Development of Air Quality Targets For the Capital Regional District

Final Report

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TABLE OF CONTENTS

Page No.

EXECUTIVE SUMMARY 1

1.0 INTRODUCTION 4

2.0 SUMMARY OF EXISTING AIR QUALITY CRITERIA 5
- 2.1 Air Quality Management Criteria 5
- 2.2 Air Quality Indicators 6

3.0 AIR QUALITY TARGETS FOR THE CRD 23
- 3.1 Rationale for Target Development.....23
- 3.2 Proposed CRD Target Levels 25

4.0 CONCLUSIONS AND RECOMMENDATIONS 33

REFERENCES 34

LIST OF TABLES

Page No.

1 Air Quality Criteria for Nitrogen Dioxide (NO_2) 7
2 Air Quality Criteria for Sulphur Dioxide (SO_2)....8
3 Air Quality Criteria for Carbon Monoxide (CO)....9
4 Air Quality Criteria for Ground Level Ozone (O_3)....10
5 Air Quality Criteria for Inhalable Particulate Matter (PM_{10})....11
6 Air Quality Criteria for Fine Particulate Matter ($PM_{2.5}$)....12
7 Air Quality Index for the Greater Vancouver Regional District....13
8 Air Quality Index for Ontario 14
9 Air Quality Index for the United States 15
10 Air Quality Index for the United Kingdom....16
11 Air Quality Indicators for New Zealand 17
12 Air Quality 'Target' Levels for the CRD....29

LIST OF FIGURES

Page No.

1 Comparison of Air Quality Index Categories for NO_2 18
2 Comparison of Air Quality Index Categories for SO_2....19
3 Comparison of Air Quality Index Categories for CO....20
4 Comparison of Air Quality Index Categories for O_3 21
5 Comparison of Air Quality Index Categories for Particulate Matter....22
6 Observed NO_2 Concentrations in the CRD....30
7 Observed SO_2 Concentrations in the CRD 30
8 Observed CO Concentrations in the CRD 31
9 Observed O_3 Concentrations in the CRD....31
10 Observed PM_{10} Concentrations in the CRD 32
11 Observed $PM_{2.5}$ Concentrations in the CRD....32

EXECUTIVE SUMMARY

The Capital Regional District (CRD) has identified a need to develop air quality target levels which can be used to report on air quality in a more meaningful way to the general public, as well as to assist the CRD in interpreting trends in air pollutant concentrations. The objective of this report is to identify suitable target levels for common air contaminants (CAC) routinely monitored in the CRD to improve reporting on air quality and to assist with interpretation of trends in air quality. The CAC's would include nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ground level ozone (O_3), inhalable particulate matter (PM_{10}), and respirable or fine particulate matter ($PM_{2.5}$).

The proposed air quality targets are not intended to be used for regulatory purposes or for managing air quality. The sole purpose of the air quality targets will be to assist the CRD staff in describing and/or interpreting pollutant concentration levels in a more meaningful way when preparing summaries of air quality monitoring data.

The overall approach adopted in the development of the proposed CRD targets was to review existing CAC criteria currently in use, or proposed for future use, in other jurisdictions, develop a rationale for the new CAC targets for the CRD, and develop a list of recommended target levels. Available information on existing air quality management criteria (objectives, guidelines, standards, targets, etc.) used in other jurisdictions was compiled through a search of internet web sites for various jurisdictions and agencies. Information was obtained from:

- Canadian Provinces, specifically Ontario, Quebec and Newfoundland;
- the U.S. Environmental Protection Agency (EPA), as well as California and the Puget Sound Air Quality Authority;
- the World Health Organization (WHO);
- the European Union (EU), as well as from the United Kingdom (UK) and Sweden; and,
- New Zealand and Australia.

Information on Air Quality Indexes (AQI) was also obtained from the Greater Vancouver Regional District (GVRD), the EPA, Ontario, New Zealand and the UK. The AQI's were used to identify breakpoint values used to differentiate between qualitative categories of air quality (e.g., good, poor, very poor) used by these jurisdictions.

The rationale for target selection utilized the following principles:

1) The overarching principle was to select criteria that are protective of public health. As such, the proposed CAC targets should be set at or below health-based criteria levels identified in scientific studies. The goal would be never to exceed these levels.

2) If the proposed CAC target levels cannot be set below health-based criteria because there is essentially no evidence of a lower limit for health effects (e.g., O_3, PM_{10} and $PM_{2.5}$), the proposed CAC targets may be defined at a level that will minimize the risk for any associated health effects.

3) The number of criteria for each CAC should be minimized. That is, move away from the current practice of having numerous levels and averaging periods for each pollutant.

4) The targets should be useful for tracking trends and assessing whether air quality is improving or deteriorating.

5) The Canada Wide Standards (issued by the Canadian Council of Ministers of the Environment) for particulate matter and ozone include a requirement for keeping clean areas clean. In addition, the WHO recommends that attempts should be made to keep air pollutant levels as low as practically achievable. The targets should be useful in assessing whether these goals are achieved.

For the three pollutants (NO_2, SO_2 and CO) whose concentrations in the CRD currently fall well below any health-based levels of concern, the CAC targets would consist of an upper-bound, health-based guideline and a baseline concentration. The health-based guidelines are derived from the WHO guidelines for NO_2 and SO_2 in Europe and the Provincial Level A objective for CO. According to the WHO, the aim in establishing the guidelines was to provide a basis for protecting public health from adverse effects of air pollutants, and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. As such, the guidelines are intended to represent pollutant levels below which exposure - for life or for a given period of time - does not constitute a significant public health risk. A provisional baseline level for NO_2, SO_2, and CO has been based on the 98th percentile value recorded at the Victoria Topaz monitoring site for each pollutant in 2002 for the purposes of presenting the concept.

For ground level ozone (O_3) and particulate matter (PM_{10} and $PM_{2.5}$) for which current air quality concentrations in the CRD exceed the Health Reference levels, the upper-bound guideline would be at a level which acknowledges that some health effects will occur but assumes that the relative risk for such effects is small. SENES suggests that the WHO guideline of 120 $\mu g/m^3$ (8-hour average) for ground level ozone provides a suitable upper-bound guideline for the CRD.

The WHO suggests that decision-makers looking to set air quality criteria for particulate matter refer to risk estimates that may help to quantify the degree of health impact that would be

deemed acceptable for their constituents. For the purposes of defining upper-bound levels for the CRD targets, SENES suggests using the current interim objective of 50 µg/m^3 for the PM_{10} upper-bound guideline. This is consistent with other Canadian jurisdictions such as Ontario, Newfoundland and British Columbia, as well as the European Union, the United Kingdom, Australia and New Zealand. For $PM_{2.5}$, SENES suggests adopting the value of 25 µg/m^3 as the upper-bound guideline for the CRD. The latter value has been adopted by Newfoundland and Australia, and was recommended by the health committees in California in 2001 (during the recently completed review of the $PM_{2.5}$ standards) and the Puget Sound Clean Air Agency in 1999.

The provisional lower-bound baselines for O_3, PM_{10} and $PM_{2.5}$ are based on the 98th percentile value of current concentrations in the CRD. For ozone, the 98th percentile value recorded at Saturna Island falls fairly close to the maximum value recorded at the remote monitoring site on the west coast of the Olympic National Park in Washington. As such, it provides a useful baseline for long-term trend reporting. The choice of the 98th percentile for both PM_{10} and $PM_{2.5}$ maintains consistency with the provisional baselines for the other four pollutants. The 98th percentile for $PM_{2.5}$ is based on monitoring at the Victoria Topaz site, while that for PM_{10} is based on the former Colwood site.

1.0 INTRODUCTION

The Capital Regional District (CRD) reports the results of air quality monitoring data collected in the CRD. There is a need to report these results in a manner that would assist the public in understanding what the various pollutant concentrations mean in terms of health impacts. Simply comparing the pollutant concentrations with established air quality objectives, guidelines and standards is deemed to be insufficient.

For this reason, the CRD has identified a need to develop air quality target levels which can be used to report on air quality in a more meaningful way to the general public, as well as to assist the CRD in interpreting trends in air pollutant concentrations. The objective of this report is to identify suitable target levels for common air contaminants (CAC) routinely monitored in the CRD to improve reporting on air quality and to assist with interpretation of trends in air quality. The CAC's would include nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ground level ozone (O_3), inhalable particulate matter (PM_{10}), and respirable or fine particulate matter ($PM_{2.5}$).

The proposed air quality targets are not intended to be used for regulatory purposes or for managing air quality. The sole purpose of the air quality targets will be to assist the CRD staff in describing and/or interpreting pollutant concentration levels in a more meaningful way when preparing summaries of air quality monitoring data. As such, the proposed air quality targets are not intended to supersede the existing Provincial objectives for regulatory purposes. However, the development of the CRD targets will assist the CRD in evaluating compliance with the expressed desire for *keeping clean areas clean* that is a component of the Canada-Wide Standards (CWS).

The overall approach adopted in the development of the proposed CRD targets was to review existing CAC criteria currently in use, or proposed for future use, in other jurisdictions, develop a rationale for the new CAC targets for the CRD, and develop a list of recommended target levels.

Although some of the air quality criteria compiled from other jurisdictions may have been developed from varying levels of scientific and toxicological analysis and rigour[1], it is anticipated that the information gathered is relevant to the intended use of the criteria as benchmarks. Further information on the rationale for the air quality criteria may be obtained from the various regulatory agencies, as well as from the references listed at the end of this report.

[1] The project relied primarily on information that was obtained from web-sites for the jurisdictions studied.

2.0 SUMMARY OF EXISTING AIR QUALITY CRITERIA

Available information on existing air quality management criteria (objectives, guidelines, standards, targets, etc.) used in other jurisdictions was compiled through a search of internet web sites for various jurisdictions and agencies. Information was obtained from:

- Canadian Provinces, specifically Ontario, Quebec and Newfoundland;
- the U.S. Environmental Protection Agency (EPA), as well as California and the Puget Sound Air Quality Authority;
- the World Health Organization;
- the European Union (EU), as well as from the United Kingdom (UK) and Sweden; and,
- New Zealand and Australia.

Information on Air Quality Indexes (AQI) was also obtained from the Greater Vancouver Regional District (GVRD), the EPA, Ontario, New Zealand and the UK. The AQI's were used to identify breakpoint values used to differentiate between qualitative categories of air quality (e.g., good, poor, very poor) used by these jurisdictions.

2.1 AIR QUALITY MANAGEMENT CRITERIA

Tables 1-6 summarize the air quality criteria used in the above jurisdictions for regulating CAC concentrations. Note that references to Maximum Desirable and Maximum Acceptable air quality criteria in these tables only apply to the National Ambient Air Quality Objectives (NAAQO) defined by Environment Canada. Level A and Level B Objectives for British Columbia are only listed in the tables if they differ from the Federal NAAQO's, and, for simplicity, the Provincial Level A Objectives have been listed beside the Federal Maximum Desirable Level, and the Level B Objectives are listed beside the Federal Maximum Acceptable Level.

The frequency of allowable exceedences of the criteria, and the year by which the criteria are to be met, are colour-coded for the relevant jurisdictions and pollutants. Acronyms listed in brackets for each jurisdiction refer to the following:

- **Canada** (CWS) – Canada-Wide Standard and (NAAQO) National Ambient Air Quality Objectives;
- **United States** (NAAQS) – National Ambient Air Quality Standard;
- **United Kingdom** (LAQM) – Local Air Quality Measures consisting of numerical objectives of pollutant concentrations for protecting human health;

- **European Union** (Limit Value) – a level defined on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained;
- **European Union** (Target Values) – a level fixed with the aim of avoiding more long-term harmful effects on human health and/or the environment as a whole, to be attained where possible over a given period;
- **European Union** (Threshold Values) – a level beyond which there are limited, temporary effects on human health in the event of short exposure of particularly sensitive sections of the population, and at which steps must be taken by Member States, as laid down in the EU Council Directives;
- **Sweden** (Targets) – concentrations of air pollutants that do not exceed low-risk concentrations for cancer or target values for the protection against diseases (with reference to persons who suffer from hypersensitivity and asthma), or effects on plants, animals, materials or cultural objects;
- **Australia** (NEPM) – National Environmental Protection Measures consisting of numerical standards for each pollutant, advisory reporting standards for $PM_{2.5}$ and goals for maximum allowable exceedences within 10 years (i.e., by 2013), except for $PM_{2.5}$ which is to be reviewed beginning in 2005.

The World Health Organization (WHO) guidelines listed in the tables are those developed for Europe in 2000. According to the WHO, the aim in establishing the guidelines was to provide a basis for protecting public health from adverse effects of air pollutants, and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. As such, the guidelines are intended to represent pollutant levels below which exposure – for life or for a given period of time – does not constitute a significant public health risk. However, the WHO also stressed that, although the guidelines are considered to be protective to human health, they should not be interpreted as giving a "green light" for pollution up to the levels specified by the guidelines, and attempts should be made to keep air pollution levels as low as practically achievable. This is consistent with the principle of *keeping clean areas clean* that is part of the CWS setting process.

2.2 AIR QUALITY INDICATORS

Tables 7-11 summarize the Air Quality Index (AQI) breakpoints between qualitative categories of air quality used by various jurisdictions. New Zealand does not have an AQI per se, but refers to air quality indicator categories which can be considered as equivalent to the AQI categories used in other jurisdictions. For ease of comparison, the AQI categories for the various jurisdictions are graphically depicted in Figures 1-5.

Table 1
Air Quality Criteria for Nitrogen Dioxide (NO_2)

Averaging Period	Canada (NAAQO)	Quebec	California	US (NAAQS)	European Union (Limit Values)	United Kingdom (LAQM)	Sweden (Targets)	WHO	Australia (NEPM)	New Zealand
1hr (Max. Acceptable)	400	410	470	480	200	200		200	230	200
24hr (Max. Desirable)							100			
24hr (Max. Acceptable)	200	210								100
annual (Max. Desirable)	60					30				
annual (Max. Acceptable)	100	100		100	40	40	20	40	57	

not to be exceeded more than 18 times per year, by 2010
not to be exceeded more than 18 times per year, by 2005
not to be exceeded more than one day per year by 2013
based on protection of vegetation; objective proposed in 2000, but not adopted
98th percentile, by 2010
protection of vegetation, by 2010
by 2005 in UK, and 2010 in the European Union

Table 2
Air Quality Criteria for Sulphur Dioxide (SO_2)

Averaging Period	Canada (NAAQO)	Ontario	Quebec	British Columbia	California	US (NAAQS)	European Union (Limit Values)	United Kingdom (LAQM)	Sweden (Targets)	WHO	New Zealand	Australia (NEPM)
15 min								266		500		
1hr (Max. Desirable)	450			450					200			
1hr (Max. Acceptable)	900	690	1310	900	655		350	350			350	530
3 hr						1300						
24hr (Max. Desirable)	150	275		160					100			
24hr (Max. Acceptable)	300		290	260	105	365	125	125		125	120	210
annual (Max. Desirable)	30			25				20	5			
annual (Max. Acceptable)	60	55	50	50		80				50	50	50

not to be exceeded more than one day per year by 2013
not to be exceeded more than 35 times per year, by 2005
not to be exceeded more than 24 times per year, by 2004 in UK and 2005 in the EU
not to be exceeded more than 3 times per year, by 2004 in the UK and 2005 in the EU
objective, for protection of ecosystems, suggested 2000 but not adopted
98th percentile, by 2010
protection of vegetation, by 2005

Table 3
Air Quality Criteria for Carbon Monoxide (CO)

Averaging Time	Canada (NAAQO)	Ontario	Quebec	British Columbia	California	US (NAAQS)	United Kingdom (LAQM)	Sweden (Targets)	WHO	Australia (NEPM)	New Zealand
15 min									100,000		
30 min									60,000		
1hr (Max. Desirable)	15,000			14,300							
1hr (Max. Acceptable)	35,000	36,200	34,000	28,000	23,000	41,000			30,000		30,000
8hr (Max. Desirable)	6,000			5,500				6,000			
8hr (Max. Acceptable)	15,000	15,700	15,000	11,000	10,000	10,000	11,600		10,000	10,440	10,000

98th percentile by 2010
not to be exceeded more than one day per year by 2013

Table 4
Air Quality Criteria for Ground Level Ozone (O_3)

Averaging Period	Canada	Ontario	Quebec	California	US	WHO	European Union		United Kingdom	Sweden	Australia	New Zealand
	(NAAQO)				(NAAQS)		(Target Value)	(Threshold Values)	(Proposed Standard)	(Targets)	(NEPM)	
1hr (Max. Desirable)	100											
1hr (Max. Acceptable)	160	165	157	180	235			200			200	150
4 hr											160	
8 hr	127.6				160	120	120	110	100	120		100
24hr (Max. Desirable)	30											
24hr (Max. Acceptable)	50							65				
annual (Max. Acceptable)	30											

protection of vegetation
health protection
not to be exceeded more than one day per year by 2013
Canada Wide Standard, 4th highest 8 hr concentration, averaged over 3 years
provisional objective, not to be exceeded more than 10 times per year by 2005
based on 3-year average of the 4th highest daily max. 8-hour average concentrations - attainment 2007-2021; under review
98th percentile, by 2010
proposed target value: not to be exceeded more than 20-25 days per year, averaged over 3 years, by 2010

note: "photochemical oxidants (as ozone)" is specified for Australia. All others as ozone.

Table 5
Air Quality Criteria for Inhalable Particulate Matter (PM_{10})

Averaging Period	**Ontario**	**British Columbia**	**California**	**US** (NAAQS)	**European Union**	**United Kingdom** (LAQM)	**New Zealand**	**Australia** (NEPM)
24 hr	50	50	50	150	50	50	50	50
annual			30	50	40	40		

interim objective, in effect until federal standard determined
not to be exceeded more than one day per year by 2013
not to be exceeded more than 35 times per year, by 2004
not to be exceeded more than 35 times per year, by 2005
to be met by 2005
99th percentile of 24-hour average concentrations

Table 6
Air Quality Criteria for Fine Particulate Matter ($PM_{2.5}$)

Averaging Period	Canada (CWS)	Newfoundland	California	US (NAAQS)	Australia (NEPM)
24 hr	30	25	25	65	25
annual			12	15	8

98th percentile annually, averaged over 3 consecutive years

based on a 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area - attainment 2009-2015; under review - a lower standard in the range of 30 - 50 has been proposed by EPA staff

based on a 3-year average of annual arithmetic mean concentrations from a single or multiple community-oriented monitors

recommended for health protection but not adopted

proposed advisory reporting standards

Table 7
Air Quality Index for the Greater Vancouver Regional District

Index Value	Category	BREAKPOINT Values (µg/m^3)						
		SO_2		NO_2	CO		PM_{10}	O_3
		1 hr	24 hr	1 hr	1 hr	8 hr	24 hr	1 hr
25	**Good**	450	150	200	15,000	6,000	25	100
50	**Fair**	900	300	400	35,000	15,000	50	160
100	**Poor**	1800	800	1000	74,000	21,000	100	300
> 100	**Very Poor**	> 1800	> 800	> 1000	> 74,000	> 21,000	> 100	> 300

Good	Air contaminants are near background levels, and pose little public health risk.
Fair	Air contaminants are relatively low, but may cause adverse effects in sensitive individuals and may have impacts on sensitive ecosystems.
Poor	Air contaminants may cause adverse effects to humans, animals, water and vegetation.
Very Poor	Air contaminants can pose significant health and environmental risks.

Table 8
Air Quality Index for Ontario

Index Value	Category	BREAKPOINT Values (µg/m³)				
		SO_2	NO_2	CO	$PM_{2.5}$	O_3
		1 hr	1 hr	1 hr	3 hr	1 hr
15	Very Good	439	200	14,500	12	46
32	Good	678	391	26,000	22	100
50	Moderate	917	487	35,400	45	160
100	Poor	5306	1003	57,400	90	298
>100	Very Poor	> 5306	> 1003	> 57,400	> 90	> 298

Very Good	No known harmful effects.
Good	No known harmful effects from CO, NO_2 and O_3; some vegetation damage from SO_2 in combination with O_3
Moderate	Blood chemistry changes but no noticeable impairment due to CO; respiratory irritation in sensitive people during vigorous exersice and some risk to people with heart/lung disorders; some vegetation damage for O_3 and SO_2; reduced visibility due to PM
Poor	Increased symptoms in smokers with heart disease for CO; some increase in bronchial reactivity in people with asthma for NO_2; greater risk for people with heart/ling disorders, respiratory irritation in sensistive people and possible lung damage during physical activity from O_3; increasing risk to vegetation for both O_3 and SO_2; reduced visibility and soiling due to PM
Very Poor	Increasing symptoms in non-smokers with heart diseases, blurred vision and some clumsiness for CO; increasing sensitivity for people with asthma and bronchitis for NO_2; high risk for people with heart/lung disorders and serious respiratory effects duruing light physical activity for O_3, plus more vegetation damage; increasing sensitivity and significant effects for people with asthma and bronchitis for SO_2 and PM

Table 9
Air Quality Index for the United States

Index Value	Category	BREAKPOINT Values (µg/m^3)						
		SO_2	NO_2	CO	$PM_{2.5}$	PM_{10}	O_3	
		24 hr	1 hr	8 hr	24 hr	24 hr	1 hr	8 hr
50	Good	90	-	5,000	15.4	54	-	120
100	Moderate	380	-	11,000	40.4	154	240	160
150	Unhealthy to Sensitive Groups	600	-	14,000	65.4	254	320	200
200	Unhealthy	800	1200	18,000	150.4	354	400	240
300	Very Unhealthy	1600	2400	35,000	250.4	424	800	700
400	Hazardous	2100	3100	47,000	350.4	504	1000	-
500		2700	3800	58,000	500.4	604	1200	-

	Cautionary Statements
Good	None
Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion
Unhealthy to Sensitive Groups	Active children and aduts, and some people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.
Unhealthy	Active children and aduts, and some people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or ehavy exertion outdoors.
Very Unhealthy	Active children and aduts, and some people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or ehavy exertion outdoors.
Hazardous	Everyone should avoid all physical activity outdoors.

Notes: Areas generally use 8 hr ozone concentrations. In some areas, the greater of 1 hr and 8 hr values are used.
NO_2 has no short term standard, and can generate an index value only above 200.
There are no index values above 300 defined for 8 hr ozone concentrations and no values below 100 for 1 hr.

Table 10
Air Quality Index for the United Kingdom

Index Value	Band	BREAKPOINT Values (µg/m^3)				
		SO_2	NO_2	CO	PM_{10}	O_3
		15-minute mean	hourly mean	8-hour mean	24-hour mean	8 hourly or hourly mean
1	**Low**	88	95	3,800	16	32
2		176	190	7,600	32	66
3		265	286	11,500	49	99
4	**Moderate**	354	381	13,400	57	126
5		442	476	15,400	66	152
6		531	572	17,300	74	179
7	**High**	708	635	19,200	82	239
8		886	700	21,200	91	299
9		1063	763	23,100	99	359
10	**Very High**	> 1063	> 763	> 23,100	> 99	> 359

Cautionary Statements

Low	Unlikely to be noticed, even by those sensitive to air pollution
Moderate	Sensitive people may notice mild effects, but these are unlikely to need action
High	Sensitive people may notice significant effects and may need to take action
Very High	Effects on sensitive people, described by High pollution, may worsen

Table 11
Air Quality Indicators for New Zealand

Category	BREAKPOINT Values (µg/m^3)								
	SO_2		NO_2		CO		O_3		PM_{10}
	1 hr	24 hr	1 hr	24 hr	1 hr	8 hr	1 hr	8 hr	24 hr
Excellent	35	12	20	10	3000	1000	15	10	5
Good	115	40	66	33	9900	3300	50	33	17
Acceptable	230	79	132	66	19800	6600	99	66	33
Alert	350	120	200	100	30000	10000	150	100	50
Action	> 350	> 120	> 200	> 100	> 30000	> 10000	> 150	> 100	> 50

Excellent	Of little concern: if maximum values are less than a 10th of the guideline, average values are likely to be much less. The 'excellent' category should not be applied to PM10 because the level of detection of most monitoring methods is not accurate enough.
Good	Peak measurements in this range are unlikely to affect air quality.
Acceptable	This is a broad category where maximum values migh be of concern in dome sensitive locations but are generally at a level that does not warrant urgent action.
Alert	This is a warning level which can lead to exceedences if trends are not curbed.
Action	Exceedences of the guideline are a cause for concern and warrant action, aprticularly if they occur on a regular basis.

Figure 1
Comparison of Air Quality Index Breakpoints for NO_2

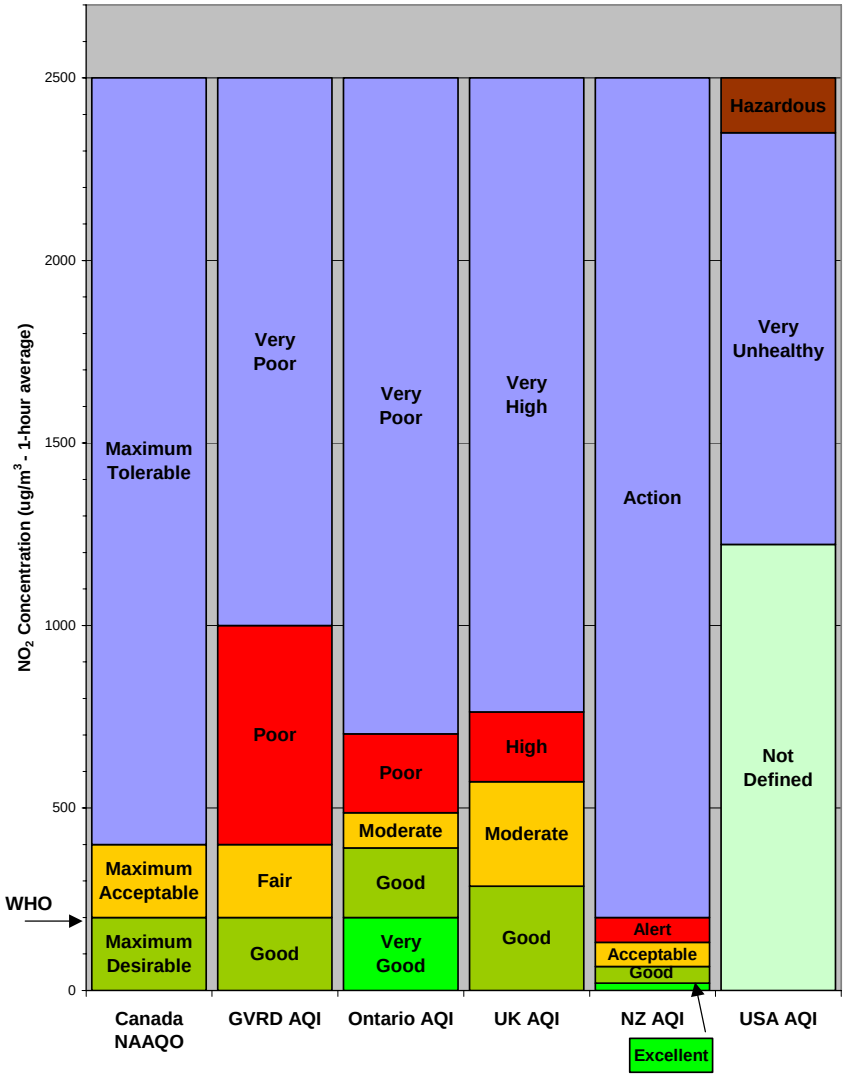


Figure 2
Comparison of Air Quality Index Breakpoints for SO_2

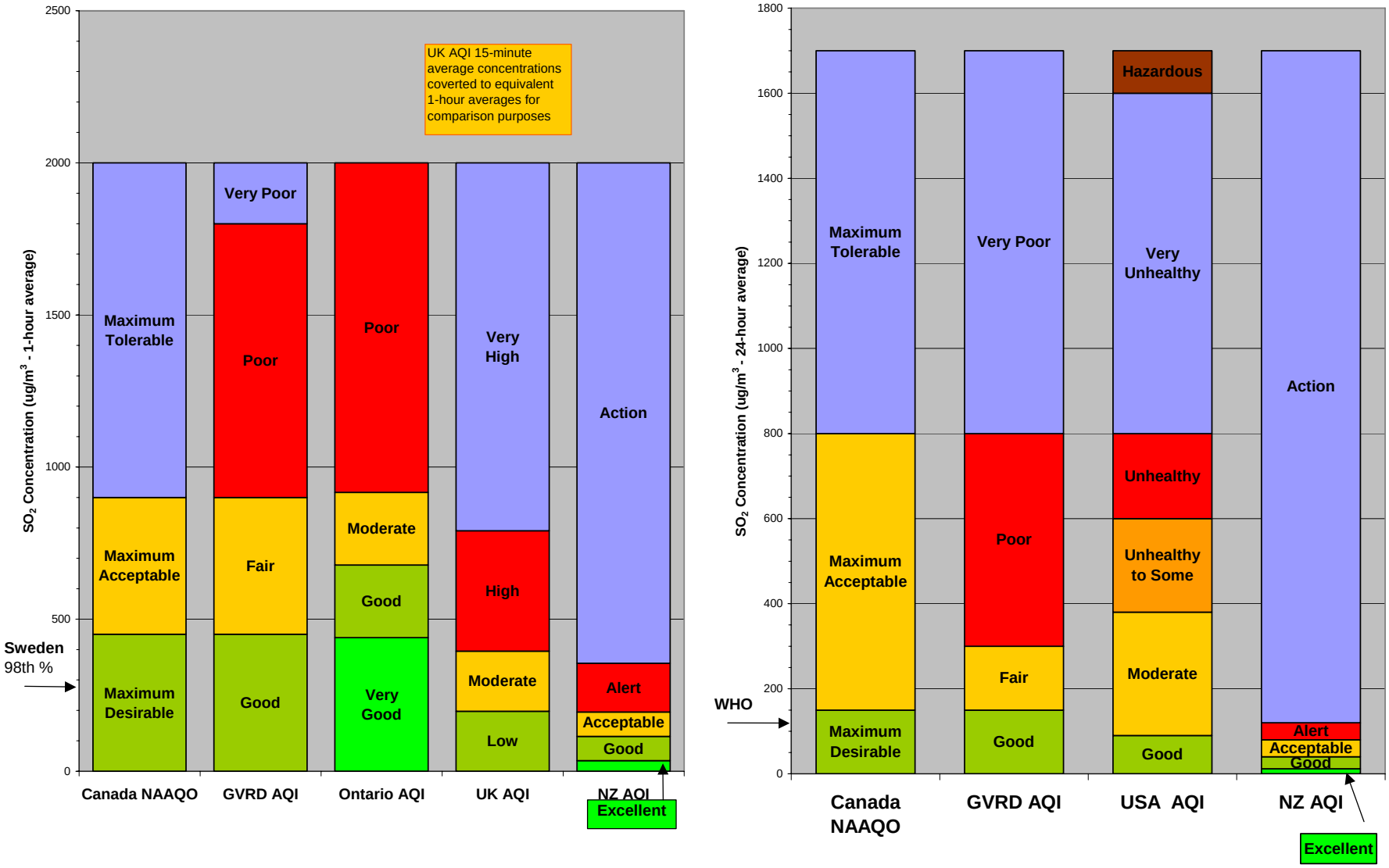


Figure 3
Comparison of Air Quality Index Breakpoints for CO

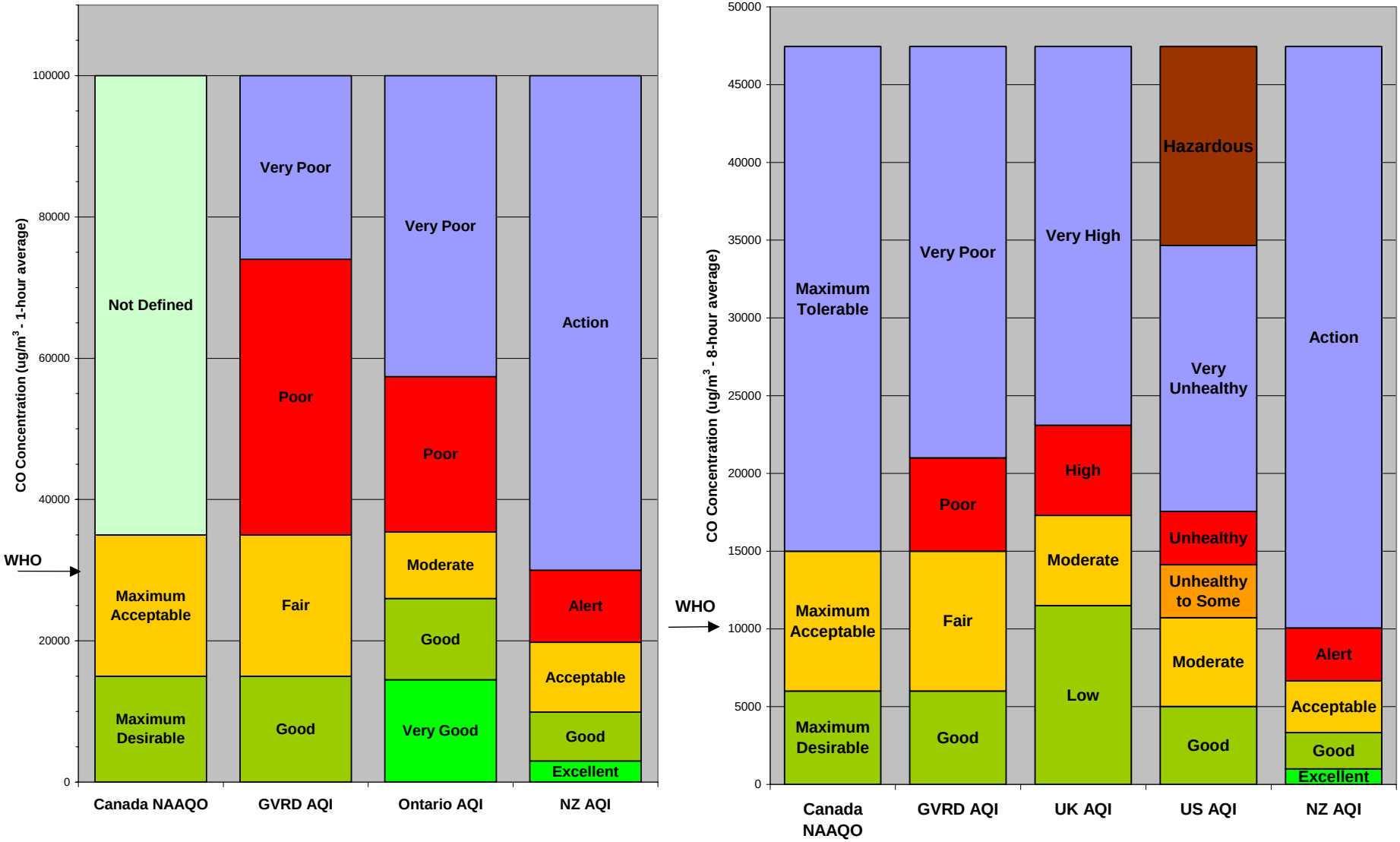


Figure 4
Comparison of Air Quality Index Breakpoints for O_3

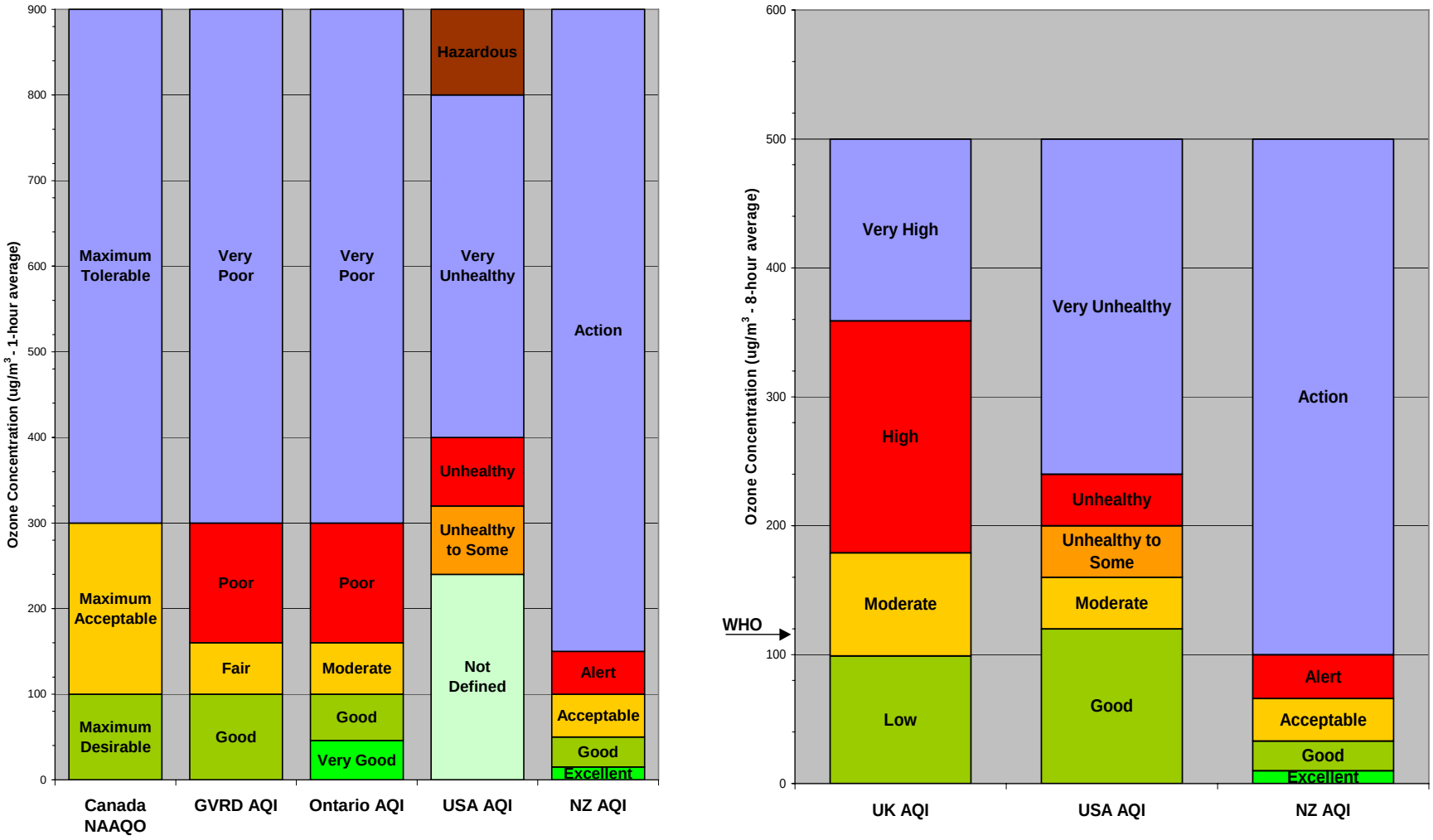
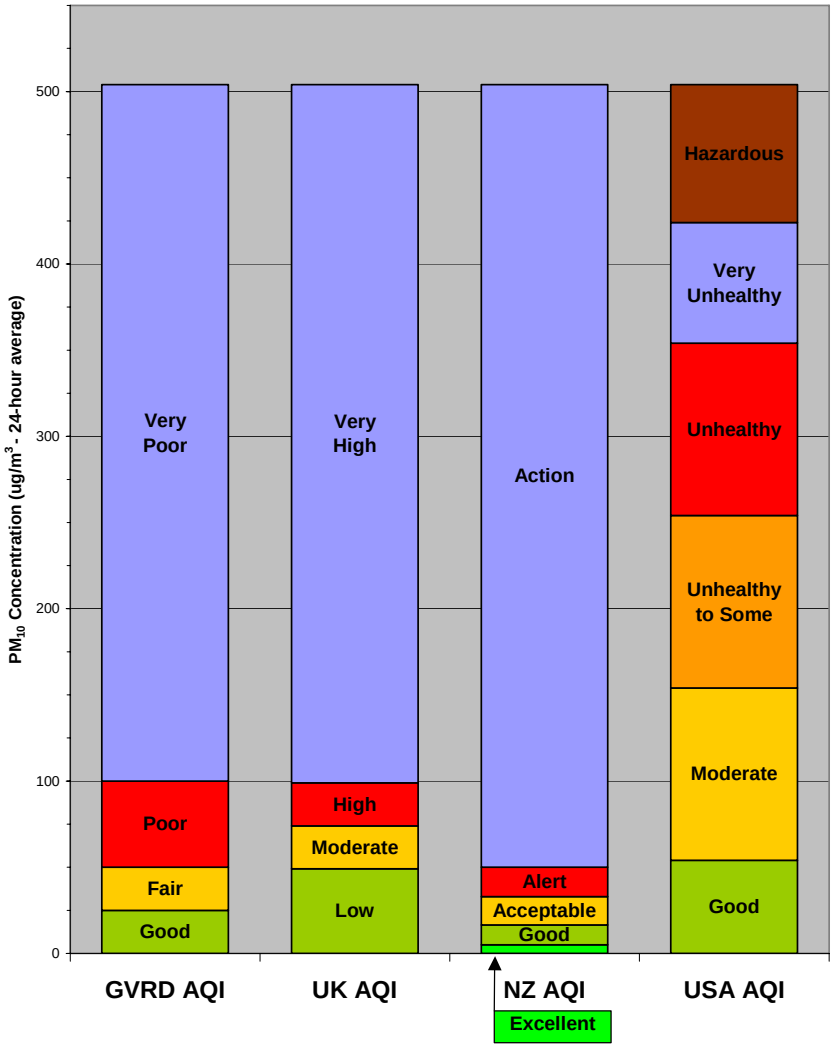
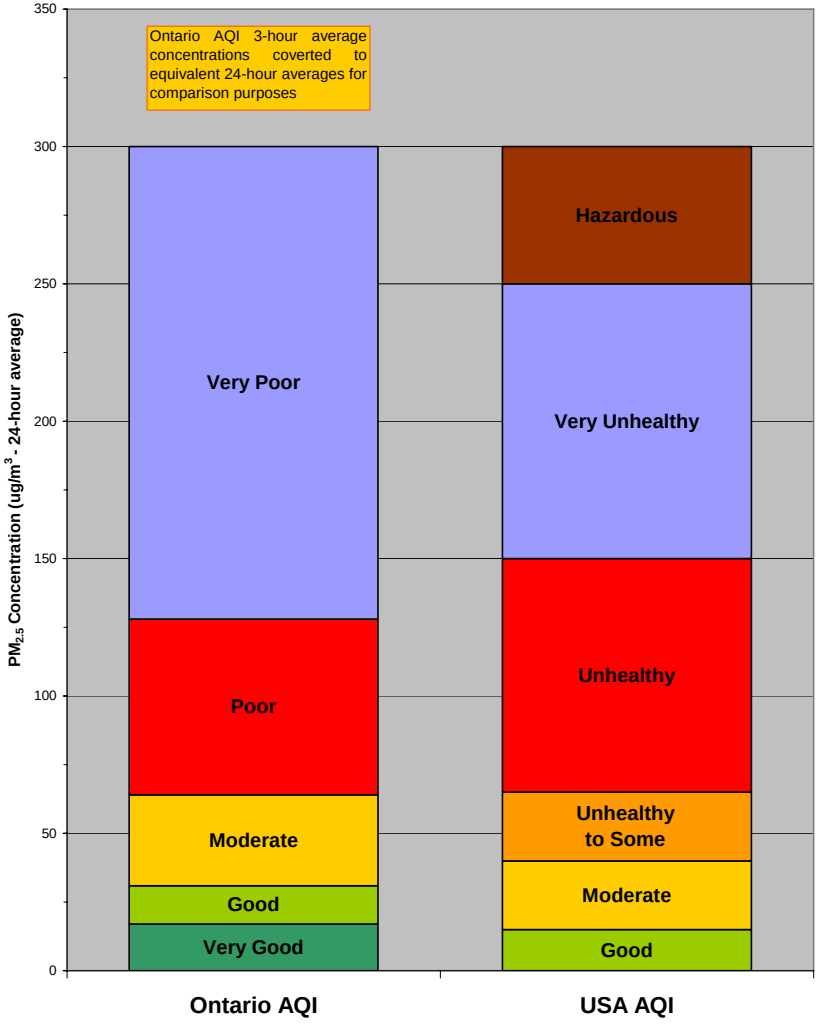


Figure 5
Comparison of Air Quality Index Breakpoints for Particulate Matter





3.0 AIR QUALITY TARGETS FOR THE CRD

An examination of the AQI breakpoints in Tables 7-11 indicates that jurisdictions generally define the breakpoint between fair/moderate and poor/high air pollutants levels as falling at their respective air quality standards, guidelines or objectives as listed in Tables 1-6. Although each jurisdiction starts with essentially the same set of research studies on the relationship between air pollutants levels and human health, the variations in the definition of *appropriate* air quality criteria and AQI categories between jurisdictions reflect social, political, economic and policy considerations in each jurisdiction. As such, all of the air quality criteria listed in Tables 1-11 can be considered as *risk-based* levels to some extent; part of the overall social, political and regulatory standard setting process under which each was developed.

Current air quality in the CRD is relatively good in comparison with other large urban areas in North America. With the exception of daily averaged ground level ozone, pollutant concentrations in the CRD are generally below the most stringent air quality objectives, guidelines and standards defined by the Provincial Government in British Columbia, by the Federal Government in Canada, or by any of the other jurisdictions listed in Tables 1-6. Concentrations of inhalable particulate matter (PM_{10}) exceed the Provincial objective about once per year at some locations, and exceed the Health Reference level of 25 $\mu g/m^3$ (24-hour average) up to 5% of the time in some locations. Concentrations of fine particulate matter ($PM_{2.5}$) exceed the Health Reference level of 15 $\mu g/m^3$ (24-hour average) for a small percentage of the time each year, but are well below the Canada-Wide Standard (CWS). Similarly, ground level ozone concentrations exceed the Health Reference level of 50 $\mu g/m^3$ for 8-hour averaged concentrations, but these levels are also exceeded in remote, pristine environments. As such, reporting on the frequency with which the ozone Health Reference level is exceeded in the CRD provides an inadequate measure of the air quality in the community.

In addition, the air quality objectives currently in use in B.C., and Canada as a whole, for other common pollutants such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and carbon monoxide (CO), were established in the 1970's, and are considered to be out-dated with respect to their relative significance for human health impacts. A discussion paper prepared for the Ministry of Water, Land and Air Protection (WLAP) has identified the need for updating the air quality objectives for these pollutants, but it is not clear when this process will be initiated, nor when it might produce results that would be of use to the CRD.

3.1 RATIONALE FOR TARGET DEVELOPMENT

The rationale used in this study for the development of the CAC target levels for the CRD can be summarized as follows:

1) The overarching principle was to select criteria that are protective of public health. As such, the proposed CAC targets should be set at or below health-based criteria levels identified in scientific studies. The goal would be never to exceed these levels.

2) If the proposed CAC target levels cannot be set below health-based criteria because there is essentially no evidence of a lower limit for health effects (e.g., O_3, PM_{10} and $PM_{2.5}$), the proposed CAC targets may be defined at a level that will minimize the risk for any associated health effects.

3) The Environmental Services Department of the CRD has also indicated a desire to use only a single averaging period for each pollutant in contrast with the current practise of having multiple averaging periods in assessing air quality using existing Provincial and Federal ambient air quality objectives, guidelines and standards. This is a reasonable suggestion for the CRD for the following reasons:

    a. NO_2 is largely derived from traffic and space heating, but there are no 8-hour or 24-hour average criteria for NO_2. Furthermore, the reported health effects for exposure to NO_2 are based on 1-hour average exposure levels. Therefore, the target criterion should be based on 1-hour NO_2 averages.
    b. The CRD has no large point sources of SO_2 and the current SO_2 concentrations in the CRD are exceptionally low. Therefore, 24-hour average concentrations provide a suitable criterion for tracking public exposure levels in the CRD.
    c. Since current CO concentrations in the CRD are very low and most of the CO in the CRD is derived from traffic and space heating, it is suggested that there is no need for a 1-hour average criterion. An 8-hour average CO concentration provides a better measure of the exposure of the overall population to CO in the CRD.
    d. The CRD does not experience high concentrations of ozone over short-term periods. As such, the 8-hour average concentrations provide a better measure of overall public exposure in the CRD with respect to health effects than do 1-hour averages.
    e. With the exception of Ontario which has recently based its AQI on 3-hour running average $PM_{2.5}$ concentration levels, short-term exposure to particulate matter is generally measured in 24-hour averages.
    f. Given the low pollutant concentration levels in the CRD, the use of annual averages seems unnecessary. Any year-to-year changes in annual concentrations would be very small, and difficult to interpret with respect to their significance. Annual average target levels could be considered at some future date if the objective were to protect ecosystems.

4) The target levels should be useful for tracking trends in air pollutant concentrations and assessing whether air quality in the CRD is improving or deteriorating.

5) In accordance with the CWS requirements for *keeping clean areas clean*, and with the WHO's recommendation that attempts should be made to keep air pollutant levels as low as practically achievable, current pollutant concentrations in the CRD should be used to define baseline concentrations against which future trends in monitored levels can be compared. The baseline level may be set at either the maximum observed concentration in the CRD to date, or at some lower percentile concentration. SENES suggests using the 98th percentile value of observed concentrations rather than the maximum value because the 98th percentile is a more stable value than the maximum observed concentration for the purposes of long-term air quality trend analysis in the CRD, and is consistent with the choice of the 98th percentile used for the $PM_{2.5}$ CWS. For trend analysis and reporting, the objective would be to track the frequency with which the target values are exceeded in any give year.

3.2 PROPOSED CRD TARGET LEVELS

Based on the above rationale, Table 12 lists CAC targets that can be considered for the CRD.

For the three pollutants (NO_2, SO_2 and CO) which currently fall well below any health-based levels of concern, the CAC targets would consist of an upper-bound, health-based guideline and a baseline concentration. The health-based guidelines are derived from the WHO guidelines for NO_2 and SO_2 in Europe and the Provincial Level A objective for CO. A provisional baseline level for NO_2, SO_2, and CO has been based on the 98th percentile value recorded at the Victoria Topaz monitoring site for each pollutant in 2002 for the purposes of presenting the concept. Additional refining is required to set this baseline and to determine whether baselines would be set for each CAC at each monitoring site.

For nitrogen dioxide, SENES suggests that the WHO guidelines for Europe provide appropriate health-based guidelines for the CRD as well. According to the WHO, a 1-hour average exposure to 365-565 µg/m^3 of NO_2 represents a clear lowest observed effects level. The WHO applied a 50% margin of safety in deriving its guideline of 200 µg/m^3 for NO_2 because of the reported statistically-significant increase in response to a bronchoconstrictor (increased airway responsiveness) to 190 µg/m^3 and a meta-analysis suggesting changes in airway responsiveness below 365 µg/m^3. However, the WHO acknowledges that the significance of the responsiveness to 190 µg/m^3 has been questioned on the basis of an inappropriate statistical analysis.

A similar rationale was used in defining the WHO's 24-hour average SO_2 guideline of 125 µg/m^3. The WHO noted that, in the presence of particulate matter, exposure to SO_2

concentrations above 250 µg/m^3 has consistently resulted in an exacerbation of symptoms among panels of selected sensitive patients. Taking the value of 250 µg/m^3 as being representative of a Lowest Observed Adverse Effects Level (LOAEL), the WHO applied an uncertainty factor of 2 to derive the guideline of 125 µg/m^3 (24-hour average). Although the WHO noted that more recent studies have suggested that adverse effects with significant public health importance have been observed at much lower levels of exposure, it was acknowledged that there remained uncertainty about whether SO_2 was the pollutant responsible for the observed adverse effects or, rather, was acting as a surrogate for some other correlated substance.

For carbon monoxide, exposure to less than 10,000 µg/m^3 CO over 8-hours is considered by the WHO to protect non-smoking, middle-aged and elderly populations with documented or latent artery disease from acute ischaemic heart attacks, and to protect the fetuses of non-smoking pregnant women from untoward hypoxic effects. British Columbia's Level A objective of 5,500 µg/m^3 (8-hour average) is approximately half the level of 10,000-11,000 µg/m^3 adopted by most jurisdictions (see Table 4), and is not significantly dissimilar from the Federal Maximum Desirable level of 6,000 µg/m^3. Thus, the B.C. Level A objective provides a suitable upper-bound, health-based guideline for the CRD because it is consistent with the approach adopted by the WHO for NO_2 and SO_2 of setting the guideline at 50% of the lowest observed effects level.

For ground level ozone (O_3) and particulate matter (PM_{10} and $PM_{2.5}$) for which current air quality concentrations exceed the Health Reference levels, the upper-bound target would be a guideline which acknowledges that some health effects will occur but assumes that the relative risk for such effects is small.

SENES suggests that the WHO guideline of 120 µg/m^3 (8-hour average) for ground level ozone provides a suitable upper-bound guideline for the CRD. The WHO reports that there are statistically-significant decrements in lung function, airway inflammatory changes, exacerbations of respiratory symptoms and symptomatic and functional exacerbations of asthma in exercising susceptible people at O_3 levels of 200 µg/m^3 and lower for exposure periods of 1-8 hours. Population studies cited by the WHO also indicate increased hospital admissions for respiratory causes at these levels. The WHO concluded that it was not possible to base a guideline on a No Observed Adverse Effects Level (NOAEL) or a Low Observed Adverse Effects Level (LOAEL). The WHO's guideline of 120 µg/m^3 (8-hour average) is based on the premise that some detectable functional responses are of little or no health concern, and that the number of people who would be so affected are too few to represent a group warranting protection from exposure to ambient ozone. It is assumed that, at this level of exposure, acute effects on public health are likely to be small. Current levels of O_3 within the CRD do not exceed this level. Therefore, it seems to be an appropriate level for an upper-bound guideline for the CRD.

As with ozone, the upper-bound target level for particulate matter in the CRD must rely on a similar approach to that used to define the ozone guideline. As reported by the WHO, epidemiological studies of short-term exposure (24-hours) to variations in PM_{10} have been associated with health effects, and the studies indicate essentially a linear exposure-response curve at concentrations in the range 20-100 $\mu g/m^3$. More recent studies suggest that the observed health effects of PM_{10} are in fact largely associated with the fine fraction of particulate matter ($PM_{2.5}$), strong acidity or sulphates which may act as a surrogate for $PM_{2.5}$ or acidity, rather than from the coarse particles in PM_{10}. The WHO notes some studies that have suggested an association between health effects and long-term average exposures to low concentrations of $PM_{2.5}$ as low as 10 $\mu g/m^3$. The consensus among researchers appears to be that the available information does not allow for the derivation of a concentration below which there would be zero risk to human health.

As such, the WHO suggests that decision-makers looking to set air quality criteria for particulate matter refer to risk estimates that may help to quantify the degree of health impact that would be deemed acceptable for their constituents. For the purposes of defining upper-bound levels for the CRD targets, SENES suggests using the current interim objective of 50 $\mu g/m^3$ for the PM_{10} upper-bound guideline. This is consistent with other jurisdictions listed in Table 5, although it should also be noted that Ontario has considered setting a potential future PM_{10} target of 40 $\mu g/m^3$. For $PM_{2.5}$, SENES suggests adopting the value of 25 $\mu g/m^3$ as the upper-bound guideline for the CRD. The latter value has been adopted by Newfoundland and Australia, and was recommended by the health committees in California in 2001 (during the recently completed review of the $PM_{2.5}$ standards) and the Puget Sound Clean Air Agency in 1999. While neither the State of California nor the Puget Sound Clean Air Agency adopted the recommendations of their health committees, there appears to be an indication of some consensus towards adoption of this value. The U.S. Environmental Protection Agency's Staff Report in August 2003 also provided the U.S. Government with suggestions for potential revisions to the $PM_{2.5}$ standard ranging from 30-50 $\mu g/m^3$.

The provisional lower-bound baselines for O_3, PM_{10} and $PM_{2.5}$ are based on the 98th percentile value of current concentrations in the CRD as indicated in Table 12. For ozone, the 98th percentile value recorded at Saturna Island falls fairly close to the maximum value recorded at the remote monitoring site on the west coast of the Olympic National Park in Washington. As such, it provides a useful baseline for long-term trend reporting. The choice of the 98th percentile for both PM_{10} and $PM_{2.5}$ as listed in Table 12 maintains consistency with the provisional baselines for the other four pollutants. The 98th percentile for $PM_{2.5}$ is based on monitoring at the Victoria Topaz site, while that for PM_{10} is based on the former Colwood site.

Figures 6-11 provide a comparison between observed pollutant concentrations in the CRD and the various proposed CRD targets discussed above. Various other criteria levels are also provided for comparison purposes.

Table 12
Air Quality 'Targets' for the Capital Regional District

Category/Averaging Time	Pollutant Concentration (in µg/m^3)						Comments
	NO_2	**SO_2**	**CO**	**O_3**	**PM_{10}**	**$PM_{2.5}$**	
Upper-bound Guideline							
1-hour	200						50% safety factor applied by WHO for NO_2
8-hour			5,500	120			WHO guideline for O_3 established as a level at which acute effects on public health are likely to be small
24-hour		125			50	25	50% safety factor applied by WHO for SO_2
Provisional Baseline							
1-hour	55						
8-hour			1,850	90			
24-hour		20			40	20	

WHO Guideline
BC Ambient Air Quality Objective
Recommended – CARB & Puget Sound; adopted in Newfoundland & Australia
Approximate 98th percentile value in 2002 at Topaz (CO, NO_2, SO_2 &$PM_{2.5}$), Colwood (PM_{10}) and Saturna (O_3)

Figure 6: Observed NO_2 Concentrations in the CRD

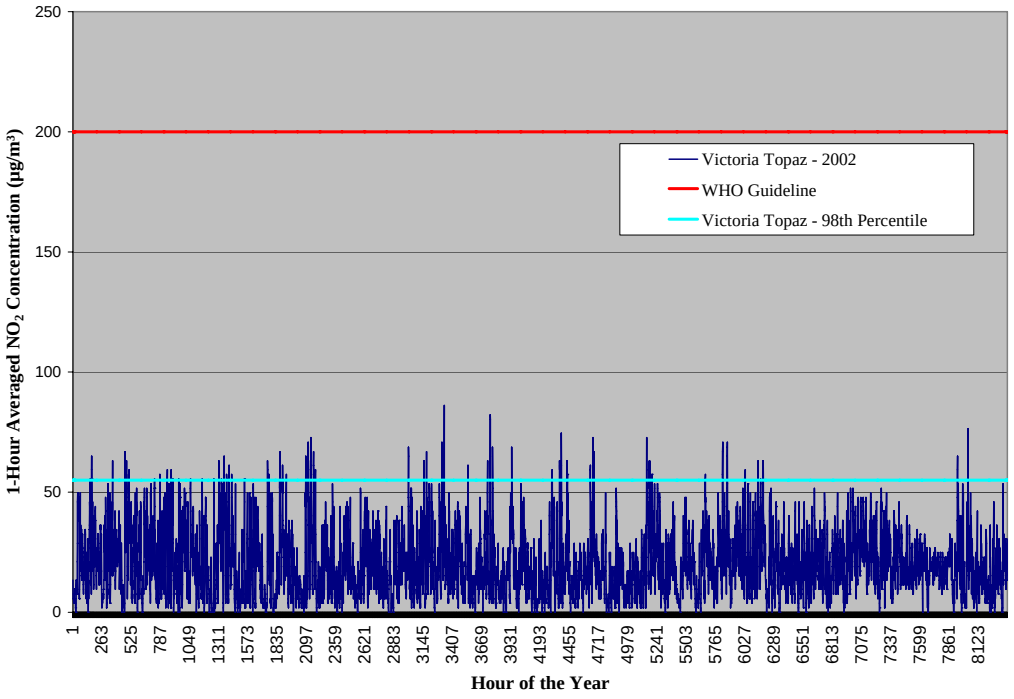


Figure 7: Observed SO_2 Concentrations in the CRD

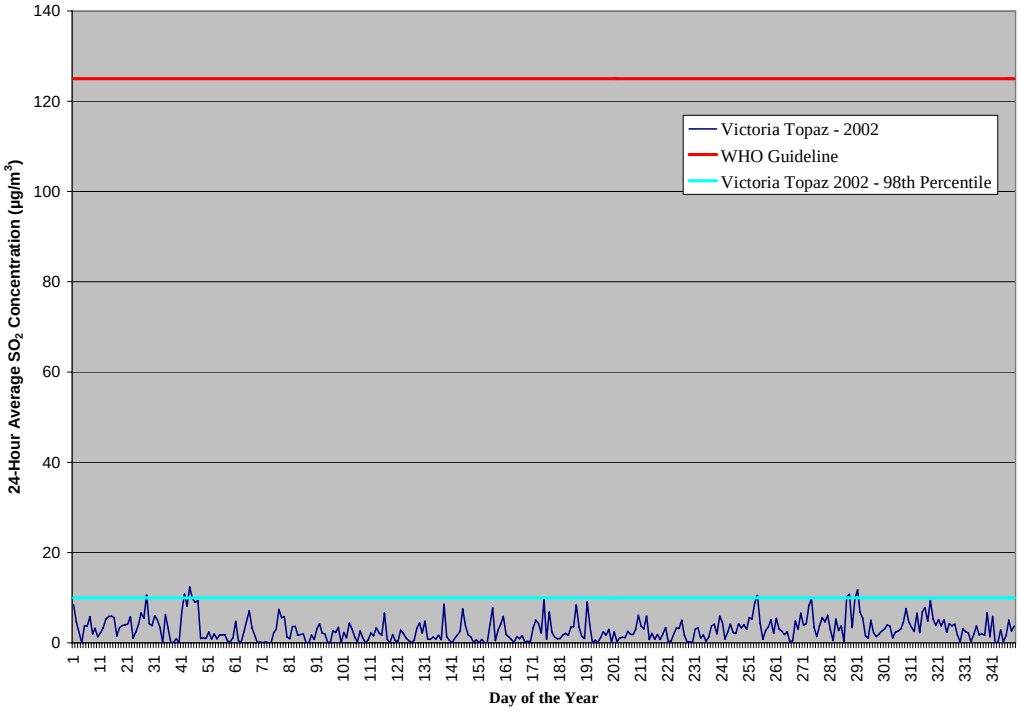


Figure 8: Observed CO Concentrations in the CRD

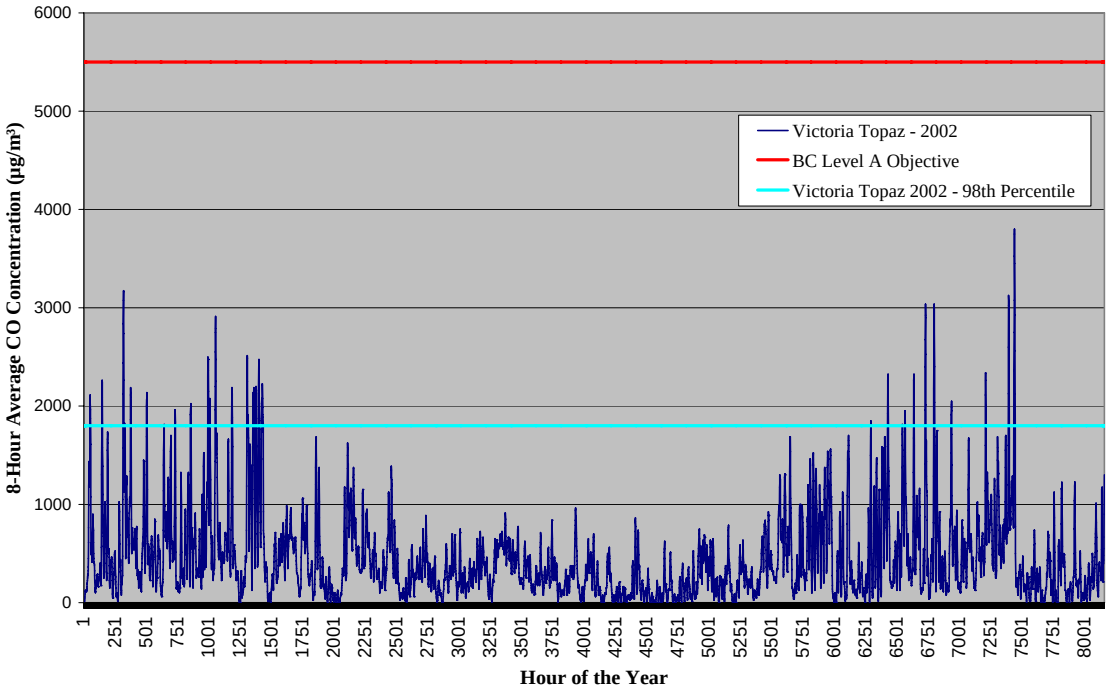


Figure 9: Observed O_3 Concentrations in the CRD

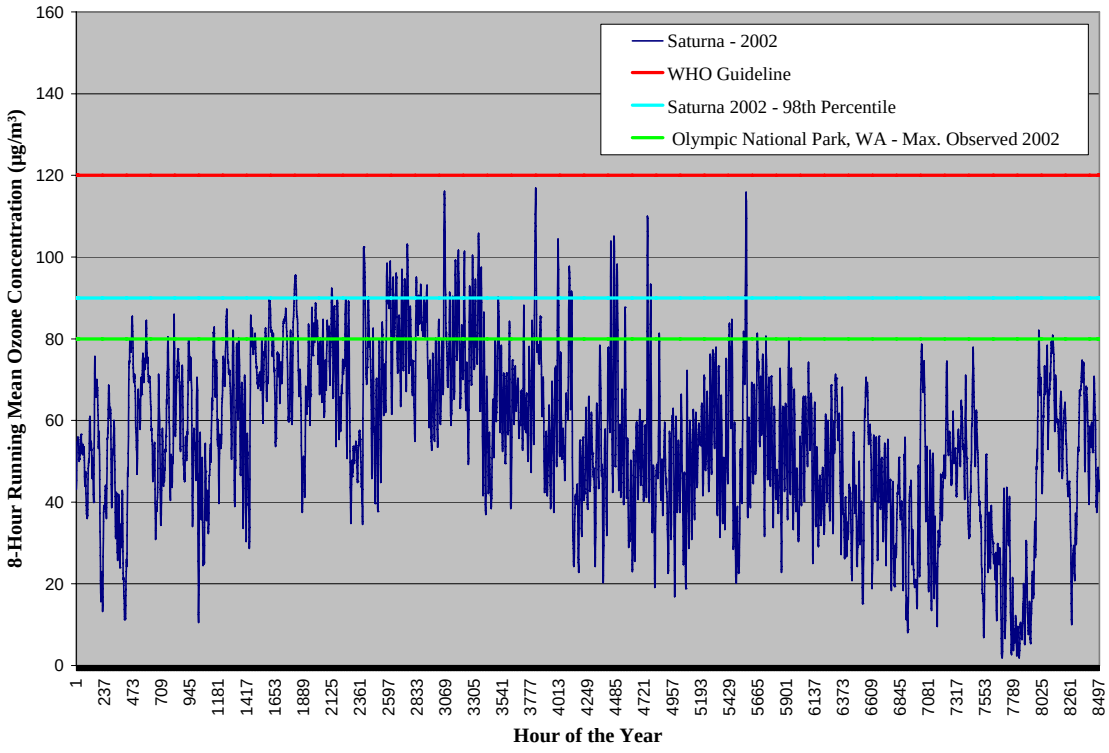


Figure 10: Observed PM_{10} Concentrations in the CRD

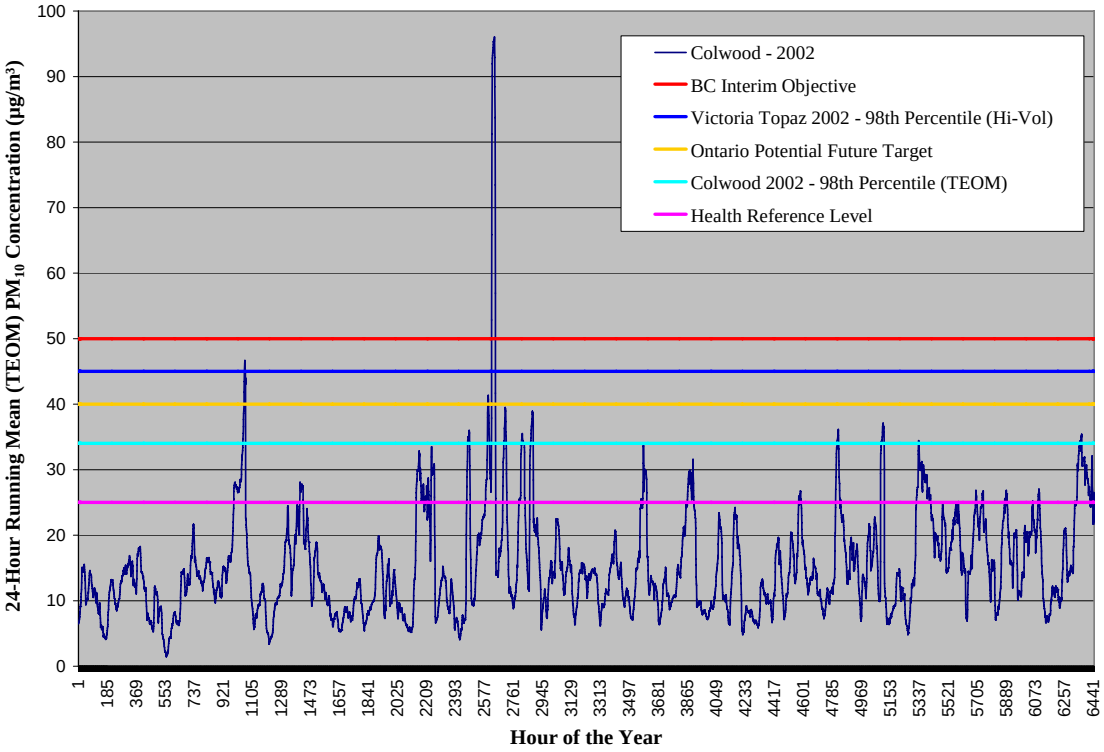
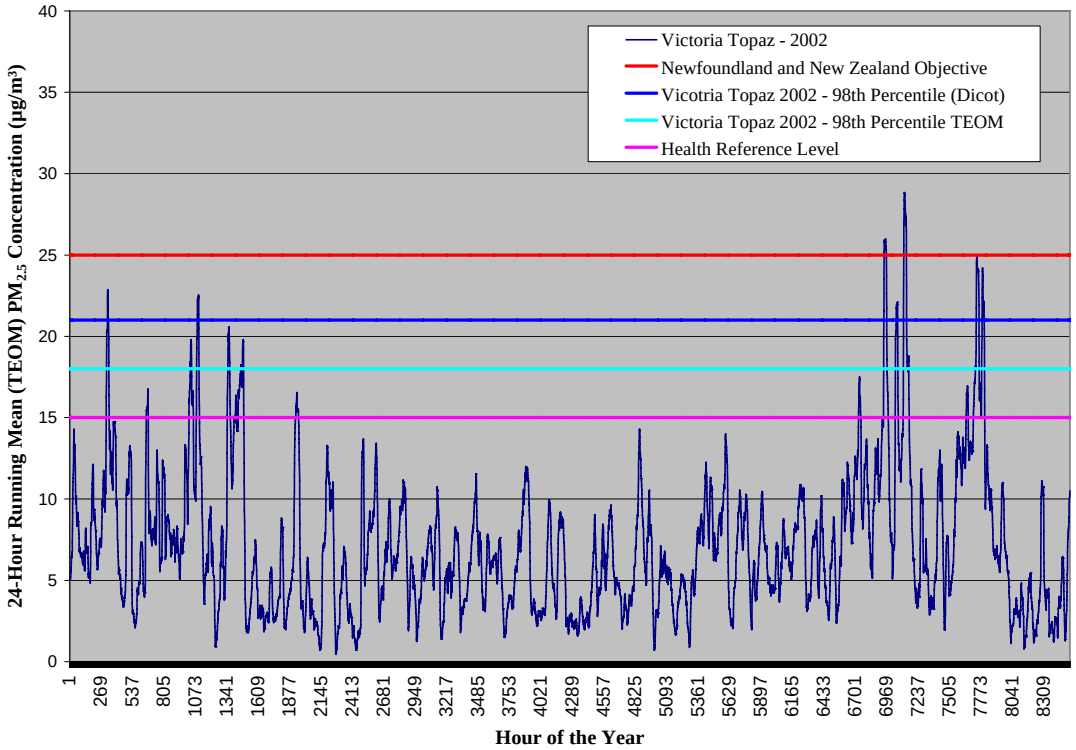


Figure 11: Observed $PM_{2.5}$ Concentrations in the CRD



4.0 CONCLUSIONS AND RECOMMENDATIONS

After a review of air quality criteria from other jurisdictions and following a rationale developed for the project, SENES has recommended the use of upper-bound guidelines and baseline levels for CAC measured in the CRD. The purpose of these targets is more meaningful reporting to the general public and assisting the CRD in interpreting trends in air quality.

The recommended upper bound guidelines for NO_2, SO_2 and CO currently fall well below any health-based levels of concern and therefore represent pollutant levels below which exposure – for life or for a given period of time – does not constitute a significant public health risk. For nitrogen dioxide, SENES suggests that the WHO 1-hour average guidelines for Europe of 200 $\mu g/m^3$. For sulphur dioxide, the WHO's 24-hour average SO_2 guideline of 125 $\mu g/m^3$ is recommended. For carbon monoxide, British Columbia's Level A objective of 5,500 $\mu g/m^3$ (8-hour average has been recommended.

For ground level ozone (O_3) and particulate matter (PM_{10} and $PM_{2.5}$) for which current air quality concentrations exceed the Health Reference levels, the upper-bound target would be a guideline which acknowledges that some health effects will occur, but assumes that the relative risk for such effects is small. SENES suggests that the WHO guideline of 120 $\mu g/m^3$ (8-hour average) for ground level ozone provides a suitable upper-bound guideline for the CRD.

As with ozone, the upper-bound target level for particulate matter in the CRD must rely on a similar approach to that used to define the ozone guideline. For the purposes of defining upper-bound levels for the CRD targets, SENES suggests using the current interim objective of 50 $\mu g/m^3$ for the PM_{10} upper-bound guideline. For $PM_{2.5}$, SENES suggests adopting the value of 25 $\mu g/m^3$ as the upper-bound guideline for the CRD. The latter value has been adopted by Newfoundland and Australia.

A provisional baseline level for NO_2, SO_2, and CO has been based on the 98^{th} percentile value recorded at the Victoria Topaz monitoring site for each pollutant in 2002 for the purposes of presenting the concept. Additional refining is required to set this baseline.

The provisional lower-bound baselines for O_3, PM_{10} and $PM_{2.5}$ are based on the 98^{th} percentile value of current concentrations in the CRD. For ozone, the 98^{th} percentile value recorded at Saturna Island falls fairly close to the maximum value recorded at the remote monitoring site on the west coast of the Olympic National Park in Washington. As such, it provides a useful baseline for long-term trend reporting. The choice of the 98^{th} percentile for both PM_{10} and $PM_{2.5}$ maintains consistency with the provisional baselines for the other four pollutants. The 98^{th} percentile for $PM_{2.5}$ is based on monitoring at the Victoria Topaz site, while that for PM_{10} is based on the former Colwood site.

REFERENCES

Australian Attorney-General's Department 2003. *National Environment Protection (Ambient Air Quality) Measure.* Prepared by the Office of Legislative Drafting, Canberra, 7 July 2003.

California Air Resources Board and Office of Environmental Health Hazard Assessment 2000. *Adequacy of California Ambient Air Quality Standards: Children's Environmental Health Protection Act.* Staff Report. State of California, California Environmental Protection Agency, December 2000.

California Air Resources Board and Office of Environmental Health Hazard Assessment 2001. *Review of the California Ambient Air Quality Standards for Particulate Matter and Sulfates.* Report to the Air Quality Advisory Committee, California Environmental Protection Agency, November 30, 2001.

Environmental Quality Standards in Japan – Air Quality: http://www.env.go.jp/en/lar/regulation/aq.html

European Union (EU) Commission 2002. *Guidance for implementing Directive 2002/3/EC of the European Parliament and of the Council of 12 February 2002 relating to ozone in ambient air.* With contributions from: R. van Aalst, V. Calabe, G. Chronopoulos, G. Dumont, J. Geiger, A. Graff, M.M. Millan, F. De Santis, J. Schneider, P. Smeets.

European Commission Directorate-General XI 1999. *Ozone Position Paper.* Final version. Prepared by the Ad-Hoc Working Group on Ozone Directive and reduction Strategy Development, July 1999.

European Commission Directorate-General XI 1999. *Ambient Air Pollution: Carbon Monoxide Position Paper*. Draft version 5.2. 17 March 1999.

European Commission Directorate-General XI 1997. *Position paper on Air Quality: nitrogen dioxide.* Working Group on Nitrogen Dioxide, November 1997.

European Commission Directorate-General XI 1997. *Ambient Air Quality by Particulate Matter. Position Paper.* Technical Working Group on Particles, April 1997.

European Commission Directorate-General XI 1997. *SO_2 Position Paper.* November 1997.

Frampton, M.W. 2000. *Nitrogen Dioxide: Evaluation of Current California Air Quality Standards with respect to Protection of Children.* Departments of Medicine and Environmental Medicine, University of Rochester School of Medicine and Dentistry, Rochester, NY. Prepared for the California Air Resources Board, California Office of Environmental Health Hazard Assessment.

Greater Vancouver Regional District: http://www.gvrd.bc.ca/air/aqi.htm

Kleinman, M.T. *Carbon Monoxide: Evaluation of Current California Air Quality Standards with respect to Protection of Children.* department of Community and Environmental Medicine, University of California, Irvine, CA. Prepared for the California Air Resources Board, California Office of Environmental Health Hazard Assessment.

Koenig, J.Q. and T.F. Mar 2000. *Sulfur Dioxide: Evaluation of Current California Air Quality Standards with respect to Protection of Children.* Department of Environmental Health, University of Washington, Seattle, WA. Prepared for the California Air Resources Board, California Office of Environmental Health Hazard Assessment.

National Environment Protection Council 2002. *Impact Statement for $PM_{2.5}$ Variation: Setting a $PM_{2.5}$ Standard in Australia.* National Environment Protection (Ambient Air Quality) Measure, October 2002.

National Environment Protection Council 2003. *Variation to the National Environment Protection (Ambient Air Quality) Measure.* June 2003. ISBN 0642 323 64X.

New Zealand Ministry for the Environment: http://www.environment.govt.nz/indicators/air/

Ontario Ministry of the Environment c.2000. *Air Quality Index (AQI) and Smog Alert Program.* Chapter 5.

Ross, B. and M. Duffy 2001. *Final Report of the Puget Sound Clean Air Agency CO/OZONE Stakeholders Group.* Prepared with the assistance of Ross & Associates Environmental Consulting, Ltd.

Ross, B. and M. Duffy 1999. *Final Report of the Puget Sound Clean Air Agency $PM_{2.5}$ Stakeholders Group.* Prepared with the assistance of Ross & Associates Environmental Consulting, Ltd.

Samet, J. and D. Krewski 2003. *Health Effects Associated with Exposure to Ambient Air Pollution.* Draft Background Paper for Discussion. Prepared for the NERAM/AIRNet Colloquium on Strategies for Clean Air and Health, November 5-7, 2003.

Secretary of State for the Environment, Transport and the Regions 2000. *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.* Presented to Parliament by Command of Her Majesty: Laid before the Scottish Parliament by the Scottish Ministers: Laid before the National Assembly for Wales by the First Secretary: Laid before the Northern Ireland Assembly by the First Ministers: January 2000.

Stedman, J.R., Lineham, E. and K. King 1999. *Quantification of the Health Effects of Air Pollution in the UK for the Review of the National Air Quality Strategy.* Prepared for The Department of the Environment, Transportation and the Regions.

Stedman, J.R., King, K., Holland, M. and H. Walton 2002. *Quantification of the health effects of air pollution in the UK for revised PM_{10} objective analysis.* Report produced for The Department for Environment, Food and Rural Affairs, Welsh Assembly Government, The Scottish Executive and the Department of the Environment in Northern Ireland, June 2002.

Swedish Environmental Objectives Council 2003. *de Facto 2003. Sweden's Environmental Objectives – will the interim targets be achieved?* ISBN 91-620-1232-0

Tager, I.B. 2000. *Ozone: Evaluation of Current California Air Quality Standards with respect to Protection of Children.* School of Public Health, University of California, Berkeley, CA. Prepared for the California Air Resources Board, California Office of Environmental Health Hazard Assessment.

Thurston, G.D. 2000. *Particulate Matter and Sulfate: Evaluation of Current California Air Quality Standards with respect to Protection of Children.* New York School of Medicine, Nelson Institute of Environmental Medicine, Tuxedo, NY. Prepared for the California Air Resources Board, California Office of Environmental Health Hazard Assessment.

United States Environmental Protection Agency 2003. *Air Quality Index. A Guide to Air Quality and Your Health.* Office of Air and Radiation, NC. EPA-454/K-03-002

World Health Organization (WHO) 2000. *Air Quality Guidelines for Europe.* Second Edition. Regional Office for Europe, Copenhagen, WHO Regional Publications, European Series, No. 91

World Health Organization (WHO) 2003. *Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide.* Report on a WHO Working Group, Bonn, Germany, 13-15 January 2003.

World Health Organization (WHO) 2000. *Quantification of the Health Effects of Exposure to Air Pollution.* Report on a WHO Working Group, European Centre for Environment and Health, Bilthoven, Netherlands, 20-22 November 2000.