	0	35	8
Maximum PM_{10}	116	113	64	91	104	41	203	116
2nd highest PM_{10}	116	111	62	86	103	38	157	71
Number of days > 100µg/m^3	3	7	0	0	3	0	7	1
Monthly exceedances (days)								
January	0	0				0		0
February	0	0				0		0
March	0	0				0		0
April	0	0	0	0	0	0	0	0
May	5	1	0	0	3	0	3	0
June	15	14	5	7	10	0	14	4
July	11	9	4	8	7	0	12	4
August	8	6	2	2	9	0	5	0
September	0	0	0	0	4	0	1	0
Winter days (123 days)								
# days < 35 µg/m^3	55	73	93	84	75	112	58	105
# days between 35-50 µg/m^3	29	20	18	20	17	5	30	9
# days > 50 µg/m^3	39	30	11	17	29	0	34	8
% days < 35 µg/m^3	45	59	76	69	62	96	48	86
% days between 35-50 µg/m^3	24	16	15	17	14	4	25	7
% days > 50 µg/m^3	32	24	9	14	24	0	28	7
Monthly averages								
May	28	19	21	20	23	17	29	16
June	53	57	32	35	46	17	57	32
July	44	42	28	31	39	17	50	26
August	43	32	31	30	38	21	40	23

Otago Regional Council