Health Effects and Benefits Estimates Associated with Air Quality Improvements Particulate Matter (PM2.5) and Ground Level Ozone

Central Okanagan Regional District
North Okanagan Regional District

February 28th, 2006

Tracey Parker – Research Economist
Environment Canada - Pacific & Yukon Region
Strategic Integration Branch
2nd Floor – 401 Burrard Street
Vancouver, B.C.
V6C 3S5
Telephone: (604) 664-4006
E-Mail: tracey.parker@ec.gc.ca

Environment Canada Environnement Canada

Tracey R. Parker
Research Economist
Environment Canada – Pacific & Yukon Region
Strategic Integration Branch
2nd Floor 401 Burrard Street
Vancouver, B.C.
V6C 3S5
Telephone: (604) 664-4006

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Includes French Translation of Executive Summary

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EXECUTIVE SUMMARY

Background

The report reviews air quality levels within the Central Okanagan Regional District *(Kelowna - Okanagan University College)* and the North Okanagan Regional District *(Vernon - Science Centre)*. Review of the Kelowna *(Okanagan University College)* air quality data reveals that the Central Okanagan region is currently meeting the Canada Wide Standards (CWS) metric for PM and ozone. However, as there is no safe level of exposure to these two air pollutants, and acceptable threshold levels have not been conclusively established, continuous efforts to improve air quality are desirable.[1]

There are known health and other impacts associated with PM and ozone. Consequently, improvements in these two air pollutants provide social welfare benefits. Using the Air Quality Valuation Model (AQVM) (Version 3.0) with modifications to the default database, the report provides estimates of health outcomes and monetized benefits associated with improvements in air quality *(PM2.5 and ozone)* from local baseline ambient concentration levels.[2] The report demonstrates that even small improvements in air quality *(PM2.5 and ozone)* will yield substantial economic benefits.

The benefits analysis provided within this report follows generally accepted estimation methods associated with air quality improvements that have been used for planning purposes in other jurisdictions. The AQVM is a recognized quantitative modeling tool developed for Health Canada and Environment Canada to evaluate *(quantify and monetize)* the health and other impacts associated with air quality improvements. The model calculates effects and monetized benefits estimates by employing the "*damage function approach*" which is based on marginal changes in air quality that are specified by the analyst. The AQVM estimates a range of outcomes and monetized values *(denoted as: low, central, high and mean)* based on low, central, and high concentration response functions (CRFs), and low, central, and high dollar values of health outcomes that are included within the model. The AQVM also employs monte-carlo simulation techniques to calculate a probability distribution, providing low, mean, central and high value estimates.

The AQVM was used in the cost/benefit analysis conducted for the Canada Wide Standards (CWS) for PM and ozone *(July-August/1999)*.[3] More recently, the information set contained within the AQVM was also relied upon within the study *"Health and Air Quality 2005 – Phase 2 – Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report" (July/2005)*.[4] The benefits analysis in this study employs similar approaches as was provided for the Greater Vancouver Regional District (GVRD) and the Fraser Valley Regional District (FVRD) within the afore-mentioned report.

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[1] Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 28).

[2] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999). Note: modifications were made to the default AQVM (Version 3.0) CRF database for PM mortality, ozone mortality and ERVs, based on: Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114). See also Jessiman, Barry, Health Canada, Personal (e-mail) communication (21/July/2003). As the dollar values of health outcomes within the default AQVM (Version 3.0) database are expressed in 1996 $'s Cdn, these values were updated to 2003 $'s Cdn.

[3] De Civita, Paul-Environment Canada, Lauraine G. Chestnut, David Mills, Robert D. Rowe – Stratus Consulting Inc, David Stieb-Health Canada, *Human Health and Environmental Benefits of Achieving Alternative Canada Wide Standards for Inhalable Particles (PM2.5, PM10 and Ground Level Ozone, Final Report*, Prepared for: The Canada Wide Standards Development Committee for PM and Ozone (July 25, 1999); Compendium of Benefits Information, (17/August/1999).

[4] Furberg, Maria M.Sc., Kathy Preston, PhD., P. Eng – RWDI Air Inc, Dave Sawyer – Marbek Resource Consultants, Dr. Michael Brauer – School of Occupational & Environmental Hygiene UBC, Dr. Robin Hanvelt – Department of Health Care and Epidemiology UBC, *Health and Air Quality 2005 – Phase 2: Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report*, B.C. Lung Association, (July 15, 2005).

Health Outcomes and Monetized Benefits Estimates

As included within the AQVM (Version 3.0), the health and other endpoints evaluated within the report are: *mortality, respiratory hospital admissions, cardiac hospital admissions, emergency room visits, adult chronic bronchitis, child bronchitis, asthma symptom days, acute respiratory symptom days, restricted activity days, minor restricted activity days, household materials soiling, and agricultural (corn) crop damage.*[5]

The estimated results employ the default AQVM (Version 3.0) concentration response function (CRF) database with modifications to PM related mortality estimates in accordance with recommendations put forward within the BC Lung Association Phase I health study.[6] The dollar values of health outcomes included in the benefits analysis are based on the AQVM (Version 3.0) database – which have been updated *(inflated)* in this report to reflect 2003 $'s Canadian.[7]

The avoided health outcomes and the monetized benefits estimates associated with a 10% improvement in PM2.5 and ozone to be realized in simulation year 2005 for the North Okanagan Regional District and the Central Okanagan Regional District from baseline ambient air quality levels *(averaged over 2002-2004)* are summarized in the tables below.[8]

North Okanagan Regional District	**Annual Benefits Estimates - 10% Improvement in PM2.5 & Ozone** (Simulation Year 2005) (Based on Central Estimates)			
	Baseline PM2.5 = 7.61 ug/m^3 *Yrly Avg of Daily Avg (Calendar Yr) (Avg 2002-2004)*		**Baseline Ozone = 34.03 ppb** *Yrly Avg of Daily Max (May-Sept) (Avg 2002-2004)*	
Health Endpoint	**No of Outcomes**	**$ Estimates**	**No of Outcomes**	**$ Estimates**
Chronic Mortality	1.21	$5,734,170	.11	$513,608
Acute Mortality	.30	$1,433,540	-	-
Chronic Bronchitis	3.38	$1,106,230	-	-
Respiratory Hospital Admissions	.26	$2,036	.45	$3,470
Cardiac Hospital Admissions	.22	$2,188	-	-
Emergency Room Visits	1.13	$760	1.81	$1,218
Asthma Symptom Days	433.50	$22,109	578.91	$29,524
Restricted Activity Days	3,858.27	$339,527	-	-
Minor Restricted Activity Day	-	-	1,748.34	$64,689
Acute Respiratory Symptom Days	5,569.91	$89,119	3,380.62	$54,090
Child Bronchitis	22.46	$7,884	-	-
Household Materials Soiling	25,636.50	$106,135	-	-
Corn Crop Damage	-	-	312.87	$8,710
Total	-	**$8,843,690**	-	**$675,309**

[5] Note: these health and other outcomes are defined on p. 95 of the report.

[6] Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114). Note: modifications to ozone related mortality and ERVs were also made to the default AQVM (Version 3.0) database based on recent recommendations by Health Canada, see: Jessiman, Barry, Health Canada, Personal (e-mail) communication (21/July/2003).

[7] Note: the dollar values of health outcomes contained within the default AQVM (Version 3.0) database are expressed in 1996 $'s Canadian. Source: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999), (p. 5-20 & 5-31). These values have been updated *(inflated)* to 2003 $'s Canadian within the results reported herein.

[8] Note: the tables show the central health effects and monetized benefits estimates. For the low, mean and high value estimates refer to p. 46 & 47 of this report.

Central Okanagan Regional District	Annual Benefits Estimates - 10% Improvement in PM2.5 & Ozone (Simulation Year 2005) (Based on Central Estimates)			
	Baseline PM2.5 = 6.78 ug/m^3 *Yrly Avg of Daily Avg (Calendar Yr) (Avg 2002-2004)*		Baseline Ozone = 44.57 ppb *Yrly Avg of Daily Max (May-Sept) (Avg 2002-2004)*	
Health Endpoint	**No of Outcomes**	**$ Estimates**	**No of Outcomes**	**$ Estimates**
Chronic Mortality	2.27	$10,758,100	.30	$1,412,730
Acute Mortality	.57	$2,689,530	-	-
Chronic Bronchitis	6.50	$2,126,380	-	-
Respiratory Hospital Admissions	.49	$3,819	1.23	$9,545
Cardiac Hospital Admissions	.41	$4,105	-	-
Emergency Room Visits	2.12	$1,426	4.97	$3,350
Asthma Symptom Days	813.31	$41,479	1,592.33	$81,209
Restricted Activity Days	7,317.54	$643,944	-	-
Minor Restricted Activity Day	-	-	4,808.96	$177,932
Acute Respiratory Symptom Days	10,450.00	$167,199	9,298.70	$148,779
Child Bronchitis	41.11	$14,430	-	-
Household Materials Soiling	47,401.70	$196,243	-	-
Corn Crop Damage	-	-	-	-
Total	-	**$16,646,630**	-	**$1,833,540**

Note: the results reported above are based on the central estimates; some totals do not add due to rounding and monte carlo simulation effects. The assumed 10% improvement in PM2.5 and ozone is arbitrary, the report does not evaluate whether/or/how the assumed 10% reduction is achievable. The reported effects are estimates *(annual predicted results)*. The percentage of monetized value associated with PM2.5 and ozone mortality is approximately 80%.

As can be seen - the estimated monetized benefits to be realized from these air quality improvements are substantial.

Based on the central estimates, a 10% improvement in PM2.5 and ozone *(to be realized in year 2005)* from baseline ambient air quality levels *(averaged over 2002-2004)* for the North Okanagan Regional District will yield an estimated value of $8,843,690 for PM2.5 *(with a lower and upper value of: $3,479,951 - $16,786,620)*, and an estimated value of $675,309 for ozone *(with a lower and upper value of: $296,020 - $1,166,090)*.

For the Central Okanagan Regional District, the estimated value for PM2.5 is $16,646,630 *(with a lower and upper value of: $6,581,351 - $31,577,950)*, and the estimated value for ozone is $1,833,540 *(with a lower and upper value of: $797,268 - $3,185,580)*.

Note that the estimates reported above are annual. Therefore, air quality improvements will yield multi-year benefits *(for the avoided impacts)* occurring in each year the air quality improvement is sustained.

Discounted Present Value Estimates

The tables below present the benefits estimates associated with a sustained 10% improvement in air quality *(PM2.5 and ozone)* from baseline concentration levels *(averaged over 2002-2004)* which may be realized over the sixteen (16) year period 2005-2020. As there is an inter-temporal dimension to the realization of these benefits, a range of discount rates of: 4%, 6%, and 8% have been applied to these values.

The North Okanagan estimates are $167,512,595 *(for the 16 year period 2005-2020)* discounted to $120,700,438 at 4%, $104,152,039 at 6%, and $90,780,782 at 8%.

The Central Okanagan estimates are $341,157,335 *(for the 16 year period 2005-2020)* discounted to $244,638,144 at 4%, $210,610,267 at 6%, and $183,164,101 at 8%.

	Discounted Present Value PM2.5 and Ozone North Okanagan Regional District 2005-2020 (16 Year Period) *(Based on Central Estimates Associated with 10% Improvement – Sim Yr 2005)*			
	r=0%	**r=4%**	**r=6%**	**r=8%**
Mortality	$134,308,986	$96,821,761	$83,567,097	$72,855,717
Morbidity	$31,125,512	$22,382,611	$19,294,622	$16,800,980
Other	$2,078,097	$1,496,066	$1,290,320	$1,124,085
Total	**$167,512,595**	**$120,700,438**	**$104,152,039**	**$90,780,782**

	Discounted Present Value PM2.5 and Ozone Central Okanagan Regional District 2005-2020 (16 Year Period) *(Based on Central Estimates Associated with 10% Improvement – Sim Yr 2005)*			
	r=0%	**r=4%**	**r=6%**	**r=8%**
Mortality	$272,824,668	$195,742,430	$168,559,923	$146,631,229
Morbidity	$64,567,370	$46,203,710	$39,736,249	$34,523,322
Other	$3,765,298	$2,692,004	$2,314,095	$2,009,550
Total	**$341,157,335**	**$244,638,144**	**$210,610,267**	**$183,164,101**

Note: mortality estimates account for approximately **80%** of the PM2.5 and ozone monetized benefits reported above. The monetized benefits estimate avoided impacts potentially realized for each year the air quality improvement is sustained.

Note that the estimated benefits associated with PM and ozone air quality improvements are substantial. However, a future analysis should also evaluate the cost side of the equation, making a comparison of the costs and benefits by calculating the net present value associated with specific policy measures to improve air quality. The source-receptor relationship *(estimating the percentage change in air quality given changes in emissions)* should also be evaluated.

Uncertainties

As described within the text of the document, there are a number of uncertainties surrounding the benefits estimates reported within this study. The uncertainties are itemized below:[9]

-value of a statistical life (VSL) used to monetize mortality – *under debate*
-discount rate – *appropriate factor to use*
-concentration response functions (CRFs) – *locally applicable risk estimates*
-use of PM2.5 - vs - PM10 ambient concentration values – *appropriate conversion factors*
-TEOM monitors - vs - manual filter-based samplers – *measurement differences*
-other impacts not included in the study – *not quantifiable*
-representative measure of exposure – *linking population to air quality monitors*
-assumed population and growth rates – *are estimates only.*

General Conclusions of the Study

Air quality improvements provide health and other benefits. The study shows that a 10% improvement in PM2.5 and ozone provide quantifiable annual benefits estimates for the North Okanagan Regional District of $8,843,690 for PM2.5 *(with a low and high value of: $3,479,951 - $16,786,620),* and $675,309 for ozone *(with a low and high value of: $296,020 - $1,166,090).*

For the Central Okanagan Regional District the quantifiable annual benefits estimates associated with a 10% improvement in PM2.5 and ozone are: $16,646,630 for PM2.5 *(with a low and high value of: $6,581,351 - $31,577,950),* and $1,833,540 for ozone *(with a low and high value of: $797,268 - $3,185,580).*

The study also demonstrates that sustained air quality improvements will yield substantial cumulative benefits associated with avoided health effects occurring over multiple years. Based on the central estimates, over the 16 year period *(2005 – 2020)* the North Okanagan Regional District may realize $167,512,595 *(discounted to $120,700,438 at 4%, $104,152,039 at 6%, and $90,780,782 at 8%),* and the Central Okanagan Regional District may realize $341,157,335 *(discounted to $244,638,144 at 4%, $210,610,267 at 6%, and $183,164,101 at 8%).*

Additional unquantifiable benefits also exist – including impacts on tourism and on local area residents associated with visibility improvements, adverse effects on important local agricultural crop yields *(particularly tree fruits and grapes*), impacts to forestry, impacts on wildlife health *(implications for bio-diversity, hunting, and non-use values)*, eco-system impacts, deposition/soiling effects to commercial enterprises, and other effects that are difficult to quantify *(including long-term cancer risk associated with toxic air pollutants)* that are not included within this report – which may be substantial.

[9] Note: a more in-depth discussion relating to uncertainties is provided within the main text of the report, (see pgs. 52, 53, 54 & 55).

Policy Implications

To achieve air quality improvements will require continued efforts to reduce emissions. This goal presents an on-going challenge to air quality managers, as the North and Central Okanagan regions are projected to experience high population growth in future years. In the immediate future air quality managers are also challenged with the requirement to meet the Canada Wide Standards (CWS) for particulate matter (PM) and ground level ozone by the year 2010. Air quality improvements will be aided by the federal agenda on clean air that will result in the gradual turn-over of the vehicle fleet to cleaner vehicles.[10]

The study shows that policies to reduce PM will have the greatest impact as they provide the highest social welfare value. However, review of the cost side of the equation is also required to attain an understanding of the net social welfare benefits associated with specific air quality management policies. Linking of the costs and benefits also requires knowledge and understanding of the source/receptor relationship *(ie. the percentage change in air quality given changes in emissions).*

It is known that the costs of measures to improve air quality vary substantially. Although a comprehensive examination of the costs associated with various emissions reduction measures within the North and Central Okanagan regions has not been evaluated within this report, some cost measures are low and are easily implemented. Examples of relatively low cost measures include those associated with transportation demand management, smart growth/urban planning, burn control programs, and effective agricultural practices. Many of these programs are already in place within the region *(such as: the Okanagan Wood Stove Exchange Program, Land Clearing and Backyard Burning Ban - Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program – Orchard Replacement and Pruning Materials).* These low cost, easily implemented emissions reduction cost measures should receive the highest priority.

[10] Note: for information on the Federal Agenda on Clean Air, refer to Environment Canada, The Clean Air Agenda – Clean Air On-line website, *http://www.ec.gc.ca/cleanair-airpur/Clean_Air_Agenda-WS51062DA3-1_En.htm*

RÉSUMÉ

Contexte

Le présent rapport examine la qualité de l'air dans le district régional d'Okanagan centre *(Kelowna – Okanagan University College)* et le district régional d'Okanagan nord *(Vernon – Science Centre)*. L'examen des données sur la qualité de l'air de Kelowna *(Okanagan University College)* révèle que la région d'Okanagan centre respecte présentement les limites des standards pancanadiens (SP) relatifs aux particules et à l'ozone. Cependant, étant donné qu'il n'y a pas de niveau d'exposition sans danger à ces deux polluants atmosphériques et que des seuils acceptables n'ont pas été établis de façon concluante, il est souhaitable de poursuivre les efforts pour améliorer la qualité de l'air[11].

Les particules et l'ozone ont des effets connus sur la santé et autres. Par conséquent, les améliorations concernant ces deux polluants atmosphériques ont des avantages pour le bien-être collectif. Utilisant le Modèle d'évaluation de la qualité de l'air (MEQA) (version 3.0) avec des modifications à la base de données choisie par défaut, le rapport donne des estimations des résultats pour la santé et des avantages monétisés liés à l'amélioration de la qualité de l'air (*$PM_{2.5}$ et ozone*) par rapport aux concentrations ambiantes de référence[12]. Le rapport montre que même de faibles améliorations de la qualité de l'air *($PM_{2.5}$ et ozone)* auront des avantages économiques substantiels.

L'analyse des avantages fournie ici suit des méthodes d'estimation généralement acceptées concernant l'amélioration de la qualité de l'air qui ont été utilisées à des fins de planification par d'autres instances. Le MEQA est un outil de modélisation reconnu qui a été élaboré pour Santé Canada et Environnement Canada en vue d'évaluer (*quantifier et monétiser*) les effets sur la santé et d'autres qui découlent d'améliorations de la qualité de l'air. Le modèle calcule les effets et des estimations d'avantages monétisés en utilisant la « *fonction de dommage* », qui est basée sur des changements marginaux de la qualité de l'air spécifiés par l'analyste. Le MEQA estime une gamme de résultats et de valeurs monétisées (*qualifiées comme suit : faible, centrale, élevée et moyenne*) en se basant sur des fonctions de réponse à des concentrations faibles, centrales et élevées et sur des valeurs faibles, centrales et élevées des résultats pour la santé inclus dans le modèle. Le MEQA utilise également des techniques de simulation de Monte Carlo pour calculer une distribution de probabilités qui donne des estimations faibles, moyennes, centrales et élevées.

Le MEQA a été utilisé dans l'analyse coûts-avantages menée pour les standards pancanadiens (SP) relatifs aux PM et à l'ozone *(juillet-août 1999)*[13]. Plus récemment, les informations contenues dans le MEQA ont également été utilisées dans l'étude *« Health and Air Quality 2005 – Phase 2 – Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report » (juillet 2005)*[14]. L'analyse des avantages effectuée dans la présente étude utilise des approches semblables à celles utilisées pour le district régional du Grand Vancouver (DRGV) et le district régional de la vallée du Fraser (DRVF) dans le rapport ci-dessus.

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[11] Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc., Damian Crawley M.Sc.-RWDI West Inc., *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (mai 2003), (p. 28).

[12] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita, Environment Canada, David Stieb, Santé Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (3 septembre 1999). **Remarque** : des modifications ont été apportées à la base de données sur les fonctions de réponse à la concentration choisies par défaut dans le MEQA (version 3.0) pour la mortalité due aux PM, la mortalité due à l'ozone et les VRE, ces modifications étant basées sur : Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc., Damian Crawley M.Sc.-RWDI West Inc., *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (mai 2003), (p. 51, 113-114); voir également Jessiman, Barry, Santé Canada, communication privée (courriel) (21 juillet 2003). Étant donné que les valeurs des résultats pour la santé dans la base de données du MEQA (version 3.0) choisie par défaut sont exprimées en dollars canadiens de 1996, elles ont été converties en dollars canadiens de 2003.

[13] De Civita, Paul, Environnement Canada, Lauraine G. Chestnut, David Mills, Robert D. Rowe – Stratus Consulting Inc., David Stieb-Health Canada, *Human Health and Environmental Benefits of Achieving Alternative Canada Wide Standards for Inhalable Particles (PM2.5, PM10 and Ground Level Ozone, Final Report.* Préparé pour : Le Comité d'élaboration des standards pancanadiens relatifs aux PM et à l'ozone (25 juillet 1999); Compendium of Benefits Information (17 août 1999).

[14] Furberg, Maria M.Sc., Kathy Preston, PhD., P. Eng – RWDI Air Inc., Dave Sawyer – Marbek Resource Consultants, Dr. Michael Brauer – School of Occupational & Environmental Hygiene UBC, Dr. Robin Hanvelt – Department of Health Care and Epidemiology UBC, *Health and Air Quality 2005 – Phase 2: Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report*, B.C. Lung Association, (15 juillet 2005).

Estimations des résultats pour la santé et les avantages monétisés

Les résultats pour la santé et autres paramètres évalués dans le rapport sont ceux du MEQA (version 3.0) : *mortalité, hospitalisations pour maladies respiratoires, hospitalisations pour maladies cardiaques, visites aux urgences, bronchite chronique chez les adultes, bronchite chez les enfants, nombre de jours de symptômes d'asthme, nombre de jours de symptômes respiratoires graves, nombre de jours d'activité restreinte, nombre de jours d'activité minimalement restreinte, souillure de matériaux domestiques, et dommages aux cultures (maïs)*[15].

Les résultats estimés utilisent la base de données de fonctions de réponse à la concentration (FRC) du MEQA (version 3.0) choisie par défaut, avec des modifications aux estimations de la mortalité liée aux PM selon les recommandations de l'étude sur la santé de la BC Lung Association[16]. Les valeurs monétaires des résultats pour la santé inclus dans l'analyse des avantages sont basés sur les données du MEQA (version 3.0) – qui ont été mises à jour *(augmentées)* dans ce rapport pour tenir compte de la valeur du dollar canadien en 2003[17].

Les effets sur la santé évités et les estimations monétisées des avantages liés à une réduction de 10 % des $PM_{2.5}$ et de l'ozone qui serait réalisée dans l'année de simulation 2005 pour le district régional d'Okanagan nord et celui d'Okanagan centre par rapport aux niveaux de référence pour la qualité de l'air ambiant *(moyennés sur la période 2002-2004)* sont résumés dans les tableaux ci-dessous[18].

District régional d'Okanagan nord	**Estimations des avantages annuels – baisse de 10 % des $PM_{2.5}$ et de l'ozone** (année de simulation 2005, basées sur les estimations centrales)			
	Référence $PM_{2.5}$ = 7,61 µg/m³ *Moy. ann. de la moy. quot. (année civile) (moy. 2002-2004)*		**Référence Ozone = 34,03 ppb** *Moy. ann. de la moy. quot. (mai-sept.) (moy. 2002-2004)*	
Paramètres relatifs à la santé	**Nombre d'effets**	**Estimation**	**Nombre d'effets**	**Estimation**
Mortalité chronique	1,21	5 734 170 $	0,11	513 608 $
Mortalité aiguë	0,30	1 433 540 $	-	-
Bronchite chronique	3,38	1 106 230 $	-	-
Hospitalisations pour maladies respiratoires	0,26	2 036 $	0,45	3 470 $
Hospitalisations pour maladies cardiaques	0,22	2 188 $	-	-
Visites aux urgences	1,13	760 $	1,81	1 218 $
Nombre de jours de symptômes d'asthme	433,50	22 109 $	578,91	29 524 $
Nombre de jours d'activité restreinte	3 858,27	339 527 $	-	-
Nombre de jours d'activité minimalement restreinte	-	-	1 748,34	64 689 $
Nombre de jours de symptômes respiratoires graves	5 569,91	89 119 $	3 380,62	54 090 $
Bronchite chez les enfants	22,46	7 884 $	-	-
Souillure de matériaux domestiques	25 636,50	106 135 $	-	-
Dommages aux cultures	-	-	312,87	8 710 $
Total	-	**8 843 690 $**	-	**675 309 $**

15 **Remarque** : Ces effets sur la santé et autres effets sont définis à la page 95 du rapport.

16 Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc., Damian Crawley M.Sc.-RWDI West Inc., *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (mai 2003), (p. 51, 113-114). **Remarque** : des modifications de la mortalité liée à l'ozone et des VRE ont également été apportées à la base de données du MEQA (version 3.0) choisie par défaut suite à des recommandations récentes de Santé Canada. Voir Jessiman, Barry, Santé Canada, communication personnelle (courriel) (21 juillet 2003).

17 **Remarque** : Les valeurs monétaires des effets sur la santé de la base de données du MEQA (version 3.0) choisie par défaut sont en dollars canadiens de 1996. Source : Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita, Environnement Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (3 septembre 1999), (p. 5-20 et 5-31). Ces valeurs ont été converties *(augmentées)* en dollars canadiens de 2003 pour les résultats cités dans ce rapport.

18 **Remarque** : Les tableaux montrent les valeurs estimatives centrales des effets sur la santé et des avantages monétisées. Pour les estimations basses, moyennes et élevées, voir les pages 46 et 47 du présent rapport.

District régional d'Okanagan centre	Estimations des avantages annuels – baisse de 10 % des $PM_{2.5}$ et de l'ozone (année de simulation 2005, basées sur les estimations centrales)			
	Référence $PM_{2.5}$ = 6,78µg/m^3 *Moy. ann. de la moy. quot. (année civile) (moy. 2002-2004)*		Référence Ozone = 44,57 ppb *Moy. ann. de la moy. quot. (mai-sept.) (moy. 2002-2004)*	
Paramètres relatifs à la santé	**Nombre d'effets**	**Estimation**	**Nombre d'effets**	**Estimation**
Mortalité chronique	2,27	10 758 100 $	0,30	1 412 730 $
Mortalité aiguë	0,57	2 689 530 $	-	-
Bronchite chronique	6,50	2 126 380 $	-	-
Hospitalisations pour maladies respiratoires	0,49	3 819 $	1,23	9 545 $
Hospitalisations pour maladies cardiaques	0,41	4 105 $	-	-
Visites aux urgences	2,12	1 426 $	4,97	3 350 $
Nombre de jours de symptômes d'asthme	813,31	41 479 $	1 592,33	81 209 $
Nombre de jours d'activité restreinte	7 317,54	643 944 $	-	-
Nombre de jours d'activité minimalement restreinte	-	-	4 808,96	177 932 $
Nombre de jours de symptômes respiratoires graves	10 450,00	167 199 $	9 298,70	148 779 $
Bronchite chez les enfants	41,11	14 430 $	-	-
Souillure de matériaux domestiques	47 401,70	196 243 $	-	-
Dommages aux cultures	-	-	-	-
Total	-	**$16,646,630**	-	**$1,833,540**

__Remarque__ : Les résultats ci-dessus sont basés sur les estimations centrales; certains totaux ne sont pas exacts parce que les valeurs ont été arrondies et que l'on a utilisé une simulation de Monte Carlo. La réduction supposée de 10 % des $PM_{2.5}$ et de l'ozone est arbitraire et le rapport n'examine pas si elle est réalisable ou comment elle pourrait l'être. Les effets mentionnés sont des estimations (*résultats prévus annuels*). Le pourcentage de la valeur monétisée lié à la mortalité due aux $PM_{2.5}$ et à l'ozone est d'environ 80 %.

Comme on peut le voir, les avantages monétisés estimés réalisables avec ces améliorations de la qualité de l'air sont substantiels.

Sur la base des estimations centrales, une réduction de 10 % des $PM_{2.5}$ et de l'ozone (*à réaliser en 2005*) par rapport aux niveaux de référence de la qualité de l'air ambiant (*moyennés sur la période 2002-2004*) pour le district régional d'Okanagan nord se traduira par une valeur estimée de 8 843 690 $ pour les $PM_{2.5}$ *(avec des valeurs basse et haute de 3 479 951 $ et 16 786 620 $, respectivement)* et une valeur estimée de 675 309 $ pour l'ozone *(avec des valeurs basse et haute de 296 020 $ et 1 166 090 $, respectivement).*

Pour le district régional d'Okanagan centre, la valeur estimée pour les $PM_{2.5}$ est de 16 646 630 $ *(avec des valeurs basse et haute de 6 581 351 $ et 31 577 950 $, respectivement),* et la valeur estimée pour l'ozone est de 1 833 540 $ *(avec des valeurs basse et haute de 797 268 $ et 3 185 580 $, respectivement).*

À noter que les estimations ci-dessus sont des valeurs annuelles. Par conséquent, les améliorations de la qualité de l'air auront des avantages sur plusieurs années (*concernant les effets évités*) durant chaque année où l'amélioration de la qualité de l'air sera maintenue.

Estimations de la valeur actualisée

Les tableaux ci-dessous présentent les estimations des avantages liés à une amélioration soutenue de 10 % de la qualité de l'air (*$PM_{2.5}$ et ozone*) par rapport aux concentrations de référence (*moyennées sur la période 2002-2004*) qui pourraient être réalisés au cours de la période de seize (16) ans 2005-2006. Étant donné qu'il y a une dimension inter-temporelle dans la réalisation de ces avantages, une gamme de taux d'actualisation (4 %, 6 % et 8 %) a été appliquée à ces valeurs.

Dans le district régional d'Okanagan nord, les estimations sont de 167 512 595 $ *(pour la période de 16 ans 2005-2020)*, actualisées à 120 700 438 $ à 4 %, 104 152 039 $ à 6 % et 90 780 782 $ à 8 %.

Dans le district régional d'Okanagan centre, les estimations sont de 341 157 335 $ *(pour la période de 16 ans 2005-2020)*, actualisées à 244 638 144 $ à 4 %, 210 610 267 $ à 6 % et 183 164 101 $ à 8 %.

	Valeurs actualisées pour les $PM_{2.5}$ et l'ozone District régional d'Okanagan nord 2005-2020 (période de 16 ans) *(Valeurs basées sur les estimations centrales liées à une amélioration de 10 % - année de simulation 2005)*			
	Taux = 0 %	**Taux = 4 %**	**Taux = 6 %**	**Taux = 8 %**
Mortalité	134 308 986 $	96 821 761 $	83 567 097 $	72 855 717 $
Morbidité	31 125 512 $	22 382 611 $	19 294 622 $	16 800 980 $
Autre	2 078 097 $	1 496 066 $	1 290 320 $	1 124 085 $
Total	**167 512 595 $**	**120 700 438 $**	**104 152 039 $**	**90 780 782 $**

	Valeurs actualisées pour les $PM_{2.5}$ et l'ozone District régional d'Okanagan centre 2005-2020 (période de 16 ans) *(Valeurs basées sur les estimations centrales liées à une amélioration de 10 % - année de simulation 2005)*			
	Taux = 0 %	**Taux = 4 %**	**Taux = 6 %**	**Taux = 8 %**
Mortalité	272 824 668 $	195 742 430 $	168 559 923 $	146 631 229 $
Morbidité	64 567 370 $	46 203 710 $	39 736 249 $	34 523 322 $
Autre	3 765 298 $	2 692 004 $	2 314 095 $	2 009 550 $
Total	**341 157 335 $**	**244 638 144 $**	**210 610 267 $**	**183 164 101 $**

Remarque : Les estimations de la mortalité représentent environ **80 %** des avantages monétisés liés aux $PM_{2.5}$ et à l'ozone mentionnés ci-dessus. L'estimation des avantages monétisés n'a pas tenu compte des impacts potentiels pour chaque année d'amélioration de la qualité de l'air.

À noter que les avantages estimés liés aux améliorations de la qualité de l'air découlant des réductions de PM et de l'ozone sont substantiels. Toutefois, une analyse future devrait également évaluer les coûts et comparer les coûts et les avantages en calculant la valeur actualisée nette associée à des mesures spécifiques visant à améliorer la qualité de l'air. La relation source-récepteur (*estimation du pourcentage de changement de la qualité de l'air à partir des changements des émissions*) devrait également être évaluée.

Incertitudes

Comme nous l'exposons dans le texte du document, il y a un certain nombre d'incertitudes entourant les estimations d'avantages de cette étude. Ce sont[19] :

-la valeur d'une vie statistique (VVS) utilisée pour monétiser la mortalité – *en cours de discussion*;
-le taux d'actualisation –*facteur approprié à utiliser*;
-les fonctions de réponse à la concentration (FRC) – *estimation de risque localement applicable*;
-utilisation des concentrations ambiantes de $PM_{2.5}$ *vs* celles de PM_{10} –*facteurs de conversion appropriés*;
-moniteurs TEOM *vs* échantillonneurs manuels à filtres – *différences de mesures*;
-autres effets non inclus dans l'étude – *non quantifiables*;
-mesure représentative de l'exposition – *liens entre la population et les dispositifs de surveillance de la qualité de l'air*;
-population et taux de croissance supposés – *estimations seulement.*

Conclusion générale de l'étude

Les améliorations de la qualité de l'air offrent des avantages pour la santé et d'autres. L'étude montre qu'une réduction de 10 % des $PM_{2.5}$ et de l'ozone offre des avantages annuels quantifiables pour le district régional d'Okanagan nord estimés à 8 843 690 $ pour les $PM_{2.5}$ *(avec des valeurs basse et haute de 3 479 951 $ et 16 786 620 $, respectivement)* et une valeur estimée de 675 309 $ pour l'ozone *(avec des valeurs basse et haute de 296 020 $ et 1 166 090 $, respectivement).*

Pour le district régional d'Okanagan centre, la valeur estimée pour les $PM_{2.5}$ est de 16 646 630 $ *(avec des valeurs basse et haute de 6 581 351 $ et 31 577 950 $, respectivement),* et la valeur estimée pour l'ozone est de 1 833 540 $ *(avec des valeurs basse et haute de 797 268 $ et 3 185 580 $, respectivement).*

L'étude montre également que des améliorations soutenues de la qualité de l'air entraîneront des avantages cumulatifs substantiels liés aux effets sur la santé évités durant de nombreuses années. Sur la base des estimations centrales, pour la période de 16 ans (*2005-2020*), le district régional d'Okanagan nord pourrait réaliser des avantages de 167 512 595 $ *(actualisés à 120 700 438 $ à 4 %, 104 152 039 $ à 6 %, et 90 780 782 $ à 8 %*), et le district régional d'Okanagan centre des avantages de 341 157 335 $ *(actualisés à 244 638 144 $ à 4 %, 210 610 267 $ à 6 %, et 183 164 101 $ à 8 %*).

Il existe également d'autres avantages non quantifiables, entre autres les effets sur le tourisme et sur les résidents locaux découlant des améliorations de la visibilité, la réduction des effets nuisibles sur les rendements agricoles locaux importants (*particulièrement les arbres fruitiers et les vignes*), les effets sur la foresterie, les effets sur la santé des animaux sauvages (*incidences sur la biodiversité, la chasse et les valeurs non utilitaires*), les effets sur les écosystèmes, les effets des dépôts/salissures sur les entreprises commerciales, et d'autres effets difficiles à quantifier (*y compris les risques de cancer à long terme liés aux polluants atmosphériques toxiques*) non inclus dans ce rapport; ces avantages pourraient être substantiels.

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[19] Remarque : On trouvera une discussion plus approfondie des incertitudes dans le corps du texte du rapport (voir p. 52-55).

Incidences sur les politiques
Il faudra poursuivre les efforts continus visant à réduire les émissions pour améliorer la qualité de l'air. Il s'agit là d'un défi permanent pour les gestionnaires de la qualité de l'air, au moment où l'on s'attend à ce que les régions d'Okanagan centre et nord voient une forte croissance démographique dans les années à venir. Dans un futur plus immédiat, les gestionnaires de la qualité de l'air devront également faire face à l'obligation de satisfaire aux standards pancanadiens (SP) relatifs aux particules (PM) et à l'ozone troposphérique d'ici 2010. Les améliorations de la qualité de l'air seront facilitées par le programme fédéral d'assainissement de l'air qui entraînera le remplacement graduel du parc de véhicules par des véhicules plus propres[20].

L'étude montre que ce sont les politiques visant à réduire les particules qui auront l'impact le plus grand, car elles offrent les meilleurs avantages pour le bien-être collectif. Cependant, un examen des coûts est également nécessaire afin de connaître les avantages nets pour le bien-être collectif qui sont liés à des stratégies spécifiques de gestion de la qualité de l'air. L'établissement du lien entre les coûts et les avantages exige également que l'on connaisse et comprenne la relation source-récepteur (*c.-à-d. le pourcentage de changement de la qualité de l'air découlant d'un changement donné des émissions*).

On sait que les coûts des mesures visant à améliorer la qualité de l'air varient substantiellement. Bien qu'un examen exhaustif des coûts liés à diverses mesures de réduction des émissions dans les régions d'Okanagan centre et nord n'ait pas été effectué dans ce rapport, certaines mesures sont peu onéreuses et faciles à mettre en œuvre. Les mesures liées à la gestion de la demande en moyens de transport, à la planification intelligente de la croissance/urbanisation, aux programmes de surveillance des brûlages et aux pratiques agricoles efficaces sont relativement peu onéreuses. Plusieurs de ces programmes sont déjà en place dans la région *(exemples : Okanagan Wood Stove Exchange Program, Land Clearing and Backyard Burning Ban - Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program – Orchard Replacement and Pruning Materials*). Ce sont ces mesures de réduction des émissions peu onéreuses et faciles à mettre en œuvre qui devraient recevoir la plus haute priorité.

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20 **Remarque** : Pour de plus amples renseignements sur le Programme de l'air pur du gouvernement fédéral, visiter le site Web d'Environnement Canada intitulé *Programme relatif à l'air pur* à l'adresse *http://www.ec.gc.ca/cleanair-airpur/default.asp?lang=Fr&n=51062DA3-1*

Health Effects and Benefits Estimates Associated with Air Quality Improvements Particulate Matter (PM2.5) and Ground Level Ozone

Central Okanagan Regional District
North Okanagan Regional District

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STUDY OBJECTIVE

This report evaluates ground level ozone and particulate matter (PM) concentration levels at the air quality monitoring sites located within the Central Okanagan Regional District and the North Okanagan Regional District. Where the historical time series permits, the concentration levels are compared against the Canada Wide Standards (CWS) air quality guidelines for particulate matter (PM) and ground level ozone, and other relevant air quality standards.

The report also quantifies the annual health and other impacts, and estimates the monetized benefits associated with a 10% improvement in air quality *(ground level ozone and particulate matter PM2.5).*[21] The human health endpoints considered within the benefits analysis include: *mortality*, and *morbidity* effects such as: *adult chronic bronchitis, respiratory hospital admissions, cardiac hospital admissions, emergency room visits, child bronchitis, asthma symptom days, restricted activity days, minor restricted activity days, and acute respiratory symptom days.* Estimates associated with *corn crop damages* and *household materials soiling* are also included. The estimates are based on the default Air Quality Valuation Model (AQVM) (Version 3.0) database with modifications to concentration response functions (CRFs) for PM related mortality using locally applicable base mortality rates *(as recommended within the BC Lung Association Phase I health study)*, and ozone mortality and emergency room visits *(as per updated CRFs recommended by Health Canada).*[22] The analysis also contains updates to the dollar values of health outcomes included within the default AQVM (Version 3.0) database – updated *(inflated)* to year 2003.[23]

There exists many precedential studies evaluating the benefits associated with improvements in air quality. The benefits analysis provided within this report follows generally accepted estimation methods that have been used for planning purposes in other jurisdictions. The AQVM is a recognized quantitative modeling tool for air quality benefits analysis, and it was used in the cost/benefit analysis conducted for the *Canada-Wide Standards (CWS) for Particulate Matter (PM) and Ozone (July-August/1999).*[24] Another noteworthy study conducted for air quality improvements that employed similar techniques is the *"BC Clean Transportation Analysis Project"*, Alchemy Consulting Inc and Levelton Engineering Ltd, (January/2000).[25] More recently, the information set included within the AQVM (Version 3.0) was also relied upon within the study *"Health and Air Quality 2005 – Phase 2: Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report", (15/July/2005).*[26] The benefits analysis provided in this study employs similar approaches as was provided for the Greater Vancouver Regional District (GVRD) and the Fraser Valley Regional District (FVRD) within the afore-mentioned report.

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21 Note: the 10% improvement in PM and ozone is arbitrarily chosen and is of no particular significance. The value was used as an example that can be extrapolated from. The report does not evaluate whether/or/how the assumed 10% is achievable.

22 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 4-11 & D-2). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113-115). See also: Jessiman, Barry – Health Canada, Personal (e-mail) Communication, (21/July/2003).

23 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-20 & 5-31).

24 De Civita, Paul-Environment Canada, Lauraine G. Chestnut, David Mills, Robert D. Rowe – Stratus Consulting Inc, David Stieb- Health Canada, *Human Health and Environmental Benefits of Achieving Alternative Canada Wide Standards for Inhalable Particles (PM2.5, PM10 and Ground Level Ozone, Final Report*, Prepared for: The Canada Wide Standards Development Committee for PM and Ozone (25/July/1999); Compendium of Benefits Information, (17/August/1999).

25 Alchemy Consulting Inc, and Levelton Engineering Ltd, in association with Constable Associates Consulting Inc and Prof. Sara C. Pryor, Indiana University, *BC Clean Transportation Analysis Project – Final Report*, (January/2000).

26 Furberg, Maria M.Sc., Kathy Preston, PhD., P. Eng – RWDI Air Inc, Dave Sawyer – Marbek Resource Consultants, Dr. Michael Brauer – School of Occupational & Environmental Hygiene UBC, Dr. Robin Hanvelt – Department of Health Care and Epidemiology UBC, *Health and Air Quality 2005 – Phase 2: Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report*, B.C. Lung Association, (15/July//2005).

STRUCTURE OF THE REPORT

As a prelude to examining the state of the airshed and presenting the benefits analysis, the chemistry and the health and environmental issues associated with ground level ozone and particulate matter (PM) air pollution are briefly reviewed. This is discussed in Section 1 of the report. Section 2 presents estimates of the emissions inventory for the Central Okanagan Regional District over the period 1995-2005. This section also reviews and compares the available emissions inventory data with the ambient particulate matter (PM) and ozone air quality concentration data.

Section 3 examines the air quality levels registered at the monitoring sites within the Central Okanagan and the North Okanagan Regional District as compared against the Canada Wide Standards (CWS) for ground level ozone and particulate matter (PM) *(historical data permitting)*. Section 4 presents the baseline air quality concentration values, the population estimates, the concentration response functions (CRFs) and the dollar values of health outcomes used in the benefits analysis.

Section 5 presents the human health and other impacts, and the monetized benefits estimates associated with an arbitrary 10% improvement in ground level ozone and particulate matter (PM2.5) concentration. Within the analysis, the estimates are based on the default AQVM (Version 3.0) database with modifications to PM related mortality using locally applicable base mortality rates in accordance with the recommendations put forward within the BC Lung Association Phase I health study.[27] Modifications to the default AQVM (Version 3.0) database are also made to ozone related mortality and emergency room visits to reflect updates to the CRFs associated with these health endpoints as provided by Health Canada.[28] The analysis also includes updates to the dollar values of health outcomes contained within the default AQVM (Version 3.0) database updated *(inflated)* to year 2003.[29]

Section 6 outlines the uncertainties associated with the benefits estimates, section 7 presents the general conclusions of the study, section 8 reports the policy implications, and section 9 presents suggestions for additional work.

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27 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999). See also: Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113 & 115).

28 Ibid. See also: Jessiman, Barry – Health Canada, Personal (e-mail) communication (21/July/2003).

29 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-20 & 5-31).

Section #1 Chemistry and Health and Environmental Issues Associated with Ground Level Ozone and PM

The chemistry and the health and other environmental issues associated with ground level ozone and particulate matter (PM) are briefly reviewed below.

1.1 Ozone

Ground level ozone is a secondary pollutant that occurs in the atmosphere when precursor gases: nitrogen oxides (NOx) *(from fossil fuel combustion),* and volatile organic compounds (VOC) *(from motor vehicles, gasoline and solvent evaporation, oil and gas production, wood combustion, and natural biogenic sources)* react in the presence of sunlight and warm temperatures.[30]

Along with pre-cursor emissions, meteorological conditions and geographical features also influence the formation of ground level ozone.

Although a background level of ground level ozone occurs naturally, extreme levels are influenced by human activities.[31] Transportation and industry are the major anthropogenic sources of these pollutants.[32]

1.2 Particulate Matter (PM)

Particulate matter (PM) are microscopic particles suspended in the air. Smaller particulates of less than 10 micrometres (PM_{10} and $PM_{2.5}$) pose a health concern. Primary particulate matter (PM) is caused from sources such as dust, and wood smoke, whereas secondary particulates are formed in the atmosphere via physical or chemical transformations involving pre-cursor gases *(ie. sulphur dioxide* SO_2*, nitrogen oxides NOx, ammonia* NH_3*, and organic gases yielding particle sulphate, nitrate, and condensed organic compounds).*[33]

High temperature fuel combustion processes, transportation, and industry are the main anthropogenic sources of these pre-cursor gases.[34]

1.3 Health Effects

Scientific evidence clearly links ambient levels of ground level ozone concentration and human health impacts.[35] Scientific evidence has also established a link between small inhalable particulates *(PM<10 micrometres in size)* that enter the lungs, and human health.[36] Although guidelines exist establishing acceptable levels, there is no evidence of a lower threshold with respect to the exposure/response relationships associated with the human health effects of these two air pollutants.[37]

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30 Environment Canada, Clean Air On-line (Ground Level O3), *http://www.ec.gc.ca/cleanair-airpur/Ground_Level_Ozone-WS590611CA-1_En.htm.*

31 Environment Canada – *Fraser Valley Smog – An Indicator of Potential Air Quality Health Risk,* (14/September/2005), *http://www.ecoinfo.ec.gc.ca/env_ind/region/smog/smog_e.cfm.*

32 Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Ground-Level Ozone, Summary Science Assessment Document* (July/1999), (p. S-4).

33 Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Particulate Matter – Part 1: Science Assessment Document - A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines,* (1999), (p. 2-1).

34 Ibid. See also: Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Particulate Matter – Executive Summary - Part 1: Science Assessment Document - A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines,* (1999), (p. 2-1).

35 Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Ground-Level Ozone, Summary Science Assessment Document* (July/1999), (p. S-24 – S-40).

36 See also: Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Particulate Matter – Executive Summary - Part 1: Science Assessment Document - A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines,* (1999), (p. 10 - 13).

37 **Note:** In June/2000, the Canadian Council of Ministers of the Environment (CCME) endorsed the Canada Wide Standards (CWS) for PM and ozone. The CWS metric for ozone is: the 4th highest measurement annually (based on 8 hour averaging time) averaged over 3 consecutive years, must not exceed 65 ppb – by the year 2010. The CWS metric for PM2.5 is: the 98th percentile ambient measurement annually (based on 24 hour averaging time) (averaged over 3 consecutive years) must not exceed 30 ug/m^3 by the year 2010. See Canadian Council of Ministers of the Environment (CCME), *Canada Wide Standards for PM and Ozone,* June 5-6, 2000, (Part I). Note: in 1999, the Federal/Provincial Working Group on Air Quality Objectives and Guidelines established 20 ppb *(1 hr daily max)* as a health reference level for ozone *(ie. the level at which statistically significant increases in health effects have been detected - not interpreted as a threshold level for effects).* The established health reference level for PM2.5 is 15 ug/m^3 *(averaged over a 24 hour period)* - not interpreted as a threshold level for effects. See source: *Fraser Valley Smog – An Indicator of Potential Air Quality Health Risk, http://www.ecoinfo.ec.gc.ca/env_ind/region/smog/smog_e.cfm.* See also: Health Canada, Environment Canada, *National Ambient Air Quality Objectives for Ground-Level Ozone – Science Assessment Document,* (July/1999) (p. 13-6, 13-7 and 13-8). See also *National Ambient Air Quality Objectives for Particulate Matter – Part 1: Science Assessment Document,* (1999), (p. 14-3). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report,* British Columbia Lung Association, (May/2003), (p. 28, 29 & 30).

This implies that health benefits will still result from air quality improvements beyond the established guidelines.

Although healthy people may be affected by extreme air quality episodes, age and health status are important factors related to susceptibility to the effects of poor air quality.[38] Those suffering from certain health ailments and respiratory diseases face greater vulnerability to exposure.[39] The human health effects associated with air pollutants were recently reported in a study *"Health and Air Quality 2002 – Phase 1 – Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects"*. The study categorized the effects as *definite*, *probable* and *possible*. The effects reported for fine particles *(PM10, PM2.5)* and ozone are itemized in table #1 below.[40]

TABLE #1
Summary of Effects of Individual Air Pollutants and Mixtures at Current Ambient Levels of Exposure

Pollutant	Definite Effects	Probable Effects	Possible Effects
Fine Particles (PM_{10}, $PM_{2.5}$)	-Time-series and cohort association with daily respiratory and cardiac mortality -Aggravation of asthma -Increased hospital admissions for respiratory and cardiac conditions -Depressed lung function in schoolchildren (acute & chronic) -Increased prevalence of bronchitis -Increased risk of lung cancer -Increased school absences -Increase in banded neutrophils	-Aggravation of acute respiratory infections -Increased risk of wheezy bronchitis in infants 4-12 months -Decreased rate of lung growth in children -Increased exhaled NO -Tachycardia in the elderly -Reduced heart rate variability -Increased c-reactive protein -Increased blood vessel constriction	-Decreased birth weight -Increased blood fibrinogen -Increased asthma prevalence
Ozone	-Increased hospital admissions for acute respiratory diseases -Aggravation of asthma -Increased bronchial responsiveness -Increased response to SO_2 -Increased reduced activity days -Increased school absences for respiratory illness -Reduced lung function	-Effect on mortality -Increased sensitivity to allergens	-Aggravation of acute respiratory infections -Chronic bronchiolitis with repetitive exposure -Increased prevalence of asthma

Source: Bates, Dr. David V. -University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report", British Columbia Lung Association, (May/2003), (p. 37).

[38] Health Canada – Environmental & Workplace Health, Health Effects of Air Pollution, *http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/effe/health_effects-effets_sante-e.html.*

[39] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 27 & 28).

[40] Ibid, (p. 37).

1.4 Other Effects Ozone and PM

High concentrations of ground level ozone also negatively impact eco-systems and natural vegetation. Agricultural crops may experience yield losses, and certain tree species are also sensitive to ozone which may impact growth rates by affecting biomass, height and photosynthesis.[41]

Although there is limited information about the effects of particulate matter (PM) on vegetation due to lack of exposure-response information, particulate matter (PM) deposition on vegetation is believed to cause increased susceptibility to disease, and decreased photosynthesis.[42] Fine particles also affect materials by soiling, eroding and corroding surfaces.[43] Particulate matter is the most visible air pollutant causing smog and reduced visibility.[44]

Acid deposition also results from pre-cursor emissions *(sulphur dioxide [SOx], nitrogen oxides [NOx] and volatile organic compounds [VOC]).* As acid deposition may adversely impact aquatic chemistry, recreational and commercial fishing damages *(ie. catch per/unit of effort)* are also associated with poor air quality.[45]

There is a large body of literature evaluating the change in risk associated with changes in ozone and particulate matter (PM) air pollution. Within the literature base, this relationship is generally defined by concentration response functions (CRFs). The literature is used by analysts to evaluate *(quantify and monetize)* the benefits associated with air quality improvements pertaining to many of these health and other outcomes.

The AQVM is a recognized quantitative modeling tool *(developed for Health Canada and Environment Canada)* to estimate *(quantify and monetize)* the health and other effects associated with air quality improvements.[46] The information set contained within the AQVM (Version 3.0) includes a CRF database for each health and other endpoint, as well as dollar values associated with each quantifiable outcome. The application of the AQVM CRF database for the benefits analysis provided within this report will be discussed in more detail in Section #4 of this report.

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[41] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Ground Level Ozone – Summary: Science Assessment Document – Report by Federal/Provincial Working Group on Air Quality Objectives & Guidelines, (July/1999) (p. s-16 –to- s-23,).

[42] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Particulate Matter, Part 1, Science Assessment Document – A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, (1999), (p. 8-1, 8-2).

[43] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Particulate Matter, Part 1, Science Assessment Document – A Report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, (1999), (p. 9-3).

[44] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Particulate Matter, Executive Summary – Part 1: Science Assessment Document, (1998), (p. 8 –to- 10).

[45] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999, (p. 5-61).

[46] Ibid.

Section #2 Air Quality Monitoring Sites Within the Central Okanagan and the North Okanagan Regional Districts and Emissions Inventories

Within the North Okanagan Regional District and the Central Okanagan Regional District ground level ozone and particulate matter (PM) are monitored at locations in Vernon and Kelowna as noted in table #2 below.

TABLE #2
Location of Air Quality Monitoring Sites Within the Central Okanagan and the North Okanagan Regional Districts

District	Monitoring Location	Pollutant	Time Series
Central Okanagan Regional District	**Kelowna** (Okanagan University College)	Ozone	Aug/1983 – Present
		PM10	Jan/1994 – Present
		PM2.5	Nov/1997 – Present
North Okanagan Regional District	**Vernon** (Science Centre)	Ozone	Oct/2002 – Present
		PM10	Oct/2002 – Present
		PM2.5	Oct/2002 – Present

Within the Central Okanagan Regional District a lengthy historical ozone series has been recorded at Kelowna *(Okanagan University College)* extending over the period August/1983 to present. At the same monitoring location, PM10 has been monitored since January/1994 to present, and PM2.5 has been monitored since November/1997 to present.

Within the North Okanagan Regional District, ground level ozone and particulates (PM10 and PM2.5) have been monitored at Vernon *(Science Centre)* effective October/2002 to present.

2.1 Emissions Inventory Central Okanagan Regional District

Emissions inventory values for area, mobile and point sources were provided by the Central Okanagan Regional District for the year 1995.[47] These values are shown in table #3 below. Emissions inventory values for point sources for the year 2000 were also provided by the Central Okanagan Regional District *(as shown in table #3 below). (Note: area and mobile source emissions estimates were provided for year 1995 only, they are assumed to be constant in the year 2000). (Note: emissions inventory estimates for the North Okanagan Regional District were not available for this report).*

47 Davis, Corey – City of Kelowna, Personal (e-mail) Communication, (August/2003).

		TABLE #3 Central Okanagan Regional District Emissions Inventory Estimates (Tonnes) (1995 and 2000)						
Tonnes of Emissions		**NOx**	**VOC**	**SOx**	**PM2.5**	**PM10**	**NH3**	**CO**
1995	**Area Sources**	499.42	5,444.01	1,303.68	866.92	2,500.59	157.88	2,763.15
	Mobile Sources	2,280.60	1,366.15	66.92	126.88	144.99	49.17	12,949.58
	Point Sources	378.11	498.53	40.35	803.01	1,207.10	0.00	5,900.31
	TOTAL	**3,158.13**	**7,308.69**	**1,410.95**	**1,796.81**	**3,852.68**	**207.05**	**21,613.04**
2000	**Area Sources**	-	-	-	-	-	-	-
	Mobile Sources	-	-	-	-	-	-	-
	Point Sources	869.65	207.42	71.09	450.83	667.83	216.00	1,043.62
	TOTAL	**3,649.67**	**7,017.58**	**1,441.69**	**1,444.63**	**3,313.41**	**423.05**	**16,756.35**

Note: table prepared using data provided from source: Corey Davis – City of Kelowna (Personal Communication – August/2003).
Note: area and mobile source emissions estimates were provided for year 1995, they are assumed to be the same in year 2000.
Note: **NOx**=Nitrogen Oxide, **VOC**=Volatile Organic Compounds, **SOx**=Sulphur Oxide, **PM**=Particulate Matter, **NH3**=Ammonia, **CO**=Carbon Monoxide.

The emissions inventory estimates for the Central Okanagan Regional District for the period 1995 –to– 2005 are presented in table #4 below. The estimates for 1996 –through– 1999 were derived by linearly interpolating between the available 1995 and 2000 values *(based on the emissions inventory estimates presented in table #3 above).*

In table #4 below, the estimated values for 2001 –through– 2005 were derived by noting the emissions reduction estimates associated with the air quality management programs in place within the Central Okanagan Regional District over the period *(as provided by C. Davis) (ie. the Great Okanagan Wood Stove Exchange Program, Land Clearing Burn Ban, Backyard Burn Ban–Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program-Orchard Replacement and Orchard Pruning Material).*[48]

TABLE #4
Central Okanagan Regional District
Emissions Inventory Estimates (1995-2005) (Tonnes)

Year	NOx	VOC	SOx	Direct PM10	Direct PM2.5	NH3	CO
1995	**3,158.13**	**7,308.69**	**1,410.95**	**3,852.68**	**1,796.81**	**207.05**	**21,613.04**
1996	*3,256.44*	*7,250.47*	*1,417.10*	*3,744.83*	*1,726.37*	*250.25*	*20,641.70*
1997	*3,354.75*	*7,192,25*	*1,423.25*	*3,636.97*	*1,655.94*	*293.45*	*19,670.36*
1998	*3,453.05*	*7,134.02*	*1,429,39*	*3,529.12*	*1,585.50*	*336.45*	*18,699.03*
1999	*3,551.36*	*7,075.80*	*1,435.54*	*3,421.26*	*1,515.07*	*379.85*	*17,727.69*
2000	**3,649.67**	**7,017.58**	**1,441.69**	**3,313.41**	**1,444.63**	**423.05**	**16,756.35**
2001	*3,649.26*	*6,994.75*	*1,441.65*	*3,310.61*	*1,441.83*	*423.05*	*16,729.85*
2002	*3,637.19*	*6,920.81*	*1,439.64*	*3,298.51*	*1,429.73*	*423.05*	*16,545.75*
2003	*3,613.61*	*6,783.85*	*1,435.70*	*3,275.78*	*1,407.00*	*423.05*	*16,195.39*
2004	*3,610.21*	*6,766.78*	*1,435.13*	*3,271.23*	*1,402.45*	*423.05*	*16,147.59*
2005	*3,606.81*	*6,749.71*	*1,434.56*	*3,266.68*	*1,397.90*	*423.05*	*16,099.79*

Note: Yr 1995 area, mobile & source emissions inventory ests were provided by C. Davis–City of Kelowna. Yr 2000 point source ests were provided by C. Davis–City of Kelowna. Area and mobile source emissions inventory ests assumed to be constant in yr 2000. Yr 1996-1999 emissions inventory ests were linearly interpolated between available endpoints. Reduction ests for 2001-2005 were derived by noting the emissions reduction ests associated with the air quality management programs in place within the Central Okanagan Reg Dist over the period *(as provided by C. Davis) (ie. the Great Okanagan Wood Stove Exchange Program, Land Clearing Burn Ban, Backyard Burn Ban–Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program-Orchard Replacement & Pruning Material).* Note: **NOx**=Nitrogen Oxide, **VOC**=Volatile Organic Compounds, **SOx**=Sulphur Oxide, **PM**=Particulate Matter, **NH3**=Ammonia, **CO**=Carbon Monoxide.

48 Ibid.

Table #5 below itemizes PM and ozone annual ambient air quality concentration levels in relation to estimated aggregate tonnes of pre-cursor and direct emissions. Note that between 1995 –to– 2004 yearly ozone concentration increased by 7.32%, whereas estimated ozone pre-cursor emissions *(NOx and VOC)* decreased by .86%. Between 1997 –to– 2004 annual PM2.5 concentration decreased by 8.53%, whereas estimated PM2.5 pre-cursor *(NOx, VOC and SOx)* and estimated direct emissions decreased by 3.11%. And between 1995 –to– 2004 annual average PM10 concentration decreased by 15.87%, whereas estimated PM10 pre-cursor *(NOx, VOC and SOx)* and estimated direct emissions decreased by 4.11%.

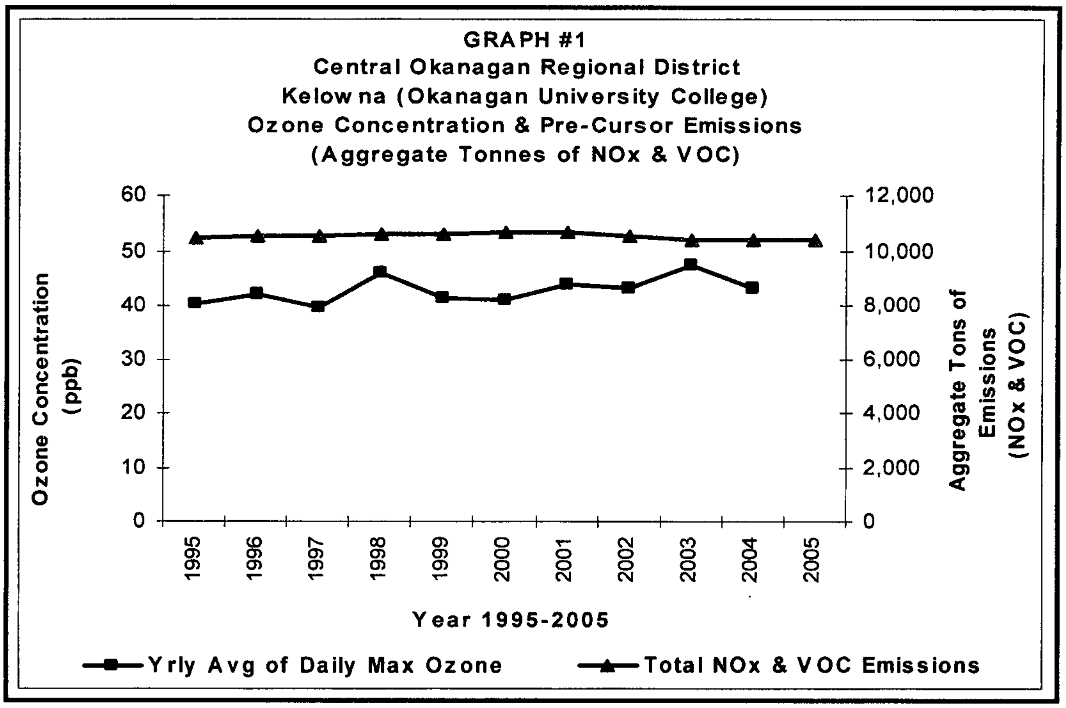
TABLE #5
Central Okanagan Regional District – Air Quality Concentration and Emissions Inventory Estimates (1995-2005)
(Aggregate Tonnes and Percentage Change)

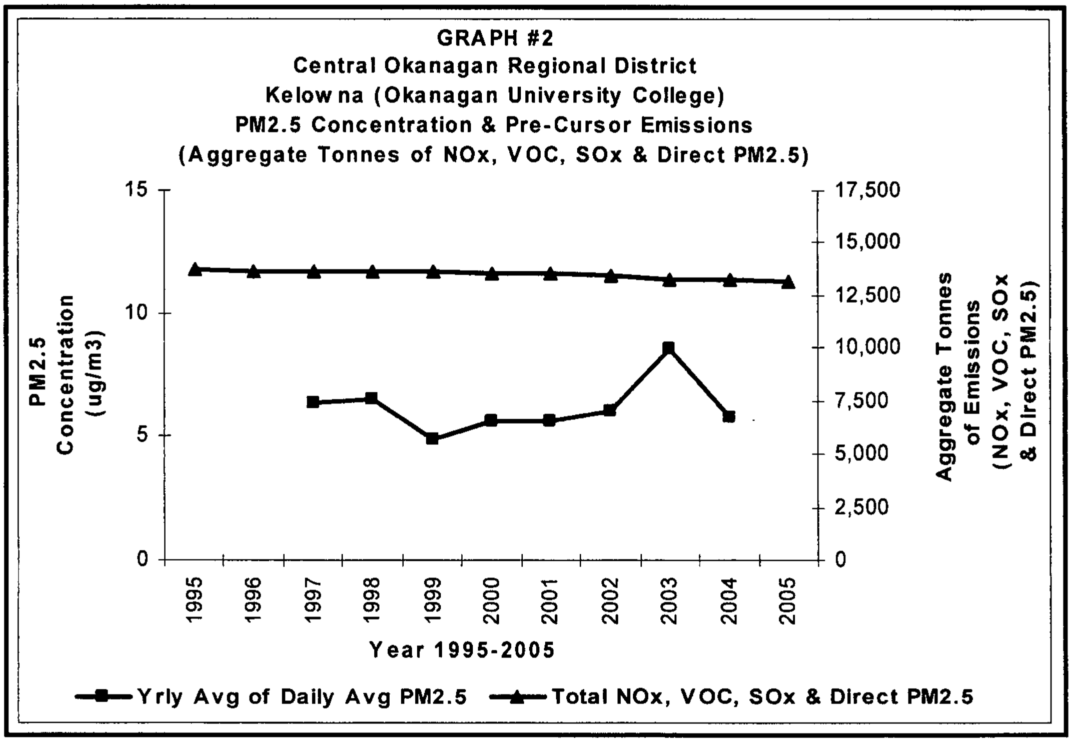
Year	Yrly Avg of Daily Max Ozone (ppb)		Yrly Avg of Daily Avg PM2.5 (ug/m^3)		Yrly Avg of Daily Avg PM10 (ug/m^3)		Ozone Pre-Cursor Emiss NOx & VOC		PM2.5 Pre-Cursor Emiss NOx, VOC, SOx & Direct PM2.5		PM10 Pre-Cursor Emiss NOx, VOC, SOx & Direct PM10	
1995	**40.32**		-		**17.33**		**10,466.82**		13,674.58		**15,730.52**	
1996	42.19	*4.64%*	-		16.13	*-6.92%*	*10,506.91*	*0.38%*	*13,650.38*		*15,668.83*	*-0.39%*
1997	39.75	*-1.41%*	**6.33**		15.51	*-3.84%*	*10,546.99*	*0.77%*	***13,626.18***		*15,607.21*	*-0.78%*
1998	46.02	*14.14%*	6.47	*2.21%*	16.66	*-7.41%*	*10,587.08*	*1.15%*	*13,601.97*	*-0.18%*	*15,545.59*	*-1.18%*
1999	41.30	*2.43%*	4.88	*-22.91%*	13.04	*-21.73%*	*10,627.16*	*1.53%*	*13,577.77*	*-0.36%*	*15,483.97*	*-1.57%*
2000	41.07	*1.86%*	5.57	*-12.01%*	14.16	*-8.59%*	**10,667.25**	*1.91%*	**13,553.57**	*-0.53%*	**15,422.35**	*-1.96*
2001	43.98	*9.08%*	5.58	*-11.85%*	14.95	*-5.58%*	*10,644.01*	*1.69%*	*13,527.49*	*-0.73%*	*15,396.27*	*-2.12%*
2002	43.23	*7.22%*	6.03	*-4.74%*	15.13	*-1.20%*	*10,558.00*	*0.87%*	*13,427.37*	*-1.47%*	*15,296.15*	*-2.76%*
2003	47.20	*17.06%*	8.53	*34.76%*	18.65	*-23.27%*	*10,397.46*	*-0.66%*	*13,240.16*	*-2.87%*	*15,108.94*	*-3.95%*
2004	**43.27**	*7.32%*	**5.79**	***-8.53%***	**15.69**	***-15.87%***	*10,376.99*	***-0.86%***	*13,214.57*	***-3.11%***	*15,083.35*	***-4.11%***
2005	-		-		-		*10,356.52*	*-1.05%*	*13,188.98*	*-3.31%*	*15,057.76*	*-4.28%*
Avg	**42.83**		**6.15**		**15.73**		**10,521.38**		**13,480.27**		**15,400.08**	

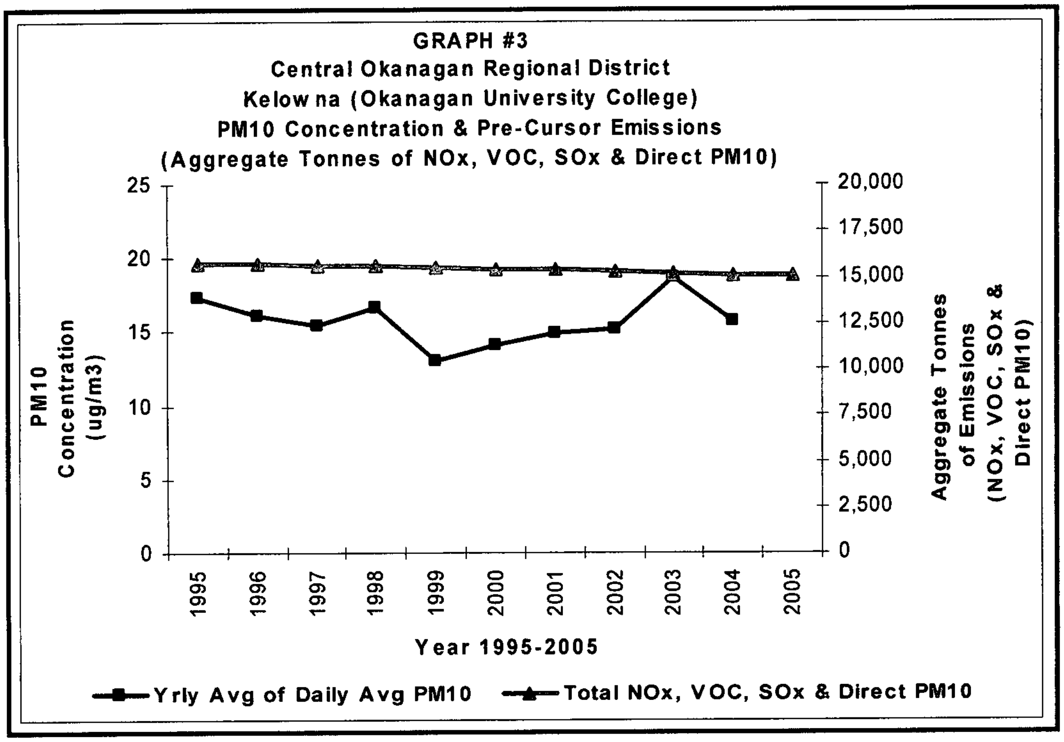
Note: ozone and PM concentration values derived using hourly data obtained from British Columbia Ministry of Water, Land and Air Protection (WLAP), Air Resources Branch, Atmospheric Data and AQI Web Service, *http://www.elp.gov.bc.ca (Unverified)*.
Note: Yr 1995 area, mobile & source emissions inventory ests provided by C. Davis–City of Kelowna. Yr 2000 point source ests derived from data provided by C. Davis–City of Kelowna. Area & mobile source emissions inventory ests derived from data assumed to be constant in yr 2000. Yr 1996-1999 emissions inventory ests were linearly interpolated between available endpoints. Reduction ests for 2001-2005 were derived by noting the emissions reduction ests associated with the air quality management programs in place within the Central Okanagan Reg Dist over the period *(as provided by C. Davis) (ie. the Great Okanagan Wood Stove Exchange Program, Land Clearing Burn Ban, Backyard Burn Ban–Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program-Orchard Replacement & Pruning Material)*.
Note: **NOx**=Nitrogen Oxide, **VOC**=Volatile Organic Compounds, **SOx**=Sulphur Oxide, **PM**=Particulate Matter, **NH3**=Ammonia, **CO**=Carbon Monoxide.

The graphs below (graph #1, #2 and #3) depict the Kelowna *(Okanagan University College)* concentration data *(yearly average of daily maximum ozone [ppb]), and yearly average of daily average PM2.5 and PM10 [ug/m^3])* plotted against the estimated aggregate tonnes of pre-cursor and direct emissions for the Central Okanagan Regional District.

The graphs reveal that aggregate tonnes of emissions have been decreasing in recent years. Excluding the year 2003 *(the Okanagan mountain forest fire year)* particulate matter (PM) concentration has also generally been declining since 1998, while ozone concentration has been increasing.


GRAPH #1
Central Okanagan Regional District
Kelowna (Okanagan University College)
Ozone Concentration & Pre-Cursor Emissions
(Aggregate Tonnes of NOx & VOC)
Ozone Concentration (ppb)
Aggregate Tons of Emissions (NOx & VOC)
60
50
40
30
20
10
0
12,000
10,000
8,000
6,000
4,000
2,000
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year 1995-2005
Yrly Avg of Daily Max Ozone
Total NOx & VOC Emissions


GRAPH #2
Central Okanagan Regional District
Kelowna (Okanagan University College)
PM2.5 Concentration & Pre-Cursor Emissions
(Aggregate Tonnes of NOx, VOC, SOx & Direct PM2.5)
PM2.5 Concentration (ug/m3)
Aggregate Tonnes of Emissions (NOx, VOC, SOx & Direct PM2.5)
15
10
5
0
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Year 1995-2005
Yrly Avg of Daily Avg PM2.5
Total NOx, VOC, SOx & Direct PM2.5



<u>Note</u>: year 2003 was the Okanagan mountain forest fire year.

Section #3 Air Quality Guidelines

Due to the health and environmental impacts associated with ground level ozone and particulate matter (PM), a number of guidelines, objectives and criteria have been established to minimize the associated human health risks and to protect the environment. These guidelines are briefly reviewed below.

3.1 Health Reference Level for Ozone and Particulate Matter (PM)

Although research suggests that there is no safe level of exposure to ground level ozone and particulate matter (PM), for measurement and comparison purposes, health reference levels have been established as a benchmark. In 1999, the *"Federal/Provincial Working Group on Air Quality Objectives and Guidelines"* established 20 ppb *(1 hour daily maximum)* as a health reference level for ozone.[49] The health reference levels established for particulate matter (PM) are: (PM_{10} – 25 ug/m^3), and ($PM_{2.5}$ – 15 ug/m^3) *(based on 24 hr averaging period).*[50] Note that the established health reference levels are not interpreted as thresholds below which impacts do not occur.

3.2 Canada Wide Standards (CWS)

The Canada Wide Standards (CWS) for particulate matter (PM) and ground level ozone were endorsed by the Canadian Council of Ministers for the Environment [CCME]) *(including federal, provincial and territorial governments – with the exception of Quebec)* on June 5th and 6th, 2000. The standards include a quantitative metric, a timetable for attaining the standard, a list of preliminary actions necessary to achieve the standard, and a public reporting framework. The numeric targets, and the established time-frames for attaining the standard for ground level ozone and particulate matter (PM) are summarized below.[51]

Ground Level Ozone Concentration
Based on an 8 hour averaging time – the fourth highest measurement annually, averaged over 3 consecutive years, is not to exceed 65 ppb, by the year 2010.

Particulate Matter (PM 2.5)
Based on 24 hour averaging time – the 98th percentile ambient measurement annually, averaged over 3 consecutive years is not to exceed 30 ug/m^3 by the year 2010.

In recognition of the lack of threshold levels for PM and ozone, the CWS also contained a stipulation for *"keeping clean areas clean"* and *"continuous improvements"* in areas that are already meeting the standards.[52] Note that the CWS metric is based on levels that were achievable throughout Canada. Consequently, the standards are heavily influenced by the existing poor air quality in southern Ontario and Quebec, which is generally more severe than air quality within British Columbia.

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[49] Environment Canada, Fraser Valley Smog - An Indicator of Potential Air Quality Health Risk, *http://www.ecoinfo.ec.gc.ca/env_ind/region/smog/smog_e.cfm.* See also: Health Canada, Environment Canada, National Ambient Air Quality Objectives for Ground-Level Ozone – Science Assessment Document, (July/1999) (p. 13-6, 13-7 and 13-8).

[50] Health Canada, Environment Canada, National Ambient Air Quality Objectives for Particulate Matter – Part 1: Science Assessment Document, (1999), (p. 14-3). See also: Environment Canada, The Clean Air Picture, AIR Sites on the PYR Green Lane, *http://www.pyr.ec.gc.ca/Air/Air_picture _e.htm* (p. 2).

[51] Canadian Council of Ministers of the Environment (CCME), Canadian Council of Ministers of the Environment – Canada-Wide Standards for Particulate Matter (PM) and Ozone, Endorsed by CCME Council of Ministers of the Environment, June 5-6, 2000, Quebec City (Part I).

[52] Canadian Council of Ministers of the Environment (CCME), Canada-Wide Standards for Particulate Matter (PM) and Ozone – Annex A – Guidance for Continuous Improvement and Keeping Clean Areas Clean Programs for PM and Ozone, Endorsed by CCME Council of Ministers, June 5-6, 2000, Quebec City.

3.3 Analysis of Air Quality Monitoring Sites Within the Central Okanagan and the North Okanagan Regional District

The tables below (table #6 and #7) present the Kelowna *(Okanagan University College)* and the Vernon *(Science Centre)* ground level ozone and particulate matter (PM) concentration data analyzed in relation to the Canada Wide Standard (CWS) metric.

TABLE #6
Canada Wide Standards (CWS) Metric - Ozone (ppb)
(Based on 8 hr averaging time – the 4th highest measurement annually) UNVERIFIED

Monitoring Site	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Kelowna Okanagan University College	63.24	50.87	57.99	55.71	56.36	58.34	58.42	60.48	57.00	60.46	59.60
Vernon Science Centre	-	-	-	-	-	-	-	-	-	48.27	42.88

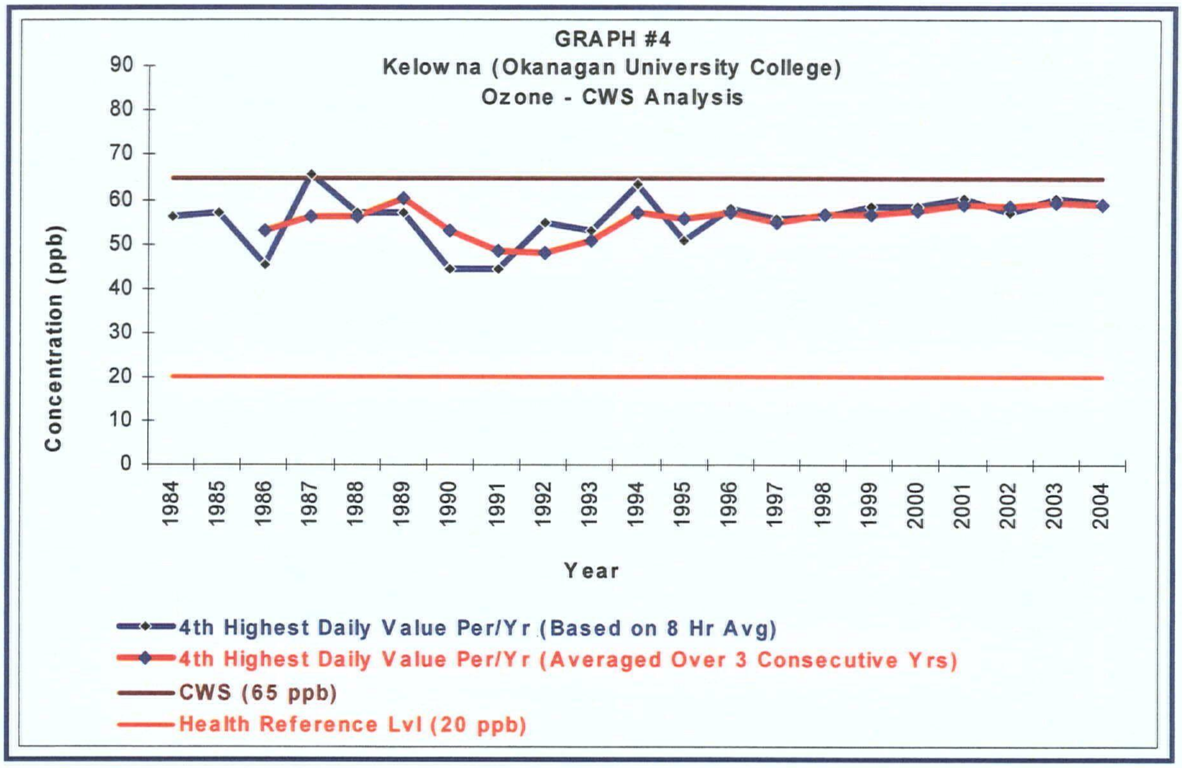
Note: values in this table estimated using hourly data obtained from BC Ministry of Water, Lands and Parks (WLAP), Air Data Archive, UNVERIFIED.
Note: Year 2002 - no data is available for Vernon Science Centre for the ozone season (series commences 15/Oct/2002).

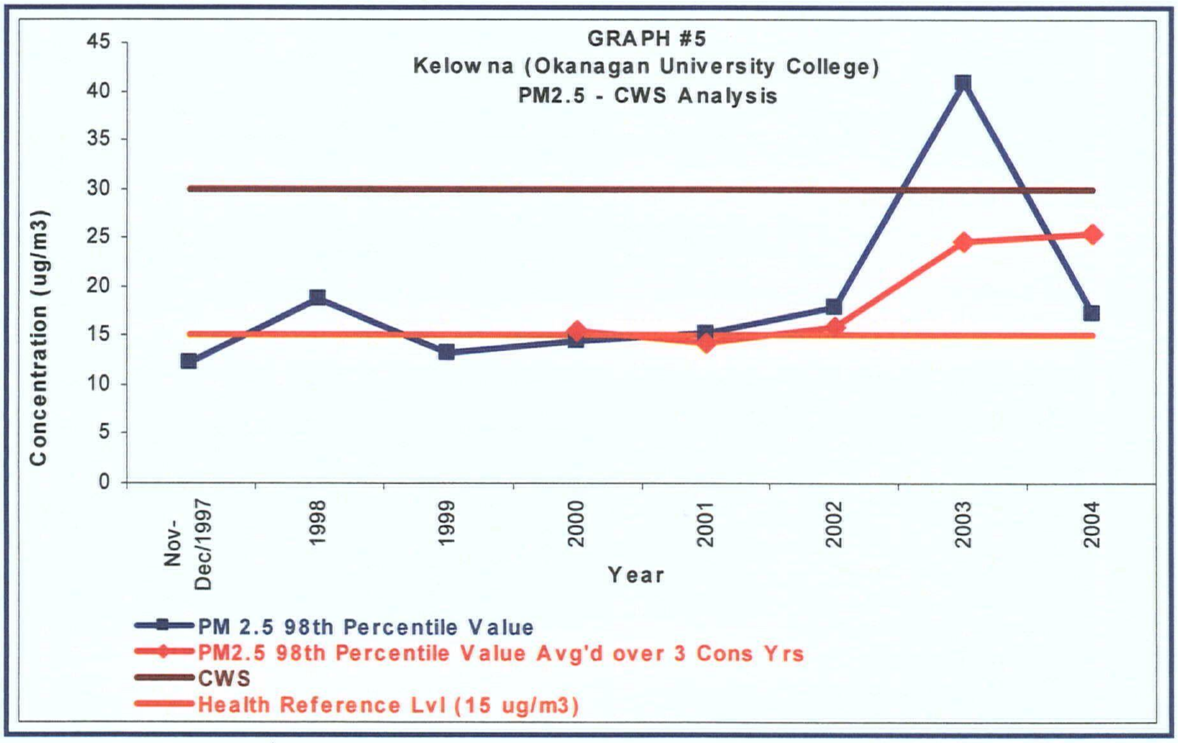
TABLE #7
Canada Wide Standards (CWS) Metric - PM 2.5 (ug/m^3)
(Based on 24 hr averaging time – the 98th percentile ambient measurement annually) UNVERIFIED

Monitoring Site	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Kelowna Okanagan University College	-	-	-	12.29** Omit	18.83	13.17	14.42	15.25	18.00	40.92***	17.21
Vernon Science Centre	-	-	-	-	-	-	-	-	24.13* Omit	27.38	18.67

Note: values in this table estimated using hourly data obtained from BC Ministry of Water, Lands and Parks, (WLAP) Air Data Archive, UNVERIFIED.
* only 76 data points available for Vernon Science Centre in calendar year 2002 (15/Oct/2002 - 31/Dec/2002).
** only 61 data points available for Kelowna College in calendar year 1997 (1/Nov/1997 - 31/Dec/1997).
*** year 2003 is the Okanagan mountain forest fire year.

The data presented in table #6 and #7 are graphically depicted below. Graph #4 and #5 below depict the Kelowna *(Okanagan University College)* ground level ozone and particulate matter (PM) concentration profiles presented in relation to the Canada Wide Standard (CWS) metric. *(Note: as the CWS metric requires at least three consecutive years of data to derive one data point, there is insufficient data available to evaluate the CWS metric for the Vernon Science Centre).*





Note: Year 2003 was the Okanagan mountain forest fire year.

Although there have been no exceedances of the CWS at the Kelowna *(Okanagan University College)* monitoring site over the historical record, due to the nature of the standard it is difficult to determine whether the trend will increase or decrease within the next few years. Local climate, geographical features and anthropogenic influences such as vehicle emissions and outdoor burning are key factors influencing regional air quality levels.[53] Given the significant population growth and expansion that is anticipated over the next decade, achievement and maintenance of the Canada Wide Standards (CWS) by the year 2010 and beyond will require continued and sustained efforts to improve air quality.

Although the ground level ozone and PM2.5 concentration levels at the Kelowna *(Okanagan University College)* air quality monitoring site do not exceed the CWS metric, there are still health and other effects associated with the current air quality levels. As can be seen in the following sections, there are substantial human health and monetary benefits to be realized by achieving marginal improvements *(or avoiding future increases)* in ground level ozone and particulate matter (PM) concentration within the region.

[53] *Regional Growth Strategy – Air Quality – Discussion Paper, Planning for the Future,* Regional District of Central Okanagan, District of Lake Country, District of Peachland, City of Kelowna, (October/2001), (p. 2).

Section #4 Air Quality Valuation Model (AQVM) (Version 3.0) - General

The Air Quality Valuation Model (AQVM) (Version 3.0) - with modifications to the default database - was used to estimate the impacts and the monetized benefits in this analysis.[54] The AQVM (Version 3.0) is a quantitative modeling tool that was developed for Environment Canada and Health Canada in September/1999 to evaluate the economic impacts associated with improved air quality. The model employs the *"damage function approach"* to estimate the health and other effects associated with changes in ground level ozone and particulate matter (PM). Within the AQVM (Version 3.0), the benefits are estimated through a series of five sequential steps:

Step #1 -the change in ambient air quality concentration is specified from established baseline concentration values.

Step #2 -concentration response functions (CRFs) are employed to define the risk associated with changes in exposure; using these CRFs low, central and high effects estimates are calculated within the AQVM (Version 3.0) for each health and other end-point.

Step #3 -monetary estimates are calculated using economic values derived from willingness to pay (WTP) techniques and cost-of-illness (COI) methods assigned to each health and other end-point.

Step #4 -uncertainty analysis is conducted using weighting assignments attached to the CRFs and the dollar values of health outcomes. A monte-carlo simulation generates a probability density function providing low, mean, and high value estimates.

Step #5 -the monetized estimates are aggregated in step #5.[55]

The AQVM (Version 3.0) has recently undergone an in-depth review. In a report dated June/2001, a Royal Society of Canada expert panel critically appraised the cost/benefit analysis prepared by Environment Canada in 1999, analyzing the impacts associated with the implementation of the Canada Wide Standards (CWS) for PM and ozone.[56] The CWS cost/benefit analysis employed the AQVM (Version 3.0) to quantify the effects and to monetize the benefits estimates.[57] The Royal Society report was comprehensive noting the strengths and weaknesses of the methodologies and the information set contained within the AQVM (Version 3.0) database suggesting areas for improvement in conducting future cost/benefit analyses.

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[54] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report,* (September 3, 1999). **Note**: the BC Lung Association Phase 1 health study recommended specific CRFs associated with PM mortality. For the morbidity estimates, the expert panel suggested using the default AQVM database – with updates provided by Health Canada. See: Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report,* British Columbia Lung Association, (May/2003), (p. 51, 65, 113 & 114).

[55] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report,* (September 3, 1999), (p. 2-1, 2-2, 2-3 & 2-4).

[56] Royal Society of Canada, *Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to The Royal Society of Canada,* (June/2001).

[57] De Civita, Paul, Lauraine G. Chestnut, David Mills, Robert D. Rowe, David Stieb, *Human Health and Environmental Benefits of Achieving Alternative Canada Wide Standards for Inhalable Particles (PM2.5, PM10 and Ground Level Ozone, Final Report,* July 25, 1999; *Compendium of Benefits Information* (17/August/1999).

Health Canada is currently working on a new air quality valuation tool referred to as the "*Air Quality Benefit Assessment Tool*" (AQBAT) that will update the AQVM (Version 3.0). The new AQBAT model was not available for use at the time of writing of this report.

Adaptation of the AQVM (Version 3.0) default database to conduct a benefits analysis for the Central Okanagan Regional District and the North Okanagan Regional District required the following:

-calculate baseline air quality values,
-determine population demographic statistics and population growth rates in accordance with the following sub-groups:
  -population under 20
  -population 20 and older
  -population 25 and older
  -population 65 and older
  -total population
  -number of households
-determine locally applicable mortality related concentration response functions (CRFs) derived from localized base mortality rates.

These data refinements are discussed below.

4.1 Baseline Air Quality Concentration Values

The metric required for the ozone benefits analysis within the AQVM (Version 3.0) is the yearly average of daily maximum ozone concentration *(expressed in ppb)* analyzed over the May-September ozone season. For particulate matter (PM) the metric used within the AQVM (Version 3.0) is yearly average *(of daily average)* values *(expressed in ug/m³)*.[58] The values are generally averaged over the most recent three years of available data to minimize the potential confounding effects of outlier years.

The annual concentration values calculated for use within the AQVM (Version 3.0) over the period (2002-2004) for the Central Okanagan Regional District and the North Okanagan Regional District are reported in table #8 below.[59]

TABLE #8
PM2.5, PM10 & Ozone - Concentration Values
Central Okanagan Regional District and North Okanagan Regional District (2002-2004)

Regional District	Monitoring Site	PM2.5 (ug/m³) (Calendar Year)			PM10 (ug/m³) (Calendar Year)			Ozone (ppb) (May-Sept Ozone Season)		
		Year	# of Days Included in Yr	Yrly Avg of Daily Avg	Year	# of Days Included in Yr	Yrly Avg of Daily Avg	Year	# of Days Included in Yr	Yrly Avg of Daily Max
Central Okanagan Regional District	**Kelowna** Okanagan University College	2002	365	6.03	2002	365	15.13	2002	153	43.23
		2003	365	8.53	2003	365	18.65	2003	153	47.20
		2004	366	5.79	2004	366	15.69	2004	153	43.27
		Avg		**6.78**	Avg		**16.49**	Avg		**44.57**
North Okanagan Regional District	**Vernon** Science Centre	2002	78	11.57 Omit	2002	76	24.72 Omit	2002	No Data	No Data
		2003	365	8.43	2003	365	22.60	2003	153	35.34
		2004	366	6.78	2004	365	21.18	2004	150	32.71
		Avg		**7.61**	Avg		**21.89**	Avg		**34.03**

Note: for year 2002, data is available for Vernon Science Centre from 15/Oct/2002 forward. Note: year 2003 was the Okanagan Mountain forest fire year.
Note: hrly data obtained from: British Columbia Ministry of Water, Land and Air Protection (WLAP), Air Resources Branch, Atmospheric Data and AQI Web Service, *(Unverified)*.

58 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 3-2).

59 Note: hourly data obtained from: British Columbia Ministry of Water Land and Air Protection (WLAP), Air Resources Branch, Atmospheric Data and AQI Web Service, *http://www.elp.gov.bc.ca, (Unverified)*.

From the data provided in table #8 above, it is noteworthy that the particulate matter (PM) concentration values are slightly higher in the North Okanagan Regional District, whereas the ground level ozone concentration levels are higher in the Central Okanagan Regional District. This may be an indication of different pollutant source mixes *(emissions),* particularly the influence of wood smoke in the North Okanagan Regional District.

Note that the particulate matter (PM) values are recorded at both the Kelowna *(Okanagan University College)* and the Vernon *(Science Centre)* monitoring sites using continuous tapered element oscillating microbalance (TEOM) sampler instruments. Hence the data at the two monitoring locations are directly comparable.

The baseline concentration values applied in the benefits analysis *(ie. the yearly concentration values averaged over the period 2002-2004)* and the values representing a 10% improvement in air quality are noted in table #9 below. Note that for the year 2002, PM data for Vernon *(Science Centre)* is only available from 15/Oct/2002 - 31/Dec/2002, so the data for that year was omitted from the baseline concentration averages applied in the benefits analysis.

TABLE #9
PM2.5 & Ozone Baseline Concentration Values Applied in the Benefits Analysis
Central Okanagan Regional District and North Okanagan Regional District

Regional District	Monitoring Site	PM2.5 (ug/m³) Yrly Avg of Daily Avg (Calendar Year)		Ozone (ppb) Yrly Avg of Daily Max (May-Sept Oz Season)	
		Baseline Avg (2002-2004)	New Value 10% Rdn	Baseline Avg (2002-2004)	New Value 10% Rdn
Central Okanagan	**Kelowna** Okanagan University College	6.78	6.10	44.57	40.11
North Okanagan	**Vernon** Science Centre	7.61	6.85	34.03	30.63
Average		7.20		39.30	

Note: from averages ∧ PM10 = 2.67 PM2.5
Note: values derived using hourly data obtained from: British Columbia Ministry of Water, Land and Air Protection (WLAP), Air Resources Branch, Atmospheric Data and AQI Web Service, *http://www.elp.gov.bc.ca, (Unverified).*

4.2 Population Demographics and Population Growth Rates

The municipal and regional district population estimates for the Central Okanagan and the North Okanagan for the years 2001, 2002, 2003 and 2004 are noted in the table #10 and #11 below.[60]

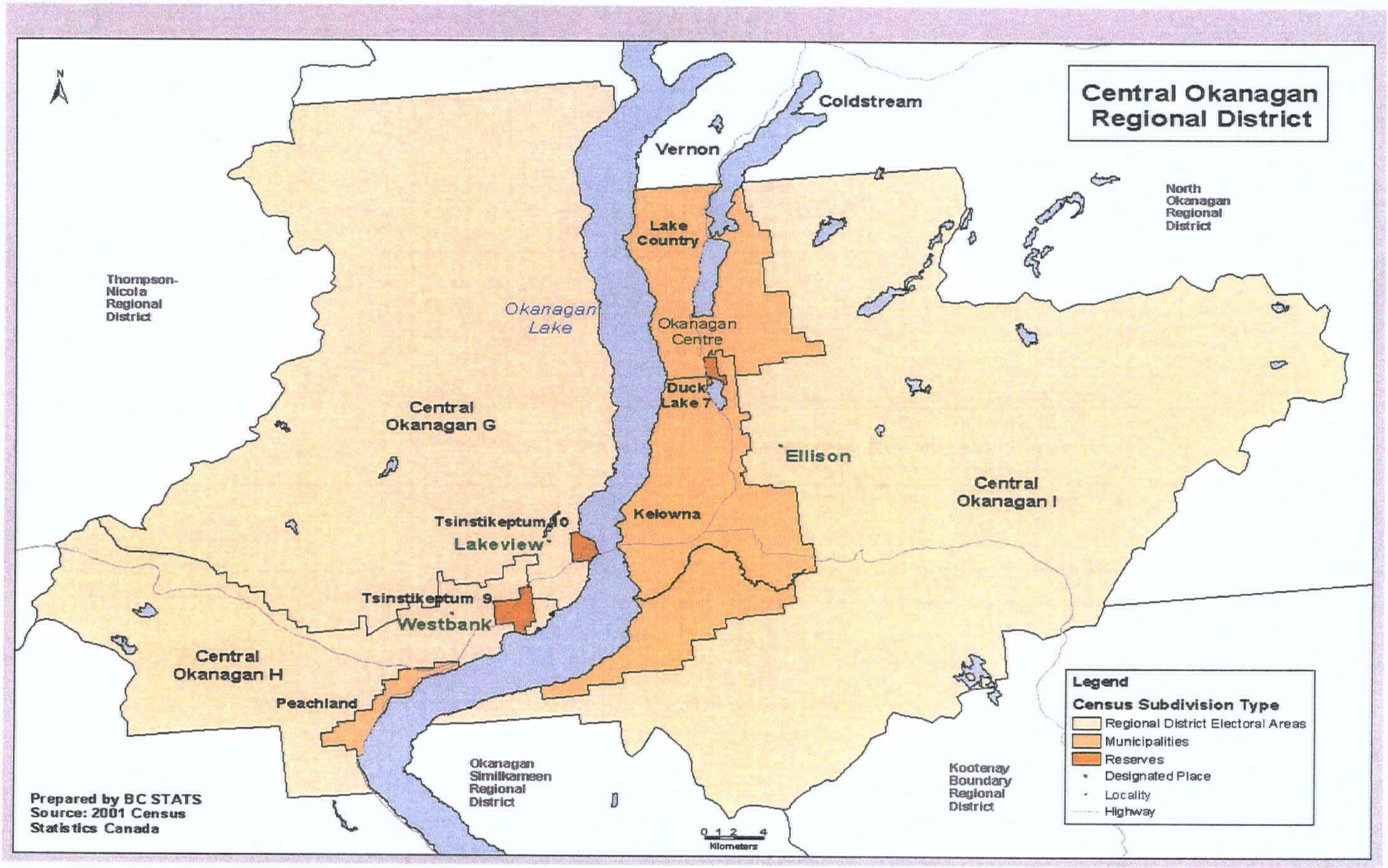
Area maps are also provided below - depicting the geographic distribution of the cities, the district municipalities, and the villages within the Central Okanagan Regional District and the North Okanagan Regional District.[61]

[60] British Columbia Stats – Ministry of Management Services, British Columbia Municipal and Regional District Population Estimates, (2004), *http://www.bcstats.gov.bc.ca*
[61] Central Okanagan and North Okanagan Regional District area maps from: BC Stats – Ministry of Management Services, *http://www.bcstats.ca.*

As shown in table #10 below, within the Central Okanagan Regional District, the city of Kelowna is the largest urban centre. Other district municipalities within the Central Okanagan Regional District include Lake Country and Peachland.

	TABLE #10 Central Okanagan Regional District Population Estimates (2001-2004)			
	2001	**2002**	**2003**	**2004**
Central Okanagan Regional District	**154,193**	156,871	160,491	162,555
-Kelowna (C)	100,495	102,259	104,688	105,621
-Lake Country (DM)	9,672	9,740	9,905	10,064
-Peachland (DM)	4,857	4,984	5,046	5,077

Note: C=city, T=town, VL=village, DM=district municipality, IGD=indian government district.
Source: BC Stats – Ministry of Management Services, British Columbia Municipal and Regional District Population estimates (2004) , *http://www.bcstats.gov.bc.ca*



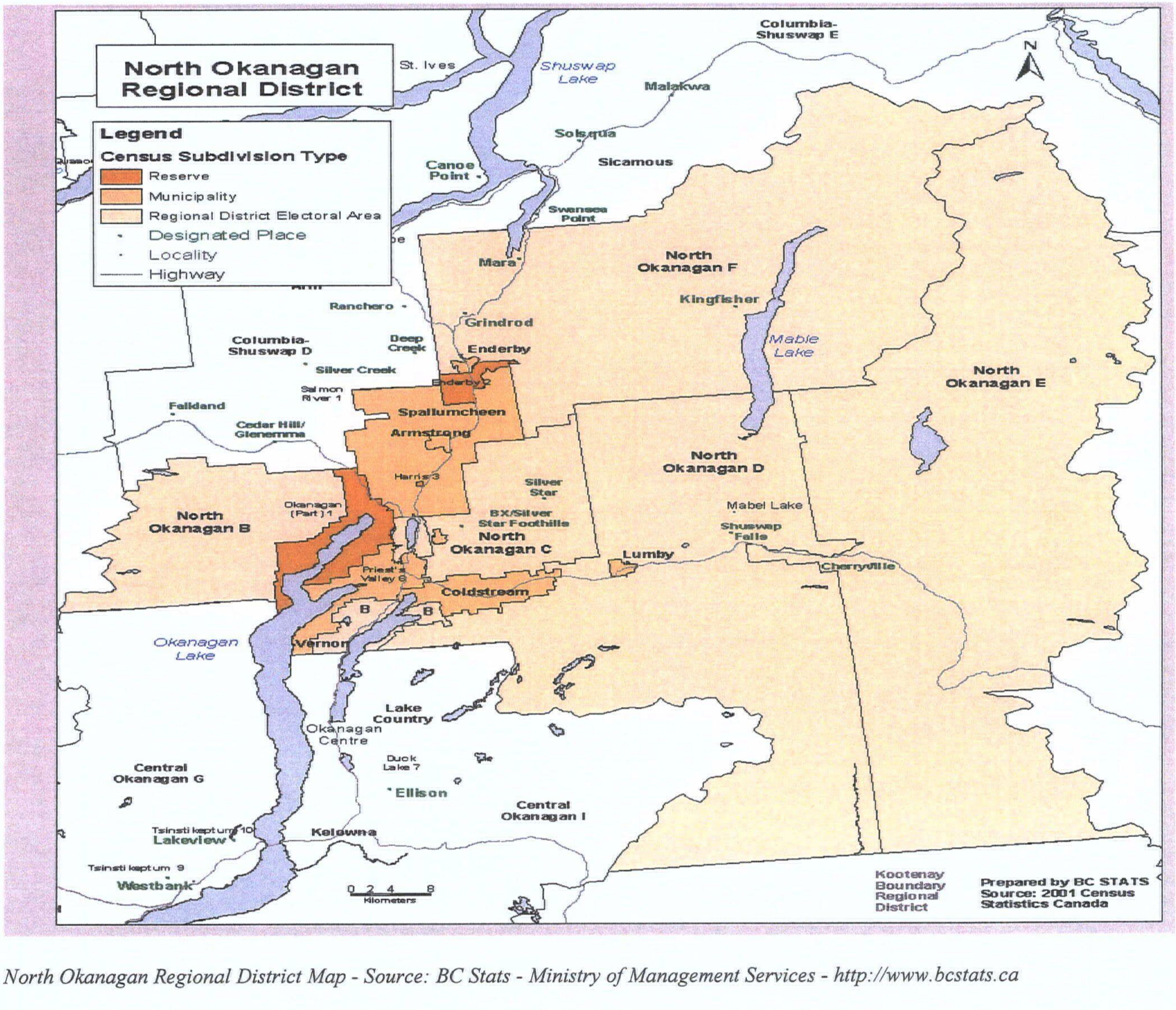
Central Okanagan Regional District Map –Source: BC Stats – Ministry of Management Services - http://www.bcstats.ca

Within the North Okanagan Regional District *(as shown in table #11 below)* the city of Vernon is the largest urban centre. Other cities, district municipalities, and villages within the North Okanagan Regional District include Armstrong, Enderby, Coldstream, Spallumcheen, and Lumby.

TABLE #11
North Okanagan Regional District
Population Estimates (2001-2004)

	2001	2002	2003	2004
North Okanagan Regional District	**76,426**	77,189	77,854	78,875
-Armstrong (C)	4,442	4,496	4,494	4,492
-Coldstream (DM)	9,504	9,618	9,803	9,896
-Enderby (C)	2,941	2,973	2,996	3,015
-Lumby (VL)	1,689	1,698	1,681	1,699
-Spallumcheen (DM)	5,358	5,385	5,404	5,633
-Vernon (C)	34,957	35,146	35,503	35,548

<u>Note</u>: C=city, T=town, VL=village, DM=district municipality, IGD=Indian government district.
Source: BC Stats – Ministry of Management Services, British Columbia Municipal and Regional District Population estimates (2004) *http://www.bcstats.gov.bc.ca*



North Okanagan Regional District Map - Source: BC Stats - Ministry of Management Services - http://www.bcstats.ca

As the concentration response functions (CRFs) included within the Air Quality Valuation Model (AQVM) (Version 3.0) are associated with specific population demographics, the AQVM (Version 3.0) requires that the population be expressed in the following sub-groups:

-population < 20 years
-population ≥ 20 years
-population ≥ 25 years
-population ≥ 65 years
-total population
-total private dwellings / households.

The AQVM (Version 3.0) also requires the user provide population growth rates specific to each of the population sub-groups within each area.

Population statistics, population growth rates, and household estimates for the Central Okanagan Regional District and the North Okanagan Regional District were derived from the BC Statistics People Projection Series #29.[62]

The population sub-group data estimates and the corresponding growth rate estimates used in the benefits analysis *(for the Central Okanagan and the North Okanagan Regional Districts)* are provided in table #12 and #13 below.

[62] **Note:** population *(forecast)* estimates and growth rates for use within the benefits analysis were developed using data provided from B.C. Stats – Ministry of Management Services, *People Projection Series #29*, *http://www.bcstats.gov.bc.ca*.

TABLE #12 - Central Okanagan Regional District - Population & Household Estimates and Growth Rates Applied in the Benefits Analysis (Based on People Projection Series #29) (Base Year = 2003)

Population & Household Estimates and Projections							
District	Year	Total	Pop <20	Pop >=20	Pop >=25	Pop >=65	Households
Central Okanagan	1988	97,986	25,087	72,899	66,256	17,031	38,320
	1989	102,275	25,917	76,358	69,854	17,957	39,910
	1990	108,676	27,540	81,136	74,553	18,974	42,310
	1991	114,671	29,014	85,657	78,814	19,991	44,533
	1992	122,041	30,913	91,128	83,615	20,856	47,538
	1993	128,907	32,625	96,282	88,162	21,449	50,366
	1994	133,681	33,872	99,809	91,429	22,169	52,384
	1995	137,761	34,879	102,882	94,512	22.989	54,125
	1996	141,623	35,725	105,898	97,308	23,855	55,787
	1997	145,430	36,489	108,941	100,292	24,677	57,631
	1998	148,782	37,018	111,764	103,042	25,557	59,118
	1999	150,349	37,047	113,302	104,430	26,032	60,047
	2000	152,198	37,249	114,949	105,977	26,664	61,096
	2001	154,193	37,305	116,888	107,690	27,358	62,449
	2002	156,025	37,105	118,920	109,155	27,831	63,147
	2003	**158,562**	**37,010**	**121,552**	**111,223**	**28,468**	**65,148**
	2004	161,057	36,803	124,254	113,403	29,004	67,332
	2005	163,717	36,600	127,117	115,730	29,595	69,433
	2006	166,439	36,470	129,969	118,284	30,190	71,623
	2007	169,309	36,429	132,880	121,065	30,729	73,468
	2008	172,209	36,499	135,710	123,850	31,299	75,239
	2009	175,152	36,568	138,584	126,748	31,912	77,048
	2010	178,258	36,642	141,616	129,742	32,415	78,966
	2011	181,481	36,807	144,674	132,789	33,056	80,877
	2012	184,861	37,060	147,801	135,887	33,983	82,808
	2013	188,361	37,438	150,923	138,986	34,952	84,695
	2014	191,984	37,906	154,078	142,145	35,843	86,571
	2015	195,627	38,361	157,266	145,397	36,896	88,476
	2016	199,219	38,825	160,394	148,548	37,888	90,340
	2017	202,875	39,470	163,405	151,704	38,910	92,057
	2018	206,473	40,157	166,316	154,747	40,056	93,692
	2019	210,063	40,892	169,171	157,749	41,224	95,271
	2020	213,649	41,564	172,085	160,740	42,494	96,913
	2021	217,192	42,254	174,938	163,722	43,805	98,509
	2022	220,795	43,013	177,782	166,587	45,117	100,071
	2023	224,410	43,750	180,660	169,400	46,449	101,663
	2024	227,973	44,339	183,634	172,128	47,866	103,377
	2025	231,514	44,921	186,593	174,948	49,239	105,085
	2026	235,019	45,479	189,540	177,682	50,620	106,794
	2027	238,501	46,001	192,500	180,367	52,049	108,527
	2028	241,957	46,492	195,465	183,063	53,485	110,276
	2029	245,385	46,945	198,440	185,864	54,849	112,049
	2030	248,781	47,360	201,421	188,626	56,051	113,842

Population & Household Growth Rate Estimates							
District	Year	Total	Pop <20	Pop >=20	Pop >=25	Pop >=65	Households
Central Okanagan	1988	.62	.68	.60	.60	.60	.59
	1989	.65	.70	.63	.63	.63	.61
	1990	.69	.74	.67	.67	.67	.65
	1991	.72	.78	.70	.71	.70	.68
	1992	.77	.84	.75	.75	.73	.73
	1993	.81	.88	.79	.79	.75	.77
	1994	.84	.92	.82	.82	.78	.80
	1995	.87	.94	.85	.85	.81	.83
	1996	.89	.97	.87	.87	.84	.86
	1997	.92	.99	.90	.90	.87	.88
	1998	.94	1.00	.92	.93	.90	.91
	1999	.95	1.00	.93	.94	.91	.92
	2000	.96	1.01	.95	.95	.94	.94
	2001	.97	1.01	.96	.97	.96	.96
	2002	.98	1.00	.98	.98	.98	.97
	2003	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
	2004	1.02	.99	1.02	1.02	1.02	1.03
	2005	1.03	.99	1.05	1.04	1.04	1.07
	2006	1.05	.99	1.07	1.06	1.06	1.10
	2007	1.07	.98	1.09	1.09	1.08	1.13
	2008	1.09	.99	1.12	1.11	1.10	1.15
	2009	1.10	.99	1.14	1.14	1.12	1.18
	2010	1.12	.99	1.17	1.17	1.14	1.21
	2011	1.14	.99	1.19	1.19	1.16	1.24
	2012	1.17	1.00	1.22	1.22	1.19	1.27
	2013	1.19	1.01	1.24	1.25	1.23	1.30
	2014	1.21	1.02	1.27	1.28	1.26	1.33
	2015	1.23	1.04	1.29	1.31	1.30	1.36
	2016	1.26	1.05	1.32	1.34	1.33	1.39
	2017	1.28	1.07	1.34	1.36	1.37	1.41
	2018	1.30	1.09	1.37	1.39	1.41	1.44
	2019	1.32	1.10	1.39	1.42	1.45	1.46
	2020	1.35	1.12	1.42	1.45	1.49	1.49
	2021	1.37	1.14	1.44	1.47	1.54	1.51
	2022	1.39	1.16	1.46	1.50	1.58	1.54
	2023	1.42	1.18	1.49	1.52	1.63	1.56
	2024	1.44	1.20	1.51	1.55	1.68	1.59
	2025	1.46	1.21	1.54	1.57	1.73	1.61
	2026	1.48	1.23	1.56	1.60	1.78	1.64
	2027	1.50	1.24	1.58	1.62	1.83	1.67
	2028	1.53	1.26	1.61	1.65	1.88	1.69
	2029	1.55	1.27	1.63	1.67	1.93	1.72
	2030	1.57	1.28	1.66	1.70	1.97	1.75

Source: Table developed using *population estimates and projections* and *household data projection estimates* from *People Projection Series #29*, Population Section, BC Stats, Ministry of Management Services, Province of British Columbia, P.O. Box 9410, Stn Prov Govt, Victoria, B.C. V8W 8V1, *http://www.bcstats.gov.bc.ca.* **Note**: data for census years (Statistics Canada).

TABLE #13 – North Okanagan Regional District - Population & Household Estimates and Growth Rates Applied in the Benefits Analysis (Based on People Projection Series #29) (Base Year = 2003)

Population & Household Estimates and Projections

District	Yr	Total	Pop <20	Pop >=20	Pop >=25	Pop >=65	Households
North Okanagan	1988	58,477	16,671	41,806	38,004	8,722	22,257
	1989	69,261	16,668	42,593	38,962	9,109	22,536
	1990	61,116	17,027	44,089	40,584	9,553	23,219
	1991	63,289	17,662	45,627	42,199	9,982	24,016
	1992	65,440	18,296	47,144	43,510	10,406	24,937
	1993	68,006	18,921	49,085	45,320	10,630	26,026
	1994	70,967	19,644	51,323	47,427	11,188	27,275
	1995	72,392	19,920	52,474	48,610	11,523	27,927
	1996	74,195	20,282	53,913	49,961	11,824	28,731
	1997	75,413	20,463	94,950	50,843	12,096	29,417
	1998	75,638	20,229	55,409	51,084	12,526	29,657
	1999	75,588	19,979	55,609	51,070	12,547	29,913
	2000	76,105	19,762	56,343	51,496	12,704	30,508
	2001	76,426	19,478	56,948	51,863	12,945	30,987
	2002	76,868	19,141	57,727	52,297	13,220	31,318
	2003	**77,116**	**18,659**	**58,457**	**52,787**	**13,548**	**32,126**
	2004	77,464	18,191	59,273	53,275	13,728	33,000
	2005	77,906	17,876	60,030	53,963	13,842	33,814
	2006	78,579	17,675	60,904	54,814	13,986	34,681
	2007	79,358	17,595	61,763	55,789	14,154	35,267
	2008	80,245	17,531	62,714	56,817	14,376	35,910
	2009	81,262	17,537	63,725	58,007	14,602	36,576
	2010	82,310	17,608	64,702	59,089	14,825	37,202
	2011	83,386	17,657	65,729	60,167	15,081	37,868
	2012	84,428	17,762	66,666	61,151	15,470	38,459
	2013	85,502	17,907	67,595	62,193	15,900	39,031
	2014	86,607	18,069	68,538	63,232	16,357	39,607
	2015	87,706	18,291	69,415	64,219	16,764	40,117
	2016	88,771	18,501	70,270	65,227	17,166	40,617
	2017	89,863	18,718	71,145	66,182	17,650	41,127
	2018	90,929	18,995	71,934	67,095	18,095	41,559
	2019	91,973	19,263	72,710	67,990	18,651	41,989
	2020	93,003	19,551	73,452	68,800	19,136	42,390
	2021	94,004	19,825	74,179	69,594	19,672	42,786
	2022	94,966	20.062	74,904	70,372	20,182	43,196
	2023	95,915	20,318	75,597	71,081	20,748	43,579
	2024	96,837	20,491	76,346	71,765	21,297	44,024
	2025	97,745	20,612	77,133	72,436	21,828	44,509
	2026	98,623	20,702	77,921	73,083	22,304	45,006
	2027	99,483	20,760	78,723	73,725	22,746	45,524
	2028	100,328	20,794	79,534	74,330	23,239	46,057
	2029	101,156	20,810	80,346	74,995	23,634	46,598
	2030	101,979	20,812	81,167	75,689	23,943	47,152

Population & Household Growth Rate Estimates

District	Yr	Total	Pop <20	Pop >=20	Pop >=25	Pop >=65	Households
North Okanagan	1988	0.76	0.89	0.72	0.72	0.64	0.69
	1989	0.77	0.89	0.73	0.74	0.67	0.70
	1990	0.79	0.91	0.75	0.77	0.71	0.72
	1991	0.82	0.95	0.78	0.80	0.74	0.75
	1992	0.85	0.98	0.81	0.82	0.77	0.78
	1993	0.88	1.01	0.84	0.86	0.78	0.81
	1994	0.92	1.05	0.88	0.90	0.83	0.85
	1995	0.94	1.07	0.90	0.92	0.85	0.87
	1996	0.96	1.09	0.92	0.95	0.87	0.89
	1997	0.98	1.10	0.94	0.96	0.89	0.92
	1998	0.98	1.08	0.95	0.97	0.92	0.92
	1999	0.98	1.07	0.95	0.97	0.93	0.93
	2000	0.99	1.06	0.96	0.98	0.94	0.95
	2001	0.99	1.04	0.97	0.98	0.96	0.96
	2002	1.00	1.03	0.99	0.99	0.98	0.97
	2003	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
	2004	1.00	0.97	1.01	1.01	1.01	1.03
	2005	1.01	0.96	1.03	1.02	1.02	1.05
	2006	1.02	0.95	1.04	1.04	1.03	1.08
	2007	1.03	0.94	1.06	1.06	1.04	1.10
	2008	1.04	0.94	1.07	1.08	1.06	1.12
	2009	1.05	0.94	1.09	1.10	1.08	1.14
	2010	1.07	0.94	1.11	1.12	1.09	1.16
	2011	1.08	0.95	1.12	1.14	1.11	1.18
	2012	1.09	0.95	1.14	1.16	1.14	1.20
	2013	1.11	0.96	1.16	1.18	1.17	1.21
	2014	1.12	0.97	1.17	1.20	1.21	1.23
	2015	1.14	0.98	1.19	1.22	1.24	1.25
	2016	1.15	0.99	1.20	1.24	1.27	1.26
	2017	1.17	1.00	1.22	1.25	1.30	1.28
	2018	1.18	1.02	1.23	1.27	1.34	1.29
	2019	1.19	1.03	1.24	1.29	1.38	1.31
	2020	1.21	1.05	1.26	1.30	1.41	1.32
	2021	1.22	1.06	1.27	1.32	1.45	1.33
	2022	1.23	1.08	1.28	1.33	1.49	1.34
	2023	1.24	1.09	1.29	1.35	1.53	1.36
	2024	1.26	1.10	1.31	1.36	1.57	1.37
	2025	1.27	1.10	1.32	1.37	1.61	1.39
	2026	1.28	1.11	1.33	1.38	1.65	1.40
	2027	1.29	1.11	1.35	1.40	1.68	1.42
	2028	1.30	1.11	1.36	1.41	1.72	1.43
	2029	1.31	1.12	1.37	1.42	1.74	1.45
	2030	1.32	1.12	1.39	1.43	1.77	1.47

Source: Table developed using *population estimates and projections* and *household data projection estimates* from *People Projection Series #29*,
Population Section, BC Stats, Ministry of Management Services, Province of British Columbia, P.O. Box 9410, Stn Prov Govt, Victoria, B.C. V8W 8V1, *http://www.bcstats.gov.bc.ca.* Note: data for census years (Statistics Canada).

4.3 Exposure/Response Relationship - Concentration Response Functions (CRFs)

Derived from the epidemiology literature, the term concentration response function (CRF) relates to the statistical association between small changes in ambient air pollution concentration and pre-mature mortality, morbidity, and other defined endpoints.[63] The CRFs represent the change in risk given a 10 ug/m^3 change in particulate matter (PM), or a 10 ppb change in ozone from baseline ambient concentration levels. For mortality, the health effects and monetized benefits are estimated by multiplying the CRF by the average annual non-accidental death rate as per the following calculation:[64]

Estimated Number of Health Outcomes	=	**Δ Concentration**	x	**CRF**	x	**Base Disease Occurrence Rate**	x	**Exposed Population**

[65]

The monetized values are derived by multiplying the estimated number of health outcomes by the dollar value of each health outcome *(as follows):*

Monetized Value of Health Outcomes	=	**Estimated Number of Health Outcomes**	x	**Dollar Value of Health Outcomes**

To address uncertainty associated with the CRFs, the AQVM (Version 3.0) incorporates low, central, and high CRF estimates selected for each health and other endpoint. Within the AQVM (Version 3.0) weights are also assigned to the low, central and high CRFs, and to the low, central and high dollar values of health outcomes. Using a monte carlo simulation, the AQVM (Version 3.0) provides a probability distribution of the estimated benefits.[66]

4.4 Effects Estimates and Monetized Values Included in the Benefits Analysis – as per AQVM (Version 3.0)

The following health endpoints are included in the benefits analysis: *mortality*, and *morbidity (ie. adult chronic bronchitis, respiratory hospital admissions, cardiac hospital admissions, emergency room visits, child bronchitis, asthma symptom days, restricted activity days, minor restricted activity days, and acute respiratory symptom days).*[67] Household materials soiling estimates and estimates of corn crop damages are also included in the analysis.[68]

The effects and monetized value estimates *(for PM2.5 and ozone)* provided within the report employ the default AQVM (Version 3.0) concentration response function (CRF) database with modifications to PM related mortality estimates in accordance with recommendations put forward within the BC Lung Association Phase I health study.[69] The CRFs employed in the benefits analysis also include recent updates to ERVs and ozone related mortality as provided by Health Canada.[70]

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63 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999) (p. 4-1).

64 **Note:** within the default AQVM (Version 3.0) database, the average Canadian non-accidental death rate [6,700/million persons/year = 6.7 x 10^{-3}] is adopted in the mortality CRF calculations. Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 4-16 & 4-17).

65 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999) (p. 4-11 –to- 4-21). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51).

66 Stratus Consulting, Air Quality Valuation Model (Version 3.0) (AQVM 3.0), Operating Instructions, (September/1999) (p. 3-21).

67 **Note**: these health and other outcomes are defined on p. 95 of the report.

68 **Note:** there are also other effects on important local area crops (ie. grapes, tree fruits, and forage crops) and other impacts that are not included within the report, as the quantitative analytical relationships are not available.

69 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999) (p. 4-11, & D-2). See also: Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114).

70 See: Jessiman, Barry, Health Canada, Personal (e-mail) communication, (21/July/2003).

The dollar values of health outcomes are based on the AQVM (Version 3.0) database, which have been updated *(inflated)* in this report to reflect 2003 $'s Canadian.[71]

The benefits analysis generally relies on the concentration response functions (CRFs) included within the default AQVM (Version 3.0) database with the following exceptions.

i). the analysis incorporates the PM mortality related CRFs as recommended within the BC Lung Association Phase 1 health study applying the estimated provincial *(age standardized) (ASMR)* base mortality rate *(of 5.12 x 10^{-3})* to these CRFs *(whereas the default AQVM - Version 3.0 database uses the Canadian base mortality rate of 6.70 x 10^{-3})*. Note that the BC Lung Association Phase I health study did not recommend CRFs pertaining to ozone mortality, however as recent studies re-affirm the statistical association between ozone and mortality, ozone mortality CRFs have been included within the benefits analysis.[72]

ii). in response to a statistical error associated with the generalized additive model (GAM) estimates for some of the CRFs included within the default AQVM (Version 3.0) database, Health Canada recommended new CRFs for PM2.5 mortality, ozone mortality, and emergency room visits.[73] The revised CRFs for ozone mortality and emergency room visits have been included in the benefits analysis, however the estimated provincial base mortality rate - rather than the Canadian base mortality rate - has been incorporated within the ozone mortality related CRFs.

A further discussion on the mortality related CRFs and the base mortality rates included in the analysis is provided below.

4.5 Locally Applicable Mortality CRFs - PM2.5

The BC Lung Association Phase I health study recommended both acute and chronic PM related mortality concentration response functions (CRFs). The CRFs provide the percentage change in total non-accidental mortality associated with a 10 ug/m^3 change in air quality concentration. The CRFs are converted to AQVM compatible units by multiplying them by the per/capita daily or total non-accidental base mortality rate and dividing by 10 to represent the CRFs in units of per/capita risk per 1 ug/m^3 change in concentration.[74]

Using the estimated BC provincial age standardized non-accidental base mortality rate *(of 5.12 x 10^{-3})* averaged over the period 2001-2003, table #14 below presents the AQVM compatible PM2.5 mortality related CRF values that were applied within the benefits analysis.[75]

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[71] **Note:** the dollar values of health outcomes contained within the default AQVM (Version 3.0) database are expressed in 1996 $'s Canadian. See: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*; (September 3, 1999) (p. 4-11, & D-2). These values have been inflated to 2003 $'s Canadian within the results reported herein.

[72] For a recent study see: Bell, Michelle L. PhD, Aidan McDermott PhD, Scott L. Zeger PhD, Jonathan M. Samet MD, Francesca Dominici PhD, *Ozone and Short-term Mortality in 95 US Urban Communities, 1987–2000*, Journal of American Medical Association (JAMA), November 17, 2004, Vol 292, No 19, (p. 2372-2378). **Note**: the ozone mortality related CRFs employed in the benefits analysis were the updated CRFs provided by Jessiman, Barry-Health Canada, applying the estimated daily provincial base mortality rate.

[73] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114). See also: Jessiman, Barry – Health Canada, Personal (e-mail) Communication, (21/July/2003).

[74] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51).

[75] **Note:** in the analysis presented in this report, the health effects for acute and chronic mortality have been added together. This differs from the default AQVM (Version 3.0) CRF database that includes only chronic PM related mortality impacts.

TABLE #14 PM2.5 Acute and Chronic Mortality CRFs and Weighting Assignments Applied within the Benefits Analysis							
Acute Daily Mortality (Source)		**Study Basis**		**CRFs Recommended by BCLA Health Study**	**AQVM Compatible Value (Yearly)**		**Weight**
Low	NMAPS (Corrected), Dominici et al (2003)	Time Series	PM10	**0.2% / 10 ug/m³**	PM2.5	.2/5.99 $\times 5.12 \times 10^{-3} \times 1/100 =$ **1.71×10^{-6}**	22%
Central	Stieb et al (2002b, 2003)	Time Series	PM2.5	**1% / 10 ug/m³**	PM2.5	**1/10** $\times 5.12 \times 10^{-3} \times 1/100 =$ **5.12×10^{-6}**	67%
High	Six Cities (Updated)	Cohort	PM2.5	**1.3% / 10 ug/m³**	PM2.5	**1.3/10** $\times 5.12 \times 10^{-3} \times 1/100 =$ **6.66×10^{-6}**	11%
Chronic Mortality (Source)		**Study Basis**		**CRFs Recommended by BCLA Health Study**	**AQVM Compatible Value (Yearly)**		**Weight**
Low	Stieb et al (2002b, 2003)	Time Series	PM10	**0.6% / 10 ug/m³**	PM2.5	**1/10** $\times 5.12 \times 10^{-3} \times 1/100 =$ **5.12×10^{-6}**	22%
Central	Pope et al (1995, 2002)	Cohort	PM2.5	**4% / 10 ug/m³**	PM2.5	**4/10** $\times 5.12 \times 10^{-3} \times 1/100 =$ **20.48×10^{-6}**	67%
High	Six Cities Study (Re-analysis)	Cohort	PM2.5	**11% / 10 ug/m³**	PM2.5	**11/10** $\times 5.12 \times 10^{-3} \times 1/100 =$ **56.32×10^{-6}**	11%

<u>Note</u>: re. Stieb CRF conversion to AQVM compatible values - refer to: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 49). See also: Stieb, D., S. Judek & R.T Burnett, *Meta-Analysis of Time-Series Studies of Air Pollution and Mortality: Effects of Gases & Particles & the Influence of Cause of Death, Age and Season*. Journal of the Air & Waste Management Association, Vol 52, (Apr/2002), (p. 470 - 484).
<u>Note</u>: conversion of PM2.5 & PM10 based on ratio of average PM10 to PM2.5 particle size ^ **(PM10 = 1.67 PM2.5)**, see AQVM (Version 3.0) (p. 4-15).
<u>Note</u>: conversion is based on the assumption the estimated annual BC non-accidental base mortality rate = (5.12×10^{-3}); this provides more conservative estimates than if the unadjusted rate was used.
Table adapted from source: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51).

In calculating the monetized benefits and effects estimates, although the ozone and PM results are additively separable, the AQVM (Version 3.0) requires that the analyst use a combination of either PM10 and ozone, or a combination of PM2.5 and ozone *(not both PM2.5 and PM10) (ie. for the effects estimates associated with particulate matter (PM), the analyst has a choice of using either PM2.5 or PM10 ambient concentration data and their respective concentration response functions [CRFs]).*[76]

The PM2.5 data has been used in this study given that it is considered to be the more harmful size fraction and given that the central and high mortality related CRF estimates recommended within the BC Lung Association Phase 1 health study are based on PM2.5 data.[77] Note however that the choice between using PM2.5 and PM10 ambient concentration data in the benefits analysis is not straight forward. Some of the complicating factors are itemized below.

[76] Stratus Consulting, *Air Quality Valuation Model (AQVM) (Version 3.0) – Operating Instructions*, (p. 1-3). Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 1-2).
[77] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51). See also: Brauer, Dr. Michael, - UBC, Personal Communication, (June/2004).

4.5.1 Conversion Factors (PM10:PM2.5 Ratios)

The concentration response functions (CRFs) derive from epidemiology studies *(estimating the relationship between health outcomes and ambient air quality)* using either PM2.5 or PM10 ambient concentration data. Note that the BC Lung Association expert panel recommended the same CRFs were applicable to both PM2.5 and PM10.[78] However PM2.5 CRFs can be converted to PM10 CRFs *(and vice-versa)* using a conversion factor.

A conversion ratio assumed within AQVM (Version 3.0) is: PM10 = 1.67 x PM2.5.[79] Therefore, to convert the acute and chronic low CRFs *(which are based on PM10 data)* to their PM2.5 equivalent values, adjustments have been made in accordance with this ratio. Note however from the Kelowna and Vernon data, the PM2.5 measurements are approximately 37.5% of PM10 *(ie. PM10 = 2.67 x PM2.5) (the Central Okanagan Regional District PM10:PM2.5 ratio is: 16.49/6.78 = 2.43, the North Okanagan Regional PM10:PM2.5 ratio is: 21.89/7.61 = 2.88, and the combined average Central and North Okanagan Regional District PM10:PM2.5 ratio is: 38.38/14.39 = 2.67) (see table #8 and #9, p. 22 and 23).*

As the ratios depend on the different source mixes of pollutants in each region, some variation in the PM10:PM2.5 ratios is to be expected. However, a substantial difference between the PM10:PM2.5 ratio noted within the default AQVM (Version 3.0) database -versus- the local PM10:PM2.5 ratio, relates to changes made in the method of recording PM2.5 data at TEOM monitors in Canada. Prior to 2002, PM2.5 data was adjusted by adding an offset of 3.0 and by factoring in a multiplier of 1.03 *(as per the US EPA practice),* however this adjustment was removed from the historical record in April/2002.[80] *(No adjustments were made to the PM10 data).* Note however the studies based on PM2.5 data recorded prior to 2002 were likely based on the adjusted data record that was approximately 3 ug/m^3 greater than the revised data archive.

The most relevant PM10:PM2.5 ratio to use in the PM10:PM2.5 conversion would be the ratios associated with the original epidemiology studies *(estimating the relationship between health outcomes and ambient air quality),* however specific information is not available as to what these ratios are. Therefore the effects estimates calculated within this study employ the PM10:PM2.5 ratio expressed within AQVM (Version 3.0) *(ie. PM10 = 1.67 x PM2.5)*[81]. Note however that use of this conversion factor *(ratio)* presents a source of uncertainty in the reported benefits estimates.

4.5.2 Differences in Air Quality Monitoring Instruments

There are differences in the PM ambient air quality concentration values recorded using continuous tapered element oscillating microbalance (TEOM) based sampling instruments -versus- manual filter-based sampling instruments. TEOM sampling instruments are commonly used in Canada, whereas manual filter-based sampling instruments are more prevalent in the US.

As some of the epidemiology studies *(estimating the relationship between health outcomes and ambient air quality)* included within the AQVM (Version 3.0) are US based, it is likely that some of the CRFs pertaining to PM were estimated using filter-based sampling instruments. As the exact relationship between the data recorded using manual filter-based sampling instruments, and the data recorded using continuous TEOM sampling instruments is not known, these instrumentation differences present a source of uncertainty in the reported benefits estimates.

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[78] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 51).

[79] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999) (p. 4-15).

[80] Suzuki, Natalie – BC Ministry of Water Land and Air Protection, Bill Taylor – Environment Canada, Particulate Matter in British Columbia, a Report on PM10 and PM2.5 Mass Concentrations up to 2000, (May/2003), (Addendum – inside front cover).

[81] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999) (p. 4-15).

4.6 Locally Applicable Mortality CRFs - Ozone

The ozone mortality related CRFs used in the analysis are the updated CRFs recommended by Health Canada in response to the generalized additive model (GAM) statistical error.[82] The ozone mortality related CRFs, the AQVM compatible values, and the weighting assignments applied in the benefits analysis using the estimated age standardized B.C. provincial daily non-accidental base mortality rate of 1.40×10^{-5} are noted in table #15 below.

TABLE #15
Ozone Mortality CRFs and Weighting Assignments Applied Within the Benefits Analysis

Ozone Mortality CRF Recommended by Health Canada		AQVM Compatible Value (Daily)	Weight
Low	L95 CI from Stieb et al 2002	$0.69 \times 10^{-4} \times 1.40 \times 10^{-5} =$ **$.97 \times 10^{-9}$**	33%
Ctrl	Central form Stieb et al 2002	$1.92 \times 10^{-4} \times 1.40 \times 10^{-5} =$ **2.68×10^{-9}**	34%
High	U95 CI from Stieb et al 2002	$3.14 \times 10^{-4} \times 1.40 \times 10^{-5} =$ **4.39×10^{-9}**	33%
Note: Conversion assumes BC daily non-accidental *(age standardized)* base mortality rate = $(5.12 \times 10^{-3})/365 = 1.4027 \times 10^{-5}$			

A further discussion regarding the base mortality rates applied within the benefits analysis is provided below.

4.7 The Base Mortality Rate

For the reported mortality health effects, the average British Columbia provincial base mortality rate was used in the analysis rather than the Canadian mortality rate, which is included within the default AQVM (Version 3.0) database.[83]

Mortality rates are published by BC Vital Statistics within *"Table 21 - Causes of Death by Gender and Age – British Columbia"*.[84] For the local air quality valuation analysis, these statistics were averaged over the period 2001-2003, providing an estimated average provincial age standardized non-accidental base mortality rate of 5.12×10^{-3} (see table #16 below).[85]

TABLE #16
British Columbia - Base Mortality Rates Applied to CRF Calculations

Year	Age Standardized Mortality Rate			Total Number of Deaths			
	All Causes	External Causes	All Causes – External Causes	All Causes	External Causes	All Causes – External Causes	
1999	58.14	4.11	54.03	27,794	1,780	26,014	Avg ASMR (All Causes – External Causes) (2001-2003)
2000	54.95	3.40	51.55	27,273	1,493	25,780	
2001	55.08	3.19	51.89	28,164	1,422	26,742	
2002	54.36	3.46	50.90	28,686	1,588	27,098	
2003	54.21	3.56	50.65	29,108	1,621	27,487	
Avg 2001-2003	**54.55**	**3.40**	**51.15**	**28,653**	**1,544**	**27,109**	**5.12×10^{-3}**

Note: External Causes of Death are: motor vehicle traffic accidents, accidental falls, and suicide. Table developed using data from source: *Table 21 – Causes of Death by Gender and Age – B.C. 1999, 2000, 2001, 2002, 2003* BC Vital Statistics, *http://www.vs.gov.bc.ca.* ASMR = Rate per 10,000 std pop Cda 1991 Census.

The mortality rates are also available aggregated by *"health regions"* and by *"local health areas"*. The rates are itemized in table #17 and #18 below.[86]

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82 Source: Jessiman, Barry – Health Canada, Personal (e-mail) Communication, (21/July/2003).

83 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 4-16 & 4-17).

84 **Note:** the ASMRs and total number of deaths available at BC Vital Statistics, *http://www.vs.gov.bc.ca/stats/annual2000d_summ.html.*

85 BC Vital Statistics, *Causes of Death by Gender and Age – British Columbia*, Table 21, 1999, 2000, 2001, 2002, 2003, *http://www.vs.gov.bc.ca.*

86 BC Vital Statistics, *Health Status Indicators BC Vital Statistics Agency Birth-Related and Mortality Statistics (1995-1999) Volume 1: Local Health Areas*, (p. 35-36, 72-75, 178-179); and *Health Status Indicators BC Vital Statistics Agency Birth-Related and Mortality Statistics 1995-1999 Volume II: Health Regions*, (p. 48-51), *http://www.vs.gov.bc.ca.*

TABLE #17

Estimated Age Standardized Mortality Rates (ASMR) – Aggregated by Local Health Area

	Local Health Area	1995 All Causes	1995 External Causes	1996 All Causes	1996 External Causes	1997 All Causes	1997 External Causes	1998 All Causes	1998 External Causes	1999 All Causes	1999 External Causes
LHA #22	Vernon Pop 1999 **58,982**	M 82.00	M 8.61	M 73.86	M 8.02	M 78.17	M 10.00	M 78.54	M 11.75	M 77.74	M 4.06
		F 56.92	F 4.48	F 53.63	F 6.27	F 47.17	F 3.54	F 51.28	F 2.93	F 48.80	F 2.85
		T 68.12	Avg **6.55**	**T 62.66**	Avg **7.15**	**T 61.39**	Avg **6.77**	**T 63.62**	Avg **7.34**	**T 61.38**	Avg **3.46**
LHA #21	Armstrong-Spallum Pop 1999 **9,904**	M 81.36	M 4.94	M 87.60	M 7.56	M 73.86	M 1.85	M 81.10	M 10.17	M 96.51	M 9.89
		F 66.12	F 4.76	F 53.84	F 4.81	F 47.53	F -	F 41.84	F 1.26	F 36.79	F 1.54
		T 73.01	Avg **4.85**	**T 69.76**	Avg **6.19**	**T 59.20**	Avg **1.85**	**T 58.53**	Avg **5.72**	**T 61.22**	Avg **5.72**
LHA #78	Enderby Pop 1999 **7,754**	M 75.17	M 16.30	M 77.99	M 13.10	M 91.75	M 15.45	M 106.51	M 13.75	M 86.14	M 18.77
		F 33.69	F 3.37	F 51.23	F 7.31	F 64.81	F 4.96	F 57.18	F 1.90	F 49.51	F 7.00
		T 55.19	Avg **9.84**	**T 63.78**	Avg **10.21**	**T 78.46**	Avg **10.21**	**T 81.09**	Avg **7.83**	**T 67.97**	Avg **12.89**
LHA #23	Central Okanagan Pop 1999 **157,750**	M 70.26	M 9.22	M 70.86	M 5.84	M 64.60	M 4.69	M 65.75	F 5.04	M 68.68	M 6.77
		F 43.04	F 2.55	F 38.87	F 1.94	F 39.92	F 3.53	F 42.57	M 1.74	F 42.89	F 1.88
		T 55.30	Avg **5.89**	**T 53.36**	Avg **3.89**	**T 50.92**	Avg **4.11**	**T 52.78**	Avg **3.39**	**T 54.20**	Avg **4.33**
	Province of BC Pop 1999 **4,029,253**	M 79.19	M 7.94	M 80.05	M 8.11	M 76.66	M 8.09	M 74.59	M 7.75	M 75.53	M 6.09
		F 49.44	F 2.97	F 49.89	F 3.02	F 48.44	F 2.96	F 48.46	F 2.83	F 46.11	F 2.20
		T 62.66	Avg **5.46**	**T 63.31**	Avg **5.57**	**T 60.90**	Avg **5.53**	**T 60.08**	Avg **5.29**	**T 58.14**	Avg **4.15**
	North Okanagan Ttl Pop 1999 **76,640**	**Avg of Ttl 65.44**	**Avg of Avg 7.08**	**Avg of Ttl 65.40**	**Avg of Avg 7.85**	**Avg of Ttl 66.35**	**Avg of Avg 6.28**	**Avg of Ttl 67.75**	**Avg of Avg 6.96**	**Avg of Ttl 63.52**	**Avg of Avg 7.36**
	Central Okanagan Ttl Pop 1999 **157,750**	**Avg of Ttl 55.30**	**Avg of Avg 5.89**	**Avg of Ttl 53.36**	**Avg of Avg 3.89**	**Avg of Ttl 50.92**	**Avg of Avg 4.11**	**Avg of Ttl 52.78**	**Avg of Avg 3.39**	**Avg of Ttl 54.20**	**Avg of Avg 4.33**

Table developed using data from source: *Health Status Indicators BC Vital Statistics Agency Birth-Related and Mortality Statistics 1995-1999 Volume 1: Local Health Areas*, p. 35-36, 72-75, 178-179.
Note: ASMR (Age Standardized Mortality rate is per 10,000 population using the 1991 Canada Census as the standard population)

Simple Avg calculated for (Vernon, Armstrong Spallumcheen, Enderby) (1995-1999). Note total external causes not available – therefore analysis uses simple average external causes (simple average M & F external causes).
[(68.12-6.55)+(73.01-4.85)+(55.19-9.84)+(62.66-7.15)+(69.76-6.19)+(63.78-10.21)+(61.39-6.77)+(59.20-1.85)+(78.46-10.21)+(63.62-7.34)+(58.53-5.72)+(81.09-7.83)+(61.38-3.46)+(61.22-5.72)+(67.97-12.89)]/15 = **58.59**

Simple Avg calculated for Central Okanagan (1995-1999). Note total external causes not available – therefore analysis uses simple average external causes (ie. simple average M & F external causes).
((55.30-5.89)+(53.36-3.89)+(50.92-4.11)+(52.78-3.39)+(54.20-4.33))/5 = (244.95/5) = **48.91**

Weighted Avg calculated for (Vernon, Armstrong Spallumcheen, Enderby) (1995-1999):
(Year 1995 and 1996) (68.12-6.55) x 56,206 + (73.01-4.85) x 9,317 + (55.19-9.84) x 7,003 + (62.66-7.15) x 57,487 + (69.76-6.19) x 9,578 + (63.78-10.21) x 7,279 +
(Year 1997 and 1998) (61.39-6.77) x 58,751 + (59.20 – 1.85) x 9,773 + (78.46 – 10.21) x 7,543 + (63.62 – 7.34) x 58,946 + (58.53 – 5.72) x 9,880 + (81.09 – 7.83) x 7,592 +
(Year 1999) (61.38 – 3.46) x 58,982 + (61.22 – 5.72) x 9,904 + (67.9 – 12.89) x 7,754 = (21,675,853/375,995) = **57.65**

TABLE #18
Estimated Age Standardized Mortality Rates (ASMR) – Aggregated by Health Region

Health Region		1995 All Causes		1995 External Causes		1996 All Causes		1996 External Causes		1997 All Causes		1997 External Causes		1998 All Causes		1998 External Causes		1999 All Causes		1999 External Causes	
#03	N Okanagan Pop 1999 **118,511**	M	78.98	M	9.49	M	73.34	M	7.87	M	78.37	M	9.95	M	82.53	M	11.57	M	79.65	M	6.34
		F	56.02	F	5.40	F	49.44	F	4.85	F	48.28	F	3.09	F	49.78	F	3.26	F	45.52	F	3.08
		T	**66.50**	**Avg**	**7.45**	**T**	**60.75**	**Avg**	**6.36**	**T**	**62.16**	**Avg**	**6.52**	**T**	**64.91**	**Avg**	**7.42**	**T**	**60.88**	**Avg**	**4.71**
#04	**S Okanagan Similkameen** Pop 1999 **231,125**	M	70.63	M	8.81	M	72.73	M	6.91	M	69.89	M	5.85	M	70.85	M	6.33	M	70.64	M	7.00
		F	43.75	F	3.37	F	44.44	F	2.58	F	41.79	F	3.42	F	45.35	F	1.63	F	44.89	F	1.92
		T	**56.09**	**Avg**	**6.09**	**T**	**57.26**	**Avg**	**4.75**	**T**	**54.39**	**Avg**	**4.64**	**T**	**56.91**	**Avg**	**3.98**	**T**	**56.46**	**Avg**	**4.46**

Table developed using data from source: *Health Status Indicators BC Vital Statistics Agency Birth-Related and Mortality Statistics 1995-1999 Volume II: Health Regions*, p. 48-51.
Note: ASMR – Age Standardized Mortality rate is the rate per 10,000 population using the 1991 Canada Census as the standard population.

Simple Avg calculated for North Okgn (1995-1999) ((66.50 - 7.45) + (60.75 – 6.36) + (62.16 – 6.52) + (64.91 – 7.42) + (60.88 – 4.71)) / 5 = **56.55**
Note total external causes not available – therefore analysis uses simple average external causes (ie. simple average M & F external causes).
Simple Avg calculated for South Okgn (1995-1999) ((56.09 - 6.09) + (57.26 - 4.75) + (54.39 - 4.64) + (56.91 – 3.98) + (56.46 – 4.46)) / 5 = **57.44**
Note total external causes not available – therefore analysis uses simple average external causes (ie. simple average M & F external causes).
Weighted Avg North Okgn (1995-1999) ((66.50-7.45) x 111,164 + (60.75 – 6.36) x 114,080 + (62.16 – 6.52) x 116,802 + (64.91 – 7.42) x 117,951 + (60.88 – 4.71) x 118,511) = 32,705,675/578,508 =**56.53**
Weighted Avg South Okgn (1995-1999) ((56.09 - 6.09) x 216,099 + (57.26 - 4.75) x 220,663 + (54.39 - 4.64) x 226,221 + (56.91 – 3.98) x 229,621+ (56.46 – 4.46) x 231,125) = 57,818,798 / 1,123,729 = **51.45**

It is difficult to estimate a local population base mortality rate that can be used for both the Central Okanagan Regional District and the North Okanagan Regional District.

Which base mortality rate is the most appropriate to use is not straight forward due to differences in the regional geographical boundaries. For example, aggregated by *"local health area"* the estimated age standardized non-accidental base mortality rate *(total all causes – average external causes)* expressed as a simple average over the period 1995-1999 for the Central Okanagan Regional District = $\mathbf{4.89 \times 10^{-3}}$, and for the North Okanagan Regional District = $\mathbf{5.86 \times 10^{-3}}$; whereas aggregated by *"health region"* the same estimated base mortality rate over the same period for the South Okanagan Similkameen = $\mathbf{5.74 \times 10^{-3}}$, and for the North Okanagan = $\mathbf{5.66 \times 10^{-3}}$. These differences *(which are not easily reconciled)* promote using the British Columbia provincial non-accidental base mortality rate, rather than more localized non-accidental base mortality rates.

The estimated simple average non-accidental base mortality rates aggregated by *"health region" (shown in table #18)* reveals that the South Okanagan base mortality rates are slightly higher than the North Okanagan base mortality rates, which provides another reason for using the British Columbia *(provincial)* base mortality rate.

As revealed by the data shown in table #17, the *"local health area"* base mortality estimates have smaller sample sizes that tend to exhibit more year to year variation. Note also that at the time of writing of this report, the *"local health area"* base mortality rates were only available until the year 2000, whereas the British Columbia base mortality rates were available for more recent years *(until the year 2003).*

Although some of the estimated *"local health area"* age standardized non-accidental mortality rates are slightly higher than the provincial rates in more recent years, the provincial non-accidental *(age standardized)* base mortality rate was used within the benefits analysis for consistency *(ie. due to differences in the base mortality rates within various geographic boundaries which were difficult to reconcile - as exhibited in table #17 and #18).*

Note also that the majority of the population included within the study area reside within the Central Okanagan Regional District, and the estimated non-accidental base mortality rate *(expressed by "local health area")* for that region is closer to the British Columbia provincial base mortality rate.

4.8 Agricultural Crop Damage - Corn

The AQVM (Version 3.0) includes estimates of tobacco, soy, wheat, and corn yield losses associated with various levels of ozone concentration. For these crops, economic estimates are derived by multiplying the change in production by the average price of the crop *(based on local crop data and crop value estimates) (ie.* $Benefits_{ij} = \Delta\ Yield_{ij} \times Avg\ Price_{ij}$*)*.[87]

Estimates of corn crops in the Central Okanagan and the North Okanagan Regional District and estimates of the value of the corn crops that were used in the benefits analysis are provided in table #19 and #20 below.[88]

TABLE #19
Corn Crop Production Estimates
Central Okanagan and North Okanagan Regional District

Regional District	Corn for Grain: Farms Reporting	Corn for Grain: Acres	Corn for Grain: Hectares	Corn for Silage: Farms Reporting	Corn for Silage: Acres	Corn for Silage: Hectares
Central Okanagan Regional District	2	x	x	3	x	x
North Okanagan Regional District	7	290	117	48	3,774	1,527

Source: Statistics Canada – 2001 Census of Agriculture – Farm Data *(see Table #13 – Hay & Field Crops by Province) (http://www.statcan.ca/english).*

TABLE #20
Estimated Value of Corn Crops - North Okanagan Regional District

Crop	Acres	Tons Per Acre	Total Tons	Estimated $ Per/Ton 2003	Estimated Value
Corn for Grain	290	39.5 bushels/ton 131.3 bushels/acre 131.3/39.5=3.32 tons/acre	290 x 3.32 = 962.80	$143	$137,680
Silage Corn	3,774	assume 16 tons/acre	3,774 x 16 = 60,384	$26	$1,569,984
Sweet Corn	Not shown in Census	-	-	-	-
W/Avg = (($143 x 962.80) + ($26 x 60,384)) = $27.84 (962.80+60,384) (Total Tons 962.8+603.84 = 61,346.80)			Estimated W/Avg Value/ton	$27.84	$1,707,664

Note: $'s per/ton and values are estimates. Table developed from sources: *1) Stats Canada – Census of Agriculture – www.statcan.ca, 2) British Columbia Ministry of Agriculture, Food and Fisheries, Planning for Profit (Summer/2001), 3) Ontario Ministry of Agriculture & Food - Grain Corn Prices (Ontario) (1981-2003) 19/Jan/2005; see also: Estimated Area, Production and Farm Value of Specified Field Crop (1988-2004) (22/Feb/2005).*

Note that corn crop damage is the only agricultural crop included in the benefits analysis as it is the only crop grown in the Central and North Okanagan Regional Districts that quantitative relationships are available for.

Although it is recognized that the principal crops grown in the region are tree fruits and grapes, the quantitative relationships to apply within the benefits analysis for these crops are not available. Note however that studies originating in California have shown negative effects on tree fruits and grape production associated with air pollution.[89]

[87] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-57 – 5-60).

[88] **Note**: tables #19 & #20 developed from: 1). Statistics Canada, *2001 Census of Agriculture – Farm Data*, *http://www.statcan.ca*, 2) British Columbia Ministry of Agriculture, Food and Fisheries, *Planning for Profit*, (Summer/2001), and 3) Ontario Ministry of Agriculture & Food, *Grain Corn Prices Ontario 1981-2003 (19/January/2005); see also: Estimated Area, Production and Farm Value of Specified Field Crops Ontario (1988-2004)*, (22/Feb/2005).

[89] Brewer, Robert F., Rulon Ashcroft, *The Effects of Ambient Oxidants on Thompson Seedless Grapes, The Effects of Present and Potential Air Pollution on Important San Joaquin Valley Crops – Grapes*, University of California, Riverside, CA 92521, Final Report on ARB Contract A1-132-33 (September 15, 1983). See also: Holmes, John R. PhD, *"Estimated Crop Yield Losses from Air Pollutants in California: 1989-1992"*, Research Notes–Brief Reports to the Scientific and Technical Community, California Environmental Protection Agency-Air Resources Board-Research Division, P.O. Box 2815, Sacramento CA 98512, (January/1997), No 97-1.

4.9 Comparison of Vernon and Kelowna Air Quality Monitoring Sites

Note that the BC Lung Association Phase I health study recommended CRFs associated with PM mortality for use within large urban areas. As the CRFs were derived from epidemiology studies conducted within large urban centres, the expert panel noted that the CRFs may not be suitable for use in smaller communities that may not have similar pollution source mixes as the large urban centres *(ie. the air quality of large urban centers is heavily influenced by traffic and industrial sources – whereas the smaller communities are influenced by other pollution source mixes, such as wood smoke or large resource industries for example).* Although it is appropriate to apply the CRFs to the City of Kelowna, application of the CRFs recommended within the BC Lung Association Phase I health study to areas outside Kelowna may be questionable, as the smaller communities may require unique CRFs be estimated for the pollution source mixes particular to these areas.[90]

As unique CRFs applicable to smaller communities throughout British Columbia were not available at the time of writing of this report, for this benefits analysis it is assumed that the pollution source mixes are similar for communities within the Central Okanagan Regional District and the North Okanagan Regional District. Adopting this assumption permits application of the CRFs recommended within the BC Lung Association Phase I health study to both areas accordingly. Note however that this assumption presents a source of uncertainty within the benefits analysis.

Comparison of the Vernon *(Science Centre)* ozone and particulate matter (PM) daily time-series data against the Kelowna *(Okanagan University College)* ozone and particulate matter (PM) daily time-series data lends some support to the assumption of similar mixes of emissions.

As shown in graph #6, #7 and #8 below, there are similarities in the ozone and particulate matter (PM) daily time-series profiles over the period 2002 - 2004. Although there are differences in the annual averages *(as noted in table #8 and #9 above),* this similarity in the daily time-series trend of the PM and ozone daily concentration data supports the assumption that the two air quality monitoring sites are influenced by similar meteorology and pollution source mixes.

Because the two urban centres *(Vernon and Kelowna)* are geographically situated close to each other *(approximately 46 kms apart),* some of the air pollution will likely be shared between the two cities. This is further evidenced by the forest fire drift towards the Vernon area in the summer of 2003. *(Note: in graph #6, and #7 shown below, the spike in the PM concentration data in August/2003 was due to the forest fires in the Kelowna Okanagan mountain area).*

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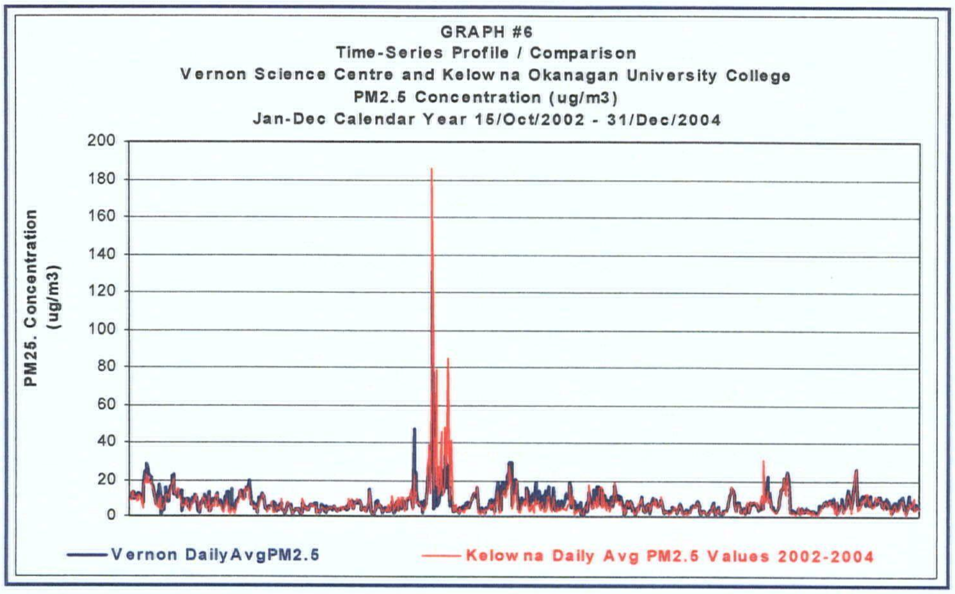
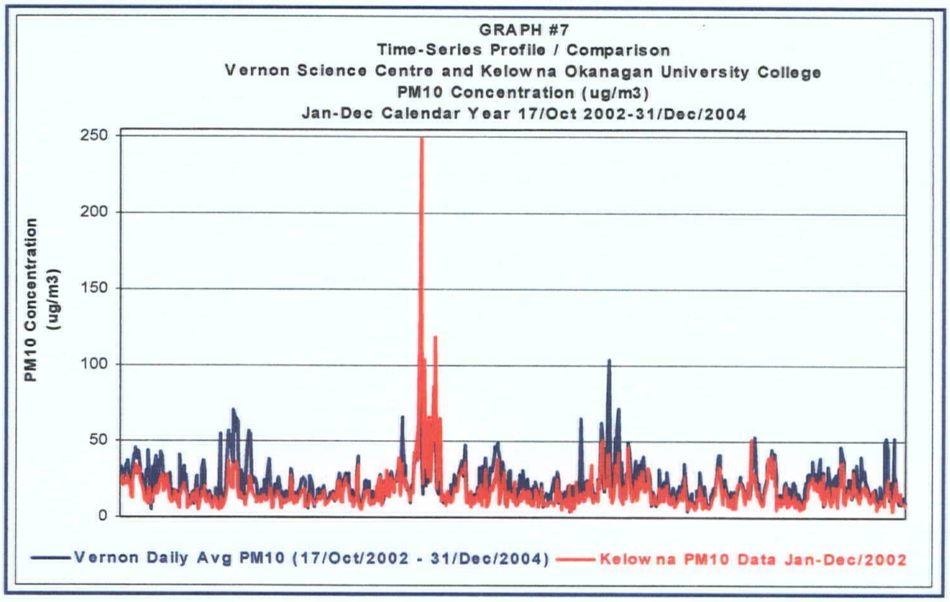
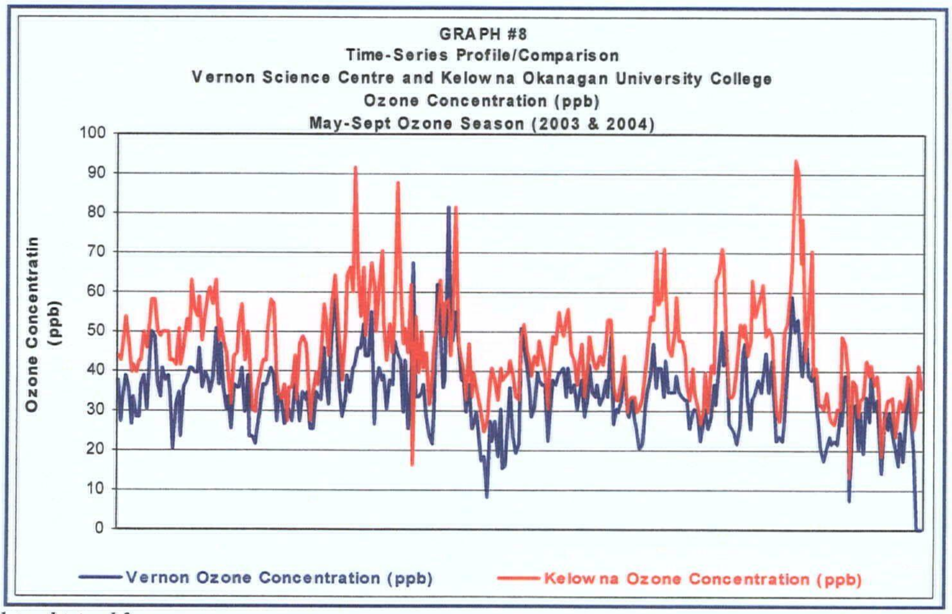
[90] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 52).







Source: hourly data obtained from:
British Columbia Ministry of Water, Land and Air Protection, Air Resources Branch & AQI Web Service, Unverified

4.10 Values - AQVM (Version 3.0) Default Database and Values Updated to Year 2003

As the dollar values of health outcomes contained within the default AQVM (Version 3.0) database are expressed in 1996 $'s Canadian, these values were updated *(inflated)* to 2003 by applying the medical cost index (MCI) to the cost-of-illness based estimates, and the consumer price index (CPI) to the contingent valuation and the wage-based estimates, as noted in table #21 below. This follows from the method put forward within the paper "*International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report)*".[91]

TABLE #21 Recommended Indices – Conversion Factors For Valuation Methods		
Valuation Method	**Appropriate Index (or Conversion Factor)**	
Cost of Illness (COI) based estimates	Medical Cost Index (MCI)	MCI is the appropriate conversation factor for COI-based estimates.
Contingent Valuation & Wage Premium Studies (measures health benefits in terms of income & foregone consumption)	Consumer Price Index (CPI)	CPI is appropriate for inflating/deflating CV or wage premium based estimates.
Source: Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report), Health Canada, (September/2002), (p. 8).		

Note that the recommended indices were applied to the original values of the studies incorporated within the AQVM (Version 3.0).[92] As many of the dollar values of health outcomes contained within the default AQVM (Version 3.0) database derive from US based studies, the conversions also used the purchasing power parity index (PPPI) for the Canadian/US currency conversions.

Based on the paper "*International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indices - Final Report*", the equations used to convert the original values used within the default AQVM (Version 3.0) database to 2003 $'s Canadian, and the indices and data applied in the conversion process are noted in table #22 and #23 below.[93]

TABLE #22
Benefits Transfer Equation

$$\$A \times \frac{\text{PPPI country1 year0}}{\text{PPPI country0 year0}} \times \frac{\text{index year1}}{\text{index year0}} = \text{estimate Canada year 1}$$

Source: Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report), Health Canada, (September/2002), (p. 13).

TABLE #23 Price Indices				
Index	**Dates**	**Series ID**		**Description**
US CPI	1913-2001	CUUR0000SA0	Source: US Bureau of Labour Statistics	All urban consumers. Base year 1982-1984. Not seasonally adjusted.
US MCI	1935-2001	MUUR0000SA5	Source: US Bureau of Labour Statistics	Subset of the CPI that includes all medical care costs and is calculated based on the US city average. Base year 1982-1984. Not seasonally adjusted.
Cda CPI	1970-2000	V737344 Table 326-0002	Source: Statistics Canada	1996 basket content for all items. Base year 1992.
Cda MCI	1970-2000	V737544 Table 326-0002	Source: Statistics Canada	1996 basket content for health care. Base year 1992.
PPPI	1980-2004	PPPs for GDP Historical Series	Source: OECD http://www.oecd.org/std/ppp	Purchasing Power Parities for GDP. Historical Series (1980-2004).
Source: Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report), Health Canada, (September/2002), (p. 9, 10).				

[91] Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report), Health Canada, (September/2002), (p. 8).

[92] Stratus Consulting, Air Quality Valuation Model Version 3.0 (AQVM 3.0), Operating Instructions, (p. 3-17, 3-18). See also Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999), (p. 5-20 & 5-31), (Chapter #5).

[93] Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report), Health Canada, (September/2002), (p. 9, 10, & 13). **Note**: see also methods described in: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999), Chapter #5 Valuation.

The consumer price indices *(all items and medical/health care)* and the purchasing power indices applied in converting the original values of the studies incorporated within the AQVM (Version 3.0) to 2003 $'s Canadian are shown in table #24 below.

TABLE #24
CPI Data (All Items & Health/Medical Care) and PPP Data Applied in Updating the Dollar Values of Health Outcomes

CONSUMER PRICE INDEX **All Urban Consumers** **Series: CUUR 0000SAO** (Sept/2004) **Not Seasonally Adjusted** **Area: US City Average** **All Items 1982-1984=100**			**CONSUMER PRICE INDEX** **All Urban Consumers** (Old Series) **Series: MUUR 0000SA5** Old **Series: CUUR 0000SAM** (Replaces above) **Not Seasonally Adjusted** **Area: US City Average** **Medical Care 1982-1984=100**			**CONSUMER PRICE INDEX** **Hist Summary** **Table #326-0002,** **Cat #62-001-XPB** **& #62-010-X1B** **All Items** **1992=100**		**CONSUMER PRICE INDEX** **Table #326-0002** **Cat #62-001-X** **& #62-010-X** **Health Care** **1992=100**		**Purchasing Power Parity (PPPs) for GDP**		
Year	**Annual Avg**	**3 Yr Avg**	**Year**	**Annual Avg**	**3 Yr Avg**	**Year**	**Annual Avg**	**Year**	**Annual Avg**	**Year**	**Canada**	**USA**
1980	82.40		1980	74.90		1980	52.40	1980	46.00	1980	1.15	1.00
1981	90.90		1981	82.90		1981	58.90	1981	51.30	1981	1.17	1.00
1982	96.50	89.93	1982	92.50	83.43	1982	65.30	1982	57.50	1982	1.20	1.00
1983	99.60	95.67	1983	100.60	92.00	1983	69.10	1983	62.40	1983	1.21	1.00
1984	103.90	**100.00**	1984	106.80	99.97	1984	72.10	1984	65.90	1984	1.21	1.00
1985	107.60	103.70	1985	113.50	106.97	1985	75.00	1985	69.30	1985	1.21	1.00
1986	109.60	107.30	1986	122.00	114.10	1986	78.10	1986	73.30	1986	1.22	1.00
1987	113.60	110.27	1987	130.10	121.87	1987	81.50	1987	78.10	1987	1.24	1.00
1988	118.30	113.83	1988	138.60	130.23	1988	84.80	1988	82.80	1988	1.25	1.00
1989	124.00	118.63	1989	149.30	139.33	1989	89.00	1989	87.20	1989	1.26	1.00
1990	130.70	124.33	1990	162.80	150.23	1990	93.30	1990	91.70	1990	1.25	1.00
1991	136.20	130.30	1991	177.00	163.03	1991	98.50	1991	96.50	1991	1.25	1.00
1992	140.30	135.73	1992	190.10	176.63	1992	100.00	1992	100.00	1992	1.23	1.00
1993	144.50	140.33	1993	201.40	189.50	1993	101.80	1993	102.80	1993	1.22	1.00
1994	148.20	144.33	1994	211.00	200.83	1994	102.00	1994	104.20	1994	1.21	1.00
1995	154.40	149.03	1995	220.50	210.97	1995	104.20	1995	104.80	1995	1.22	1.00
1996	156.90	153.17	1996	228.20	219.90	1996	105.90	1996	105.90	1996	1.21	1.00
1997	160.50	157.27	1997	234.60	227.77	1997	107.60	1997	107.40	1997	1.21	1.00
1998	163.00	160.13	1998	242.10	234.97	1998	108.60	1998	109.80	1998	1.19	1.00
1999	166.60	163.37	1999	250.60	242.43	1999	110.50	1999	112.30	1999	1.19	1.00
2000	172.20	167.27	2000	260.80	251.17	2000	113.50	2000	114.80	2000	1.21	1.00
2001	177.10	171.97	2001	272.80	261.40	2001	116.40	2001	117.90	2001	1.20	1.00
2002	179.90	176.40	2002	285.60	273.07	2002	119.00	2002	120.00	2002	1.19	1.00
2003	184.00	180.33	2003	297.10	285.17	2003	122.30	2003	122.20	2003	1.21	1.00
Source: US Dept of Labor Bureau of Labor Statistics *www.bls.gov*			Source: US Dept of Labor Bureau of Labor Statistics *www.bls.gov*			Source: Stats Canada *www.statscan.ca*		Source: Stats Canada *www.statscan.ca*		Source: OECD *http://www.oecd.org/std/ppp*		

Source: US Department of Labour – Bureau of Labour Statistics *(www.bls.gov)*.
Source: Statistics Canada *(www.statscan.ca)*.
Source: Organization for Economic Cooperation and Development (OECD) *(http://www.oecd..org/std/ppp)*.

The 1996 Canadian dollar values of health outcomes contained within the default AQVM (Version 3.0) database and the calculations used to update *(inflate)* the original dollar values applied within the AQVM (Version 3.0) to 2003 $'s Canadian are itemized in table #25 below.

TABLE #25
Dollar Values of Health Outcomes Included within AQVM -Version 3.0 and Calculations Used to Inflate the Original Values to 2003 $'s Cdn

		$ Value of Health Outcome AQVM (3.0) (1996 $'s Cdn)		$ Value of Health Outcome Updated (Inflated) to 2003 $'s Cdn	
Health Effect	**Study Basis**	**Year 1996**		**Year 2003**	
Mortality (MORT) VSL – WTP	Rowe et al (1995) (<65 years old) Similar to values Cropper & Freeman 1991	Low	$3.1 Mill	$ 3.1 x (122.3/105.9)	$3.58 Mill
		Ctrl	$5.2 Mill	$ 5.2 x (122.3/105.9)	$6.00 Mill
		High	$10.4 Mill	$10.4 x (122.3/105.9)	$12.01 Mill
	Assumes the VSL for persons 65 and older is 75% of the VSL for <65	Low	$2.3 Mill	$2.3 x (122.3/105.9)	$2.47 Mill
		Ctrl	$3.9 Mill	$3.9 x (122.3/105.9)	$4.18 Mill
		High	$7.8 Mill	$7.8 x (122.3/105.9)	$8.36 Mill
	Jones-Lee et al (1985) Age Weighted VSL Assumes 85% of deaths are persons >= 65	Low	$2.4 Mill	$2.4 x (122.3/105.9)	$2.77 Mill
		Ctrl	$4.1 Mill	$4.1 x (122.3/105.9)	$4.73 Mill
		High	$8.2 Mill	$8.2 x (122.3/105.9)	$9.47 Mill
Chronic Bronchitis (CB) WTP	Viscusi et al (1991) Krupnick & Cropper (1992)	Low	$175,000	$300,000 x 1.25 x (113.5/93.3) x .42	$206,455
		Ctrl	$266,000	$475,000 x 1.25 x (113.5/93.3) x .42	$326,887
		High	$465,000	$800,000 x 1.25 x (113.5/93.3) x .42	$550,547
Respiratory Hospital Admiss (RHA) Adj COI	CIHI 1994	Low	$3,300	$7,786 x .50	$3,893
		Ctrl	$6,600	[(5.7 x $146) + ($3,061)] x 2	$7,786
		High	$9,800	$7,786 x 1.50	$11,679
Cardiac Hospital Admissions (CHA) Adj COI	CIHI 1994	Low	$4,200	$9,929 x .50	$4,965
		Ctrl	$8,400	[(5.6 x $146) + ($4,147)] x 2	$9,929
		High	$12,600	$9,929 x 1.50	$14,894
Emergency Room Visits (ERV) Adj COI	Rowe et al (1986)	Low	$290	$674 x .50	$337
		Ctrl	$570	($146 + $191) x 2	$674
		High	$860	$674 x 1.50	$1,011
Child Bronchitis (CB) Adj COI	Krupnick & Cropper (1989)	Low	$150	$351 x .50	$176
		Ctrl	$310	[$42 x (100.6/576.0) x 1.21 x (122.2/62.4)] x 2	$351
		High	$460	$351 x 1.5	$527
Asthma Symptom Days (ASD) WTP	Rowe & Chestnut (1986)	Low	$17	$9 x 1.21 x (122.3/72.1)	$18
		Ctrl	$46	$25 x 1.21 x (122.3/72.1)	$51
		High	$75	$41 x 1.21 x (122.3/72.1)	$84
Acute Resp Symptom Days (ARSD) WTP	Loehman et al (1979), Tolley et al (1986a)	Low	$7	$4 x 1.21 x (122.3/72.1)	$8
		Ctrl	$15	$8 x 1.21 x (122.3/72.1)	$16
		High	$22	$12 x 1.21 x (122.3/72.1)	$25
Minor Restricted Activity Days (MRAD) WTP	Krupnick & Kopp (1988)	Low	$20	$11 x 1.21 x (122.3/72.1)	$23
		Ctrl	$33	$18 x 1.21 x (122.3/72.1)	$37
		High	$57	$31 x 1.21 x (122.3/72.1)	$64
Restricted Activity Days (RAD) WTP & Adj COI	Loehman et al (1979)	Low	$37	$88 x .50	$44
		Ctrl	$73	[0.20 x $146 x 2] + [0.80 x $37***]	$88
		High	$110	$88 x 1.5	$132
Agricultural Crop Damage (ACD)	Estimates (based on local crop data) (Parker/2005) (see p. 37 of this report)	Low	-	Ctrl Estimate: W/Avg $/ton of Corn LFV $27.84 (North Okgn Reg District)	$27.84 per/ton
		Ctrl	-		
		High	-		
Household Materials Soiling (HHMS) WTP	Mathtech (1983)	Low	$1.75	$.48 x 1.25 x 122.3/93.3 = $0.786 x 2.63	$2.07
		Ctrl	$3.50	(Twice the low estimate)	$4.14
		High	$8.75	(Five times the low estimate)	$10.35

All methods and references in this table from source: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita - Environment Canada, David Stieb - Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0, Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-19 & 5-20, Table 5-4; and p. 5-31, Table 5-7, Methods used to inflate values are described in Chapter #5 Economic Valuation, p. 5-1 –to- 5-61). See also methods described within: Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, *International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report)*, Health Canada, (September/2002), (p. 9, 10, & 13). Note: assumed average wage Cda ∧ ($146.00 = $18.27 x 8), Source: Avg Hrly Wages of Employees by Selected Characteristics and Profession, Unadjusted by Prov *(Mthly) http://www.statcan.ca/english/pgdb/labr69a.htm*

The health and welfare effects, the concentration response functions (CRFs), the probability weights and the dollar values of health outcomes associated with each health and other endpoint included in the benefits estimation are provided in the table #26 below for PM2.5, and table #27 below for ozone.

The dollar values of health outcomes are expressed in 1996 *(as per the default AQVM-Version 3.0 database)* and 2003 $'s Canadian *(as updated / inflated for this study).*

TABLE #26

CRFs and Dollar Values of Health Outcomes Applied in the Benefits Analysis for PM2.5

Health Effect		% of Population	Factor Day/Yr	CRFs & Probability Weighting Assignments: AQVM (Version 3.0)	CRF's	Weights	BC Lung Association	CRFs	Weights	Dollar Values of Health Outcomes: AQVM (Version 3.0) (1996 $'s Cdn)		Wts	Estimated Values (2003 $'s Cdn)		Wts
Chronic Mortality (WTP)	Annual mortality risk per 1 ug/m³ change in annual avg $PM_{2.5}$ concentration	100% of pop	x 1	**Low** **Ctrl** **High** Pope et al (2002) Rev as per Hlth Cdn Low Ctrl High Pope et al 1995, Schwartz et al 1996a AQVM p D-2 & p 3-16	**1.58 x 10-5** **2.82 x 10-5** **4.07 x 10-5** .87 x 10-5 2.14 x 10-5 4.82 x 10-5	**25%** **50%** **25%** 22% 67% 11%	Low Ctrl High Low: Stieb et al (2002b, 2003) Ctrl: Pope et al (1995) & (2002) High: 6 Cities – Re-analysis Source: BCLA Phase 1 Health Study - p 51 Note Assumes BC Non-Accidental Base Mort Rt =(avg of 2001, 2002, 2003) = 5.12 x 10-3	5.12 x 10-6 20.48 x 10-6 56.32 x 10-6	22% 67% 11%	Low Ctrl High	$2.40 Mill $4.10 Mill $8.20 Mill	33% 50% 17%	Low Ctrl High	$2.77 Mill $4.73 Mill $9.47 Mill	33% 50% 17%
Acute Mortality (WTP)	Annual mortality risk per 1 ug/m³ change in annual avg $PM_{2.5}$ concentration	100% of pop	x 1	(Not included within default AQVM CRF database)			Low Ctrl High (NMAPS Corrected, Dominici et al 2003) (Stieb et al 2002b, 2003) (Six Cities Updated)	1.71 x 10-6 5.12 x 10-6 6.66 x 10-6	22% 67% 11%	Low Ctrl High	$2.40 Mill $4.10 Mill $8.20 Mill	33% 50% 17%	Low Ctrl High	$2.77 Mill $4.73 Mill $9.47 Mill	33% 50% 17%
Chronic Bronchitis (WTP)	Annual risk per 1 ug/m³ change in annual avg $PM_{2.5}$ concentration	For pop 25 yrs & older	x 1	Low Ctrl High	4.13 x 10-5 8.27 x 10-5 1.24 x 10-4	25% 50% 25%	Same as aside			Low Ctrl High	$175,000 $266,000 $465,000	33% 34% 33%	Low Ctrl High	$206,455 $326,887 $550,547	33% 34% 33%
Respiratory Hospital Admissions (COI)	Daily risk factors per 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	100% of pop	x 365	Low Ctrl High	1.00 x 10-8 1.21 x 10-8 1.42 x 10-8	25% 50% 25%	Same as aside			Low Ctrl High	$3,300 $6,600 $9,800	33% 34% 33%	Low Ctrl High	$3,893 $7,786 $11,679	33% 34% 33%
Cardiac Hospital Admissions (Adjusted COI)	Daily risk per 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	100% of pop	x 365	Low Ctrl High	7.90 x 10-9 1.02 x 10-8 1.26 x 10-8	25% 50% 25%	Same as aside			Low Ctrl High	$4,200 $8,400 $12,600	33% 34% 33%	Low Ctrl High	$4,965 $9,929 $14,894	33% 34% 33%
Adjusted Net Emergency Room Visits (Adjusted COI)	Daily risk factors per 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	100% of pop	x 365	Low Ctrl High **Low** **Ctrl** **High**	4.62 x 10-8 5.61 x 10-8 6.61 x 10-8 **4.30 x 10-8** **5.22 x 10-8** **6.15 x 10-8**	25% 50% 25% **25%** **50%** **25%**	Same as bold-face shaded cell aside			Low Ctrl High	$290 $570 $860	33% 34% 33%	Low Ctrl High	$337 $674 $1,011	33% 34% 33%
Asthma Symptom Days (WTP)	Daily risk factors given a 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	For pop with asthma (7.6 % of pop)	x 365	Low Ctrl High	1.62 x 10-4 2.64 x 10-4 3.65 x 10-4	33% 34% 33%	Same as aside			Low Ctrl High	$17 $46 $75	33% 34% 33%	Low Ctrl High	$18 $51 $84	33% 34% 33%
Restricted Activity Days (WTP)	Daily risk factors given a 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	For non-asthmatic pop (92.4% of pop) 20 yrs & older	x 365	Low Ctrl High	1.31 x 10-4 2.50 x 10-4 3.95 x 10-4	25% 50% 25%	Same as aside			Low Ctrl High	$37 $73 $110	33% 34% 33%	Low Ctrl High	$44 $88 $132	33% 34% 33%
Net Days with Acute Respiratory Symptoms (WTP)	Daily risk factors given a 1 ug/m³ change in daily avg $PM_{2.5}$ concentration	For non-asthmatic pop (92.4% of pop)	x 365	Low Ctrl High	1.25 x 10-4 2.79 x 10-4 4.14 x 10-4	25% 50% 25%	Same as aside			Low Ctrl High	$7 $15 $22	33% 34% 33%	Low Ctrl High	$8 $16 $25	33% 34% 33%
Child Acute Bronchitis (Adjusted COI)	Annual risk factors given a 1 ug/m³ change in annual avg $PM_{2.5}$ concentration	For pop under age 20	x 1	Low Ctrl High	6.20 x 10-4 1.65 x 10-3 2.69 x 10-3	25% 50% 25%	Same as aside			Low Ctrl High	$150 $310 $460	33% 34% 33%	Low Ctrl High	$176 $351 $527	33% 34% 33%
Household Materials Soiling (WTP)	Annual household materials soiling	N/A	x 1	Low Ctrl High	- 1.00 -	- 100% -	N/A			Low Ctrl High	$1.75 $3.50 $8.75	33% 34% 33%	Low Ctrl High	$2.07 $4.14 $10.35	33% 34% 33%

Source: the morbidity CRFs are from *AQVM (Version 3.0) Methodology* (p. D-2, Table D-1), *AQVM Oper Instrs* (p. 3-18), and the *BCLA Phase I Health Study* (p. 113) (except **bold face shaded cell values are the revised CRFs adjusted for the stat error – provided by Hlth Cda** - not included in the default AQVM (Version 3.0) database – but referenced in the BCLA Phase I health study. (See *AQVM Version 3: Report 2, Methodology*, for dollar values of health outcomes (p. 5-20, 5-31, Chapter #5, p. 5-1 – 5-61)). All methods and references in this table from source: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita - Environment Canada, David Stieb - Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999). See also: Bates, Dr. David V. -University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report"*, British Columbia Lung Association, (May/2003), (p. 51 & 113).

Chronic Mortality	CRF Applicable to PM 2.5	Assumed PM 2.5 AQVM Compatible Value using BC Avg Non-Accidental Base Age Standardized Mortality Rate ASMR
Stieb et al 2002b 2003	1%/10 ug/m³	$(1/10) \times (5.12\times10^{-3}) \times (1/100) = \mathbf{5.12\times10^{-6}}$
Pope et al 1995	4%/10 ug/m³	$(4/10) \times (5.12\times10^{-3}) \times (1/100) = \mathbf{20.48 \times 10^{-6}}$
6 Cities–Re-analysis	11%/10 ug/m³	$(11/10) \times (5.12\times10^{-3}) \times (1/100) = \mathbf{56.32 \times 10^{-6}}$

TABLE #27

CRFs and Dollar Values of Health Outcomes Applied in the Benefits Analysis for Ozone

Health Effect		% of Population	Factor Day/Yr	CRFs & Probability Weighting Assignments: AQVM (Version 3.0) CRFs		AQVM Weights	BC Lung Association CRFs		BCLA Weights	Dollar Values of Health Outcomes: AQVM (Version 3.0) (1996 $'s Cdn)		Wts	Estimated Values (2003 $'s Cdn)		Wts
Mortality (WTP)	Daily mortality risk factors given a 1 ppb change in daily high hour ozone concentration	100% of pop	x 153	**Low**	**1.28 x 10-9**	**25%**	Low	0							
				Ctrl	**3.55 x 10-9**	**50%**	Ctrl	0							
				High	**5.81 x 10-9**	**25%**	High	0							
				Source : BCLA, p 114			Source: BCLA, p 52								
				Low	0	33%	Low	.97 x 10-9	33%	Low	$2.40 Mill	33%	Low	$2.77 Mill	33%
				Ctrl	4.3 x 10-9	34%	Ctrl	2.68 x 10-9	34%	Ctrl	$4.10 Mill	50%	Ctrl	$4.73 Mill	50%
				High	7.4 x 10-9	33%	High	4.39 x 10-9	33%	High	$8.20 Mill	17%	High	$9.47 Mill	17%
				Source: AQVM Methodology Report Table 4-3, p 4-11 & AQVM Oper Instr pg 3-15			Stieb et al (2002) Source: Hlth Cda Rev CRFs with Prov base mrt rate=1.40x10-5								
Respiratory Hospital Admissions (COI)	Daily risk factors given a 1 ppb change in daily high hour ozone concentration	100% of pop	x 153	Low	6.00 x 10-9	25%	Same as aside			Low	$3,300	33%	Low	$3,893	33%
				Ctrl	1.10 x 10-8	50%				Ctrl	$6,600	34%	Ctrl	$7,786	34%
				High	1.60 x 10-8	25%				High	$9,800	33%	High	$11,679	33%
Adjusted Net Emergency Room Visits (Adjusted COI)	Daily risk factors given a 1 ppb change in daily high-hour ozone concentration	100% of pop	x 153	Low	2.6 x 10-8	25%	Same as bold-face shaded cell aside			Low	$290	33%	Low	$337	33%
				Ctrl	4.7 x 10-8	50%				Ctrl	$570	34%	Ctrl	$674	34%
				High	6.9 x 10-8	25%				High	$860	33%	High	$1,011	33%
				Low	**2.43 x 10-8**	**25%**									
				Ctrl	**4.46 x 10-8**	**50%**									
				High	**6.48 x 10-8**	**25%**									
Asthma Symptom Days (WTP)	Daily risk factors given a 1 ppb change in daily high-hour ozone concentration	For pop with asthma (7.6% of pop)	x 153	Low	1.06 x 10-4	33%	Same as aside			Low	$17	33%	Low	$18	33%
				Ctrl	1.88 x 10-4	50%				Ctrl	$46	34%	Ctrl	$51	34%
				High	5.20 x 10-4	17%				High	$75	33%	High	$84	33%
Minor Restricted Activity Days (WTP)	Daily risk factors given a 1 ppb change in daily high hour ozone concentration	For non-asthmatic pop (92.4% of pop)	x 153	Low	1.93 x 10-5	25%	Same as aside			Low	$20	33%	Low	$23	33%
				Ctrl	4.67 x 10-5	50%				Ctrl	$33	34%	Ctrl	$37	34%
				High	7.40 x 10-5	25%				High	$57	33%	High	$64	33%
Net Day with Acute Respiratory Symptoms (WTP)	Daily risk factors given a 1 ppb change in daily high hour ozone concentration	For non-asthmatic pop (92.4% of pop)	x 153	Low	5.07 x 10-5	25%	Same as aside			Low	$7	33%	Low	$8	33%
				Ctrl	9.03 x 10-5	50%				Ctrl	$15	34%	Ctrl	$16	34%
				High	1.30 x 10-4	25%				High	$22	33%	High	$25	33%
Agricultural Crop Damage (Corn)	Percent reduction in annual yield	N/A	x 1	Low	0.00 x 10-3	33%	N/A			Low	-	-	Low	-	-
				Ctrl	1.50 x 10-3	34%				Ctrl	-	100%	Ctrl	$27.84	100%
				High	2.00 x 10-3	33%				High	-	-	High	-	-

Source: the morbidity CRFs are from *AQVM (Version 3.0) Methodology*, (Table 4-3, p. 4-11); the *AQVM Operating Instructions* p. 3-18, and the *BCLA Phase I Health Study(* p. 114); (except **bold face (shaded cell) values are the revised CRFs adjusted for the statistical error** (these are not listed in the AQVM database – but they are referenced in the BCLA Phase I health study) **(also provided by Hlth Cda – as per B Jessiman)**).

(See *AQVM Version 3: Report 2, Methodology* for dollar values of health outcomes (p. 5-20 and 5-31, Chapter #5 p. 5-1 – 5-61). All methods and references in this table from source: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita - Environment Canada, David Stieb - Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999). See also: Bates, Dr. David V. -University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*", British Columbia Lung Association, (May/2003), (p. 114).

Section #5 Annualized Effects and Monetized Benefits Estimates

The human health *(and other)* impacts and the monetized benefits estimates associated with a 10% improvement in ground level ozone and particulate matter (PM2.5) concentration are reported below.

5.1 PM2.5 & Ozone - BC Lung Association – Recommended Acute & Chronic CRFs for PM Mortality (Base Mort Rate $5.12x10^{-3}$) (Values Updated to 2003 $'s Cdn) (With Updates to Ozone Mort and ERVs as per CRFs Provided by Health Canada)

The annual effects and monetized benefits estimates associated with a 10% improvement in PM2.5 and ozone for the North Okanagan Regional District and the Central Okanagan Regional District are presented in table #29 and #30 below. Low, central, high, and mean effects and monetized benefits estimates are provided within table #29 and #30 for each of the health and other outcomes included in the analysis *(ie. mortality, adult chronic bronchitis, respiratory and cardiac hospital admissions, emergency room visits, child bronchitis, asthma symptom days, restricted activity days, minor restricted activity days, acute respiratory symptom days, household materials soiling, and corn crop damages).*

The effects estimates presented in table #29 below employed the default AQVM (Version 3.0) CRF database with modifications to PM2.5 mortality based on the recommendations put forward within the B.C. Lung Association Phase I health study, and with modifications to ozone mortality and emergency room visits *(in accordance with updates provided by Health Canada).*[94] The monetized benefits estimates presented in table #30 below employed the default AQVM (Version 3.0) database with the dollar values of health outcomes updated *(inflated)* to 2003 $'s Canadian.[95]

Note that the annual effects and monetized benefits estimates presented are linear – so that a 1% improvement is 1/10th of the 10% results, and a 20% improvement is two times the 10% results. Note also that the reported effects and the monetized benefits estimates are annual, with the avoided effects realized in each year the air quality improvement is sustained.

Table #28 below provides a summary of the annual aggregate monetized benefits estimates *(reported in table #30).* For the North Okanagan Regional District, the central estimate for PM2.5 is $8,843,690, and the low, mean and high *(percentile)* estimates for PM2.5 are: $3,479,951, $9,322,990 and $16,786,620 *(respectively).* The central estimate for ozone is: $675,309, and the low, mean and high *(percentile)* estimates for ozone are: $296,020, $705,279 and $1,166,090 *(respectively).*

For the Central Okanagan Regional District, the central estimate for PM2.5 is $16,646,630, and the low, mean and high *(percentile)* estimates for PM2.5 are: $6,581,351, $17,550,030 and $31,577,950 *(respectively).* The central estimate value for ozone is $1,833,540 and the low, mean and high *(percentile)* estimates for ozone are: $797,268, $1,921,190 and $3,185,580 *(respectively).*

TABLE #28
Aggregate Annual Monetized Benefits Estimates Associated with a 10% Improvement in PM2.5 & Ozone (Simulation Yr 2005)
Central Okanagan Regional District and North Okanagan Regional District

Regional District	PM2.5				Ozone			
	10% Low	Mean	90% High	Central Est	10% Low	Mean	90% High	Central Est
North Okanagan	$3,479,951	$9,322,990	$16,786,620	$8,843,690	$296,020	$705,279	$1,166,090	$675,309
Central Okanagan	$6,581,351	$17,550,030	$31,577,950	$16,646,630	$797,268	$1,921,190	$3,185,580	$1,833,540

94 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999) (p. 4-11 & D-2). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 51, 113, and 114). See also: Jessiman, Barry Personal (e-mail) communication (21/July/2003).

95 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999) (p. 5-20 & 5-31).

TABLE #29
Annual Estimated Impacts (Effects/Outcomes/Events)
Associated with a 10% Improvement in PM2.5 and Ozone (Simulation Year 2005)
North Okanagan Regional District and Central Okanagan Regional District
(BCLA Acute & Chronic CRFs for PM Mortality) (Base Mortality Rate = 5.12x10^{-3})

North Okanagan Reg District	PM2.5				Ozone			
Health Outcome	Low	Mean	High	Central Est	Low	Mean	High	Central Est
Chronic Mortality	.30	1.25	3.33	1.21	.04	.11	.18	.11
Acute Mortality	.10	.27	.39	.30	-	-	-	-
Chronic Bronchitis	1.69	3.38	5.07	3.38	-	-	-	-
Respiratory Hospital Admiss	.22	.26	.31	.26	.24	.45	.65	.45
Cardiac Hospital Admiss	.17	.22	.27	.22	-	-	-	-
Emergency Room Visits	.93	1.13	1.33	1.13	.98	1.81	2.63	1.81
Asthma Symptom Days	266.01	432.96	599.35	433.50	326.40	669.38	1,601.23	578.91
Restricted Activity Days	2,021.73	3,958.58	6,096.06	3,858.27	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	722.55	1,747.40	2,770.38	1,748.34
Acute Respiratory Symptom Days	2,495.48	5,475.09	8,265.03	5,569.91	1,898.09	3,381.55	4,866.89	3,380.62
Child Bronchitis	8.44	22.50	36.62	22.46	-	-	-	-
Household Materials Soiling	0	25,636.50	0	25,636.50	-	-	-	-
Corn Crop Damage	-	-	-	-	0	244.04	417.16	312.87
Central Okanagan Reg District	**PM2.5**				**Ozone**			
Health Outcome	**Low**	**Mean**	**High**	**Central Est**	**Low**	**Mean**	**High**	**Central Est**
Chronic Mortality	.57	2.34	6.25	2.27	.11	.30	.49	.30
Acute Mortality	.19	.50	.74	.57	-	-	-	-
Chronic Bronchitis	3.25	6.50	9.75	6.50	-	-	-	-
Respiratory Hospital Admiss	.41	.49	.58	.49	.67	1.23	1.78	1.23
Cardiac Hospital Admiss	.32	.41	.51	.41	-	-	-	-
Emergency Room Visits	1.74	2.12	2.49	2.12	2.71	4.97	7.22	4.97
Asthma Symptom Days	499.08	812.29	1,214.46	813.31	897.81	1,841.18	4,404.33	1,592.33
Restricted Activity Days	3,834.39	7,507.80	11,561.70	7,317.54	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	1,987.43	4,806.39	7,620.20	4,808.96
Acute Respiratory Symptom Days	4,681.88	10,272.00	15,506.40	10,450.00	5,220.87	9,301.28	13,386.80	9,298.70
Child Bronchitis	15.45	41.17	67.02	41.11	-	-	-	-
Household Materials Soiling	0	47,401.70	0	47,401.70	-	-	-	-
Corn Crop Damage	-	-	-	-	0	0	0	0
Nrth & Ctrl Okgn Reg Dist	**PM2.5**				**Ozone**			
Health Outcome	**Low**	**Mean**	**High**	**Central Est**	**Low**	**Mean**	**High**	**Central Est**
Chronic Mortality	.87	3.58	9.59	3.49	.15	.41	.67	.41
Acute Mortality	.29	.77	1.13	.87	-	-	-	-
Chronic Bronchitis	4.94	9.89	14.83	9.89	-	-	-	-
Respiratory Hospital Admiss	.62	.75	.88	.75	.91	1.67	2.43	1.67
Cardiac Hospital Admiss	.49	.64	.78	.63	-	-	-	-
Emergency Room Visits	2.67	3.25	3.82	3.24	3.69	6.77	9.85	6.78
Asthma Symptom Days	765.09	1,245.25	1,723.81	1,246.81	1,224.21	2,510.56	6,005.56	2,171.24
Restricted Activity Days	5,856.12	11,466.38	17,657.76	11,175.81	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	2,709.98	6,553.79	10,390.58	6,557.30
Acute Respiratory Symptom Days	7,177.36	15,747.09	23,771.43	16,019.91	7,118.96	12,682.83	18,253.69	12,679.32
Child Bronchitis	23.89	63.67	103.64	63.57	-	-	-	-
Household Materials Soiling	0	73,038.20	0	73,038.20	-	-	-	-
Corn Crop Damage	-	-	-	-	0	244.04	417.16	312.87

Note: air quality benefits analysis is more suitable for application to large population groups, as disaggregation into smaller population sub-groups reduces the mortality and morbidity impacts to smaller fractions. The reported effects are annual predicted/estimated results. Substantial year to year variability may occur for smaller populations. Fractions are reported as the results average out over longer periods of time for larger populations.

TABLE #30
Annual Monetized Benefits Estimates
Associated with a 10% Improvement in PM2.5 and Ozone (Simulation Year 2005)
North Okanagan Regional District and Central Okanagan Regional District
(BCLA Acute & Chronic CRFs for PM Mortality) (Base Mortality Rate = $5.12x10^{-3}$) (Values Updated to 2003 $'s Cdn)

Nrth Okanagan Reg District	PM2.5				Ozone			
Health Outcome	10% Low	Mean	90% High	Central Est	10% Low	Mean	90% High	Central Est
Chronic Mortality	$1,433,540	$6,181,750	$11,480,500	$5,734,170	$108,865	$533,395	$1,028,300	$513,608
Acute Mortality	$478,781	$1,310,260	$2,870,120	$1,433,540	-	-	-	-
Chronic Bronchitis	$552,444	$1,214,960	$1,863,120	$1,106,230	-	-	-	-
Resp Hospital Admiss	$1,018	$2,026	$3,053	$2,036	$1,735	$3,496	$5,205	$3,470
Cardiac Hospital Admiss	$1,094	$2,211	$3,282	$2,188	-	-	-	-
Emergency Room Visits	$380	$761	$1,140	$760	$609	$1,218	$1,827	$1,218
Asthma Symptom Days	$4,788	$22,358	$50,345	$22,109	$5,875	$34,673	$81,663	$29,524
Restricted Activity Days	$169,764	$347,036	$536,453	$339,527	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$26,734	$70,939	$111,894	$64,689
Acute Resp Symptom Days	$39,928	$91,313	$139,248	$89,119	$27,045	$54,741	$84,515	$54,090
Child Bronchitis	$2,963	$7,982	$12,854	$7,884	-	-	-	-
Household Materials Soiling	$53,068	$142,338	$265,338	$106,135	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$6,815	$11,614	$8,710
TOTAL	$3,479,951	$9,322,990	$16,786,620	$8,843,690	$296,020	$705,279	$1,166,090	$675,309
Ctrl Okanagan Reg District	**PM2.5**				**Ozone**			
Health Outcome	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
Chronic Mortality	$2,689,530	$11,597,800	$21,539,000	$10,758,100	$299,443	$1,467,150	$2,828,440	$1,412,730
Acute Mortality	$898,261	$2,458,230	$5,384,750	$2,689,530	-	-	-	-
Chronic Bronchitis	$1,061,900	$2,335,380	$3,581,270	$2,126,380	-	-	-	-
Resp Hospital Admiss	$1,909	$3,802	$5,728	$3,819	$4,772	$9,617	$14,317	$9,545
Cardiac Hospital Admiss	$2,053	$4,147	$6,158	$4,105	-	-	-	-
Emergency Room Visits	$713	$1,428	$2,139	$1,426	$1,675	$3,351	$5,025	$3,350
Asthma Symptom Days	$8,983	$41,947	$94,455	$41,479	$16,161	$95,372	$224,621	$81,209
Restricted Activity Days	$321,972	$658,184	$1,017,430	$643,944	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$73,535	$195,124	$307,774	$177,932
Acute Resp Symptom Days	$74,910	$171,315	$261,249	$167,199	$74,390	$150,571	$232,468	$148,779
Child Bronchitis	$5,422	$14,609	$23,525	$14,430	-	-	-	-
Household Materials Soiling	$98,122	$263,181	$490,607	$196,243	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$0	$0	$0
TOTAL	$6,581,351	$17,550,030	$31,577,950	$16,646,630	$797,268	$1,921,190	$3,185,580	$1,833,540
Nrth & Ctrl Okg Reg Dist	**PM2.5**				**Ozone**			
Health Outcome	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
Chronic Mortality	$4,123,070	$17,779,550	$33,019,500	$16,492,270	$408,308	$2,000,545	$3,856,740	$1,926,338
Acute Mortality	$1,377,042	$3,768,490	$8,254,870	$4,123,070	-	-	-	-
Chronic Bronchitis	$1,614,344	$3,550,340	$5,444,390	$3,232,610	-	-	-	-
Resp Hospital Admiss	$2,927	$5,828	$8,782	$5,854	$6,507	$13,113	$19,522	$13,015
Cardiac Hospital Admiss	$3,147	$6,358	$9,440	$6,293	-	-	-	-
Emergency Room Visits	$1,093	$2,189	$3,279	$2,186	$2,284	$4,570	$6,852	$4,568
Asthma Symptom Days	$13,772	$64,305	$144,800	$63,587	$22,036	$130,045	$306,284	$110,733
Restricted Activity Days	$491,736	$1,005,220	$1,553,883	$983,471	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$100,269	$266,063	$419,668	$242,621
Acute Resp Symptom Days	$114,838	$262,628	$400,497	$256,318	$101,435	$205,312	$316,983	$202,869
Child Bronchitis	$8,385	$22,592	$36,378	$22,314	-	-	-	-
Household Materials Soiling	$151,189	$405,519	$755,945	$302,378	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$6,815	$11,614	$8,710
TOTAL	$10,061,302	$26,873,020	$48,364,570	$25,490,320	$1,093,288	$2,626,469	$4,351,670	$2,508,849

Note: some totals do not add due to rounding and monte carlo simulation effects.

As noted, the annual mortality related benefits estimates for PM2.5 and ozone reported above employ the PM2.5 CRFs recommended within the BC Lung Association Phase I health study and the ozone CRFs recommended by Health Canada, applying the simple average age-standardized non-accidental British Columbia base mortality rate *(see table #14, #15 and #16, p. 31 and 33).*[96] In the benefits estimates provided in table #30, the dollar values of health outcomes included in the default AQVM (Version 3.0) database have been updated *(inflated)* to 2003 $'s Canadian.[97] The PM2.5 and ozone mortality related effects and the monetized value estimates *(as provided within table #29 and #30 above)* are summarized in table #31 below.

TABLE #31
Annual Chronic and Acute Mortality Effects and Monetized Value Estimates (PM2.5 & Ozone) (Simulation Yr 2005)
BC Lung Association Recommended CRFs (Using BC Base Mortality Rates) – Values Updated to 2003 $'s Cdn

Effects Estimates	PM2.5 Chronic & Acute Mortality				Ozone Mortality			
	Low	Mean	High	Central Est	Low	Mean	High	Central Est
North Okanagan	.40	1.52	3.72	1.51	.04	.11	.18	.11
Central Okanagan	.76	2.84	6.99	2.84	.11	.30	.49	.30
Total (Nth & Ctrl Okgn)	1.16	4.36	10.71	4.35	.15	.41	.67	.41
Monetized Value Estimates	**PM2.5 Chronic & Acute Mortality**				**Ozone Mortality**			
	10% Low	Mean	90% High	Central Est	10% Low	Mean	90% High	Central Est
North Okanagan	$1,912,321	$7,492,010	$14,350,620	$7,167,710	$108,865	$533,395	$1,028,300	$513,608
Central Okanagan	$3,587,791	$14,056,030	$26,923,750	$13,447,630	$299,443	$1,467,150	$2,828,440	$1,412,730
Total (Nth & Ctrl Okgn)	$5,500,112	$21,548,040	$41,274,370	$20,615,340	$408,308	$2,000,545	$3,856,740	$1,926,338

For comparison purposes, the annual mortality related effects and the monetized benefits estimates that result using the PM2.5 and ozone mortality related CRFs recommended by Health Canada *(applying the Canadian base mortality rate)* with the dollar values of health outcomes updated to 2003 $'s Canadian are provided in table #32 below.

TABLE #32
Annual Mortality Effects and Monetized Value Estimates (PM2.5 & Ozone) (Simulation Yr 2005)
Health Canada Recommended CRFs (Using Cdn Base Mortality Rates) – Values Updated to 2003 $'s Cdn

Effects Estimates	PM2.5 Mortality				Ozone Mortality			
	Low	Mean	High	Central Est	Low	Mean	High	Central Est
North Okanagan	.94	1.67	2.41	1.67	.05	.14	.24	.14
Central Okanagan	1.75	3.13	4.52	3.13	.14	.40	.65	.40
Total (Nth & Ctrl Okgn)	2.69	4.80	6.93	4.80	.19	.54	.89	.54
Monetized Value Estimates	**PM2.5 Mortality**				**Ozone Mortality**			
	10% Low	Mean	90% High	Central Est	10% Low	Mean	90% High	Central Est
North Okanagan	$4,423,820	$8,253,240	$15,808,100	$7,895,680	$245,306	$700,924	$1,362,120	$680,340
Central Okanagan	$8,299,720	$15,484,300	$29,658,200	$14,813,400	$674,736	$1,927,960	$3,746,630	$1,871,340
Total (Nth & Ctrl Okgn)	$12,723,540	$23,737,540	$45,466,300	$22,709,080	$920,042	$2,628,884	$5,108,750	$2,551,680

Note that the monetized benefits estimates reported within table #31 and #32 above are directly comparable as they are both expressed in 2003 $'s Canadian. The difference in the reported results *(in table #31 and #32 above)* relates to the assumed PM2.5 and ozone mortality related CRFs, and the assumed base mortality rates applied within each analysis *(see table #14, #15 and #16, p. 31 and 33).* Although the low and high health effects and the monetized benefits estimates are lower in table #31 than those reported within table #32, the central and mean health effects and the monetized value estimates are similar.

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[96] Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113, and 114). See also: Jessiman, Barry Personal (e-mail) communication (21/July/2003). See also Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999) (p. 4-11 & D-2).

[97] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-20 & 5-31, Chapter #5 p. 5-1 – 5-61). See also: Pattanayak, Subhrendu K., Julia M. Wing, Brooks M. Depro, George L. Van Houtven (Research Triangle Institute); Paul De Civita and David M. Stieb, Health Canada; Bryan Hubbell, US Environmental Protection Agency, *International Health Benefits Transfer Application Tool: The Use of PPP and Inflation Indicies (Final Report)*, Health Canada, (September/2002), (p. 9, 10, & 13).

5.2 Benefits Associated with Marginal Improvements in Air Quality

Table #33 and #34 below present the estimated benefits that may be realized by the North Okanagan Regional District and the Central Okanagan Regional District *(here shown for simulation year 2005)* if air quality concentrations were improved incrementally *(by the levels indicated)* from baseline PM2.5 and ozone concentration values averaged over the period 2002-2004. Based on the results provided above - the annual monetized estimates include: *mortality (acute & chronic), respiratory hospital admissions, cardiac hospital admissions, emergency room visits, adult chronic bronchitis, child bronchitis, asthma symptom days, acute respiratory symptom days, restricted activity days, minor restricted activity days, agriculture crop damage (corn) and household materials soiling.*[98]

The analysis reveals there are substantial benefits associated with achieving targeted air quality improvements. For example, if the North Okanagan Regional District was to achieve an incremental improvement in PM2.5 concentration from current baseline ambient concentration levels *(averaged over 2002-2004)* to 7.0 ug/m^3 *(an 8.02% improvement),* the central estimate annual benefits would be $7,098,225, and a 1.56% improvement in ozone would yield estimated annual benefits of $105,269. If the Central Okanagan Regional District was to achieve an incremental improvement in PM2.5 concentration from current baseline ambient concentration levels *(averaged over 2002-2004)* to 6.00 ug/m^3 *(an 11.50% improvement),* the central estimate annual benefits would be $19,094,663, and a 1.28% improvement in ozone would yield estimated annual benefits of $234,331.

TABLE #33
PM2.5 - Estimated Total Annual Monetized Value (Simulation Year 2005)
North Okanagan Regional District and Central Okanagan Regional District

North Okangan Regional District Baseline Concentration - Vernon (Science Centre) Yrly Avg PM2.5 Concentration (Calendar Year) (Averaged over 2002-2004)=**7.61 ug/m³**						Central Okanagan Regional District Baseline Concentration – Kelowna (Okanagan University College) Yrly Avg PM2.5 Concentration (Calendar Year) (Averaged over 2002-2004)=**6.78 ug/m³**					
PM2.5 ug/m³	**% Chg from Baseline**	**10% Low**	**Mean**	**90% High**	**Central Estimate**	**PM2.5 ug/m³**	**% Chg from Baseline**	**10% Low**	**Mean**	**90% High**	**Central Estimate**
7.61	-	-	-	-	-	**6.78**	-	-	-	-	-
7.00	-8.0158%	$2,793,119	$7,482,926	$13,473,471	$7,098,225	**6.00**	-11.5044%	$7,549,196	$20,130,917	$36,198,825	$19,094,663
6.50	-14.5861%	$5,082,560	$13,616,472	$24,517,300	$12,916,442	**5.50**	-18.8791%	$12,388,425	$33,035,351	$59,403,200	$31,334,833
6.00	-21.1564%	$7,372,001	$19,750,018	$35,561,129	$18,734,659	**5.00**	-26.2537%	$17,277,654	$45,939,784	$82,607,575	$43,575,002
5.50	-27.7267%	$9,661,443	$25,883,564	$46,604,958	$24,552,876	**4.50**	-33.6283%	$22,066,883	$58,844,218	$105,811,950	$55,815,171
5.00	-34.2970%	$11,950,884	$32,017,110	$57,648,787	$30,371,093	**4.00**	-41.0029%	$26,906,111	$71,748,652	$129,016,325	$68,055,340

TABLE #34
Ozone - Estimated Total Annual Monetized Value (Simulation Year 2005)
North Okanagan Regional District and Central Okanagan Regional District

North Okangan Regional District Baseline Concentration - Vernon (Science Centre) Yrly Avg of Daily Max Ozone Conc (May-Sept Ozone Season) (Averaged over 2002-2004)=**34.03 ppb**						Central Okanagan Regional District Baseline Concentration – Kelowna (Okanagan University College) Yrly Avg of Daily Max Ozone Conc (May-Sept Ozone Season) (Averaged over 2002-2004)=**44.57 ppb**					
Ozone ppb	**% Chg from Baseline**	**10% Low**	**Mean**	**90% High**	**Central Estimate**	**Ozone ppb**	**% Chg from Baseline**	**10% Low**	**Mean**	**90% High**	**Central Estimate**
34.03	-	-	-	-	-	**44.57**	-	-	-	-	-
33.50	-1.5574%	$46,144	$109,941	$181,773	$105,269	**44.00**	-1.2789%	$101,893	$245,533	$407,126	$234,331
33.00	-3.0267%	$89,677	$213,658	$353,257	$204,579	**43.50**	-2.4007%	$191,273	$460,913	$764,254	$439,885
32.50	-4.4960%	$133,209	$317,376	$524,741	$303,889	**43.00**	-3.5225%	$280,653	$676,293	$1,121,381	$645,449
32.00	-5.9653%	$176,741	$421,093	$696,224	$403,199	**42.50**	-4.6444%	$370,032	$891,673	$1,478,509	$850,993
31.50	-7.4346%	$220,274	$524,811	$867,708	$502,509	**42.00**	-5.7662%	$459,412	$1,107,053	$1,835,637	$1,056,547

98 Note: The low, mean, high and central value estimates presented in table #33 and #34 provide lower and upper value estimates associated with the benefits analysis.

5.3 Discounted Present Value

The annual monetized benefits associated with a 10% improvement in PM2.5 and ozone *(from baseline levels – averaged over 2002-2004)* occurring in years 2005 and 2020 are presented in table #36 below.

The present value of benefits are estimated by discounting the annual benefits that accrue over time. The discounted present value of the benefits associated with the avoided health and other effects for a sustained 10% improvement in PM2.5 and ozone *(from baseline concentration levels averaged over 2002-2004)* which may be realized over the sixteen year period (2005 - 2020) are also presented in table #36 *(discounted at 4%, 6%, and 8% respectively).*

A summary of these values *(itemized as mortality, morbidity, other and total)* are reported in table #35 below. The estimated present value benefits are also presented *(in table #35),* discounted at r=4%, r=6%, and r=8% respectively.

The North Okanagan estimates are $167,512,595 *(for the avoided impacts over the sixteen year period 2005-2020)* discounted to $120,700,438 at 4%, $104,152,039 at 6%, and $90,780,782 at 8%.

The Central Okanagan Regional District estimates are $341,157,335 *(for the avoided impacts over the sixteen year period 2005-2020)* discounted to $244,638,144 at 4%, $210,610,267 at 6%, and $183,164,101 at 8%.

The results reported are based on the central estimates for avoided impacts associated with a 10% improvement in PM2.5 and ozone *(from baseline concentration levels averaged over 2002-2004)* using the CRFs for PM related mortality recommended within the BC Lung Association Phase I health study *(applying the average provincial age standardized non-accidental base mortality rate)* and using the dollar values of health outcomes included within the AQVM (Version 3.0) database updated *(inflated)* to 2003 $'s Canadian.

TABLE #35
Discounted Present Value (PV) - (PM2.5 and Ozone) (2005-2020) (16 Years)
(Based on Central Estimates) (2003 $'s Cdn)

North Okanagan Regional District	**r=0%**	**r=4%**	**r=6%**	**r=8%**
Mortality	$134,308,986	$96,821,761	$83,567,097	$72,855,717
Morbidity	$31,125,512	$22,382,611	$19,294,622	$16,800,980
Other	$2,078,097	$1,496,066	$1,290,320	$1,124,085
Total	**$167,512,595**	**$120,700,438**	**$104,152,039**	**$90,780,782**
Central Okanagan Regional District	**r=0%**	**r=4%**	**r=6%**	**r=8%**
Mortality	$272,824,668	$195,742,430	$168,559,923	$146,631,229
Morbidity	$64,567,370	$46,203,710	$39,736,249	$34,523,322
Other	$3,765,298	$2,692,004	$2,314,095	$2,009,550
Total	**$341,157,335**	**$244,638,144**	**$210,610,267**	**$183,164,101**

Note: based on the benefits estimates associated with a 10% improvement in air quality (PM2.5 & ozone) from baseline concentration values averaged over 2002-2004 calculated for simulation year 2005, the values represent avoided annual impacts potentially realized in each year the air quality improvement is sustained.

Table #35 *(above)* reveals that the cumulative annual benefits resulting from the avoided impacts associated with a sustained 10% improvement in air quality over the 16 year period (2005-2020) are substantial. Note however that the present value of the estimated benefits over time is smaller the higher the assumed discount rate.

TABLE #36 – Estimated Annual Benefits to be Realized in Years 2005 & 2020, and Estimated Discounted Benefits to be Realized over 2005-2020 (discounted at r=4%, r=6%, and r=8%) Results are Based on a 10% Improvement in PM2.5 and Ozone (Simulation Year 2005) (from Baseline Air Quality Concentration Levels Averaged over 2002-2004) (Based on Central Estimates) (BCLA Recommended CRFs for PM Mort) (Base Mort Rate = 5.12x10^{-3}) (Values Updated *[Inflated]* to 2003 $'s Cdn)

North Okanagan Regional District	Year 2005		Year 2020		Total Benefits 2005-2020		PV 4% 2005-2020		PV 6% 2005-2020		PV 8% 2005-2020	
	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chr Mort	$5,734,170	$513,608	$6,869,649	$615,313	$100,262,814	$8,980,512	$72,278,278	$6,473,945	$62,383,557	$5,587,678	$54,387,420	$4,871,466
Act Mort	$1,433,540	-	$1,717,409	-	$25,065,660	-	$18,069,538	-	$15,595,862	-	$13,596,831	-
Chr Bronch	$1,106,230	-	$1,409,901	-	$20,248,347	-	$14,546,071	-	$12,532,980	-	$10,907,867	-
Resp Hosp Admis	$2,036	$3,470	$2,439	$4,157	$35,591	$60,675	$25,657	$43,740	$22,145	$37,752	$19,306	$32,913
Cardiac Hosp Admis	$2,188	-	$2,621	-	$38,260	-	$27,581		$23,805	-	$20,754	
Emerg Room Visits	$760	$1,218	$911	$1,459	$13,291	$21,296	$9,582	$15,352	$8,270	$13,250	$7,210	$11,552
Asthma Sympt Day	$22,109	$29,524	$26,486	$35,371	$386,570	$516,235	$278,674	$372,148	$240,524	$321,202	$209,695	$280,031
Rstr Activity Day	$339,527	-	$415,344	-	$6,042,262	-	$4,350,666	-	$3,752,777	-	$3,269,741	
Mnr Rstr Activity Day	-	$64,689	-	$77,498	-	$1,131,088	-	$815,388	-	$703,763	-	$613,557
Act Resp Sympt Day	$89,119	$54,090	$106,766	$64,801	$1,558,252	$945,770	$1,123,325	$681,794	$969,545	$588,458	$845,272	$513,032
Child Bronchitis	$7,884	-	$8,623	-	$127,874	-	$92,633	-	$80,150	-	$70,050	-
HH Material Soiling	$106,135	-	$133,427	-	$1,938,733	-	$1,394,572	-	$1,202,295	-	$1,046,987	-
Crop Damage (Corn)	-	$8,710	-	$8,710	-	$139,364	-	$101,495	-	$88,025	-	$77,098
TOTAL	**$8,843,697**	**$675,309**	**$10,693,577**	**$807,309**	**$155,717,654**	**$11,794,941**	**$112,196,576**	**$8,503,862**	**$96,811,911**	**$7,340,129**	**$84,381,133**	**$6,399,649**

Central Okanagan Regional District	Year 2005		Year 2020		Total Benefits 2005-2020		PV 4% 2005-2020		PV 6% 2005-2020		PV 8% 2005-2020	
	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chr Mort	$10,758,100	$1,412,730	$14,100,422	$1,851,636	$197,510,360	$25,936,626	$141,706,973	$18,608,648	$122,028,303	$16,024,488	$106,153,109	$13,939,793
Act Mort	$2,689,530	-	$3,525,112	-	$49,377,682	-	$35,426,809	-	$30,507,132	-	$26,538,327	-
Chr Bronch	$2,126,380	-	$2,964,664	-	$40,523,896	-	$28,968,365	-	$24,900,827	-	$21,623,464	-
Resp Hosp Admis	$3,819	$9,545	$5,005	$12,510	$70,112	$175,236	$50,303	$125,726	$43,317	$108,267	$37,362	$94,182
Cardiac Hosp Admis	$4,105	-	$5,381	-	$75,370	-	$54,075	-	$46,566	-	$40,508	-
Emerg Room Visits	$1,426	$3,350	$1,869	$4,391	$26,183	$61,505	$18,786	$44,128	$16,177	$38,000	$14,072	$33,056
Asthma Sympt Day	$41,479	$81,209	$54,365	$106,439	$761,519	$1,490,934	$546,364	$1,069,695	$470,491	$921,147	$409,283	$801,311
Rstr Activity Day	$643,944	-	$870,858	-	$12,075,483	-	$8,647,349	-	$7,439,439	-	$6,465,542	-
Mnr Rstr Activity Day	-	$177,932	-	$233,212	-	$3,266,693	-	$2,343,741	-	$2,018,269	-	$1,755,704
Act Resp Sympt Day	$167,199	$148,779	$219,144	$195,002	$3,069,644	$2,731,467	$2,202,365	$1,959,735	$1,896,525	$1,687,589	$1,649,798	$1,468,043
Child Bronchitis	$14,430	-	$16,324	-	$239,327	-	$173,079	-	$149,635	-	$130,676	-
HH Material Soiling	$196,243	-	$273,273	-	$3,765,298	-	$2,692,004	-	$2,314,095	-	$2,009,550	-
Crop Damage (Corn)	-	$0	-	$0		$0	-	$0	-	$0	-	$0
TOTAL	**$16,646,630**	**$1,833,540**	**$22,036,419**	**$2,403,190**	**$307,494,874**	**$33,662,461**	**$220,486,472**	**$24,151,672**	**$189,812,507**	**$20,797,760**	**$165,072,012**	**$18,092,089**

North & Central Okanagan Reg District	Year 2005		Year 2020		Total Benefits 2005-2020		PV 4% 2005-2020		PV 6% 2005-2020		PV 8% 2005-2020	
	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chr Mort	$16,492,270	$1,926,338	$20,970,072	$2,466,949	$297,773,174	$34,917,138	$213,985,251	$25,082,593	$184,411,860	$21,612,166	$160,540,529	$18,811,258
Act Mort	$4,123,070	-	$5,242,521	-	$74,443,342	-	$53,496,347	-	$46,102,995	-	$40,135,158	-
Chr Bronch	$3,232,610	-	$4,374,565	-	$60,772,243	-	$43,514,436	-	$37,433,806	-	$32,531,331	-
Resp Hosp Admis	$5,854	$13,015	$7,444	$16,668	$105,703	$235,912	$75,960	$169,466	$65,462	$146,019	$56,988	$127,095
Cardiac Hosp Admis	$6,293	-	$8,002	-	$113,630	-	$81,657	-	$70,371	-	$61,262	-
Emerg Room Visits	$2,186	$4,568	$2,780	$5,850	$39,475	$82,801	$28,367	$59,480	$24,447	$51,250	$21,282	$44,608
Asthma Sympt Day	$63,587	$110,733	$80,852	$141,810	$1,148,089	$2,007,169	$825,038	$1,441,842	$711,015	$1,242,349	$618,977	$1,081,342
Rstr Activity Day	$983,471	-	$1,286,201	-	$18,117,745	-	$12,998,015	-	$11,192,216	-	$9,735,283	-
Mnr Rstr Activity Day	-	$242,621	-	$310,710	-	$4,397,781	-	$3,159,129	-	$2,722,032	-	$2,369,261
Act Resp Sympt Day	$256,318	$202,869	$325,910	$259,802	$4,627,896	$3,677,237	$3,325,691	$2,641,259	$2,866,070	$2,276,047	$2,495,070	$1,981,075
Child Bronchitis	$22,314	-	$24,948	-	$367,201	-	$265,711	-	$229,785	-	$200,726	-
HH Material Soiling	$302,378	-	$406,700	-	$5,704,031	-	$4,086,575	-	$3,516,390	-	$3,056,537	-
Crop Damage (Corn)	-	$8,710	-	$8,710	-	$139,364	-	$101,495	-	$88,025	-	$77,098
TOTAL	**$25,490,327**	**$2,508,849**	**$32,729,995**	**$3,210,499**	**$463,212,528**	**$45,457,402**	**$332,683,047**	**$32,655,534**	**$286,624,417**	**$28,137,888**	**$249,453,144**	**$24,491,737**

Note: some totals do not add due to rounding and monte carlo simulation effects

Section #6 **Sources of Uncertainty in the Analysis**

Note that there are a number of sources of uncertainty inherent within this study which are identified below.

6.1 Value of a Statistical Life (VSL)

The low, central and high values of a statistical life (VSL) applied within this study are: $2.77 mill, $4.73 mill, and $9.47 mill respectively, expressed in 2003 $'s Canadian. The default AQVM (Version 3.0) database expresses the values in 1996 $'s Canadian, therefore for this study the values have been updated *(inflated)* to 2003 $'s Canadian. As the value estimates associated with mortality represent approximately 80% of the monetized benefits estimates reported in this study, the VSL has a substantial influence on the study results and conclusions. *(This is less true for the cost of illness (COI) estimates associated with the morbidity health endpoints included in the study).*

The age-weighted VSL from the AQVM (Version 3.0) database was used in this study. This value assumes that 85% of the deaths associated with air pollution occur to persons age 65 and older.[99]

Note that the VSL values incorporated within the AQVM (Version 3.0) database are based on willingness to pay (WTP) estimates derived from contingent valuation (CV) and labour market studies.[100] However there is on-going research about what is the appropriate value to use for mortality endpoints. The research concerns whether the most susceptible segment of the population to the impacts of air pollution *(ie. individuals who are older – and those with compromised health)* have a higher willingness to pay or a lower willingness to pay associated with the risk of mortality.[101] There is also on-going research concerning the recognition and incorporation of latency *(or lag of effect)* into the VSL estimates.[102] Others advocate the use of *quality adjusted life years* and *value of life year saved (VSLY)*, rather than the *value of a statistical life.*[103]

Although the research concerning the magnitude of the VSL is on-going, the use of the VSL in principle was generally supported by a recent Royal Society report *(an expert panel that reviewed the cost/benefit analysis conducted for the Canada Wide Standards)*. The panel recommended continued reliance on the willingness to pay (WTP) approach.[104]

On more theoretical grounds, some economists argue that *willingness to accept* (WTA) is a better metric to use when evaluating environmental damages.[105] Note that willingness to accept (WTA) values are generally higher than willingness to pay (WTP) values.

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99 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999), (p. 5-20).

100 Ibid, (p. 5-11, 5-12, 5-13 & 5-14).

101 Royal Society of Canada, *Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to The Royal Society of Canada*, (June/2001), (p. 167 & 168). See also: Krupnick, Alan, Anna Alberini, Maureen Cropper, Nathalie Simon, Bernie O'Brien, Ron Goeree, and Martin Heintzelman, *Age, Health and the Willingness to Pay for Mortality Risk Reductions: A Contingent Valuation Survey of Ontario Residents*, Resources for the Future, (September/2000), Discussion Paper 00-37. See also: Alberini, Anna, Maureen Cropper, Alan Krupnick, and Nathalie B. Simon, *Does the Value of a Statistical Life Vary with Age and Health Status? Evidence from the United States and Canada*, Resources for the Future, (April/2002), Discussion Paper 02-19. See also: Smith, V. Kerry, Huyn Kim, and Donald H. Taylor Jr., *Do the "Near" Elderly Value Mortality Risks Differently*, The Review of Economics and Statistics, 86, Issue #1, (February/2004). See also: Viscusi, W. Kip, and Joseph E. Aldy, *Labor Market Estimates of the Senior Discount for the Value of Statistical Life*, Discussion Paper, Resources for the Future, (Feb/2006), RFF DP 06-12.

102 Royal Society of Canada, *Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to The Royal Society of Canada*, (June/2001 (p. 168). See also: Alberini, Anna, Maureen Cropper, Alan Krupnick and Nathalie B. Simon, *Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?* Resources for the Future, Discussion Paper 04-13, (April/2004).

103 For discussion on these concepts see: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consultant Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, "*Air Quality Valuation Model (Version 3.0) Report 2: Methodology, Final Report*", (September 3, 1999), (p. 5-21, 5-22 & 5-23). See also: Royal Society of Canada, *Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to The Royal Society of Canada*, (p. 168). See also: Freeman, A. Myrick. - Dept of Economics - Bowdoin College, Brunswick, ME., James K. Hammitt - Center for Risk Analysis - Harvard School of Public Health, Boston, MA, Paul. De Civita – Economic Analysis & Evaluation Division Healthy Environments and Consumer Safety Branch - Health Canada, Ottawa, Ontario, "*Essay – On Quality Adjusted Life Years (QALYs) and Environmental/Consumer Safety Valuation*", Association of Environmental and Resource Economists (AERE), Newsletter Volume 22, No. 1 (May/2002).

104 Royal Society of Canada, *Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to The Royal Society of Canada*, (June/2001), (p. 185).

105 Knetsch, Jack L., *Environmental Valuation: Some Problems of Wrong Questions and Misleading Answers*, Environmental Values, 3 (4): 351-368 (Win 1994). See also: Knetsch, Jack L., *Reference States: Fairness, and Choice of Measure to Value Environmental Changes*, in Bazerman, M.H., D.M. Messick, A.E. Tenbrunsel, and K.A. Wade-Benzoni, eds., *Environment, Ethics and Behaviour: The Psychology of Environmental Valuation and Degradation*, The New Lexington Press, San Francisco (1997) (p. 13 - 32).

6.2 Discount Rate

To evaluate the discounted present value of the benefits associated with sustained air quality improvements over time, a range of discount rates *(4%, 6%, and 8%)* are presented within the report. The study reveals that the choice of discount rate may substantially impact the conclusions. The higher the discount rate, the lower the discounted present value of the cumulative benefits associated with the annual avoided health and other impacts.

Note however that there is on-going debate associated with applying large discount rates to health and environmental related benefits that occur in the future. Part of the debate centers on the fact that discounting raises questions related to *inter-generational justice*.[106] Included in this debate is whether the value of human health in the future is worth less than the value of human health in the present.[107] Indeed, some advocate that discounting should not be applied *(or a lower rate of discounting should be applied)* to environmental health outcomes.[108] A counter-argument advanced is that discounting is properly applied to resources devoted to regulatory benefits.[109]

The *"social discount rate"* is most applicable for cost/benefit analysis of this nature and the practice cited within the "*Treasury Board Benefit Cost Analysis Guide - Draft (July/1998)*" is to apply a 10% discount rate, using 8%, and 12% for sensitivity analysis.[110] Note however that some recent studies evaluating the health effects associated with air pollution have used different ranges of discount rates. In particular, the cost/benefit analysis prepared by Environment Canada for the Canada Wide Standards (CWS) relating to PM and ozone applied a range of discount rates of: 2%, 5%, and 7.5%.[111] The range of discount rates applied within a recent BC Lung Association study evaluating the impacts associated with air quality within the Lower Fraser Valley are: 3%, 6%, and 10%.[112]

6.3 Concentration Response Functions (CRFs)

There is uncertainty associated with the application of the concentration response functions (CRFs) used in this study to the smaller communities within the two regional districts. The uncertainty extends from the local application of studies estimating relationships between air pollution and mortality, and morbidity impacts that were derived in other jurisdictions which may have different source mixes of pollution. The source mix of pollutants in small communities may vary substantially from the source mix of pollutants in large urban settings *(such as Kelowna)*. It is therefore questionable whether the CRFs derived from large urban centres apply locally to the smaller communities. Within this study, the CRF database derived from large urban centres has been applied to the Kelowna area based on the recommendation put forward within the BC Lung Association Phase I Health study.[113] Although the daily time-series data suggests that the air quality levels at the two monitoring sites *(located in Vernon and Kelowna)* follow similar trends, it is uncertain whether these relationships hold for the smaller communities in the regions *(see graphs provided on p. 34 and 35)*. Therefore, the general application of the CRFs derived from large urban settings to all the populations residing within the two regional districts should be recognized as a potential source of uncertainty.

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106 Pearce, David W., R. Kerry Turner, Economics of Natural Resources and the Environment, The John Hopkins University Press, Baltimore, Maryland, (1990), (p. 221-224).

107 For discussion re. discounting of human health outcomes see: Krupnick, Alan J., Valuing Health Outcomes: Policy Choices and Technical Issues, Resources for the Future (March/2004), (p. 36).

108 For some discussion relating to this topic see: Hutton, Guy, Considerations in Evaluating the Cost Effectiveness of Environmental Health Interventions, Time Period and Discounting, World Health Organization, *http://www.who.int/docstore/peh/burden/WSH00-10/WSH00-10-7.htm.*

109 Sunstein, Cass R., Arden Rowell, On Discounting Regulatory Benefits: Risk, Money and Intergenerational Equity, AEI Brookings Joint Center for Regulatory Studies, Working Paper 05-08 (May/2005), (p. 27).

110 Treasury Board, Benefit Cost Analysis Guide, Draft (Jul/1998), (p. 35), *http://www.tbs-sct.gc.ca/fin/sigs/revolving_funds/bcag/bca2_e.asp.*

111 Royal Society of Canada, Report of an Expert Panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone to the Royal Society of Canada, (June/2001), (p. 184). See also: De Civita, Paul, Lauraine G. Chestnut, David Mills, Robert D. Rowe, David Stieb, Human Health and Environmental Benefits of Achieving Alternative Canada Wide Standards for Inhalable Particles (PM2.5, PM10 and Ground Level Ozone, Final Report, July 25, 1999; Compendium of Benefits Information, (17/August/1999).

112 Furberg, Maria M.Sc., Kathy Preston, PhD., P. Eng – RWDI Air Inc, Dave Sawyer – Marbek Resource Consultants, Dr. Michael Brauer – School of Occupational & Environmental Hygiene UBC, Dr. Robin Hanvelt – Department of Health Care and Epidemiology UBC, Health and Air Quality 2005 – Phase 2: Valuation of Health Impacts from Air Quality in the Lower Fraser Valley Airshed – Final Report, B.C. Lung Association, (July 15, 2005), (p. 94), *http://www.bc.lung.ca.*

113 Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report", British Columbia Lung Association, (May/2003), (p. 30, 31 & 52).

6.4 Use of PM2.5 –Versus– PM10 Ambient Concentration Values

In calculating the monetized benefits and effects estimates, although the ozone and PM results are additively separable, the AQVM (Version 3.0) requires that the analyst use a combination of either PM10 and ozone, or a combination of PM2.5 and ozone *(not both PM2.5 and PM10 ambient concentration data) (ie. for the effects estimates associated with particulate matter, the analyst has a choice of using either PM2.5 or PM10 ambient concentration data and their respective concentration response functions [CRFs]).*[114]

Although the BC Lung Association Phase I health study expert panel did not assess whether PM10 or PM2.5 should be used in the air quality benefits exercise, the PM2.5 data has been used in this study given that it is considered to be the more harmful size fraction, and given that the central and high estimates recommended within the BC Lung Association Phase I health study are based on PM2.5.[115]

Note that the method of recording PM2.5 data at continuous tapered element oscillating microbalance (TEOM) monitors in Canada was revised in 2002. Prior to that time, PM2.5 data was adjusted by adding an offset of 3.0 and by factoring in a multiplier of 1.03 *(as per the US EPA practice).*[116] This adjustment was removed from the historical record in April/2002, however it is noteworthy that epidemiological studies *(estimating the relationship between air quality and human health)* derived from PM2.5 data recorded prior to 2002 were likely based on the adjusted data record that was approximately 3 ug/m^3 greater than the revised data archive. As some of the CRFs were most likely derived using PM2.5 ambient concentration data that included the offset, removal of the offset would effectively result in the PM2.5 estimates presented herein being lower than if the old scale was used *(ie. for a percentage change in air quality, the results are under-estimated). (Note that the PM10 data was not adjusted downward).*

6.5 TEOM –Versus– Manual Filter Based Sampling Instruments

Note that there are differences in the PM ambient air quality concentration values recorded using continuous tapered element oscillating microbalance (TEOM) based sampling instruments versus manual dichotomous filter-based sampling instruments. TEOM sampling instruments are commonly used in Canada, whereas manual filter-based sampling instruments are more prevalent in the US. As some of the epidemiology studies estimating the relationship between air quality and human health included within the AQVM (Version 3.0) are US based, it is likely that some of the CRFs pertaining to PM were estimated using filter-based sampling instruments. As the ambient PM2.5 concentration values used within this study derive from TEOM sampling instruments, there is a potential for the PM estimates presented herein to be biased.

Although the exact relationship between air quality concentration data recorded using manual filter-based sampling instruments and continuous TEOM sampling instruments is not known, the influence of this uncertainty on the estimates reported herein is possibly a downward bias in the results (*ie. based on the assumption that manual filter-based monitoring instruments provide slightly higher readings than continuous TEOM monitoring instruments, for a percentage change in air quality, the results are under-estimated).*[117]

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[114] Stratus Consulting, Air Quality Valuation Model (AQVM) (Version 3.0) – Operating Instructions, (p. 1-3). See also: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999), (p 4-1).

[115] Brauer, Dr. Michael, University of British Columbia, Personal Communication, (June/2004). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report", British Columbia Lung Association, (May/2003), (p. 51).

[116] Suzuki, Natalie-BC Ministry of Water Land and Air Protection, Bill Taylor-Environment Canada, Particulate Matter in British Columbia, a Report on PM10 and PM2.5 Mass Concentrations up to 2000, (May/2003), (addendum - inside front cover).

[117] **Note**: the assumption is based on observed differences in PM2.5 data recorded using continuous TEOM monitors located in Canada *(the Lower Fraser Valley)* –versus– PM2.5 data recorded at nearby US monitoring sites *(Whatcom County, USA) (in close proximity to the Lower Fraser Valley)* using manual filter-based monitors.

6.6 Other Impacts Not Included in the Study

The aggregate benefits estimates reported within this report are also undervalued, as this study does not include impacts on the tourism industry *(recreation)* and on local area residents associated with visibility improvements, adverse effects on important local agricultural crop yields *(particularly tree fruits and grapes),* impacts to forestry, impacts to wildlife health *(implications for bio-diversity, hunting and non-use values),* eco-system impacts, deposition/soiling effects to commercial enterprises, and other effects that are difficult to quantify *(ie. long-term cancer risk associated with toxic air pollutants)* that are not included within this report - which may be substantial. These estimates are not included as generally accepted concentration response functions (CRFs) and other databases are not available to evaluate these impacts.

6.7 Representative Measure of Exposure - Linking Population to Air Quality Monitors

This study uses annual average values of ambient concentration at two different monitoring sites within the area as a representative measure of exposure of the population. The ambient values are used in the benefits analysis as the epidemiology studies *(estimating the relationship between air quality and human health)* are generally based on representative ambient air quality monitoring sites rather than personal exposure monitors. Note however that this approach does not capture the variation in personal exposure that may be experienced among the general population.[118] As there are most likely differences in personal exposure within the study area, individual personal exposure may be overestimated or underestimated accordingly. It is also uncertain whether the location of the two air quality monitors used within this study represents the average exposure of the populations residing in the regions.

6.8 Population Estimates and Population Growth Rates

The population values and the population growth rates assumed within this study are estimates. These assumed population values and population growth rates are a source of uncertainty within the benefits analysis.

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[118] Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase I Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 7).

Section #7 **General Conclusions of the Study**

Air quality improvements provide health and other benefits. The study shows that a 10% improvement in PM2.5 provides estimated quantifiable annual benefits for the North Okanagan Regional District of $8,843,690 *(with a low, a mean, and a high value of: $3,479,951, $9,322,990 and $16,786,620 respectively).* The estimated quantifiable annual benefits for ozone are: $675,309 *(with a low, a mean and a high value of: $296,020, $705,279 and $1,166,090 respectively).*

For the Central Okanagan Regional District the estimated quantifiable annual benefits associated with a 10% improvement in PM2.5 are: $16,646,630 *(with a low, a mean and a high value of: $6,581,351, $17,550,030 and $31,577,950 respectively).* The estimated quantifiable annual benefits for ozone are: $1,833,540 *(with a low, a mean and a high value of: $797,268, $1,921,190 and $3,185,580 respectively).*

Sustained air quality improvements yield substantial cumulative benefits *(associated with the annual avoided health and other impacts).* Based on the central estimates, over the sixteen (16) year period 2005-2020 the North Okanagan Regional District may realize $167,512,595 *(discounted to $120,700,438 at 4%; $104,152,039 at 6%, and $90,780,782 at 8%);* and the Central Okanagan Regional District may realize $341,157,335 *(discounted to $244,638,144 at 4%, $210,610,267 at 6%, and $183,164,101 at 8%).*

Substantial unquantifiable benefits also exist – including impacts on the tourism industry *(recreation)* and on local area residents associated with visibility improvements, adverse effects on important local agricultural crop yields *(particularly tree fruits and grapes),* impacts to forestry, impacts to wildlife health *(implications for bio-diversity, hunting and non-use values),* eco-system impacts, deposition/soiling effects to commercial enterprises, and other effects that are difficult to quantify *(ie. long-term cancer risk associated with toxic air pollutants)* that are not included within this report – which may be substantial.

Section #8 Policy Implications

To achieve air quality improvements will require continued efforts to reduce emissions. This will present an on-going challenge to air quality managers as the North and Central Okanagan regions are projected to experience high population growth in future years. In the immediate future air quality managers are also challenged with the requirement to meet the Canada Wide Standards (CWS) for particulate matter (PM) and ground level ozone by the year 2010. Air quality improvements will be aided by the federal agenda on clean air that will result in the gradual turn-over of the vehicle fleet to cleaner vehicles.[119]

The study shows that additional efforts to improve air quality will yield substantial economic benefits. Policies to reduce PM will have the most impact as they will provide the greatest social welfare value. However, review of the cost side of the equation is also necessary to gain an understanding of the net social welfare benefits associated with specific air quality management policies. Linking the costs and benefits also requires knowledge and understanding of the source/receptor relationship *(ie. the relationship between emissions and ambient air quality).*

It is known that the costs of measures to improve air quality vary substantially. Although a comprehensive examination of the costs associated with various emissions reduction measures within the North and Central Okanagan regions has not been evaluated within this report, some cost measures are low and are easily implemented. Examples of relatively low cost measures include those associated with transportation demand management, smart growth/urban planning, burn control programs, and effective agricultural practices. Many of these programs are already in place within the region *(such as: the Okanagan Wood Stove Exchange Program, Land Cleaning and Backyard Burning Ban - Peachland, Go Green Commuter Challenge, Agricultural Wood Waste Pilot Project, Proposed Agricultural Wood Waste Chipping Program – Orchard Replacement and Pruning Materials).* These low cost, easily implemented emissions reduction cost measures should receive the highest priority.

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119 Note: for information on the Federal Agenda on Clean Air, refer to Environment Canada, *The Clean Air Agenda* – Clean Air On-line website, *http://www.ec.gc.ca/cleanair-airpur/Clean_Air_Agenda-WS51062DA3-1_En.htm*

Section #9 **Recommendations for Future Work**

i). The AQVM (Version 3.0) was released in September/1999. The model was prepared for Health Canada and Environment Canada by Stratus Consulting Inc *(Chestnut, Mills, Rowe).*[120] More recently, Health Canada has been working on an updated version of the AQVM referred to as the *"Air Quality Benefits Assessment Tool"* (AQBAT). At the time of writing of this report, the new AQBAT tool was not available for use. It is recommended that the annual effects and the monetized benefits estimates presented herein be re-estimated using the new AQBAT tool when it is released by Health Canada if there are significant changes in the concentration response functions (CRFs) or other key factors included within the model.

ii). It would be beneficial to estimate locally applicable concentration response functions (CRFs) for the smaller communities *(particularly within the North Okanagan Regional District).* Although some existing studies are available estimating concentration response functions (CRFs) that are applicable in smaller resource based communities *(especially those with different source mixes of pollutants)* there is a lack of quantitative information in this area.[121] The relationships between air quality and mortality and morbidity health endpoints in smaller resource based communities with different source mixes of pollutants is an area requiring future research.

iii). It is useful to analyze the costs associated with air quality improvements within the region and to conduct a comprehensive cost/benefit analysis by evaluating specific emissions reductions scenarios. However, linking of the costs and benefits associated with air quality improvements requires knowledge of the source/receptor relationship *(ie. the change in ozone and PM concentration given changes in emissions).* If a cost/benefit analysis is desired as a next step, future work could include the development of a locally applicable source/receptor tool estimating the relationship between the percentage change in ozone and PM concentration associated with percentage changes in pre-cursor emissions *(NOx, VOC, SOx, direct PM and NH_3) (see diagram #1 below).* A comprehensive cost/benefit analysis would also permit comparison of the benefits of specific emissions reduction measures against their corresponding costs, resulting in economically efficient emission reduction measures.

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[120] Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, *Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report*, (September 3, 1999).

[121] Note: for a recent study in this area see: McGowan, J., P. Hider, E. Chacko, I. Town, *Particulate Air Pollution and Hospital Admissions in Christchurch New Zealand*, Australian and New Zealand Journal of Public Health, (2002), 26: 23-30.

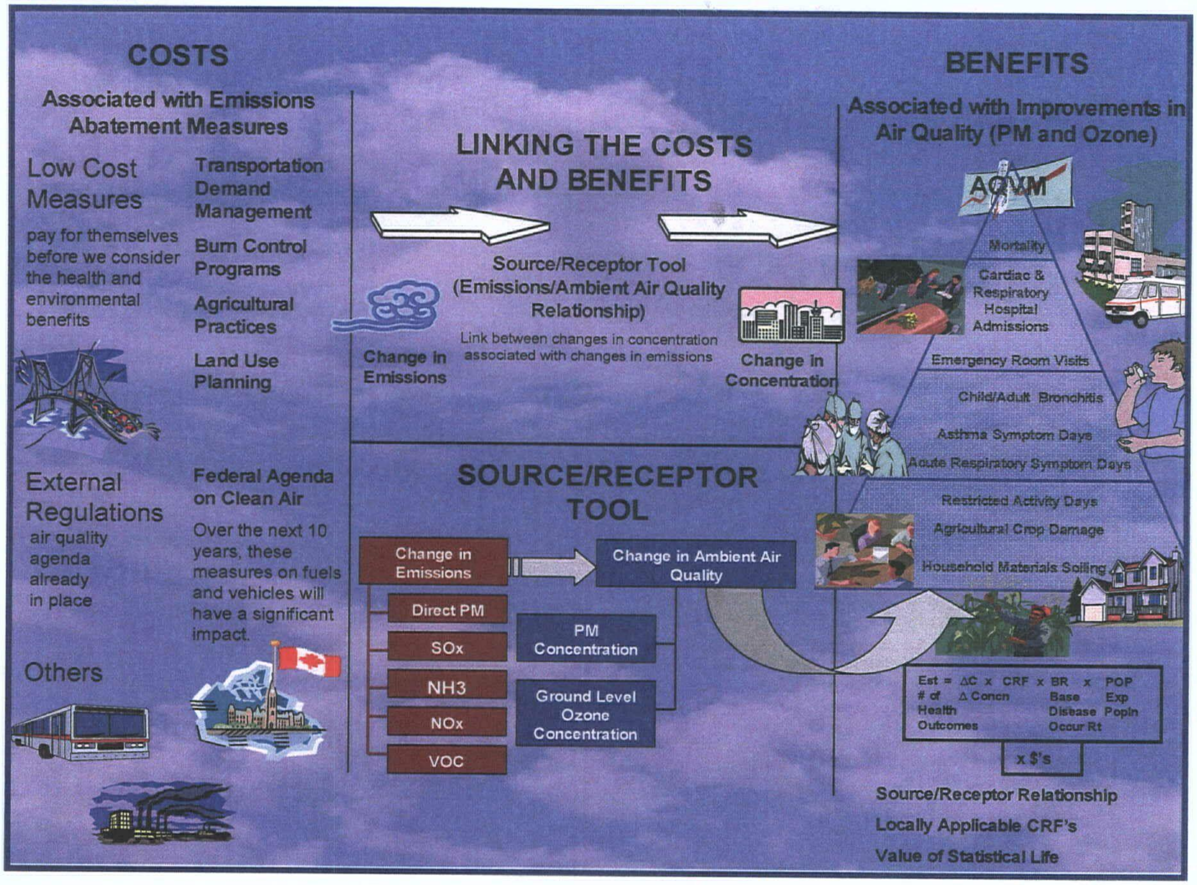

Diagram #1 – Linking the Costs and Benefits

LIST OF ACRONYMS

AQBAT	Air Quality Benefits Assessment Tool
AQVM	Air Quality Valuation Model (Version 3.0)
ARSD	Acute Respiratory Symptom Day
ASD	Asthma Symptom Day
B	Child Bronchitis
CAC	Criteria Air Contaminant
CB	Chronic Bronchitis
CCME	Canadian Council of Ministers of the Environment
CHA	Cardiac Hospital Admissions
CO	Carbon Monoxide
COI	Cost of Illness
CPI	Consumer Price Index
CRF	Concentration Response Function
CV	Contingent Valuation
CWS	Canada Wide Standards
ERV	Emergency Room Visit
GAM	Generalized Additive Model
HHMS	Household Materials Soiling
MCI	Medical Cost Index
MORT	Mortality
MRAD	Minor Restricted Activity Day
NH_3	Ammonia
NOx	Nitrogen Oxide
OECD	Organization for Economic Cooperation and Development
Ozone	Ground Level Ozone
PM	Particulate Matter
PPPI	Purchasing Power Parity Index
PV	Present Value
RAD	Restricted Activity Day
RHA	Respiratory Hospital Admissions
SOx	Sulphur Oxide
TEOM	Tapered Element Oscillating Microbalance
VOC	Volatile Organic Compounds
VSL	Value of Statistical Life
WTA	Willingness to Accept
WTP	Willingness to Pay

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APPENDIX

TABLE #A-1 North Okanagan Regional District – Scenario #1 - Benefits Estimates - PM 2.5 & Ozone

BCLA Recommended CRFs for PM Mort. Ozone Mort & ERV CRFs as per Hlth Cda. All other CRFs from default AQVM (3.0) database.

Mort est include BC Base Mort Rate (5.12 x 10^{-3}) AQVM (3.0) Dollar Values of Health Outcomes Updated to 2003 $'s Cdn (Persons with asthma assumed = 7.6%)

North Okanagan Regional District		PM 2.5	Benefits 10% Chg in PM 2.5 Baseline Yr 2004 = 7.61 ug/m^3 Simulation Yr 2005 = 6.85 ug/m^3		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	.3031 $1,433,540	1.2456 $6,181,750	3.3338 $11,480,500	1.2123 $5,734,170
MORT x1	CRFs 2003 Value	5.12 x 10^{-6} 22% $2.77 Mill 33%	20.48 x 10^{-6} 67% $4.73 Mill 50%	56.32 x 10^{-6} 11% $9.47 Mill 17%	
Acute Mortality	# of Cases $ Benefit	.1012 $478,471	.2687 $1,310,269	.3942 $2,870,120	.3031 $1,433,540
MORT x1	CRFs 2003 Value	1.71 x 10^{-6} 22% $2.77 Mill 33%	5.12 x 10^{-6} 67% $4.73 Mill 50%	6.66 x 10^{-6} 11% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	0.2161 $1,017.75	0.2614 $2,026.38	0.3068 $3,053.26	.2614 $2,035.50
Admiss RHA x365	CRFs 2003 Value	1.00 x 10^{-8} 25% $3,893 33%	1.21 x 10^{-8} 50% $7,786 34%	1.42 x 10^{-8} 25% $11,679 33%	
Cardiac Hosp	# of Cases $ Benefit	.1707 $1,094.19	.2209 $2,210.55	.2722 $3,282.34	.2204 $2,188.15
Admiss CHA x365	CRFs 2003 Value	.79 x 10^{-8} 25% $4,965 33%	1.02 x 10^{-8} 50% $9,929 34%	1.26 x 10^{-8} 25% $14,894 33%	
Net Emerg Room	# of Cases $ Benefit	.9291 $380.08	1.1284 $760.98	1.3288 $1,140.23	1.1278 $760.16
Visits ERV x365	CRFs 2003 Value	4.30 x 10^{-8} 25% $337 33%	5.22 x 10^{-8} 50% $674 34%	6.15 x 10^{-8} 25% $1,011 33%	
Adult Chronic	# of Cases $ Benefit	1.6900 $552,444	3.3831 $1,214,960	5.0741 $1,863,120	3.3841 $1,106,230
Bronch CB pop ≥25 x1	CRFs 2003 Value	4.13 x 10^{-5} 25% $206,455 33%	8.27 x 10^{-5} 50% $326,887 34%	12.4 x 10^{-5} 25% $550,547 33%	
Child	# of Cases $ Benefit	8.4404 $2,962.59	22.4965 $7,982.49	36.6206 $12,853.80	22.4625 $7,884.32
Bronchitis B pop < 20 x1	CRFs 2003 Value	.62 x 10^{-3} 25% $176 33%	1.65 x 10^{-3} 50% $351 34%	2.69 x 10^{-3} 25% $527 33%	
Asthma Sympt Days	# of Cases $ Benefit	266.0120 $4,788.21	432.9590 $22,358.10	599.3480 $50,345.20	433.5010 $22,108.50
ASD 7.6% of pop x365	CRFs 2003 Value	1.62 x 10^{-4} 33% $18 33%	2.64 x 10^{-4} 34% $51 34%	3.65 x 10^{-4} 33% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	2,495.48 $39,927.70	5,475.09 $91,312.60	8,265.03 $139,248.00	5,569.91 $89,118.60
ARS 92.4% of pop x365	CRFs 2003 Value	1.25 x 10^{-4} 25% $8 33%	2.79 x 10^{-4} 50% $16 34%	4.14 x 10^{-4} 25% $25 33%	
Restricted Activity Day	# of Cases $ Benefit	2,021.73 $169,764.00	3,958.58 $347,036.00	6,096.06 $536,453.00	3,858.27 $339,527.00
RAD 92.4% of pop ≥ 20 x365	CRFs 2003 Value	1.31 x 10^{-4} 25% $44 33%	2.50 x 10^{-4} 50% $88 34%	3.95 x 10^{-4} 25% $132 33%	
HH Materials Soiling	# of Cases $ Benefit	0 $53,067.70	25,635.50 $142,338.00	0 $265,338.00	25,636.50 $106,135.00
HHMS x1	CRFs 2003 Value	$2.07 33%	1 100% $4.14 34%	$10.35 33%	
TOTAL BENEFIT		$3,479,951	$9,322,990	$16,786,620	$8,843,690

Note: some totals do not add due to rounding and monte carlo simulation effects.

North Okanagan Regional District		Ozone	Benefits 10% Chg in Ozone Baseline Yr 2004 = 34.03 ppb Simulation Yr 2005 = 30.63 ppb		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.0393 $108,865	.1086 $533,395	.1779 $1,028,300	.1086 $513,608
MORT x153	CRFs 2003 Value	.97 x 10^{-9} 33% $2.77 Mill 33%	2.68 x 10^{-9} 34% $4.73 Mill 50%	4.39 x 10^{-9} 33% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.2431 $1,735.06	.4457 $3,496.36	.6483 $5,205.17	.4457 $3,470.11
Admiss RHA x153	CRFs 2003 Value	.6 x 10^{-8} 25% $3,893 33%	1.1 x 10^{-8} 50% $7,786 34%	1.6 x 10^{-8} 25% $11,679 33%	
Net Emerg Room	# of Cases $ Benefit	.9846 $608.98	1.8060 $1,218.35	2.6255 $1,826.93	1.8071 $1,217.95
Visits ERV x153	CRFs 2003 Value	2.43 x 10^{-8} 25% $337 33%	4.46 x 10^{-8} 50% $674 34%	6.48 x 10^{-8} 25% $1,011 33%	
Asthma Sympt Day	# of Cases $ Benefit	326.4040 $5,875.27	669.3750 $34,673.30	1,601.2300 $81,662.60	578.9050 $29,524.20
ASD 7.6% of pop x153	CRFs 2003 Value	1.06 x 10^{-4} 33% $18 33%	1.88 x 10^{-4} 50% $51 34%	5.20 x 10^{-4} 17% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	1,898.0900 $27,044.90	3,381.5500 $54,741.30	4,866.8900 $84,515.40	3,380.6200 $54,089.90
ARS 92.4% of pop x153	CRFs 2003 Value	5.07 x 10^{-5} 25% $8 33%	9.03 x 10^{-5} 50% $16 34%	13.0 x 10^{-5} 25% $25 33%	
Minor Restr Activity Day	# of Cases $ Benefit	722.5460 $26,734.20	1,747.4000 $70,938.70	2,770.3800 $111,894.00	1,748.3400 $64,688.50
MRAD 92.4% of pop x153	CRFs 2003 Value	1.93 x 10^{-5} 25% $23 33%	4.67 x 10^{-5} 50% $37 34%	7.40 x 10^{-5} 25% $64 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0 $0	244.0380 $6,815.49	417.1580 $11,613.70	312.8690 $8,710.26
(Corn) x1	CRFs 2003 Value	0 33%	1.5 x 10^{-3} 34% $27.84 100%	2.00 x 10^{-3} 33%	
TOTAL BENEFIT		$296,020	$705,279	$1,166,090	$675,309

Grand Total (PM2.5 & Ozone)

10% Low:	$4,208,361
Mean:	$10,028,270
90% High:	$17,613,720
Central Est:	$9,519,000

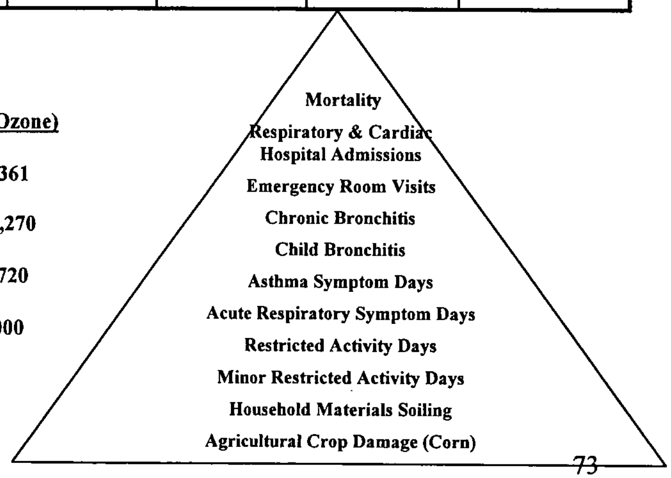

TABLE #A-2 <u>Central Okanagan Regional District –Scenario #1 - Benefits Estimates - PM 2.5 & Ozone</u>

BCLA Recommended CRFs for PM Mort. Ozone Mort & ERV CRFs as per Hlth Cda. All other CRFs from default AQVM (3.0) database.

Mort ests include BC Base Mort Rate (5.12 x 10^{-3}). AQVM (3.0) Dollar Values of Health Outcomes Updated to 2003 $'s Cdn (Persons with asthma assumed = 7.6%)

Central Okanagan Regional District		PM 2.5	Benefits 10% Chg in PM 2.5, Baseline Yr 2004 = 6.78 ug/m^3, Simulation Yr 2005 = 6.10 ug/m^3		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	.5686 $2,689,530	2.3370 $11,597,800	6.2547 $21,539,000	2.2744 $10,758,100
MORT x1	CRFs 2003 Value	5.12 x 10^{-6} 22% $2.77 Mill 33%	20.48 x 10^{-6} 67% $4.73 Mill 50%	56.32 x 10^{-6} 11% $9.47 Mill 17%	
Acute Mortality	# of Cases $ Benefit	.1899 $898,261	.5041 $2,458,230	.7396 $5,384,750	.5686 $2,689,530
MORT x1	CRFs 2003 Value	1.71 x 10^{-6} 22% $2.77 Mill 33%	5.12 x 10^{-6} 67% $4.73 Mill 50%	6.66 x 10^{-6} 11% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.4054 $1,909.45	.4905 $3,801.77	.5756 $5,728.34	.4905 $3,818.90
Admiss RHA x365	CRFs 2003 Value	1.00 x 10^{-8} 25% $3,893 33%	1.21 x 10^{-8} 50% $7,786 34%	1.42 x 10^{-8} 25% $11,679 33%	
Cardiac Hosp	# of Cases $ Benefit	.3202 $2,052.85	.4145 $4,171.31	.5108 $6,158.14	.4135 $4,105.29
Admiss CHA x365	CRFs 2003 Value	.79 x 10^{-8} 25% $4,965 33%	1.02 x 10^{-8} 50% $9,929 34%	1.26 x 10^{-8} 25% $14,894 33%	
Net Emerg Room	# of Cases $ Benefit	1.7430 $713.08	2.1170 $1,427.70	2.4930 $2,139.24	2.1160 $1,426.16
Visits ERV x365	CRFs 2003 Value	4.30 x 10^{-8} 25% $337 33%	5.22 x 10^{-8} 50% $674 34%	6.15 x 10^{-8} 25%$1,011 33%	
Adult Chronic	# of Cases $ Benefit	3.2485 $1,061,900	6.5030 $2,335,380	9.7535 $3,581,270	6.5049 $2,126,380
Bronch CB pop ≥25 x1	CRFs 2003 Value	4.13 x 10^{-5} 25% $206,455 33%	8.27 x 10^{-5} 50% $326,887 34%	12.4 x 10^{-5} 25% $550,547 33%	
Child	# of Cases $ Benefit	15.4474 $5,422.03	41.1723 $14,609.30	67.0217 $23,524.60	41.1100 $14,429.60
Bronchitis B pop < 20 x1	CRFs 2003 Value	.62 x 10^{-3} 25% $176 33%	1.65 x 10^{-3} 50% $351 34%	2.69 x 10^{-3} 25% $527 33%	
Asthma Sympt Days	# of Cases $ Benefit	499.0760 $8,893.37	812.2920 $41,947.00	1,124.4600 $94,454.80	813.3090 $41,478.80
ASD 7.6% of pop x365	CRFs 2003 Value	1.62 x 10^{-4} 33% $18 33%	2.64 x 10^{-4} 34% $51 34%	3.65 x 10^{-4} 33% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	4,681.88 $74,910.00	10,272.00 $171,315.00	15,506.40 $261,249.00	10,450.00 $167,199.00
ARS 92.4% of pop x365	CRFs 2003 Value	1.25 x 10^{-4} 25% $8 33%	2.79 x 10^{-4} 50% $16 34%	4.14 x 10^{-4} 25% $25 33%	
Restricted Activity Day	# of Cases $ Benefit	3,834.39 $321,972.00	7,507.80 $658,184.00	11,561.70 $1,017,430.00	7,317.54 $643,944.00
RAD 92.4% of pop ≥ 20 x365	CRFs 2003 Value	1.31 x 10^{-4} 25% $44 33%	2.50 x 10^{-4} 50% $88 34%	3.95 x 10^{-4} 25% $132 33%	
HH Materials Soiling	# of Cases $ Benefit	0 $98,121.50	47,401.70 $263,181.00	0 $490,607.00	47,401.00 $196,243.00
HHMS x1	CRFs 2003 Value	$2.07 33%	1 100% $4.14 34%	$10.35 33%	
TOTAL BENEFIT		$6,581,351	$17,550,030	$31,577,950	$16,646,630

<u>Note</u>: some totals do not add due to rounding and monte carlo simulation effects.

Central Okanagan Regional District		Ozone	Benefits 10% Chg in Ozone, Baseline Yr 2004 = 44.57 ppb, Simulation Yr 2005 = 40.11 ppb		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.1081 $299,443.00	.2987 $1,467,150	.4892 $2,828,440	.2987 $1,412,730
MORT x153	CRFs 2003 Value	.97 x 10^{-9} 33% $2.77 Mill 33%	2.68 x 10^{-9} 34% $4.73 Mill 50%	4.39 x 10^{-9} 33% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.6687 $4,772.43	1.2259 $9,617.06	1.7831 $14,317.30	1.2259 $9,544.86
Admiss RHA x153	CRFs 2003 Value	.6 x 10^{-8} 25% $3,893 33%	1.1 x 10^{-8} 50% $7,786 34%	1.6 x 10^{-8} 25% $11,679 33%	
Net Emerg Room	# of Cases $ Benefit	2.7081 $1,675.05	4.9677 $3,351.19	7.2217 $5,025.15	4.9705 $3,350.10
Visits ERV x153	CRFs 2003 Value	2.43 x 10^{-8} 25% $337 33%	4.46 x 10^{-8} 50% $674 34%	6.48 x 10^{-8} 25% $1,011 33%	
Asthma Sympt Day	# of Cases $ Benefit	897.8050 $16,160.50	1,841.1800 $95,372.10	4,404.3300 $224,621.00	1,592.3300 $81,209.00
ASD 7.6% of pop x153	CRFs 2003 Value	1.06 x 10^{-4} 33% $18 33%	1.88 x 10^{-4} 50% $51 34%	5.20 x 10^{-4} 17% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	5,220.8700 $74,389.60	9,301.2800 $150,571.00	13,386.8000 $232,468.00	9,298.7000 $148,779.00
ARS 92.4% of pop x153	CRFs 2003 Value	5.07 x 10^{-5} 25% $8 33%	9.03 x 10^{-5} 50% $16 34%	13.0 x 10^{-5} 25% $25 33%	
Minor Restr Activity Day	# of Cases $ Benefit	1,987.4300 $73,534.90	4,806.3900 $195,124.00	7,620.2000 $307,774.00	4,808.9600 $177,932.00
MRAD 92.4% of pop x153	CRFs 2003 Value	1.93 x 10^{-5} 25% $23 33%	4.67 x 10^{-5} 50% $37 34%	7.40 x 10^{-5} 25% $64 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0 $0	0 $0	0 $0	0 $0
(Corn) x1	CRFs 2003 Value	0 33%	1.5 x 10^{-3} 34% $27.84 100%	2.00 x 10^{-3} 33%	
TOTAL BENEFIT		$797,268	$1,921,190	$3,185,580	$1,833,540

<u>Grand Total (PM2.5 & Ozone)</u>

10% Low: **$8,552,011**

Mean: **$19,471,230**

90% High: **$33,875,850**

Central Est: **$18,480,230**

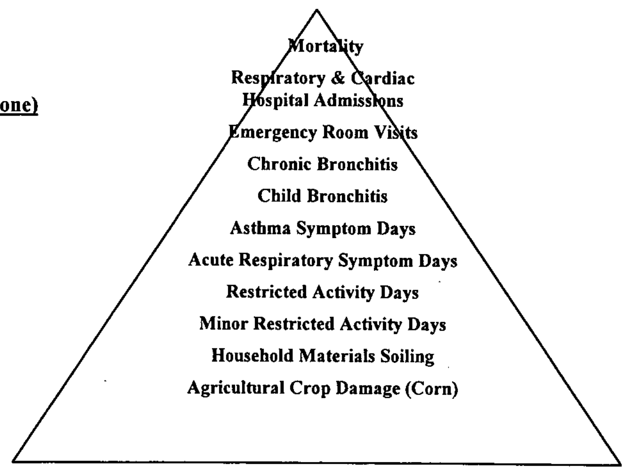

TABLE #A-3 North & Central Okanagan Regional District – Scenario #1 - Benefits Estimates - PM 2.5 & Ozone

BCLA Recommended CRFs for PM Mort. Ozone Mort & ERV CRFs as per Hlth Cda. All other CRFs from default AQVM (3.0) database.

Mort ests include BC Base Mort Rate (5.12×10^{-3}). AQVM (3.0) Dollar Values of Health Outcomes Updated to 2003 $'s Cdn (Persons with asthma assumed = 7.6%)

Ctrl & Nrth Okanagan Regional Districts		PM 2.5	Benefits 10% Chg in PM 2.5 Baseline Yr 2004, Simulation Yr 2005		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	.8717 $4,123,070	3.5826 $17,779,550	9.5885 $33,019,500	3.4867 $16,492,270
MORT x1	CRFs 2003 Value	5.12×10^{-6} 22% $2.77 Mill 33%	20.48×10^{-6} 67% $4.73 Mill 50%	56.32×10^{-6} 11% $9.47 Mill 17%	
Acute Mortality	# of Cases $ Benefit	.2911 $1,377,042	.7728 $3,768,490	1.1339 $8,254,870	.8717 $4,123,070
MORT x1	CRFs 2003 Value	1.71×10^{-6} 22% $2.77 Mill 33%	5.12×10^{-6} 67% $4.73 Mill 50%	6.66×10^{-6} 11% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.6214 $2,927.20	.7519 $5,828.15	.8824 $8,781.60	.7519 $5,854.40
Admiss RHA x365	CRFs 2003 Value	1.00×10^{-8} 25% $3,893 33%	1.21×10^{-8} 50% $7,786 34%	1.42×10^{-8} 25% $11,679 33%	
Cardiac Hosp	# of Cases $ Benefit	.4909 $3,147.04	.6354 $6,357.86	.7830 $9,440.48	.6338 $6,293.44
Admiss CHA x365	CRFs 2003 Value	$.79 \times 10^{-8}$ 25% $4,965 33%	1.02×10^{-8} 50% $9,929 34%	1.26×10^{-8} 25% $14,894 33%	
Net Emerg Room	# of Cases $ Benefit	2.6721 $1,093.16	3.2454 $2,188.68	3.8217 $3,279.47	3.2438 $2,186.32
Visits ERV x365	CRFs 2003 Value	4.30×10^{-8} 25% $337 33%	5.22×10^{-8} 50% $674 34%	6.15×10^{-8} 25% $1,011 33%	
Adult Chronic	# of Cases $ Benefit	4.9386 $1,614,344	9.8861 $3,550,340	14.8276 $5,444,390	9.8891 $3,232,610
Bronch CB pop ≥25 x1	CRFs 2003 Value	4.13×10^{-5} 25% $206,455 33%	8.27×10^{-5} 50% $326,887 34%	12.4×10^{-5} 25% $550,547 33%	
Child	# of Cases $ Benefit	23.8878 $8,384.62	63.6688 $22,591.79	103.6423 $36,378.40	63.5725 $22,313.92
Bronchitis B pop < 20 x1	CRFs 2003 Value	$.62 \times 10^{-3}$ 25% $176 33%	1.65×10^{-3} 50% $351 34%	2.69×10^{-3} 25% $527 33%	
Asthma Sympt Days	# of Cases $ Benefit	765.0880 $13,771.58	1,245.2510 $64,305.10	1,723.8080 $144,800.00	1,246.8100 $63,587.30
ASD 7.6% of pop x365	CRFs 2003 Value	1.62×10^{-4} 33% $18 33%	2.64×10^{-4} 34% $51 34%	3.65×10^{-4} 33% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	7,177.36 $114,837.70	15,747.09 $262,627.60	23,771.43 $400,497.00	16,019.91 $256,317.60
ARS 92.4% of pop x365	CRFs 2003 Value	1.25×10^{-4} 25% $8 33%	2.79×10^{-4} 50% $16 34%	4.14×10^{-4} 25% $25 33%	
Restricted Activity Day	# of Cases $ Benefit	5,856.12 $491,736.00	11,466.38 $1,005,220.00	17,657.76 $1,553,883.00	11,175.81 $983,471.00
RAD 92.4% of pop ≥ 20 x365	CRFs 2003 Value	1.31×10^{-4} 25% $44 33%	2.50×10^{-4} 50% $88 34%	3.95×10^{-4} 25% $132 33%	
HH Materials Soiling	# of Cases $ Benefit	0 $151,189.20	73,038.20 $405,519.00	0 $755,945.00	73,038.20 $302,378.00
HHMS x1	CRFs 2003 Value	$2.07 33%	1 100% $4.14 34%	$10.35 33%	
TOTAL BENEFIT		$10,061,302	$26,873,020	$48,364,570	$25,490,320

Note: some totals do not add due to rounding and monte carlo simulation effects.

Ctrl & Nrth Okgn Regional Districts		Ozone	Benefits 10% Chg in Ozone Baseline Yr 2004, Simulation Yr 2005		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.1474 $408,308	.4073 $2,000,545	.6671 $3,856,740	.4073 $1,926,338
MORT x153	CRFs 2003 Value	$.97 \times 10^{-9}$ 25% $2.77 Mill 33%	2.68×10^{-9} 50% $4.73 Mill 50%	4.39×10^{-9} 25% $9.47 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.9118 $6,507.49	1.6716 $13,113.42	2.4314 $19,522.47	1.6716 $13,014.97
Admiss RHA x153	CRFs 2003 Value	$.6 \times 10^{-8}$ 25% $3,893 33%	1.1×10^{-8} 50% $7,786 34%	1.6×10^{-8} 25% $11,679 33%	
Net Emerg Room	# of Cases $ Benefit	3.6927 $2,284.03	6.7737 $4,569.54	9.8472 $6,852.08	6.7775 $4,568.05
Visits ERV x153	CRFs 2003 Value	2.43×10^{-8} 25% $337 33%	4.46×10^{-8} 50% $674 34%	6.48×10^{-8} 25% $1,011 33%	
Asthma Sympt Day	# of Cases $ Benefit	1,224.2090 $22,035.77	2,510.5550 $130,045.40	6,005.5600 $306,283.60	2,171.2350 $110,733.20
ASD 7.6% of pop x153	CRFs 2003 Value	1.06×10^{-4} 33% $18 33%	1.88×10^{-4} 50% $51 34%	5.20×10^{-4} 17% $84 33%	
Acute Resp Symp Days	# of Cases $ Benefit	7,118.96 $101,434.50	12,682.83 $205,312.30	18,253.69 $316,983.40	12,679.32 $202,868.90
ARS 92.4% of pop x153	CRFs 2003 Value	5.07×10^{-5} 25% $8 33%	9.03×10^{-5} 50% $16 34%	13.0×10^{-5} 25% $25 33%	
Minor Restr Activity Day	# of Cases $ Benefit	2,709.9760 $100,269.10	6,553.7900 $266,062.70	10,390.5800 $419,668.00	6,557.3000 $242,620.50
MRAD 92.4% of pop x153	CRFs 2003 Value	1.93×10^{-5} 25% $23 33%	4.67×10^{-5} 50% $37 34%	7.40×10^{-5} 25% $64 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0 $0	244.0380 $6,815.49	417.1580 $11,613.70	312.8690 $8,710.26
(Corn) x1	CRFs 2003 Value	0 33%	1.5×10^{-3} 34% $27.84 100%	2.00×10^{-3} 33%	
TOTAL BENEFIT		$1,093,288	$2,626,469	$4,351,670	$2,508,849

Grand Total (PM2.5 & Ozone)

10% Low:	$12,760,372
Mean:	$29,499,500
90% High:	$51,489,570
Central Est:	$27,999,230

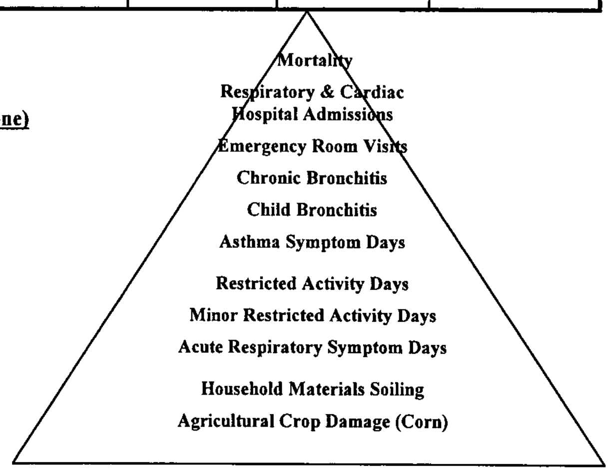

Table #A-4 - Review of Table Addition Discrepancies – Scenario #1

North Okanagan	PM2.5				Ozone				Total PM2.5 & Ozone			
Regional District	10% Low	Mean	90% High	Ctrl Est	10% Low	Mean	90% High	Ctrl Est	10% Low	Mean	90% High	Ctrl Est
Values Generated by AQVM Output	$3,479,951.00	$9,322,990.00	$16,786,620.00	$8,843,690.00	$296,020.00	$705,279.00	$1,166,090.00	$675,309.00	$4,208,361.00	$10,028,270.00	$17,613,720.00	$9,519,000.00
Values derived by Adding Totals	$2,737,767.22	$9,322,995.10	$17,225,453.83	$8,843,697.23	$170,863.41	$705,278.50	$1,325,017.80	$675,308.92	$2,908,630.63	$10,028,273.60	$18,550,471.63	$9,519,006.15
CentralOkanagan	**PM2.5**				**Ozone**				**Total PM2.5 & Ozone**			
Regional District	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**
Values Generated by AQVM Output	$6,581,351.00	$17,550,030.00	$31,577,950.00	$16,646,630.00	$797,268.00	$1,921,190.00	$3,185,580.00	$1,833,540.00	$8,552,011.00	$19,471,230.00	$33,875,850.00	$18,480,230.00
Values derived by Adding Totals	$5,163,775.28	$17,550,023.08	$32,406,311.12	$16,646,654.75	$469,975.48	$1,921,185.35	$3,612,645.45	$1,833,544.96	$5,633,750.78	$19,471,208.43	$36,018,956.57	$18,480,199.71
North & Ctrl	**PM2.5**				**Ozone**				**Total PM2.5 & Ozone**			
Okan Reg District	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**
Values Generated by AQVM Output	$10,061,302.00	$26,873,020.00	$48,364,570.00	$25,490,320.00	$640,838.89	$2,626,463.85	$4,937,663.25	$2,508,849.00	$12,760,372.00	$29,499,500.00	$51,489,570.00	$27,999,230.00
Values derived by Adding Totals	$7,901,542.50	$26,873,018.18	$49,631,764.95	$25,490,351.98	$640,838.89	$2,626,463.85	$4.937,663.25	$2,508,853.88	$8,542,381.39	$29,499,482.03	$54,569,428.20	$27,999,205.86

Table #A-5 Discounted Benefits (2005 – 2010 – 2020) - Scenario #1

10% Improvement in PM2.5 & Ozone, (BCLA CRFs for PM Mort) (Base Mort Rate – 5.12 x 10^{-3}) (Values Updated to 2003)

Discounted Benefits (2005 – 2010, 2005 - 2020) 10% IMPROVEMENT IN PM2.5 AND OZONE (Based on average estimates - Scenario #1) (BCLA CRF for PM Mort) (Base Mort Rate = 5.12x10-3) (Values Updated to 2003)

The monetized benefits associated with a sustained 10% improvement in PM2.5 and ground level ozone occurring in years 2005, 2010 and 2020 are presented below.

The discounted present value of the benefits accruing between 2005 - 2010 and 2005 - 2020 are presented discounted at 4%, 6%, and 8% respectively.

20-Feb-06

											Ttl Bnfts Accruing 2005-2010		6 years				Ttl Bnfts Accruing to Yr 2020		16 years			
	2005		2010		2020		Ttl Bnfts 2005-2010		Ttl Bnfts 2005-2020		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%	
Nrth Okanagan Reg District	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chronic Mortality (Ttl Pop)	$5,734,170	$513,608	$6,074,814	$544,119	$6,869,649	$615,313	$35,313,403	$3,163,012	$100,262,814	$8,980,512	$30,814,202	$2,760,019	$28,887,390	$2,587,435	$27,141,603	$2,431,066	$72,278,278	$6,473,945	$62,383,557	$5,587,678	$54,387,420	$4,871,466
Acute Mortality (Ttl Pop)	$1,433,540		$1,518,701		$1,717,409		$8,828,335		$25,065,660		$7,703,537		$7,221,835		$6,785,369		$18,069,538		$15,595,862		$13,596,831	
Chronic Bronchitis (Pop >=25)	$1,106,230		$1,214,684		$1,409,901		$6,962,742		$20,248,347		$6,070,279		$5,688,254		$5,342,226		$14,546,071		$12,532,980		$10,907,867	
Resp Hospital Admiss (Ttl Pop)	$2,036	$3,470	$2,156	$3,676	$2,439	$4,157	$12,535	$21,370	$35,591	$60,675	$10,938	$18,648	$10,254	$17,482	$9,635	$16,425	$25,657	$43,740	$22,145	$37,752	$19,306	$32,913
Cardiac Hospital Admiss (Ttl Pop)	$2,188		$2,318		$2,621		$13,476		$38,260		$11,759		$11,023		$10,357		$27,581		$23,805		$20,754	
Emergency Room Visits (Ttl Pop)	$760	$1,218	$805	$1,290	$911	$1,459	$4,681	$7,501	$13,291	$21,296	$4,085	$6,545	$3,829	$6,136	$3,598	$5,765	$9,582	$15,352	$8,270	$13,250	$7,210	$11,552
Asthma Symptom Days (7.6% of Ttl Pop)	$22,109	$29,524	$23,422	$31,278	$26,486	$35,371	$136,153	$181,822	$386,570	$516,235	$118,806	$158,657	$111,377	$148,736	$104,646	$139,747	$278,674	$372,148	$240,524	$321,202	$209,695	$280,031
Restricted Activity Days (92.4% of Pop >= age 20)	$339,527		$365,898		$415,344		$2,109,682		$6,042,262		$1,840,055		$1,724,615		$1,620,040		$4,350,666		$3,752,777		$3,269,741	
Minor Restr Activity Days (92.4% of Ttl Pop)		$64,689		$68,531		$77,498		$398,379		$1,131,088		$347,622		$325,885		$306,191		$815,388		$703,763		$613,557
Acute Resp Symptom Days (92.4% of Ttl Pop)	$89,119	$54,090	$94,413	$57,303	$106,766	$64,801	$548,829	$333,108	$1,558,252	$945,770	$478,904	$290,668	$448,958	$272,492	$421,826	$256,024	$1,123,325	$681,794	$969,545	$588,458	$845,272	$513,032
Child Bronchitis (Pop <= age 20)	$7,884		$7,720		$8,623		$46,567		$127,874		$40,703		$38,190		$35,911		$92,633		$80,150		$70,050	
Household Materials Soiling (All Households)	$106,135		$117,254		$133,427		$672,188		$1,938,733		$585,984		$549,084		$515,660		$1,394,572		$1,202,295		$1,046,987	
Agricultural Crop Damage (All Corn Acres)		$8,710		$8,710		$8,710		$52,262		$139,364		$45,660		$42,831		$40,266		$101,495		$88,025		$77,098
TOTAL	$8,843,697	$675,309	$9,422,185	$714,909	$10,693,577	$807,309	$54,648,593	$4,157,453	$155,717,654	$11,794,841	$47,679,253	$3,627,818	$44,694,811	$3,400,997	$41,990,892	$3,196,484	$112,196,576	$8,503,862	$96,611,911	$7,340,129	$84,381,133	$6,399,649

											Ttl Bnfts Accruing 2005-2010		6 years				Ttl Bnfts Accruing to Yr 2020					
	2005		2010		2020		Ttl Bnfts 2005-2010		Ttl Bnfts 2005-2020		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%	
Ctrl Okanagan Reg District	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chronic Mortality (Ttl Pop)	$10,758,100	$1,412,730	$11,698,128	$1,536,172	$14,100,422	$1,851,636	$67,473,132	$8,860,423	$197,510,360	$25,936,626	$58,839,531	$7,726,678	$55,143,189	$7,241,282	$51,794,758	$6,801,573	$141,706,973	$18,608,648	$122,028,303	$16,024,488	$106,153,109	$13,939,793
Acute Mortality (Ttl Pop)	$2,689,530		$2,924,537		$3,525,112		$16,868,314		$49,377,682		$14,709,910		$13,785,823		$12,948,713		$35,426,809		$30,507,132		$26,538,327	
Chronic Bronchitis (Pop >=25)	$2,126,380		$2,392,178		$2,964,664		$13,514,781		$40,523,896		$11,775,919		$11,031,855		$10,358,058		$28,968,365		$24,900,827		$21,623,464	
Resp Hospital Admiss (Ttl Pop)	$3,818	$9,545	$4,153	$10,379	$5,005	$12,510	$23,952	$59,864	$70,112	$175,236	$20,887	$52,204	$19,575	$48,924	$18,386	$45,954	$50,303	$125,726	$43,317	$108,267	$37,682	$94,182
Cardiac Hospital Admiss (Ttl Pop)	$4,105		$4,464		$5,381		$25,748		$75,370		$22,453		$21,043		$19,765		$54,075		$46,566		$40,508	
Emergency Room Visits (Ttl Pop)	$1,426	$3,350	$1,551	$3,643	$1,869	$4,391	$8,945	$21,011	$26,183	$61,505	$7,800	$18,323	$7,310	$17,172	$6,866	$16,129	$18,786	$44,128	$16,177	$38,000	$14,072	$33,056
Asthma Symptom Days (7.6% of Ttl Pop)	$41,479	$81,209	$45,103	$88,305	$54,365	$106,439	$260,149	$509,330	$761,519	$1,490,934	$226,861	$444,156	$212,609	$416,256	$199,699	$390,980	$546,364	$1,069,695	$470,491	$921,147	$409,283	$801,311
Restricted Activity Days (92.4% of Pop >= age 20)	$643,944		$717,538		$870,858		$4,072,179		$12,075,483		$3,549,016		$3,325,125		$3,122,361		$8,647,349		$7,439,439		$6,465,542	
Minor Restr Activity Days (92.4% of Ttl Pop)		$177,932		$193,478		$233,212		$1,115,962		$3,266,693		$973,168		$912,033		$856,652		$2,343,741		$2,018,269		$1,755,704
Acute Resp Symptom Days (92.4% of Ttl Pop)	$167,199	$148,779	$181,809	$161,779	$219,144	$195,002	$1,048,646	$933,119	$3,069,644	$2,731,467	$914,465	$813,721	$857,016	$762,602	$804,978	$716,295	$2,202,365	$1,959,735	$1,896,525	$1,687,589	$1,649,798	$1,468,043
Child Bronchitis (Pop <= age 20)	$14,430		$14,430		$16,324		$86,432		$239,327		$75,512		$70,833		$66,591		$173,079		$149,635		$130,676	
Household Materials Soiling (All Households)	$196,243		$221,920		$273,273		$1,254,468		$3,765,298		$1,093,019		$1,023,925		$961,356		$2,692,004		$2,314,095		$2,009,550	
Agricultural Crop Damage (All Corn Acres)		$0		$0		$0		$0		$0		$0		$0		$0		$0		$0		$0
TOTAL	$16,646,630	$1,833,540	$18,205,809	$1,993,758	$22,036,419	$2,403,190	$104,838,765	$11,499,709	$307,494,874	$33,662,461	$91,235,375	$10,028,251	$85,488,304	$9,398,268	$80,301,531	$8,827,583	$220,488,472	$24,151,672	$189,812,507	$20,797,760	$165,072,012	$18,092,089

											Ttl Bnfts Accruing 2005-2010		6 years				Ttl Bnfts Accruing to Yr 2020					
	2005		2010		2020		Ttl Bnfts 2005-2010		Ttl Bnfts 2005-2020		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%		Discounted PV 4%		Discounted PV 6%		Discounted PV 8%	
Nrth & Ctrl Okgn Reg Dist	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone	PM2.5	Ozone
Chronic Mortality (Ttl Pop)	$16,492,270	$1,926,338	$17,772,942	$2,080,292	$20,970,072	$2,466,949	$102,786,535	$12,023,435	$297,773,174	$34,917,138	$89,653,733	$10,486,697	$84,030,579	$9,828,718	$78,936,381	$9,232,639	$213,985,251	$25,082,593	$184,411,860	$21,612,166	$160,540,529	$18,811,258
Acute Mortality (Ttl Pop)	$4,123,070	$0	$4,443,238	$0	$5,242,521	$0	$25,696,650	$0	$74,443,342	$0	$22,413,447	$0	$21,007,658	$0	$19,734,102	$0	$53,496,347	$0	$46,102,995	$0	$40,135,158	$0
Chronic Bronchitis (Pop >=25)	$3,232,610	$0	$3,606,861	$0	$4,374,565	$0	$20,477,522	$0	$60,772,243	$0	$17,846,199	$0	$16,720,109	$0	$15,700,285	$0	$43,514,436	$0	$37,433,806	$0	$32,531,331	$0
Resp Hospital Admiss (Ttl Pop)	$5,854	$13,015	$6,309	$14,055	$7,444	$16,668	$36,487	$81,234	$105,703	$235,912	$31,825	$70,852	$29,829	$66,406	$28,021	$62,379	$75,960	$169,466	$65,462	$146,019	$56,988	$127,095
Cardiac Hospital Admiss (Ttl Pop)	$6,293	$0	$6,782	$0	$8,002	$0	$39,223	$0	$113,630	$0	$34,212	$0	$32,066	$0	$30,122	$0	$81,657	$0	$70,371	$0	$61,262	$0
Emergency Room Visits (Ttl Pop)	$2,186	$4,568	$2,356	$4,933	$2,780	$5,850	$13,626	$28,512	$39,475	$82,601	$11,885	$24,868	$11,140	$23,307	$10,464	$21,894	$28,367	$59,480	$24,447	$51,250	$21,282	$44,608
Asthma Symptom Days (7.6% of Ttl Pop)	$63,587	$110,733	$68,525	$119,583	$80,852	$141,810	$396,302	$691,153	$1,148,089	$2,007,169	$345,667	$602,615	$323,987	$564,992	$304,346	$530,727	$825,038	$1,441,842	$711,015	$1,242,349	$618,977	$1,081,342
Restricted Activity Days (92.4% of Pop >= age 20)	$983,471	$0	$1,083,436	$0	$1,286,201	$0	$6,181,862	$0	$18,117,745	$0	$5,389,071	$0	$5,049,740	$0	$4,742,401	$0	$12,998,015	$0	$11,192,216	$0	$9,735,283	$0
Minor Restr Activity Days (92.4% of Ttl Pop)	$0	$242,621	$0	$262,011	$0	$310,710	$0	$1,514,341	$0	$4,397,781	$0	$1,320,790	$0	$1,237,918	$0	$1,162,842	$0	$3,159,129	$0	$2,722,032	$0	$2,369,261
Acute Resp Symptom Days (92.4% of Ttl Pop)	$256,318	$202,869	$276,221	$219,082	$325,910	$259,802	$1,597,476	$1,266,227	$4,627,896	$3,677,237	$1,393,370	$1,104,388	$1,305,976	$1,035,094	$1,226,804	$972,319	$3,325,691	$2,641,529	$2,866,070	$2,276,047	$2,495,070	$1,981,075
Child Bronchitis (Pop <= age 20)	$22,314	$0	$22,150	$0	$24,948	$0	$132,999	$0	$367,201	$0	$116,216	$0	$109,023	$0	$102,502	$0	$265,711	$0	$229,785	$0	$200,726	$0
Household Materials Soiling (All Households)	$302,378	$0	$339,174	$0	$406,700	$0	$1,926,676	$0	$5,704,031	$0	$1,679,003	$0	$1,573,009	$0	$1,477,017	$0	$4,088,575	$0	$3,516,390	$0	$3,056,537	$0
Agricultural Crop Damage (All Corn Acres)	$0	$8,710	$0	$8,710	$0	$8,710	$0	$52,262	$0	$139,364	$0	$45,660	$0	$42,831	$0	$40,266	$0	$101,495	$0	$88,025	$0	$77,098
TOTAL	$25,490,327	$2,508,845	$27,827,984	$2,708,686	$32,729,995	$3,210,498	$159,285,355	$15,657,162	$463,212,528	$45,457,402	$138,914,628	$13,656,070	$130,183,118	$12,799,266	$122,292,423	$12,023,067	$332,683,047	$32,655,534	$286,824,417	$28,137,888	$249,453,144	$24,491,737

Scenario #2 - PM2.5 & Ozone - (Default AQVM - Version 3.0 Database - 1996 $'s Cdn)
With updates to PM Mortality, Ozone Mortality and ERV CRFs (as per Health Canada)

(Scenario #2 is included in the appendix of this report for sensitivity analysis – as a frame of reference only).

For sensitivity analysis, the annual effects and monetized benefits estimates associated with a 10% improvement in PM2.5 and ozone *(scenario #2)* for the North Okanagan Regional District and the Central Okanagan Regional District are presented in table A-8 and A-9 below. The *scenario #2* analysis employs the default AQVM (Version 3.0) CRF database with updates to PM2.5 mortality, ozone mortality, and emergency room visits as recommended by Health Canada.[122] The dollar values of health outcomes *(included within scenario #2)* are based on the default AQVM (Version 3.0) database expressed in 1996 $'s Canadian.[123]

The CRFs associated with PM2.5 and ozone mortality employed in *scenario #2* are shown in table #A-6 below. *(Note: these are updated CRFs as provided by Health Canada in response to the GAM statistical error using the Cdn base mort rates).*

TABLE #A-6 – Scenario #2
PM2.5 and Ozone Mortality CRFs and Weighting Assignments - Applied within the Benefits Analysis

PM2.5 Mortality		CRF	Weight	Ozone Mortality		CRF	Weight
Low	Pope et al (2002)	**1.58×10^{-5}**	25%	**Low**	Stieb et al (2002)	**1.28×10^{-9}**	25%
Central	*(Revised as per*	**2.82×10^{-5}**	50%	**Central**		**3.55×10^{-9}**	50%
High	*Health Canada)*	**4.07×10^{-5}**	25%	**High**		**5.81×10^{-9}**	25%

Source: Jessiman, Barry – Health Canada, Personal (e-mail) Communication, (21/July/2003). See also: Bates, Dr. David V.-University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 113, 114). **Note:** PM2.5 conversation assumes 1997 annual all cause mortality rate = **7.19E-03.** **Note:** ozone conversion assumes 1997 daily non-traumatic mortality rate = **1.85 E-05**

Differences in the CRFs applied for PM2.5 and ozone mortality within the main report *(scenario #1) –vs–* those applied within *scenario #2* relate to the assumed CRFs, and to the base mortality rates applied *(the CRFs employed within the main report -scenario #1 - assume a non-accidental base mortality rate for PM2.5 of: 5.12×10^{-3} (annual), and for ozone of: 1.40×10^{-5} (daily) – whereas the CRFs employed within scenario #2 assume a base mortality rate for PM2.5 of: 7.19×10^{-3} (annual), and for ozone of: 1.85×10^{-5} (daily)).*

Table #A-7 below provides a summary of the aggregate monetized benefits estimates. For the North Okanagan Regional District, the central estimate value for PM2.5 is $8,232,390, and the low, mean and high *(percentile)* estimates are: $4,754,120, $8,960,740, and $14,960,400 *(respectively).* The central estimate value for ozone is: $733,710, and the low, mean and high *(percentile)* estimates are: $318,078, $756,486, and $1,304,350 *(respectively)* For the Central Okanagan Regional District, the central estimate value for PM2.5 is $15,489,700, and the low, mean and high *(percentile)* estimates are: $8,938,190, $16,354,200, and $28,101,600 *(respectively).* The central estimate value for ozone is $1,994,180, and the low, mean and high *(percentile)* estimates are: $854,873, $2,063,030, and $3,566,240 *(respectively).*

TABLE #A-7
Scenario #2 - Aggregate Monetized Benefits Estimates (PM2.5 and Ozone)
Central Okanagan Regional District and North Okanagan Regional District (Year 2005)

Regional District	PM2.5				Ozone			
	10% Low	Mean	90% High	Central Est	10% Low	Mean	90% High	Central Est
North Okanagan	$4,754,120	$8,690,740	$14,960,400	$8,232,390	$318,078	$756,846	$1,304,350	$733,710
Central Okanagan	$8,938,190	$16,354,200	$28,101,600	$15,489,700	$854,873	$2,063,030	$3,566,240	$1,994,180

122 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita–Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final. Report, (September 3, 1999) (p. 4-11 & D-1) See also: Jessiman, Barry, Health Canada, E-mail communication, (21/July/2003). See also: Bates, Dr. David V. -University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114).

123 The scenario #1 estimates presented with the main text of the report are based on the default AQVM (Version 3.0) CRF database with modifications to PM related mortality using locally applicable base mortality rates as per recommendations within the BCLA Phase I health study. Modifications to the default AQVM (Version 3.0) CRF database are also made to ozone related mortality and ERVs to reflect updates to the CRFs associated with these health endpoints as provided by Health Canada. The *scenario #1 results presented within the main text of the report* also include updates to the dollar values of health outcomes contained within the default AQVM (Version 3.0) database, updated *(inflated)* to year 2003 $'s Canadian.

TABLE #A-8 – Scenario #2
Annual Impacts (Effects/Outcomes/Events) Associated with a 10% Improvement in PM2.5 and Ozone (Simulation Yr 2005)
North Okanagan Regional District and Central Okanagan Regional District
Default AQVM (Version 3.0) CRFs (With Updates to PM & Ozone Mortality & ERV CRFs as per Health Canada)

North Okanagan Reg District	PM2.5				Ozone			
Health Outcome	Low	Mean	High	Central Est	Low	Mean	High	Central Est
Mortality	.94	1.67	2.41	1.67	.05	.14	.24	.14
Chronic Bronchitis	1.69	3.38	5.07	3.38	-	-	-	-
Respiratory Hospital Admiss	.22	.26	.31	.26	.24	.45	.65	.45
Cardiac Hospital Admiss	.17	.22	.27	.22	-	-	-	-
Emergency Room Visits	.93	1.13	1.33	1.13	.98	1.81	2.63	1.81
Asthma Symptom Days	210.01	341.81	473.17	342.24	257.69	528.45	1,264.13	457.03
Restricted Activity Days	2,056.74	4,027.13	6,201.62	3,925.08	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	735.06	1,777.66	2,818.36	1,778.61
Acute Respiratory Symptom Days	2,538.69	5,569.89	8,408.15	5,666.36	1,930.95	3,440.11	4,951.17	3,439.16
Child Bronchitis	8.44	22.50	36.62	22.46	-	-	-	-
Household Materials Soiling	0.00	25,636.50	0.00	25,636.50	-	-	-	-
Corn Crop Damage	-	-	-	-	0.00	244.04	417.16	312.87
Central Okanagan Reg District	**PM2.5**				**Ozone**			
Health Outcome	**Low**	**Mean**	**High**	**Central Est**	**Low**	**Mean**	**High**	**Central Est**
Mortality	1.75	3.13	4.52	3.13	.14	.40	.65	.40
Chronic Bronchitis	3.25	6.50	9.75	6.50	-	-	-	-
Respiratory Hospital Admiss	.41	.49	.58	.49	.67	1.23	1.78	1.23
Cardiac Hospital Admiss	.32	.41	.51	.41	-	-	-	-
Emergency Room Visits	1.74	2.12	2.49	2.12	2.71	4.97	7.22	4.97
Asthma Symptom Days	394.01	641.28	887.73	642.09	708.79	1,453.56	3,477.10	1,257.11
Restricted Activity Days	3,900.79	7,637.80	11,761.90	7,444.25	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	2,021.84	4,889.62	7,752.15	4,892.24
Acute Respiratory Symptom Days	4,762.95	10,449.90	15,774.90	10,630.90	5,311.27	9,462.34	13,618.60	9,459.72
Child Bronchitis	15.45	41.17	67.02	41.11	-	-	-	-
Household Materials Soiling	0.00	47,401.70	0.00	47,401.70	-	-	-	-
Corn Crop Damage	-	-	-	-	0.00	0.00	0.00	0.00
Nrth & Ctrl Okgn Reg Dist	**PM2.5**				**Ozone**			
Health Outcome	**Low**	**Mean**	**High**	**Central Est**	**Low**	**Mean**	**High**	**Central Est**
Mortality	2.69	4.81	6.93	4.80	.19	.54	.88	.54
Chronic Bronchitis	4.94	9.89	14.83	9.89	-	-	-	-
Respiratory Hospital Admiss	.62	.75	.88	.75	.91	1.67	2.43	1.67
Cardiac Hospital Admiss	.49	.64	.78	.63	-	-	-	-
Emergency Room Visits	2.67	3.25	3.82	3.24	3.69	6.77	9.85	6.78
Asthma Symptom Days	604.02	983.09	1,360.90	984.32	966.48	1,982.01	4,741.23	1,714.14
Restricted Activity Days	5,957.53	11,664.93	17,963.52	11,369.33	-	-	-	-
Minor Restricted Activity Days	-	-	-	-	2,756.90	6,667.28	10,570.51	6,670.85
Acute Respiratory Symptom Days	7,301.64	16,019.79	24,183.05	16,297.26	7,242.22	12,902.45	18,569.77	12,898.88
Child Bronchitis	23.89	63.67	103.64	63.57	-	-	-	-
Household Materials Soiling	0.00	73,038.20	0.00	73,038.20	-	-	-	-
Corn Crop Damage	-	-	-	-	0.00	244.04	417.16	312.87

<u>Note</u>: the air quality benefits analysis is more suitable for application to large population groups, as disaggregation into smaller population sub-groups reduces the mortality and morbidity impacts to smaller fractions. The reported health effects are annual predicted results. Substantial year to year variability may occur for smaller populations. Fractions are reported as the results average out over longer periods of time for larger populations.

TABLE #A-9 – Scenario #2

Annual Monetized Benefits Estimates Associated with a 10% Improvement in PM2.5 and Ozone (Simulation Yr 2005)

North Okanagan Regional District and Central Okanagan Regional District

Default AQVM (Version 3.0) CRFs (With Updates to PM & Ozone Mortality & ERV CRFs as per Health Canada) (1996 $'s Cdn)

Nrth Okanagan Reg District	PM2.5				Ozone			
Health Outcome	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
Mortality	$3,834,600	$7,150,780	$13,688,100	$6,844,040	$212,633	$607,300	$1,179,450	$589,723
Chronic Bronchitis	$449,544	$1,014,880	$1,573,620	$900,177	-	-	-	-
Resp Hospital Admiss	$863	$1,709	$2,562	$1,725	$1,471	$2,949	$4,368	$2,942
Cardiac Hospital Admiss	$926	$1,870	$2,777	$1,851	-	-	-	-
Emergency Room Visits	$327	$647	$970	$643	$524	$1,036	$1,554	$1,030
Asthma Symptom Days	$3,570	$15,918	$35,488	$15,743	$4,381	$24,686	$58,150	$21,023
Restricted Activity Days	$145,228	$294,201	$452,718	$286,531	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$24,257	$64,011	$101,381	$58,694
Acute Resp Symptom Days	$38,080	$83,431	$126,122	$84,995	$24,074	$50,049	$75,661	$51,587
Child Bronchitis	$2,617	$6,969	$11,352	$6,963	-	-	-	-
Household Materials Soiling	$44,864	$120,334	$224,320	$89,728	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$6,815	$11,614	$8,710
TOTAL	$4,754,120	$8,690,740	$14,960,400	$8,232,390	$318,078	$756,846	$1,304,350	$733,710
Ctrl Okanagan Reg District	**PM2.5**				**Ozone**			
Health Outcome	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
Mortality	$7,194,260	$13,415,900	$25,680,800	$12,840,400	$584,866	$1,670,430	$3,244,180	$1,622,090
Chronic Bronchitis	$864,109	$1,950,780	$3,024,790	$1,730,310	-	-	-	-
Resp Hospital Admiss	$1,619	$3,206	$4,807	$3,237	$4,045	$8,110	$12,014	$8,091
Cardiac Hospital Admiss	$1,737	$3,509	$5,210	$3,473	-	-	-	-
Emergency Room Visits	$614	$1,214	$1,820	$1,206	$1,441	$2,851	$4,275	$2,833
Asthma Symptom Days	$6,698	$29,865	$66,580	$29,536	$12,050	$67,900	$159,947	$57,827
Restricted Activity Days	$275,437	$557,978	$858,620	$543,430	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$66,721	$176,068	$278,857	$161,444
Acute Resp Symptom Days	$71,444	$156,528	$236,623	$159,464	$66,218	$137,665	$208,114	$141,896
Child Bronchitis	$4,789	$12,755	$20,777	$12,744	-	-	-	-
Household Materials Soiling	$82,953	$222,496	$414,765	$165,906	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$0	$0	$0
TOTAL	$8,938,190	$16,354,200	$28,101,600	$15,489,700	$854,873	$2,063,030	$3,566,240	$1,994,180
Nrth & Ctrl Okg Reg Dist	**PM2.5**				**Ozone**			
Health Outcome	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
Mortality	$11,028,860	$20,566,680	$39,368,900	$19,684,440	$797,499	$2,277,730	$4,423,630	$2,211,813
Chronic Bronchitis	$1,313,653	$2,965,660	$4,598,410	$2,630,487	-	-	-	-
Resp Hospital Admiss	$2,481	$4,916	$7,369	$4,963	$5,516	$11,059	$16,382	$11,032
Cardiac Hospital Admiss	$2,662	$5,379	$7,986	$5,324	-	-	-	-
Emergency Room Visits	$941	$1,862	$2,790	$1,849	$1,965	$3,887	$5,829	$3,863
Asthma Symptom Days	$10,268	$45,784	$102,068	$45,279	$16,430	$92,586	$218,097	$78,850
Restricted Activity Days	$420,665	$852,179	$1,311,338	$829,961	-	-	-	-
Minor Restr Activity Days	-	-	-	-	$90,978	$240,079	$380,238	$220,138
Acute Resp Symptom Days	$109,525	$239,959	$362,745	$244,459	$90,292	$187,714	$283,775	$193,483
Child Bronchitis	$7,405	$19,724	$32,129	$19,707	-	-	-	-
Household Materials Soiling	$127,817	$324,830	$639,085	$255,634	-	-	-	-
Corn Crop Damage	-	-	-	-	$0	$6,815	$11,614	$8,710
TOTAL	$13,692,310	$25,044,940	$43,062,000	$23,722,090	$1,172,951	$2,819,876	$4,870,590	$2,727,890

<u>Note</u>: some totals do not add due to rounding and monte carlo simulation effects.

Comparison - Scenario #2 Results - and - Scenario #1 Results (Presented Within the Report)

A comparison of the results presented within the main report *(scenario #1)* and the *scenario #2* results is provided in table #A-10 below.

As revealed in table #A-10, the aggregate results are similar. Note however, the *(scenario #1)* results *(presented in the main report)* are preferred as they incorporate the most recent *(up-to-date)* CRF recommendations as put forward within the BC Lung Association Phase 1 health study.[124] *(Note that the default AQVM - Version 3.0 database was developed in 1999, and does not include the recent recommendations put forward within the BC Lung Association – Phase 1 health study, May/2003).*

The *(scenario #1)* results presented within the main report also include local *(provincial)* base mortality rates and dollar value of health outcomes that have been updated *(inflated)* to 2003 $'s Canadian. *(Note that the dollar values of health outcomes within the default AQVM Version 3.0 database employed in the scenario #2 results are expressed in 1996 $'s Canadian).*[125]

TABLE #A-10
Comparison of Annual Monetized Benefits Estimates (Scenario #1) – Versus – (Scenario #2)
North Okanagan Regional District and Central Okanagan Regional District

Scenario #1 Main Report	**PM2.5**				**Ozone**			
Regional District	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
North Okanagan	$3,479,951	$9,322,990	$16,786,620	$8,843,690	$296,020	$705,279	$1,166,090	$675,309
Central Okanagan	$6,581,351	$17,550,030	$31,577,950	$16,646,630	$797,268	$1,921,190	$3,185,580	$1,833,540
Scenario #2 Appendix	**PM2.5**				**Ozone**			
Regional District	**10% Low**	**Mean**	**90% High**	**Central Est**	**10% Low**	**Mean**	**90% High**	**Central Est**
North Okanagan	$4,754,120	$8,690,740	$14;960,400	$8,232,390	$318,078	$756,846	$1,304,350	$733,710
Central Okanagan	$8,938,190	$16,354,200	$28,101,600	$15,489,700	$854,873	$2,063,030	$3,566,240	$1,994,180

124 Bates, Dr. David V. - University of British Columbia (Emeritus), Dr. Jane Koenig-University of Washington, Dr. Michael Brauer–University of British Columbia, Dr. Robert Caton-RWDI West Inc, Damian Crawley M.Sc.-RWDI West Inc, *Health and Air Quality 2002 – Phase 1 Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report*, British Columbia Lung Association, (May/2003), (p. 51, 113 & 114).

125 Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc, Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0) Report 2: Methodology, Final Report, (September 3, 1999) (p. 5-20 & 5-31).

TABLE #A-11 North Okanagan Regional District - Scenario #2 - Benefits Estimates - PM2.5 & Ozone
Default AQVM Database (Version 3.0) CRF's and Dollar Value of Health Outcomes (1996 $s Cdn), except that Ozone & PM2.5 Mort CRFs & ERV CRFs as per Hlth Cda. (Persons with Asthma Assumed = 6%)

North Okanagan Regional District		PM 2.5	Benefits 10% Chg in PM 2.5 Baseline Yr 2004 = 7.61 ug/m³ Simulation Yr 2005 = 6.85 ug/m³		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	.9353 $3,834,600	1.6708 $7,150,780	2.4092 $13,688,100	1.6693 $6,844,040
MORT x1	CRFs 1996 Value	1.58×10^{-5} 25% $2.40 Mill 33%	2.82×10^{-5} 50% $4.10 Mill 50%	4.07×10^{-5} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.2161 $862.72	.2614 $1,709.07	.3068 $2,562.03	.2614 $1,725.45
Admiss RHA x365	CRFs 1996 Value	1.00×10^{-8} 25% $3,300 33%	1.21×10^{-8} 50% $6,600 34%	1.42×10^{-8} 25% $9,800 33%	
Cardiac Hosp	# of Cases $ Benefit	.1707 $925.60	.2209 $1,870.08	.2722 $2,776.79	.2204 $1,851.19
Admiss CHA x365	CRFs 1996 Value	$.79 \times 10^{-8}$ 25% $4,200 33%	1.02×10^{-8} 50% $8,400 34%	1.26×10^{-8} 25% $12,600 33%	
Emerg Room	# of Cases $ Benefit	.9291 $327.07	1.1284 $647.26	1.3288 $969.93	1.1278 $642.86
Visits ERV x365	CRFs 1996 Value	4.30×10^{-8} 25% $290 33%	5.22×10^{-8} 50% $570 34%	6.15×10^{-8} 25% $860 33%	
Adult Chronic	# of Cases $ Benefit	1.6900 $449,544	3.3831 $1,014,880	5.0741 $1,573,620	3.3841 $900,177
Bronch CB pop ≥25 x1	CRFs 1996 Value	4.13×10^{-5} 25% $175,000 33%	8.27×10^{-5} 50% $266,000 34%	12.4×10^{-5} 25% $465,000 33%	
Child	# of Cases $ Benefit	8.4404 $2,616.54	22.4965 $6,969.26	36.6206 $11,352.40	22.4625 $6,963.36
Bronchitis B pop < 20 x1	CRFs 1996 Value	$.62 \times 10^{-3}$ 25% $150 33%	1.65×10^{-3} 50% $310 34%	2.69×10^{-3} 25% $460 33%	
Asthma Sympt Days	# of Cases $ Benefit	210.0900 $3,570.16	341.8100 $15,918.40	473.1690 $35,487.70	342.2370 $15,742.90
ASD 7.6% of pop x365	CRFs 1996 Value	1.62×10^{-4} 33% $17 33%	2.64×10^{-4} 34% $46 34%	3.65×10^{-4} 33% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	2,538.69 $38,080.40	5,569.89 $83,431.00	8,408.15 $126,122.00	5,666.36 $84,995.40
ARS 92.4% of pop x365	CRFs 1996 Value	1.25×10^{-4} 25% $7 33%	2.79×10^{-4} 50% $15 34%	4.14×10^{-4} 25% $22 33%	
Restricted Activity Day	# of Cases $ Benefit	2,056.7400 $145,228.00	4,027.1300 $294,201.00	6,201.6200 $452,718.00	3,925.0800 $286,531.00
RAD 92.4% of pop ≥ 20 x365	CRFs 1996 Value	1.31×10^{-4} 25% $37 33%	2.50×10^{-4} 50% $73 34%	3.95×10^{-4} 25% $110 33%	
HH Materials Soiling	# of Cases $ Benefit	0.0000 $44,864.00	25,636.50 $120,334.00	0.0000 $224,320.00	25,636.50 $89,727.90
HHMS x1	CRFs 1996 Value	$1.75 33%	1 100% $3.50 34%	$8.75 33%	
TOTAL BENEFIT		$4,754,120	$8,690,740	$14,960,400	$8,232,390

Note: some totals do not add due to rounding and monte carlo simulation effects.

North Okanagan Regional District		Ozone	Benefits 10% Chg in Ozone Baseline Yr 2004 = 34.03 ppb Simulation Yr 2005 = 30.63 ppb		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.0519 $212,633	.1437 $607,300	.2354 $1,179,450	.1438 $589,723
MORT x153	CRFs 1996 Value	1.28×10^{-9} 25% $2.40 Mill 33%	3.55×10^{-9} 50% $4.10 Mill 50%	5.81×10^{-9} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.2431 $1,470.76	.4457 $2,948.62	.6483 $4,367.72	.4457 $2,941.53
Admiss RHA x153	CRFs 1996 Value	$.6 \times 10^{-8}$ 25% $3,300 33%	1.1×10^{-8} 50% $6,600 34%	1.6×10^{-8} 25% $9,800 33%	
Emerg Room	# of Cases $ Benefit	.9846 $524.05	1.8060 $1,036.42	2.6255 $1,554.07	1.8071 $1,030.02
Visits ERV x153	CRFs 1996 Value	2.43×10^{-8} 25% $290 33%	4.46×10^{-8} 50% $570 34%	6.48×10^{-8} 25% $860 33%	
Asthma Sympt Day	# of Cases $ Benefit	257.6870 $4,380.69	528.4540 $24,685.60	1,264.1300 $58,149.90	457.0310 $21,023.40
ASD 7.6% of pop x153	CRFs 1996 Value	1.06×10^{-4} 33% $17 33%	1.88×10^{-4} 50% $46 34%	5.20×10^{-4} 17% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	1,930.95 $24,074.10	3,440.11 $50,049.30	4,951.17 $75,661.40	3,439.16 $51,587.30
ARS 92.4% of pop x153	CRFs 1996 Value	5.07×10^{-5} 25% $7 33%	9.03×10^{-5} 50% $15 34%	13.0×10^{-5} 25% $22 33%	
Minor Restr Activity Day	# of Cases $ Benefit	735.0580 $24,256.90	1,777.6600 $64,010.80	2,818.3600 $101,381.00	1,778.6100 $58,694.20
MRAD 92.4% of pop x153	CRFs 1996 Value	1.93×10^{-5} 25% $20 33%	4.67×10^{-5} 50% $33 34%	7.40×10^{-5} 25% $57 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0.0000 $0.00	244.0380 $6,815.49	417.1580 $11,613.70	312.8690 $8,710.26
(Corn) x1	CRFs 1996 Value	0 33%	1.5×10^{-3} 34% $27.84 100%	2.00×10^{-3} 33%	
TOTAL BENEFIT		$318,078	$756,846	$1,304,350	$733,710

Grand Total (PM2.5 & Ozone)

10% Low:	$5,381,750
Mean:	$9,447,590
90% High:	$15,713,900
Central Est:	$8,966,110

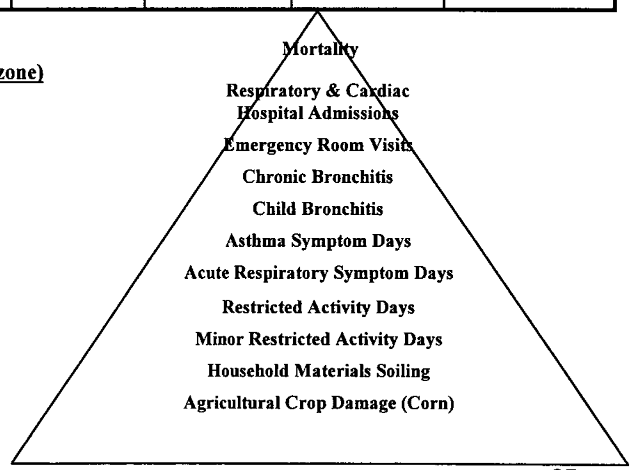

TABLE #A-12 Central Okanagan Regional District - Scenario #2 - Benefits Estimates - PM2.5 & Ozone

Default AQVM Database (Version 3.0) CRF's and Dollar Value of Health Outcomes (1996 $s Cdn), except that Ozone & PM2.5 Mort CRFs & ERV CRFs as per Hlth Cda. (Persons with Asthma Assumed = 6%)

Central Okanagan Regional District		PM 2.5	Benefits 10% Chg in PM 2.5 Baseline Yr 2004 = 6.78 ug/m^3 Simulation Yr 2005 = 6.10 ug/m^3		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	1.7547 $7,194,260	3.1346 $13,415,900	4.5200 $25,680,800	3.1318 $12,840,400
MORT x1	CRFs 1996 Value	1.58×10^{-5} 25% $2.40 Mill 33%	2.82×10^{-5} 50% $4.10 Mill 50%	4.07×10^{-5} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.4054 $1,618.59	.4905 $3,206.46	.5756 $4,806.73	.4905 $3,237.18
Admiss RHA x365	CRFs 1996 Value	1.00×10^{-8} 25% $3,300 33%	1.21×10^{-8} 50% $6,600 34%	1.42×10^{-8} 25% $9,800 33%	
Cardiac Hosp	# of Cases $ Benefit	.3202 $1,736.55	.4145 $3,508.54	.5108 $5,209.65	.4135 $3,473.10
Admiss CHA x365	CRFs 1996 Value	$.79 \times 10^{-8}$ 25% $4,200 33%	1.02×10^{-8} 50% $8,400 34%	1.26×10^{-8} 25% $12,600 33%	
Emerg Room	# of Cases $ Benefit	1.7430 $613.63	2.1170 $1,214.35	2.4930 $1,819.73	2.1160 $1,206.10
Visits ERV x 365	CRFs 1996 Value	4.30×10^{-8} 25% $290 33%	5.22×10^{-8} 50% $570 34%	6.15×10^{-8} 25% $860 33%	
Adult Chronic	# of Cases $ Benefit	3.2485 $864,109	6.5030 $1,950,780	9.7535 $3,024,790	6.5049 $1,730,310
Bronch CB pop ≥25 x1	CRFs 1996 Value	4.13×10^{-5} 25% $175,000 33%	8.27×10^{-5} 50% $266,000 34%	12.4×10^{-5} 25% $465,000 33%	
Child	# of Cases $ Benefit	15.4474 $4,788.69	41.1723 $12,754.90	67.0217 $20,776.70	41.1100 $12,744.10
Bronchitis B pop < 20 x1	CRFs 1996 Value	$.62 \times 10^{-3}$ 25% $150 33%	1.65×10^{-3} 50% $310 34%	2.69×10^{-3} 25% $460 33%	
Asthma Sympt Days	# of Cases $ Benefit	394.0070 $6,698.13	641.2840 $29,865.10	887.7330 $66,580.00	642.0860 $29,536.00
ASD 7.6% of pop x365	CRFs 1996 Value	1.62×10^{-4} 33% $17 33%	2.64×10^{-4} 34% $46 34%	3.65×10^{-4} 33% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	4,762.95 $71,444.20	10,449.90 $156,528.00	15,774.90 $236,623.00	10,630.90 $159,464.00
ARS 92.4% of pop x365	CRFs 1996 Value	1.25×10^{-4} 25% $7 33%	2.79×10^{-4} 50% $15 34%	4.14×10^{-4} 25% $22 33%	
Restricted Activity Day	# of Cases $ Benefit	3,900.79 $275,437.00	7,637.80 $557,978.00	11,761.90 $858,620.00	7,444.25 $543,430.00
RAD 92.4% of pop ≥ 20 x365	CRFs 1996 Value	1.31×10^{-4} 25% $37 33%	2.50×10^{-4} 50% $73 34%	3.95×10^{-4} 25% $110 33%	
HH Materials Soiling	# of Cases $ Benefit	0.00 $82,952.90	47,410.70 $222,496.00	0.00 $414,765.00	47,401.70 $165,906.00
HHMS x1	CRFs 1996 Value	$1.75 33%	1 100% $3.50 34%	$8.75 33%	
TOTAL BENEFIT		$8,938,190	$16,354,200	$28,101,600	$15,489,700

Note: some totals do not add due to rounding and monte carlo simulation effects.

Central Okanagan Regional District		Ozone	Benefits 10% Chg in Ozone Baseline Yr 2004 = 44.57 ppb Simulation Yr 2005 = 40.11 ppb		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.1427 $584,866	.3954 $1,670,430	.6475 $3,244,180	.3956 $1,622,090
MORT x153	CRFs 1996 Value	1.28×10^{-9} 25% $2.40 Mill 33%	3.55×10^{-9} 50% $4.10 Mill 50%	5.81×10^{-9} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.6687 $4,045.47	1.2259 $8,110.45	1.7831 $12,013.80	1.2259 $8,090.95
Admiss RHA x153	CRFs 1996 Value	$.6 \times 10^{-8}$ 25% $3,300 33%	1.1×10^{-8} 50% $6,600 34%	1.6×10^{-8} 25% $9,800 33%	
Emerg Room	# of Cases $ Benefit	2.7081 $1,441.44	4.9677 $2,850.78	7.2217 $4,274.60	4.9705 $2,833.17
Visits ERV x153	CRFs 1996 Value	2.43×10^{-8} 25% $290 33%	4.46×10^{-8} 50% $570 34%	6.48×10^{-8} 25% $860 33%	
Asthma Sympt Day	# of Cases $ Benefit	708.7940 $12,049.50	1,453.5600 $67,900.20	3,477.1000 $159,947.00	1,257.1100 $57,826.90
ASD 7.6% of pop x153	CRFs 1996 Value	1.06×10^{-4} 33% $17 33%	1.88×10^{-4} 50% $46 34%	5.20×10^{-4} 17% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	5,311.27 $66,218	9,462.34 $137,665	13,618.60 $208,114	9,459.72 $141,896
ARS 92.4% of pop x153	CRFs 1996 Value	5.07×10^{-5} 25% $7 33%	9.03×10^{-5} 50% $15 34%	13.0×10^{-5} 25% $22 33%	
Minor Restr Activity Day	# of Cases $ Benefit	2,021.84 $66,720.90	4,889.62 $176,068.00	7,752.15 $278,857.00	4,892.24 $161,444.00
MRAD 92.4% of pop x153	CRFs 1996bValue	1.93×10^{-5} 25% $20 33%	4.67×10^{-5} 50% $33 34%	7.40×10^{-5} 25% $57 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0 $0.00	0 $0.00	0 $0.00	0 $0.00
(Corn) x1	CRFs 1996 Value	0 33%	1.5×10^{-3} 34% $27.84 100%	2.00×10^{-3} 33%	
TOTAL BENEFIT		$854,873	$2,063,030	$3,566,240	$1,994,180

Grand Total (PM2.5 & Ozone)

10% Low: $10,591,300

Mean: $18,417,300

90% High: $30,083,500

Central Est: $17,483,900

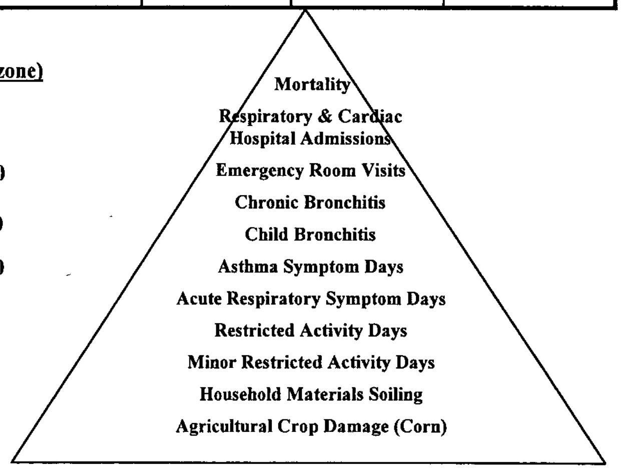

TABLE #A-13 North & Central Okanagan Regional District - Scenario #2 - Benefits Estimates - PM2.5 & Ozone
Default AQVM Database (Version 3.0) CRF's and Dollar Value of Health Outcomes (1996 $s Cdn), except that Ozone & PM2.5 Mort CRFs & ERV CRFs as per Hlth Cda. (Persons with Asthma Assumed = 6%)

Nrth & Ctrl Okanagan Regional Districts		PM 2.5	Benefits 10% Chg in PM 2.5		
Effect		10% Low	Mean	90% High	Central Est
Chronic Mortality	# of Cases $ Benefit	2.6900 $11,028,860	4.8053 $20,566,680	6.9292 $39,368,900	4.8011 $19,684,440
MORT x1	CRFs 1996 Value	1.58×10^{-5} 25% $2.40 Mill 33%	2.82×10^{-5} 50% $4.10 Mill 50%	4.07×10^{-5} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.6214 $2,481.31	.7519 $4,915.53	.8824 $7,368.76	.7519 $4,962.63
Admiss RHA x365	CRFs 1996 Value	1.00×10^{-8} 25% $3,300 33%	1.21×10^{-8} 50% $6,600 34%	1.42×10^{-8} 25% $9,800 33%	
Cardiac Hosp	# of Cases $ Benefit	.4909 $2,662.15	.6354 $5,378.62	.7830 $7,986.44	.6338 $5,324.29
Admiss CHA x365	CRFs 1996 Value	$.79 \times 10^{-8}$ 25% $4,200 33%	1.02×10^{-8} 50% $8,400 34%	1.26×10^{-8} 25% $12,600 33%	
Emerg Room	# of Cases $ Benefit	2.6721 $940.70	3.2454 $1,861.61	3.8217 $2,789.66	3.2438 $1,848.96
Visits ERV x365	CRFs 1996 Value	4.30×10^{-8} 25% $290 33%	5.22×10^{-8} 50% $570 34%	6.15×10^{-8} 25% $860 33%	
Adult Chronic	# of Cases $ Benefit	4.9386 $1,313,653	9.8861 $2,965,660	14.8276 $4,598,410	9.8891 $2,630,487
Bronch CB pop ≥25 x1	CRFs 1996 Value	4.13×10^{-5} 25% $175,000 33%	8.27×10^{-5} 50% $266,000 34%	12.4×10^{-5} 25% $465,000 33%	
Child	# of Cases $ Benefit	23.8878 $7,405.23	63.6688 $19,724.16	103.6423 $32,129.10	63.5725 $19,707.46
Bronchitis B pop < 20 x1	CRFs 1996 Value	$.62 \times 10^{-3}$ 25% $150 33%	1.65×10^{-3} 50% $310 34%	2.69×10^{-3} 25% $460 33%	
Asthma Sympt Days	# of Cases $ Benefit	604.0160 $10,268.29	983.0940 $45,783.50	1,360.9020 $102,067.70	984.3230 $45,278.90
ASD 7.6% of pop x365	CRFs 1996 Value	1.62×10^{-4} 33% $17 33%	2.64×10^{-4} 34% $46 34%	3.65×10^{-4} 33% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	7,301.64 $109,524.60	16,019.79 $239,959.00	24,183.05 $362,745.00	16,297.26 $244,459.40
ARS 92.4% of pop x365	CRFs 1996 Value	1.25×10^{-4} 25% $7 33%	2.79×10^{-4} 50% $15 34%	4.14×10^{-4} 25% $22 33%	
Restricted Activity Day	# of Cases $ Benefit	5,957.53 $420,665.00	11,664.93 $852,179.00	17,963.52 $1,311,338.00	11,369.33 $829,961.00
RAD 92.4% of pop ≥ 20 x365	CRFs 1996 Value	1.31×10^{-4} 25% $37 33%	2.50×10^{-4} 50% $73 34%	3.95×10^{-4} 25% $110 33%	
HH Materials Soiling	# of Cases $ Benefit	0.0000 $127,816.90	73,038.20 $342,830.00	0.0000 $639,085.00	73,038.20 $255,633.90
HHMS x1	CRFs 1996 Value	$1.75 33%	1 100% $3.50 34%	$8.75 33%	
TOTAL BENEFIT		$13,692,310	$25,044,940	$43,062,000	$23,722,090

Note: some totals do not add due to rounding and monte carlo simulation effects

Nrth & Ctrl Okanagan Regional Districts		Ozone	Benefits 10% Chg in Ozone		
Effect		10% Low	Mean	90% High	Central Est
Mortality	# of Cases $ Benefit	.1945 $797,499	.5391 $2,277,730	.8829 $4,423,630	.5395 $2,211,813
MORT x153	CRFs 1996 Value	1.28×10^{-9} 25% $2.40 Mill 33%	3.55×10^{-9} 50% $4.10 Mill 50%	5.81×10^{-9} 25% $8.20 Mill 17%	
Resp Hospital	# of Cases $ Benefit	.9118 $5,516.23	1.6716 $11,059.07	2.4314 $16,381.52	1.6716 $11,032.48
Admiss RHA x153	CRFs 1996 Value	$.6 \times 10^{-8}$ 25% $3,300 33%	1.1×10^{-8} 50% $6,600 34%	1.6×10^{-8} 25% $9,800 33%	
Emerg Room	# of Cases $ Benefit	3.6927 $1,965.49	6.7737 $3,887.20	9.8472 $5,828.67	6.7775 $3,863.19
Visits ERV x153	CRFs 1996 Value	2.43×10^{-8} 25% $290 33%	4.46×10^{-8} 50% $570 34%	6.48×10^{-8} 25% $860 33%	
Asthma Sympt Day	# of Cases $ Benefit	966.4810 $16,430.19	1,982.0140 $92,585.80	4,741.2300 $218,096.90	1,714.1410 $78,850.30
ASD 7.6% of pop x153	CRFs 1996 Value	1.06×10^{-4} 33% $17 33%	1.88×10^{-4} 50% $46 34%	5.20×10^{-4} 17% $75 33%	
Acute Resp Symp Days	# of Cases $ Benefit	7,242.2200 $90,292.10	12,902.4500 $187,714.30	18,569.7700 $283,775.40	12,898.8800 $193,483.30
ARS 92.4% of pop x153	CRFs 1996 Value	5.07×10^{-5} 25% $7 33%	9.03×10^{-5} 50% $15 34%	13.0×10^{-5} 25% $22 33%	
Minor Restr Activity Day	# of Cases $ Benefit	2,756.8980 $90,977.80	6,667.2800 $240,078.80	10,570.5100 $380,238.00	6,670.8500 $220,138.20
MRAD 92.4% of pop x153	CRFs 1996 Value	1.93×10^{-5} 25% $20 33%	4.67×10^{-5} 50% $33 34%	7.40×10^{-5} 25% $57 33%	
Agricultural Crop Damage	# of Cases $ Benefit	0.0000 $0.00	244.0380 $6,815.49	417.1580 $11,613.70	312.8690 $8,710.26
(Corn) x1	CRFs 1996 Value	0 33%	1.5×10^{-3} 34% $27.84 100%	2.00×10^{-3} 33%	
TOTAL BENEFIT		$1,172,951	$2,819,876	$4,870,590	$2,727,890

Grand Total (PM2.5 & Ozone)

10% Low: $15,973,050

Mean: $27,864,890

90% High: $45,797,400

Central Est: $26,450,010

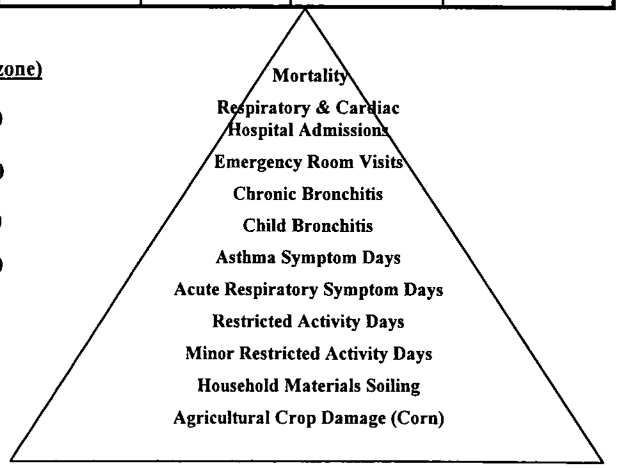

Table #A-14
Review of Table Addition Discrepancies - Scenario #2

North Okanagan	PM2.5				Ozone				Total PM2.5 & Ozone			
Regional District	10% Low	Mean	90% High	Ctrl Est	10% Low	Mean	90% High	Ctrl Est	10% Low	Mean	90% High	Ctrl Est
Values Generated by AQVM Output	$4,754,120.00	$8,690,740.00	$14,960,400.00	$8,232,390.00	$318,078.00	$756,846.00	$1,304,350.00	$733,710.00	$5,381,750.00	$9,447,590.00	$15,713,900.00	$8,966,110.00
Values derived by Adding Totals	$4,520,618.49	$8,690,740.07	$16,118,028.85	$8,232,397.06	$267,339.50	$756,846.23	$1,432,177.79	$733,709.71	$4,787,957.99	$9,447,586.30	$17,550,206.64	$8,966,106.77
Central Okanagan	**PM2.5**				**Ozone**				**Total PM2.5 & Ozone**			
Regional District	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**
Values Generated by AQVM Output	$8,938,190.00	$16,354,200.00	$28,101,600.00	$15,489,700.00	$854,873.00	$2,063,030.00	$3,566,240.00	$1,994,180.00	$10,591,300.00	$18,417,300.00	$30,083,500.00	$17,483,900.00
Values derived by Adding Totals	$8,503,658.69	$16,354,231.35	$30,314,790.81	$15,489,706.48	$735,341.31	$2,063,024.43	$3,907,386.40	$1,994,181.02	$9,239,000.00	$18,417,255.78	$34,222,177.21	$17,483,887.50
North & Ctrl Okan	**PM2.5**				**Scenario #2 – Ozone**				**Total PM2.5 & Ozone**			
Reg District	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**	**10% Low**	**Mean**	**90% High**	**Ctrl Est**
Values Generated by AQVM Output	$13,692,310.00	$25,044,940.00	$43,062,000.00	$23,722,090.00	$1,172,951.00	$2,819,876.00	$4,870,590.00	$2,727,890.00	$15,973,050.00	$27,864,890.00	$45,797,400.00	$26,450,010.00
Values derived by Adding Totals	$13,024,277.18	$25,044,971.42	$46,432,819.66	$23,722,103.54	$1,002,680.81	$2,819,870.66	$5,339,564.10	$2,727,890.73	$14,026,957.99	$27,864,842.0	$51,772,363.85	$26,449,994.27

Endpoint	Table #A-15 (Developed From AQVM – Version 3.0) (Chapter #4) Definitions and Primary Source References			CRFs and Dollar Values of Health Outcomes (2003 $'s Cdn) Applied in Benefits Analysis	PM2.5 (AQVM p. D-1) & BCLA Phase 1 Hlth Study (p. 51 & 113)		Ozone (AQVM p. 3-44, 4-11, 5-59) & BCLA Phase 1 Health Study (p. 114)		Estimated Value 2003 $'s Cdn (See AQVM –Version 3.0 - Chapter #5)	
					Primary Source	CRF	Study	CRF	Primary Source	Value
Acute Mortality (Mort) *(WTP) (Total Pop)*	-incidence of mortality	-annual risk factor given a: 1 ug/m^3 change in yrly avg PM2.5 conc *(calendar yr)*	*x1*	 Low Ctrl High	NMMAPS (Corrected) Dominici et al 2003 Stieb et al 2002b, 2003 Six-Cities (Updated)	 1.71 x 10-6 5.12 x 10-6 6.66 x 10-6	- - -	- - -	Age Weighted VSL – *assumes 85% of mortality occurs to persons ≥ 65* Rowe et al 1995 & Jones Lee et al 1985	 $2.77 Mill $4.73 Mill $9.47 Mill
Chronic Mortality (Mort) *(WTP) (Total Pop)*		-daily risk factor given a: 1 ppb change in daily high hr ozone conc *(May-Sept ozone season)*	*x153*	Low Ctrl High	Stieb et al 2002b, 2003 Pope et al 1995 & 2002 Six-Cities (Re-Analysis)	5.12 x 10-6 20.48 x 10-6 56.32 x 10-6	Stieb et al 2002 Health Canada Revised	.97 x 10-9 2.68 x 10-9 4.39 x 10-9	*same as above*	*same as above*
Adult Chronic Bronchitis (CB) *(WTP) (Pop ≥ 25)*	-incidence of developing new case of chronic bronchitis *(chronic inflammation of bronchial tube)*	-annual risk factor given a: 1 ug/m^3 change in yrly avg PM2.5 conc *(calendar yr)*	*x1*	Low Ctrl High	Abbey et al 1995b	4.13 x 10-5 8.27 x 10-5 12.4 x 10-5	- - -	- - -	Viscusi et al 1991 & Krupnick & Cropper 1992 *(full welfare effect asst'd with CB)*	$206,455 $326,887 $550,548
Respiratory Hospital Admissions (RHA) *(Adj COI) (Total Pop)*	-incidence of hospital admissions associated with the respiratory system *(breathing airways & lungs)*	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc 1 ppb change in daily high hr ozone conc	*x365* *x153*	Low Ctrl High	Burnett et al 1995	1.00 x 10-8 1.21 x 10-8 1.42 x 10-8	Burnett et al 1997	6.00 x 10-9 11.0 x 10-9 16.0 x 10-9	CIHI 1994 *(lost wages, cost of hosp stay index to A/C for pain, suffering & activity loss)*	$3,893 $7,786 $11,679
Cardiac Hospital Admissions (CHA) *(Adj COI) (Total Pop)*	-incidence of hospital admissions associated with the heart and the cardiovascular system	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc	*x365*	Low Ctrl High	Burnett et al 1995	.79 x 10-8 1.02 x 10-8 1.26 x 10-8	- - -	- - -	CIHI 1994 *(lost wages, cost of hosp stay, index to A/C for pain, suffering & activity loss)*	$4,965 $9,929 $14,894
Net Emergency Room Visits (ERV) *(Adj COI) (Total Pop)*	-incidence of visits to a hospital emergency room *(department)*	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc 1 ppb change in daily high hr oz conc	*x365* *x153*	Low Ctrl High	Stieb et al 1995 Revised *(Health Canada)*	4.30 x 10-8 5.22 x 10-8 6.15 x 10-8	Stieb et al 1995 Revised *(Health Canada)*	2.43 x 10-8 4.46 x 10-8 6.48 x 10-8	*(lost wages, est cost of ERV, index to A/C for pain, suffering & activity loss)*	$337 $674 $1,011
Child Acute Bronchitis (CB) *(Adj COI) (Pop < 20)*	-incidence of acute bronchitis *(acute inflammation of bronchial tube)* in children	-annual risk factor given a: 1 ug/m^3 change in yrly avg PM2.5 conc	*x1*	Low Ctrl High	Dockery et al 1996	.62 x 10-3 1.65 x 10-3 2.69 x 10-3	- - -	- - -	Krupnick & Cropper 1989 *(est avg med treatment cost, index to A/C for pain, suffering & activity loss)*	$176 $351 $527
Asthma Symptom Days (ASD) *(WTP) (Asthmatic Pop)*	-incidence of days when a asthma symptoms are exacerbated *(applies to individuals with asthma)*	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc 1 ppb change in daily high hr oz conc	*x365* *x153*	Low Ctrl High	Whittemore & Korn 1980 Ostro et al 1991	1.62 x 10-4 2.64 x 10-4 3.65 x 10-4	Whittemore & Korn 1980 Stock et al 1988	1.06 x 10-4 1.88 x 10-4 5.20 x 10-4	Rowe & Chestnut 1986	$18 $51 $84
Net Acute Respiratory Symptom Days (ARSD) *(WTP) (Non-asthmatic pop)*	-incidence of days with respiratory symptoms *(chest discomfort, coughing, wheezing, sore throat, head cold, chest cold, sinus trouble, hay fever, headache, & doctor diagnosed flu)*.	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc 1 ppb change in daily high hr ozone conc	*x365* *x153*	Low Ctrl High	Krupnick et al 1990	1.25 x 10-4 2.79 x 10-4 4.14 x 10-4	Krupnick et al 1990	5.07 x 10-5 9.03 x 10-5 13.0 x 10-5	Loehman et al 1979 Tolley et al 1986a	$8 $16 $25
Minor Restricted Activity Days (MRAD) *(WTP) (Non-asthmatic pop ≥ 20)*	-incidence of days when some activities are reduced *(ie. less stringent activities or rest are undertaken)* no work absences	-daily risk factor given a: 1 ppb change in daily high hr ozone conc	*x153*	Low Ctrl High	- - -	- - -	Ostro & Rothschild 1989	1.93 x 10-5 4.67 x 10-5 7.40 x 10-5	Krupnick & Kopp 1988	$23 $37 $64
Restricted Activity Days (RAD) *(WTP & Adj COI) (Non-asthmatic pop ≥ 20)*	-incidence of days spent in bed, days absent from work, and days when activities are partially reduced	-daily risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc	*x365*	Low Ctrl High	Ostro 1987 Ostro & Rothschild 1989	1.31 x 10-4 2.50 x 10-4 3.95 x 10-4	- - -	- - -	Krupnick & Kopp 1988, *lost wages index to A/C for pain, suffering & activity loss, estimate of MRAD*	$44 $88 $132
Agricultural Crop Damage *(Corn) (tonnes)*	-incidence of crop damages *(reduction in annual corn crop yield) (tonnes)*	-annual risk factor *(percentage reduction in crop yield)* for a 1 ppb change in daily high hour ozone conc	*x1*	Low Ctrl High	- - -	- - -	Heagle et al 1988	0.00 x 10-3 1.50 x 10-3 2.00 x 10-3	*(Parker) (locally estimated weighted avg price of corn crop) (sweet corn & sileage)*	$27.84
Household Materials Soiling (HHMS) *(WTP) (All Households)*	-incidence *(annual household material soiling) (damage) (number of households)*	-annual risk factor given a: 1 ug/m^3 change in daily avg PM2.5 conc	*x1*	Low Ctrl High		- 1.0 -	- - -	- - -	Manual et al 1982 McClelland et al 1991 Watson & Jaksch 1982	$2.07 $4.14 $10.35

All methodologies/definitions/sources (etc) reflected in this table from: Chestnut, Lauraine G., David Mills, Robert D. Rowe, Stratus Consulting Inc., Scientific Authorities: Paul De Civita-Environment Canada, David Stieb-Health Canada, Air Quality Valuation Model Version 3.0 (AQVM 3.0) Report 2: Methodology, Final Report, (September 3, 1999). (Values p. 5-20, 5-31) (Chapter #5 - Economic Valuation p. 5-1 through 5-71), (CRFs Chapter #4, p. 4-11, 5-59, 5-53 & D-2).
For acute and chronic PM related mortality CRFs see: Bates, Dr. David V. – UBC (Emeritus), Dr. Jane Koenig – University of Washington, Dr. Michael Brauer – UBC, Dr. Robert Caton – RWDI West Inc, Damian Crawley M.Sc – RWDI West Inc, Health and Air Quality 2002 – Phase I – Methods for Estimating and Applying Relationships Between Air Pollution and Health Effects – Final Report, BCLA, (May/2003), (p. 51, 113 & 114). For ozone mortality related CRFs and ERV CRFs see: Jessiman, Barry (Health Canada) Personal (e-mail) communication 21/July/2003.
Note: acute and chronic mortality CRFs *(shown above)* assume estimated annual base mortality rate = **5.12 x 10-3**, and estimated daily base mortality rate = **1.40 x 10-5**. ***Note:** Net ERVs– subtracts RHAs. ****Note:** Net ARSDs subtracts MRADs.