Environment Waikato Technical Report 2004/31

Ozone Concentrations in Hamilton – Summer 2003/04

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Executive Summary

Monitoring of ozone concentrations was carried out by Environment Waikato at the Peachgrove Road monitoring site during the summer of 2003/04. This report details the results of the monitoring including a comparison to national ambient air quality guidelines for ozone, an assessment of the meteorological conditions during the monitoring period and an evaluation of the likelihood that results are typical of summer ozone concentrations in Hamilton.

The maximum measured ozone concentrations during the monitoring period were 80 µg m^{-3} (1-hour average) and 63 µg m^{-3} (8-hour average). These compare to ambient air quality guidelines of 150 µg m^{-3} and 100 µg m^{-3} respectively. The proposed national environmental standard for ozone is 150 µg m^{-3} (1-hour average).

A comparison of ozone concentrations to meteorological conditions in Hamilton indicates that highest concentrations occur under low wind speeds (less than 3 m s^{-1}) and elevated temperatures (over 20 ° C). In most instances the maximum concentrations occurred during the evening (4pm to 6pm) period and are likely to be as a result of precursor emissions from the evening traffic peak. These coincided with days when temperatures remained high during the early evening period.

Daily variations in ozone concentrations show that, on average, concentrations are highest during the early afternoon (around 2pm) coinciding with the highest average daily temperatures. Concentrations of ozone typically increase from around 7am and decrease from around 2pm to 9pm.

It is likely that peak summer ozone concentrations in Hamilton would be higher than those measured during the summer of 2003/04. This conclusion is based on a comparison of wind speeds and temperatures during January to March 2004 to similar periods for 2003 and 2002. This comparison showed similar meteorology for 2003 and 2004 but higher temperatures and lower wind speeds during 2002. Concentrations of ozone in 2002 were therefore likely to be higher than those measured during 2004.

1 Introduction

Exposure to concentrations of ozone in the ambient air can result in a variety of health impacts. These effects range from premature mortality to hospital admissions, emergency room visits, respiratory symptoms and effects on lung function. These impacts can occur as a result of both physiological and pathological changes in the respiratory system. Ozone is also harmful to vegetation and some materials such as plastics and rubber.

National ambient air guidelines for ozone have been set at 150 μgm^{-3} (1-hour average) and 100 μgm^{-3} (8-hour average, MfE, 2002). However, epidemiological studies indicate that there is no safe level of ozone below which adverse health effects do not occur. The Ministry for the Environment (2003) proposed National Environmental Indicators (NES) includes a value for ozone of 150 $\mu g\ m^{-3}$ (1-hour average). In addition to the guideline and NES values, MfE provides air quality indicator categories for the reporting of concentrations of contaminants (Table 1.2).

Monitoring for ozone is not a priority in many areas of New Zealand because conditions are not considered conducive to ozone formation. However, McKendry (1997) identified Hamilton as having the potential for elevated ozone concentrations based on an assessment of meteorological conditions and because of the presence of emissions of the precursor contaminants, nitrogen dioxide and volatile organic compounds. These contaminants react with oxygen (O_2) in presence of sunlight to form ozone (O_3) as shown in Equations 3.1-3.3.

$$NO_2 + O_2 \rightarrow O_3 + NO$$

Equation 3.1

In a reverse process, NO slowly reacts with O_3 and destroys it 24 hours a day to make NO_2 and O_2.

$$NO + O_3 \rightarrow NO_2 + O_2$$

Equation 3.2

In sunlight, VOCs recycle NOx by reacting with NO to produce more NO_2, fuelling the original reaction to form more O_3.

$$VOCs + NO \rightarrow NO_2 \text{ which leads to } NO_2 + O_2 \rightarrow O_3 + NO$$

Equation 3.3

Meteorological conditions conducive to ozone formation include warm temperatures, sunlight and low wind speeds.

Table 1-1: Ministry for the Environment's Environmental Performance Indicator categories for air quality

Category	Value relative to guideline	Comment
Excellent	Less than 10% of the guideline	Of little concern: if maximum values are less than a tenth of the guideline, average values are likely to be much less
Good	Between 10% and 33% of the guideline	Peak measurements in this range are unlikely to affect air quality
Acceptable	Between 33% and 66% of the guideline	A broad category, where maximum values might be of concern in some sensitive locations but generally they are at a level that does not warrant urgent action
Alert	Between 66% and 100% of the guideline	This is a warning level, which can lead to exceedences if trends are not curbed
Action	More than 100% of the guideline	Exceedences of the guideline are a cause for concern and warrant action, particularly if they occur on a regular basis

2 Monitoring programme

The monitoring site used to measure concentrations of ozone in Hamilton was the Peachgrove Road site. This site is described in detail in previous reports (e.g., Wilton, 2002) and is consistent with the "Residential Peak" site classification as described in *Good Practice Guideline for Air Quality Monitoring and Data Management* (MfE, 1999). Although unlikely to measure maximum ozone concentrations in the vicinity of the Hamilton area, the site was selected as representative of air quality in a high exposure area. An additional monitoring site approximately 20 kilometres to the east of Hamilton was identified as the most probable site for measuring maximum ozone concentrations (Wilton, 2003). However, the population exposed would be limited owing to the rural nature of the area.

The monitoring was carried out from the 20 November 2003 with the final summer calibration being carried out on the 25 March 2004. Equipment calibration was carried out by NIWA for Environment Waikato. As the initial calibration was not carried out until 27 November, data prior to this point were deemed invalid. Data were collected continuously and logged at 10-minute intervals. Missing data were limited to times when calibrations were carried out on the sampler on the 21 January 2004 and the 25 March 2004.

Data collection was limited to summer months as this was when the potential for ozone formation was highest as a result of the warmer summer temperatures. Meteorological data were also collected at the monitoring site and used to compare meteorological conditions to previous summers and to determine conditions conducive to elevated ozone concentrations at the site.

The equipment used was a Thermo Environmental model 49 ozone analyser. This uses the technique of UV absorption to determine concentrations of ozone and complies with AS3580.4.1-1990. Concentrations of ozone were measured in parts per billion and converted to µg m^{-3} based on the New Zealand standard temperature conversion of zero degrees.

3 Results

3.1 Concentrations of ozone

Concentrations of ozone measured in Hamilton during the summer of 2003/04 are shown in Figure 3.1. The maximum measured hourly average ozone concentration measured at the site was 80 µg m^{-3}. This compares to an hourly average guideline concentration and NES of 150 µg m^{-3}. This occurred on the 11 January at 6pm. The maximum eight-hour average ozone concentration was 63 µg m^{-3}. This is less than 66% of the eight-hour average guideline for ozone of 100 µg m^{-3}.

Figure 3.2 compares hourly average and eight-hour average ozone concentrations measured in Hamilton from 27 November 2003 to 25 March 2004 to MfE air quality indicator categories (as described in Table 1.2). The majority of the hourly average concentrations were within the "excellent" or "good" categories with only a small proportion of data in January greater than 33% of the air quality guideline and NES for ozone. The eight-hour average concentrations were largely within the "good" category with 5-14% of the monthly data falling within the "acceptable" (33-66% of the guideline) category.

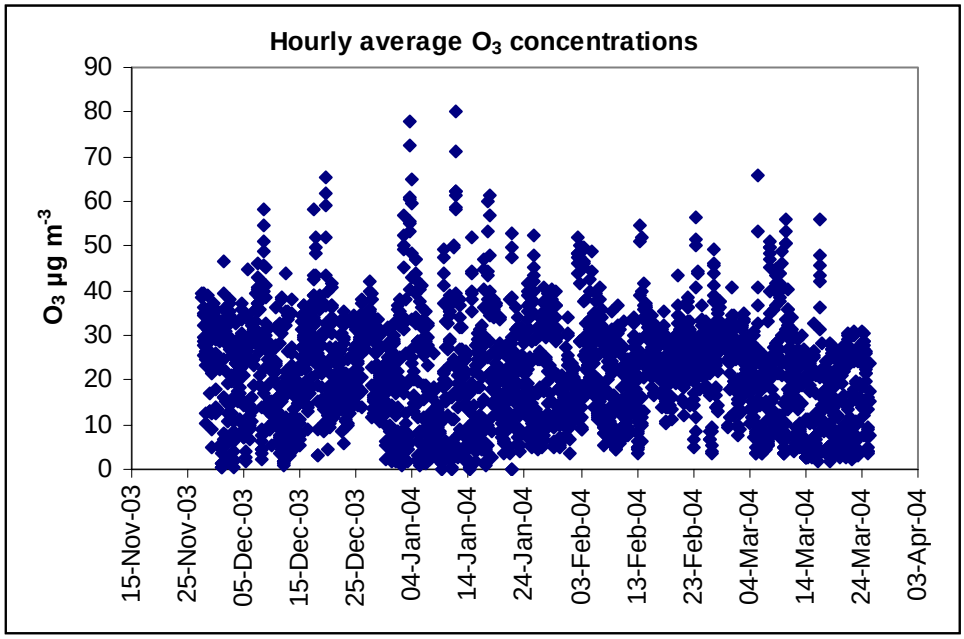

Figure 3-1: Hourly average ozone concentrations measured in Hamilton from 27 November 2003 to 25 March 2004

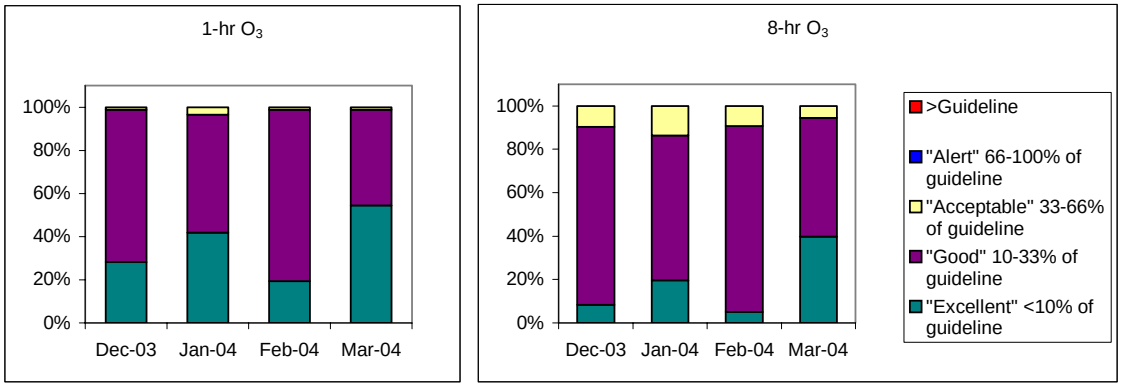

Figure 3-2: Comparison of hourly and eight hour average ozone concentrations measured in Hamilton to MfE air quality indicator categories

An analysis of the wind trajectory on the day when the maximum concentration of ozone was measured indicates that emissions from within Hamilton are only likely to have impacted on ozone concentrations at the monitoring site for the hour previous to the maximum concentrations being measured. Thus the peak concentration of ozone relates to precursor emissions in Hamilton during the evening traffic peak and does not include the impact of daytime or morning emissions as the trajectories showed no re-circulation of emissions from 8am to 6pm.

Daily variations in ozone concentrations in Hamilton show average hourly concentrations are highest around 1-2 pm (Figure 3.3). This coincides with the peak in average daily temperature of 22.2 ° C at 2pm.

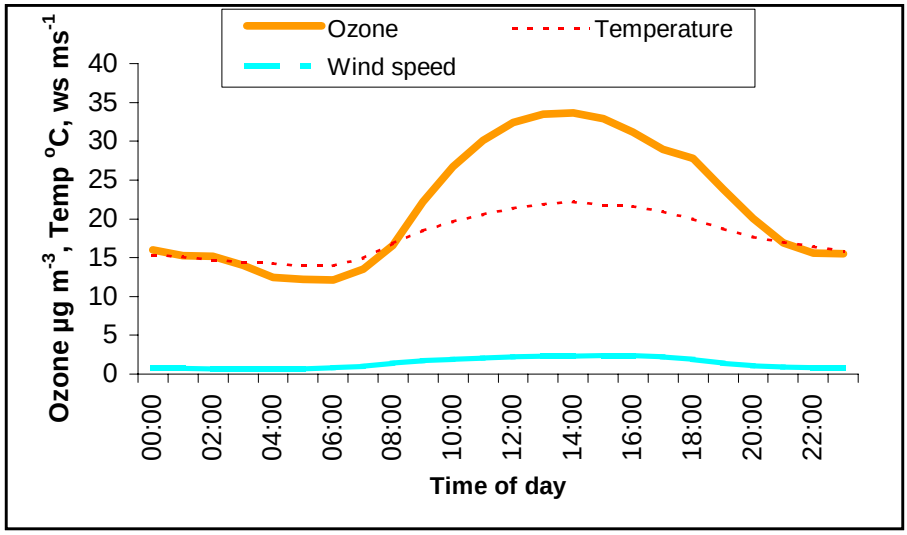

Figure 3-3: Daily variations in ozone concentrations from November 2003 to March 2004

3.2 Meteorology

The meteorological conditions in Hamilton during the monitoring period are of interest for two reasons. A comparison of meteorology to elevated ozone concentrations can assist in determining the meteorological conditions under which elevated ozone concentrations at the site are likely to occur. This information can assist in the design of future monitoring programmes for ozone and in evaluating the probability of higher ozone concentrations in and around Hamilton.

A comparison between meteorological conditions during the monitoring period to the same dates for previous years is also of value. This assessment can determine whether meteorology occurring during the monitoring period is typical of a Hamilton summer and consequently the extent of further monitoring required to adequately assess the impact of ozone concentrations in Hamilton.

3.2.1 Comparison of meteorology and ozone concentrations

Figure 3.4 compares ozone concentrations measured in Hamilton to hourly average wind speed, wind direction, temperature and relative humidity data. Highest ozone concentrations were measured under wind speeds of around 2 m s^{-1}, westerly and north to easterly winds, elevated temperatures (greater than about 20 ° C) and when the relative humidity was low (less than 60%).

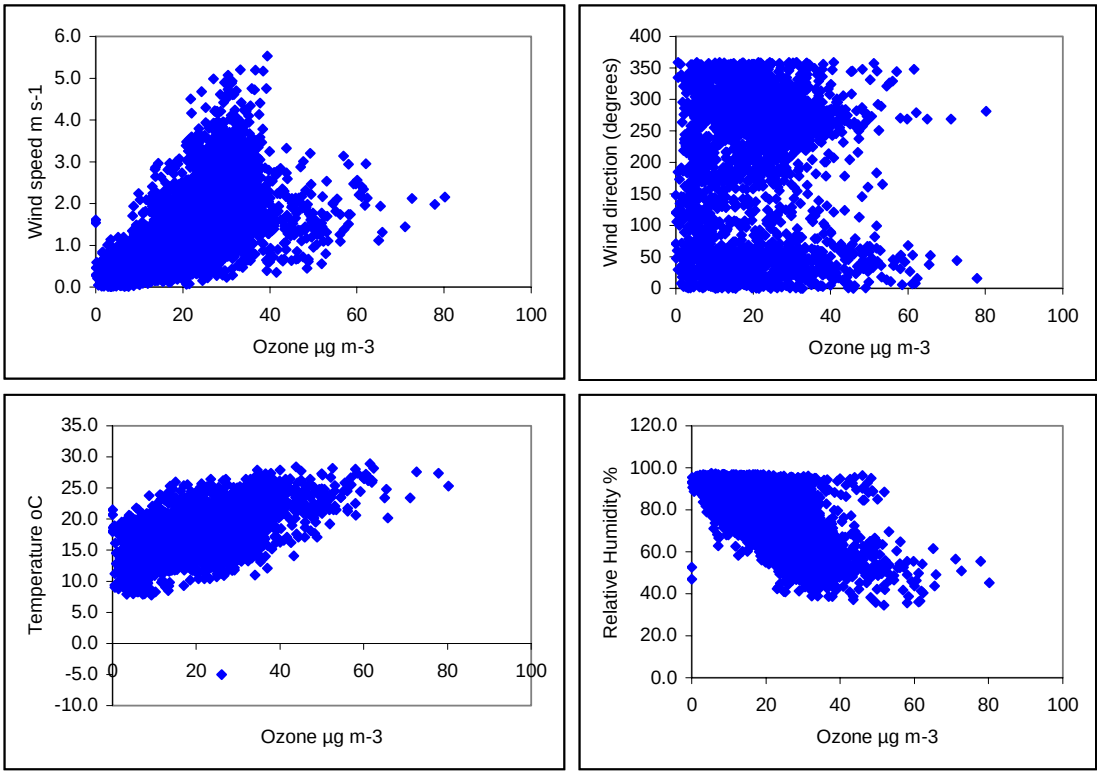

Figure 3-4: Comparison of ozone concentrations in Hamilton to wind speed, wind direction, air temperature and relative humidity

3.2.2 Comparison of meteorological conditions to previous years

The main meteorological parameters that impact on ozone formation are temperature and wind speed, with higher temperatures and low wind speeds being more conducive to higher concentrations. Figures 3.5 and 3.6 compare hourly average air temperature and wind speed and direction from January to March 2004 to the same period in 2002 and 2003. These indicate similar air temperatures during the 2003 and 2004 periods, with both periods having lower average temperatures than during 2002.

The higher temperatures and lower wind speeds during 2002 are also illustrated in Figure 3.7, which shows daily variations in average wind speed and temperature for 2002, 2003 and 2004. The average wind speed for the period January to March in 2002 was 1.2 m s^{-1} compared to 1.4 m s^{-1} for 2003 and 2004. Similarly, the average temperature in 2002 was 4 degrees higher at 22 ° C compared to 18 ° C during 2003 and 2004.

Based on these results, meteorological conditions during the summer of 2003/04 are unlikely to represent worst-case summer conditions for the formation of ozone. It is likely that higher ozone concentrations would have occurred during 2002 given the lower wind speeds and higher average temperatures.

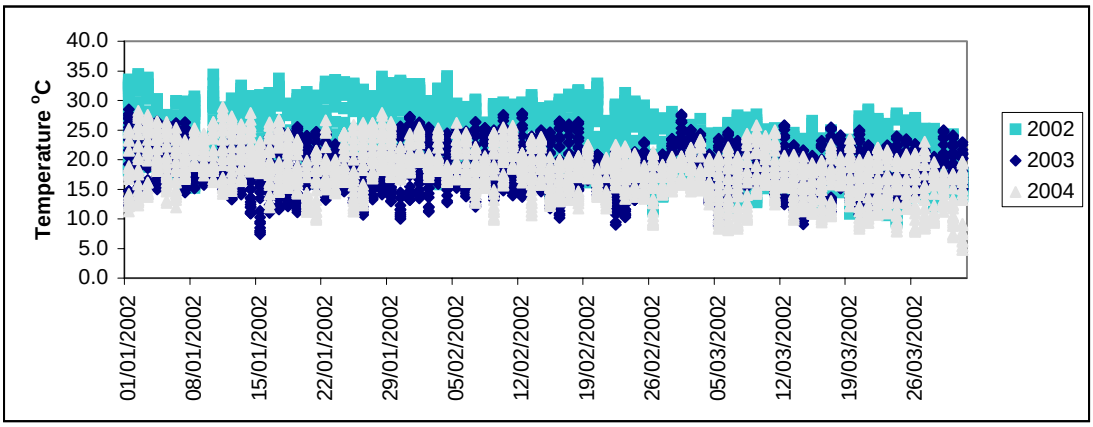

Figure 3-5: Comparison of air temperature from January to March 2002 to 2004

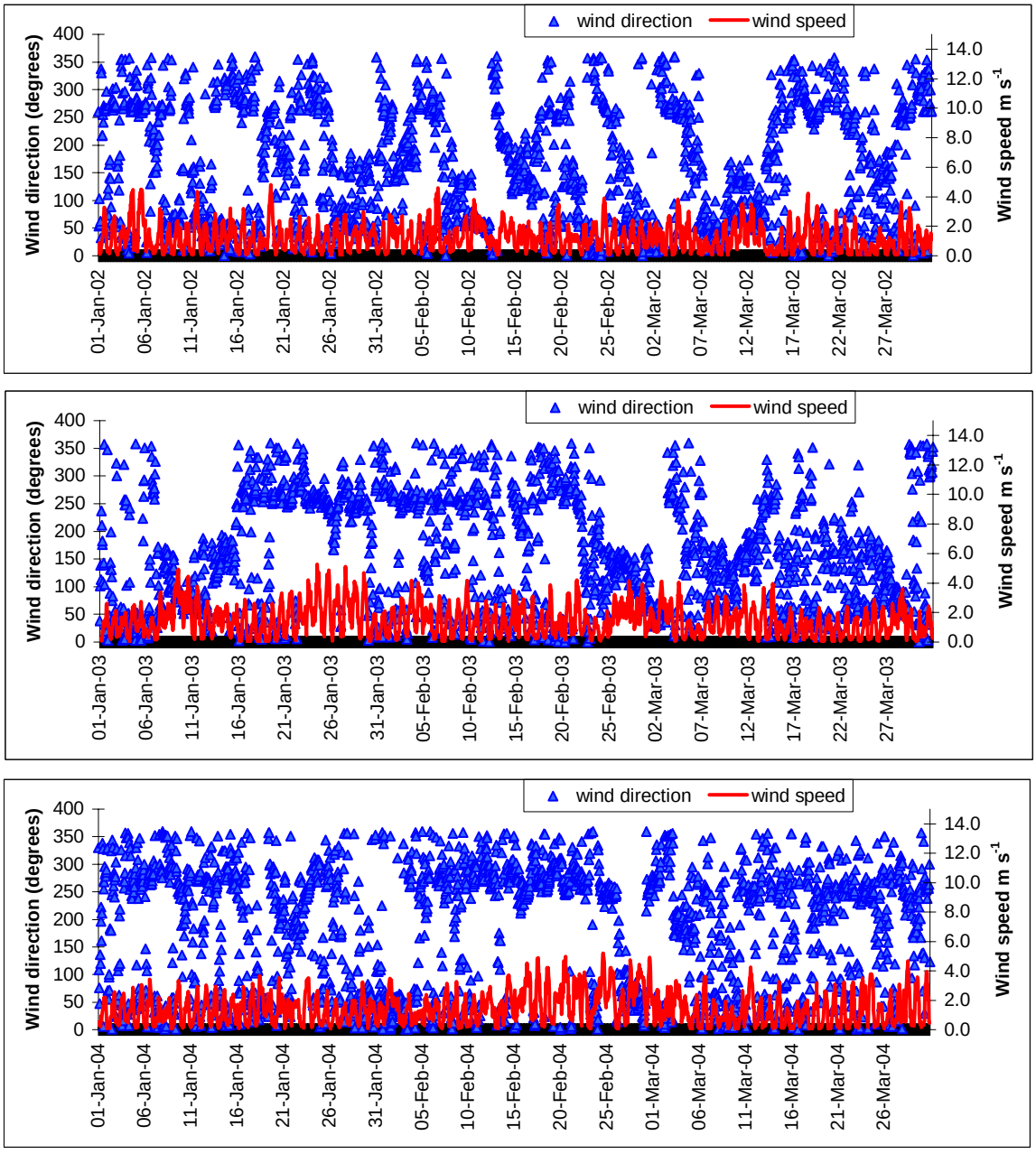

Figure 3-6: Hourly average wind speed and direction in Hamilton from January to March 2002 to 2004

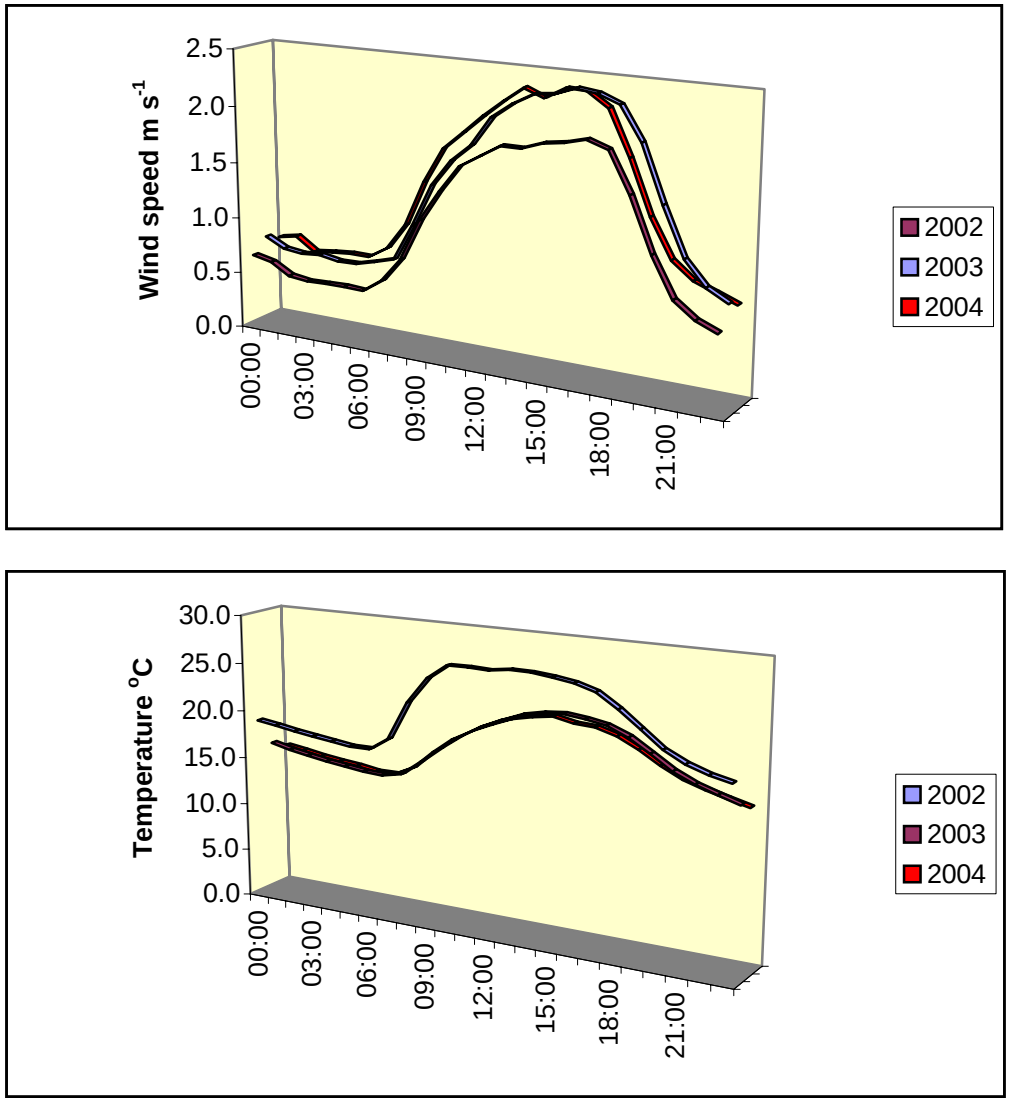

Figure 3-7: Daily variations in average wind speed and temperature from January to March 2002 to 2004

4 Summary

Air quality monitoring for ozone was carried out at the Peachgrove Road monitoring site in Hamilton during the summer of 2003/ 04.

The maximum ozone concentrations measured during this period were 80 µg m^{-3} (one-hour average) and 63 µg m^{-3} (eight-hour average). These compare to hourly and eight-hour average guidelines of 150 µg m^{-3} and 100 µg m^{-3} respectively. The maximum hourly average concentration was measured at 6pm on 11 January 2004 and is likely to have occurred as a result of emissions during the evening traffic peak.

Elevated ozone concentrations were found to occur with low wind speeds, elevated temperatures and low relative humidity. The highest ozone concentrations occurred during the period from 4pm to 6pm.

A comparison of meteorological conditions during the summer periods in 2002 and 2003 indicates similar meteorology during 2003 with 2002 having both lower wind speeds and higher average temperatures. It is likely that higher concentrations of ozone would have been measured in Hamilton had monitoring been carried out during 2002.

5 Recommendations

That air quality monitoring for ozone be carried out in Hamilton for a further two summers to assess the potential for elevated concentrations under different meteorological conditions. Analysis of results should include an evaluation of meteorological conditions to 2002, 2003 and 2004. The need for further monitoring in Hamilton should then be evaluated based on the concentrations measured and the meteorological assessment.

As indicated in Wilton (2002), it is likely that higher ozone concentrations could occur in areas outside of Hamilton. Additional ozone monitoring could be carried out for example in an area 20 kilometres east of Hamilton City to determine the potential concentrations in excess of guidelines outside of Hamilton. This monitoring could be conducted during the summer of 2006/07 or at the conclusion of the Hamilton study.

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