Environmental Indicator: Air Quality Impacts From Inhalable Particulates and Ozone

Primary Indicator: ***Percentage of monitored communities exposed to health risks from inhalable particulates where PM_{10} is greater than 25$\mu g/m^3$ at least 5% of the time.***

Selection of the Indicator: Suspended particulate matter (PM) is composed of tiny, airborne solid or liquid particles other than pure water. It includes naturally occurring dust, as well as soot, smoke and other particles emitted by vehicles, power plants, factories, construction and other human activities. Particles with aerodynamic diameters of 10 micrometers (μm) or less are referred to as *inhalable particulates* or PM_{10}. Particles larger than 10 μm settle to the ground relatively quickly and are of little concern from a health perspective because they tend to collect in the throat and nose, and are eliminated from the body by sneezing, coughing and nose blowing, or through the digestive system. Inhalable particulates, however, bypass the body's outer defense mechanisms and penetrate into the lungs, posing a threat to human health. Recent studies suggest that smaller particles, 2.5 μm in diameter ($PM_{2.5}$), pose a greater threat to human health than PM_{10}.

This indicator considers the percentage of communities throughout British Columbia where air quality monitoring stations recorded PM_{10} levels above 25 $\mu g/m^3$ for more than 5% of the time. The level of 25 $\mu g/m^3$ is the level at which there is statistical evidence of health effects (CEPA/FPAC, 1998). Although current health studies have not been able to determine a threshold concentration below which there are no effects (Schwartz, et al. 1996), 25 $\mu g/m^3$ is a generally accepted standard among scientists. Five percent of the exposure time per year, corresponds to an exposure equivalent of 18 days/year.

The British Columbia Provincial Health Officer has identified inhalable airborne particulates as an important outdoor contaminant in British Columbia (Provincial Health Officer, 1998). It is not possible to conclude if it is the particle size, mass or composition that is directly responsible for health effects, however, the smaller the particle size, the deeper it penetrates into the lungs. Once in the lungs, particles affect pulmonary function on either a temporary or permanent basis. Inhalable particulate matter contributes to the development of chronic bronchitis and may be a predisposing factor to acute bacterial and viral bronchitis. It also aggravates bronchial asthma, late stages of chronic bronchitis, pulmonary emphysema, existing cardiovascular disease, and several other lung-related impairments. Senior citizens and people with existing lung or heart problems are most at risk from PM_{10}, but healthy adults and children can also be affected.

Air quality in British Columbia communities is rated in an Air Quality Index, showing the inhalable particulate concentrations as GOOD (0-25 $\mu g/m^3$), FAIR (26-50 $\mu g/m^3$), POOR (51-100 $\mu g/m^3$), or VERY POOR (more than 100 $\mu g/m^3$).

Data and Sources:

Table. 1. Percentage of monitored communities where inhalable particulate (PM_{10}) concentrations were above > 25 μg/m^3 for more than 5% of the time.

Year						
1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
79% (19)	92% (24)	85% (27)	75% (32)	79% (33)	62% (37)	63% (40)

Source: BC Ministry Of Environment, Lands & Parks, 2000, Air Resources Branch.
Note: Number of communities monitored annually is given in brackets ( ).

Table 2. Percentage of time inhalable particulates (PM_{10}) exceeded 25μg/m^3 in monitored communities.

Site Name	Sampler type*	% of time PM_{10} >25μg/m^3						
		1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
100 Mile House	nc	d	46.8	30.9	13.0	d	18.1	14.5
Abbotsford	nc	17.0	d	n	n	n	n	n
Abbotsford library	c	d	d	d	12.6	9.4	n	n
Boston Bar	c	n	n	n	n	n	d	29.0
Burnaby South	c	d	11.8	7.9	6.8	8.0	4.1	4.7
Burns Lake Fire Centre	c	n	n	n	d	25.8	17.4	d
Campbell River Tyee Split	c	n	n	n	d	8.8	2.5	1.6
Castlegar	nc	d	31.0	d	37.3	d	17.5	28.1
Chetwynd	nc	n	d	d	22.7	24.3	26.3	5.2
Chilliwack Airport	c	n	d	10.3	6.3	10.4	n	5.8
Cranbrook S.P.	nc	38.3	d	d	17.2	46.6	d	n
Creston PC School	c	d	d	d	15.2	d	d	19.8
Duncan Deykin Avenue	c	n	n	n	n	d	0.5	1.4
Golden	nc	58.6	54.4	45.8	44.3	60.7	d	d
Grand Forks	nc	d	d	27.9	d	d	40.4	37.9
Hope Airport	c	n	n	d	3.0	4.7	0.5	0.5
Houston Firehall	c	d	20.1	14.6	24.2	19.4	21.0	11.0
Invermere Forest	nc	d	21.3	18.0	32.7	d	28.3	31.7
Kamloops Brocklehurst	c	16.1	16.7	13.7	5.5	7.7	7.1	4.4
Kelowna College	c	20.2	17.6	16.4	11.7	14.5	5.2	6.7
Kitimat Riverlodge	c	n	n	n	n	d	0.0	0.3
Kitsilano	c	5.8	7.7	4.7	3.6	5.5	4.4	2.5
Langdale Elementry	c	n	n	0.0	0.5	d	d	0.6
Langley	c	4.5	d	4.4	1.8	d	3.3	2.2
Merritt	nc	55.6	d	d	37.5	56.7	d	d
Mission	nc	29.4	32.1	13.6	8.5	11.7	20.3	11.5
Nelson	nc	d	13.8	20.0	27.6	44.4	25.0	12.1
North Delta	c	8.7	d	8.6	2.5	d	3.3	n
Penticton	nc	d	d	d	10.5	d	n	n

Site Name	Sampler type*	% of time PM_{10} >25µg/m^3						
		1994	1995	1996	1997	1998	1999	2000
Penticton MOE	nc	n	n	n	d	25.9	10.9	10.0
Pitt Meadows Airport	nc	5.4	6.9	d	n	n	n	n
Port Alberni Courthouse	nc	3.5	d	d	d	n	n	n
Port Alberni Townsite	c	n	n	n	d	1.8	0.3	1.1
Port Moody Rocky Pt	c	14.3	15.6	8.6	6.7	8.8	d	3.1
Powell River Cranberry Lake	c	n	n	7.6	4.7	4.2	0.3	0.8
PRG Plaza 400	c	28.3	33.6	25.7	26.2	31.0	20.7	20.1
Quadra Island Lighthouse	c	n	n	n	d	1.8	0.6	0.6
Quesnel Senior Secondary	c	d	30.7	24.3	35.4	36.2	31.8	25.6
Radium	nc	n	n	n	n	d	2.8	15.0
Revelstoke	nc	d	d	d	d	38.1	31.6	27.3
Richmond South	c	4.7	8.7	12.4	8.8	3.8	1.1	4.2
Skookumchuk	nc	1.7	3.5	5.3	3.3	16.4	14.0	d
Smithers St Josephs	c	17.4	17.1	10.4	13.6	19.8	10.7	11.0
Slocan	nc	d	d	n	n	d	27.7	12.5
Squamish	c	d	16.3	15.0	d	4.7	11.1	10.3
Surrey East	c	5.2	3.5	4.4	2.8	4.2	1.4	1.4
Telkwa	c	n	n	n	n	23.4	11.0	d
Terrace	nc	d	23.3	d	n	n	11.1	10.6
Terrace BC Hydro	nc	n	d	23.7	d	d	d	d
Terrace BC Access Centre	c	n	n	d	10.5	10.7	11.1	10.6
Trail	c	d	d	d	d	8.3	d	5.4
Vernon City Hall	nc	d	d	30.8	d	d	d	d
Victoria PAPS	nc	d	5.4	d	d	n	n	n
Victoria Topaz	nc	n	n	n	n	d	d	22.0
Westsyde	nc	30.0	13.3	10.0	n	n	n	n
Williams Lake Columneetza School	c	d	30.4	d	21.6	25.5	14.5	18.8
total number of communities monitored		19	24	27	32	33	37	40
total number of communities exposed to health risks (>25µg/m^3) more than 5% of the time		15	22	23	24	26	23	25
Percentage of communities exposed to health risks (>25ug/m3) more than 5% of the time		78.9%	91.7%	85.2%	75.0%	78.8%	62.2%	62.5%

Source: BC Ministry of Environment, Lands & Parks, 2000, Air Resources Branch.

* nc = non-continuous sampling; c = continuous sampling; n = data were not available, d = data were available, but did not meet the requirement for this analysis.

Note: For a community to be included in this analysis, data must have been collected for 75% of the days in at least 11 months of that year.

Methodology and Reliability: This indicator shows the percentage of monitored communities where the concentration of inhalable particulates exceeded 25 μg/m^3 for more than 5% of the time during the year. Although living with health risks from inhalable particulates for even 5% of the year may seem intolerable to some people, the criterion was chosen so that only communities that are at higher health risks from inhalable particulates would be included in this analysis.

Data from two types of sampling devices were used to determine the percentage of time PM_{10} exceeded 25 μg/m^3. Continuous measurements were obtained using a Tapered Element Oscillating Microbalance (TEOM®). Non-continuous measurements were obtained using either a Size-Selective Inlet (SSI) high-volume sampler, or a Partisol® sampler. Both the SSI and Partisol® samplers are typically operated over a 24-hour period once every six days. Where both continuous and non-continuous samplers were used in a community, the data from the continuous samplers were chosen because they offer a more detailed study of inhalable particulate concentration in the area.

When comparing these two methods it is important to note the differences in the way that samples are collected:

- Non-continuous Samplers (SSI or Partisol Samplers)
  Non-continuous samplers draw air through an inlet that separates particles 10 μm in diameter, or smaller, from those larger than 10 μm.[1] Particles are collected on a pre-weighed filter and sent to a laboratory for analysis. The weight of the particles divided by the volume of air filtered determines the concentration of inhalable particulates in the air.

- Continuous Samplers (TEOM® samplers)
  Continuous samplers use an inlet designed to exclude particles greater than 10 μm in diameter from the air sample stream. A filter sits at the end of a tapered, hollow tube that is maintained in a clamped-free mode (like a tine on a tuning fork). The air sample stream is drawn through the filter, where particles are deposited, and through the tapered tube to a flow controller. As the filter mass changes, the oscillating frequency of the tube changes. PM_{10} concentrations can be determined through the corresponding frequency change. To eliminate interference from particle-bound water, the air stream is heated to a temperature of 40^{o}C, thereby driving off any available water[2].

Both continuous and non-continuous sampling methodologies may underestimate the percentage of time that PM_{10} poses a health risk, but for different reasons. The non-continuous samplers typically operate only once every six days, so they run the risk of missing some of the high PM_{10} days. TEOM® instruments operate continuously, but may volatilise a portion of the PM_{10} due to its high sampling temperature. In heating the air stream, the TEOM® can also drive off semi-volatile compounds such as ammonium nitrate and certain hydrocarbons. This may result in a

[1] Inlet design is based on a 50% cutpoint of 10 μm. The 50% cutpoint is the particle size at which the sampler collects 50% of the sample and rejects 50%. This means that particles above 10 μm are collected, but at progressively less efficiency.

[2] The TEOM® was originally designed to operate at a sampling temperature of 50^{o}C, however, due to concerns over excessive volatilization, the sampling temperature was reduced to 40^{o}C in all BC instruments as of Jan. 1, 1998.

difference of as much as 30% between the continuous and noncontinuous sampling methods[3]. The difference depends on environmental conditions, such as temperature, as well as the composition of the particles.

Data Inclusion Criteria

Data from non-continuous PM_{10} samplers were used only when TEOM® data were not available for a community. Data reporting requirements included a minimum of 75% of possible samples per month and a minimum of 11 valid months per year. This translates to a minimum of 4 samples per month from the non-continuous monitoring sites (assuming sampling takes place every six days), and a minimum of 540 hours per month at the TEOM® sites, although these amounts will vary with the number of days in the month.

References:

Air Resources Branch. 1995. *Fine Particulates, What They Are and How They Affect Us.* Ministry of Environment, Lands and Parks, Air Resources Branch. http://wlapwww.gov.bc.ca/air/particulates/fpwtaaht.html

Canadian Environmental Protection Act (CEPA)/Federal Provincial (FPAC)Working Group on Air Quality Objectives and Guidelines. 1998. National Ambient Air Quality Objectives for Particulate Matter. Science Assessment Document.

Provincial Health Officer. 1998. *A Report on the Health of British Columbians: Provincial Health Officers Annual Report 1998*. BC Ministry of Health and Ministry Responsible for Seniors.

Schwartz, J., Dockey, D.W. and Neas, L.M. (1996) Is daily mortality associated specifically with fine particles? J. Air Waste Manage. Assoc. 46: 927-939.

Vedal, S. 1995. *Health Effects of Inhalable Particulates: Implications for British Columbia*. Report prepared for the Air Resources Branch, British Columbia Ministry of Environment, Lands and Parks.

Secondary Measure: ***Location of health risks from inhalable particulates.***

Selection of Indicator: This indicator shows the percentage of time in 2000 that air quality monitoring stations in each community used in the primary indicator (above) recorded levels above 25 $\mu g/m^3$, the level at which health effects have been demonstrated.

[3] This value is based on studies done in the UK, which indicated that the TEOMs underestimated the highly-volatile compounds by 15-30%. The UK use the 30% figure when comparing their data to data collected by other EU countries.

Data and Source:

Table 3. Percentage of time in 2000 that air quality monitoring stations in each community recorded levels above 25 μg/m^3 (this is a subset of data in Table 2.)

Location of sampling station	Sampler type*	Percent of time in 2000 > 25μg/m3
100 Mile House	nc	14.5
Boston Bar	c	29.0
Burnaby South	c	4.7
Campbell River Tyee Split	c	1.6
Castlegar	nc	28.1
Chetwynd	nc	5.2
Chilliwack Airport	c	5.8
Creston PC School	c	19.8
Duncan Deykin Avenue	c	1.4
Grand Forks	nc	37.9
Hope Airport	c	0.05
Houston Firehall	c	11.0
Invermere Forest	nc	31.7
Kamloops Brocklehurst	c	4.4
Kelowna College	c	6.7
Kitimat Riverlodge	c	3.0
Kitsilano	c	2.5
Langdale Elementry	c	0.6
Langley	c	2.2
Mission	nc	11.5
Nelson	nc	12.1
Port Alberni Townsite	c	1.1
Port Moody Rocky Pt	c	3.1
Powell River Cranberry Lake	c	0.8
PRG Plaza 400	c	20.1
Quadra Island Lighthouse	c	0.6
Quesnel Senior Secondary	c	25.6
Radium	nc	15.0
Revelstoke	nc	27.3
Richmond South	c	4.2
Smithers St Josephs	c	11.0
Slocan	nc	12.5
Squamish	c	10.3
Surrey East	c	11.0
Terrace	nc	10.6
Terrace BC Access Centre	c	10.6
Trail	c	5.4
Victoria PAPS	nc	22.0
Williams Lake Columneetza School	c	18.8

Source: BC Ministry of Environment, Lands and Parks, 2000. Air Resources Branch.

* c = continuous sampler; nc = non-continuous sampler.

Note: A community was included in this analysis if data had been collected for a minimum of 75% of the days in at least 11 months of that year.

Methodology and Reliability: The communities in the table are those for which the minimum data inclusion requirements were met. In any community with several reporting stations, data from the station that was most representative of overall community air quality were used. Some stations located near industrial sources are more representative of local air quality.

There has been considerable debate in the scientific community about the level at which health effects begin from inhalable particulate matter. Early research suggested that increased mortality from exposure to particles began at PM_{10} levels above 20 $\mu g/m^3$, however, later studies have placed the health risk level at 25 $\mu g/m^3$. This is now the generally accepted standard within the scientific community, and the level adopted for this indicator.

Secondary Indicator: ***4th highest 8-hour daily maximum ozone concentration averaged over 3 years (1998-2000).***

Selection of the Indicator: Although ozone in the stratosphere (the ozone layer) is beneficial and filters out harmful ultraviolet rays, ground-level ozone is a pollutant and can be damaging to human health and the environment. Ground-level ozone is also a major component of photochemical smog. Ozone is a secondary pollutant, formed through chemical reactions involving nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight. Ground-level ozone also occurs naturally and can come from down-mixing from the stratosphere.

Nitrogen oxides are primarily emitted during combustion of fossil fuels and biomass. Human contributions come from vehicles, thermal electric power plants and certain industrial processes. Volatile organic compounds are emitted during the incomplete combustion of fuel as well as the evaporation of fuels, solvents, paints and dry-cleaning fluids. Natural sources, mainly biogenic emissions from vegetation, can make a significant contribution. These pollutants can be transported hundreds of kilometres downwind, resulting in elevated ozone concentrations in areas well removed from the sites where precursor emissions are greatest.

Ozone exhibits strong temporal patterns. Seasonally, hourly concentrations in urban areas are typically highest in the summer when temperatures are highest, the sun is most intense and longer days enhance photochemistry. In areas influenced by natural sources, monthly maxima tend to occur in the spring, when weather conditions that favour intrusions from the ozone-rich stratosphere are believed to be most prevalent. Ozone also shows strong diurnal patterns during the summer, with concentrations peaking in the afternoon and decreasing through the night, from lack of sunlight and other chemical reactions.

Numerous health effects have been associated with ambient concentrations of ozone. The impact of ozone on human health is mainly through the respiratory system as it is a respiratory irritant that damages the lung tissue. Epidemiological studies show a range of effects, from coughs and shortness of breath to hospitalisations and mortality. The effects can be observed within the first hours of exposure to ozone and may last for several hours, or even days, after exposure ceases (Borja-Aburto and Loomis, 1997). The studies do not show a threshold, above which the risk of mortality or hospitalisations increases; rather, the risk of population health effects increases linearly as ozone increases (CEPA/FPAC, 1999). Even at hourly concentrations as low as 20 ppb, respiratory symptoms such as eye, nose and throat irritation, cough, increased mucus production, chest tightness, and others, have been shown to occur (Borja-Aburto and Loomis,

1997). The elderly, children and people with respiratory disease (mainly asthma, chronic obstructive pulmonary disease and allergic rhinitis) are most sensitive to ground-level ozone. Exercise or strenuous work outdoors can exacerbate symptoms. The effects of long-term exposure to ozone are not known. The health effects of ozone can be confounded by the presence of other pollutants.

Ozone is one of the most harmful air pollutants to vegetation. It can be toxic at very high concentrations, resulting in leaf damage, crop yield loss and reduced biomass production. Exposure to moderately high concentrations of ozone can increase susceptibility to pests and injury from other environmental stresses. Ozone can also damage materials, such as natural rubber and textile fabrics, and change the colour of some dyes.

This indicator was selected to take into account the new Canada-Wide Standards (CWS) for ground-level ozone. The standards were ratified in June, 2000, with the caveat that they may need to be revisited in future to be fully protective of human health. The standard is set at 65 ppb for an 8-hour average, based on the 4th highest measurement annually, averaged over 3 consecutive years. This level is to be achieved by 2010. It is important to stress that the standards are meant to minimise risk, but human health effects have been demonstrated at concentrations below this.

Prior to introduction of the CWS, the focus of standards in Canada was on the 1-hour maximum. The National Ambient Air Quality Objective (NAAQO) is 82 ppb for a 1-hour period. The CWS now take precedence, however, the 1-hour objective is still used for real-time reporting, such as the Air Quality Index. A CEPA/FPAC review (1999) showed that there was a high correlation between the 1-hour and 8-hour maximum concentrations.

In addition to the standard, a health reference level was established by the Federal/Provincial Working Group on Air Quality Objectives and Guidelines that provides an estimate of the lowest level at which statistically significant increases in health responses have been detected. The level was set at 20 ppb (non-accidental mortality) for a daily maximum 1-hour average. This low concentration, however, can be exceeded at background concentrations, without anthropogenic input. It is difficult to determine a background concentration for ozone because the precursor pollutants can
travel large distances. To estimate background ozone concentrations, without anthropogenic input, measurements from remote sites were used. In Canada, background daily 1-hour maximum ranges from 35-48 ppb (CEPA/FPAC, 1999).

Other jurisdictions have also adopted or are in the process of adopting 8-hour criteria. In the United States, the Environmental Protection Agency (EPA) has concluded that longer exposure periods can be of greater concern even at lower ozone concentrations (US EPA, 1996). The EPA is switching from a 1-hour standard of 120 ppb to an 8-hour standard of 80 ppb, based on the 3-year average of the annual 4th highest daily maximum 8-hour concentration. In the United Kingdom, the standard for ground-level ozone is 50 ppb for an 8-hour average and the World Health Organisation has set a standard of 60 ppb for 8-hour running averages of ozone concentrations.

Data and Sources:

All of the stations in BC are currently meeting the CWS for ozone. It is interesting to note that three of the four highest concentrations are measured at sites outside of the Lower Fraser Valley (LFV). These sites are affected more by natural sources of ozone (e.g., stratospheric down-mixing) and the maximum monthly concentrations occur in the spring. The eastern LFV is a location of high ozone concentrations because of its many anthropogenic sources.

Table 4. Fourth Highest Daily 8-hour Measurement of ozone concentration, averaged for 1998-2000.

City	Ozone Concentration (ppb)
Abbotsford	45
Vancouver	47
Nanaimo	47.5
Chilliwack	51.8
Saturna	53.8
Pitt Meadows	54.2
Langley	55.3
Kelowna	57.0
Maple Ridge	58.0
Kamloops	58.2
Prince George	58.2
Hope	58.5
Smithers	60.0

Source: Environment Canada, based on data collected from Ministry of Water, Land and Air Protection monitoring network (with exception of Saturna site).

Methodology and Reliability: Ozone is being monitored at more than 25 sites across BC. The majority are located in the Lower Fraser Valley; none are in the Kootenays. Ground-level ozone is measured with an ultraviolet (UV) absorption sampler. UV absorption monitors are based on the principle that ozone absorbs strongly in the 254nm range, which coincides with the emission line of low-pressure mercury lamps. Ozone measurements can be derived by comparing the transmission of a 254nm light through clean air (where a scrubber has removed ozone) with light transmitted through sample air. The disadvantage of the UV absorption method is that other contaminants that absorb 254nm light may be removed by the scrubber and therefore contribute to an overestimation of ozone concentrations. Hourly average ozone concentrations are recorded on a continuous basis.

Data Inclusion Criteria

Data were used if there was a minimum of 75% of possible sample days per month and a minimum of 11 months of data per year.

References:

Borja-Aburto, Victor Hugo and Dana Loomis. "Outdoor Air III: Ozone." *Topics in Environmental Epidemiology*. Ed. Kyle Steenland and David Savitz. New York: Oxford University Press. 1997. 184-199

CEPA/FPAC. 1999. *National Ambient Air Quality Objectives for Ground-Level Ozone Summary Science Assessment Document* August 1999

United States Environmental Protection Agency. 1996. *National Ambient Air Quality Standards for Ozone: Proposed Decision*. Washington, DC; Nov 29, 1996. Report NO 40 CFR Part 50

Secondary Measure: ***Across Canada comparisons of ozone levels.***
(not included in *Environmental Trends 2002* report)

Selection of Indicator: While the primary indicator looked at the ground-level ozone concentrations in cities across BC, this indicator compares those cities to others in Canada. The same criterion was used (4th highest daily 8-hour average ozone concentration, averaged over 3 years). Historically, using the one-hour NAAQO, three regions in Canada experienced the highest levels of ground-level ozone: the Windsor-Quebec City corridor, Southern Atlantic Region and the Lower Fraser Valley. The first two locations have high concentrations due to transboundary pollution from the US. The highest concentrations of ozone are in southern Ontario; levels in other cities in Canada met the CWS of 65 ppb for an 8-hour average.

In the tables (below) Canadian sites are divided into residential and urban areas. This is because ozone concentrations can vary within short distances, depending on the sources of precursor pollutants. Among residential areas in Canada, BC Lower Mainland communities have among the lowest ozone concentrations. Although still under the standard, BC communities outside the Lower Mainland rank in the top half of the group of city centre sites. The Okanagan region has recently been identified as an area with the potential for future episodes of elevated ozone concentrations (Air Resources Branch, 1998).

Data and Sources:

Table 5. Residential Sites in Canada: Fourth Highest Daily 8-hour Measurement of ozone concentration, averaged for 1998-2000

Residential Site	Ozone Concentration (ppb)
Toronto	84
Kingston	78
Hull	77
Montreal	70
Edmonton	61
Brandon	60
Moncton	58
Maple Ridge	58
Winnipeg	58
Chilliwack	52
Vancouver	45
Abbotsford	45

Table 6. City Centre Sites in Canada: Fourth Highest Daily 8-hour Measurement of ozone concentration, averaged for 1998-2000

City Centre Site	Ozone Concentration (ppb)
Windsor	85
Toronto	76
Montreal	65
Halifax	59
Prince George	58
Penticton	58
Kamloops	58
Kelowna	57
Ottawa	54
Edmonton	53
St. John	49
Winnipeg	47
Victoria	47
Regina	40
Yellowknife	35
Vancouver	34

Source: Environment Canada, 2001

Methodology and Reliability: For cities where data were available from more than one site, one site was chosen to be representative. Not all cities across the country were included due to space and data constraints.

References:

Ministry of Environment, Lands & Parks.1998. *Air Quality Report for British Columbia: Ground-Level Ozone Concentrations (1986-1997)*. Air Resources Branch.