Air Quality Indices: A Review

A report prepared for Environment Canada

by Pollution Probe

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Table of Contents

Appendices

List of Tables

Executive Summary

This report provides background information that Pollution Probe hopes will assist in the development of a national Air Quality Index in Canada. It includes a historical review that explains how the index was devised and modified, and how it has been used in various parts of Canada. The parallel development of the US Pollutant Standards Index (PSI) and its successor, the Air Quality Index (AQI), is also discussed to indicate how a similar jurisdiction, using a comparable index has gone about the process of revision to ensure that it remains scientifically accurate and socially relevant.

Based upon this background information, the issues that need to be addressed in revising the National Index of the Quality of the Air/Indice de qualité de l'air (IQUA), or creating a new national Air Quality Index, are then explored.

Historical Background

The National Index of the Quality of the Air/ Indice de qualité de l'air (IQUA)

The National Index of the Quality of the Air/ Indice de qualité de l'air (IQUA) provides Canadians with real-time information on the state of community air quality. Devised in 1976 by a Federal Ad Hoc Sub-Committee of the Federal/Provincial Committee on Air Pollution, the index was based on National Air Quality Objectives.

In designing IQUA the Federal Ad Hoc Sub-Committee sought to produce an index that was:

- Readily understandable by the public;
- Consistent with sensed and monitored air quality;
- Inclusive of the major pollutants and their synergies;
- Expandable for other pollutants and averaging times as required;
- Comparable among communities; and,
- Usable as an alert system.

To achieve these goals, the Sub-Committee devised an index in which sub-indices for a variety of air pollution parameters (pollutant averaging times) were calculated based on segmented line functions defined by the "maximum desirable," "maximum acceptable," and "maximum tolerable" National Air Quality Objective categories.[1] These were assigned arbitrary values of 0–25 (good/bon), 26–50 (fair/passable), 51–100 (poor/pauvre) and over 100 (very poor/très pauvre). Index values for release to the public were then established by taking the highest available sub-index value for the time period to which the index applied. In the original version of the index, sub-indices were established for 1-hour and 24-hour sulphur dioxide; 24-hour Coefficient of Haze; 1-hour and 8-hour carbon monoxide; 1-hour and 24-hour nitrogen dioxide; and 1-hour ozone.

Between 1988 and 1991, a successor Ad Hoc Sub-Committee on the Air Quality Index proposed modifications to the original index format.[2] The recommendations included the establishment of sub-indices to measure 1-hour Coefficient of Haze concentrations; 24-hour PM_{10} to measure the level of inhalable particulates; 24-hour Total Suspended Particulate concentrations, as a surrogate for continuous Total Suspended Particulate; and 1-hour Total Reduced Sulphur concentrations. In addition the Sub-Committee produced a matrix of "Examples of Types of Effects Used as Break Points."

IQUA has been widely employed on a non-legislated basis throughout Canada for over 20 years with minor modifications in some provinces to reflect local conditions. It is now

being used not only to provide information on air quality but also as the basis for air quality management plans, and air quality alert systems. A summary of these uses/modifications is provided in Table I.

United States National Air Quality Index

The Pollutant Standards Index

At approximately the same time Canadian authorities were developing IQUA, the US Environmental Protection Agency (US EPA) under Clean Air Act requirements, produced a parallel air quality index known initially as the Pollutant Standards Index (PSI). This index incorporated the five "criteria pollutants" (particulate matter, sulphur dioxide, carbon monoxide, nitrogen oxide and ground level ozone) for which the agency had set national health-based standards — National Ambient Air Quality Standards (NAAQS) and Significant Harm Levels (SHLs). As in the case of IQUA, the PSI was based on sub-indices defined by segmented line functions where the short-term NAAQS was assigned a value of 100 and the SHL a value of 500. The highest sub-index defined the PSI value for any given time period but where more than one pollutant exceeded the 100 level, information was given on this contaminant/averaging time too. In addition, the annual standard or a concentration equal to half the value of the short-term standard was assigned to an index value of 50. Index values 0–100 were described as "good," 101–200 as "unhealthful," and above this as "very unhealthful." Use of the index was mandated in all metropolitan areas with a population in excess of 250,000. The US EPA advocated calculation of the index on a daily basis and encouraged State officials to incorporate progressive prevention action in the form of health advisories and emission cutbacks. In 1979, the US EPA made changes to the PSI to reflect revisions to the NAAQA for ozone, and also established requirements for the reporting of PSI index values.

The Air Quality Index (AQI)

In July, 1999 the US EPA made major changes to its index, including renaming it the Air Quality Index (AQI). These changes incorporated:

- revisions to the primary health-based national ambient air quality standards for ground-level ozone and particulate matter (issued by the US EPA in 1997);
- separate values for $PM_{2.5}$ and for PM_{10};
- a new category in the index "unhealthy for sensitive groups" in the index range of 101–150;
- colour symbols to represent different ranges of AQI values;
- mandatory requirements for authorities to supply information to the public on health effects at various index levels; and,
- mandatory requirements for the calculation and reporting of the AQI in metropolitan areas with populations in excess of 350,000.

The US EPA encouraged use of the AQI in community alert and control programs, air quality forecasting and real time mapping of pollution (especially ozone) concentrations, linking the index in the process to public education and health programs, meeting specific emission reduction targets and commitments to reducing traffic congestion.

Issues in Revising the Index of the Quality of the Air/Indice de qualité de l'air (IQUA)

Since IQUA was developed there have been a number of significant developments that affect the validity of the index, and the way in which it is being used. These include:

- Rejection by the Working Group on Air Quality Objectives and Guidelines of the previous "maximum desirable," "maximum acceptable" and "maximum tolerable" air quality criteria;

- Recognition that the standards for many of the contaminants used in the index are known to be outdated, but they have not been updated;

- Substantial evidence from epidemiological data that "threshold" or "safe levels" for common pollutants do not exist, particularly at typical concentrations found in Canada;

- Difficulty in defining effects at various index levels (to the natural environment and to human health);

- Development of more sophisticated and sensitive instrumentation for the real-time monitoring of contaminants, such as particulate and fine particulate;

- Improved communication tools; and,

- Increased awareness that air quality is a community health problem in major urban centres, smaller communities and even rural areas.

In addition there are a number of issues that the existing index fails to take into account or addresses only in part. These include:

- Lack of consistency in the reporting of the index;

- Difficulties associated with the operation of both the US AQI and IQUA particularly in border communities; and,

- The reconciling of different uses to which IQUA has been put and the linking of IQUA to control actions.

Recommendations

This report recommends the development and incorporation of:

- A mechanism to review IQUA (or a new Canadian AQI) on a regular, or as required, basis that would include representatives from all the main stakeholders including: governments, the medical profession, special interest groups, and environmental and industrial interest groups;

- Ways to include new thinking on standards in the production of IQUA/AQI sub-indices;

- Methodologies to further facilitate comparisons between IQUA/AQI readings and those for AQI in the US, particularly in border communities;

- Improved health messaging;

- Protocols to ensure consistent use of IQUA/ AQI within Canada, with minimum community population reporting thresholds similar to those specified under the Canada-Wide Standards (CWS) process;

- Uniform and improved public relations materials (similar to those developed by the US EPA for their AQI) should be developed for IQUA (or a new Canadian AQI) and their use encouraged throughout Canada;

- Measures to involve news media and their audiences in the IQUA/AQI; and,

- Assessment of the feasibility and desirability of incorporating IQUA/AQI into emission control programs especially in alert situations.

1.0 Introduction

Over the past 30 years Canadians, in common with citizens of other countries, have shown consistent and continued concern about the state of their natural environment. This concern has been reflected in the results of innumerable polls and surveys, in the establishment of several highly successful public environmental lobby groups, and in the priority which governments and industry have accorded environmental concerns. To match this level of interest, governments have developed a number of ways to provide the public with objective information about the state of their local, regional and national environments. These supply information on such matters as the nature and quantity of emissions and discharges to the environment, and their effect on the state of the media into which they are being discharged. They also reflect the impact which "pollution" is having on human health and welfare, the damage and injury which it is inflicting on animals and plants, and its effects on the earth's water resources and atmosphere.

Environmental information which Canadian governments are providing to the public comes in a number of forms. At a high level of sophistication, annual reports such as business plans, state of the environment reviews, and site or subject specific analyses are routinely being produced, generally for limited audiences with the time, interest and necessary background to digest their contents. In addition to these detailed documents governments have also produced various materials with more general appeal. Among these are "indicators of environmental quality" which track and report on the status of various environmental parameters generally on a continuous or time-specific basis. These indicators give the public the opportunity to track the state of their local, regional and national environment without the need for an understanding of the details of the monitoring data upon which they are based. More recently, governments throughout the world have also started to use real-time access to sophisticated database management programs to provide their citizens with access to site specific emissions and discharge data in summary form.

An agreement by the Canadian Ministers of the Environment on "the set of initial actions to reduce the pollutants that cause particulate matter (PM) and ground-level ozone" has lately given some added impetus to this issue by committing to:

> provide more thorough and timely air quality information to government, industry and the public by:
>
> (a) Linking jurisdictional databases of ambient air quality data; and,
>
> (b) Facilitating access to existing public information.[3]

One of the principal measures of environmental quality is the National Index of the Quality of the Air/Indice de qualité de l'air (IQUA). This indicator was produced by a Federal Ad Hoc Subcommittee of the Federal/Provincial Committee on Air Pollution Indices in 1976. It has provided a mechanism for summarizing, comparing and encapsulating the significance of ambient air quality data from the National Air Pollution System and the various provincial and territorial monitoring systems across the country. It has formed the basis for regular reporting by the media on air quality and is also linked in some locations to regulatory control mechanisms that ensure action is taken when unacceptable air quality is observed or forecasted.

Since 1993 a number of authorities in locations with critical smog problems have been issuing "Smog Advisories" based on ground level ozone monitoring and meteorological forecasts when ozone levels are expected to exceed the "acceptable concentration" of 80 ppb. In some areas more elaborate ozone forecasting programs have also been recently adopted to

provide the public with information on ozone levels on a regular basis throughout the smog season. The Air Quality Index is often used to communicate this information. Several jurisdictions are also moving into the provision of real-time visual materials using index values based upon sophisticated mapping of air quality data and air quality modelling.

This paper will review the development and use of the Canadian Index of Quality of the Air/ Indice de qualité de l'air (IQUA):

- including its design, adoption by the provinces and other jurisdictions, revisions made to it, and media treatment of IQUA data and associated information;
- the parallel development and use of air quality indices in the US and extension there of air quality indices into community action/ alert programs, air quality forecasting and real-time mapping;
- opportunities involving air quality indices to further improve public information about air quality in Canada; and,
- potential processes for developing new or revised information tools for use in Canada.

2.0 Development and Use of the Canadian National Short and Long Term Indices of Air Quality/Indices de Qualité de l'air (IQUA)

2.1 Criteria Used in the Design of the National Short and Long Term Indices of Air Quality/ Indices de Qualité de l'air (IQUA)

The basic objective of any air quality index, whether it is to be applied to either short or long time periods, is to transform measured values of individual air pollution-related parameters (air quality data) into a single number or descriptive term. Ideally any index should reflect both the measured and publicly perceived quality of the ambient air for the time period it covers. As a result, air pollution indices attempt to standardize and synthesize air pollution information and permit comparisons to be readily undertaken, and to satisfy public demands for accurate, easy to interpret data. Air pollution indices can and have been used extensively in a number of jurisdictions to inform the public about daily changes in air pollution levels, to act as the basis for high air pollution "episode" warning systems, and to provide information on temporal and spatial changes in air pollution. Because the requirements of short term and long term indices are somewhat different, the Federal/Provincial Subcommittee on Air Pollution Indices produced two separate indices — "A Short Term Air Quality Index" and "An Annual Air Quality Index." Although these indices are different, they shared several common characteristics.

In its design of both these indices, the Federal/ Provincial Ad Hoc Subcommittee on Air Pollution Indices used the following criteria:

"The index should:

1. be readily understandable by the public;
2. be consistent with sensed air quality;
3. include the major pollutants and their synergisms;[4]
4. be expandable for other pollutants and averaging times;
5. be related to National Ambient Air Quality Objectives for Canada ("desirable", "acceptable" and "tolerable") and other criteria used in individual provinces;
6. avoid "eclipsing" (eclipsing occurs when an (air pollution) index does not indicate poor air quality despite the fact that concentrations of one or more air pollutants may have reached unacceptably high values);
7. be comparable between communities;
8. be usable as an alert system;"
9. be based on valid air quality data obtained from monitoring stations that are situated so as to represent the general air quality in the community;
10. be a "severe index" which reflects the worst effects; and,
11. assume that effects of all pollutants have the same importance with respect to the quality of the air at the defined objective levels (desirable, acceptable and tolerable).

Table I: Comparison of Values Used as Breakpoint Concentrations

Table 1(a): Canadian Index of the Quality of the Air (l'indice de la qualité de l'air) (IQUA); Canada-Wide Standards; and the Ontario Air Quality Index

Pollutant	Averaging Time	Maximum Desirable IQUA Value (25)	Maximum Acceptable IQUA Value (50)	Maximum Tolerable IQUA Value (100)	Canada-Wide Standard Index Value* (100)	Ontario AQI Concentrations Index Values (32)	(50)	(100)
Sulphur Dioxide	**Annual**	0.01 ppm	0.02 ppm					
	24-hour	0.06 ppm	0.11 ppm	0.31 ppm				
	1-hour	0.17 ppm	0.34 ppm	(2.0 ppm)		0.25 ppm	0.35 ppm	2.0 ppm
Suspended Particulate	**Annual**	60 µg/m^3	70 µg/m^3					
	24-hour	(60 µg/m^3)	120 µg/m^3	400 µg/m^3	($PM_{2.5}$) 30 :g/m$^{3\#}$			
Ozone	**Annual**		0.015 ppm					
	1-hour	0.05 ppm	0.08 ppm	0.15 ppm		0.051 ppm	0.080 ppm	0.149ppm
	8-hour				0.065 ppm			
Carbon Monoxide	**8-hour**	5 ppm	13 ppm	17 ppm		9 ppm	9 ppm	13 ppm
	1-hour	13 ppm	31 ppm	(64 ppm)		22 ppm		31 ppm
Nitrogen Dioxide	**Annual**	0.03 ppm	0.05 ppm	(1.0 ppm)				
	1-hour	(0.11 ppm)	0.21 ppm	0.53 ppm		0.21ppm		0.26 ppm
Inhalable Particulate — Coefficient of Haze (COH)	**1-hour**	1.7 COH Units	4.0 COH Units	6 COH Units				
	24-hour	0.25 COH Units	0.84 COH Units	2.5 COH Units				
Inhalable Particulate PM_{10}	**24-hour**	30 µg/m^3	55 µg/m^3	95 µg/m^3				
Totally Reduced Sulphur (TRS)	**1-hour**	0.005 ppm	0.01 ppm	0.10 ppm				

*Canada-Wide Standards — Due to be implemented by 2010
Based on the 98th percentile measured over three consecutive years
Numbers shown in brackets are interpolations or extrapolations
Sources:
Environment Canada "Guideline for the Index of the Quality of the Air" (Environment Canada, Ottawa, 1996)
Ontario Ministry of the Environment "A Guide to the Ontario Air Quality Index System" (Queen's Printer, Toronto, 1991)
Canadian Council of Ministers of the Environment "Particulate Matter and Ozone Canada-wide Standards" (CCME, Winnepeg, nd) www.ccme.ca/ccme

The Subcommittee also noted that if index values from different sites are to be used for comparisons that:

1. the data and siting of all monitoring sites used should be well documented; and,

2. all pollutants of concern should be monitored.[5,6]

And, that in the case of the short term index that it should ideally show considerable variation from day to day to help maintain interest in the reported data.

At an early stage in its deliberations the committee also realized that the needs of short term (daily) indices and long term (annual) indices are substantially different. Therefore it decided to produce separate indices for each usage.

Table 1(b): US Air Quality Index (AQI)

Pollutant/ Breakpoints	Moderate 51-100	Unhealthy for sensitive groups 101-150	Unhealthy 151-200	Very Unhealthy 201-300	Hazardous 301-400	401-500	$501
Corresponding Index Value to Breakpoint	51	101	151	201	301	401	$501
Ozone 1-hr	No short term AQS	0.13 ppm	0.16 ppm	0.20 ppm	0.40 ppm	0.50 ppm	0.60 ppm
Ozone[1] 8-hr	0.064 ppm	0.084 ppm	0.104 ppm	0.124 ppm	0.374 ppm	No values given – treat same as l hour	
$PM_{2.5}$ 24-hr	15.4 µg/m^3	40.4 µg/m^3	65.4 µg/m^3	150.4 µg/m^3	250.4 µg/m^3	350.4 µg/m^3	500.4µg/m^3
PM_{10} 24-hr	54 µg/m^3	154 µg/m^3	254 µg/m^3	354 µg/m^3	424 µg/m^3	504 µg/m^3	604µg/m^3
Carbon Monoxide 8-hr	4.4 ppm	9.4 ppm	12.4 ppm	15.4 ppm	30.4 ppm	40.4 ppm	50.4 ppm
Sulphur Dioxide 1-hr	0.034 ppm	0.144 ppm	0.224 ppm	0.304 ppm	0.604 ppm	0.804 ppm	1.04ppm
Nitrogen Oxide 1-hr	No short term criterion available			0.65 ppm	1.25 ppm	1.65 ppm	2.04 ppm

[1]Areas are generally required to report the AQI based on 8-hour ozone values. However, there are a small number of areas where an AQI based 1-hour ozone values would be more precautionary. In these cases, in addition to calculating the 8-hour ozone index value, the 1-hour ozone index value may be calculated and the maximum of the two values reported.
Note: The index level of 100 is associated with the numerical level of the short-term standard) averaging time of 24 hours or less, except in the case of NO_2 for which no short-term standard has been set. The index value of 50 is associated with the numerical level of the annual standard for a pollutant if there is one, at one half the level of the short-term standard for the pollutant, or at the level at which it is appropriate to begin to provide guidance on cautionary language. Other levels are derived by linear extrapolation.
Source: Federal Register Vol. 64, No. 149 Environmental Protection Agency 40 CFR Part 58 Air Quality Index Reporting "Final Rule."

2.2 Determination of the National Short Term Air Quality Index/ Indice de Qualité de l'air (IQUA)

In working within the constraints outlined above, the Federal/Provincial Ad Hoc Committee had two basic choices in its production of a short term index:

- to develop a "maximum pollutant" index in which the data are reported for only one pollutant, namely the one with the maximum value among those monitored; or,

- to construct an "individual pollutant" index in which numbers for all pollutants (and averaging times) would be used.[7]

A "maximum pollutant" approach was selected to make optimal use of available air quality data, to produce an index as easy to interpret as possible, and to avoid eclipsing problems. Given that for some air quality monitoring stations as many as ten air pollutant parameters (different contaminants and averaging times)[8] were being produced, this meant that a method had to be developed to objectively compare their relative severity and to translate them to a common scale. The committee therefore agreed to develop sub-indices for each parameter based on the "maximum desirable," "maximum acceptable" and "maximum tolerable"[9] criteria developed by other subcommittees of the Federal/Provincial Committee, and where these were not available equivalent criteria developed by the provinces. On each sub-index the "desirable" level was scaled on a log scale to produce an index from 0–25, the "acceptable" level an index from 26–50, and the "tolerable level" from 51–100, producing a segmented line function. Using the "maximum pollutant" philosophy, the reported index at any time is the highest sub-index at that time (see Table I).

To make the index easier for the public to use and to encourage its adoption by the media, the numerical ranges of 0–25, 26–50, 51–100 and >100 were assigned verbal descriptors of "good," "fair," "poor" and "very poor" respectively. (In French, these translate into "Bon," "Passable," "Pauvre" and "Très pauvre").[10]

In the final report on the proposed short term index the following observation on the way in which it should be used was included:

> The Committee recommends that the IQUA be routinely calculated and released (to the media) along with corresponding verbal descriptors at least twice a day so that it can be carried on the wire services. When the index exceeds a value of 50, the committee recommends that it be released hourly until such time as the value is less than 50.

2.3 Determination of the National Long Term Index of Air Quality/Indice de qualité de l'air (IQUA))

Following the development of the short term index in early 1980, the Federal/Provincial Subcommittee on Air Pollution Indices set about the task of producing a long term index.[11] This was an important task because at the time bodies such as the Economic Council of Canada were attempting to assemble socio-economic indicators which incorporated air quality as one of their parameters but had no clear methodology for doing so.

The principal uses of annual indices according to the Subcommittee were to:

- indicate air quality trends;
- permit comparisons of air quality in different urban areas; and,
- provide a single-value indicator of air quality for users other than environmental entities.

The long term index that the committee produced, like their short term index, used the National Air Quality Objectives to define the break points on an open-ended log scale. Thus, a value of 0 on the index was set to represent zero concentration; a value of 25 to a concentration equal to the Maximum Desirable Air Quality Objective; a value of 50 to the Maximum Acceptable Value; and 100 to the Maximum Tolerable Objective. These points were joined by straight lines and where values were missing, points were determined by linear interpolation or extrapolation, with the exception of the value of 25 for suspended particulate matter which was pro-rated from the annual average objectives. For each pollutant-averaging time combination, calculation of the appropriate index value was defined by the 98th percentile value where there are over 100 data observations.

If the pollutant index was calculated for a particular pollutant for different averaging times the largest pollutant index was used to represent that contaminant. In cases where there are 99 or fewer pieces of data the committee decided to use the second highest value.[12] Where more than one single number for each location was found the three highest of these values were then averaged to produce the final index.

2.4 Revisions to the Short Term and Long Term Air Quality Indices, 1988–1991

In the period of 1988 to 1991, IQUA was reviewed by an Ad Hoc Subcommittee to the Federal/Provincial Advisory Committee on Air Quality. This Subcommittee was comprised of representatives from Environment Canada's Environmental Protection Service and Atmospheric Environment Service, Health Canada and provincial governments. It concluded that use of the long term index should be discontinued, and that amendments should be made to the short term index to: include a health effects matrix and several new sub-indices, including ones for inhalable particulate (PM_{10}), coefficient of haze (COH) and hydrogen sulphide. The Environmental Protection Service of Environment Canada eventually published the findings of the subcommittee in 1996.[13] By this time responsibility for setting air quality objectives

had passed to the Federal/Provincial Working Group on Air Quality Objectives and Guidelines (WGAQOG). This group rejected the "Maximum Desirable, Acceptable and Tolerable" format for establishing air quality criteria, which forms the basis for the IQUA, and engaged in the process of defining a new protocol for the development of national ambient air quality objectives.[14]

2.5 Usage of the National Short Term Air Quality Index/Indice de Qualité de l'air (IQUA) by Provincial, Territorial and Local Authorities

2.5.1 British Columbia

Responsibility for air management in British Columbia is divided between the Greater Vancouver Regional District (GVRD) and the province.

2.5.1.1 Province of British Columbia

At the present time, outside the area managed by the GVRD (Lower Mainland), the province of British Columbia uses the original IQUA format with the addition of sub-indices for PM_{10} based on British Columbia's objectives, using the IQUA method of calculation. Provincial monitors (currently in 36 locations), are "polled" hourly, and posted directly to the Ministry of the Environment's website. When hourly levels of the index go above 25 and 50 the computer system automatically issues email alerts to users who have indicated a wish to be kept informed. In addition, Ministry staff has the option to use the IQUA to issue air quality advisories, episode alerts and burning bans based on the index.

During the recent Canada-Wide Standards (CWS) process British Columbia consistently supported the updating IQUA to:

- incorporate $PM_{2.5}$ as a pollutant of concern;
- review the index "breakpoints" (25,50,100);
- incorporate the latest scientific assessment documents for PM and ozone; and,
- enhance the index to provide a more meaningful measure of air quality factoring in chronic and synergistic effects.[15]

2.5.1.2 Greater Vancouver Regional District (GVRD) (Lower Mainland)

In the Lower Mainland of British Columbia, GVRD uses the approved version of the IQUA developed by the Federal/Provincial Subcommittee on Air Pollution Indices with the addition of sub-indices based on additional provincial and/or regional objectives (for example PM_{10}).[16] The index is calculated hourly and daily and is currently distributed via fax, websites and telephone to the public and media sources twice a day although plans exist to report electronically on an hourly basis in the near future. It is currently regarded by GVRD as the primary means for relating existing and forecast air quality levels to the public on a near real-time basis. No change in this status is anticipated in the short term. As new information on the health effects of pollutants becomes available, and changes are made to regional and provincial objectives, the district will continue to advocate modifications and updating of the AQI to ensure it is meeting the changing needs of stakeholders. Of particular concern to the authority at the present time is the need to update short term objectives to incorporate new health findings and to ensure that they are compatible with the ongoing process of establishing Canada-Wide Standards.[17]

2.5.2 The Yukon

The government of the Yukon doesn't currently use the IQUA, primarily because the territory doesn't yet possess any telemetered continuous monitoring equipment. Environment Canada has promised some new equipment for the coming financial year. This will probably include ozone and $PM_{2.5}$ monitors which when added to existing CO and NO_X monitors may cause this situation to change and enable the authorities to produce index levels using a modified IQUA which takes account of $PM_{2.5}$.[18]

2.5.3 Alberta

Alberta has used the Index of the Quality of the Air since 1978. Currently the Index is calculated for a total of nine stations in the province — three in Calgary, three in Edmonton and one each in Fort McMurray, Fort Saskatchewan and Red Deer. The basic format of Alberta's IQUA is identical to the national index with the exception that, as of 1995, the dust and smoke component of the latter has been replaced by one representing $PM_{2.5}$ concentrations. Maximum desirable, acceptable and tolerable levels

Table II: Effects of Contaminants at Breakpoints Used in the Index of the Quality of the Air

National Ambient Air Quality Objectives/ Averaging Time	Carbon Monoxide (1hr, 8hr)	Nitrogen Dioxide (1hr)	Ozone (1hr)	Sulphur Dioxide (1hr, 24hr)	Suspended Particulate (24hr)
Beyond Tolerable (Very Poor Range) $101	Physiological stress on individuals with cardiovascular and respiratory disease; possibly increased mortality.	Increasing sensitivity of patients with asthma and bronchitis	Impairment of respiratory function; increased respiratory symptoms.	Hypersensitive individuals may experience breathing difficulties; increased morbidity	Increasing sensitivity in patients with asthma and bronchitis.
Maximum Tolerable (Poor Range) 51–100	Increasing cardiovascular symptoms in non-smokers with heart disease. Some visual impairment	Increased rate of respiratory illness from long-term exposure. Odour and atmospheric discoloration	Decreasing performance by some athletes exercising heavily	Increasing sensitivity of patients with asthma and bronchitis. Odourous. Increasing vegetation damage and sensitivity.	Visibility decreased. Soiling evident. Increased frequency and severity of lower respiratory disease in children.
Maximum Acceptable (Fair Range) 26–50	Increasing cardiovascular symptoms in smokers with heart disease. Blood chemistry changing	No known human health effects	Increasing injury to some species of vegetation	Increasing (foliar) injury to species of vegetation	Decreasing visibility
Maximum Desirable (Good Range) 0–25	No effects	No objective	Materials are affected by ambient air levels of oxidants.	No effects	No objective

Notes:
1. Examples extracted from the National Air Quality Objectives published from 1974–1978.
2. Health Canada and Environment Canada advise that the matrix is provided as an example only and does not represent the full nature or extent of the health and environmental effects.
3. The levels do not apply to chemically active particles.

Source: Environment Canada "Guideline for the Index of the Quality of the Air" Report EPS 1/AP/3 (Environment Canada, Ottawa, 1996)

included in the National Air Quality Objectives and in IQUA have been inserted into guidelines under Alberta's Environmental Protection and Enhancement Act.

Public access to index levels, which are calculated and issued hourly, is available through two dedicated 1-800 phone lines. When it is issued in a written form, the index is accompanied by the suggested messages published by Environment Canada (see Table II).[19]

2.5.4 Saskatchewan

It is believed that Saskatchewan has never used the IQUA.

2.5.5 Manitoba

Manitoba uses the IQUA, but only at one station located in Winnipeg. Data from this monitoring location are reported hourly and are sent to the media including the local cable TV channels. The province has based its air quality standards directly on the federal government's air quality objectives, so it is able to use the nationally developed index with only minor modifications to incorporate real-time particulate analyzer data. One notable variation in the Manitoba index is in the messaging designed to increase the index's interpretability. This indicates the following "impacts associated with each range" of the index:

Good — no effects;

Fair — noticeable health effect unlikely, some environmental effects may be observed;

Poor — some people, especially those with pre-existing health problems may notice health effects, some environmental effects may be observed; and,

Very Poor — health effects may be experienced by all, and especially those with respiratory conditions, some environmental effects may be observed.[20]

This message would appear to be somewhat at odds with the examples of effects issued by the federal government (see Table II) which indicate environmental effects even in the "good" range, and pronounced consequences to health from high carbon monoxide levels in the "fair" range.[21]

2.5.6 North West Territories

The North West Territories currently doesn't use the IQUA or any other method to supply real-time air pollution data to the public. Air quality problems in the area are mainly the result of local road dust in the spring and forest fire smoke in the summer. Neither of these types of emissions fit particularly well at present within the IQUA structure. They also don't correspond particularly well with current predictive models and it is thought this would restrict the utility of reporting any index that included them.[22]

2.5.7 Ontario

Ontario has made extensive use of the main concepts of the IQUA since 1977. From the outset though the province adopted a slightly different format for its index (which is known as the Ontario Air Quality Index (AQI)) to accommodate its previously developed Air Pollution Index (API)[23] and its own ambient air quality criteria, which are related to point of impingement standards used for approval and control purposes. The need to integrate the API into the air quality index structure means that boundaries for the various sub-index and index categories in Ontario were set at 0–15 (Very Good); 16–31 (Good); 32–49 (Moderate); 50–99 (Poor) and over 100 (Very Poor) instead of 0–25, 26–50 and 51–100. The criteria levels employed initially to establish these boundaries, except in the case of ozone, were consistent with the National Air Quality Standards in IQUA. For the index values of 15 and 31 that are used in the Ontario Air Quality Index, the province used interpolations based on the Maximum Desirable levels. In 1995, new, more stringent bounds for the ozone sub-index were adopted following the

Table III: Changes to Ontario's Ozone (1-hour average) API Sub Index, 1995

Index Level	Pollutant Concentration Ranges Used in API Ozone Sub-Index 1989–1994	Pollutant Concentration Ranges Used in API Ozone Sub-Index 1995+
0 – 15 "Very Good"	0 – 50 ppb	0 – 23 ppb
16 – 31 "Good"	51 – 80 ppb	24 – 50 ppb
32 – 49 "Moderate"	81 – 120 ppb	51 – 80 ppb
50 – 99 "Poor"	121 – 199 ppb	81 –149 ppb
[3] **100 "Very Poor"**	≥ 200 ppb	≥150 ppb

Source: Internal Files — Air Quality and Meteorology Section, Monitoring and Reporting Branch, Ontario Ministry of the Environment

recommendations of a 1995 expert panel of the Canadian Smog Advisory Program.[24] These changes are shown in Table III.

In addition to sub-indices for CO (1-hour and 8-hour); NO_2, O_3, and SO_2 (and the API), the Ontario index currently includes Total Reduced Sulphur (TRS) compounds in locations where this is a problem pollutant, and fine particulate ($PM_{2.5}$)[25] which is now replacing TSP in most locations.

The Ontario Ministry of the Environment currently calculates and publishes an index for 34 urban and rural sites in the province. Data from these sites are monitored in real-time and "telemetered" to enable the ministry to use the data almost immediately in the production of the AQI.[26] Values are released to the media at least five times a day and are accompanied by Air Quality Index forecasts to keep the public informed on expected changes in AQI values. Typically published index levels provide the numeric value with a verbal category descriptor for each site, the pollutant with the highest sub-index, and any health effects. A matrix of effects of various contaminants at different index levels is also available (see Table IV).

Recently a colour scheme has also been added to the various categories: "very good" air quality is represented by blue; "good" by green; "moderate" by yellow, "poor" by orange; and "very poor" by red.[27] A two-week and two-day history of each site also accompanies these data.

2.5.7.1 "The Smog Alert Network"

Based on the Air Quality Index, the province of Ontario now also operates "The Smog Alert Network," a location-specific notification service that provides advanced warning that poor air quality as a result of elevated levels of ozone, may be experienced. Based on US models, the network provides an opportunity for people to "subscribe" to the service and receive electronic mail notification of the status of a Smog Alert. By subscribing to the service people receive three types of messages issued by the Ontario Ministry of the Environment during the smog season:

Smog Watch — when there is a [predicted] 50 percent chance that the AQI will exceed 50 within the next three days;

Smog Advisory — when there is a strong likelihood that the AQI will exceed 50 within the next 24 hours or if a smog day has happened without warning, or is about to occur; and,

Termination Notice — once a smog advisory is over.

The information given out by the Smog Alert Network is also available on two 1-800 lines (English and French)[28] and a local (416) area code number in Toronto.

2.5.7.2 Municipal Partnerships

In partnership with the Ontario Ministry of the Environment several municipalities in Ontario including: the city of Toronto;[29] the city of Mississauga;[30] the Regional Municipality of Hamilton;[31] and Waterloo Regional Council[32] have "joined" Ontario's Smog Alert Response Plan. A number of others, including Halton Region; the city of London; the town of Markham; and Niagara Region have also committed to work with the ministry in the production and implementation of Smog Alert Response Plans in the foreseeable future.[33] To assist them in formulating their plans the ministry has produced a municipal response guide to Smog Alerts.[34]

2.5.8 Quebec

Responsibility for air pollution control in Quebec is split between the Communauté Urbaine de Montreal(CUM)/Montreal Urban Community (MUC), which has jurisdiction on the Island of Montreal, and the Quebec government which is the responsible authority in the remainder of the province.

Table IV: Effects of Contaminants at Breakpoints Used in the Ontario Air Quality Index

Index Value	Category	Carbon Monoxide CO	Nitrogen Dioxide NO_2	Ozone O_3	Sulphur Dioxide SO_2	Suspended Particulate TSP	Air Pollution Index (SO_2)	Total Reduced Sulphur (TRS)
Over 100	Very Poor	Increasing cardio-vascular symptoms in non-smokers with heart disease, some visual impairment	Increasing sensitivity of patients with asthma and bronchitis	Light exercise produces respiratory effects in patients with chronic pulmonary disease	Increasing sensitivity in patients with asthma and bronchitis	Increasing sensitivity in patients with asthma and bronchitis	Significant respiratory effects in patients with asthma and bronchitis	Sensitive individuals may suffer nausea and headaches due to severe odor
50-99	Poor	Increased cardio-vascular symptoms in smokers with heart disease	Odor and discoloration – some increase in bronchial reactivity in asthmatics	Decreasing performance by athletes exercising heavily	Odorous Increasing vegetation damage	Visibility decreased. Soiling evident	Increased symptoms in patients with chronic respiratory disease	Extremely odorous
32-49	Moderate	Blood chemistry changes but no detectable impairment	Odorous	Injurious to many vegetation species e.g. white beans, tomatoes	Injurious to some species of vegetation	Some decrease in visibility	Injurious to vegetation due to sulphur dioxide	Odorous
16-31	Good	No effects	Slight odor	Injurious to some vegetation species in combination with SO_2 (24hrs)	Injurious to some vegetation in combination with O_3(24hrs)	No effects	No effects	Slight odors
0-15	Very Good	No effects	No effects	No effects	No effects	No effects	No effects	No effects

Source: "The New AQI — A Broader Measure of Air Quality" [Pamphlet] (Environment Ontario, Toronto, nd)

2.5.8.1 CUM/MUC

The index used by CUM/MUC since 1981 is a variant on the IQUA. It is made up of sub-indices for six parameters (SO_2 24-hour average, CO 8-hour average, O_3 hourly average, NO_2 hourly average, and $PM_{2.5}$ and PM_{10}). Instead of a segmented line function, with break points derived from the Maximum Desirable, Acceptable and Tolerable National Air Quality Objectives, these sub-indices employ a straight-line function based on just Maximum Acceptable levels or in the case of PM "accepted" values. Calculation of the index is then the product of a simple equation:

$$\text{Index Value} = \frac{\text{Measured Value}}{\text{"Norme" or IQUA Value}} \times 50$$ [35]

CUM/MUC monitors the six parameters continuously at 12 stations on the Island of Montreal and releases the index values to the media on a daily basis together with forecasts for the following 24-hour period. In these public statements index levels between 1 and 25 are described as "Bon" ("Good"); 26–50 as "Acceptable"; and 51–100 as "Mauvais" ("Poor"). Although CUM/MUC runs a website,[36] which includes extensive material on the index, it does not incorporate any text describing health effects or material damage that might be observed at critical levels.[37]

2.5.8.2 Province of Quebec

To date in the Province of Quebec only CUM/MUC has developed and used an air quality index to provide information on air quality to the public.[38]

2.5.9 New Brunswick

2.5.9.1 New Brunswick AQI (IQUA)

The New Brunswick Department of the Environment and Local Government produces IQUA levels routinely three times per day, seven days a week using an index which includes: sulphur dioxide, nitrogen dioxide, carbon monoxide, ozone, hydrogen sulphide and suspended particulate as measured by the Coefficient of Haze. Index values are calculated using the standardized approach of the IQUA and National Air Quality Objectives.

Three stations, located in downtown Saint John, and in the east and west ends of the city, have full monitoring capabilities (SO_2, Suspended Particulate Matter [COH], NO_2, TRS and CO). Index values are also calculated for nine other sites but these are based on the monitoring of a more restricted number of parameters — TRS and SO_2 in St. John to indicate the impact of Irving Pulp and Paper Company's "kraft mill;" and NO_x monitors in rural locations to reflect ozone levels. Published index values, which can be found on the Weather Network, on the government of New Brunswick's website, and are given out on a dedicated phone line, are in the standard format associated with IQUA with actual numerical values and verbal descriptors being provided. In the event of an index value in excess of 50 ("Poor"), the Department of the Environment and Local Government informs the district medical health officer who "may issue a health warning." Such warnings indicate that persons with respiratory disease or those particularly sensitive to air pollutants may experience some discomfort. At this point the local public health office or the Department of Health and Community Services can also issue similar messages. When the Index enters the "Fair" range (26–50), industries can also be alerted that they may be required to reduce

emissions according to their legally binding Certificates of Approval. At levels in excess of 50, the Department of the Environment advises the local public health office and a precautionary message may be issued. An index rating of 100 ("Very Poor") would be accompanied by advice from the Department of Health and Community Services and information or orders from the Department of the Environment regarding emission reductions from industrial and other sources. [39,40,41,42,43]

2.5.9.2 Southern New Brunswick Smog Prediction Pilot Project

In 1993 Environment Canada, under the auspices of its Smog Advisory Program,[44] initiated the production of a special bulletin to alert the public when 1-hour ozone concentrations in excess of 80 ppb or an index level of 50 were predicted. Use of predictive models by the New Brunswick Weather Centre in connection with this program made the area a highly suitable one to launch the Smog Prediction Pilot Project in the summer of 1997. Under this project, messages were prepared by the Weather Centre and issued twice daily for public dissemination through various media. Success of the program[45] led to a permanent program being created for the 1998 smog season and to a recommendation to expand the program geographically to other areas of the province and to incorporate the full range of pollution parameters in the forecast.[46] This recommendation was acted on in 2000 when the program was expanded to include all of the Maritime provinces.

2.5.9.3 Air Resource Management Areas in New Brunswick

As part of its "Clean Air Strategy for New Brunswick" the province has also established Air Resource Management Areas (ARMAs). These permit specific regional air quality objectives to be established in formal Air Management Plans. The Saint John–Fundy ARMA committee made a number of recommendations, such as emergency cutbacks in emissions, some of which are related directly to IQUA values.[47]

2.5.10 Nova Scotia

The government of Nova Scotia has produced an air quality index for the Halifax–Dartmouth area since 1996, based essentially on the format of the IQUA.[48] Data for the index come from two stations — measuring sulphur dioxide, nitrogen dioxide and ozone. The sub-indices for these pollutants are based on Nova Scotia Objectives for the definition of the "Good" air quality category and on the National Ambient Air Quality "Maximum Acceptable" Objectives for the "Fair" category. Public accessibility to the index is limited to weekdays between October and April, but from May until September it is available twice per day, seven days a week.

In information on the index, the following material on effects is provided:

> Smog is made of many harmful components. The more smog people breathe in, the more likely they are to experience adverse effects. Sensitive people may experience symptoms after only one or two hours outdoors. Health Canada scientists have found that hospitalizations for respiratory ailments are significantly increased by air pollution.[49]
>
> Good or fair air quality pose no health effect from the four pollutants. A poor rating may result in a mild aggravation of symptoms in sensitive individuals. Very poor may cause significant aggravation of persons with heart and lung disease.[50]

On August 2, 2000 Environment Canada, in conjunction with the government of Nova Scotia, initiated a new daily smog forecast program based on the IQUA values. Twice-a-day forecasts will be available through the media, on dedicated phone lines in Halifax, Yarmouth, New Glasgow and Sydney, and on Environment Canada's website.

The provincial Department of Health has also announced that it would issue a "Health Advisory" together with the forecasts when smog levels are "exceedingly high."

2.5.11 Prince Edward Island

Prince Edward Island does not currently use the IQUA or any other air quality index.[51]

2.5.12 Newfoundland

Newfoundland does not currently use the IQUA or any other air quality index.[52]

2.6 Summary

The Air Quality Index/Indice de qualité de l'air (IQUA) has been used extensively for over 25 years by various levels of government in Canada.[53] It has been modified formally and informally over this time period by Environment Canada, and by its users, to embrace new scientific findings and to incorporate updated messages concerning the health and other impacts of air pollution. Lack of public input to these amendments, and an absence of consistency in how the index is being used and interpreted in different communities are however notable and indicate areas of opportunity.

3.0 US National Air Quality Indices

3.1 The Pollutant Standards Index

At approximately the same time the Canadian Federal/Provincial Committee was producing its air quality index, the US Environmental Protection Agency (US EPA) was engaged in a parallel endeavor to find a uniform system to measure and report on air quality in all metropolitan areas with a population in excess of 200,000.[54] The result was an index known as the Pollutant Standards Index (PSI) that was remarkably similar in many ways to the Canadian index. The PSI was designed to measure the five major pollutants (particulate matter, sulphur dioxide, carbon monoxide, nitrogen oxide and ground-level ozone) known as "criteria pollutants," for which the US EPA had at that time set national health-based standards — National Ambient Air Quality Standards (NAAQS) and Significant Harm Levels (SHLs) — under the Clean Air Act.[55]

In the PSI, all measured pollutant concentrations were converted to a scale of 0–500. An index value of 100 was ascribed to the numerical level of the short term (i.e., averaging time of 24-hours or less) primary NAAQS and a level of 500 to the SHLs. Other points on the scale were established at 50 (the annual standard level or a concentration equal to one half the value of the short term standard used to define an index value of 100), 200 and 300 to define "good," "unhealthful," and "very unhealthful" levels. These intervals were acclaimed at the time as having "a margin of safety that, based on current knowledge, (which) protects highly susceptible member(s) of the public" particularly against the effects of acute (short term) rather than chronic (long term) effects. The US EPA advocated calculation of the index value on a daily basis for each of the five criteria pollutants and the reporting of the highest value and identification of the pollutant responsible. Where two or more pollutants exceeded the level of 100, although the PSI value released was the one pertaining to the pollutant with the highest level, information on the other pollutants was also released. Levels above 100 could be associated with progressive preventive action by state or local officials involving issuance of health advisories for citizens or susceptible groups to limit their activities, and for industries to cut back on emissions. At a PSI level of 400, the US EPA deemed that "emergency" conditions would exist and that this would require cessation of most industrial and commercial activity.

In 1979 the US EPA made changes to the PSI.[56] These reflected revisions to the NAAQS for ozone and also established requirements for the reporting of PSI values, although broad discretion in this regard was still left up to the reporting agency. The US EPA provided the following as a "typical" radio or television announcement to help in the communication process:

> The pollution index reported at noon today is 150, and the air is considered unhealthful. The pollutant causing this problem is ozone, which, along with other components of smog, can cause eye, nose and throat irritation, as well as chest pain. We expect the concentration of ozone to diminish this afternoon. People with respiratory ailments and heart disease should reduce physical exertion and outdoor activity at this time. The forecast for tomorrow calls for no change in the index.

It was suggested that more detailed information could be provided to the public through recorded telephone reports and newspapers. The documentation on the PSI stressed that it could not be used as means to rank the relative healthfulness of different cities because this is function of a number of variables not included in the index including: population exposure; transportation patterns; degree of industrialization; and, the ability of the

monitoring sites to represent air quality in the community. It also indicated that the PSI does not attempt to take account of possible adverse health effects associated with combinations of pollutants, known as synergisms.[57]

3.2 The (US) "Air Quality Index"

In July 1999, the US EPA issued its new "Air Quality Index" (AQI) replacing the Pollutant Standards Index (PSI). The principal differences between the two indices are that the new AQI:

- incorporates revisions to the primary health-based national ambient air quality standards for ground-level ozone and particulate matter, issued by the US EPA in 1997, incorporating separate values for particulate matter of 2.5 and 10.0 micrograms ($PM_{2.5}$ and PM_{10}) respectively;

- includes a new category in the index described as "unhealthy for sensitive groups" (index value of 101–150) and the addition of an optional cautionary statement, which can be used at the upper bounds of the "moderate" range of the 8-hour ozone standard;

- incorporates colour symbols to represent different ranges of AQI values ("scaled" in the manner of colour topographical maps from green to maroon) which "must be used" if the index is reported in a colour format;

- includes mandatory requirements for the authorities to supply information to the public on the health effects which may be encountered at the various levels, including a requirement to report a pollutant-specific "sensitive group statement" when the index is above 100;

- mandates that the AQI shall be routinely collected, and state and local authorities shall be required to report it, for all metropolitan areas with more than 350,000 people (previously the threshold was urban areas with populations of more than 200,000);

- incorporates a new matrix of index values and cautionary statements for each pollutant (see Tables I(b) and V);[58] and,

- calculation of the AQI is similar to that of the PSI — using concentration data obtained daily from "population-oriented State/Local Air Monitoring Stations (SLAMS)" for all pollutants except particulate matter (PM).[59]

3.3 Extension of Air Quality Indices in the US into Community Alert Programs: Air Quality Forecasting and Real-Time Mapping of Pollution Concentrations

In an effort to promote behaviour change on the part of the public, air quality indices are now being used in the US in conjunction with community "alert programs."[60] These programs are generally voluntary rather than regulatory. They typically provide for progressive steps that governments, the public, businesses and industry can take to reduce emissions when unacceptably high levels of air pollution, as measured by the AQI, are forecast. The goals associated with the programs include everything from specific items such as retaining or regaining attainment status with National Ambient Air Quality Standards,[61] to educating the public, enhancing public health, meeting specific emission reduction targets and commitments and reducing traffic congestion. Actions associated with community alert programs include transportation-related measures such as trip reduction initiatives, postponement of specific activities such as refueling or lawn cutting. Typically such programs relate suggested voluntary actions with air quality index levels.

Table V: US EPA Air Quality Index Health Categories and Cautionary Statements

Index Values	Color Code	Levels of Health Concern	Cautionary Statements — Ozone[1]	Cautionary Statements — Small Particulate Matter 2.5 μm[2]	Cautionary Statements — Particulate Matter 10μm [2]	Cautionary Statements Carbon Monoxide[3]	Cautionary Statements Sulphur Dioxide[4]
0–50	Green	**Good —** Air quality poses little or no risk.	None	None	None	None	None
51–100	Yellow	**Moderate —** Air quality acceptable but may be some concern for very small number of people e.g., people sensitive to ozone.	Unusually sensitive people should consider limiting prolonged outdoor exertion.	None	None	None	None
101–150	Orange	**Unhealthy** — Anyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.	Active children and adults and people with respiratory disease, such as asthma, should limit prolonged outdoor exertion.	People with respiratory or heart disease, the elderly, and children should limit prolonged exertion.	People with respiratory disease, such as asthma, should limit outdoor exertion.	People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO such as heavy traffic.	People with asthma should consider limiting outdoor exertion.
151–200	Red	**Unhealthy** — Everyone may begin to experience health effects. Members of sensitive groups may experience more serious health effects.	Active children and adults and people with respiratory disease such as asthma should avoid prolonged outdoor exertion: everyone else should limit prolonged outdoor exertion.	People with respiratory or heart disease, the elderly, and children should avoid prolonged exertion; everyone else should limit prolonged exertion.	People with respiratory disease such as asthma, should avoid outdoor exertion; everyone else, especially the elderly and children, should limit outdoor exertion.	People with cardiovascular disease such as angina, should limit moderate exertion and avoid sources of CO such as heavy traffic.	Children, asthmatics, and people with heart or lung disease should limit outdoor exertion.
201–300	Purple	**Very unhealthy** — Triggers health alerts. Everyone liable to experience more serious health effects.	Active children and adults and people with respiratory disease such as asthma should avoid all outdoor exertion; everyone else, especially children should limit outdoor exertion.	People with respiratory or heart disease, the elderly, and children should avoid any outdoor activity, everyone else should avoid prolonged exertion.	People with respiratory disease such as asthma, should avoid outdoor exertion; everyone else, especially the elderly and children, should limit outdoor exertion.	People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO such as heavy traffic.	Children, asthmatics, and people with heart or lung disease should avoid outdoor exertion; everyone else should limit outdoor exertion.
301–500	Maroon	**Hazardous —** Triggers health warnings of emergency condition. The entire population is more likely to be affected.	Everyone should avoid all outdoor exertion.	Everyone should avoid any outdoor exertion, people with respiratory or heart diseases, the elderly, and children should remain indoors.	Everyone should avoid any outdoor exertion, people with respiratory or heart diseases, the elderly, and children should remain indoors.	People with cardiovascular disease, such as angina, should limit heavy exertion and avoid sources of CO such as heavy traffic; everyone else should limit heavy exertion.	Children, asthmatics, and people with heart or lung disease should remain indoors; everyone else should avoid outdoor exertion.

Footnotes for Table V

[1]**Ozone —** Active children are particularly susceptible to high ozone levels because they often spend a large part of the summer (when the problem is worse) playing outdoors. All people who are active outdoors are at increased risk because during physical activity, ozone penetrates deeper into the parts of the lungs that are more vulnerable to injury. People with respiratory diseases that make their lungs more vulnerable to ozone may experience health effects earlier and at lower ozone levels than less sensitive individuals. Though scientists don't know why, some healthy people experience health effects at more moderate levels of outdoor exertion or at lower ozone levels than the average person. Ozone can irritate the respiratory system, causing coughing, throat irritation, and/or an uncomfortable sensation in the chest. Ozone can reduce lung function and make it more difficult to breathe deeply and vigorously. Breathing may become more rapid and shallow than normal. This reduction in lung function may limit a person's ability to participate in vigorous outdoor activities. Ozone can aggravate asthma. When ozone levels are high, more people with asthma have attacks that require a doctor's attention or the use of other medication. One reason this happens is that ozone makes people more sensitive to allergens, the most common triggers of asthma attacks. Ozone can increase susceptibility to respiratory infections. Ozone can inflame and damage the linings of the lungs. Within a few days, the damaged cells are shed and replaced — much like the skin peels after a sunburn. Animal studies suggest that if this type of inflamation happens repeatedly over a long time period (months–lifetime), lung tissue may become permanently scarred, resulting in less lung elasticity, permanent loss of lung function, and a lower quality of life.

[2]**Particulate Matter —** When exposed to PM, people with existing heart or lung diseases such as asthma, chronic obstructive pulmonary disease, congestive heart disease, or ischemic heart disease are at increased risk of premature death from heart or lung diseases. The elderly are also sensitive to PM exposure. They are at increased risk of admission to hospitals or emergency rooms and premature death from heart or lung diseases. When exposed to PM, children and people with existing lung disease may not be able to breathe as deeply or vigorously as they normally would, and they may experience symptoms such as coughing and shortness of breath. PM can increase susceptibility to respiratory diseases, such as asthma and chronic bronchitis, causing more use of medication and more doctor visits.

[3]**Carbon Mononoxide —** People with cardiovascular disease, such as angina, are most at risk form carbon monoxide. These individuals may experience chest pain and more cardiovascular symptoms if they are exposed to carbon monoxide particularly while exercising. People with marginal or compromised cardiovascular and respiratory systems (for example, individuals with congestive heart failure, cerebrovascular disease, anemia, chronic obstructive lung disease), and possibly fetuses and young infants, may also be at greater risk from carbon monoxide pollution. In healthy individuals, exposure to higher levels of carbon monoxide can affect mental alertness and vision.

[4]**Sulphur Dioxide —** Children and adults with asthma who are active outdoors are most vulnerable to the health effects of sulphur dioxide. The primary effect they experience, even with brief exposure is a narrowing of the airways (bronchoconstriction), which may cause symptoms such as wheezing, chest tightness and shortness of breath. Symptoms increase as sulphur dioxide concentrations and/or breathing rates increase. When exposure ceases, lung function typically returns to normal within an hour. At very high levels, sulphur dioxide may cause wheezing, chest tightening, and shortness of breath in people who do not have asthma. Long term exposure to both sulphur dioxide and fine particles can cause respiratory illness, alter the lung's defence mechanisms, and aggravate existing cardiovascular disease. People who may be most susceptible to these effects include individuals with cardiovascular disease or chronic lung disease, as well as children and the elderly.

Source: United States Environmental Protection Agency. "Air Quality Index — A Guide to Air Quality and Your Health." (US EPA, Washington, D.C, 1999) http://www.epa.gov/airnow/publications.html.

The Air Quality Index Reporting Provisions issued by the US EPA in 1999,[62] in addition to making specific changes to the Air Quality Index, also included a commitment by the US EPA to provide states and local agencies with the necessary support to:

- put in place community action alert-based programs to inform the public about air quality;
- educate the public about the impacts of air pollution; and,
- assist states and local agencies in meeting air quality standards.

To help initiate such programs, the organization's Office of Mobile Sources developed a report entitled "Community Action Programs: Blueprint for Program Design"[63] describing how to establish, run and evaluate an episodic control program. In addition, the US EPA is committed to providing information on ambient air quality levels for all NAAQS pollutants from a network of selected stations on a near real-time basis. It is also producing the "Ozone Mapping System" (OMS) which provides near real-time information on ozone concentrations in animated images (movies) together with still-frame images (maps) of the previous 24-hour peak levels, and forecasts of the next day's peak ozone level.

3.3.1 Community Action/Alert Programs

In line with the support for Community Action Programs indicated in the 1999 revisions to the Air Quality Index, several US states and state authorities have established or supported such programs.[64] These initiatives have been oriented primarily at reducing community ozone levels — ozone being a common problem in several parts of the US in the spring, summer and fall, particularly suited to community involvement.

Typically, community action programs are tied to the AQI by way of "Air Pollution Watches" or "Alerts" and "Air Pollution Warnings." An air pollution "Watch" occurs when predicted AQI values for the following 24 hours are in excess of 100 (85 ppb in the case of the 8-hour average ozone level), and this is regarded as a pre-emptive measure. "Warnings" or "Alerts" are issued when ozone levels are above 100 and therefore in the "Unhealthy for Sensitive Groups," "Unhealthy" or "Very Unhealthy" categories. Warnings concerning the state of the air quality during "Watches" and "Warnings" are usually issued by community action groups through electronic mail, to local authorities, news organizations and to individual citizens who have indicated a wish to be informed.[65]

3.3.2 Public Access to Real-Time Air Quality Data

In addition to providing electronic mail notification during air quality "Watches" and "Warnings," US air quality monitoring agencies, with the support of the US EPA, are also enhancing public awareness of air quality issues through the use of searchable databases. From such databases that are now available for a number of locations in the US, people who are interested in up-to-date information on air quality in their area, can obtain real time information on the AQI. Available data includes current maxima for each of the parameters measured, high levels for the day, and for the previous 24-hour period, together with summary information on health effects of measured parameters.[66]

3.3.3 Ozone Mapping

The Ozone Mapping Project (also known as Real-time Data Reporting Initiative) is a cooperative effort of the US EPA, state and local air pollution agencies, and regional organizations including: the Mid-Atlantic Regional Air Management Association (MARAMA); the Northeast States for Coordinated Air Use Management (NESCAUM); the northeast Ozone Transport Commission (OTC); the Lake

Michigan Air Directors' Consortium (LADCCO); SouthEast States Air Resources Managers (SESARM); and Central States Air Resource Agencies (CenSARA). It seeks to make simple and timely information about ground-level ozone available to the public in the form of animated (movies) or still-frame images (maps) based on isopleth[67] mapping.[68] Typically, animated images of today's peak ozone levels and still-frame images of yesterday's peak ozone levels and tomorrow's forecasted peak levels are displayed continuously during smog seasons. Archived data can also be retrieved for any period and location where the system was in operation. Isopleth values correspond to the AQI category limits and use the colour scheme laid out in the 1999 revisions to the index. Both movies and maps are highly compatible with television programming. They offer a good instant visual presentation of up-to-date information on air pollution episodes, and also provide control agencies and community action organizations with another point of contact with the public. This permits better explanation of the significance of the problem at hand, for significantly affected groups to take appropriate action, and for promotion of efforts which government organizations are making to deal with the situation. Use of these publication materials also allows for regular full exposure of the types of voluntary behavioural adjustments that individuals can take in both the short and long term to help reduce the problem at a time when it is uppermost in the public's minds. Daily ozone maps are available during the smog season (May 1 through September 30) on the US EPA's AIRNOW web site and on local television and news reports.[69]

In 2000 under the auspices of the New England Governors and Eastern Canadian Premiers, the ozone mapping project was extended into Canada, and made accessible through both the AIRNOW website and Environment Canada's Greenlane. The AIRNOW website maps ozone concentrations in terms of the US AQI using the 8-hour ozone sub-index, whereas the Greenlane website maps ozone on the basis of a 1-hour average in parts per billion (ppb), with adjusted colour scaling to reflect the Canadian advisory threshold of 82 ppb for that averaging period.

4. Improving the Canadian Index as a Public Information Tool

From the descriptions in Sections 2 and 3 of how air quality index systems have been developed and used in Canada and the US, it can be seen that although a common approach has been taken in the two countries there are many critical differences. There are also variations in the ways in which index data are being generated and used within Canada, although these are surprisingly minor (see Table VI).

One of the critical differences between the two approaches is that changes to the US AQI have been effected within a very methodical, legal-administrative structure, whereas those made to the IQUA in Canada have been made with no such framework. Under the circumstances the basis of the IQUA has remained relatively stable — all but the CUM/MUC use the agreed on format for calculating the index, and all but the Communauté and Ontario use common breakpoints in the line functions which make up the index. Differences as demonstrated in Section 2 are to be found mainly in the manner in which the index is reported and in the ways in which it is being used other than to just supply information to the public on current air quality. To examine the changes to IQUA that might be beneficial, recent US experience will be examined together with topics that have been suggested by stakeholders such as environmental interests groups, users, and provincial and territorial government representatives.

Table VI: Comparison of US API and Canada's IQUA

	Canada's Air Quality Index (IQUA)	**US Air Pollution Index (API) (AQI after 1999)**
Date Created/ Revised	Created 1976 — Approved 1980 Informally partially revised 1996	Created 1976 Formally Revised 1999
Authority	Environment Canada Guideline	US Clean Air Act
Compliance Status	Voluntary	Mandatory for Standard Metropolitan Areas with populations above 350,000
Reporting Requirements	None	Mandatory reporting requirements at levels over 100
Basis	National Ambient Air Quality Standards — includes damage and injury to plants, animals, and materials	National Ambient Air Quality Standards and Significant Harm Levels
Method of Calculation	Calculation of Sub-Indices for each contaminant/averaging time Reporting maximum Sub-Index as IQUA	Calculation of Sub-Indices for each Contaminant. Reporting maximum Sub-Index (Sub-Indices) as API
Parameters Included:	SO_2 (1hr, 24hr), CO (1hr, 8hrs), NO_2 (1hr), O_3 (1hr), COH (1hr, 24hr), PM_{10} (24hr), TSP (24hr) TRS (1hr)	SO_2, (1hr), CO (1hr), NO_2, O_3, (1hr) (8hr), PM_{10}, (24hr) $PM_{2.5}$ (24hr)
Basis for break points	Maximum Desirable, Acceptable and Tolerable Levels set by Federal/Provincial Committee on Air Pollution (no longer in existence)	National Ambient Air Quality Standards and Significant Harm Levels
Levels/ Descriptors/ Color used in presentation	0-25 Good (Bon) 26-50 Fair (Passable) 51-100 Poor (Pauvre) $101 Very Poor (TrJs Pauvre)	0- 50 Good Green 51-100 Moderate Yellow 101-150 Unhealthy for sensitive groups Orange 151-200 Unhealthy Red 201-300 Very Unhealthy Purple 301-400 ("Emergency") Maroon 401-500 Hazardous Maroon
Messaging	No recent guidance	Suggested wording provided
Forecasting	Potential addition to index	"Should be reported" Guideline provided

4.1 Lessons from the US Experience

The US AQI is the product of requirements made under section 319 of the Clean Air Act. This section directs the Administrator to:

> promulgate regulations establishing an air quality monitoring system throughout the United States which utilized uniform air quality monitoring criteria and methodology and measures such air quality according to a uniform air quality index" and "provides for daily analysis and reporting of air quality based upon such uniform air quality index….[70]

Because the index is grounded in legislation, and is a mandatory instrument, the US EPA has conducted periodic reviews of the index in a formal manner with complete documentation, which are published or referenced in the federal register, stakeholder consultations and focus groups.

4.1.1 Revisions made to the US Index in 1979

The US EPA made changes in 1979 to its Pollutant Standards Index to "reflect revisions to the National Ambient Air Quality Standards for ozone, and to establish requirements for reporting." These requirements included definition of the jurisdictions required to publicly report the index, what they were required to report, how they were required to report it, and the reporting frequency and calculation methods which they had to use.[71]

4.1.2 Revisions made to the US Index in 1999

In December 1998, the US EPA published a set of proposals to further refine its air quality index. These proposals followed a workshop held in January 1998 for state and local air pollution agencies designed to provide a preview and opportunity for input on mooted changes to the PSI. Items discussed included:

- the ozone sub-index, where there was a perceived need to incorporate the results of recent scientific findings;
- ozone mapping and air quality forecasting;
- state/local real-time data reporting and Ozone Action Day programs (community action programs); and,
- ways in which the index could best be linked to state and local programs.

Following the workshop, the US EPA continued coordination with state and local agencies and associations,[72] put a number of information materials relevant to the proposals on its AIRNOW web site, and between August and October 1998 organized a series of focus groups with varying characteristics.[73,74]

The revisions the US EPA produced in 1999 took account of these inputs, together with written comments sent directly to the agency. They included:

- changing the name of the index from Pollutant Standards Index to Air Quality Index;
- incorporation of 1997 revisions to the ozone and particulate matter NAAQS whereby the 1-hour NAAQS for ozone was replaced by an 8-hour standard, and the NAAQS for particulate matter was augmented with a 24-hour and annual standard for fine particulate, measured as $PM_{2.5}$;
- addition of representative colours for the various categories of index values to correspond to critical break points and to verbal descriptors (black and white images can still be used but if colour is employed in the presentation of the index then these colours must be used);

- inclusion of an additional category in the index between index values of 101 and 150 with the descriptor "unhealthy for sensitive groups" to take account of the increasing number of individuals who could potentially experience effects;

- additional messaging to accompany both the "unhealthy" and "very unhealthy" categories to reflect the understanding that when air quality moves into the "unhealthy" range and above, individuals who were affected at lower levels, are more likely to experience serious effects;

- revisions to the reporting requirements to ensure that the AQI is reported in all Metropolitan Statistical Areas (MSA) with a population in excess of 350,000 (the previous requirement was all urbanized areas with a population over 250,000);

- optional ("encouraged") messaging concerning appropriate health effects and cautionary statements for all AQI values over 100 instead of just for the pollutant causing the maximum level; the AQI for subdivisions of the MSA if there are important differences within the MSA; possible causes for high values and actual pollutant values; reporting of index values in rural or small urban areas affected by pollutants transported from an MSA where reporting is required; and expansion of coverage of the AQI when values are in excess of 100 to include all major news media;

- a number of proposed, new education and outreach activities to further enhance public understanding of the AQI; and,

- cooperation with "public health interest organizations to support their efforts to provide more immediate and interactive education and outreach…."[75]

4.2 Changing the Canadian Index of Air Quality

4.2.1 The Issues Involved in Changing the Index of Air Quality

The IQUA was designed at a time when calculations to produce it required main frame computers and when the means for displaying data were comparatively restricted. In the intervening years a number of other things have also changed:

- standards for many of the contaminants in the index are outdated and have not been updated;

- increasingly powerful techniques used in the analysis of epidemiological data for large population datasets have removed the appearance and expectation of health thresholds or "safe levels" for common air pollutants within the current ambient range;

- The Working Group on Air Quality Objectives and Guidelines has rejected further use of the "maximum desirable," "maximum acceptable" and "maximum tolerable" levels which are currently used to define the breakpoints in the IQUA's sub-indices. (The Working Group believes these categories are no longer scientifically defensible. It has developed a protocol that defines a reference level as a "level above which there are demonstrated effects on human health and/or the environment. It provides a scientific basis for establishing goals for air quality management");[76]

- monitoring techniques have permitted the use of more sophisticated, more sensitive instrumentation and for the direct real-time monitoring of contaminants such as particulate and fine particulate;[77]

- transfer of information by way of electronic media has increased substantially, permitting the use of more sophisticated tools to provide information to the public; and,

- public perception of air quality as a "community health problem" appears to have increased even in smaller communities and rural areas, and there is an increased expectation that the IQUA, a new Canadian AQI, will address both local and regional air quality issues.

There are also some minor issues related to the non-standardization of IQUA across the country. What is probably of even greater importance though is that there are now major differences between the US and Canadian indices despite their common characteristics. This makes them somewhat incompatible and therefore confusing in many areas of Canada where the two countries share a common border.

4.2.1.1 Changes in Standards

The Canadian Air Quality Index faces similar problems to those encountered in the US with respect to new scientific opinion on adequate protection levels for specific chemicals. Both indices were based initially on establishing "threshold health effects levels." In the case of the US PSI/AQI, the level of 100 was established at the national AAQS for each pollutant/ averaging time considered, and the level of 500 was established at the "Significant Harm Level." Similarly, the Canadian index relied on national objectives set initially in the 1970s — the value of the "Maximum Desirable" concentration being set at 25; the "Maximum Acceptable" at 50; and the "Maximum Tolerable" at 100. Recent medical evidence suggests that for most chemicals the concept of thresholds is inappropriate — effects of many contaminants are now acknowledged as being felt by sensitive individuals at levels considerably below those established in standards. Canada has recently been reviewing its standards in the context of a national initiative spearheaded by the Canadian Council of Ministers of the Environment (CCME). This activity known as Canada-Wide Standards (CWS) is focused on providing "priority ambient environmental standards for the quality of air, water, soil, biota, other media and for other components of ecosystems as well as ecosystems themselves."[78]

In terms of air quality indices, the only significant CWS review to date has been that done for particulate matter and ozone. The review process[79] indicated there are significant health and environmental effects associated with these pollutants. They have been linked to serious health impacts including chronic bronchitis, asthma and premature deaths. Additionally, particulates are associated with reduced visibility, while ozone has been observed to be a factor in increasing damage and vulnerability to disease in plants.

A CWS for particulate matter smaller than 2.5 microns has therefore been set at 30 $\mu g/m^3$ averaged over 24 hours, with a target date of 2010 for achievement. The CWS for ozone has similarly been set at 0.065 ppm averaged over 8 hours, to be achieved by 2010. It should be noted that the standards recognize and take into account that there is a significant transboundary flow of air contaminants from the US in many areas, and that high background levels of both PM and ozone may also occur through natural events in some parts of the country.

In response to the CWS, Ontario has indicated it is considering generating its Air Quality Index with sub-indices based upon them. Statistically, the recommended CWS for ozone is considered to be more conservative than the existing 1-hour objective that is incorporated into both the national IQUA and Ontario's AQI. To deal with possible peak values in an 8-hour average, which might exceed the existing 1-hour level, Ontario may retain the existing 1-hour average sub-index, in addition to using a sub-index based upon the 8-hour CWS. Other provinces have indicated similar expectations but appear to be waiting on a national process before taking action.

4.2.1.2 Standardization in the Use of IQUA and the Lack of a Formal Mechanism for Revisions

In the conclusions of Section 2, it was noted that IQUA was already subject to variations in format and use across the country. These variations in fact started almost immediately following the initial formulation of the index. Ontario, which was represented on the Federal/Provincial Committee that formulated the index, for instance announced immediately that it would have to use a modified version of IQUA to incorporate its existing Air Pollution Index (API).[80] Other variations are to be found in the messaging which accompanies the index, the sub-indices which are included in the index, and in the coverage which is provided in various provinces.

The US has avoided these types of problems because its index is exclusively health related, and therefore subject to federal law. This in turn enables the federal authority (the US EPA) to dictate the way in which the index is used, including where it must be monitored and published, and to control the mechanism by which it is revised. Given that use of the index in Canada is at the discretion of provincial and territorial governments, other than with reference to the aid that the federal government provides in the area of air pollutant monitoring, the federal authority has little or no power to insist on consistency. The absence of a widely agreed on mechanism to update the index exacerbates this situation.

4.2.1.3 Differences between IQUA and the US AQI

Of equal importance to the various forms of IQUA that are in use in various parts of Canada is the issue of compatibility between the Canadian (IQUA) and US (AQI) indices. With their sub-indices based on different criteria, totally dissimilar scales, somewhat incompatible messaging, and distinct philosophies on standard setting, index values from the two systems are very difficult to compare.[81] This is obviously a significant problem in communities close to the border, but also presents considerable difficulties in integrating any programs based upon air quality indices such as ozone episode mapping. Use of common colours to depict equivalent categories of each index goes some way to overcoming this problem but clearly this is an item that requires further investigation to ensure that everything possible is done to improve compatibility.[82]

4.2.1.4 Messaging, Display and Dissemination of Information About IQUA

A key ingredient to the success of any information program is its messaging and display of data. In the case of IQUA these items have essentially been left to individual Canadian jurisdictions to evolve. A more proactive approach by the federal government in developing and publicizing would be beneficial in this context.

4.2.1.4.1 Messaging Associated with IQUA

Messaging to accompany IQUA index levels has been published by a number of organizations in Canada — branches of the federal government, provincial ministries of the environment and public interest groups. This information generally takes one of two forms: a summary of observed effects at various index levels, or prescriptive messaging informing people of potential behavioural adjustments that they can make to minimize the impact associated with high index readings. The latter type of messaging is particularly important when the index is being used in the forecasting of air pollution episodes and issues of public health and safety are involved.

A matrix of the types of effects associated with various contaminant/averaging times and the break points in the index which *could* accompany messages about IQUA was produced by Environment Canada in 1996, but it was based on material extracted from the National Air Quality Objectives published between 1974 and 1978 and its use was never prescribed (see

Table II). The US by comparison, produced an updated document in June 2000 (see Table I(b)), which links its index levels to observed health effects recorded in recent scientific literature. Because the US AQI is a mandated instrument these messages are the ones which currently accompany its presentation in brochures, newspapers and television.

Recent efforts in this area in Canada have come primarily from interest groups such as medical, and heart and lung associations. The medical profession has been particularly concerned about messaging during ozone episodes and has published a number of documents on the subject. These explore current scientific understanding and offer advice to physicians and their patients on action that they can take in the event of an episode. They include "smog advisory health matrices for ozone and suspended particles," a "Ground Level Ozone Position Paper" produced by the Ontario Medical Association (OMA),[83] smog advisory health messages for physicians and patients (also produced by OMA)[84] (see Table VII), and pamphlets produced by the Ontario College of Family Physicians.[85] The British Columbia Medical Association's concern appears to be of a more general nature. They have recently linked with The David Suzuki Foundation to produce a pamphlet and poster[86] on air quality. These materials have been circulated to all of the British Columbia Medical Association's membership for distribution to the public upon request.[87] The lung associations (The Canadian Lung Association and various provincial chapters) have likewise issued advice on the general effects of high ozone levels, and on what people should do in the event of a pollution episode based on smog levels.[88]

All of these organizations are trying to get the message out to the public that specific individuals, particularly those with sensitivity to atmospheric pollutants, may experience a variety of effects as a result of exposure to ozone. These effects may occur in sensitive individuals below the normal standard-related levels associated with IQUA. Typically they include throat irritation, coughing, shortness of breath and wheezing. People with pre-existing chronic problems such as asthma, heart and lung disease, and children and the elderly are particularly vulnerable. In terms of behavioural adjustments people are encouraged to avoid outdoor exercise and sports particularly if they are asthmatics, and especially later in the day. They are also encouraged to avoid using personal vehicles and to delay such things as grass and hedge cutting with gasoline powered equipment.

The Ontario College of Family Physicians has produced the following health message that appears to encapsulate the beliefs of all of the medical associations on this subject.

> During the episode, individuals may experience eye irritation. Heavy exercise during the episode may cause respiratory symptoms. People with heart or lung disease [including asthma] may experience worsening of their condition. Outdoor activity should be reduced, and if necessary, consult your physician.
>
> Physicians should be aware of the advisory, [be] knowledgeable about the effects of smog and counsel their patients as follows:

- Encourage patients to listen for the smog advisories, and the UV index;
- The probability and severity of effects increases with increasing exposure, depending on ozone level, time spent outdoors and rate of breathing, which increases with exercise and is higher in children;
- Symptoms may include throat irritation, cough, shortness of breath and wheezing;
- Patients with asthma, chronic respiratory or cardiac disease, children and the elderly are

Table VII: Air Quality Index Pollutants and Their Impact (OMA)

Index Value	Category	Carbon Monoxide CO	Nitrogen Dioxide NO_2	Ozone O_3	Sulphur Dioxide SO_2	Suspended Particulate TSP	Sulphur Dioxide (SO_2)+ Partidulate	Total Reduced Sulphur (TRS)
Over 100	Very Poor	Increased symptoms in non-smokers with heart disease; blurred vision; some clumsiness	Increased sensitivity in asthmatics and people with bronchitis	Serious respiratory effects, even during light physical activity; people with heart/lung disorders at high risk; more vegetation damage	Increased sensitivity in asthmatics and people with bronchitis	Severe odour some people may experience nausea and headaches.	Significant effects for asthmatics and people with bronchitis	Severe odour; some people may experience nausea and headaches
50-99	Poor	Increased symptoms in smokers with heart disease	Air smells and looks brown. Some increase in bronchial reactivity in asthmatics.	Sensitive people may experience irritation when breathing and possible lung damage when physically active; people with heart/ung disorders at greater risk; damage to some plants	Odorous: increased vegetation damage	Decreased visibility; soiling evident	Increased symptoms for people with chronic lung disease	Strong odour
32-49	Moderate	Blood chemistry changes but no noticeable impairment	Odour	Respiratory irritation in sensitive people during vigorous exercise; people with heart/lung disorders at some risk; damages very sensitive plants	Damages some vegetation	Some decrease in visibility	Damages vegetation (e.g tomatoes, white bean due to SO_2)	Odour
16-31	Good	No known harmful effects	Slight odour	Damages some vegetation in association with sulphur dioxide	Damages some vegetation in association with ozone	No known harmful effects	No known harmful effects	Slight odour
0-15	Very Good	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects	No known harmful effects

Source: Boadway, B.T. et al. "Health Effects of Ground Level Ozone, Acid Aerosols andj Particulate Matter" Can. Respir. J Vol 5 #5 Sept/Oct 1998 p.381

more sensitive. They should monitor their disease [well-being] closely, and increase medication doses as prescribed if necessary;

- People should avoid strenuous outdoor exercise, especially during the afternoon and early evening when ozone levels are highest. Choose indoor activities at these times; and,

- During a smog episode, it might be advisable to reschedule outdoor sports events, especially those for children, as outdoor exercise might pose a risk of exacerbating asthma in the 5–10% of children with asthma, and of causing respiratory symptoms in others. Morning events when ozone levels are lower would be safer.[89]

4.2.1.4.2 Availability of Public Information Materials

Published information materials are an important feature of any program that is aimed at raising public awareness. IQUA has suffered somewhat in this respect since although a federal/provincial committee developed it, the responsibility for delivery lies with the provinces and territories. The result is a patchwork of public information materials, in both print and electronic formats, of varying relevance to current issues.

Among the materials that have been found on IQUA which are publicly available, are the following.

Government of Canada

1. Environment Canada **"Guideline for the Index of the Quality of the Air** (Ministry of Public Works and Government Services Canada, 1996) — a technical document which provides a basis for authorities to calculate and issue the index. It supplies information on breakpoints; the types of effects associated with the breakpoints (1974–78 data), and guidelines on the use of the index.

2. Environment Canada **"Smog Fact Sheet,"** [Fact Sheet] (Meteorological Service of Canada, Ottawa, 1999) http://www.smc-msc.ec.gc.ca/cd/factsheets/smog — provides summary information on the work of Environment Canada in smog research. Also includes information about smog or air quality advisories, the air quality index and smog forecasts, together with advice for people to reduce exposure to smog.

Government of Ontario

1. Air Resources Branch, Ontario Ministry of the Environment "**A Guide to the Ontario Air Quality Index System"** (Queen's Printer for Ontario, Toronto, 1991) — a detailed technical description of the Ontario version of the IQUA.

2. Ontario Ministry of the Environment **"Ontario AQI Summary"** and **"Air Quality Index"** — [separate frames for each location where the index is measured] (Queen's Printer for Ontario, Toronto, issued daily) http://www.airqualityontario.com/reports/summary.cfm.

3. Environment Ontario **"The New AQI — A Broader Measure of Air Quality"** [Pamphlet intended for distribution to the media] (Environment Ontario, Toronto, nd (1992–95)) — includes information on what the index measures; how it will be released to the media; a matrix of effects of different pollutants at different index levels; and typical news broadcasts based on the index.

Government of Manitoba

1. Manitoba Ministry of Conservation **"Winnipeg Air Quality Index"** [Pamphlet in Frequently Asked Question Format] (Manitoba Conservation, Winnipeg, 1995) http://www.gov.mb.ca/environ/prgareas/air/aquindex.html.

By way of contrast, although measurement and calculation of the AQI in the US is a mandated responsibility of the state level of government, the federal government has been very active in promotion of the index and in producing publications and educational materials based upon it. The result is public relations materials of consistent quality, giving identical messages throughout the country. Relevant documents, all of which are in "plain language," available from the AIRNOW website, (http://www.epa.gov/airnow/publications.html) include:

- "**Revisions to the Air Quality Index** " (1999) [fact sheet] — explains the most recent (1999) revisions to the US Index and the benefits associated with them.[90]

- "**Air Quality Index — A Guide to Air Quality and Your Health**"[91] — explains the structure of the index; how it is being used as a communication device; and outlines the health evidence upon which it is based.

- "**Air Quality Index Logo**" — downloadable logo for use on web sites, newspapers etc. to provide a unique identifier for index "products."

- "**Guideline for Reporting of Daily Air Quality: Air Quality Index (AQI**)"[92] — detailed document which outlines for state governments the reporting requirements under Part 58 of 40 CFR concerning the index — including reporting areas, reporting periods and identification of the critical pollutant; the descriptors and "colours" (including suggested colour formulae) to be used in reporting of the index; messaging which must be used for pollutant specific groups when the index is over 100 for sensitive groups;[93] optional items which can be included in the index; model announcements; and web page designs.

- **Interactive Air Quality Index Calculator** — a simple PC program which permits cross reference of ambient ozone concentrations and index values.

- **"Ozone and Your Health"**[94] **—** a high quality colour fold out pamphlet explaining the ozone problem and how it relates to the Air Quality Index; a colour representation of the index.

- **"Ozone: Good Up High, Bad Nearby"**[95] — a "Frequently Asked Questions" type fact sheet aimed at explaining the difference between ground level and stratospheric ozone with information on long and short term behavioural adjustments which will help control ground level ozone problems.

- **"Ozone Monitoring, Mapping and Public Outreach: Delivering Real-Time Ozone Information to Your Community"**[96] — a workbook for local authorities on setting up an ozone information program. This work includes how to monitor and map ozone, and also provides detailed material on how to set up a program designed to achieve greater public understanding and awareness of the ozone problem and behavioural adjustments.

In addition to these US EPA sponsored materials, there are also sophisticated information tools put out by environmental public interest groups including a demonstration CD[97] and a short video tape which can be used to show the capabilities of ozone mapping.[98,99]

4.2.1.5 Improving the Coverage of the IQUA

The IQUA, or a variant on it, is currently issued in 12 out of the 13 Canadian cities with populations above 350,000, the current threshold for compulsory reporting of the AQI in the United States. If the previous threshold of 250,000, used for the PSI is applied there is similarly only one city where the IQUA is not reported, namely Quebec City (population 689,700).[100]

The normal coverage that IQUA receives in cities where it is issued is fairly consistent. It is regularly transmitted to the news media through wire services, and most local daily print sources

incorporate it into their weather forecast sections. It usually appears together with information on such items as the UV Index and the Probability of Precipitation — two similar tools which government departments have devised to provide the public with scientific information in an easy to understand form.[101] When index values are elevated, particularly in the event of a "Smog Episode," news coverage of both the index and the problem significantly increase and frequently have reached front page/ top billing status.

4.2.1.5.1 Minimum Population Thresholds for Reporting IQUA

As noted previously, the reporting of IQUA (or any air quality index) is not the subject of legislation in Canada as it is in the US. This makes the issue of reporting thresholds somewhat moot, unless the federal authority decides to exert considerable pressure on non-participating urban centres. For the purposes of Canada-Wide Standards for particulate and ozone, a threshold population of 100,000 has been specified for annual and five-year reports on levels, and trends and compliance.[102]

Logically this exercise and the issue of reporting of the index could be addressed together. If a threshold of this nature were to be employed then it would be necessary to report the index in 12 metropolitan areas where it is not used currently: Saskatoon (population 232,600); Regina (population 200,500); St. John's (population 175,100; Chicoutimi-JonquiPre (population 161,600); Sherbrooke (population 153,200); Trois RiviPres (population 141,800); Kelowna (population 136,500); Barrie (population 118,800); Cape Breton (population 117,800); Moncton (population 113,500); Brantford (population 100,300) and Peterborough (population 100,200).

4.2.1.5.2 Making IQUA More Newsworthy

In identifying ways to make IQUA more newsworthy, the authorities are faced with similar problems to those identified by the US EPA in 1999 when they revised the PSI/AQI. The measures announced in the US at the time would therefore also seem appropriate for consideration in Canada in this context, namely:

- an increase in "contacts with news providers to better inform them about the importance of including accurate, timely and understandable information in their broadcasts and reporting, and to enlist them as full partners in the implementation of the AQI;"
- formation of "new associations with health care providers [in recognition of their position as the most trusted source of health effects information] to keep them informed about air pollution health effects;"
- expansion of "direct outreach to the public through a variety of means including materials tailored to school-age children, the Spanish-speaking community and others;" and,
- support to public health interest organizations' "efforts to provide more immediate and interactive education and outreach to all of these groups."[103]

4.2.1.5.3 Linking the IQUA to Control Activities

The province of Ontario established the precedent for linking an index to control activities when it created the Air Pollution Index (API) in 1969. By virtue of regulatory authority, currently contained in O. Reg. 346 – Air Pollution – General, when specific levels of this index[104] are attained emission sources can be ordered to reduce their emissions by changing fuels, reducing production, or in the case of Ontario Power Generation by switching generation to sources outside the area of high air pollution readings, or to facilities which don't affect air quality. Other provinces, including British Columbia and New Brunswick also have the capability to link index values to control industrial activities through other instruments such as certificates of approval. To date intermittent control of emission sources in Canada, based on index readings, has been limited to industrial facilities, but evidence from Europe would suggest that the concept could also be effectively extended to mobile sources.[105]

Establishing linkages between index levels and control actions helps raise public awareness of air quality problems because the government is seen at this point as "taking an effective action" and this generally is linked to news releases and to media exposure. It also provides proactive industries and government authorities, with an opportunity to demonstrate ways in which they can affect adverse pollution levels.[106]

5.0 Conclusions and Recommendations

A Federal/Provincial subcommittee devised IQUA in 1976. Since that time the index has been used successfully in its original form, or with minor variations, on a daily basis in a number of communities in Canada.

During the 25 years that have passed since the index was created there have been a number of developments affecting air quality indices including:

- changes in the public's use of mass media and other information sources;
- improvements in the technology for monitoring, processing and reporting of data;
- new thinking on the relationship between air quality and public health; and,
- innovative tools such as ozone mapping, smog forecasting, and smog alerts.

On the basis of these changes which have been described in this report, a review of IQUA would be timely. It is important to ensure that the Canadian air quality index system is delivering fully on its original objectives, embracing current scientific thinking and is also satisfying new needs. Based upon the subjects examined in this paper, items that such a review should address include:

- setting up a mechanism to review and revise IQUA, or a new Canadian air quality index, either on a regular, or as required, basis. (This process should incorporate representatives from all the main stakeholders, including: governments (federal, provincial/territorial, local); the medical profession; special public interest groups, particularly those representing people who experience medical problems from air pollution; and environmental and industrial interest groups with an interest in air quality issues;
- identifying ways to incorporate new thinking on standards included in the production of the IQUA/IAQ sub-indices;
- producing methodologies to facilitate comparisons between IQUA/AQI readings and those for AQI in the US, particularly useful in border communities;
- improving the health effects messaging associated with the index;
- establishing protocols to ensure consistent use of the index within Canada, including such things as minimum reporting thresholds for the index;
- creating improved and uniform public relations materials related to the index;
- working with representatives of the media to ensure the relevance of the index to news media and their audiences; and,
- assessing the feasibility and desirability of incorporating the index into control activities particularly in alert situations.

Any review process which might be set up in Canada to address these items should be as open as possible to improve the scope of the index. In this context, the mechanism used initially to create the index, which did not involve stakeholders, and was not conducted in public, would appear to be totally inappropriate. Instead, a more open, more inclusive approach is suggested. The US, when recently faced with the task of reviewing its index effectively, acknowledged this requirement by electing to use a multifaceted consultation process. This process involved stakeholder meetings and focus groups constituted to represent the general public and special interest groups, in addition to a formal review activity based on posting proposals and soliciting comments. Only at the end of this process was the US EPA able to post a "Final Rule."

With these types of modifications, IQUA or a new Canadian AQI can and should become an integral part of all air management programs in the country and thereby contribute to a greater understanding of air quality issues. As a result it will also be a far more effective tool for use in socially significant new initiatives such as near-real-time mapping of air pollution episodes and smog forecasting.

End Notes

1. **Maximum Desirable Level** was defined as "a long term goal for Air Quality and … the basis for an anti-degredation policy for unpolluted areas."
   Maximum Acceptable Level was defined as the level which provides "adequate protection against harmful effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being."
   Maximum Tolerable Level "denotes concentrations that require abatement without delay to avoid further deterioration of conditions to an air quality which endangers the prevailing Canadian life-style, or ultimately, to an air quality that poses a substantial risk to the public." Use of these levels means that when it was devised the index was meant to indicate more than just effects on human health.

2. The Committee's findings were published in modified form in: Environment Canada. "Guideline for the Index of the Quality of the Air." Report EPS 1/AP/3 (Environment Canada, Ottawa, 1996).

3. Canadian Council of Ministers of the Environment. "Joint Initial Actions to Reduce Pollutant Emissions that Contribute toe Particulate Matter and Ground-Level Ozone." (CCME, Winnipeg, 2000) http://www.ccme.ca/3e_priorities/3ea_harmonization/3ea2_cws/3ea2.html.

4. Synergism is the term given to situations where two or more pollutants combine in their effects.

5. Young, J.W.S. et al. "A Proposed Air Quality Index for Canada — Une proposition d'indice de qualité de l'air pour le Canada." Proceedings of the Fourth International Air Congress, Tokyo, Japan, 1977.

6. "Guideline for A Short Term Air Quality Index — A Report by the Federal/Provincial Committee on Air Pollution." (Minister of Supply and Services Canada, Ottawa, March, 1980). (Updated and reprinted as: Environment Canada "Guideline for the Index of the Quality of the Air." Report EPS 1/AP/3. (Environment Canada, Ottawa, 1996).

7. For a full discussion of the two types of indices with examples see: Saundeson, H.P. "Observations on Local and National Air Quality Indices." The Science of the Total Environment, 8 (1977) pp. 39–51.

8. The contaminant/averaging times used in the short-term index are as follows: sulphur dioxide — hourly avg. and 24-hour runring avg., soiling index — 24-hour running avg. (Coefficient of Haze Units), carbon monoxide — hourly avg. and 8 hr-running avg., nitrogen dioxide — hourly avg. and 24 hr.avg. and ozone-hourly avg. In Ontario, the Air Pollution Index is also included. At the time the index was formulated it was decided that air quality objectives for Total Suspended Particulate (TSP) could not be fairly represented by the IQUA due to the lack of extensive employment of real-time particulate monitors. Because of the importance of particulate to an air quality index the Federal Provincial Subcommittee suggested that daily 24 hour TSP (HiVol) measurements, Coefficient of Haze(COH)/Visibility or COH/inhalable particulate "may be considered as interim surrogates for continuous TSP." In an appendix to a 1996 report ("Guideline for the Index of the Quality of the Air." Report EPS 1/AP/3 (Environment Canada, Ottawa, 1996)) Environment Canada elaborated substantially on this point. Recognizing that COH had been measured at many stations in Canada as a surrogate for real-time measurements

of particulate, and that some provinces/local authorities had developed their own IQUA sub-indices for this parameter, they made the following observations:

- "There is no consistent general (country-wide) relationship between COH, TSP, CO and visibility, COH and inhalable particulate (PM_{10}), or COH and respirable particulate ($PM_{2.5}$)
- Real time monitors are [now] available for TSP, PM_{10}, $PM_{2.5}$ and visibility.
- There is a National Ambient Air Quality Objective for TSP
- There is a continuous monitor for particulates (24-hour) which can be used if sampling results are equivalent to the High Volume Sampler Method
- Visibility sub-indices measured as COH are not based on National Ambient Air Quality Objectives
- National Ambient Air Quality Objective for inhalable particulate have not yet been set. The 24-hour COH is [frequently] substituted as an estimate for inhalable particulate and the conversion for national average conditions is described by the formula PM_{10}= 60[COH]0.5. Monitoring equipment certified by US EPA can be used to calculate PM_{10}."

9. The **Maximum Desirable Level** was defined as "a long term goal for Air Quality and …the basis of an anti-degredation policy for unpolluted areas." **The Maximum Acceptable Level** was defined as the level which provides "adequate protection against harmful effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being." **The Maximum Tolerable Level** "denotes concentrations that require abatement without delay to avoid further deterioration of conditions to an air quality which endangers the prevailing Canadian life-style, or ultimately, to an air quality that poses a substantial risk to public health."
Federal/Provincial Committee on Air Pollution "Guideline for A Short Term Air Quality Index — A Report to the Federal Provincial Committee on Air Pollution." March, 1980.

10. The committee suggested the index "can be calculated for each hour of the day and consideration is given to the last 1-hour average and the last 8-hour and 24-hour running average concentrations."

11. "Guidelines for an Annual Air Quality Index (Lignes directrices s'applicquant à l'indice annuel de la qualité de l'air) — A Report by the Federal Provincial Committee on Air Pollution." (Minister of Supply and Services Canada, Ottawa, August, 1980).

12. Use of the 98th percentile was in agreement with World Health Organization guidelines in use at the time.

13. Environment Canada. "Guidelines for the Index of the Quality of the Air." Report EPS 1/AP/3 (Environment Canada, Ottawa, 1996).
The report included a table entitled "Examples of Types of Effects Used as Break Points" with a caveat that "Health Canada and Environment Canada advise that the matrix is provided as an example only and does not represent the full nature or extent of the health and environmental effects."

14. Federal/Provincial Working Group on Air Quality Objectives and Guidelines. "Protocol for the Development of National Ambient Air Quality Objectives." (Environment Canada, Ottawa, 1996).

15. Personal communication from Robert Marsh, Ministry of the Environment, B.C. Feb.28, 2000.

16. GVRD has used PM_{10} in its index since 1994 and uses 30 mg/m^3 as a reference concentration.

17. Personal communication from Ken Stubbs, Greater Vancouver Regional District, Feb.28, 2000.

18. The Yukon and the North West Territories have considerable air pollution problems in winter in urban areas when space heating and high vehicle use are combined with long-lasting inversion episodes.
Personal communication from Pat Paslowski, Yukon Government, March 1, 2000.

19. A number of relevant pamphlets on Alberta's use of the index can be found on The Clean Air Strategies Website http://www.casadata.org/IQUA.

20. Manitoba Conservation. "Winnipeg Air Quality Index." (pamphlet) (Manitoba Conservation, Winnipeg, MA, 1995) http://www.gov.mb.ca/environ/prgareas/air/aquindex.html.

21. Environment Canada. "Guideline for the Index of the Quality of the Air." loc.cit.

22. Personal communication from Jim Sparling, NWT Government, Feb. 28. 2000.

23. Ontario's API was developed primarily as an intermittent emission control device to ensure reductions in emissions of sulphur dioxide and particulate matter during prolonged inversion conditions. [It was also used as a device to inform the public about air quality in their areas until the AQUI was produced] In 1970, when the API was devised these two pollutants were seen by experts as presenting the greatest threat to human health particularly when they were found together (a synergistic reaction). The status of the API is defined in O.Reg. 346 Air Pollution — General. In 1986, as part of an extensive review of air pollution regulations, inclusion of just two chemicals in the API, and the appropriateness of having both an Air Quality Index and an Air Pollution Index (which is included as a parameter in the AQI) were examined at length. It was decided as a result of the review not to recommend changes at that time. (See: "Proceedings of Air Pollution General Workshop Nov. 14/15, 1985 (Ontario Ministry of the Environment, Toronto, 1986) and "Stopping Air Pollution At It's Source — Clean Air Program Draft Regulation Overview" (Ontario Ministry of the Environment, Toronto, 1990).

24. Steib, D.M., Pengelly, L.D., Arron, N, Taylor, S,M. and Raizenne, M.E. "Health Effects of Air Pollution in Canada, Expert Panel Findings for the Canadian Smog Advisory Program." Canadian Respiratory Journal, 1995, 2(3) pp. 155–160.

25. PM_{10} and $PM_{2.5}$ refer to two sizes of particulate matter and acid aerosols. PM_{10} refers to particulate matter less than 10 micrometers in diameter; $PM_{2.5}$ to particulate matter less than 2.5 micrometers in diameter. The former are regarded as "inhalable" particulate; the latter as "respirable" and capable of penetrating the lung.
Ontario Medical Association. "Ground Level Ozone Position Paper." (OMA, Toronto, 1998).

26. "Telemetering" consists of logging, transmitting, and processing air quality data. "Data from each of the monitoring instruments are collected every two seconds by the on-site data logger and transmitted to the regional data processing unit where five minute averages are computed and stored. The data are then transmitted to [a] central computer every hour. The central computer is programmed to calculate the AQI, the API, various statistical averages and to generate hourly, daily and monthly reports." System supervisors can intervene in the process if they become aware of spurious data in the system.

27. "Ontario AQI Summary" http://www.airquality.ontario.com/reports/summary.cfm. These colours are "scaled" similarly to the ones used in the US AQI. The verbal descriptors and categories are also like those used in IQUA (the Ontario index uses "very good" and "good" to describe values 0–15 16–31, whereas IQUA uses "good" to decribe index levels 0–25, and the word "moderate" for the category 32–49 instead of "fair" used in IQUA to describe values 26–50). See Table IV.

28. Ontario Ministry of the Environment. "Join the Smog Alert Network." [Fact Sheet] (Ontario Ministry of the Environment, Toronto, 2000) http://wwww.airqualityontario.com/alerts/signup.cfm.

29. City of Toronto. "The SMOG Report — make it or break it." [Pamphlet] (City of Toronto, Toronto, 1998–2001) http://www.city .toronto.on.ca/healthycity/smog_report.htm. A comprehensive list of resource materials on this subject, which includes fact sheets that provide general information on smog together with specific advice for vulnerable such as seniors and people with preexisting heart and lung disease, can be found in the bibliography under "City of Toronto."

30. Environment Mississauga. "City of Mississauga Smog Response Plan 2000." [Pamphlet] (City of Mississauga, Mississauga, 2000).

31. City of Hamilton and Region of Hamilton-Wentworth – Hamilton-Wentworth Air Quality Improvement Committee. "Corporate Smog Plan for City of Hamilton/Region of Hamilton-Wentworth." (Hamilton-Wentworth Air Quality Initiative, Hamilton, 1999) wysiwyg://18/http://www.airquality.hamilton.on.ca/smogplan.html.

32. "Clean Air Plan" delivered to Regional Municipality of Waterloo Regional Council, Oct. 13, 1999.

33. Ontario Ministry of the Environment. "Our Municipal Partners." [Pamphlet] (Queen's Printer for Ontario, Toronto, 2000) http://www.airqualityontario.com/science/partners.cfm.

34. Ontario Ministry of the Environment. "Smog Alert: A Municipal Response Guide." (Ontario Ministry of the Environment, Toronto, 1999).

35. Using this approach rather than the one presented by the Ad Hoc Sub Committee on Air Pollution Indices over-exaggerates most index levels (8-hour CO is the only one which is under-represented) but the various sub-indices and hence the index itself are easier to calculate.

36. http://www.cum.qc.ca/rsqa

37. Personal communication with Claude Gagnon, Service de l'environnement de la Communaute Urbaine de Montreal February 28th, 2001.

38. Personal communication from Jacques Ghilsain, MinistPre de l'Environnement du Quebec, 28th February 2001.

39. [New Brunswick] Index of the Quality of Air/Indice de la qualité de l'air (IQUA) (New Brunswick Department of the Environment and Local Government/Ministere de l'Envirionnement et Gouvernements locaux, Fredericton, 2001) http://www.gov.nb.ca/scripts/environm/air.

40. Environment New Brunswick. "Our Environment — An Air Quality Index for Saint John — The IQUA System." [Pamphlet] (Environment New Brunswick, Fredericton, nd).

41. Saint John–Fundy Air Resource Management Area Subcommittee on Education. "Air Quality and Health in Saint John." [Pamphlet] (Health Canada, Ottawa, 1997).

42. New Brunswick Department of the Environment. "Air Quality Monitoring in Southern New Brunswick — The IQUA System." (New Brunswick Department of the Environment, Fredericton, nd).

43. New Brunswick Department of the Environment. "Air Quality Monitoring in New Brunswick." (New Brunswick Department of the Environment, Fredericton, 1996).

44. In partnership with: New Brunswick Department of the Environment; New Brunswick Health and Community Services; New Brunswick Lung Association; Saint John — Citizens' Coalition for Clean Air (CCCA); and the Saint John–Fundy Air Resource Management Area Committee.

45. One of the interesting aspects to the study was that a study of public opinions was conducted in the pilot project area in late November 1997 to evaluate the effectiveness of this type of information . The results indicated:
    - smog was regarded by the majority of respondents to be a serious health hazard to people in the area;
    - smog forecasts were most commonly accessed through television;
    - primary sources of smog forecast information were considered by the majority of correspondents to be reliable "most of the time;"
    - the majority of respondents (66%) thought that it was at least "somewhat important" to hear smog forecasts when they were issued;
    - respondents acknowledged the ease of obtaining and understanding smog forecasts; and,
    - the majority of people consulted indicated the (pilot) program should be extended.

    They also showed though that while awareness of smog advisories was high only a small number of respondents were able to say they had made any behavioural adjustments even during a smog advisory.
    A complete description of the study and its results can be found in Stieb, D., Paola, J. and Neuman, K. "Do Smog Advisories Work? Results of an Evaluation of the Canadian Smog Advisory Program." Canadian Journal of Public Health, Vol. 87(3) pp. 166–169.

46. Environment Canada. "Southern New Brunswick Smog Prediction Pilot Project, 1997 — Evaluation Report." (Minister of Public Works and Government Services, Ottawa, 1998) http://www/atl.ec.gc.ca/reports/pdf/smog.pdf.

47. Saint John–Fundy Air Resources Management Area Subcommittee on Education. loc.cit.

48. Nova Scotia Department of the Environment and Labour. "Air Quality Index for Halifax–Dartmouth." (Nova Scotia Department of the Environment and Labour, Halifax, 2000).

49. Environment Canada. "Nova Scotia Smog Forecast Launched in Halifax as Part of Canada's Clean Air Strategy." News Release, Aug. 2, 2000 http://www.atl.ec.gc.caundefined.

50. "Air Quality Index for Halifax–Dartmouth." loc.cit. This summary information would appear to contradict information published by Environment Canada that indicates carbon monoxide even at the "fair" level causes" increasing cardiovascular symptoms in smokers with heart disease and changes in blood chemistry.

51. Personal communication with Todd Fraser, Prince Edward Island Department of Fisheries, Aquaculture and Environment, 14th March, 2001.

52. Personal communication with Peter Haring, Newfoundland Department of Environment and Labour, 21st March, 2001.

53. Index values are currently being issued in all Canadian Metropolitan Areas with populations in excess of 250,000 with the exception of Quebec City (pop. 689,700) and Victoria (pop. 316,000). ("Canadian Metropolitan Areas" (Statistics Canada, Ottawa, 2000) http://sites.netwscape.net/fcsklabrie/canmetro.htm).

54. US Environmental Protection Agency – Office of Air Quality Planning and Standards. "Measuring Air Quality — The Pollutant Standards Index." Report EPA 451/K-94-001 (US EPA, Washington, nd) http://www/epa.gov/oar/oaqps/psi.html.

55. A critical difference between the US EPA Index and the Canadian IQUA is that the former was based on health-based ambient air quality criteria. The latter, by virtue of the Maximum Acceptable and Desirable Levels, theoretically incorporates protection for soils, water, vegetation, materials, animals, visibility, personal comfort and well-being, and anti-degredation considerations for pristine areas.
Fisheries and Environment Canada. "Criteria for National Air Quality Objectives — Report of the Federal/Provincial Committee on Air Pollution" (Fisheries and Environment Canada, Ottawa, 1976).

56. US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, Federal Register, Vol. 64, No. 149 August 4, 1999 pp. 42530–42549.

57. US Environmental Protection Agency – Office of Air Quality Planning and Standards. "Measuring Air Quality — The Pollutant Standards Index." Report EPA 451/K-94-001 (US EPA, Washington, nd) http://www/epa.gov/oar/oaqps/psi.html.

58. US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, Federal Register, Vol. 64, No. 149 August 4, 1999 pp. 42530–42549.

59. In the case of PM (either PM2.5 or PM10) index issuing authorities can use monitors which are not reference or equivalent methods provided these can be related statistically to reference methods.

60. Alert Programs are also known as "voluntary action programs," "community action programs," and "episodic control programs."

61. The attainment status of a region is a critical economic issue — in non-attainment areas more restrictive rules apply to new emission sources, and certain types of federal funding to States are also jeopardized. In addition, under the US Clean Air Act, Non-Attainment Areas are required to develop a written plan (known as a State Implementation Plan (SIP)) detailing the steps the state

is proposing to improve air quality and meet applicable standards. A SIP to deal with ozone exceedences will typically include requirements such as:

- vapor recovery nozzles on gasoline pumps;
- cleaner burning reformulations of gasoline to reduce VOC's NO_x and other pollutants;
- strict NO_x emission limits for power plants and industrial combustion sources;
- enhanced vehicle inspection programs; and,
- strict limitations on solvent usage in factories.

62. US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." Federal Register, Vol 64, number 149 August 1999 pp. 4250–42549.

63. US Environmental Protection Agency. "Community Action Programs: Blueprint for Program Design." (EPA 420-R-98-003) (US EPA, Office of Mobile Sources, Ann Arbor, MI, 1998).

64. A good example of such a program run by a State Authority is the North Texas Clean Air Coalition. The mission of this organization is to "promote voluntary actions to help improve air quality in the North Texas Region." Its corporate sponsors include several national corporations and it has provided through its literature a whole range of measures which businesses, organizations, and the public can employ on an emergency basis, during alert situations, and on a regular basis. Among the behavioural adjustments suggested there are a number of alternatives to traditional commuting; changes in the use of fleet vehicles; postponement of specific tasks (e.g., use of outdoor power equipment and use of volatile paint materials). The Coalition's website can be accessed at http://www.northtexasair.org See also: "The Month of May Marks Start of Ozone Season in Dallas/Fort Worth Metroplex" [News Release] and "North Texas Clean Air Coalition Unveils New Grant Program" [News Release] http://www.northtexasair.org/news.html
Other agencies with programs include:
"Partnership for a Smog-Free Georgia" http://www.doe.k12.ga.us/transportation/psgbasics.html
"West Michigan Clean Air Coalition" http://www.wmcac.org
"Partners for Clean Air" (NE Illinois) http://www.cleantheair.org/overview.shtml

65. The Province of Ontario initiated an alert system for elevated levels of SO_2 and particulate matter in 1969 based on similar principles, except that the main aim was to provide a mechanism to temporarily increase controls on industrial emission sources. See: Shenfeld, L. and Frantisak, F. "Ontario's Air Pollution Index." Journal of the Air Pollution Control Association, (20) 1970 p. 612.

66. See: South Coast Air Quality Management District Web site http://www.aqmd.gov/smog/area17.shtml. Raw data are displayed on this site "taken directly from the District's telemetry system." A note indicates "the data are unvalidated and, therefore, subject to change."
Also: University of Iowa Hygenic Laboratory Web site http://www/uhl.uiowa.edu/Appplication/Services/AirQuality/Rt.cgi

67. Isopleth mapping involves drawing imaginary lines on a map linking locations with the same characteristics, based on data sets and estimations. In the case of ozone mapping the isopleths join locations with the same ozone concentrations.

68. In 1999 the ozone mapping coverage was expanded to include 31 states and over 1500 monitors in eastern and central US and California "Air Quality Index Reporting" EPA 40 CFR Part 58 loc.cit.

69. US EPA AIRNOW website http://www.epa.gov/airnow. Along with the Ozone Map this website contains information on ozone health effects in the "Health Facts" section, and emission reduction activities in the "What You Can Do" section. It also provides links to real time data, and community action program web sites maintained by State and local agencies around the world.

70. Section 319 US Clean Air Act. Public Law 101-549 101st Congress.

71. US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, pp. 42530–42543.

72. Groups consulted included: the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials, the Northeast States for Coordinated Use and Management, the northeast Ozone Transport Commission, Mid-Atlantic Regional Air Management Association, the California Air Resources Board, the California Air Pollution Control Officers Association, and the South Coast Air Quality.

73. Focus groups were held in eight locations with different ozone levels:
Miami, FL — people over 50 yrs of age with chronic lung diseases — particular attention to publications
Chicago, Il — urban residents with children who had asthma — particular attention to publications
Los Angeles, CA — journalists
Denver, CO; Atlanta, GA; Houston, TX; San Bernardino, CA; and St. Louis, MO — public

74. US Environmental Protection Agency. "Air Quality Index Reporting." 40 CFR Part 58, pp. 67818–67834.

75. US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, pp. 42530–42543.

76. Environment Canada. "Protocol for the Development of National Ambient Air Quality Objectives." (Prepared by the Federal/Provincial Working Group on Air Quality Objectives and Guidelines) (Environment Canada, Ottawa, 1996).

77. When the IQUA was first devised the only way of monitoring particulate on a real-time basis was to use something called the "coefficient of haze" (COH) which assessed the light-scattering qualities of particulate. Many Canadian jurisdictions (including Ontario) developed their own IQUA sub-indices for COH. The following points should be noted:
    - COH and PM_{10} (inhalable particulate) were not included in the National Ambient Air Objectives, therefore any sub-index based on them was "unofficial."
    - There is no consistent relationship between COH and TSP, COH and visibility, COH and inhalable particulate (PM_{10}) or respirable particulate ($PM_{2.5}$).
    - Real-time monitors now exist for TSP, PM_{10} and $PM_{2.5}$.

    Environment Canada. "Guideline for the Index of the Quality of the Air." (Minister of Public Works and Government Services, Ottawa, 1996).

78. Canadian Council of Ministers of the Environment. "Canada-wide Environmental Standards Sub-Agreement." (CCME, Winnipeg, 1998) http://www.ccme.ca/ccme.

79. The CWS review built upon earlier reviews undertaken by the Federal/Provincial Working Group on Air Quality Objectives and Guidelines (WGAQOG) under the auspices of the Canadian Environmental Protection Act. WGAQOG was charged with the responsibility of developing and periodically reassessing NAAQ Objectives for air borne contaminants.
See: Environment Canada. "National Ambient Air Quality Objectives for Particulate Matter — Executive Summary — A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines." (Ministry of Public Works and Government Services, Ottawa, 1998).

80. The principal difference between the Ontario AQI and IQUA is that the former uses 32,50 and 100 as significant break points instead of 25, 50 and 100.

81. Canadian IQUA data have very recently been incorporated into US ozone maps and US AQI data have been used in Canadian maps. In both cases the data are portrayed in the format of the jurisdiction which is publishing the maps.

82. Environment Canada. "Guideline for the Index of the Quality of the Air." (Minister of Public Works and Government Services Canada, Ottawa, 1996). Table 1.

83. Ontario Medical Association. "OMA Ground Level Ozone Position Paper." (Ontario Medical Association, Toronto, 1998) http://www.oma.org/phealth/ground.htm.

84. Abelsohn, A., Gray, J.E. and Boadway, B.T. "OMA Smog Advisory Health Messages for Physicians and Patients." Ontario Medical Review, May 1999 pp. 19–20.

    Abelsohn, A., Gray, J.E. and Boadway, B.T. "OMA Smog Advisory Health Messages for Physicians and Patients." [Feature Article] (Ontario Medical Association, Toronto, nd) http://www.oma.org/phealth/99smog.htm.

    Ontario Medical Association. "Information for Patients — Smog Advisory Health Messages for Children." http://www.oma.org/phealhh/smogchld.htm.

    Ontario Medical Association. "Information for Patients — Smog Advisory Health Messages for Smog-Sensitive Individuals." htttp://www.oma.org/phealht/smogssi.htm.

    Ontario Medical Association. "The Health Effects of Ground-level Ozone, Acid Aerosols and Particulate Matter." (Ontario Medical Association, Toronto, 1998) www.oma.org. [Key recommendations — "Beware the Air You Breathe: Ontario's Doctors Call for Cleaner Air" available at http://www.oma.org/pcomm/pressrel/1998/may12.htm.]

85. Ontario College of Family Physicians. "Smog and Human Health — Pamphlet for Primary Care Physicians." [Pamphlet] (Ontario College of Family Physicians, Toronto, nd). [The] Ontario College of Family Physicians. "Smog and Human Health." (The Ontario College of Family Physcians, Toronto, nd) http://www.cfpc.ca/ocfp/commun/smog.html.
86. British Columbia Medical Association/David Suzuki Foundation. "Air Pollution, Smog, and Global Warning Can Affect Your Health: Find Out What You Can Do About Them." [Pamphlet] "This Is About All We Should Be Adding To Our Air." [Poster] (British Columbia Medical Association and the David Suzuki Foundation, Vancouver, 2000) http://www.bcma.org/whatsnews/inthenews/campaigns/cleanaircompany/default.asp.

87. Canadian Medical Association. "BC Doctors Speak Out About Pollution." Canadian Medical Association Journal Today, May 29, 2000 http://www.cma.ca/cmaj/index.asp.

88. The Lung Association. "Health Concerns — Just Because the Air Doesn't Stink, Doesn't Mean the Air Doesn't Stink." (The Lung Association, Toronto, 1999) http://www.lung.ca/cando/theair.html.

The Lung Association. "SMOG DAYS: The Lung Association Encourages Action to Avoid Harm to the Lungs." [Press Release] May 1, 1999 (The Lung Association, Toronto).

Environment Canada/New Brunswick Lung Association. "Clean Air Now — Partnership for the Future." Conference July 23, 1998 (Dartmouth, Nova Scotia).

The work which the New Brunswick Lung Association has done in terms of public education and awareness (e.g., Clean Air Now — CANDO program; televised panel discussions, public fact sheets, Clean Air Month) with respect to air pollution is highlighted in Section 6.3 of Environment Canada "Southern New Brunswick Smog Prediction Pilot Project, 1997 Evaluation Report (Ministry of Public Works and Government Services, Ottawa, 1998).

89. Ontario College of Family Physicians. "Smog and Human Health — Pamphlet for Primary Care Physicians." [Pamphlet] (Ontario College of Family Physicians, Toronto, nd) p.3.

90. US Environmental Protection Agency. "Revisions to the Air Quality Index." [Fact Sheet] (US EPA, Washington, 1999).

91. US Environmental Protection Agency. "Air Quality Index — A Guide to Air Quality and Your Health." (US EPA, Washington, 2000).

92. US Environmental Protection Agency. "Guideline for Reporting of Daily Air Quality — Air Quality Index." (US EPA, Office of Air Quality Planning and Standards, Triangle Park, N.C., 1999).

93. For 1-hour ozone the equivalent level under Canada's current IQUA would be approximately 85. If the Canada-Wide Standard of 0.065 ppm — 8hour average is to be used in the Index as the equivalent of a Maximum Tolerable level (i.e., giving an index level of 100) this would be equivalent to the US AQI level of 50.

94. US Environmental Protection Agency. "Ozone and Your Health." [Pamphlet] (US EPA, Office of Air and Radiation, Washington, 1999).

95. National Campaign Against Dirty Power, Clear the Air. "Air Quality Reporting — 2000 Ozone Map." [Demonstration CD] (The National Campaign Against Dirty Power, Washington, 2000).

96. US Environmental Protection Agency. "Ozone Monitoring, Mapping, and Public Outreach." (US EPA – National Risk Management Laboratory, Office of Research and Development, Cinncinnati, 1999).

97. National Campaign Against Dirty Power, Clear the Air. "Air Quality Reporting — 2000 Ozone Map." [Demonstration CD] (The National Campaign Against Dirty Power, Washington, 2000).

98. National Environmental Trust. "Introduction to the Ozone Map." [VCR Tape] (National Environmental Trust, Washington, 1998).

99. The National Coalition Against Dirty Power also provides a "Smog Watch" Program which provides the location or site address where the AQI is above 100 due to smog (.085 ppm).

100. Population data from Statistics Canada "Canadian Metropolitan Areas, 2000" http://sites.netscape.net/fcsklabrie/ca

101. For a discussion of the public reaction to the UV Index, see: Teoli, N. "The UV Index — Keeping the Public Informed" (Pollution Probe, Toronto, 2000).

102. Canadian Council of Ministers of the Environment. "Canada-Wide Standards for Particulate Matter (PM) and Ozone." (Canadian Council of Ministers of the Environment, Council of Ministers, Québec City, 2000) http://www.ccme,ca/ccme.

103. US Environmental Protection Agency "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, pp. 42530–42543.

104. Ontario's API is currently a sub-index of the province's version of the AQI in addition to being a regulatory instrument.

105. Paris, France has implemented such a program — when an emergency is declared (as it was in October 1999) restrictions on vehicles entering the city are employed based on license plate numbers.

106. The City of Toronto Smog Plan for example includes actions which City agencies will take in the event of "smog alerts" which include restricting specific activities which might exacerbate air pollution.
See: City of Toronto. "Smog Alert Response Plan." [Fact Sheet] (City of Toronto, Department of Public Health, Toronto, nd).

Appendix 1: A Sample Calculation of the Long Term Index*

Contaminant/Averaging Time	**Actual Measured Values**	**Index Value**
98th percentile 1-hour avg. SO_2	= 150 micrograms per cubic meter	8
98th percentile 24-hour avg. SO_2	= 100 micrograms per cubic meter	17
98th percentile 24-hour avg. SPM	= 130 micrograms per cubic meter	53
98th percentile 1-hour CO	= 8 micrograms per cubic meter	13
98th percentile 8-hour running avg. CO	= 7 micrograms per cubic meter	29
98th percentile 1-hour NO_2	= 130 micrograms per cubic meter	16
98th percentile 24-hour running avg. NO_2	= 91 micrograms per cubic meter	23
98th percentile 1-hour running avg. O_3	= 175 micrograms per cubic meter	56

(SO_2 = Sulphur dioxide; SPM = Suspended Particulate Matter; CO = Carbon monoxide; NO_2 = Nitrogen dioxide; O_3 = Ozone)

The 3 highest pollutant indices of different pollutants are:

O_3 = 56
SPM = 53
SO_2 = 29

Arithmetic Average of these values = 46
This numerical value corresponds to a verbal descriptor of Fair (Passable)**

Note: The committee attached the following cautions and requirements to avoid misuse and misrepresentation of the index:

1. A minimum of 66% of valid data in any one calendar quarter are required
2. If a pollutant index cannot be calculated because of the previous requirement if a value is needed for any purpose the previous year's value shall be used
3. When comparisons are made among cities, complete monitor/site documentation should be included in the report.
4. Area averaging of individual monitoring station indices is not recommended
5. Retrospective indices should not be calculated unless the station meets the National Air Pollution Surveillance (NAPS) Class 1 requirements or equivalent approval by a provincial/territorial authority.

* "Guidelines for an Annual Air Quality Index (Lignes directrices s'applicquant à l'indice annuel de la qualité de l'air) – A Report by the Federal/Provincial Committee on Air Pollution," (Minister of Supply and Services Canada, Ottawa, August, 1980)

** The verbal descriptors which correspond to the numerical index values are:

Good/Bon	0 to 25
Fair/Passable	26 to 50
Poor/Pauvre	51 to 100
Very Poor/Très Pauvre	100 +

Bibliography

Abelsohn, A., Gray, J.E., Boadway, B.T. "OMA Smog Advisory Health Messages for Physicians and Patients." Ontario Medical Review, May 1999 pp. 19–20.

Abelsohn, A., Gray, J.E., Boadway, B.T. "OMA Smog Advisory Health Messages for Physicians and Patients." [Feature Article] (Ontario Medical Association, Toronto, nd) http://www.oma.org/phealth/99smog.htm.

Boadway, B.T., MacPhail, J. and Jacobson, C. "Ontario Medical Association Position Paper on Health Effects of Ground Level Ozone, Acid Aerosols, and Particulate Matter." Can. Respir. J., Vol 5 #5, Sept/Oct. 1998 pp. 367–383.

Canadian Medical Association. "B.C. Doctors Speak Out About Pollution." Canadian Medical Association Journal Today, May 29, 2000 http://www.cma.ca/cmaj/index.asp.

British Columbia Medical Association/David Suzuki Foundation. "Air Pollution, Smog, and Global Warning Can Affect Your Health: Find Out What You Can Do About Them." [Pamphlet] http://www.bcma.org/whatsnews/inthenews/campaigns/cleanaircompany/default.asp.

British Columbia Medical Association/David Suzuki Foundation. "This Is About All We Should Be Adding To Our Air." [Poster] (British Columbia Medical Association and the David Suzuki Foundation , Vancouver, 2000) http://www.bcma.org/whatsnews/inthenews/campaigns/cleanaircompany/default.asp.

Canadian Council of Ministers of the Environment. "Joint Initial Actions to Reduce Pollutant Emissions that Contribute to Particulate Matter and Ground-Level Ozone." (CCME, Winnipeg, 2000) http://www.ccme.ca/3e_priorities/3ea_harmonization/3ea2_cws/3ea2.html.

Canadian Council of Ministers of the Environment. "Canada-wide Environmental Standards Sub-Agreement." (CCME, Winnipeg, 1998) http://www.ccme.ca/ccme.

Canadian Council of Ministers of the Environment. "Reducing Smog." [Fact Sheet] (CCME, Winnipeg, nd) http://www.ccme.ca/ccme.

Canadian Council of Ministers of the Environment. "Particulate Matter and Ozone Canada-wide Standards." (CCME, Winnipeg, nd) http://www.ccme.ca/ccme.

City of Hamilton and Region of Hamilton-Wentworth – Hamilton-Wentworth Air Quality Improvement Committee. "Corporate Smog Plan for City of Hamilton/Region of Hamilton-Wentworth." (Hamilton-Wentworth Air Quality Initiative, Hamilton, 1999) wysiwyg://18/http://www.airquality.hamilton.on.ca/smogplan.html

City of Toronto – Medical Officer of Health. "Corporate Smog Alert Response Plan, 1998 Implementation Plan." Memorandum to City Council from Dr. Sheela V. Basrur, Medical Officer of Health, May 28, 1998.

City of Toronto. "The Smog Report — Make It or Break It." (City of Toronto, Toronto, 1998) http://www.city.toronto.on.ca/healthyci.

City of Toronto – Department of Public Health. "Smog." [Fact Sheet] (City of Toronto, Department of Public Health, Toronto, 1998–2001) http://www.city.toronto.on.ca/health/sm.

City of Toronto. "The SMOG Report — Make it or Break it." [Pamphlet] (City of Toronto, Toronto, 1998–2001) http://www.city .toronto.on.ca/healthycity/smog_report.htm.

City of Toronto – Department of Public Health. "1999 Corporate Smog Alert Response Plan." (unpublished).

City of Toronto – Department of Public Health. "2000 Smog Alert Program." (unpublished).

City of Toronto – Department of Public Health. "Toronto's Air: Let's Make it Healthy." (Toronto Public Health, Health Promotion and Environmental Protection Office, Toronto, 2000).

City of Toronto – Department of Public Health. "Smog Watch & Advisory." [Fact Sheet] (Toronto Department of Public Health, Toronto, nd).

City of Toronto – Department of Public Health. "The Air You Breathe — Planning Your Day During a Smog Alert." [Poster and Pamphlet] (Toronto Department of Public Health, Toronto, nd).

City of Toronto. "3 Min. Idle Limit — An Idling Control By-law." [Pamphlet] (City of Toronto, Works and Emergency Services/Health Promotion and Environmental Protection Unit, Department of Public Health, Toronto, nd).

City of Toronto. "Curb Pollution — Idling Causes It." By-law 673-1998 [Poster] (City of Toronto, Works and Emergency Services/Health Promotion and Environmental Protection Unit, Department of Public Health, Toronto, nd).

City of Toronto. "3 Min. Idle Limit — An Idling Control By-law." [Pamhlet] (City of Toronto, Works and Emergency Services/Health Promotion and Environmental Protection Unit, Department of Public Health, Toronto, nd).

City of Toronto. "City of Toronto — Smog Alert Response Plan." [Fact Sheet] (City of Toronto, Department of Public Health, Toronto, nd).

City of Toronto. "Smog and Children." [Fact Sheet] (City of Toronto, Department of Public Health, Toronto, nd).

City of Toronto. "Breathing Shouldn't Hurt! Smog Alert — Act When You Hear the Alert." [Pamphlet] (City of Toronto, Department of Public Health, Toronto, nd).

City of Toronto. "Today Is a Smog Alert Day. These Procedures Are In Effect — Doing our Share for Cleaner Air." [Bulletin Clip Board] (City of Toronto, Department of Public Health, Toronto, nd).

Fisheries and Environment Canada. "Criteria for National Air Quality Objectives — Report of the Federal/Provincial Committee on Air Pollution." (Environment Canada, Ottawa, 1976).

Environment Canada. "Guideline for A Short Term Air Quality Index — A Report by the Federal/ Provincial Committee on Air Pollution." (Minister of Supply and Services Canada, Ottawa, March, 1980).

Environment Canada. "Guidelines for an Annual Air Quality Index (Lignes directrices s'applicquant à l'indice annuel de la qualité de l'air) — A Report by the Federal/Provincial Committee on Air Pollution." (Minister of Supply and Services Canada, Ottawa, August, 1980).

Environment Canada. "Guideline for the Index of the Quality of the Air." Report EPS 1/AP/3 (Ministry of Public Works and Government Services Canada, 1996).

Environment Canada. "Smog — Let's Clean the Air." [Fact Sheet] (Environment Canada – GLIMR, 1996) http://www.on.ec.gc.ca/glimr/data/climate-flyer/smog.html.

Environment Canada. "Protocol for the Development of National Ambient Air Quality Objectives." (Prepared by the Federal/Provincial Working Group on Air Quality Objectives and Guidelines) (Environment Canada, Ottawa, 1996).

Environment Canada. "Southern New Brunswick Smog Prediction Pilot Project, 1997 — Evaluation Report." (Minister of Public Works and Government Services, Ottawa, 1998) http://www/atl.ec.gc.ca/reports/pdf/smog.pdf.

Environment Canada. "National Ambient Air Quality Objectives for Particulate Matter — Executive Summary. A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines." (Ministry of Public Works and Government Services, Ottawa, 1998).

Environment Canada. "Smog Fact Sheet." [Fact Sheet] (Meteorological Service of Canada, Ottawa, 1999) http://www.smc-msc.ec.gc.ca/cd/factsheets/smog.

Environment Canada. "(Ozone)Health and Education Messages." (Environment Canada, Meteorological Service of Canada Atlantic Region/Atmospheric Science Division, Halifax, 2000) wysiwyg://15/http://www.atl.ec.gc.ca/ms.

Environment Canada/New Brunswick Lung Association. "Clean Air Now — Partnership for the Future." Conference July 23, 1998 (Dartmouth, Nova Scotia).

Environment Mississauga. "City of Mississauga Smog Response Plan 2000." [Pamphlet] (City of Mississauga, Mississauga, 2000).

Environment New Brunswick. "Our Environment — An Air Quality Index for Saint John — The IQUA System." [Pamphlet] (Environment New Brunswick, Fredericton, nd).

New Brunswick Department of the Environment. "Air Quality Monitoring in Southern New Brunswick — The IQUA System" (New Brunswick Department of the Environment, Fredericton, nd).

New Brunswick Department of the Environment. "Air Quality Monitoring in New Brunswick." (New Brunswick Department of the Environment, Fredericton, 1996) http://www.gov.nb.ca/environm\operatin\air_main.htm.

Environment New Brunswick. "[New Brunswick] Index of the Quality of Air/Indice de la qualité de l'air (IQUA) (New Brunswick Department of the Environment and Local Government/Ministere de l'Environnement et Gouvernements locaux , Fredericton, 2001) http://www.gov.nb.ca/scripts/environm/air.

Manitoba Ministry of Conservation. "Winnipeg Air Quality Index." [Pamphlet in "Frequently Asked Question Format"] (Manitoba Conservation, Winnipeg, 1995) http://www.gov.mb.ca/environ/prgareas/air/aquindex.html.

National Campaign Against Dirty Power. "Clean the Air. Air Quality Reporting — 2000 Ozone Map." [Demo CD] (Clean The Air, Washington, 2000) http://www.cleartheair.org/.

National Environmental Trust. "Introduction to the Ozone Map." [VCR Tape] (National Environmental Trust, Washington, 1998) http:www.environet.org.

North Texas Clean Air Coalition. "The Month of May Marks Start of Ozone Season in Dallas/Fort Worth Metroplex" [News Release] and "North Texas Clean Air Coalition Unveils New Grant Program." [News Release] http://www.northtexasair.org/news.html.

Nova Scotia Department of the Environment and Labour. "Air Quality Index for Halifax–Dartmouth." (Nova Scotia Department of the Environment and Labour, Halifax, 2000) http://www.gov.ns.ca/enla/rmep/air_qual.htm.

Nova Scotia Department of the Environment and Labour. "Environment — Adams Announces Air Quality Index for Metro." [News Release] (Nova Scotia Department of the Environment, Halifax, April 22, 1996).

Environment Canada. "Nova Scotia Smog Forecast Launched in Halifax as Part of Canada's Clean Air Strategy." [News Release] (Environment Canada, Halifax, Aug. 2, 2000) http://www.atl.ec.gc.caundefined.

Ontario College of Family Physicians. "Smog and Human Health — Pamphlet for Primary Care Physicians." [Pamphlet] (Ontario College of Family Physicians, Toronto, nd).

Ontario College of Family Physicians. "Smog and Human Health." (The Ontario College of Family Physcians, Toronto, nd) http://www.cfpc.ca/ocfp/commun/smog.html.

Ontario Medical Association. "OMA Ground Level Ozone Position Paper." (Ontario Medical Association, Toronto, 1998) http://www.oma.org/phealth/ground.htm.

Ontario Medical Association. "The Health Effects of Ground-level Ozone, Acid Aerosols and Particulate Matter." (Ontario Medical Association, Toronto, 1998) www.oma.org.

Ontario Medical Association. "Beware the Air You Breathe: Ontario's Doctors Call for Cleaner Air." (Ontario Medical Association, Toronto, 1998) http://www.oma.org/pcomm/pressrel/1998/may12.htm.

Ontario Medical Association. "Information for Patients — Smog Advisory Health Messages for Children." (Ontario Medical Association, Toronto, nd) http://www.oma.org/phealhh/smogchld.htm.

Ontario Medical Association. "Information for Patients — Smog Advisory Health Messages for Smog-Sensitive Individuals." (Ontario Medical Association, Toronto, nd) htttp://www.oma.org/phealht/smogssi.htm.

Ontario Ministry of the Environment. "Proceedings of Air Pollution General Workshop Nov. 14/15, 1985." (Ontario Ministry of the Environment, Toronto, 1986).

Ontario Ministry of the Environment. "Stopping Air Pollution At It's Source — Clean Air Program Draft Regulation Overview." (Ontario Ministry of the Environment, Toronto, 1990).

Ontario Ministry of the Environment – Air Resources Branch. "A Guide to the Ontario Air Quality Index System." (Queen's Printer for Ontario, Toronto, 1991).

Ontario Ministry of the Environment. "The New AQI — A Broader Measure of Air Quality." [Pamphlet] (Environment Ontario, Toronto, nd (1992–95).

Ontario Ministry of the Environment. "Smog Alert: A Municipal Response Guide." (Ontario Ministry of the Environment, Toronto, 1999).

Ontario Ministry of the Environment. "Join the Smog Alert Network." [Fact Sheet] (Ontario Ministry of the Environment, Toronto, 2000) http://www.airqualityontario.com/alerts/signup.cfm.

Ontario Ministry of the Environment. "Our Municipal Partners." [Pamphlet] (Queen's Printer for Ontario, Toronto, 2000) http://www.airqualityontario.com/science/partners.cfm.

Ontario Ministry of the Environment. "Ontario AQI Summary." (Queen's Printer for Ontario, Toronto, issued daily) http://www.airqualityontario.com/reports/summary.cfm.

Ontario Ministry of the Environment. "Air Quality Index." (Queen's Printer for Ontario, Toronto, issued daily) http://www.airqualityontario.com/reports/summary.cfm.

Ontario Ministry of the Environment. "Ontario AQI Summary." (Ontario Ministry of the Environment, Toronto, nd) http://www.airquality.ontario.com/reports/summary.cfm.

Pollution Probe. "The United States Environmental Protection Agency's Air Quality Index and Ozone Map — Providing the Tools for Public Engagement." [Fact Sheet] (Pollution Probe, Toronto, nd).

Regional Municipality of Waterloo Regional Council. "Clean Air Plan." Delivered to Regional Municipality of Waterloo Regional Council, Oct. 13, 1999.

Saint John–Fundy Air Resource Management Area Subcommittee on Education. "Air Quality and Health in Saint John." [Pamphlet] (Health Canada, Ottawa, 1997).

Saundeson, H.P. "Observations on Local and National Air Quality Indices." The Science of the Total Environment, 8 (1977) pp. 39–51.

Shenfeld, L. and Frantisak, F. "Ontario's Air Pollution Index." Journal of the Air Pollution Control Association, (20) 1970 p. 612.

Statistics Canada. "Canadian Metropolitan Areas." (Statistics Canada, Ottawa, 2000) http://sites.netwscape.net/fcsklabrie/canmetro.htm.

Stieb, D., Paola, J. and Neuman, K. "Do Smog Advisories Work? Results of an Evaluation of the Canadian Smog Advisory Program." Canadian Journal of Public Health, Vol. 87 (3) pp. 166–169.

Stieb, D.M., Pengelly, L.D., Arron, N., Taylor, S.M. and Raizenne, M.E. "Health Effects of Air Pollution in Canada — Expert Panel Findings for the Canadian Smog Advisory Program." Canadian Respiratory Journal, 1995, 2(3) pp. 155–160.

The Lung Association. "Health Concerns — Just Because the Air Doesn't Stink, Doesn't Mean the Air Doesn't Stink." (The Lung Association, Toronto, 1999) http://www.lung.ca/cando/theair.html.

The Lung Association. "SMOG DAYS: The Lung Association Encourages Action to Avoid Harm to the Lungs." [Press Release] May 1, 1999 (The Lung Association, Toronto).

US Clean Air Act, 1990. Section 319.

US Environmental Protection Agency. "Community Action Programs: Blueprint for Program Design." (EPA 420-R-98-003) (US EPA, Office of Mobile Sources, Ann Arbor, MI, 1998).

US Environmental Protection Agency. "Air Quality Index Reporting — Final Rule." 40 CFR Part 58, Federal Register, Vol. 64, No. 149, August 4, 1999 pp. 42530–42549.

US Environmental Protection Agency. "Air Quality Index Reporting." 40 CFR Part 58, pp. 67818–67834.

US Environmental Protection Agency. "Revisions to the Air Quality Index." [fact sheet] (US EPA, Washington 1999) http://www.epa.gov/airnow/publications.html.

US Environmental Protection Agency. "Ozone Monitoring, Mapping, and Public Outreach." (US EPA, National Risk Management Laboratory, Office of Research and Development, Cinncinnati, 1999) http://www.epa.gov/airnow.

US Environmental Protection Agency. "Guideline for Reporting of Daily Air Quality — Air Quality Index." (US EPA, Office of Air Quality Planning and Standards, Triangle Park, N.C., 1999) http://www.epa.gov/airnow.

US Environmental Protection Agency. "Ozone and Your Health" [Pamphlet] (US EPA, Office of Air and Radiation, Washington, 1999) http://www.epa.gov/airnow.

US Environmental Protection Agency. "Air Quality Index — A Guide to Air Quality and Your Health." (US EPA, Washington, 2000) http://www.epa.gov/airnow.

US Environmental Protection Agency – Office of Air Quality Planning and Standards. "Measuring Air Quality — The Pollutant Standards Index." Report EPA 451/K-94-001 (US EPA, Washington, nd) http://www/epa.gov/oar/oaqps/psi.html.

Young, J.W.S., Fry, R.J., Hewings, J.M., Kelley, D.G., Lack J.C., Munn, R.E., Roireau, H.J., Shaw, R.W. and Shenfeld, L. "A Proposed Air Quality Index for Canada — Une proposition d'indice de qualité de l'air pour le Canada." Proceedings of the Fourth International Air Congress, Tokyo, Japan, 1977.

Websites

City of Toronto Department of Health Website http://www.city.toronto.on.ca/health/sm

Clean Air Strategies Website http://www.casadata.org/IQUA

Environment Canada Greenlane Website http://www.on.ec.gc.ca

National Environmental Trust Website http://environet.org/

North Texas Clean Air Coalition's Website http://www.northtexasair.org

Partners for Clean Air (Northeastern Illinois) Website http://www.cleantheair.org/overview.shtml

Partnership for a Smog-Free Georgia Website http://www.doe.k12.ga.us/transportation/psgbasics.html

South Coast Air Quality Management District Website http://www.aqmd.gov/smog/area17.shtml

West Michigan Clean Air Coalition Website http://www.wmcac.org

US Environmental Protection Agency AIRNOW Website http://www.epa.gov/airnow

University of Iowa Hygenic Laboratory Website http://www/uhl.uiowa.edu/Appplication/Services/AirQuality/Rt.cgi