Summer 1998
Air Quality Monitoring Project

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January, 1999

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1. Preamble

Two groups within the Central Okanagan are directly involved in addressing aspects of regional air quality: the City of Kelowna's Okanagan Air Quality Technical Steering Committee (OAQTSC) and the Regional District of the Central Okanagan's Air Quality Committee (RDCO-AQC).

In order to have a more comprehensive overview of regional air quality the OAQTSC identified a need for additional spatial measurements of air quality parameters, particularly ozone and PM_{10} (the main contributors to poor air quality episodes in the region). With this in mind, it was suggested that a request be made to have the Provincial Ministry of Environment Mobile Air Monitoring Station located in the Central Okanagan during the summer of 1999. For optimum use of the mobile monitor, locations should be predetermined to maximize sample time and minimize costs. To accomplish this, it was decided that during the summer of 1998 an air quality monitoring project be carried out. Specifically, this project would utilize low cost passive samplers to measure ozone and portable monitors to measure PM_{10} at several sites within the Central Okanagan.

This report summarizes the data obtained by the monitoring project. In addition, some provisional analyses of data obtained from the Provincial monitoring stations are also included.

2. Introduction

The air quality in the Central Okanagan, as expressed by the BC Government's Air Quality Index, is for the most part classified as "good" (89% in 1997), however there are periodic episodes of "fair" (11% in 1997) and "poor" (less than 1% in 1997) indices (City of Kelowna, 1998). The two major contributors to these incidences of unsatisfactory air quality are:

(a) particulate matter less than 10 μm (micrometers) in diameter (PM_{10}) and
(b) ozone gas.

Both pollutants can pose as health hazards; particulate matter can lead to unsightly haze, and ozone, which can reduce crop yields and attack materials (such as plastics), also, has the potential to promote unsightly photochemical smog (Bunce, 1991)

The major air pollutants (ozone, carbon monoxide, sulphur dioxide, nitrogen dioxide, PM_{10}) are continuously monitored by the Provincial Ministry of Environment at Okanagan University College's (OUC) KLO Road campus. In 1997, a $PM_{2.5}$ monitor was added to the system. Hourly and daily average values for the aforementioned pollutants are entered into a Provincial database.

The air quality data collected is used to generate the Air Quality Index (AQI). On comparing data over several years trends in air quality may be identified. The development of a regional air quality model would attempt to correlate these trends with such variables as population growth, combustion activities, traffic patterns, industrial and

agricultural practices and meteorological parameters such as temperature, wind speed, sunlight intensity, air stability, etc. The model could then be used to predict future trends in air quality. The development of such a model is a long-term goal of the OAQTSC, and would be of value to local representatives charged with implementing air quality initiatives.

In the short term the OAQTSC identified the need for additional data at locations other than that of the Provincial monitor. The KLO Road site is centrally situated but it is unknown if the data collected is representative of the whole region. It is possible to request the Provincial Ministry of Environment mobile monitoring unit to be used for a regional study. The set-up time, however, would restrict its use to only a few sites during a summer sampling program. In addition, the operating costs of the unit are a factor in the feasibility of a mobile monitor study.

In order to help determine potential locations to situate the mobile monitor for its optimum use, the OAQTSC initiated a low cost study of the spatial variation of ozone and PM_{10} in the Central Okanagan during the summer, 1998. In 1994-95, a similar study was carried out using atmospheric nitrogen dioxide as the target analyte. It was found that the Province's KLO Road monitor consistently registered readings that were low in comparison to other sites. Sites adjacent to the Highway 97 recorded values up to 250% greater than those obtained at KLO Road (Bruce and Gow, 1997). This is not surprising as nitrogen dioxide is produced indirectly from vehicle emissions.

The OAQTSC requested support for the ozone/PM_{10} spatial variation monitoring program. Grants for the project were received from the RDCO, Okanagan University College, Deep River Science Academy and, later from CPPI (Canadian Petroleum Products Institute). The City of Kelowna also supported the project through an in-kind donation of staff time.

Sampling and analyses were carried out by OUC students, Deep River Science Academy students as well as by the authors of this report.

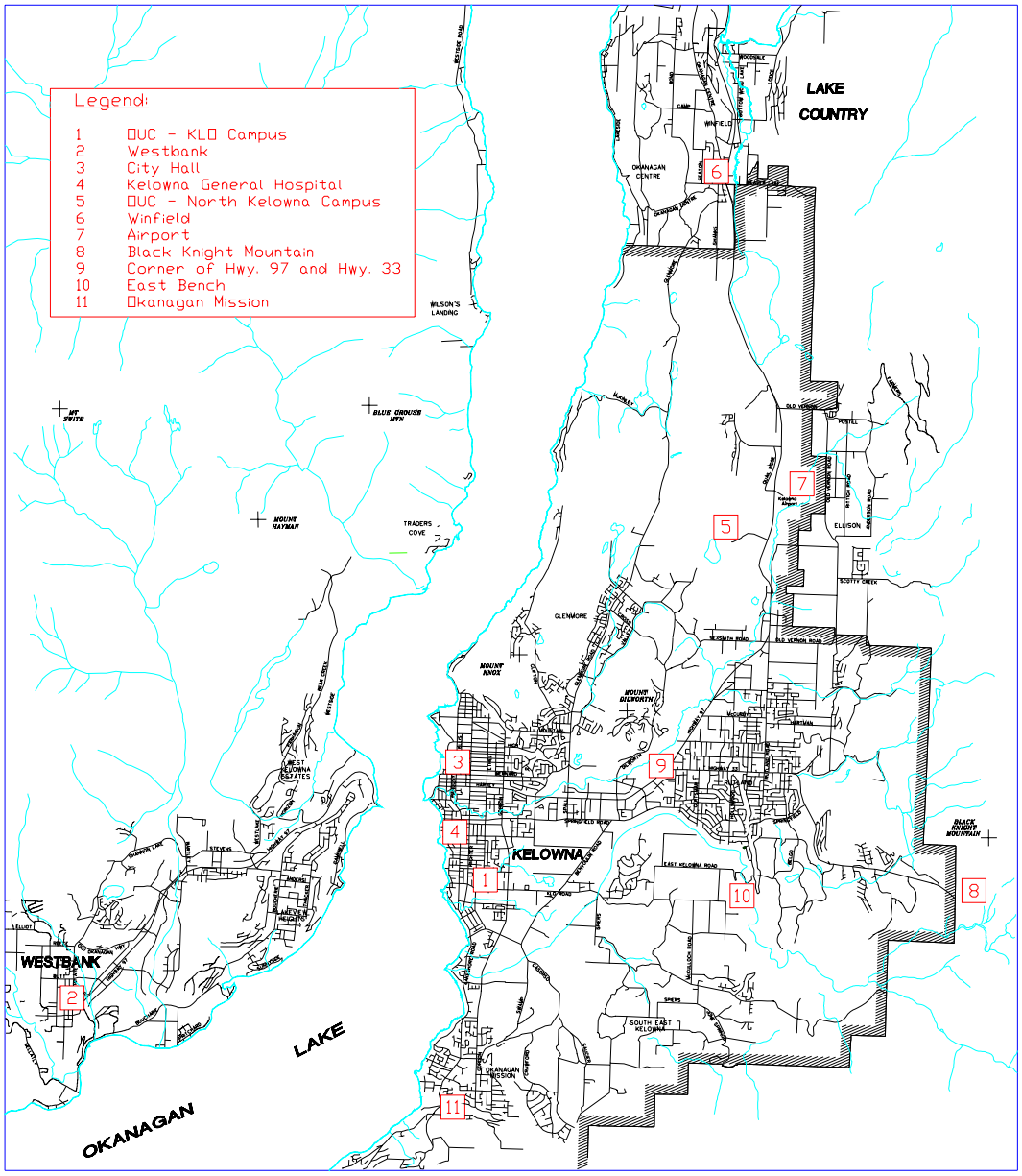
3. Project Description

3.1 Ozone Monitoring Project

Monitoring ozone at a number of sites using monitors similar to that at the Provincial Monitoring Station at KLO Road would require a large capital outlay. Inexpensive low-tech passive monitors that gather data averaged over several days have recently been developed for ozone determinations. A comparison of two commercially available passive monitors was carried out in May/June. A sampler produced by Maxxam Analytics (Edmonton) was established as being superior to a US manufactured device and was selected for use in the project. In addition, it was also more economic to purchase and operate.

Passive ozone monitors were placed at ten representative sites, from Winfield to Westbank (see Figure 1). A control monitor was situated adjacent to the Province's KLO Rd. monitor. The passive monitors contain a chemical that reacts with atmospheric ozone. After the 7-day sampling period, the monitors were returned to the Chemistry Laboratories at OUC where the extent of ozone induced chemical reaction was measured using an ion chromatograph. The data obtained was then converted to a weekly average ozone concentration.

Figure 1: Monitoring Locations



3.2 PM_{10} Monitoring Project

The Provincial Ministry of Environment provided 4 portable MiniVol PM_{10} air sampling monitors for the project. These devices pump air, at a known flow rate, through a filter that traps the particulate matter less than 10 μm in diameter. The change in mass of the filter divided by the volume of air passed through the filter gives a PM_{10} value, in micrograms per cubic meter.

The four filter units were placed at sites in Winfield, Westbank, City Hall and East Kelowna. Sampling was carried out for 24 hours every three days, from May until mid-November. Alternate sampling dates correspond with the National Air Pollution Surveillance Network (NAPS). This is a network of Federal Government high volume air samplers that run at various locations across Canada every 6 days. Data collected during the sampling period will be entered into the NAPS database. Battery problems occurred when the temperatures dropped resulting in poor data capture in October and November. The filters were sent for weighing to the "AIRmetrics" Laboratory in Oregon.

4. Data

4.1 Ozone Data

The data in Table 1 indicates the ozone determinations for two series of sites. The agreement between the passive (KLO) and continuous monitors at KLO Road (Actual) were within about 15% of each other. This variation is typical in comparing the two different technologies.

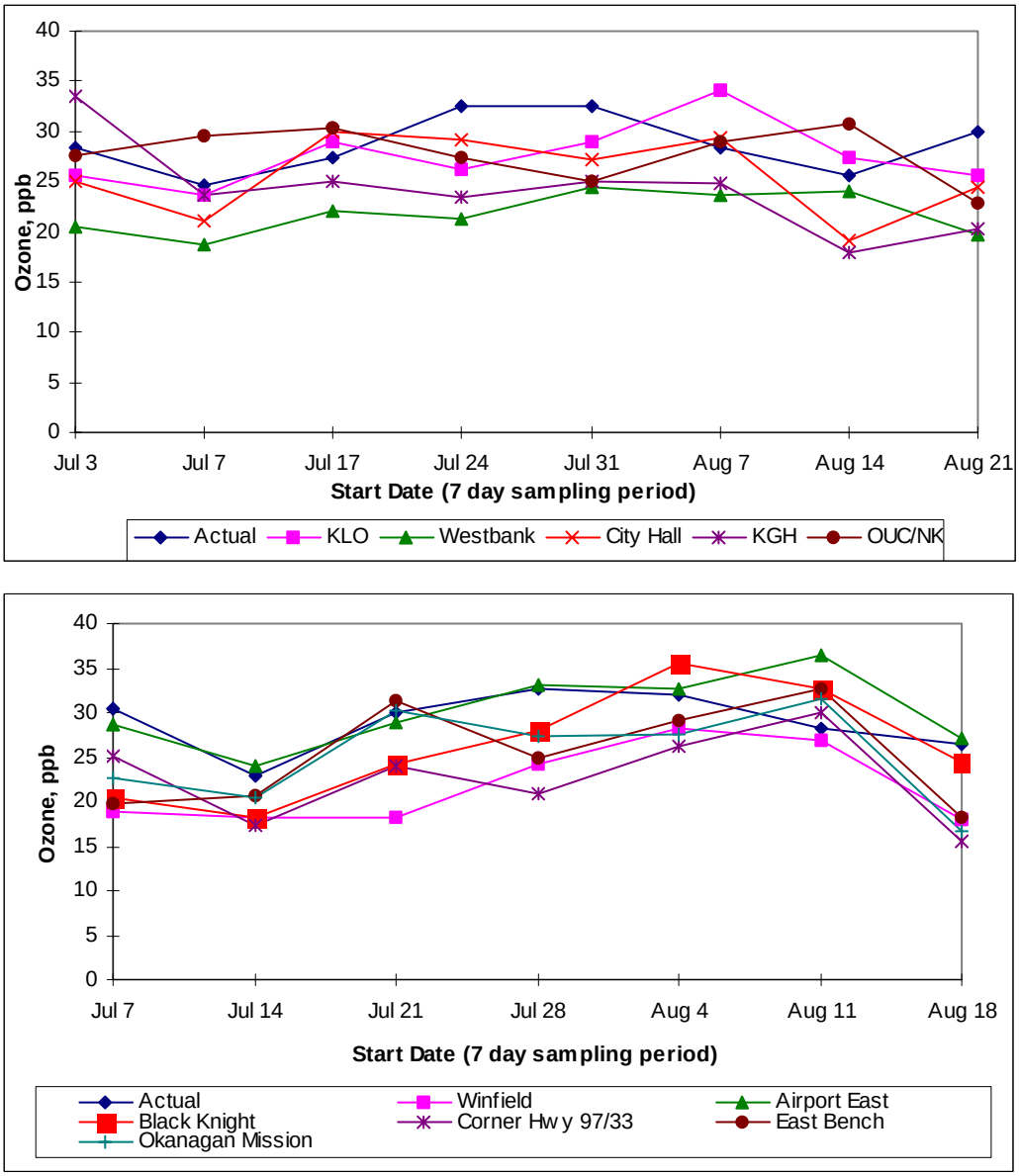
Table 1 – Weekly Averaged Ozone Concentrations in parts per billion, ppb.

Period	Actual	KLO	Westbank	City Hall	KGH	OUC/NK
July 3-10	28.4	25.6	20.5	25.1	33.5	27.6
July 10-17	24.6	23.6	18.7	21.1	23.6	29.5
July 17-24	27.4	28.9	22	30	25	30.4
July 24-31	32.5	26.3	21.2	29.2	23.4	27.4
Jul 31-Aug 7	32.5	28.9	24.5	27.2	25.1	25
Aug 7-14	28.4	34	23.6	29.3	24.9	28.9
Aug 14-21	25.7	27.3	24.1	19.2	18	30.7
Aug 21-28	30	25.6	19.8	24.4	20.3	22.8
Average	**28.7**	**27.5**	**21.8**	**25.7**	**24.2**	**27.8**

Period	Actual	Winfield	Airport East	Black Knight	Corner Hwy 97/33	East Bench	Okanagan Mission
July 7-14	30.5	18.8	28.6	20.4	25.1	19.8	22.7
July 14-21	22.8	18.3	24	18.3	17.4	20.7	20.4
July 21-28	29.9	18.2	28.9	24.2	24.1	31.3	30.2
Jul 28-Aug 4	32.6	24.3	33.2	28.1	20.8	25	27.3
Aug 4-11	32.1	28.3	32.6	35.6	26.3	29.1	27.6
Aug 11-18	28.3	27	36.4	32.6	30	32.7	31.6
Aug 18-25	26.4	17.9	27.1	24.4	15.6	18.2	16.6
Average	**28.9**	**21.8**	**30.1**	**26.2**	**22.8**	**25.3**	**25.2**

The data from Table 1 is shown graphically in Figure 2. With a few minor exceptions the general shapes of the graphs are similar. The weekly average ozone concentrations throughout the two-month sampling period follow similar trends at all the sites.

Figure 2: Variation of ozone concentration at each sampling site with time



The average ozone concentration at each site is also indicated in Table 1. The Westbank and Winfield locations have values about 30% lower than the other locations. The corner of Highways 97/33 also has a low value, which may be related to the high nitrogen dioxide concentration, found at this site in a previous study. The other sites have remarkably similar values.

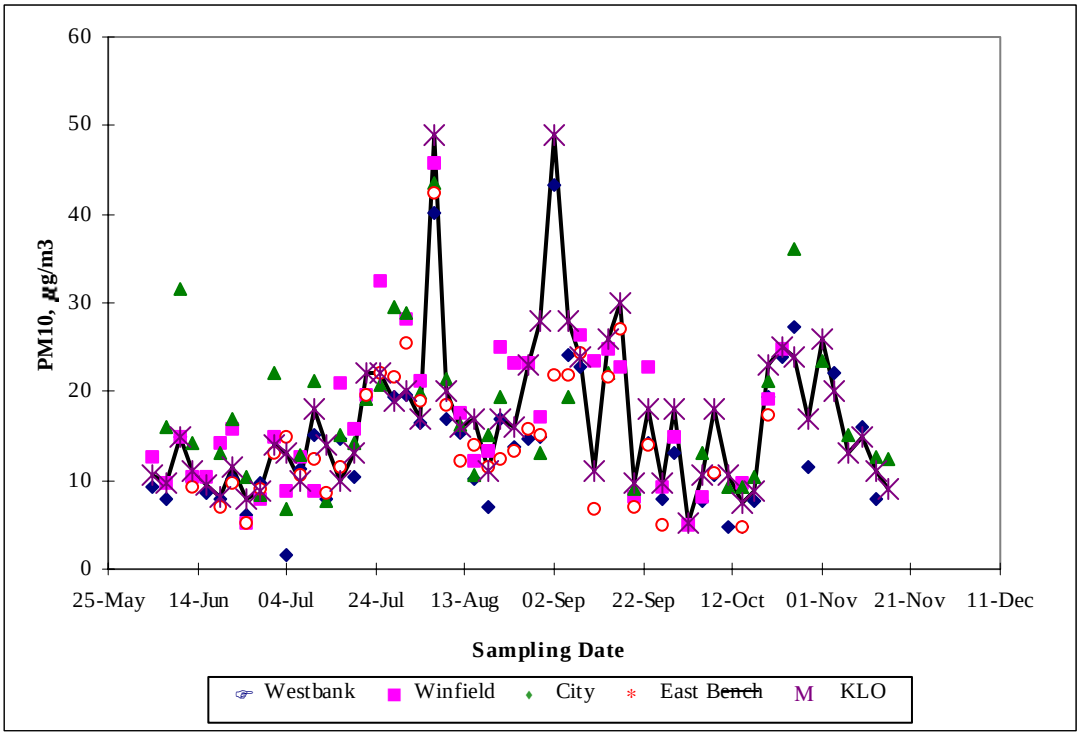
This indicates that ozone is generated and dispersed fairly evenly throughout the City but is lower at the northern and southern extremes of the region. It can be concluded that the data obtained at the Provincial monitor is certainly representative of the City's air quality, unlike the nitrogen dioxide variations found in the 1994/95 study.

Ozone studies in the Fraser Valley show peak ozone concentrations at Abbotsford, down wind from the pollutant gases generated by vehicles in the Vancouver region and carried to Abbotsford by prevailing winds (BC Environment, 1992). Is there a similar ozone plume downwind (east) from the traffic areas in the Central Okanagan? This study did not establish the presence of such a plume, further studies are required to establish this conclusively.

4.2 PM_{10} Data

The data obtained from the 4 monitoring sites as well as the KLO monitor is shown graphically in Figure 3. Outstanding features in the data are the spikes in the graph coincident with the two major forest fires near Salmon Arm and Tulameen. A bulge in October/November may be indicative of the agricultural burning period and/or the onset of the use of domestic wood-burning appliances in response to cooler weather. With a few exceptions the data points on a particular sampling day do not exhibit a large spread.

Figure 3: Variation of PM_{10} Concentration with time at each sample site.
Note that the solid line represents the data from the Provincial KLO Road Monitor.



Average values of PM_{10} obtained at the 5 sites, in $\mu g/m^3$, are:

- Westbank 14.4
- Winfield 17.0
- City Hall 17.5
- East Bench 15.0
- Provincial Monitor 16.9

Similar to the ozone results, variations are not large, of the order of 20% difference between the largest and smallest.

Comparing the data at the 5 sites it is apparent that again the KLO Rd monitor data gives a good estimate of the regional PM_{10} dispersion. This is probably because particles in the coarse fraction of PM_{10} stay in the atmosphere for a few hours to a few days, and the fine fraction of PM_{10} can remain in the air for days to and hence are dispersed fairly evenly throughout the airshed (BC Environment, 1994).

4.3 Other Data

4.3.1. Comparison of Kelowna and Vernon Data

The above data on ozone and PM_{10} indicates a fairly even dispersion of these pollutants in the Central Okanagan. It is unknown whether this generalization can be extended to the whole Okanagan Airshed. There are no permanent air monitors in Vernon or Penticton. However, the Province situated their mobile monitoring unit in Vernon from December 1996 until May 1997. It is difficult to make conclusions on just a few data points but a remarkably strong correlation appears between the PM_{10} and ozone data for the two cities, see Figures 4 and 5. The plotted values are for monthly averages. The equivalent graphs for nitrogen dioxide, Figure 6, show almost no correlation.

Figure 4a: Comparison of PM10 monthly average data between Kelowna and Vernon, 1995-96

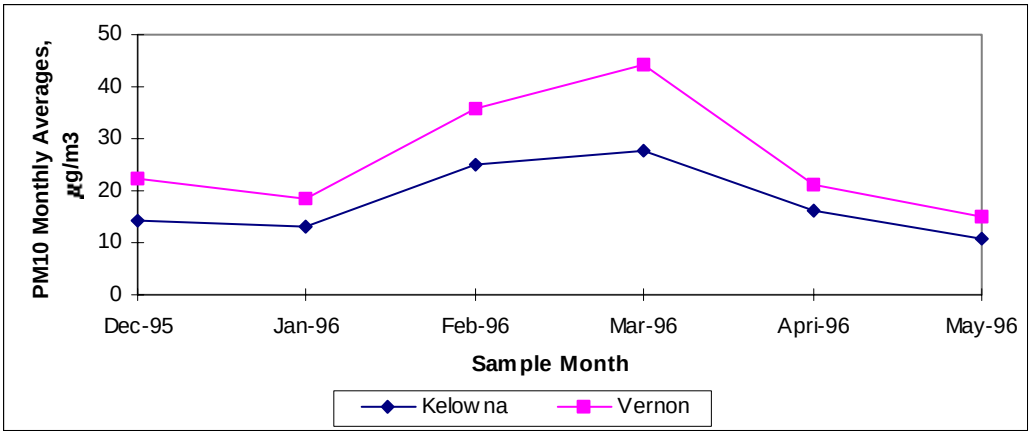


Figure 4b: PM_{10} Correlation between Vernon and Kelowna

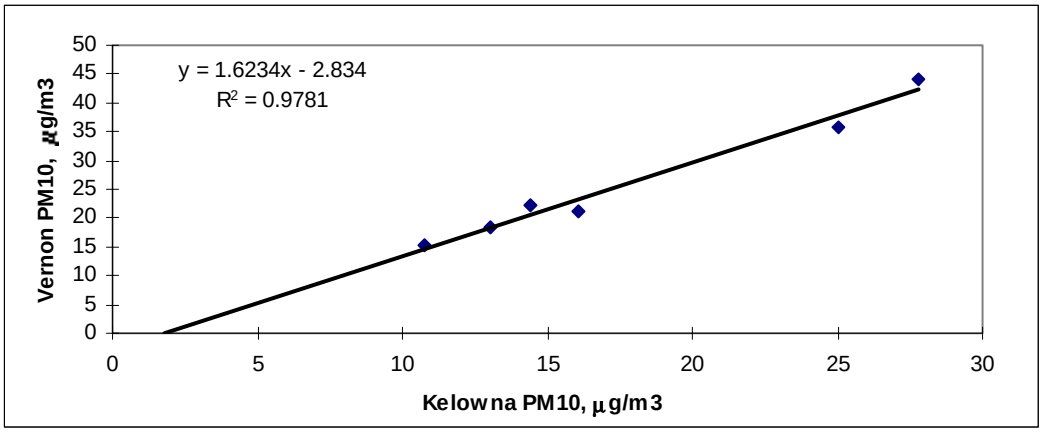


Figure 5a: Comparison of monthly average ozone data between Kelowna and Vernon, 1995-96

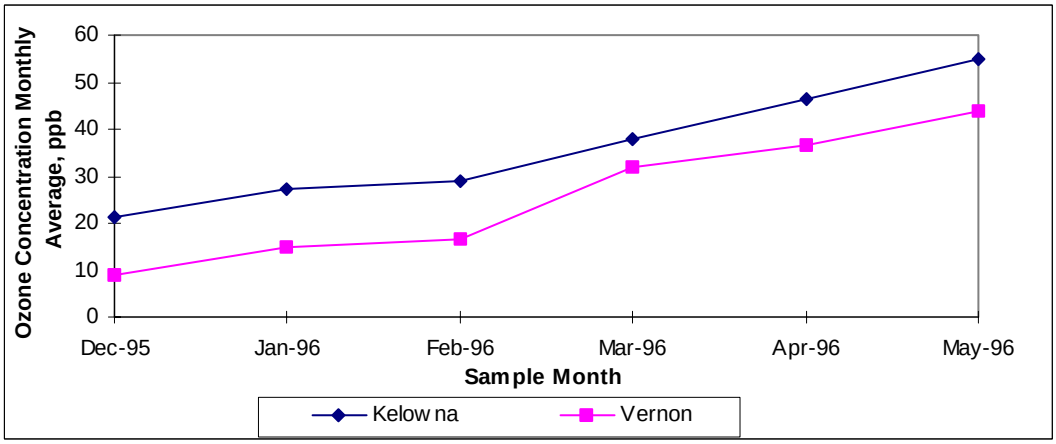


Figure 5b: Ozone Correlation between Vernon and Kelowna

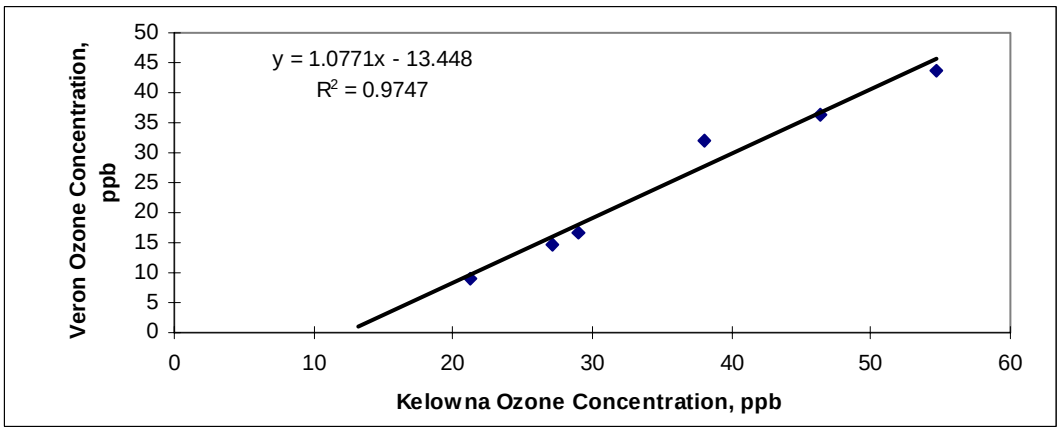


Figure 6a: Comparison of monthly average nitrogen dioxide data between Kelowna and Vernon, 1995-96

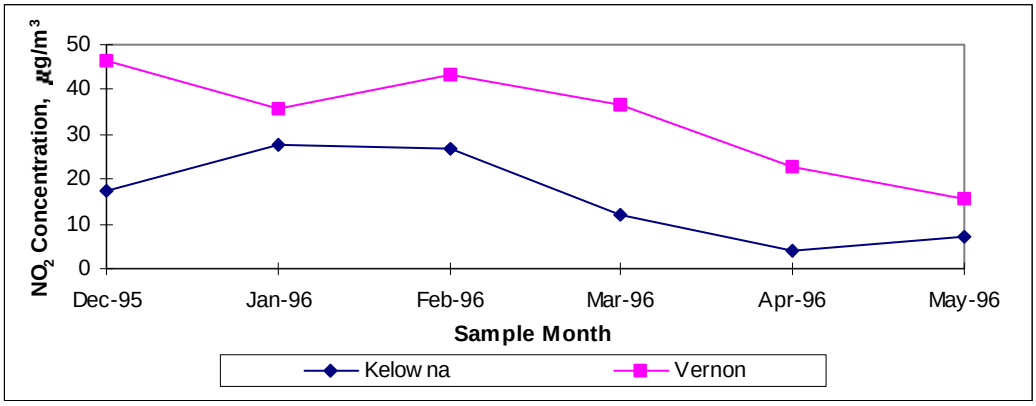
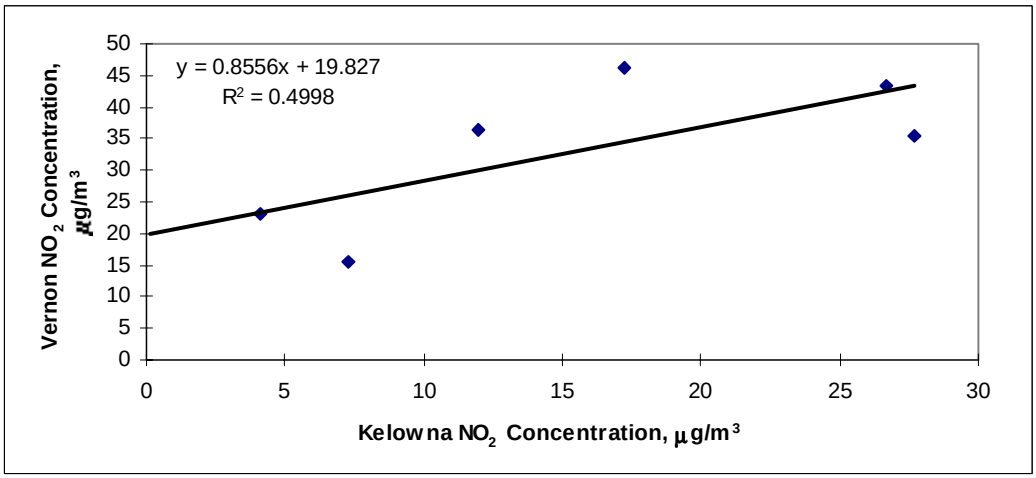


Figure 6b: NO_2 Correlation between Vernon and Kelowna



It may be concluded, within the reservations of considering only a few data points, that there is indeed a proportionality between the monthly averaged ozone and PM_{10} values measured in Kelowna and Vernon. PM_{10} is close to 50% higher in Vernon than Kelowna and ozone is about 45% higher in Kelowna than Vernon. It should be noted that the data from a summertime study, the peak ozone production period, may contradict these findings.

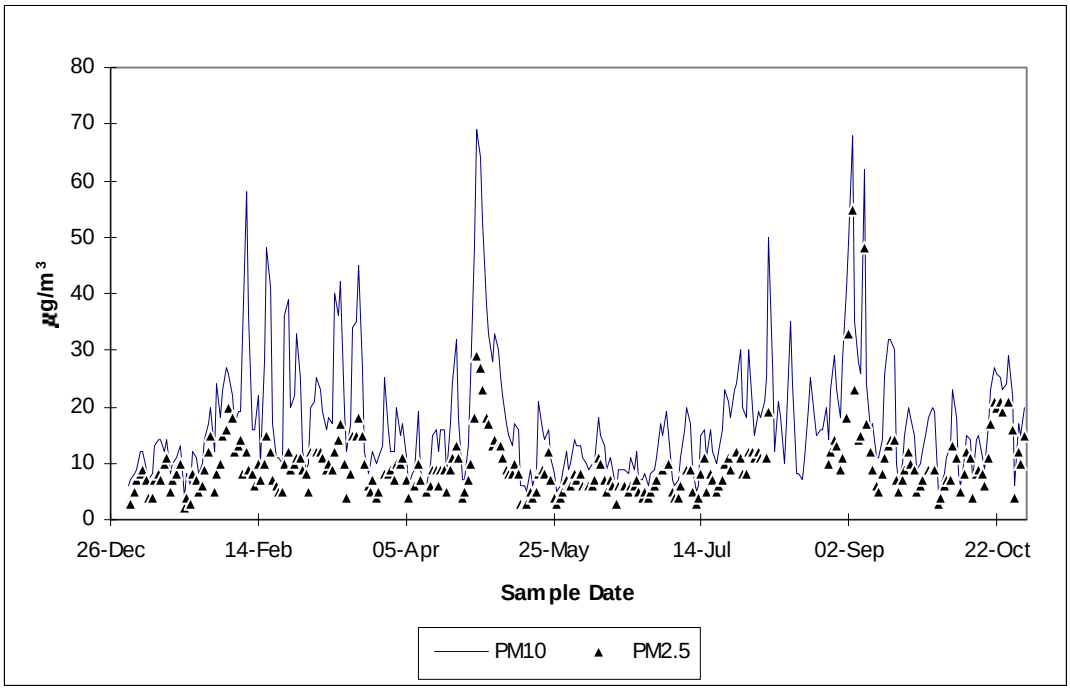
4.3.2. Correlation between PM_{10}/$PM_{2.5}$

Although PM_{10} has been measured in Kelowna, $PM_{2.5}$ has only been monitored since 1997. In the US a recommended standard for $PM_{2.5}$ has been established. This is because particles less than 2.5 µm in diameter are liable to be inhaled more deeply into the lung causing breathing difficulties and sometimes permanent damage to lungs (BC Environment, 1994).

Is there a correlation between PM_{10} and $PM_{2.5}$ as measured in Kelowna? A correlation between the two may indicate a constancy of source.

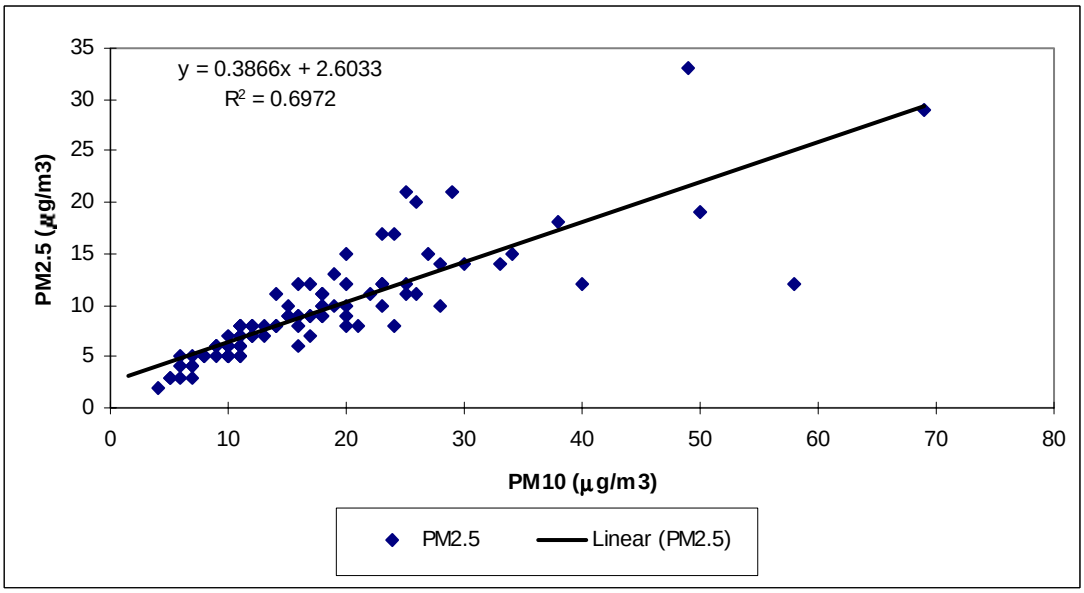
Figure 7a shows the daily average values of PM_{10} and $PM_{2.5}$ for January to November, 1998.

Figure 7a: Comparison of Kelowna PM_{10} and $PM_{2.5}$ Data 1998



When plotted against each other (Figure 7b) the data indicates a good linear relationship at low PM_{10} values becoming much more scattered at higher values. The $PM_{2.5}$ is approximately 60% of that for PM_{10}.

Figure 7b: Correlation between PM_{10}/$PM_{2.5}$



4.3.3. Annual Trends

The Provincial KLO Road monitor has been fully operational for 5 years although ozone data has been collected for 15 years. Can trends in Okanagan Air Quality be detected from this data set?

Monthly averaged values for ozone and PM_{10} are plotted for each year in Figures 8 and 9.

Figure 8: Variation of Kelowna's Average Monthly PM10 Data (1994-1998)

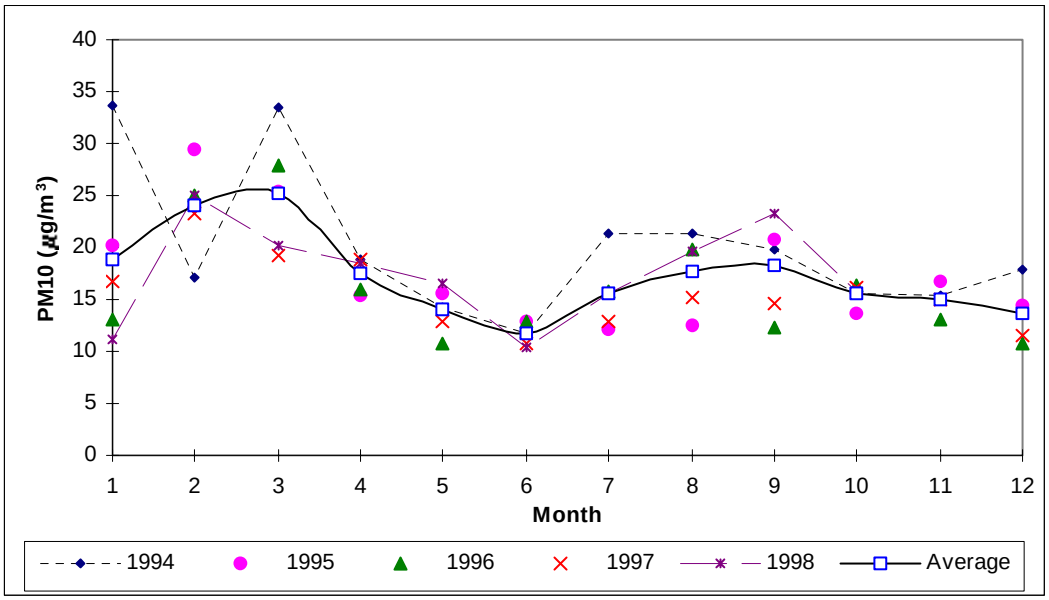
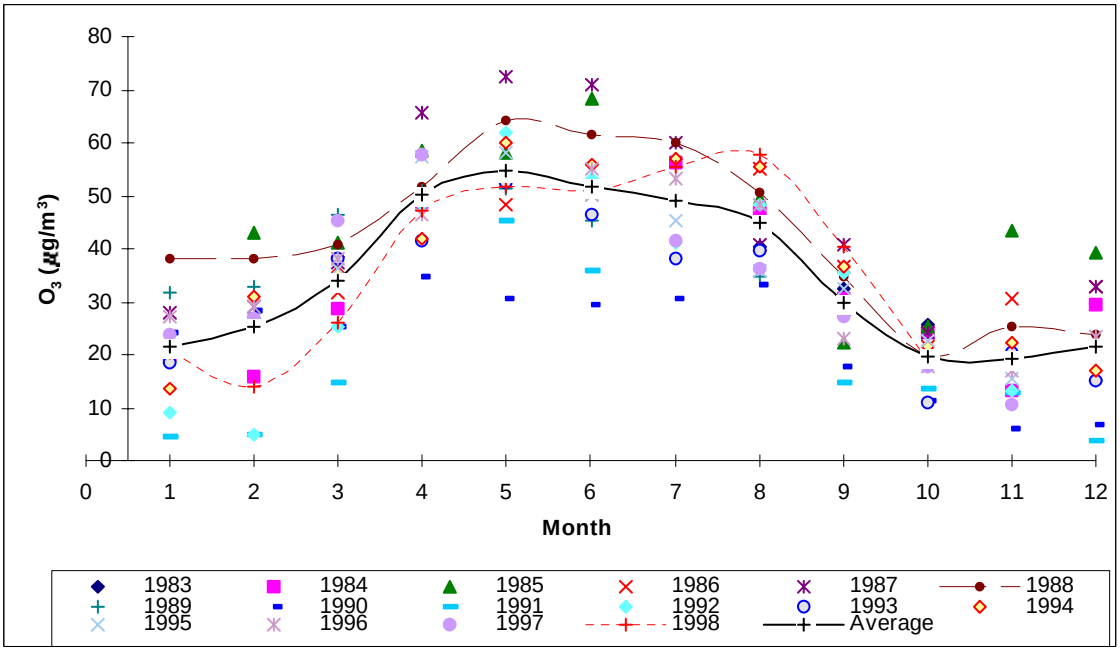


Figure 9: Variation of Kelowna's Average Monthly Ozone Data (1983-1998)



In each case only broad generalizations may be made. Spurious data points need to be investigated more thoroughly.

The 5 years of monthly average PM_{10} data (Figure 8) show no obvious trends to suggest that the air quality is changing.

For ozone there are very large extremes in values varying from 1990 a good year to 1987 a bad year. The graphs show lines drawn to compare 1998 with 1988 and also the overall 15-year monthly average. At a glance it appears that this year, 1998, had below average ozone for the first six months and above average for the next 4 months. The November and December data were not included in the Provincial database at the time of writing this report.

From a cursory examination one cannot conclude that there has been a measurable change in average monthly ozone concentrations over the past 15 years.

5. Conclusions

It should be emphasized that the concentration of ozone, PM_{10}, nitrogen dioxide, etc. are constantly changing and that weekly averaged data will not detect short term fluctuations in these parameters.

- The ozone monitoring indicates that there may be a concentration of ozone in the central "bowl" of the Central Okanagan region. Concentrations of this gas in Winfield, Westbank are at least 30% lower. Comparison of limited data between Vernon and KLO Road showed a similar trend. The KLO Rd continuous monitor gives good representative ozone values for the City and its immediate environs.

- The concentration of PM_{10} appears to be fairly evenly dispersed within the region with differences of 10% between the urban and more rural monitoring sites.

- There is a reasonably strong correlation of monthly averaged ozone and PM_{10} values between Kelowna and Vernon. This is not the case for nitrogen dioxide.

- At concentrations less than 30 $\mu g/m^3$, there is reasonably strong correlation between PM_{10} and $PM_{2.5}$ as measured by the KLO Rd. monitors. This may reflect a constancy in the sources of these particles.

- Preliminary comparisons of ozone data accumulated over the past 15 years and PM_{10} over the past 5 years do not indicate noticeable trends - the air quality has not dramatically changed.

- There appears to be no need to request that the Provincial mobile monitor be used in the Central Okanagan in 1999.

6. Further Studies

The following outlines potential further studies that could be completed for the Central Okanagan to gain further understanding about the air quality in the region.

- **Correlations Between Air Quality Variables.** It is most unfortunate that the position of Air Quality Meteorologist, previously occupied by Peter Reid, has not received funding. This means continuous interpretation of the air quality parameters being measured by the Province's monitor in Kelowna is not being done. There is a need for a comprehensive statistical analysis of this large database to ascertain correlations between variables in order to identify trends in air quality parameters. The data from 15 years of ozone measurements is a prime candidate for multivariate analysis.

- **Valley-Wide Study of Ozone and PM_{10}**. Preliminary studies between Vernon and Kelowna show a strong correlation for ozone and PM_{10} between the two locations, the data, however, is very limited. A 12-month study at several locations from Armstrong to Osoyoos, would help establish a better pollutant profile.

- **Source and Content of PM_{10}**. A survey initiated by the City of Kelowna identified that the public regarded air quality as the environmental issue of greatest concern (Benchmark Research Inc., 1998). The two major contributors to low air quality in the Central Okanagan are PM_{10}, which drives the air quality index about 65% of the time, and ozone, responsible for the remaining 35%. There is a need to identify and quantify the PM_{10} sources and to analyse PM_{10} material for inorganic and organic content.

- **Volatile Hydrocarbon Study.** The Okanagan could be prone to incidences of toxic and unsightly photochemical smog. High summertime temperatures, strong sunlight and high concentrations of ozone, nitrogen dioxide and hydrocarbons are the essential ingredients for smog formation. A further study could be to analyze and identify the volatile hydrocarbons in the atmosphere and to determine their sources.

- **Air Quality and Health Degradation Study**. A major concern of poor air quality is the effect that it may have on those with weak respiratory systems - especially, infants, the elderly and those with identifiable respiratory ailments, such as asthma. There is a need to gather information that may correlate degradation of air quality with degradation of health. A recent Federal Government announcement by the Ministries of Health and Environment indicates that funding is available for such a study. The application deadline for this year is February 26, 1999.

7. Acknowledgments

The 1998 monitoring project was initiated by OAQTSC, chaired by Mark Watt. Funding was gratefully received from RDCO-AQC, Okanagan University College, CPPI

(Canadian Petroleum Products Institute), Deep River Science Academy and an in-kind donation from the City of Kelowna.

Credit and thanks are accorded to Mr. Steve Josefowich, Air Quality Technician with BC Ministry of Environment, Lands and Parks who obtained the PM_{10} samplers, arranged for their set-up and servicing, trained our technicians in their operation and also arranged for funding to purchase the air filters and their laboratory processing costs.

Dr. Hongmao Tang of Maxxam Analytical, supplier of the ozone samplers, should also be acknowledged for twice visiting Kelowna to help with method development, data handling and quality control. His enthusiasm is infectious.

Finally, full credit must go to Mr. Mike Wilson and Ms. Teresa Rawsthorne, students from OUC, who were responsible for most of the sampling and laboratory analysis.

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