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Alberta Sulphur Terminals Ltd.
Bruderheim Sulphur Forming and Shipping Facility

Volume IIA

1. Introduction

Project Number 62720000
June 2007

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Executive Summary

The proponent, Alberta Sulphur Terminals Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), is applying to Alberta Environment (AENV) and the Natural Resources Conservation Board (NRCB) for approval to construct and operate a sulphur forming and shipping facility (the Project). The Project will be developed on a portion of Section 35, Township 55, Range 20, West of the 4th Meridian (35-55-20 W4M – the Site), approximately 2.2 km east of Bruderheim, Alberta, in the Industrial Heartland area of Lamont County.

The Environmental Impact Assessment (EIA) study area comprises the Principal Development Area (PDA), Local Study Area (LSA) and Regional Study Area (RSA). The PDA was defined as the area within the Site that will contain the Project including rail and road access for receiving and shipping molten sulphur, molten sulphur unloading and transfer facilities, sulphur forming facilities to produce sulphur pastilles, loading and shipping facilities for formed sulphur and sulphur pastilles temporary storage area. The LSA for the majority of disciplines assessed in the EIA is the Site (Groundwater, Historical Resources, Surface Water Quantity and Surface Water Quality) or the Site plus a 200 m buffer zone (Aquatics, Biodiversity and Fragmentation, Land Use and Reclamation, Soil, Vegetation and Wildlife). The RSA for the majority of disciplines is the Site plus a 500 m buffer zone (Surface Water Quantity and Surface Water Quality) or the Site plus a 1,000 m buffer zone (Aquatics, Biodiversity and Fragmentation, Soil, Vegetation and Wildlife).

The EIA will assist regulators and the public in understanding and evaluating the potential effects and benefits of the Project during construction, operation and reclamation. The EIA identifies and assesses peak disturbance, residual impacts and cumulative effects associated with the Project. The EIA evaluates potential impacts to physical, biophysical and historical resources, in addition to potential socio-economic impacts. It also identifies mitigative measures and adaptive management plans to reduce or eliminate potential adverse effects.

For each individual impact assessment, a qualitative, final evaluation rating was used where specific guidelines did not exist. This rating was a combination of quantitative analysis and professional judgment that takes into account the various descriptors for each attribute (direction, magnitude, geographic extent, duration, confidence and reversibility) and the potential effects of the specific impact. This rating was applied to residual impacts and cumulative effects. The following table lists the ratings applied and the level of action required for each.

Table ES-1: Final Impact Ratings

Rating	Level of Action
Class 1	The predicted trend in an indicator under projected land use development could threaten the long-term sustainability of the quantity or quality of the indicator in the LSA and RSA. An action plan, developed jointly by regional stakeholders, could be developed to monitor the affected indicator, identify and implement further mitigation measures to reduce any impact and promote recovery of the indicator, where appropriate. This class of impact might also be applicable to an exceedance of a regulatory guideline or where the impact is expected to have long-term effects.
Class 2	The predicted trend in an indicator under projected land use development will likely result in a decline in the quantity or quality of the indicator. The decline could be to lower-than-baseline but stable levels in the LSA and RSA after closure and into the foreseeable future. In addition to responsible industrial operational practices, monitoring and recovery initiatives could be required if additional land use activities occur in the study area before closure of the projected land use development. This class of impact might also be applicable to an exceedance of a regulatory guideline or where the impact is expected to have mid-term effects, but where recovery will take place shortly after closure of the projected land use development.

Table ES-1: Final Impact Ratings (Cont'd)

Rating	Level of Action
Class 3	The predicted trend in an indicator under projected land use development could result in a slight decline in the quantity or quality of the indicator in the LSA and RSA during the life of the projected land use development, but resource levels should recover to baseline after closure. In some cases, a short-term, low to moderate magnitude impact could occur, but recovery will take place within five years. No new resource management initiatives are necessary. Responsible industrial operational practices should continue. This class of impact could also be applicable where regulatory guidelines are not exceeded, but where a relative change in magnitude of an indicator occurs.
Class 4	The projected land use development results in no change and no contribution toward affecting the quantity or quality of the indicator in the LSA and RSA during the life of the projected land use development. Responsible industrial operational practices should continue. Therefore, no cumulative effects result from the Project.

Volume IIA – Air, Noise and Human Health

Section 2: Climate and Air Quality

The climate and meteorological analyses included the following parameters:

- ambient temperature
- precipitation
- wind
- relative humidity
- visibility
- severe weather

The Project will be the source of criteria air contaminants (i.e., carbon dioxide (CO), hydrogen sulphide (H_2S), nitrogen oxides (NO_x), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2)).There will be no significant sources of volatile organic compounds (VOC) or polycyclic aromatic hydrocarbons (PAH). Four air quality issues addressed in the assessment, in conformance with the Terms of Reference (TOR) of the EIA, included:

- air emissions of criteria air contaminants – industrial emissions of criteria air contaminants associated with Project operations and from operations at surrounding industries
- acid deposition – emissions of potential acid forming substances such as SO_2 and NO_x
- particulate deposition – emissions of sulphur particles and subsequent deposition
- ozone formation – the potential for ozone (O_3) creation as a result of photochemical reactions with NO_x and VOC

The assessment demonstrated that emissions associated with the Project would result in ground-level concentrations of air contaminants less than maximum values stipulated in Alberta's Ambient Air Quality Objectives (AAAQO).They should therefore, not have any adverse effects on the environment.

Air quality assessments were made for a time frame that included the present and extended over the projected life of the Project, which is expected to be about 25 years. Three cases were selected for detailed assessment: baseline, application and cumulative. The baseline case considers impacts of current and approved air quality regimes in the study area. The application case addresses the air quality occurring immediately after completion of the Project while the cumulative effects case assesses the effects of announced future development following Project completion.

Conclusions of the air quality assessments considered results of existing ambient air quality monitoring as well as results based upon plume dispersion modelling. This modelling was relied upon for predictions of air quality implications of point, fugitive and mobile emission sources associated with the Project and neighbouring industries.

Air quality monitoring data relating to CO, H_2S, NO_x, $PM_{2.5}$ and SO_2 are available from regional observational sites maintained by the Fort Air Partnership (FAP). AST is a member of the Fort Air Partnership (FAP) which was established to run an air monitoring system in the Fort Saskatchewan area. The FAP exists to develop relevant credible information that can be used to manage air quality, protect environmental health and influence policy.

The plume dispersion modelling relied upon the CALPUFF model. This model is a multi-layer, non-steady-state dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and deposition. The plume dispersion model sequentially calculates hourly pollutant concentrations resulting from multiple sources and incorporates near-source effects, such as building downwash, chimney downdraft influences and partial plume penetrations into elevated stable atmospheric layers. It also allows for long-range effects such as pollutant removal (wet scavenging and dry deposition), chemical transformations and vertical wind shear. The model is well known within the air quality modelling discipline, widely accepted, well documented and is regularly updated as new data and correlations are obtained. Studies have shown that air concentrations resulting from generating station emissions predicted using CALPUFF, compare favourably with observed values.

AST will mitigate its emissions through the installation of low NO_x boilers. Exhausts from the liquid sulphur storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed one ppm by volume. Dust suppression in the rail-out area will be achieved with the use of a proprietary dust suppression agent and release aid as well as water. Dust suppression agents will be applied to all transfer points as behind the hopper and at the rail-out. The asphalt pad transversed by the front end loader will be swept and washed on a daily basis.

Plume dispersion calculations were performed for a wide range of emission sources in a manner consistent with AENV's Air Quality Model Guideline (model input files are included as part of this EIA). Results of the calculations show that maximum ground-level concentrations of air emissions attributable to the Project and other local and regional sources should remain below existing AAAQO. There should, be no noticeable changes in air quality with respect to adverse effects on the environment (including odors and visibility) and no adverse effects on the environment with respect to harmful ground-level pollutant concentrations, soil and water acidification or O_3 creation (all ranked as Class 4). An interactive effect that may occur as a result of co-exposure of a receptor to all emissions has been discussed in Volume IIA, Section 4: Public Health and Safety.

The above conclusions with respect to acceptability of Project emissions will be evaluated by AST through an air monitoring program at the boundary of the Project site. This will entail continuous measurements of wind, H_2S and $PM_{2.5}$.

Further analyses also demonstrated that there should be no adverse acidity effects within the region of the proposed Project and that Project emissions will not lead to ozone creation. Estimated depositions of sulphur particulates were localized with a maximum value at plant boundary of about 1.1 kg/ha/y.

Specific air quality and cumulative air quality effects are discussed in sections of the EIA related to wildlife, vegetation, water and soils.

Section 3: Noise and Light

A Noise Impact Assessment (NIA) for the proposed Project evaluated the expected noise impact of the Project on a study area that included residential locations in the vicinity of the proposed facility. The noise sources affecting existing sound levels in the area include Highway 15 and Highway 45 road traffic, the CN and CP rail lines, the Canexus Chemicals Canada plant in Section 34, local traffic, residential activities and natural sounds.

This NIA focused on determining the impact on selected residential locations in the immediate vicinity of the Project. The assessment evaluated the following:

- the current sound environment; including the contribution from the existing sound sources such as the nearby highways (Highway 15 and Highway 45) and the two rail lines
- the contribution of the Project, associated truck traffic and associated rail traffic alone
- the cumulative effect of the addition of the Project and associated truck and rail traffic to the existing sound levels

AENV has no specific noise regulations that are applicable to the Project. In the absence of specific AENV regulations, it is recommended that the Alberta Energy and Utilities Board (EUB) Noise Control Directive be used. The EUB regulation is applicable to energy industry facilities similar to the Project. The Directive specifies maximum allowable outdoor sound levels for noise from operation of energy industry facilities. Sound levels for noise from the Project were determined for identified residences in accordance with the Directive's requirements.

The evaluation of noise from the proposed facility noise sources and associated transportation noise sources was performed by computer modelling, in order to determine predicted sound level contributions at the various residential locations. The modelling assumed standard noise mitigation measures in the facility design and also included conservative assumptions which will make the predicted facility contributions conservative (i.e., high).

The following tables summarize the existing sound levels, predicted sound levels, the combined sound levels and the EUB Permissible Sound Level (PSL) for the daytime (Table ES-2) and the nighttime (Table ES-3).

Table ES-2: Predicted Daytime Sound Levels

Residence	Existing Daytime Sound Level	Predicted Daytime Sound Level Contribution (dBA L_{eq})		Combined Daytime Sound Levels (dBA L_{eq})		Daytime EUB PSL (dBA L_{eq})
		Facility Sources Only	Facility + Transportation Sources Together	Facility Sources Only	Facility + Transportation Sources Together	
Residence 1	53.0	39.0	44.6	53.2	53.6	55
Residence 2	48.1	32.3	37.0	48.2	48.4	55
Residence 3	44.6	34.4	38.9	45.0	45.6	55
Residence 4	48.7	31.4	38.2	48.8	49.1	50
Residence 5	48.7	31.8	39.6	48.8	49.2	55

Table ES-3: Predicted Nighttime Sound Levels

Residence	Existing Nighttime Sound Level	Predicted Nighttime Sound Level Contribution (dBA L_{eq})		Combined Nighttime Sound Levels (dBA L_{eq})		Nighttime EUB PSL (dBA L_{eq})
		Facility Sources Only	Facility + Transportation Sources Together	Facility Sources Only	Facility + Transportation Sources Together	
Residence 1	46.7	39.0	41.1	47.4	47.8	45
Residence 2	43.8	32.3	34.9	44.1	44.3	45
Residence 3	40.7	34.4	37.4	41.6	42.4	45
Residence 4	44.4	31.4	36.6	44.6	45.1	40
Residence 5	44.4	31.8	37.9	44.6	45.3	45

The predictions have been split out to present the Project sources alone and then the Project and transportation sources together. The Project sources alone represent the continuous sound level emanating from the facility and would be representative of the usual noise impact from the facility. The Project and transportation sources together include the additional sound energy from the associated truck and rail traffic and would be representative of the maximum noise impact from the facility. The measured baseline noise conditions are shown in column 2 of the two tables. The baseline noise conditions include contributions from Highway 15 and Highway 45 road traffic, CN and CP rail lines, Canexus Chemicals Canada plant in Section 34, local traffic, residential activities and natural sounds.

The predicted sound level contributions from the Project alone or the Project and associated transportation together are at least 3 dBA below the existing sound levels, resulting in incremental sound level increases of no more than 1.7 dB. The predicted sound level contributions from the Project and associated truck traffic together are at least 3 dBA below the EUB PSL.

While there are no applicable regulations or guidelines for noise emissions resulting from construction activities, the EUB Directive specifies that construction noise must be considered. Predictions of construction noise impact at the residential locations have been calculated and the excavation and steel erection phases are expected to be the noisiest construction phase. The predicted sound level contribution due to construction activity alone ranges from 47–55 dBA, depending upon the distance each residence is from the Project. AST has also indicated that most construction activities will be confined to daytime hours. Predicted noise levels are within acceptable levels cited in other provincial legislation.

The cumulative predicted sound level of the proposed Project and existing sound level are below the EUB nighttime requirements at two of the five residences. For two residences (Residence 1 and Residence 4), the current measured nighttime sound levels already exceed the EUB PSL. It is, therefore, impossible for the cumulative sound level to be below EUB requirements. In this case, it is more appropriate to determine the incremental impact. For Residence 1, the incremental impact is 1.1 dB and for Residence 4 the incremental impact is 0.7 dB, which can be considered an insignificant impact. For Residence 5, the cumulative predicted sound level is 0.3 dB above the nighttime PSL. The major contributor to the cumulative predicted sound level is the measured sound level, rather than the Project. HFP Acoustical Consultants therefore, believes it is more appropriate to determine the incremental impact. For Residence 5, the incremental impact is 0.9 dB. Again, this can be considered an insignificant impact.

It can be concluded that an acceptable minimum impact scenario (Class 3) will occur as a result of the proposed Project, as the predicted sound levels are all below the EUB PSL or have a minimal incremental impact. When combined with the existing sound levels, the PSLs will still be met at all but one residence where current sound levels are below the PSLs. The incremental impact is predicted to be no more than 1.7 dBA at all residences, which will not be a noticeable change in sound level.

Section 4: Public Health and Safety

The Human Health Risk Assessment (HHRA) examined short- and long-term effects associated with Project emissions in combination with existing or approved developments in the region, as well as proposed future developments. The chemicals of potential concern (COPC) identified in relation to the Project were CO, H_2S, nitrogen dioxide (NO_2), SO_2 and $PM_{2.5}$. Worst-case predicted concentrations were evaluated in addition to measured background concentrations for the baseline, application and cumulative effects analysis (CEA) assessment cases.

Exposure to air was determined to be the only relevant human exposure pathway. Due to controls associated with the Principal Development Area, Site characteristics and the physico-chemical properties of the COPC, other potential exposure pathways (surface water, groundwater and soil) were determined to be not relevant to this assessment. The potential for human exposure to the COPC via pathways other than air was determined to be negligible.

All COPC were evaluated independently for potential acute and chronic health risks. COPC with similar toxicological endpoints may produce an additive effect when combined and the potential for mixture effects were evaluated. The common endpoint identified within the group of COPC was respiratory irritation and as such, respiratory irritants were evaluated as a mixture.

In the acute health risk assessment, Project air emissions were evaluated by comparing maximum predicted short-term air concentrations (including background) with health based exposure limits that are protective of sensitive individuals. Slight exceedances were predicted for the respiratory irritant mixture. Due to the degree of conservatism incorporated into the risk assessment, health risks related to respiratory irritants are not anticipated. With respect to the chronic health risk assessment, the predicted long-term air concentrations met the health-based guidelines for all COPC, suggesting that chronic health risks were negligible in all cases. The final impact ratings are Class 3 for acute health risks and Class 4 for chronic health risks. Overall, the Project is not anticipated to have an adverse effect on human health.

Table ES-4: Volume IIA Final Impact Summary Table for the Application Case

Potential Impact	Geographic Extent	Magnitude	Direction	Duration	Reversibility	Confidence	Rating
Air Quality							
Criteria pollutants	Local	Negligible	Negative	Long term	Reversible	High	4
Non-criteria substances	Local	Negligible	Negative	Long term	Reversible	High	4
Ozone	Local	Negligible	Uncertain	Long term	Reversible	High	4
Acid deposition	Local	Negligible	Negative	Long term	Reversible	High	4
Noise							
Noise from normal operations	Local	Low to moderate	Negative	Mid-term	Reversible	High	3
Construction noise	Local	Low to moderate	Negative	Short-term	Reversible	High	3
Transportation noise	Local	Low to moderate	Negative	Mid-term	Reversible	High	3
Non-routine operations (e.g., steam blow-down, emergency power generators)	Local	Low to moderate	Negative	Short-term	Reversible	Moderate	3
Public Health and Safety							
Acute health risks	Local	Low	Negative	Short term	Reversible	High	3
Chronic health risks	Local	Negligible	Negative	Long term	Reversible	High	4

Acronyms, Abbreviations and Defined Terms

Acronym	Definition
$(NH_4)_2SO_4$	ammonium sulphate
35-55-20-W4M	Section 35, Township 55, Range 20, West of the 4th Meridian (the Site)
A	symbol for hole area from the action leakage rate formula
A	cross-sectional area available for flow
A1	Agricultural Use Area 1
A2	Agricultural Use Area 2
AAAQO	Alberta Ambient Air Quality Objectives
AADT	average annual daily traffic
AAF	Alberta Agriculture and Food
AAFRD	Alberta Agriculture Food and Rural Development
abiotic	not biological; not involving or produced by organisms
ACD	Alberta Community Development
acid	molecule that is able to give up a proton (H^+) to, or accept electrons from, a base; gives a solution with a pH of less than 7
acidification	reduction of the pH of soil, waterways and lakes
adaptive planning	flexibility built into design and layout to accommodate future modifications required by changed standards, limits and guidelines
AENV	Alberta Environment
aerobic bacteria	bacteria that require oxygen to survive and grow
AET	areal evapotranspiration
AFSC	Agricultural Financial Services Corporation
AIH	Alberta Industrial Heartland: a large industrial centre in central Alberta including Edmonton, Fort Saskatchewan, Strathcona County, Sturgeon County and Lamont County
AII	industrial total
ALF	available labour force
ALR	action leakage rate – leakage expected to occur through a synthetic impermeable liner having 2 holes of 2 mm in diameter every 1-ha of area
alumina catalyst	medium used to regenerate and recycle amines used to adsorb hydrogen sulphide gas
amine units	process units used to remove hydrogen sulphide from a gaseous process stream using amine compounds
anaerobic bacteria	bacteria that do not require oxygen to survive and grow
ANC	acid-neutralizing capacity
ANHIC	Alberta Natural Heritage Information Centre
ANPC	Alberta Native Plant Council
AO	aesthetic objectives
APA	Agricultural Policy Area
API	American Petroleum Institute

Acronym	Definition
aquatics	aquatic resource conditions, including fish and benthic invertebrate habitat capability and their characteristics in waterbodies
aquifer	an underground porous geological formation that stores or carries water
ARET	accelerated reduction/elimination of toxics
ASIC	Alberta Soil Information Centre
ASL	ambient sound level
ASP	Alberta's Industrial Heartland Area Structure Plan/Lamont County
asphalt bulk sulphur storage pad	storage pad used to stockpile formed sulphur pastilles in preparation for shipment
ASRD	Alberta Sustainable Resource Development
ASRL	Alberta Sulphur Research Ltd.
AST	Alberta Sulphur Terminals Ltd.
ASWQ	Alberta Surface Water Quality
AVI	Alberta Vegetation Inventory
AWI	Alberta Wetland Inventory
BC MWLAP	British Columbia Ministry of Environment, Lands and Parks
bioavailability	the degree to which toxic substances or other pollutants present in the environment are available to potentially biodegradative microorganisms
bitumen upgrader	term used for a refining facility that converts bitumen (heavy oil) into a lighter grade synthetic oil that can be further refined to make useable products such as gasoline and diesel
BSL	basic sound level
BTEX	benzene, toluene, ethylbenzene and xylenes
buffer	a solution or liquid with a chemical constitution allowing it to neutralize acids or bases without a great change in pH
CA	annual crop total
Ca^{2+}	calcium ion
$CaCO_3$	calcium carbonate
CALPUFF	California Puff Model
camlock	fitting used to quick-connect pipes and hoses
CanSIS	Canadian Soil Information System
capital spending	expenditures by a company for plant and equipment
carbonate alkalinity	carbonate alkalinity is a measure of the amount of negative carbonate and bicarbonate ions in solution
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of the Environment
CCS	CCS Income Trust
CCS	Canadian Crude Separators
CDWQG	Canadian Drinking Water Quality Guidelines

Acronym	Definition
CEA	cumulative effects analysis
CEPA	Canadian Environmental Protection Act
CGCM3	Coupled Global Climate Model 3
Class II waste disposal facility	landfill facility that is designed and permitted to dispose of non-hazardous solid wastes in the Province of Alberta
clay soil liner	low permeability containment layer constructed using compacted clay soil
CLU	contemporary land use
cm	centimetre
cm y^{-1}	centimetres per year
CN	Canadian National Railway
CNR	Command Notification System
CO	carbon monoxide
CO_2	carbon dioxide
CO_3^{2-}	carbonate ion
COD	chemical oxygen demand – used to indirectly measure the amount of organic compounds in water
collection hopper	receptacle that collects formed sulphur pastilles and directs those pastilles onto a conveyor belt
Compliance Source Emissions Testing	testing implemented on sources of air emissions, such as combustion stacks, to verify that those emissions comply with regulated standards
conditioning unit	unit in the sulphur forming process that regulates the rate and temperature of the liquid sulphur that is fed into the process
COPC	chemicals of potential concern
COSEWIC	Committee on the Status of Endangered Wildlife
CP	perennial crop total
CPNVI	Central Parkland Native Vegetation Inventory
CPR	Canadian Pacific Railway
CPR1	cardiopulmonary resuscitation
CPR2	uncultivated pasture total
CPUE	catch per unit effort
CR	concentration ratio
CSL	comprehensive sound level
CWQ	Canadian Water Quality
CWS	Canada-wide Standards
dBA	A-weighted decibel
dBC	C-weighted sound levels
degassed sulphur	sulphur that contains less than 10 ppm by weight of hydrogen sulphide
DFO	Department of Fisheries and Oceans
DO	dissolved oxygen

Acronym	Definition
DOC	dissolved organic carbon
double containment system	containment system for storing potentially hazardous liquids that includes two independent containment layers
draw down tube	tube used to control (reduce) fluid levels in a containment vessel
duplex filter	filter designed to remove two types of impurities, such as particulate and organic matter
dust suppression package	process component that suppresses dust that may be emitted to atmosphere at a material transfer point
EC	electrical conductivity
EC20	concentration that affects 20% of text organisms
EC50	concentration that affects 50% of test organisms
EIA	Environmental Impact Assessment
elemental	a pure substance that cannot be broken down into different kinds of matter
emergency response	the action taken after an event to minimize the consequences of an emergency
EMS	environmental management system
EMS	Emergency Medical Services
EOC	Emergency Operations System
EPEA	*Environmental Protection and Enhancement Act*
ER	exposure ratio
ERP	Emergency Response Plan
ESA	Environmental Significant Areas
EUB	Alberta Energy and Utilities Board
FAP	Fort Air Partnership
feed tank	tank at the beginning of the sulphur processing system that is used to control the rate of sulphur feed to the forming process
ferrous iron	iron with an oxidation number of +2
fish/trap-hour	fish catch rate; fish caught per hour
FMZ	Fur Management Zone
FOLC	The Friends of Lamont County for Responsible Industrial and Community Development
FONG	open, non-patterned graminoid dominated fen
formed sulphur	sulphur that has been formed into solid pastilles using the Rotoformer process
fugitive dust	dust that is not emitted from definable point sources
fugitive sulphur emissions	sulphur emissions that are not emitted from definable point sources
FWHIS	Fish and Wildlife Historical Information System
g	the gravitational constant (9.8 m/s^2)
$g\ s^{-1}$	grams per second
GHG	greenhouse gases
GIS	geographic information system

Acronym	Definition
GJ/mon	gigajoules per month
gm/t	grams per tonne
groundwater	water beneath the earth's surface in underground streams and aquifers
gypsum	a soft white mineral composed of hydrous sulfate of lime
H	Hour
H&S	Health and safety
H^+	hydrogen ion; the symbol for a proton
H_2CO_3	carbonic acid
H_2O	Water
H_2S	hydrogen sulphide
H_2SO_4	hydrogen sulphate
ha	hectare
HADD	harmful alteration, disruption, or destruction of fish habitat
HAZCO	HAZCO Environmental Services
HCO_3	bicarbonate
HDPE	high density polyethylene
HEC	human equivalent condition
HHRA	Human Health Risk Assessment
HNO_3	nitric acid
HP	horsepower
HRIA	Historical Resources Impact Assessment
HRV	historical resources value
hw	the symbol for liquid depth from the action leakage rate formula
hydraulic conductivity	the extent to which a given substance allows water to flow through it
hydrogen plant feedstock	plant that is used to generated hydrogen gas, which is in turn used in the heavy oil upgrading and/or oil refining process
hydrogeological	pertaining to the geology of ground water with emphasis on its chemistry and movement
i	hydraulic gradient in the surficial deposits
I/C	Industrial/Commercial District
ICS	Incident Command System
infrastructure	basic facilities, such as transportation, communications, power supplies and buildings, that enable an organization, project or community to function
interstitial water	subsurface water contained in pore spaces between grains of rock and sediment
IPCC	Intergovernmental Panel on Climate Change
ISQG	Interim Freshwater Sediment Quality Guidelines
ITE	Institute of Transportation Engineers
K	hydraulic conductivity

Acronym	Definition
K	degrees Kelvin
K^+	potassium ion
keq H^+/(ha•y)	kiloequivalents of hydrogen ions per hectare per year
kg	kilogram
kg s^{-1}	kilograms per second
kg/d	kilograms per day
kg/ha/y	kilograms per hectare per year
kg/t	kilograms per tonne
km	kilometres
km/h^{-1}	kilometres per hour
km^2	square kilometre
kPa	kiloPascals
kraft pulp	pulp produced by a process where the active cooking agent is a mixture of sodium hydroxide and sodium sulphide
Kw	kilowatt
L/min	litres per minute
L/s	litres per second
LCC	Lamont County Council
Le Chatelier's Principal	used to predict the effect of changing the amount of reactants, products, temperature or system volume on the composition of a chemical system at equilibrium
leak detection layer	layer located between the primary and secondary containment layers that is used to monitor the integrity of the primary containment layer
LEK	local environmental knowledge
L_{eq}	energy equivalent sound level
Level I fire	minor fire that can be isolated or controlled and is not of a serious nature
Level II fire	fire that cannot be isolated or controlled, but can be managed by local fire and emergency response service
Level III fire	fire that cannot be isolated or controlled and cannot be managed by local fire and emergency response service
L_{max}	maximum sound level for a given time period
load out conveyor	conveyor used to transfer formed sulphur onto rail cars
LOAEL	lowest observed adverse effect level
LOS	level of service
LSA	Local Study Area
LST	local standard time
LUB	Land Use Bylaw
LZ	landing zone
m	metre
m/m	metres per minute

Acronym	Definition
m/s^{-1}	metres per second
m/y	metres per year
m^2	metres squared
m^2/day	metres squared per day
m^3	cubic metres
$m^3\ h^{-1}$	cubic metres per hour
m^3/day	metres cubed per day
m^3/s	metres cubed per second
m^3/y	metres cubed per year
MAC	maximum acceptable concentrations
Man-hours	number of workers multiplied by hours worked
masl	metres above sea level
mbgs	metres below ground surface
MDBP	Municipal Development Plan Bylaw
meq	milliequivalents
meq/L	milliequivalents per litre
metallic sulfides	compounds formed by metal elements bonding to sulphides
metering pump assembly	process unit that measures flow volumes and rates through a pump
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
Mg^{2+}	magnesium ion
mitigation	any action taken to permanently eliminate or reduce the long-term risk to human life, property and function from hazards
mL	millilitre
mL/minute	millilitres per minute
mm	millimetre
mm day^{-1}	millimetres per day
mm/y	millimetres per year
MP	McElroy-Pooler dispersion coefficient
MPC	Municipal Planning Commission
MPOI	maximum points of infringement
MRL	minimal risk limit
MSDS	Material Safety Data Sheets
MVC	motor-vehicle collisions
MWH/mon	power flux per month

Acronym	Definition
N	Nitrogen
n	number of individuals
n.d.	not defined
n/a	not applicable
Na^+	sodium ion
NAAQO	National Ambient Air Quality Objectives
$NaHCO_3$	sodium bicarbonate
NCIA	Northeast Capital Industrial Association
Ne	effective porosity
neutralization sludge	sludge formed by the neutralization of sulphuric acid using either caustic soda or lime
NGO	non-governmental organizations
NH_4NO_3	ammonium nitrate
NIA	noise impact assessment
NO	nitric oxide
NO_2	nitrogen dioxide
NO_2^-	nitrite ion
NO_3^-	nitrate ion
NOAEL	no observed adverse effect level
NO_x	nitrogen oxides
NPRI	National Pollutants Release Inventory
NR CAER	Northeast Region Community Awareness and Emergency Response
NRC	Natural Regions Committee
NRCB	Natural Resources Conservation Board
NTU	nephelometric turbidity unit
O_2	oxygen
O_3	ozone
^oC	degrees Celsius
off-specification sulphur	sulphur that does not comply with shipping specifications either because of excessive mineral or organic content
OH^-	hydroxide ion
OM	organic matter
oxidation	the removal of electrons from an element or compound
ozone precursors	chemical compounds, such as carbon monoxide, methane, non-methane hydrocarbons and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone
PAH	polycyclic aromatic hydrocarbons
PAI	potential acid input
PDA	Principal Development Area

Acronym	Definition
PEL	probable effect levels
PEMS	Prairie Emergency Medical Systems
PET	potential evapotranspiration
PFRA	Prairie Farm Rehabilitation Administration
PG	Pasquill-Gifford dispersion coefficient or atmospheric stability class
pH	measure of the acidity or basicity (alkalinity) of a material when dissolved in water
piezometer	instrument which measures hydraulic pressures
PM_{10}	particulate matter 10 microns or smaller
$PM_{2.5}$	particulate matter with mean aerodynamical diameter less than 2.5 µm
ppb	parts per billion
ppm	parts per million
precipitate	separate as a fine suspension of solid particles
protons	positively charged particles forming part of atomic nuclei
psi	pounds per square inch
PSL	permissible sound level
pump hanger	device for vertically positioning a pump
PW	pumping well
Q	symbol for action leakage rate from the action leakage rate formula; groundwater contributions
QA	quality assurance
QC	quality control
R.R.	Range Road
radial stacking conveyor	conveyor that places formed sulphur in a radial pattern
rail transfer loop	rail line placed in an approximately circular pattern
RCMP	Royal Canadian Mounted Police
Rd	road
Receiving tank	tank used to receive liquid sulphur delivered by rail or truck
recirculation loop	water circulation loop that returns spent cooling water to the start of the cooling water circuit
reduction	addition of electrons to an element or compound
RELAD	Regional Lagrangian Acid Deposition
RfC	reference condition
RGDR	regional gas dosimetry ratio
Rotoform emissions	particulate sulphur emissions for the Rotoform process
ROW	right(s) of way
RSA	Regional Study Area
runoff control system	system of ditches and culverts used to collect runoff from the sulphur processing area to the stormwater collection pond

Acronym	Definition
S	Sulphur
s^{-1}	per second
S_2O_3	thiosulfate
SABA	supplied air breathing apparatus
Sandvik Rotoform process	sulphur forming process developed and patented by Sandvik and referred to as the Rotoform process
SAR	sodium adsorption ratio
SAR	species at risk
SARA	*Species at Risk Act*
saturated	most concentrated solution possible at a given temperature
SCA	soil correlation area
SCBA	self-contained breathing apparatus
SEIA	Socio-Economic Impact Assessment
SIL	survey intensity level
Site	Section 35-55-20 W4M
S^o	symbol for elemental sulphur
SO_2	sulphur dioxide
SO_4^{2-}	sulphate ion
SO_4^{2-}	sulphate anion
SO_4^{2-}	Sulphate
sour gas	hydrogen sulfide gas; H_2S
SO_x	sulphur oxides
specific gravity	the ratio of the density of a material to the density of water
spontaneous combustion	self-ignition of combustible material through the chemical action of its parts
stakeholders	people or organizations with an interest or share in an undertaking, such as a commercial venture
sulphur acidification	lowering of pH in soils or water by sulphur dioxide
sulphur forming	process of converting liquid sulphur into solid sulphur particles
sulphur pastille	sulphur pastilles of uniform shape, stability and quality formed by the Sandvik Rotoform process
sulphur recovery	separation and recovery of sulphur from a hydrocarbon refining process
sulphur train	a train used to convey liquid or solid sulphur
sulphuric acid	a strong acid; H_2SO_4
surface water	water that flows in streams and rivers, natural lakes, in wetlands, and in reservoirs constructed by humans
surface water runoff collection pond	pond used to collect and contain surface runoff from the sulphur forming and handling area
surge bin	bin used to collect and store surges in solid sulphur pastilles

Acronym	Definition
sweet fuel gas	methane that is used as fuel and does not contain hydrogen sulphide
t/d	tonnes per day
t/y	tonnes per year
TDS	total dissolved solids
TEH	total exactable hydrocarbons
temperature conditioned	sulphur that is conditioned and controlled to be in a specific temperature range
TIA	traffic impact assessment
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TOR	Terms of Reference
totalizer	metering device that totals the volume of liquid passed through that meter
TP	total phosphorus
TPH	total petroleum hydrocarbons
TRV	toxicological reference values
TSS	total suspended solids; the weight of particles suspended in water
Twp	Township
UF	urban fringe
USEPA	United States Environmental Protection Agency
USGPM	US gallons per minute
USLE	universal soil loss equation
UTM	universal transverse mercator
V	Velocity
visible sheen	collection of hydrocarbons that is visible on the surface of a waterbody
VOC	volatile organic compounds
W4M	West of the 4^{th} Meridian
WA	*Water Act*
wetland	area regularly saturated by surface water or groundwater and characterized by a prevalence of vegetation adapted for life in saturated soil conditions (e.g., swamps, bogs, fens, marshes and estuaries)
WHMIS	Workplace Hazardous Materials Information System – national chemical hazard communication system for regulation of information pertaining to hazardous materials
WMU	Wildlife Management Unit
WVC	wildlife-vehicle collisions
y	year
µeq/L	microequivalents per litre
$\mu g\ m^{-3}$	micrograms per cubic metre
µm	microns (micrometres)
µS/cm	Microsiemens per centimetre

1. Introduction

The proponent, Alberta Sulphur Terminals Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), is applying to Alberta Environment (AENV) and the Natural Resources Conservation Board (NRCB) for approval to construct and operate a facility for sulphur receiving and forming, temporary sulphur pastille storage and shipment for export (the Project). The facility is to be developed on a portion of Section 35, Township 55, Range 20, West of the 4^{th} Meridian (35-55-20 W4M – the Site), approximately 2.2 km east of Bruderheim, Alberta, in the Industrial Heartland area of Lamont County (Figure 1.1-1).

The purpose of this Environmental Impact Assessment (EIA) is to assess and report the potential environmental and socio-economic impacts of the Project. The EIA portion of this application has been organized into four sub-volumes:

Volume IIA – Air, Noise and Human Health

1. Introduction
2. Climate and Air Quality
3. Noise and Light
4. Public Health and Safety

Volume IIB – Water and Aquatic Resources

5. Introduction
6. Groundwater Quality and Quantity
7. Surface Water Quantity
8. Surface Water Quality
9. Aquatic Resources

Volume IIC – Terrestrial Ecosystems

1. Introduction
2. Soil
3. Vegetation
4. Wildlife
5. Biodiversity and Fragmentation

Volume IID – Land Use, Historical, Socio-Economics and Public Consultation

6. Introduction
7. Land Use and Reclamation
8. Historical Resources
9. Socio-Economic Assessment
10. Public Consultation Requirements

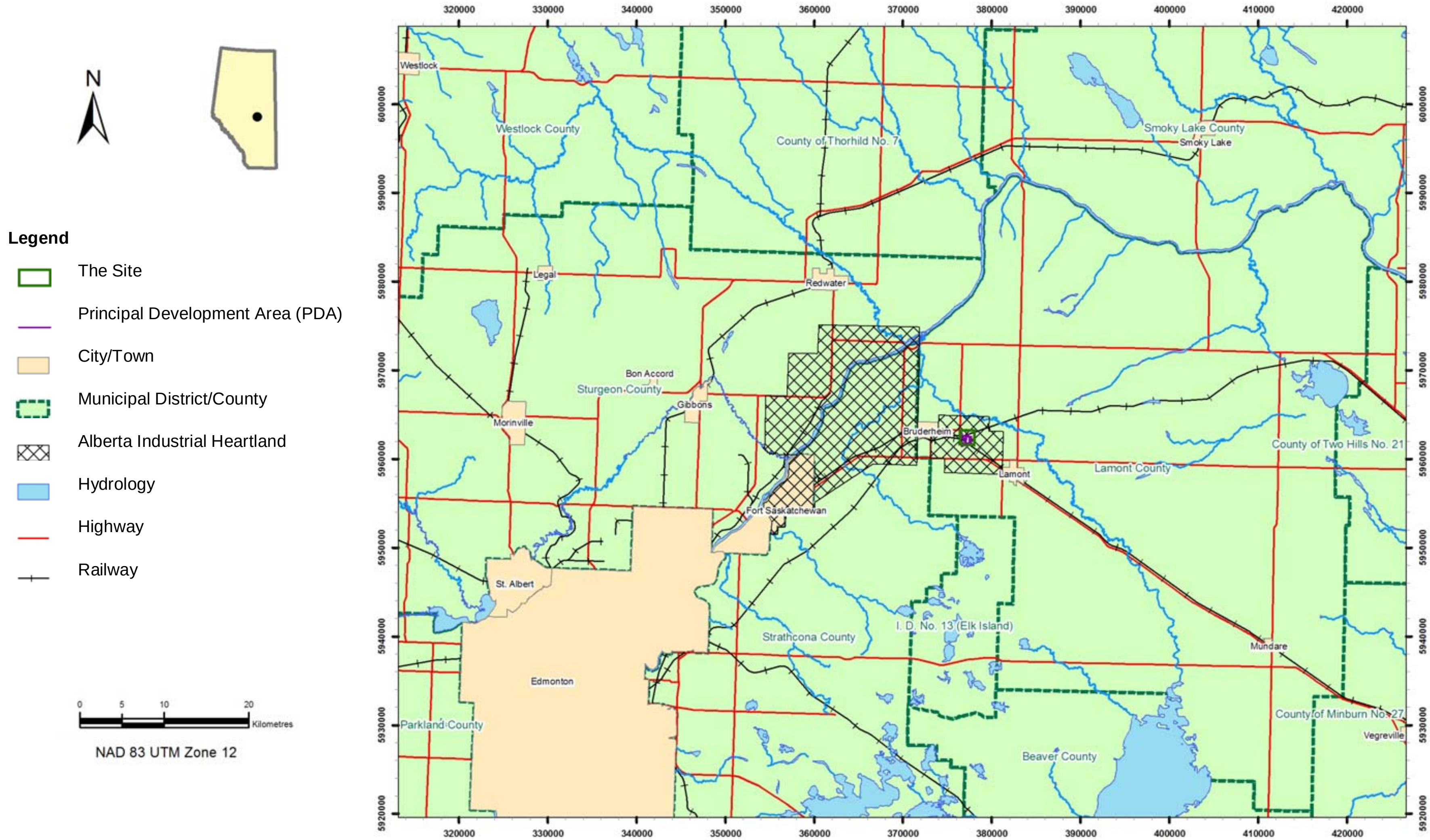

Figure 1.1-1: Regional Setting

This EIA forms part of the application for the Project submitted by AST and has been prepared according to the following requirements:

- AENV: *Environmental Protection and Enhancement Act* (EPEA)
- AENV: Final Terms of Reference (TOR: AENV 2007)
- NRCB*: Natural Resources Conservation Board Act* (NRCB 2001)
- Permit to Divert Groundwater, to be issued by AENV under the Water Regulation of the *Water Act*: to provide up to 24,000 m^3 of cooling water per year to supply water during periods when the volume of water collected in the stormwater runoff control pond is not sufficient to operate the sulphur forming cooling system
- Development Permit issued by Lamont County under the *Municipal Government Act* (Government of Alberta 2000a) to allow construction of surface facilities associated with the Project
- authorization under the *Historical Resources Act* (Government of Alberta 2000b) for clearance to construct the Project

The concordance table that correlates the various clauses of the TOR to the application and EIA can be found in Volume I.

1.1 Project Description

The Project encompasses construction and operation of a facility for sulphur receiving and forming, temporary sulphur pastille storage and shipment for export. All infrastructure and activities will be confined to the lands owned by HAZCO. The Project includes:

- rail and road access for receiving molten sulphur
- molten sulphur unloading and transfer facilities
- sulphur forming facilities to produce sulphur pastilles
- loading and shipping facilities for formed sulphur
- sulphur pastilles temporary storage area

The Project will service oil and gas production and refining operations located in the Fort Saskatchewan area as well as northeastern Alberta. With increased applications, approvals and operation of bitumen upgraders and ongoing sulphur recovery initiatives, a shortage of sulphur forming facilities in Alberta is now apparent. AST will provide oil and gas producers in the area with a state-of-the-art sulphur forming, temporary pastille storage and shipping facility with design elements and monitoring programs that focus on environmental protection.

1.1.1 Sulphur Generation

The sulphur that would be accepted, formed and shipped by the Project is generated primarily by bitumen upgrading facilities located in the Fort Saskatchewan, Fort McMurray and Lloydminster areas. Amine units are part of the upgrader sulphur plant and remove H_2S from all upgrading gas streams, which produces sweet fuel gas (low sulphur content) and hydrogen plant feedstock. The plant consists of H_2S removal units (amine units) and sulphur recovery units, which convert H_2S to elemental sulphur.

The sulphur recovery units oxidize or burn part of the H_2S into SO_2, which then reacts with H_2S to form liquid elemental sulphur and water. The initial reaction takes place in the burners of a reaction boiler and in-line burners before the converters/condensers, known as sulphur "trains". First, second and third stage converters containing a (bauxite) alumina catalyst promote the reaction of H_2S with SO_2 at temperatures from 204–316°C. Modern processes reduce sulphur emissions and improve sulphur recovery.

Sulphur is recovered as a liquid by condensing sulphur vapour from the gases in the steam-generating heat exchangers of each sulphur train. The liquid sulphur is then gathered and stored, and entrained residual H_2S is removed from the stored sulphur.

Upgrading facilities at Lloydminster, Fort McMurray and Fort Saskatchewan currently generate sulphur at a rate of approximately 1 million tonnes/year (t/y). The rate of sulphur production in these areas is expected to rise to approximately 2 million t/y by 2008, and 3 million t/y by 2013 as upgrading operations are expanded to accommodate the increased production associated with heavy oil.

1.1.2 Project Components and Development Timing

The primary components of the proposed sulphur forming and shipping facility are:

- infrastructure for the reception of liquid sulphur and shipment of formed sulphur
- storage facilities for liquid and formed sulphur
- sulphur forming facilities
- sulphur transfer and loading infrastructure

1.1.2.1 Sulphur Reception

Liquid sulphur can be received at the facility by railcar, truck or (in future) pipeline. Only liquid sulphur that has been degassed to a maximum of 10 ppm H_2S will be accepted. Upon arrival, the liquid sulphur is unloaded via a pumping station into insulated and heated receiving tanks. Liquid sulphur is then pumped to a feed tank where it is filtered and temperature conditioned prior to being formed.

1.1.2.2 Sulphur Holding

Storage is provided for sulphur in its liquid form, prior to being formed, as well as in its pastille form, prior to being shipped. The sole purpose is to allow efficient operation of the forming facilities, while accommodating delivery and shipping. Liquid sulphur will be stored in 3,000 t, insulated and clad, steel tanks that meet the requirements of EUB Directive 55 (EUB 2001, Internet site) and API 650 modified (API 1998). The initial development will include three 3,000 t tanks, rising to six – 3,000 t tanks at maximum capacity. Formed sulphur will be stored on a double-lined asphalt pad equipped with run-on and runoff controls. This pad has the capacity to store 90,000 t of finished product, approximately half of which will be established as part of initial construction.

1.1.2.3 Sulphur Forming

After the sulphur is transferred to the receiving tanks, it is pumped through a duplex filter and conditioning unit and cooled to an optimal forming temperature of 125°C. The sulphur enters a recirculation loop that feeds the Rotoform HS® drop forming equipment. The feed to the Rotoformer uses metering equipment and nozzles specifically designed to provide a continuous sulphur feed across a rotating stainless steel belt. The belt is cooled by cold water jets sprayed against the underside of the rotating belt, causing the pastilles to cool and solidify above.

1.1.2.4 Transfer and Shipping Infrastructure

The solid pastilles are deposited into a collection hopper, conveyed to a radial stacking conveyor and the asphalt bulk sulphur storage pad. A wind screen will be built upwind of the sulphur pastille stockpile. Initially, a front-end loader will transfer the stockpiled sulphur to a surge bin equipped with a dust suppression package. The dust treated product will then be deposited on a load-out conveyor equipped with weight measurements and totalizer and onto rail or trucks for shipment. An automated loading system will be introduced as part of future expansion to full production. In this instance, the formed sulphur will be transferred into vertical holding bins that are used to directly load rail cars. The EIA is based on a forming capacity of 6,000 t/d, half of which will be associated with initial construction.

Water utilized by the Rotoform HS® equipment will be sent through a closed loop cooling tower which provides filtration and temperature reduction. Make-up water for the cooling tower will be supplied from a runoff pond which is designed to collect and treat surface water from the Site and also serves as the source of fire protection water. Additional make-up water will be provided by a groundwater supply well.

1.1.2.5 Development Schedule

The proposed facilities will be developed in stages to accommodate the rate of sulphur production generated by existing and proposed oil sands development programs as well as market conditions. The initial stage will include the development of all Project components with sufficient capacity to process approximately 3,000 t/d of sulphur. Subsequent expansions will occur to process approximately 6,000 t/d of sulphur. The anticipated timing for the initial stage of development is summarized in Table 1.1-1 and is dependent on the pace and outcome of the regulatory process.

Table 1.1-1: Initial Development Timing

Task	Anticipated Timeframe
Project disclosure	2005
EIA scoping	Early 2006
EIA implementation	2006
Application submission	Mid 2007
Detailed design	Late 2007
Construction	Early 2008
First operations	Mid 2008
Project lifespan	Indefinite

The receipt, forming, temporary storage and shipping of formed sulphur will occur continuously over the lifespan of the facility (estimated to be at least 25 years), assuming there is a viable international market for sulphur produced in Alberta.

Failure to meet the proposed timeline, or approve the Project in general, will result in the blocking of incremental volumes of sulphur produced by oil sands upgrading facilities, either in new locations or at existing facilities. For example, sulphur produced by Syncrude is currently being stored in above-ground blocks, and Suncor is considering this option for sulphur generated by its Voyageur upgrader. Sulphur forming facilities are currently not available to the independent upgraders that are scheduled to come on-line in the next few years.

1.2 Spatial Boundaries

1.2.1 Principal Development Area

The Principal Development Area (PDA) is located within a portion of Section 35-55-20 W4M (the Site) and comprises the area of disturbance and development as illustrated in Figure 1.1-1. The PDA contains the sulphur forming and shipping facility, located in the west-central portion of the Site, and rail transfer loop used to receive and ship sulphur.

1.2.2 Local Study Area

The LSA for the majority of disciplines assessed in the EIA is the Site (groundwater, historical resources, surface water quantity and surface water quality) or the Site plus a 200 m buffer zone (aquatics, biodiversity and fragmentation, land use and reclamation, soil, vegetation and wildlife).

1.2.3 Regional Study Area

The RSA incorporates the LSA into a larger geographical area where potential regional effects could occur. As with the LSA, the extent of the RSA for each EIA component was determined according to the indicators used. Where no impact (Class 4) is predicted within the LSA, no analysis of regional effects was undertaken.

1.2.3.1 Cumulative Effects Study Areas

Cumulative effects assessments (CEA) are only applicable when other announced, but yet-to-be approved, projects exist that would affect the same area. Cumulative effects were generally assessed within the RSA for each specific EIA component. Where no impact is predicted within the LSA, no analysis of cumulative effects was undertaken (see Section 1.5.3).

1.3 Temporal Boundaries

The Project schedule is preliminary and subject to modification in response to the receipt of regulatory approvals, business considerations and weather factors. Assuming favourable regulatory approval and market conditions, construction of the Project is scheduled to begin in early 2008 with initial sulphur processing starting in mid 2008. The Project is expected to operate for at least 25 years. A detailed schedule is provided in Volume I.

Temporal boundaries used in this assessment vary depending on the disciplines and the resource assessed. Temporal boundaries extend from June 2006 for the baseline assessments to five years after reclamation of the Project for the Land Use and Reclamation assessment.

1.4 Assessment Criteria

The purpose of the EIA is to assess and report on the potential impacts associated with the construction and operation of the Project. This includes impacts to the biophysical landscape as well as socio-economic and cultural impacts to local communities and historical sites. The EIA also includes preventative, mitigative and compensatory actions to reduce impacts of the Project.

Impact assessments were based upon measured, predicted or reasonably expected changes in some attributes of a selected indicator. The choice of indicators was determined from reviewing other EIAs completed in the Alberta Industrial Heartland for applicability to this region through input from stakeholders and the professional judgment of scientists conducting the EIA.

For each identified indicator, an assessment of the potential residual impact was made using the attributes of:

- direction
- geographical extent
- magnitude
- duration
- confidence
- reversibility

The definition of each attribute used in the assessment is given below.

1.4.1 Direction

The direction of impact may be described as positive (beneficial), negative (detrimental) or neutral:

- Positive: measured or estimated impact represents a real or potential increase in abundance, quality or other attribute of the indicator
- Negative: measured or estimated impact represents a real or potential decrease in abundance, quality or other attribute of the indicator
- Neutral: a "neutral" direction indicates there is no impact to quantify; therefore, no quantitative assessment (e.g., extent, magnitude, duration) is possible; the confidence (based on an understanding of cause and effect relationship(s) and the quality and quantity of available data) in the assessment is discussed below

1.4.2 Geographic Extent

Impacts may be confined to small local areas, or may occur over a large geographic extent. Generally, impacts may be local or regional:

- Local: measured or estimated impact occurs only within the boundaries of the LSA
- Regional: measured or estimated impact occurs beyond the boundaries of the LSA and mainly within the boundaries of the RSA

1.4.3 Magnitude

Three levels of magnitude have been selected:

- Negligible: measured or estimated impact represents a 1% or less change in the indicator (quality, quantity or other attribute) from baseline conditions
- Low to Moderate: measured or estimated impact represents a greater than 1% to 10% change in the indicator (quality, quantity or other attribute) from baseline conditions
- Moderate to High: measured or estimated impact represents a greater than 10% change in the indicator (quality, quantity or other attribute) from baseline conditions

Some disciplines have specific threshold values (e.g., AAAQOs (AENV 2005, Internet site)) that determine the magnitude of the impact, rather than a combination of quantitative analysis and professional judgment that is used where specific guidelines and regulations do not exist.

1.4.4 Duration

Some impacts may persist for short periods of time, others may be virtually permanent. The following designations for duration are used:

- Short-term: measured or estimated impact persists for no longer than five years
- Mid-term: measured or estimated impact persists to the end of the operational life of the Project
- Long-term: measured or estimated impact is measurable beyond the end of the operational life of the Project

1.4.5 Confidence

All measurements or predictions of direction, magnitude, geographic extent and duration of an impact are made on the basis of available data and understanding of the Project. The confidence ratings used are:

- Low: no clear understanding of cause and effect is evident because of the lack of a relevant information base or directly relevant data. This generally applies to conditions relevant to the RSA where no data was collected or available, and no detail is available regarding other planned developments.
- Moderate: a good understanding of cause and effect is evident from the existing knowledge base; however, there is limited data or a lack of directly applicable data. This generally applies to conditions within the LSA where larger-scale data was collected, but the resource in question is very site-specific and could not be surveyed within this year's time frame or models were used but could not be validated.
- High: a good understanding of cause and effect is available from the existing knowledge base and good, directly-applicable data are available. This generally applies to conditions within the LSA where data was collected and information about the Project was available (e.g., footprint).

1.4.6 Reversibility

All disciplines provide basic explanation regarding whether or not the impact is reversible.

1.4.7 Final Impact Rating

For each individual impact assessment, a qualitative, final evaluation rating has been used where specific guidelines do not exist. This rating is a combination of quantitative analysis and professional judgment that takes into account the various descriptors for each attribute (direction, magnitude, geographic extent, duration, confidence and reversibility), and the potential effects of the specific impact. For some indicators, there are specific threshold values that will determine an indicator's ranking (e.g., for air quality, human health). Other indicators have no such threshold value and a combination of objective analysis and subjective professional judgment is used. Impact classification does not always relate directly to standard descriptors used to explain the impact occurring; this is often seen where a relative change of high magnitude is occurring, yet the impact is classified as Class 3 because the overall effect (e.g., impacts to one small stream within a watershed) may be unmeasureable.

The final impact rating is an aggregated, relative, numerical ranking determined by both the analysis of impact and the level of action the author recommends, as a professional, as necessary to address the impact. This ranking is applied to both the Project-specific impacts and cumulative effects residual impacts (see Table 1.4-1).

Table 1.4-1: Final Impact Rating

Rating	Level of Action
Class 1	The predicted trend in an indicator under projected land use development could threaten the long-term sustainability of the quantity or quality of the indicator in the local and regional study areas. An action plan, developed jointly by regional stakeholders, could be developed to monitor the affected indicator, identify and implement further mitigation measures to reduce any impact, and promote recovery of the indicator, where appropriate. This class of impact might also be applicable to an exceedance of a regulatory guideline, or where the impact is expected to have long-term effects.
Class 2	The predicted trend in an indicator under projected land use development will likely result in a decline in the quantity or quality of the indicator. The decline could be to lower-than-baseline but stable levels in the LSA and RSA after closure and into the foreseeable future. In addition to responsible industrial operational practices, monitoring and recovery initiatives could be required if additional land use activities occur in the study area before closure of the projected land use development. This class of impact might also be applicable to an exceedance of a regulatory guideline, or where the impact is expected to have mid-term effects, but where recovery will take place shortly after closure of the projected land use development.
Class 3	The predicted trend in an indicator under projected land use development could result in a slight decline in the quantity or quality of the indicator in the LSA and RSA during the life of the projected land use development, but resource levels should recover to baseline after closure. In some cases, a short-term, low to moderate magnitude impact could occur, but recovery will take place within five years. No new resource management initiatives are necessary. Responsible industrial operational practices should continue. This class of impact could also be applicable where regulatory guidelines are not exceeded, but where a relative change in magnitude of an indicator occurs.
Class 4	The projected land use development results in no change and no contribution toward affecting the quantity or quality of the indicator in the LSA and RSA during the life of the projected land use development. Responsible industrial operational practices should continue. Therefore, no cumulative effects result from the Project.

1.5 Assessment Scenarios

The assessment was based on three cases – baseline case, application case and cumulative effects case as required by the TOR (AENV 2007). Impacts of the Project were evaluated from a project-specific and cumulative perspective by undertaking comparisons of change within these cases. These generally included comparisons of the environmental characteristics occurring in the baseline case with environmental conditions predicted to occur in the application case and in the cumulative effects case (see Figure 1.5-1).

1.5.1 Baseline Case

The baseline case includes the existing environmental and socio-economic conditions and existing and approved projects and activities as of June, 2006.

1.5.2 Application Case

The application case includes the baseline case plus the Project within the LSA. Construction and operation of the Project will occur sequentially. A maximum worst-case disturbance case was assessed for the application case in which all construction and operation components of the Project were assumed to occur concurrently. This conservative, worst-case approach over-predicted the Project impacts. In some cases, impacts were evaluated at closure (decommissioning and reclamation) to determine residual effects at that time.

1.5.3 Cumulative Effects Case

The cumulative effects case includes baseline, application and existing projects or activities in combination with other planned projects or activities that could occur within the same geographic area (spatial) and within the same time (temporal). The Project Inclusion List in Table 1.5-1 shows existing and planned projects or activities.

Cumulative effects were evaluated where Class 1, 2 or 3 impacts were identified for that particular discipline (as per impact ratings explained in Section 1.4.7). Class 4 ratings indicate that no change would occur as a result of the Project. Therefore, a cumulative effects assessment was not undertaken for issues identified as Class 4.

1.5.3.1 Project Inclusion List

The Project Inclusion List (see Table 1.5-1) includes the various anthropogenic disturbances on the landscape that must be included in the applicable assessment case to effectively determine project and cumulative effects. As the study areas for each component vary, the project inclusion for a particular assessment also varies. Therefore, each component has modified the comprehensive project inclusion list for their assessment. The projects included for cumulative effects include other operators as well as facilities associated with the Project.

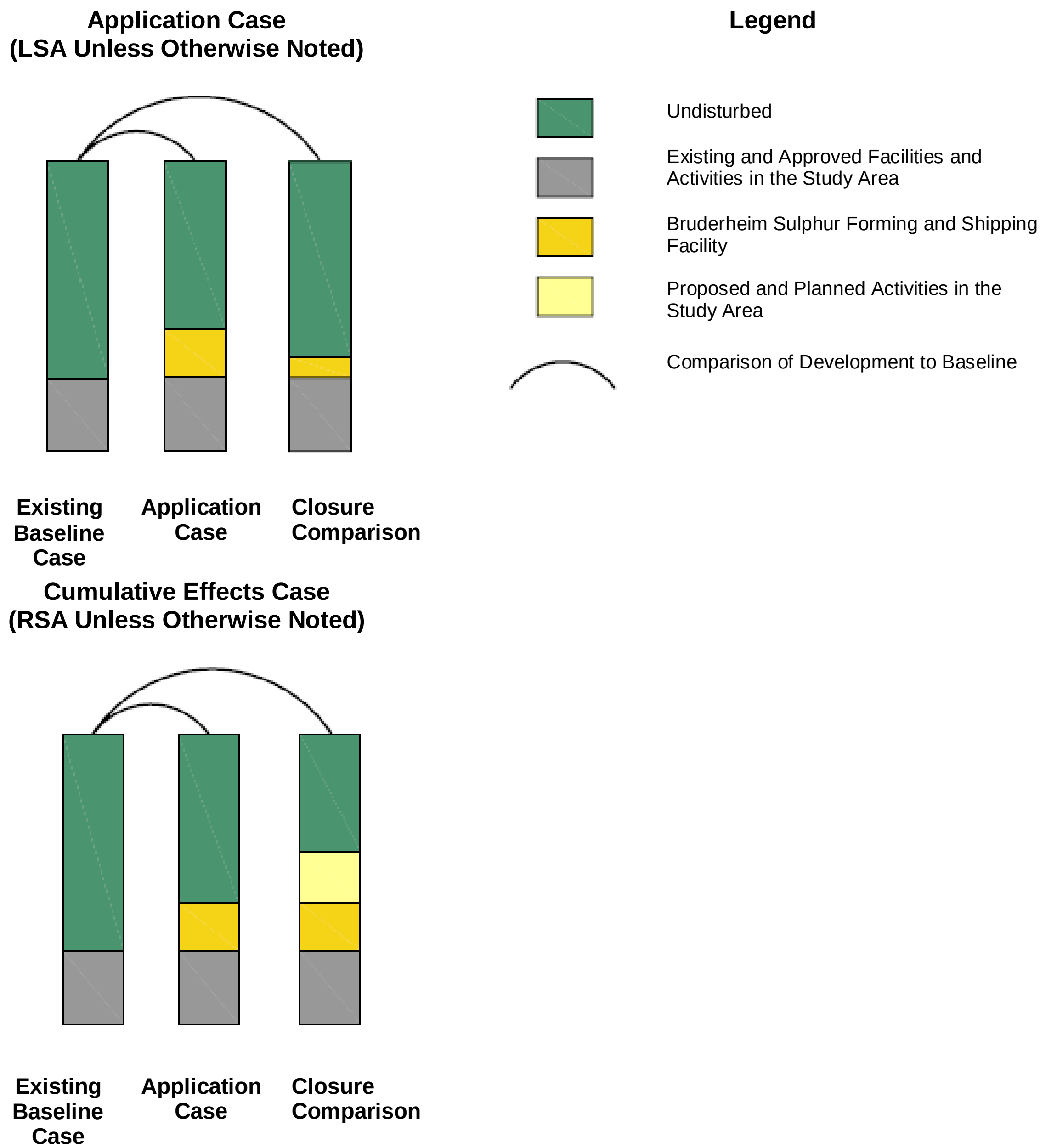

Figure 1.5-1: Comparisons of Change for Impact Assessment

Table 1.5-1: Project Inclusion List

Operator	Facility	Project Status		
		Existing	Approved (Not Operating)	Planned (Not Approved)
Access Pipeline	Redwater Trim Blending Facility		X	
Agrium Products Inc.	Fort Saskatchewan Fertilizer Plant	X		
Agrium Products Inc.	Redwater Fertilizer Plant	X		
Air Liquide Canada	Scotford Cogeneration Power Plant	X		
Alberta Sulphur Terminals	Bruderheim Sulphur Forming Facility			X
ARC Resources	Redwater Gas Conservation Plant	X		
ATCO Midstream	Fort Saskatchewan Sour Gas Plant	X		
Aux Sable Canada	Heartland Offgas Project			X
BA Energy	Heartland Bitumen Upgrader		X	
BP Canada Energy	Fort Saskatchewan Fractionation Plant	X		
Bunge Canada	Fort Sask. Oilseed Processing Plant	X		
Canexus Chemicals Canada	Bruderheim Sodium Chlorate Plant	X		
CE Alberta BioClean	Fort Saskatchewan Chemical Plant		X	
Degussa Canada Inc.	Gibbons Hydrogen Peroxide Plant	X		
Dow Chemical Canada	Fort Saskatchewan Chemical Plant	X		
ERCO Worldwide	Bruderheim Sodium Chlorate Plant	X		
Keyera Energy	Fort Saskatchewan Fractionation Facility	X		
Marsulex	Fort Saskatchewan Chemical Plant	X		
Newalta Corporation	Redwater Disposal Facility	X		
North West Upgrading Inc.	North West Upgrader Project			X
Petro-Canada Oilsands Inc.	Sturgeon Upgrader Project			X
Prospec Chemicals	Fort Saskatchewan Xanthate Plant	X		
Provident Energy Ltd.	Redwater Fractionation Facility	X		
Redwater Water Disposal Company	Redwater Waste Disposal Facility	X		
Shell Canada Limited	Scotford Upgrader	X	X expansion	
Shell Canada Products	Scotford Oil Refinery	X		
Shell Chemicals Canada	Scotford Styrene & MEG Plant	X		
Sherritt International Corporation	Fort Saskatchewan Fertilizer Plant	X		X
Synenco Energy Ltd.	Northern Lights Upgrader Project			X
Terasen Pipelines	Heartland Storage Tank Terminal			X
TransAlta Cogeneration	Fort Sask. Cogeneration Power Plant	X		
TransCanada Energy	Redwater Cogeneration Power Plant	X		

1.6 References

1.6.1 Literature Cited

Alberta Environment (AENV). 1999. *The Water Act.*

Alberta Environment (AENV). 2007. *Final Terms of Reference, Environmental Impact Assessment (EIA) Report for the Proposed Bruderheim Sulphur Forming and Shipping Facility.* March 13, 2007. Alberta Environment, Edmonton, AB.

Alberta Environmental Protection and Enhancement ACT (EPEA). 1993. Environmental Assessment Regulation 112/93.

American Petroleum Institute (API). 1998. *Welded Steel Tanks for Oil Storage*, 10th Edition. American Petroleum Institute, Washington, D.C.

Government of Alberta. 2000a. *Municipal Government Act,* RSA 2000, cM-26.

Government of Alberta. 2000b. *Alberta Historical Resources Act.*

Government of Alberta. 2001. *Natural Resources Conservation Board Act*.

1.6.2 Internet Site

Alberta Energy and Utilities Board (EUB). 2001. Directive 055: Storage Requirements for the Upstream Petroleum Industry (2001-12). (Formerly Guide 55). December 2001. Available at: www.eub.ca\Docs\Documents\Directives. Accessed February 2007.

Alberta Environment (AENV). 2005. Existing Ambient Air Quality Objectives. Available at: http://www3.gov.ab.ca/env/air/OGS/objexisting. Accessed May 2006.

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resources & energy

Alberta Sulphur Terminals Ltd.
Bruderheim Sulphur Forming and Shipping Facility

Volume IIA – Air, Noise and Public Health

2. Climate and Air Quality

Project Number 62720000
June 2007

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APPENDICES

Executive Summary

Alberta Sulphur Terminals Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), retained D.M. Leahey & Associates Limited/Jacques Whitford Limited to complete an assessment of the proposed Bruderheim Sulphur Forming and Shipping Facility (the Project) located in Section 35-55-20-W4M (the Site). The climate and meteorological analyses include the following parameters:

- ambient temperature
- precipitation
- wind
- relative humidity
- visibility
- severe weather

The Project will be the source of criteria air contaminants (i.e., CO, H_2S, NO_x, $PM_{2.5}$, SO_2).There will be no significant sources of volatile organic compounds (VOCs) or polycyclic aromatic hydrocarbons (PAHs). Four air quality issues addressed in the assessment, in conformance with the Terms of Reference (TOR), include:

- air emissions of criteria air contaminants – industrial emissions of criteria air contaminants associated with Project operations and from operations at surrounding industries
- acid deposition – emissions of potential acid forming substances such as SO_2 and NO_x
- particulate deposition – emissions of sulphur particles and subsequent deposition
- ozone formation – potential for O_3 creation as a result of photochemical reactions with NO_x and VOC

The air quality assessment demonstrated that emissions associated with the Project will result in ground-level concentrations of air contaminants less than maximum values stipulated in the Alberta Ambient Air Quality Objectives (AAAQO). They should, therefore, not have any adverse effects on the environment.

Climate and Air Quality

Aspects of the TOR relevant to the air quality assessment are as follows.

Discuss baseline climatic and air quality conditions. Review emission sources and discuss emissions from industrial development within the Environmental Impact Assessment (EIA) Study Areas. Consider emission point sources as well as fugitive and mobile emissions. Identify components of the Project that will affect air quality from a local and regional perspective, and:

a) identify any regional air monitoring in the area and describe AST's participation in regional forums (e.g., Northeast Capital Industrial Association, Fort Air Partnership);

b) discuss appropriate air quality parameters such as SO_2, carbon monoxide (CO), H_2S, NO_x and particulates ($PM_{2.5}$/10) (specifically including, but not limited to, sulphur compounds), and O_3, volatile organic compounds (VOC), and polycyclic aromatic hydrocarbons (PAH);

c) estimate ground-level concentrations of appropriate air quality parameters. Discuss any expected changes to particulate deposition or acidic deposition (PAI) patterns. Justify the selection of models used and identify any model shortcomings or constraints on findings. Complete modelling in accordance with Alberta Environment's Air Quality Model Guideline. Include model input files;

d) identify the potential for reduced air quality (including odors and visibility) resulting from the Project and discuss any implications of the expected air quality for environmental protection and public health;

e) discuss interactive effects that may occur as a result of co-exposure of a receptor to all emissions and discuss limitations in the present understanding of this subject;

f) describe how air quality impacts resulting from the Project will be mitigated;

g) identify ambient air quality monitoring and receptor monitoring that will be conducted during operation of the Project to assess air quality and the effectiveness of mitigation;

h) assess Project specific air quality and cumulative air quality impacts, and implications for other environmental resources, including habitat diversity and quantity, vegetation resources, water quality and soil conservation. Discuss the relative contribution of the Project (e.g., after mitigation) to regional cumulative effects.

i) assess the cumulative effects on the air quality of the EIA Study Area and include any related emissions increases from the Project; and

j) describe the monitoring programs AST will implement to assess air quality and the effectiveness of mitigation during the Project's development operation.

Air quality assessments were made for a time frame that included the present and extended over the projected life of the Project, which is expected to be 25 years. Three cases were selected for detailed assessment: baseline, application and cumulative. The baseline case considers impacts of current and approved air quality regimes in the study area. The application case addresses the air quality occurring immediately after completion of the Project while the cumulative effects case assesses the effects of announced future developments in the Local Study Area (LSA) following Project completion.

Conclusions of the air quality assessments considered results of existing ambient air quality monitoring as well as results based upon plume dispersion modelling. This modelling was relied upon for predictions of air quality implications of point, fugitive and mobile emission sources associated with the Project and neighbouring industries.

Air quality monitoring data relating to CO, H_2S, NO_x, $PM_{2.5}$ and SO_2 are available from regional observational sites maintained by the Fort Air Partnership (FAP). AST is a member of the FAP which was established to run an air monitoring system in the Fort Saskatchewan area. It exists to develop relevant credible information that can be used to manage air quality, protect environmental health and influence policy.

The plume dispersion modelling relied upon the CALPUFF model. This model is a multi-layer, non-steady-state dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and deposition. The plume dispersion model sequentially calculates hourly pollutant concentrations resulting from multiple sources and incorporates near-source effects, such as building downwash, chimney downdraft influences and partial plume penetrations, into elevated stable atmospheric layers. It also allows for long-range effects such as pollutant removal (wet scavenging and dry deposition), chemical transformations and vertical wind shear. The model is well known within the air quality modelling discipline, widely accepted, well documented and is regularly updated as new data and correlations are obtained. Studies show that air pollutant concentrations resulting from generating station emissions that were predicted using CALPUFF, compare favourably with observed values.

AST will mitigate its emissions through the installation of low NO_x boilers. Exhausts from the liquid sulphur storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed 1 ppm by volume. Dust suppression in the rail-out area will be achieved with the use of a proprietary dust suppression agent and release aid as well as water. Dust suppression agents will be applied to all transfer points including behind the hopper and at the rail-out. The asphalt pad transversed by the front end loader will be swept and washed on a daily basis.

Plume dispersion calculations were performed for a wide range of emission sources in a manner consistent with Alberta Environment's Air Quality Model Guideline (model input files were included as part of this EIA). Results of the calculations showed that maximum ground-level concentrations of air emissions attributable to the Project and other local and regional sources should remain below existing AAAQO. There should, in consequence, be no noticeable changes in air quality with respect to adverse effects on the environment (including odours and visibility). Interactive effects that may occur as a result of co-exposure of a receptor to all emissions are discussed in Public Health and Safety (Section 4 of this Volume).

The above conclusions with respect to acceptability of Project emissions will be evaluated by AST through an air monitoring program at the boundary of the Site. This will entail continuous measurements of wind, H_2S and fine particulates ($PM_{2.5}$).

Further analyses also demonstrated that there should be no adverse acidity effects within the region of the proposed Project and that Project emissions will not lead to ozone creation. Estimated depositions of sulphur particulates were localized with a maximum value at the plant boundary of 1.1 kg/ha/y.

Specific air quality and cumulative air quality effects are discussed in sections of the EIA related to wildlife, vegetation, water quality and soils.

Climate Change

AST is committed to addressing climate change, and improving its overall carbon emissions in a manner consistent with Alberta's goals, targets and actions to reduce greenhouse gas emissions in the province, as outlined in *Alberta & Climate Change: Taking Action* (AENV 2002). The Project itself will have minimum impact on increasing atmospheric greenhouse gases. Changes to climate are expected to have very little impact to the Project because the associated activities and proposed Site are not sensitive to changing climatic conditions, with the exception of water supply for which an adaptation plan has been developed.

Aspects of the TOR relevant to the climate change assessment are as follows.

Discuss the following:

a) *review and discuss climate change and the local and/or regional, inter-provincial/territorial changes to environmental conditions resulting from climate conditions, including trends and projections where available;*

Climate change refers to a significant shift from one climate regime to another. Concern is growing because average global temperatures are rising, and measurable increases in temperatures and changes in precipitation patterns were observed in Alberta. It is estimated that the temperature in Bruderheim has increased by 0.4°C per decade between 1960 and 1995. These changes appear to be related to an increase in greenhouse gases that trap heat in the atmosphere. For example, carbon dioxide (CO_2) levels are increasing and it is estimated that the atmospheric CO_2 concentration will double by approximately 2050.

The results from the Canadian Climate Centre's most recent diagnostic tool for climate modelling, the $CGCM^3$ global climate model, were used to estimate future climate change impacts at the Site. Data generated by the $CGCM^3$ model was based on the Intergovernmental Panel on Climate Change (IPCC) scenario IS92a. This scenario predicted temperature and precipitation over Western Canada for the time-slice simulation between 2040 and 2049.

Under the IS92a climate scenario, the Project area is expected to warm by approximately 2–3°C by 2050 relative to the 1975–1984 mean. Precipitation is expected to decrease by up to 0.25 mm/d (91 mm/y, or approximately 25%) relative to the 1975–1984 mean, although there is low confidence in any long-term precipitation forecasts relative to temperature predictions.

b) *identify stages or elements of the Project that are sensitive to changes or variability in climate parameters. Discuss what impacts the change to climate parameters may have on elements of the Project that are sensitive to climate parameters; and*

Changes to climate are expected to have very little impact to the Project because the associated activities and proposed Site are not sensitive to changing climatic conditions. The primary component of the Project that may be sensitive to climate change would be the supply of water for non-contact cooling of sulphur during the forming process. The predicted reduction in precipitation and, by extension, runoff may be enough to constrain the operations by 2040 (2040 is beyond the temporal boundary of the project for the purpose of doing the EIA). An alternative water supply would need to be identified if this were the case.

c) *comment on the adaptability of the Project in the event the region's climate changes. Discuss any follow-up programs and adaptive management considerations.*

AST has identified the Lamont County Water Utility as a fall-back option for delivering water to the Project. Further, the design and capacity of the stormwater management system may need to be adjusted to account for changing precipitation trends, should these changes occur.

2. Climate and Air Quality

2.1 Introduction

Alberta Sulphur Terminals Ltd. (AST) is requesting regulatory approval for the construction, operation and reclamation of a sulphur forming and shipping facility (the Project) for the Bruderheim area located in Section 35-55-20-W4M (the Site). The Site is located approximately 2.2 km east of Bruderheim, Alberta, within the Industrial Heartland area of Lamont County.

Liquid sulphur will be delivered to the proposed facility by truck, rail tank car or future pipeline. Although only degassed liquid sulphur with a maximum H_2S content of 10 ppm will be accepted at the facility, venting and management systems will be incorporated into the reception process. Upon delivery, liquid sulphur will be transferred via a pumping station into insulated, heated tanks, each having a holding capacity of approximately 3,000 tonnes (t). The Environmental Impact Assessment (EIA) is based on a total molten storage tank sulphur capacity of 18,000 t. Exhausts from the storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed 1 ppm by volume.

The pastille forming process first involves pumping sulphur from receiving tanks to a feed tank. It is then pumped from the feed tank at a rate of 6,000 t/d through a duplex filter and conditioning unit which cools the sulphur to an optimal forming temperature of 125°C. The cooled liquid is fed to the Rotoform drop forming equipment. Resulting pastilles with typical diameters of about 3 mm are gathered into a collection hopper, conveyed to a radial stacking conveyor and deposited on an asphalt bulk storage pad with a capacity of 90,000 t. This storage pad will be shielded from the wind by a 6.1 m screen. The pastilles will be periodically loaded onto rail cars for shipment. Loading operations involve the combined use of front end loaders and a conveyor belt. Pastilles may suffer some mechanical damage during the storage and loading process. Particle sizes resulting from the mechanical interactions remain relatively large. Measurements have shown that 99.8% of all sulphur pastilles/particles still retain diameters of greater than 2 mm (Maxxam Analytics Inc. 2005).

Dust suppression in the rail-out area will be achieved with the use of a proprietary dust suppression agent and release aid, as well as water. Dust suppression agents will be applied to all transfer points including behind the hopper and at the rail-out.

Air emissions associated with pastille forming, storage and shipping operations contain a wide variety of components, including:

- sulphur dioxide (SO_2)
- nitrogen oxides (NO_x)
- carbon monoxide (CO)
- fine particulate matter ($PM_{2.5}$)

Maximum ground-level concentrations of criteria air contaminants (Environment Canada 2004, Internet site) such as SO_2, nitrogen dioxide (NO_2), CO, $PM_{2.5}$ and ozone (O_3) are governed by provincial (Alberta Environment, AENV 2006a, Internet site) and federal objectives (Health Canada 2005, Internet site). With the exception of O_3, these air emissions are primary pollutants (i.e., they are emitted directly from the source). Ozone is a secondary pollutant (i.e., not emitted directly, but created in the atmosphere by chemical reactions) that is sometimes formed as a consequence of interactions among O_3, nitrogen oxides (NO_x) and volatile organic compounds (VOC). Ozone can also be formed as a result of reactions among natural air constituents.

Occasionally, O_3 in the stratosphere becomes mixed with air at ground level, resulting in higher natural O_3 levels at the earth's surface. Sulphur and NO_x emissions may be chemically transformed into sulphates and nitrates that could result in the acidification of soil and water systems. Critical, target and monitoring loads were adopted by AENV for evaluating and managing acid deposition (CASA and AENV 1999). Sulphur particles contribute to airborne dust and when deposited, may result in local acidification of soils and water. The Project will not have any significant air emissions of non-criteria contaminants such as VOCs (e.g., benzene, toluene) or polycyclic aromatic compounds (PAH) (e.g., benzo(a)pyrene, chrysene). This section assesses issues relating to the acceptability of ground-level concentrations of criteria air contaminant emissions associated with the Project through an evaluation of observational data and dispersion modelling predictions. It also deals with issues pertaining to O_3 creation and acid deposition.

2.2 Issues Scoping

Four air quality issues potentially relate to the Project's operation, including:

- air emissions of criteria air contaminants – industrial emissions of criteria air contaminants associated with Project operations and from operations at surrounding industries could result in ground-level concentrations in excess of applicable regulatory objectives and guidelines
- acid deposition – emissions of potential acid forming substances such as SO_2 and NO_x could result in acid deposition in excess of critical loads adopted by AENV
- acid deposition – emissions of sulphur particles and subsequent deposition may result in local soil/water acidification
- ozone formation – O_3 can be created as a result of photochemical reactions with NO_x, VOC and ambient air

2.3 Methods

The air quality issues were assessed by evaluating data collected from air monitoring stations and predicted air quality using computer models. The data were evaluated against applicable air quality guidelines and deposition limits as defined by regulatory authorities.

2.3.1 Spatial and Temporal Boundaries

2.3.1.1 <u>Spatial Boundaries</u>

Figure 2.3-1 is a map of the Climate and Air Quality Local Study Area (LSA) northeast of Edmonton. It shows the locations of 32 existing, planned and proposed major industries with respect to the Site. The only industry within 12 km of the Project is the Bruderheim Sodium Chlorate Plant operated by Canexus Chemicals Canada Ltd. Partnership (Canexus).

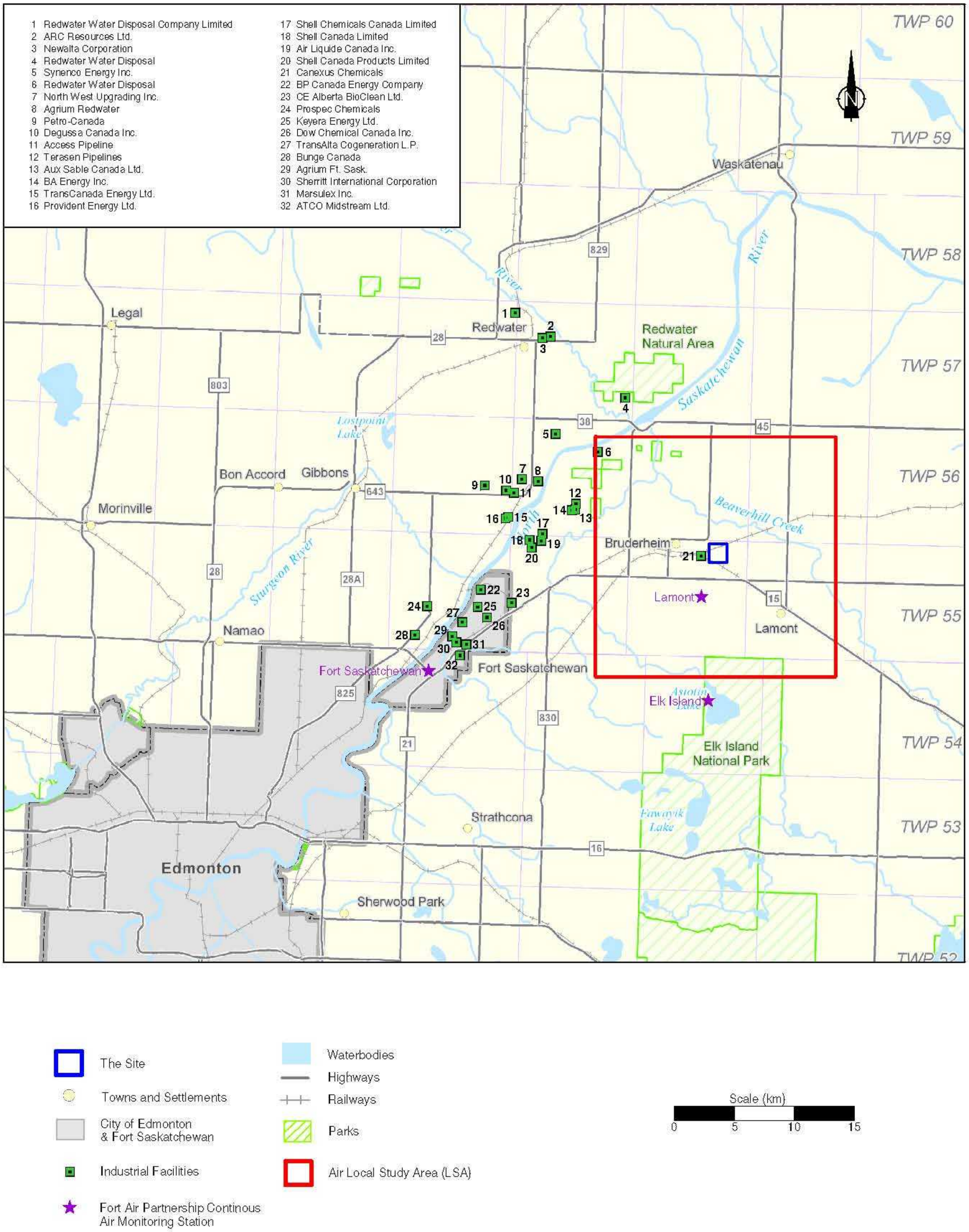
The LSA surrounding the Project is outlined in red in Figure 2.3-1. AST's proposed facility fenceline, denoted by the solid blue line, is situated approximately 2.2 km east of Bruderheim, within the vicinity of the Canexus Plant. The facility is located near the junction of railway tracks owned by Canadian Pacific (CPR) and Canadian National (CN) railways. The surrounding topography is characterized by regular terrain, typical of a Parkland setting. The LSA includes all areas where estimated ground-level pollutant concentrations attributable to emissions from the Project would be greater than 10% of regulatory guidelines. It thus includes measurable effects of the Project alone and effects of the Project in combination with other activities.

At and beyond the LSA boundary, the anticipated environmental conditions should be similar with and without the Project (AENV 2003). It also includes all areas encompassed by significant potential acid input (PAI) in terms of hydrogen ion per hectare per year (keq H^+/(ha•y)) attributable to Project emissions.

2.3.1.2 Temporal Boundaries

Air quality assessments were made for a time frame that included the present and extended over the projected life of the Project, which is expected to be 25 years. Three cases were selected for detailed assessment: baseline, application and cumulative.

The baseline case considers impacts of current and approved air quality regimes in the study area. The application case addresses the air quality occurring immediately after completion of the Project while the cumulative effects case assesses the effects of announced future development following Project completion. Table 2.3-1 lists the existing, approved and proposed projects within the general region northeast of Edmonton, as shown in Figure 2.3-1. For a full description of the schedule for construction, operation, decommissioning and reclamation, refer to Volume I: Project Description.



Map of the Regional Study Area (RSA) Showing Locations of Major Industries with Respect to the Project Proposed for a Site near Bruderheim.

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Table 2.3-1: Project Inclusion List

Operator	Facility	Project Status		
		Existing	Approved (Not Operating)	Planned (Not Approved)
Access Pipeline	Redwater Trim Blending Facility			X
Agrium Products Inc.	Fort Saskatchewan Fertilizer Plant	X		
Agrium Products Inc.	Redwater Fertilizer Plant	X		
Air Liquide Canada	Scotford Cogeneration Power Plant	X		
Alberta Sulphur Terminals	Bruderheim Sulphur Forming Facility			X
ARC Resources	Redwater Gas Conservation Plant	X		
ATCO Midstream	Fort Saskatchewan Sour Gas Plant	X		
Aux Sable Canada	Heartland Offgas Project			X
BA Energy	Heartland Bitumen Upgrader		X	
BP Canada Energy	Fort Saskatchewan Fractionation Plant	X		
Bunge Canada	Fort Sask. Oilseed Processing Plant	X		
Canexus Chemicals Canada	Bruderheim Sodium Chlorate Plant	X		
CE Alberta BioClean	Fort Saskatchewan Chemical Plant		X	
Degussa Canada Inc.	Gibbons Hydrogen Peroxide Plant	X		
Dow Chemical Canada	Fort Saskatchewan Chemical Plant	X		
ERCO Worldwide	Bruderheim Sodium Chlorate Plant	X		
Keyera Energy	Fort Saskatchewan Fractionation Facility	X		
Marsulex	Fort Saskatchewan Chemical Plant	X		
Newalta Corporation	Redwater Disposal Facility	X		
North West Upgrading Inc.	North West Upgrader Project			X
Petro-Canada Oilsands Inc.	Sturgeon Upgrader Project			X
Prospec Chemicals	Fort Saskatchewan Xanthate Plant	X		
Provident Energy Ltd.	Redwater Fractionation Facility	X		
Redwater Water Disposal Company	Redwater Waste Disposal Facility	X		
Shell Canada Limited	Scotford Upgrader	X	X expansion	
Shell Canada Products	Scotford Oil Refinery	X		

Table 2.3-1: Project Inclusion List (Cont'd)

Operator	Facility	Project Status		
		Existing	Approved (Not Operating)	Planned (Not Approved)
Shell Chemicals Canada	Scotford Styrene & MEG Plant	X		
Sherritt International Corporation	Fort Saskatchewan Fertilizer Plant	X		X
Synenco Energy Ltd.	Northern Lights Upgrader Project			X
Terasen Pipelines	Heartland Storage Tank Terminal			X
TransAlta Cogeneration	Fort Sask. Cogeneration Power Plant	X		
TransCanada Energy	Redwater Cogeneration Power Plant	X		

2.3.1.3 Air Monitoring Data

The first step in the assessment of baseline air quality is the evaluation of existing air quality and climate data. These data are useful for determining current regional air quality.

AST is a member of the Fort Air Partnership (FAP) which was established to run an air monitoring system in the Fort Saskatchewan area. The FAP exists to develop relevant credible information that can be used to manage air quality, protect environmental health and influence policy. Information relating to regional ground-level concentrations of the criteria pollutants is available from continuous monitoring stations operated at Fort Saskatchewan, Lamont and Elk Island. Locations of these stations are shown in Figure 2.3-1. Their sites were chosen so that air quality measurements would be representative of regional conditions. For this reason they may not always be situated in areas where industrial air quality impacts are predicted to be at their maximum values.

2.3.1.4 Dispersion Modelling

The second step in the assessment of baseline air quality is based on predictions using air quality dispersion models. The models were used in accordance with AENV guidelines (AENV 2003) to predict ground-level concentrations of air emissions under specified meteorological and topographical conditions.

Plume dispersion models were used to assess the potential impacts of air emissions associated with the Project and also from the Canexus Sodium Chlorate Plant. The dispersion models predict ground-level concentrations during specified meteorological conditions using a set of given emissions. Models can be used to provide predictions concerning:

- temporal and spatial patterns of air quality throughout a given area
- contributions from each type of source to changes in air quality
- meteorological conditions under which unacceptable air quality could occur
- the most appropriate location for monitoring air quality in an area
- potential consequences of remedial actions designed to decrease air emissions

Changes in ambient air quality associated with emissions from the Project and the Canexus facility were predicted using the CALPUFF dispersion model (Scire et al. 1999). This model is a multi-layer, non-steady-state dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and deposition. The plume dispersion model sequentially calculates hourly pollutant concentrations resulting from multiple sources and incorporates near-source effects, such as building downwash, chimney downdraft influences and partial plume penetrations into elevated stable atmospheric layers. It also allows for long-range effects such as pollutant removal (wet scavenging and dry deposition), chemical transformations and vertical wind shear. The model is well known within the air quality modelling discipline, widely accepted, well documented and is regularly updated as new data and correlations are obtained. Studies have shown that air pollutant concentrations resulting from generating station emissions predicted using CALPUFF, compare favourably with observed values (Strimaitis et al. 1998). For a more detailed description of the CALPUFF model and its parameters, including meteorological variables and model options employed in this study, refer to Appendix I.

For dispersion modelling, AENV (2003) allows calculated concentrations to exceed the ambient air quality criteria provided the predicted exceedances do not occur more than 8 hours on an annual basis (i.e., 0.10% of the time). This means that the eight highest hourly average concentrations may be rejected annually. The rejections are allowed because various approximations applied to develop the meteorological dataset used for plume dispersion predictions will occasionally result in unrepresentative values. Therefore, maximum predicted hourly average concentrations of air emissions presented in this study will always pertain to the 99.9% value.

Air emissions from the Project are emitted primarily from identifiable point sources. Fugitive emissions were combined, for study purposes, into larger area sources and are assumed to be uniform over that particular area. Both point and area source emissions can be theoretically evaluated, in terms of ground-level air quality impacts, through the use of plume dispersion models.

Irregular terrain has the potential to influence plume dispersion because of wind channeling, thermally developed wind systems and plume impaction on high terrain. Terrain within 20 km of the proposed AST Project tends to be regular with few topographical features.

Concentrations of NO_2 occur partly as a result of nitric oxide scavenging by O_3. Estimates of NO_2 were made through use of the ozone limiting method (OLM) whereby O_3 and NO_x are assumed to react to form NO_2 (AENV 2003). The CALPUFF model, with its chemical conversion equations, was also employed for estimating ground-level concentrations of secondary pollutants (e.g., sulphates (SO_4^{2-}) and nitrates (NO_3^-), which occur as a result of chemical transformations of primary pollutants (SO_2 and NO_x). These secondary pollutant particles are in the $PM_{2.5}$ range and along with the primary $PM_{2.5}$ emissions make up the total predicted $PM_{2.5}$ concentration. The CALPUFF model was also used for predicting PAI.

2.3.2 Air Quality Objectives, Guidelines and Criteria

Conclusions of this air quality study relating to the acceptability of estimated ground-level concentrations rely upon objectives, guidelines and criteria formulated and accepted by regulatory agencies. Table 2.3-2 describes the recommended objectives and their general intent for criteria air contaminants used by Environment Canada for the categories desirable, acceptable and tolerable (Furmanczyk 1994). The desirable objective is the most stringent. Table 2.3-3 shows the current Alberta Ambient Air Quality Objectives (AAAQO) (AENV 2006a, Internet site) for SO_2, NO_2, CO, H_2S and O_3 and comparable National Ambient Air Quality Objectives (NAAQO). Most of Alberta's objectives correspond to the national desirable category. The objectives with respect to H_2S were established for the prevention of odour nuisances. The other objectives were established for the protection of vegetation and human health. Objectives are not usually established expressly for visibility protection. This is because visibility impairment tends to occur at contaminant concentrations larger than those levels deemed protective of vegetation and human health.

Table 2.3-2: National Ambient Air Quality Objectives

Objective	Description
Maximum desirable (most stringent)	Long-term goal for air quality. Provides a basis for anti-degradation policy for unpolluted parts of the country and for continuing development of control technology
Maximum acceptable	Provides adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and wellbeing
Maximum tolerable (least stringent)	Indicates that appropriate abatement strategies are required without delay to avoid further deterioration to air quality to protect the health of the general population

Table 2.3-3: Alberta and National Ambient Air Quality Objectives for CO, NO_2, O_3, SO_2 and H_2S

Parameter	AAAQO [1,2]		NAAQO [1,3]			
			Desirable Objective		Acceptable Objective	
	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm	$\mu g/m^3$	ppm
Carbon monoxide						
1-hour maximum	15,000	13.0	15,000	13.0	34,600	30.0
8-hour maximum	6,000	5.0	6,000	5.0	12,700	11.0
Nitrogen dioxide						
1-hour maximum	400	0.21	N/A	N/A	400	0.21
24-hour maximum	200	0.11	N/A	N/A	200	0.11
Annual mean	60	0.032	60	0.032	100	0.05
Ozone						
1-hour maximum	160	0.082	100	0.050	160	0.082
Sulphur dioxide						
1-hour maximum	450	0.17	450	0.17	900	0.34
24-hour maximum	150	0.06	150	0.06	300	0.11
Annual mean	30	0.01	30	0.01	60	0.02
Hydrogen sulphide						
1-hour maximum	14	0.010	N/A	N/A	N/A	N/A
24-hour maximum	4	0.003	N/A	N/A	N/A	N/A

Notes:
[1] Concentrations are given in $\mu g/m^3$ at 25°C, 101.325 kPa, dry basis and ppm by volume.
[2] AAAQO = Alberta Ambient Air Quality Objective.
[3] NAAQO = National Ambient Air Quality Objective.
N/A – not available.

Canada's long term air quality management goal for O_3 and fine particulate matter is to minimize the risks of these pollutants to human health and the environment. As a result, Canada-Wide Standards (CWS) were established for both pollutants. They represent a balance between the desire to achieve the best health and environmental protection possible in the near term and the feasibility and costs of reducing pollutant emissions that contribute to elevated levels of O_3 and particulate matter in the ambient air. As a basic requirement, jurisdictions will report on CWS for population centres over 100,000. The CWS achievement will be based on community-oriented monitoring sites (e.g., sites located where people live, work and play) rather than at the expected maximum impact point for specific emission sources. Recently established CWS for O_3 and $PM_{2.5}$ are presented in Table 2.3-4. They are to be implemented by year 2010. They were used for this study because the Project will be in operation beyond the implementation year of 2010. The CWS for $PM_{2.5}$ corresponds to a visible range of about 40 km (Environment Canada 1999).

Table 2.3-4: Canada-wide Standards for O_3 and $PM_{2.5}$

Air Contaminant	Canada-wide Standard
O_3	130 µg/m^3 (65 ppb) averaged over an 8-hour period. Achievement will be based on the fourth highest measurement annually, averaged over three consecutive years
$PM_{2.5}$	30 µg/m^3 averaged over a 24-hour period. Achievement will be based on the 98th percentile ambient measurement annually, averaged over three consecutive years

AENV has a particulate matter and O_3 management framework developed in response to its endorsement of the CWS for $PM_{2.5}$ and O_3. It is based upon four action levels involving: monitored data, surveillance actions, a management plan and a mandatory plan to reduce ambient concentrations below CWS values. Each level of action above the monitoring level is triggered by threshold observational criteria. For example, the surveillance action criteria for $PM_{2.5}$ of 15 µg/m^3 is based on the 98th percentile ambient measurement annually, averaged over three consecutive years. The surveillance action trigger for O_3 is an 8-hour average of 58 ppb and achievement is based on the 4th highest measurement annually averaged over three consecutive years. An annual analysis of ambient $PM_{2.5}$ and O_3 concentrations as observed at monitoring stations included in Alberta's ambient air quality monitoring system determines the appropriate action level for each area of the province. The monitoring stations, which include the FAP monitoring units, are situated such that their measurements assess representative regional air quality levels rather than localized maximum air quality impacts associated with industrial emissions. More details of the action framework can be found in AENV (2006b, Internet site).

2.3.2.1 *Deposition Criteria*

Emissions of SO_2 and NO_x result in wet and dry deposition to ground surfaces (soil and water) of potentially acidifying anions such as sulphates and nitrates. Adverse effects of these depositions on soil and water chemistry can be partly or entirely neutralized through the deposition of basic cations, such as calcium, magnesium, potassium and sodium. The cations may be of natural origin (e.g., wind blown dust) or from human activity. PAI is assessed by assuming the acidifying potential of deposited sulphur and nitrogen compounds such as SO_2, sulphates (SO_4^{2-}), NO_2, nitric oxide (NO), nitric acid (HNO_3) and nitrates (NO_3^-). This assumption is conservative since vegetation can use much of the deposited material as nutrients. Nonetheless, the concept of PAI can be useful as a parameter for managing and evaluating deposition of acid-forming emissions.

AENV has adopted critical, target and monitoring loads for PAI for evaluating and managing the effects of industrial emissions of acidifying gases (CASA and AENV 1999):

- critical load – the highest load that will not cause chemical changes leading to long-term harmful effects
- target load – level that considers the critical load and is practically and politically achievable. If this target is exceeded, a management plan must be developed through a

consultation process to reduce emissions of acidic gases so the PAI is below the target load

- monitoring load – level that triggers monitoring and research actions

Table 2.3-5 shows values of critical, target and monitoring loads applied in Alberta for high, medium and low sensitivity soils. The critical loads shown in the table were established on the basis of research conducted in Europe and an assessment of Alberta soil and water sensitivity. The target and monitoring loads were established on the basis of consensus reached after four years of work by a wide range of stakeholders brought together in the Target Loading Subgroup of CASA.

Table 2.3-5: PAI Critical, Target and Monitoring Loads for Alberta

Soil Type	Critical Load keq H^+/(ha•y)	Target Load keq H^+/(ha•y)	Monitoring Load keq H^+/(ha•y)
High sensitivity	0.25	0.22	0.17
Medium sensitivity	0.50	0.45	0.35
Low sensitivity	1.00	0.90	0.70

RELAD is a three-layer mass-conserving regional scale Lagrangian model that simulates ground-level ambient concentrations and wet and dry deposition of SO_2, hydrogen sulphate (H_2SO_4), ammonium sulphate ($(NH_4)_2SO_4$), NO_x, HNO_3 and ammonium nitrate (NH_4NO_3). The RELAD model domain is from 47°N to 62°N latitude and from 100°W to 130°W longitude (British Columbia, Alberta, Saskatchewan, portions of Manitoba and the northern territories and the northwestern United States) with a resolution of 1° latitude by 1° longitude (approximately 111 km by 60 km).

In order to run the RELAD model, three data sets are required. The first is an emissions inventory, a database of SO_2 and NO_x emissions from within each of the grid cells in the model domain. Emissions were categorized as rising from large point sources (tall stacks), area sources (e.g., urban centres) and linear sources (e.g., highways) within the individual cells. The second data requirement is an estimate of each of the various chemical reactions and rates of reactions that occur among the acid-forming substances emitted into the atmosphere. The third required data set contains meteorological data (wind speed, wind direction, air temperature, relative humidity and mixing depths). A more detailed description of the calculation of PAI through use of the RELAD model can be found in Cheng et al. (1997).

The provincial process for evaluating and managing acid deposition will be re-evaluated by AENV to ensure that it is compatible with revised or alternate models if:

- RELAD is substantially changed
- the basis for application of the RELAD results is changed (e.g., application of the results to grid cells of a size other than 1° latitude by 1° longitude)
- a different model is used for estimating potential acid deposition

Potential acid deposition for the Bruderheim area, as well as for the rest of Alberta, will be assessed by AENV every five years (CASA and AENV 1999). Each of these assessments will include updated emission inventories, receptor sensitivity research and meteorological data and will be based upon results generated from the RELAD model. More frequent assessments were not deemed useful because the required databases will not change substantially or be available on a two or three-year cycle.

Estimates of local PAI patterns were obtained through the use of the CALPUFF dispersion model.

2.4 Baseline Case

A baseline assessment was performed for air quality impacts considering the following factors:

- a summary of the regional climatology
- a review of existing air emission sources at the Canexus Sodium Chlorate Plant which lies adjacent to the Project
- an evaluation of observed air quality data
- an assessment of predicted air quality impacts of existing local emissions as obtained using air quality dispersion models

2.4.1 Climate and Meteorology

Climate and meteorology are key inputs into the understanding of current air quality and predicting the future air quality. Wind data were collected at the Lamont air quality monitoring station while all other climate data were collected at the nearest source of climatological information, the Edmonton International Airport at Leduc, Alberta. The climate and meteorological analyses included the following parameters:

- ambient temperature
- precipitation
- wind
- relative humidity
- visibility
- severe weather

A summary of the climate and meteorological analyses is presented in the following sections. For detailed results of the analyses, see Appendix II.

2.4.1.1 Temperature

The annual mean temperature for the Bruderheim area is about 3°C. A record high temperature of 35.3°C in August and a record low of -48.3°C in January were recorded. Freezing temperatures have occurred during every month of the year except July. An extreme summer minimum temperature of -6.1°C was recorded in June.

2.4.1.2 Precipitation

Annual average total precipitation is 460 mm consisting of 355 mm of rain and 105 cm of snow. Slightly more than half of the annual rainfall occurs in the summer in June, July and August. The wettest month is July, when average total precipitation is 95 mm. The driest months are January through March with average total monthly precipitation ranging from 13–27.3 mm. Measurable snowfalls have occurred in all months except June and July.

2.4.1.3 Wind

Winds in the study area are predominately from the west-southwest sector. Calm wind conditions occur about 1.5% of the time. Wind speeds seldom exceed values of 50 km/h^{-1} (13.9 m/s^{-1}).

2.4.1.4 Relative Humidity and Moisture Deficit

The mean annual relative humidity in the region is about 68%, fluctuating to its lowest point in late spring and the highest in mid-summer. May tends to have the lowest relative humidity with an average of 58%, whereas August tends to have the highest with an average of 73%.

2.4.1.5 Visibility

Visibility in the area, as measured at the Edmonton International Airport, is greater than 9 km about 93% of the time. Visibility is less than 1 km for only about 1.0% of the time.

2.4.1.6 Severe Weather

Severe weather is characterized by such phenomena as thunderstorms, freezing rain and hail. Thunderstorms occur, on average, about eight days during the month of July, but only one day during September. Freezing rain occurs at an average of about two days during November and December. Hail occurs about three times a year in June, July and August.

2.4.2 Baseline Case Emission Sources

The location of the Project with respect to existing, approved and planned industrial projects has been shown in Figure 2.3-1. The Canexus Chemicals Sodium Chlorate Plant is the only industry located within 12 km of the Site. Table 2.4-1 presents emission parameters for criteria contaminants associated with its operation. The boiler exhaust vent is the only significant source of NO_x. The baghouses and vaculoaders are minor sources of fine particulates.

Emission parameters for the other existing but more distant industrial sources shown in Figure 2.3-1 may be found elsewhere (e.g., Jacques Whitford-AXYS (2006)).

2.4.3 Results of Air Quality Monitoring

Observations of regional ambient air quality are available for concentrations of H_2S, NO_2, O_3, SO_2 and $PM_{2.5}$ from three FAP monitoring stations, including Fort Saskatchewan, Lamont and Elk Island. These monitoring stations are located at distances of 25, 4 and 12 km respectively from the Site in the southwest, south-southwest and south direction (refer to Figure 2.3-1). Monitoring periods at the three monitoring stations evaluated for this assessment ranged from January 1, 2001–October 31, 2006 and are 70, 58 and 46 months in length, respectively.

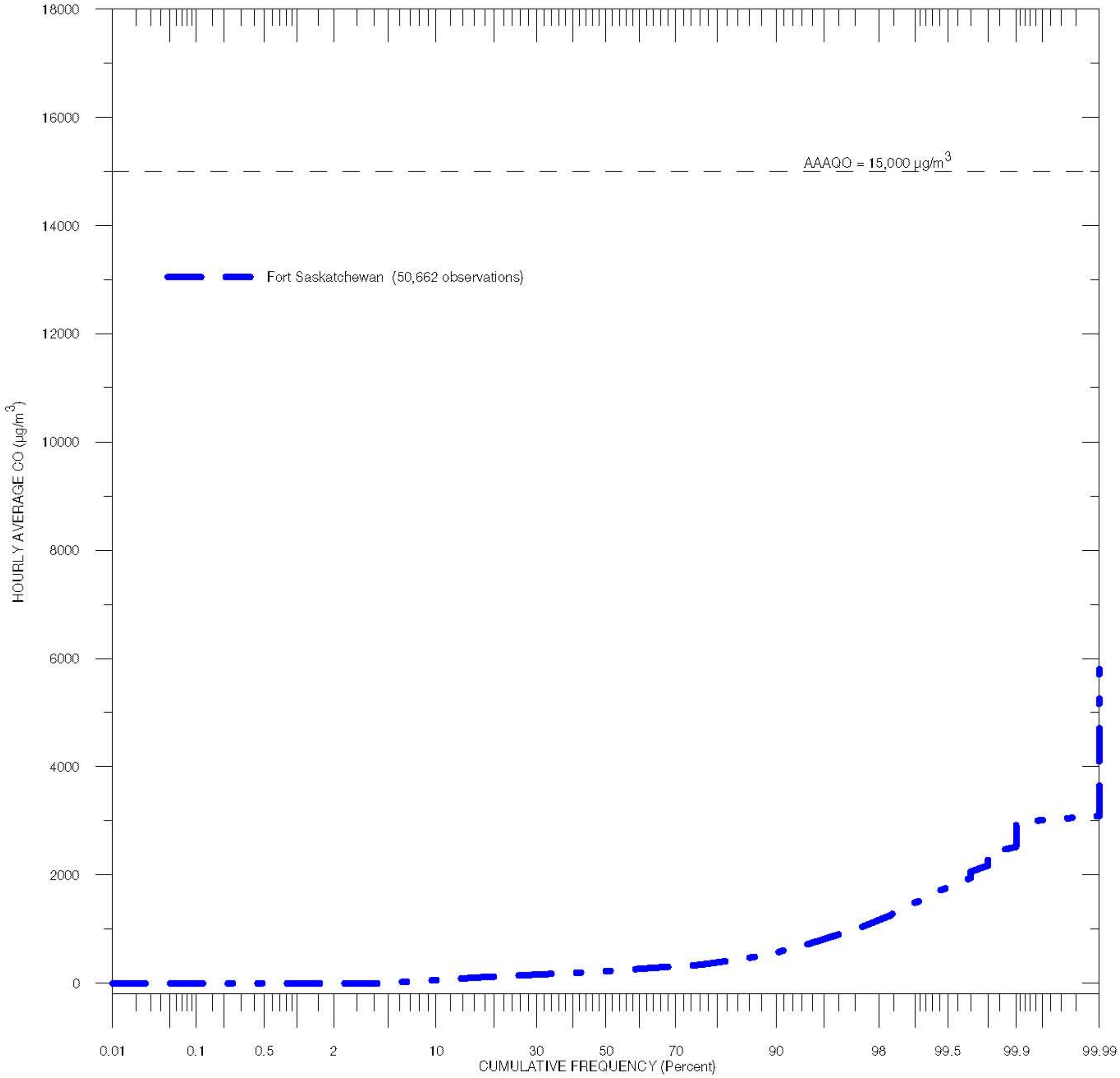
2.4.3.1 Carbon Monoxide

Figure 2.4-1 and Figure 2.4-2 present cumulative frequencies of hourly and 8-hourly average concentrations of CO as observed at the Fort Saskatchewan monitoring station. The number of data points upon which the graphs are based is shown in brackets. There is no monitoring for CO at the Lamont and Elk Island stations.

Table 2.4-1: Stack and Emission Parameters for Continuous Point Sources at the Canexus Chemicals Bruderheim Sodium Chlorate Plant (Criteria Contaminants)

Parameter		Boiler Exhaust Vent	Flare Stack (Pilot)	Fluidized Bed Dryer Unit Scrubber Vent	Sodium Chlorate Hopper Baghouses		Vaculoaders	
					Vent #1	Vent #2	Vent #1	Vent #2
Release direction		Vertical	Vertical	Horizontal	Horizontal	Horizontal	Horizontal	Horizontal
Base elevation (m)		646	646	646	646	646	646	646
Stack height (m)		9.0	18.3	23.5	20.4	20.4	10.7	10.7
Stack diameter (m)		0.61	0.51	0.46	0.10	0.10	0.08	0.08
Exit temperature	°C	194	1000	40	24	37	34	45
	K	467	1273	313	297	310	307	318
Exit velocity ($m\ s^{-1}$)		8.0	0.01	1.0[1]	1.0[1]	1.0[1]	1.0[1]	1.0[1]
Emission rates ($g\ s^{-1}$)	CO	0.159[3]	0.003[3]	-	-	-	-	-
	NO_x[2]	0.189	0.003	-	-	-	-	-
	$PM_{2.5}$	0.0144[3]	0.0002[3]	0.0067	0.0001	0.0001	0.0035	0.0036

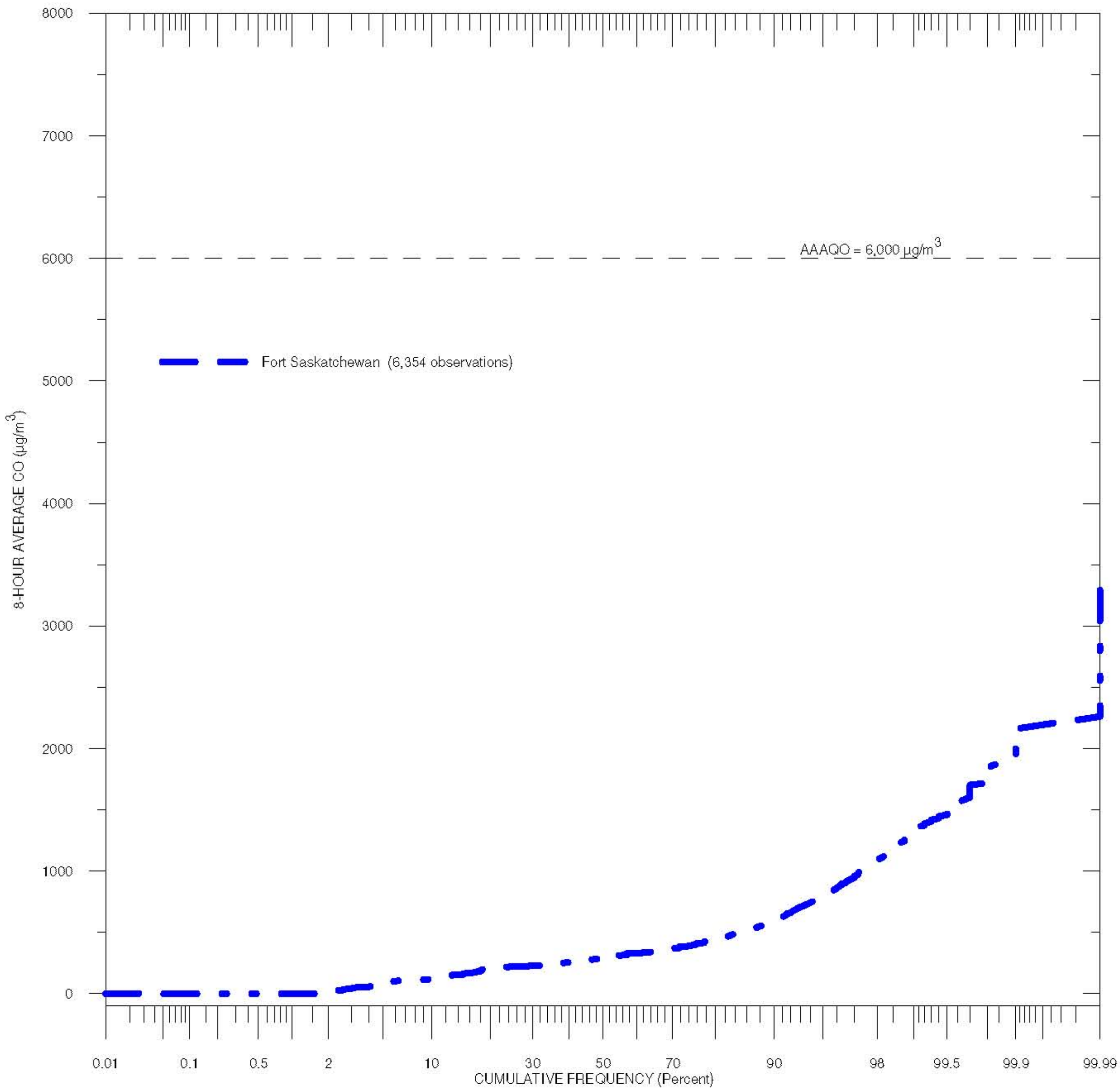
Notes:
1 Exit velocity assumed equal to 1.0 m s-1 for horizontal stacks.
2 NO_x as NO_2 equivalent.
3 Estimated based on the USEPA AP-42, Section 1.4, Natural Gas Combustion, Table 1.4-1 and Table 1.4-2.



Cumulative Frequency Distributions of Hourly Average CO Concentrations (µg/m³) as Observed at the Fort Saskatchewan Air Quality Monitoring Station.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-1	

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/CO 1-hr.srf



DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-2	

Cumulative Frequency Distributions of 8-hour Average CO Concentrations (µg/m^3) as Observed at the Fort Saskatchewan Air Quality Monitoring Station.

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/CO 8-hr.srf

The maximum observed hourly and 8-hourly concentrations were about 5,800 and 3,300 µg/m^3, respectively. All concentrations were much less than the relevant AAAQO values of 15,000 and 6,000 µg/m^3.

2.4.3.2 Hydrogen Sulphide

An analysis of observed data showed that relatively high concentrations of H_2S tended to persist in the Lamont area for lengthy periods during the spring and summer of 2005. This tendency, which ceased abruptly on June 30, 2005, could have been associated with regional oil and gas developments.

Figure 2.4-3 presents cumulative frequencies of hourly averages of H_2S concentrations as observed at Lamont and Fort Saskatchewan over two periods. The first period extends from the beginning of the observational period up to the end of June 2005. The second period is from July 1, 2005–October 31, 2006. An examination of Figure 2.4-3 shows that significantly higher H_2S concentrations occurred during the first period. Thus, for example, maximum observed H_2S concentrations at Lamont prior to and following June 30, 2005 were respectively 18.1 and 8.0 µg/m^3. The same tendency for higher concentrations to occur prior to June 30, 2005 was also apparent at Fort Saskatchewan.

Figure 2.4-4 is similar to Figure 2.4-3 except that it shows daily rather than hourly averages. There is a very distinct difference between the distributions of daily average H_2S concentrations occurring at Lamont before and after June 30, 2005. Maximum observed values during the first and second periods were respectively 3.9 and 2.2 µg/m^3. The difference is almost a factor of two. This difference between the two frequency distributions was less evident at Fort Saskatchewan.

It has been assumed in this report that values of H_2S observed since June 30, 2005 best represent current conditions within the LSA.

2.4.3.3 Nitrogen Dioxide

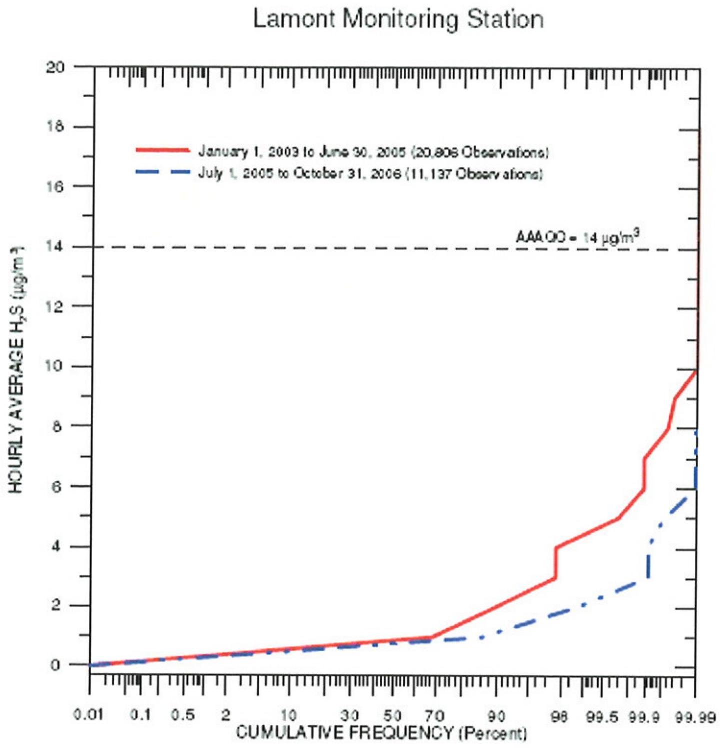
Cumulative frequencies of hourly average ground-level concentrations (µg/m^3) of NO_2 observed at the Lamont, Fort Saskatchewan and Elk Island monitoring stations are shown in Figure 2.4-5. All observed hourly average concentrations are much less than the AAAQO of 400 µg/m^3. The highest concentration observed at Lamont, the closest station to the Project, is approximately 100 µg/m^3.

Figure 2.4-6 is similar to Figure 2.4-5 except that it shows daily average concentrations of NO_2. It demonstrates that daily averages were also much less than the pertinent AAAQO of 200 µg/m^3. The highest concentration observed at Lamont was only about 40 µg/m^3.

The highest annual average NO_2 concentrations observed at the Lamont, Fort Saskatchewan and Elk Island locations were respectively about 4, 18 and 3 µg/m^3. All values are very much less than the relevant AAAQO of 60 µg/m^3.

2.4.3.4 Ozone

Ozone is not a primary pollutant. It is formed as a secondary pollutant as the result of chemical reactions among NO_x and volatile organic compounds. The reactions are complex and depend on meteorological conditions. Some meteorological conditions favour reactions that lead to O_3 production, whereas others favour O_3 destruction. In addition, reactions that create O_3 likely occur simultaneously with those that destroy O_3.



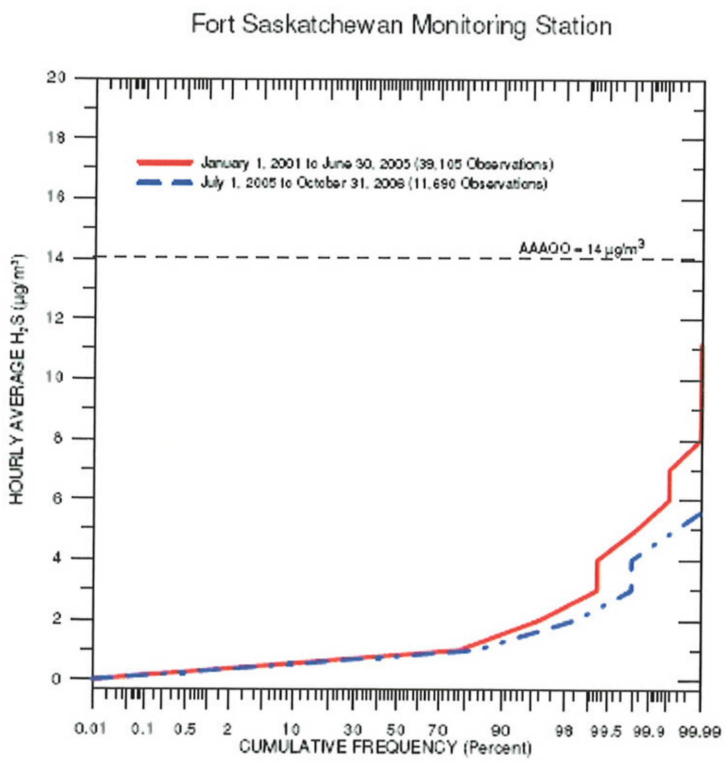
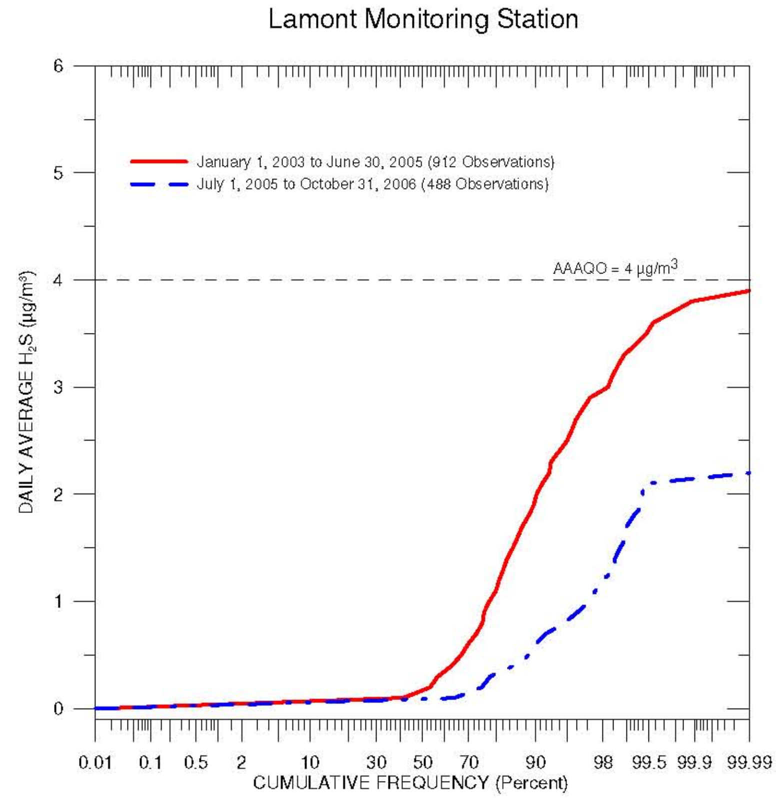
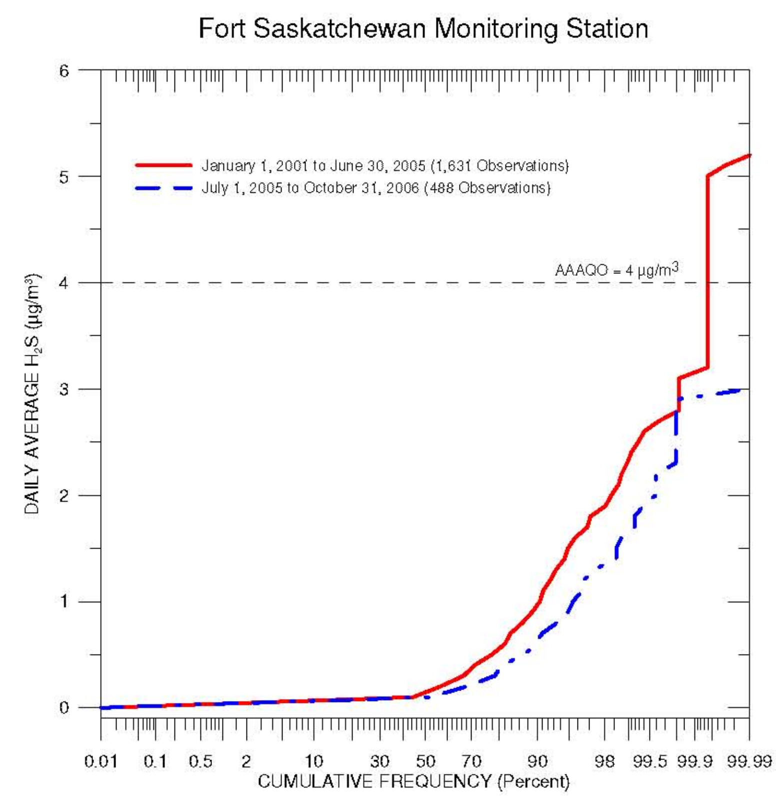


Figure 2.4-3: Cumulative Frequency Distributions of Hourly Average H_2S Concentrations (µg/m^3) Observed over the Indicated Periods at the Lamont and Fort Saskatchewan Air Quality Monitoring Stations

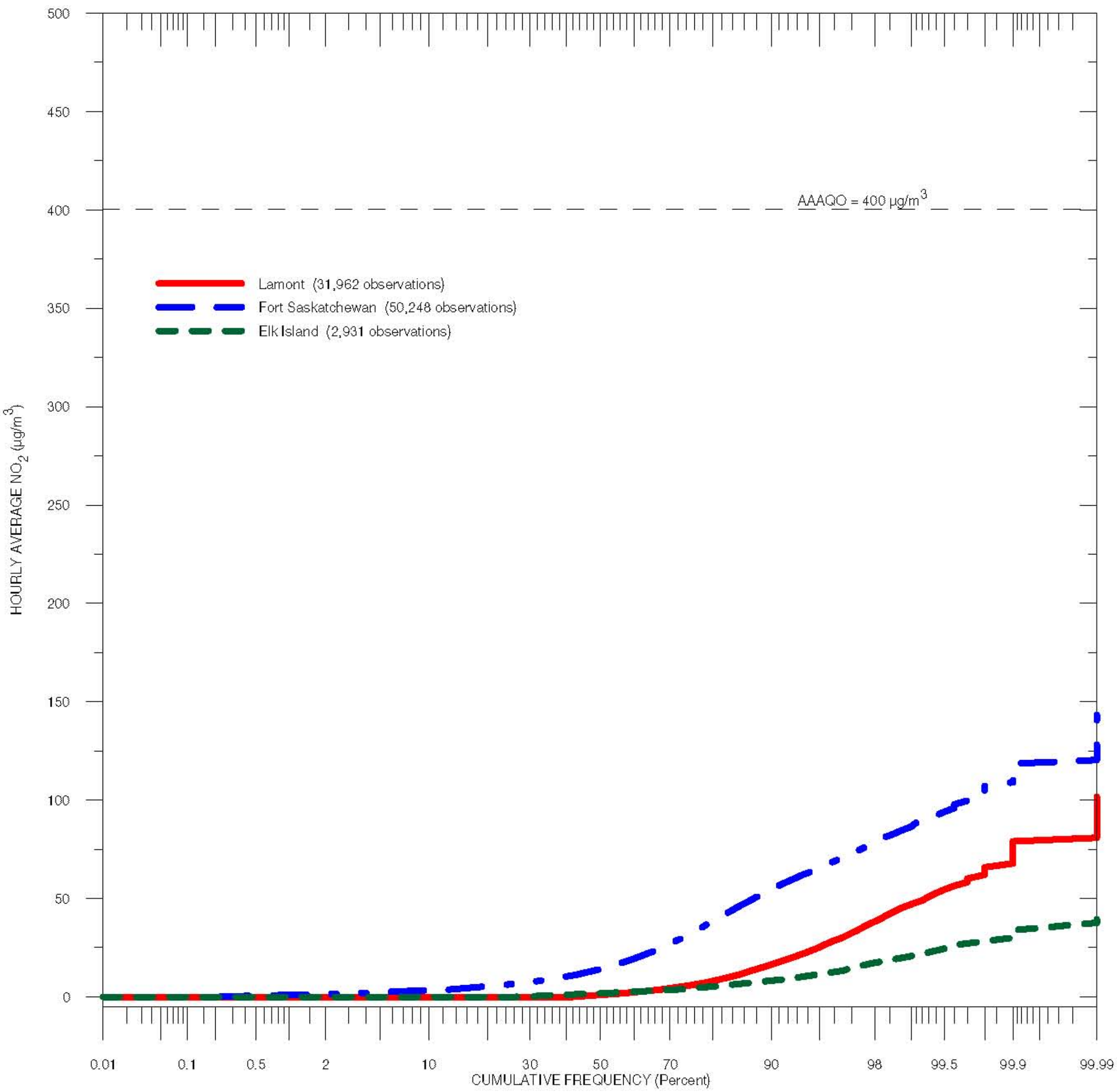




Cumulative Frequency Fistributions of Daily Average H_2S Concentrations (µg/m^3) as Observed Over the Indicated Periods at the Lamont, and Fort Saskatchewan Air Quality Monitoring Stations.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED		FIGURE: 2.4-4

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/H2S 24-hr Split.srf



Cumulative Frequency Distributions of Hourly Average NO_2 Concentrations (µg/m^3) as Observed at the Lamont, Fort Saskatchewan, and Elk Island Air Quality Monitoring Stations.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-5	

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/NO2 1-hr.srf

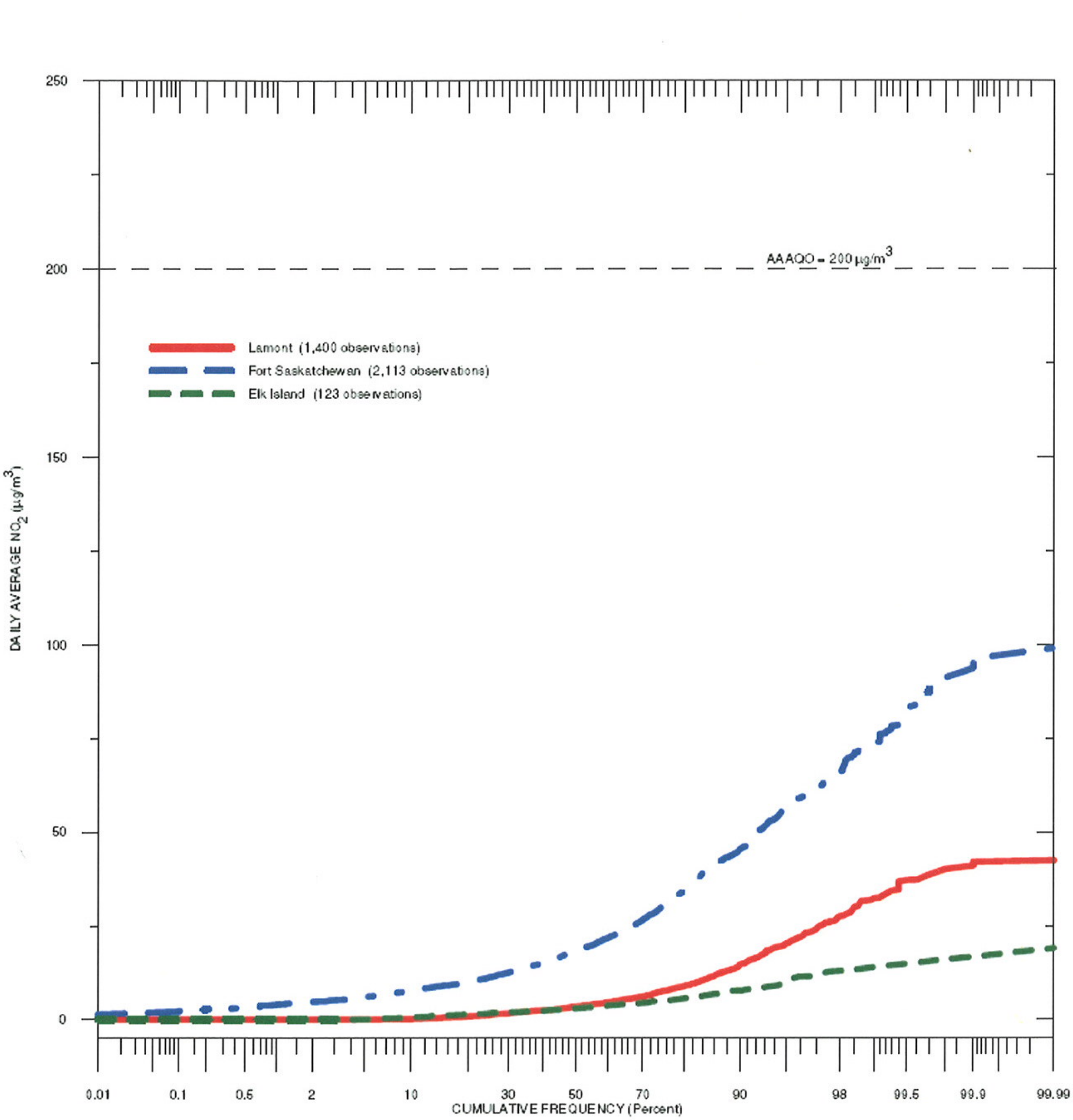


Figure 2.4-6: Cumulative Frequency Distributions of Daily Average NO_2 Concentrations ($\mu g/m^3$) Observed at the Lamont, Fort Saskatchewan and Elk Island Air Quality Monitoring Stations

Conditions that favour reactions leading to O_3 production include:

- ambient temperature above 25°C
- a shallow mixing height (less than 500 m)
- calm or low wind speed conditions (less than 5 km/h^{-1})
- appropriate ratios of volatile organic compounds to NO_x concentrations

Ozone creation is unlikely to occur unless these conditions are met. Ozone creation, when it does occur, tends to reach its maximum value in the centre of a city or in a nearby suburbs (e.g., Mulholland et al. 1998; Baumgardner and Edgerton 1998).

Ambient air quality data with respect to O_3 concentrations within Alberta show that the AAAQO may occasionally be exceeded in all areas of Alberta (CASA 2006, Internet site). These excursions are most common in remote rural sites adjacent to mountain areas.

An examination of Alberta O_3 meteorology by Leahey and Morrow (1999) showed that conditions favourable for creating ozone rarely, if ever, occur. It was concluded that O_3 data in Alberta should consistently show evidence of O_3 depletion because of chemical reactions with NO. This conclusion was tested through an examination of hourly average concentration data for O_3 and NO_x collected at 15 stationary monitoring sites in Alberta. These sites varied widely in geographical location and represented conditions in large cities (Edmonton, Calgary), small cities (Fort Saskatchewan, Fort McMurray) and rural areas. The information was analyzed for days with ambient temperatures exceeding 25°C to determine both median and extreme O_3 values associated with given NO_x values. The analysis encompassed more than 48,000 hours of data.

Results of the evaluation showed that anthropogenic NO_x emissions tended to result in O_3 reduction. The reduction in all areas is consistent with NO scavenging. Leahey and Morrow (1999) concluded that, under the meteorological conditions that predominate in Alberta, anthropogenic NO_x emissions result in reduced ambient O_3 concentrations.

Figure 2.4-7 shows cumulative frequencies of hourly average ozone concentrations observed at the Lamont, Fort Saskatchewan and Elk Island monitoring stations. The AAAQO of 160 $\mu g/m^3$ was marginally exceeded at all three stations. The lowest ozone concentrations tended to be observed in Fort Saskatchewan where NO_2 concentrations are greatest (see Figure 2.4-5 and Figure 2.4-6). Median values of hourly average O_3 concentrations observed at Lamont, Fort Saskatchewan and Elk Island were respectively about 57, 40 and 55 $\mu g/m^3$. The greatest hourly average O_3 concentrations observed at these stations were 190, 171 and 181 $\mu g/m^3$.

Figure 2.4-8 is similar to Figure 2.4-7 except that it shows the 8-hourly average O_3 concentrations, which are addressed by the relevant CWS. The highest O_3 values tend to occur at Lamont. The latest fourth highest 8-hourly average O_3 concentration values measured annually over the last three full years (2003, 2004 and 2005) at Lamont, Fort Saskatchewan and Elk Island are respectively 112, 104 and 111 $\mu g/m^3$. All O_3 values are less than the CWS of 130 $\mu g/m^3$.Figure 2.4-9 shows median and maximum values of hourly average O_3 concentrations as a function of hourly average NO_x concentrations observed at the three FAP monitoring stations. As expected, all observed values show evidence of O_3 depletion with increasing values of NO_x.

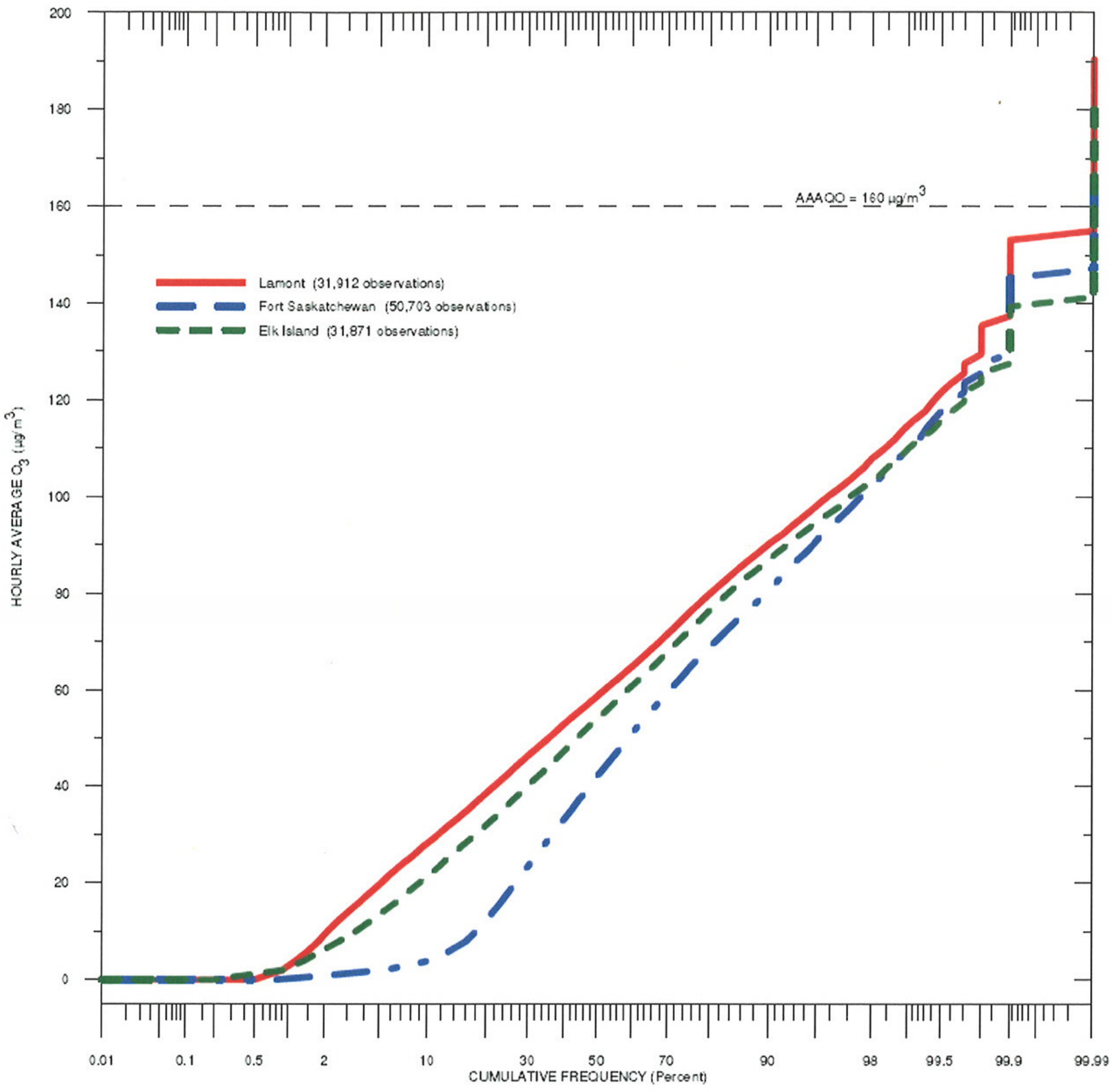
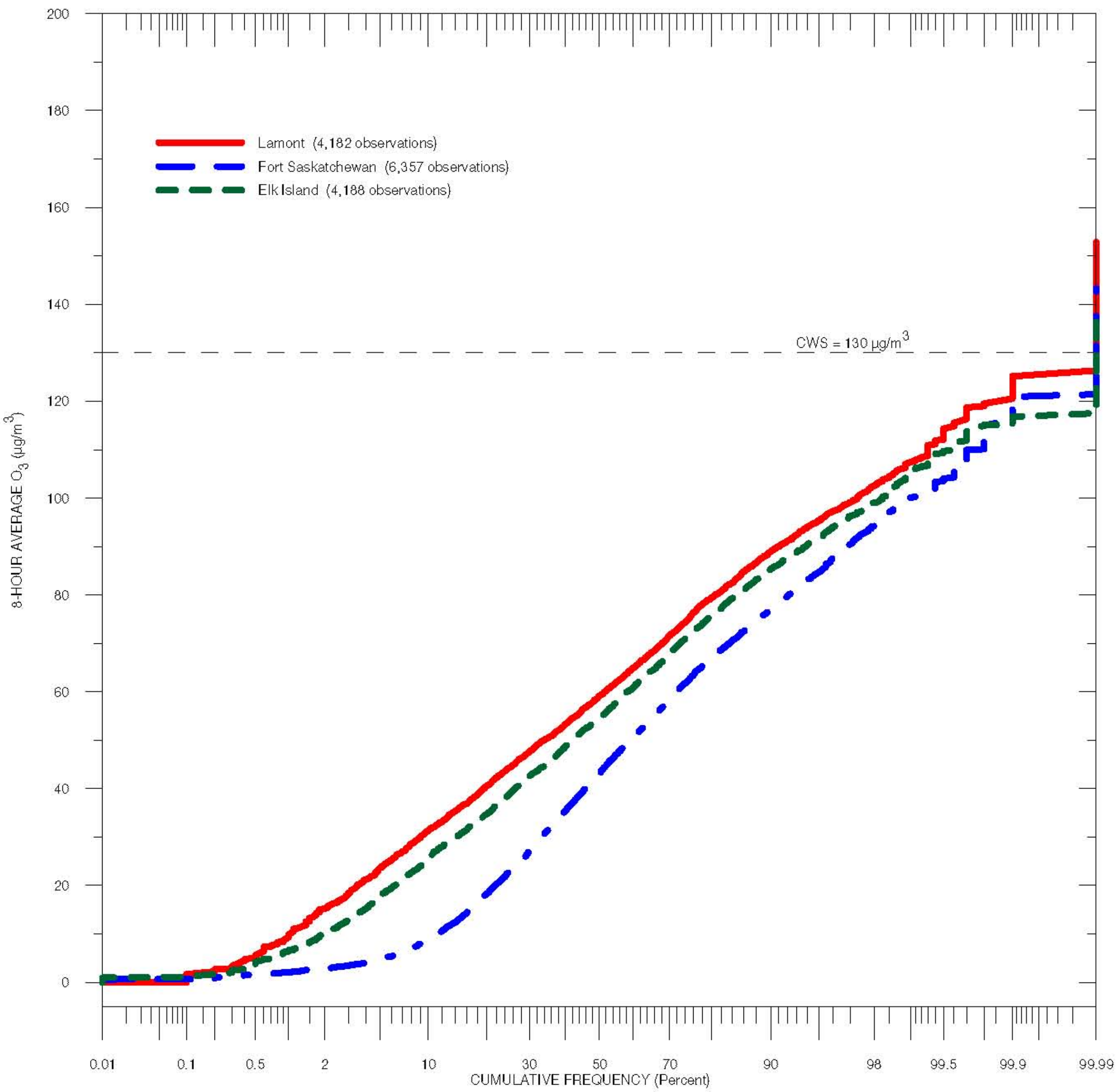
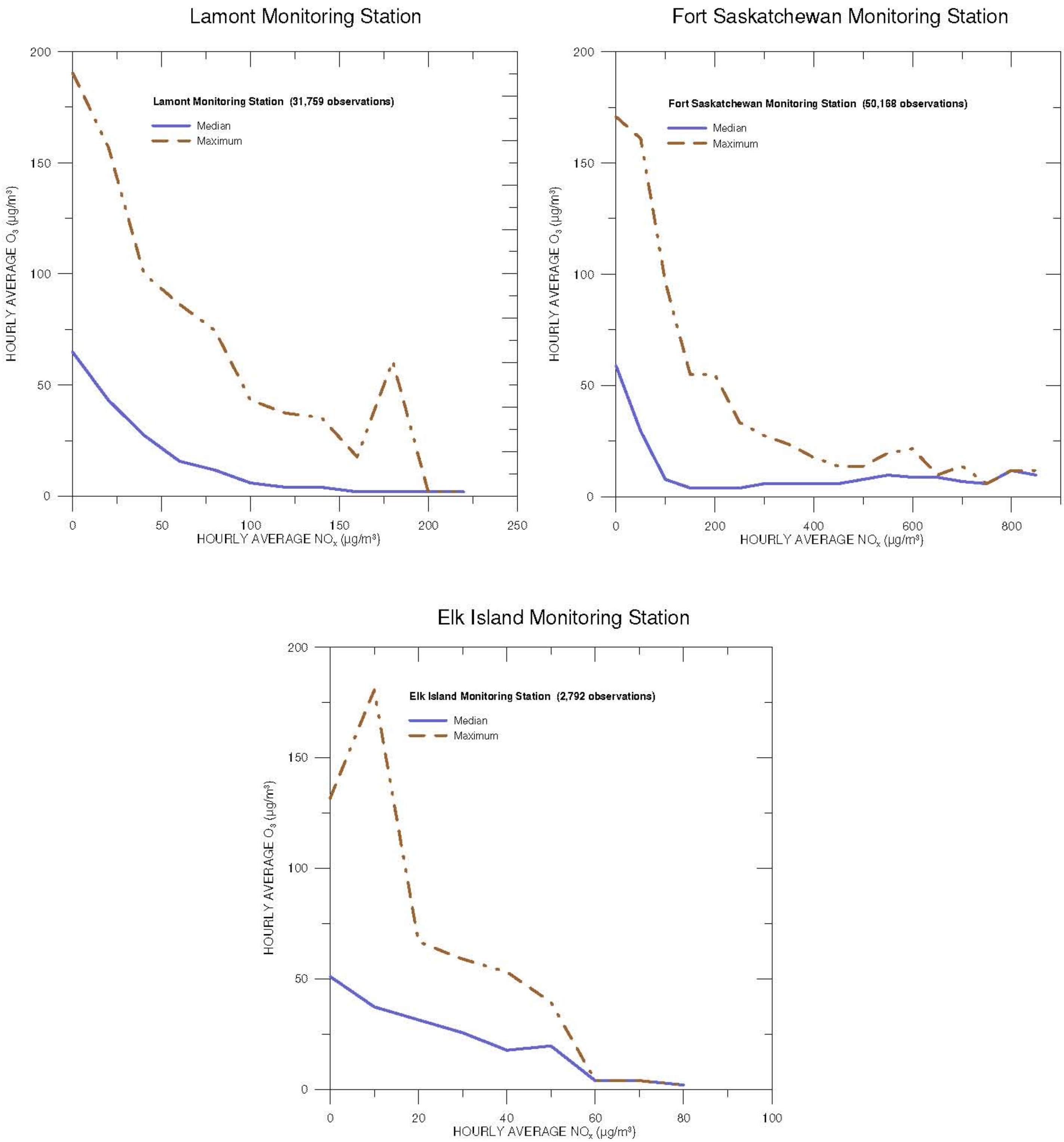


Figure 2.4-7: Cumulative Frequency Distributions of Hourly Average O_3 Concentrations ($\mu g/m^3$) Observed at the Lamont, Fort Saskatchewan and Elk Island Air Quality Monitoring Stations



Cumulative Frequency Distributions of 8-hour Average O_3 Concentrations (µg/m^3) as Observed at the Lamont, Fort Saskatchewan, and Elk Island Air Quality Monitoring Stations.	DRAWN BY: AF	EDITED BY: LH	DATE Apr 10/07
	APPROVED	FIGURE: 2.4-8	

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/O3 8-hr.srf



Observed Relationship between Ambient Ozone and Ambient NO_x Concentrations at the Indicated Monitoring Stations.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-9	

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/NOx vs O3 All Sites.srf

2.4.3.5 Fine Particulate Matter

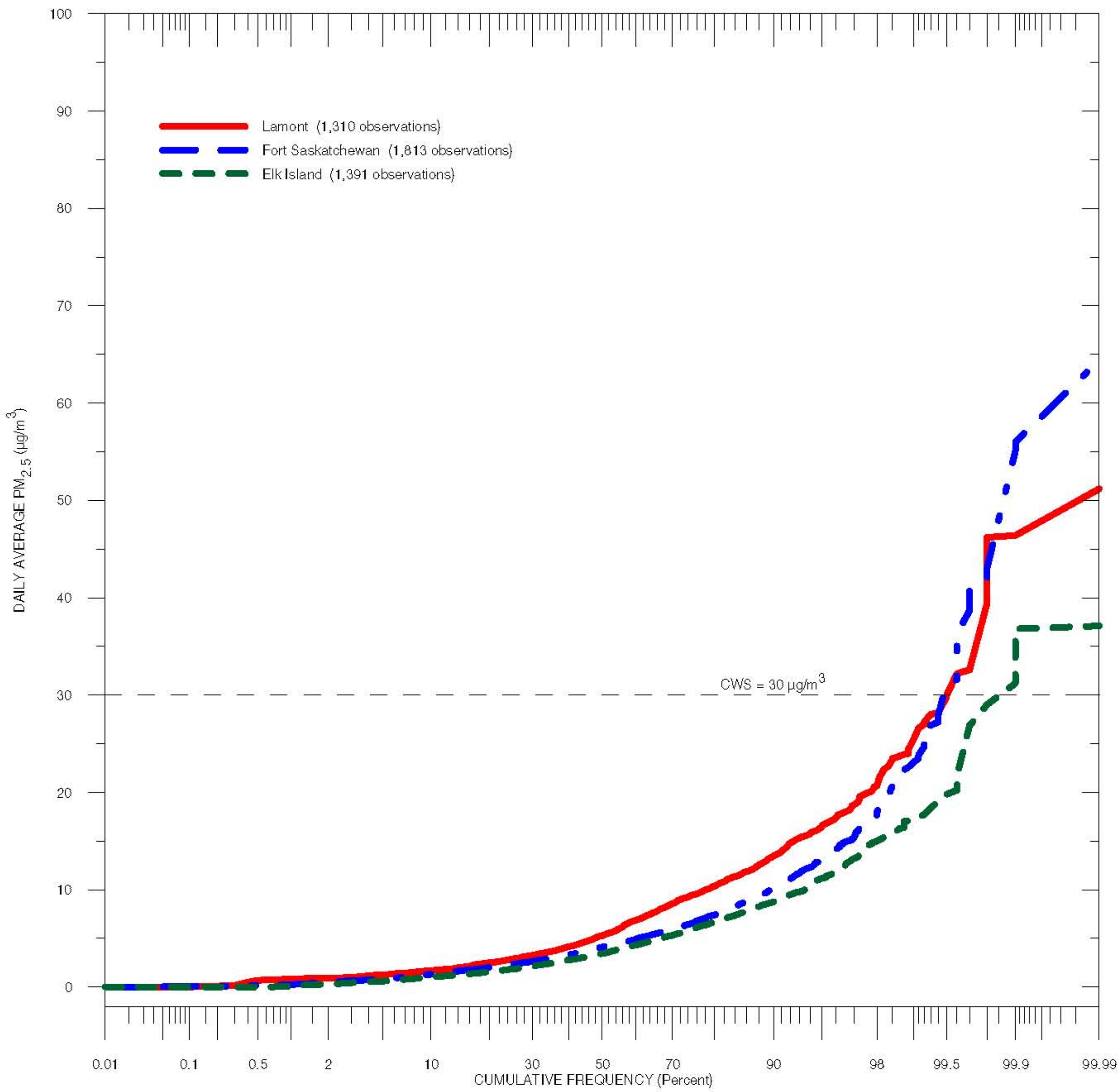
Cumulative frequencies of daily average $PM_{2.5}$ concentrations observed at the three FAP monitoring stations are presented in Figure 2.4-10. The largest concentrations tend to occur in the agricultural community of Lamont. The median value at Lamont is 5.3 µg/m^3. The latest three year average 98th percentile values for Lamont, Fort Saskatchewan and Elk Island are respectively about 20.5, 17.1 and 13.5 µg/m^3. All values are less than the CWS of 30 µg/m^3.

2.4.3.6 Sulphur Dioxide

Figure 2.4-11 and Figure 2.4-12 respectively present frequency distributions of hourly and daily average SO_2 concentrations observed at Lamont and Fort Saskatchewan. Ambient concentrations of sulphur dioxide are not measured at Elk Island. Observed concentrations are usually very low with respect to the AAAQO values of 450 and 150 µg/m^3. The 99.9th hourly average values observed at Lamont and Fort Saskatchewan are only about 50 µg/m^3. Comparable values for the daily averages are about 20 and 25 µg/m^3 respectively. Maximum annual average SO_2 concentrations observed at Lamont and Fort Saskatchewan were about 3 µg/m^3. This value is small when compared to the relevant AAAQO of 30 µg/m^3.

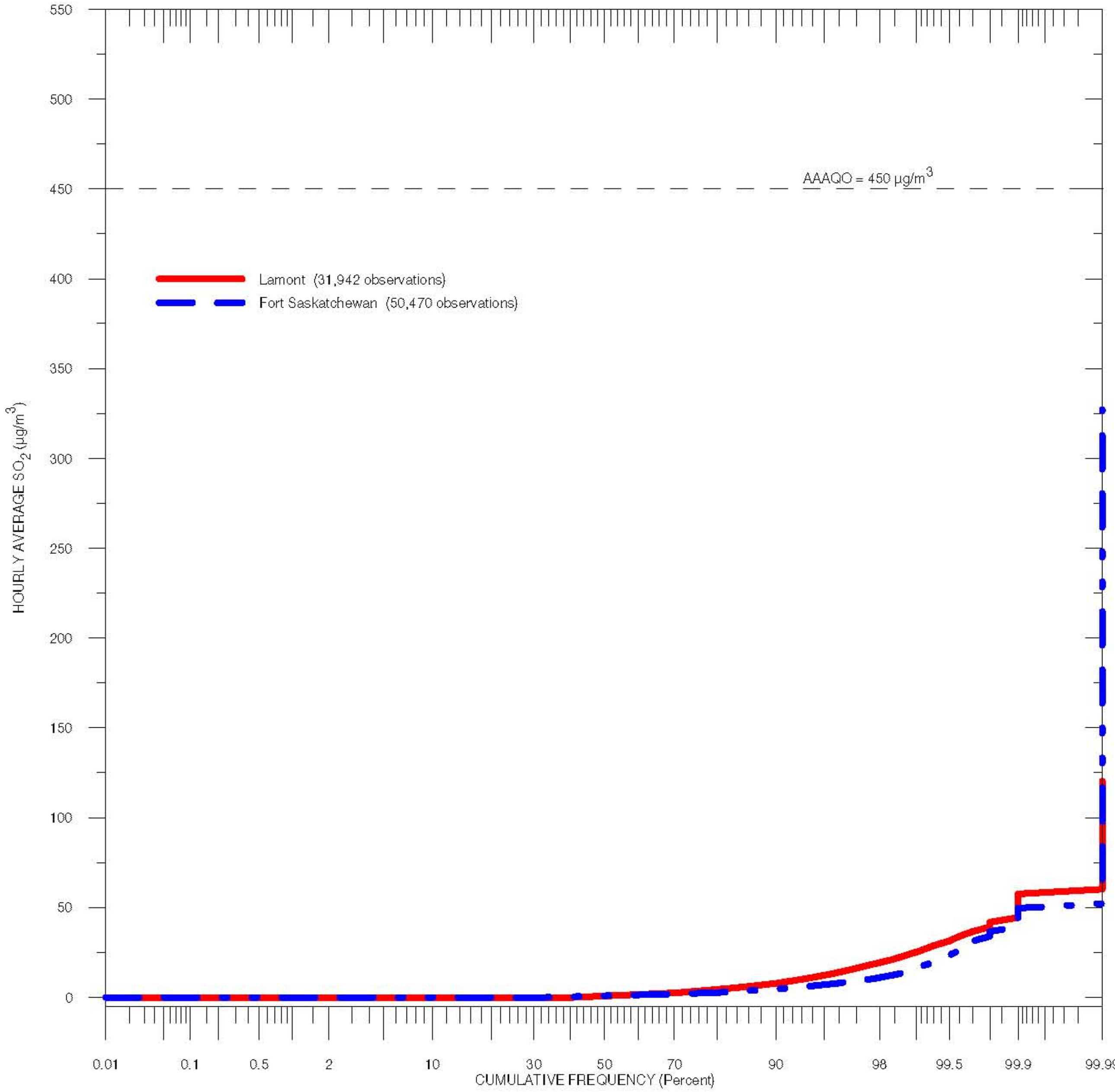
2.4.3.7 Summary of Air Quality Observations

Table 2.4-2 presents the median, 98th percentile and maximum hourly and daily average concentrations for the various criteria pollutants observed at Lamont, Fort Saskatchewan and Elk Island together with relevant AAAQO values. All maximum values as described above are less than the relevant AAAQO. Median values are especially small. Data presented in this table demonstrates that air quality in the region surrounding Bruderheim is currently well within acceptable levels.



Cumulative Frequency Distributions of Daily Average $PM_{2.5}$ Concentrations (µg/m^3) as Observed at the Lamont, Fort Saskatchewan, and Elk Island Air Quality Monitoring Stations.	DRAWN BY: AF	EDITED BY: LH	DATE Apr 10/07
	APPROVED	FIGURE: 2.4-10	

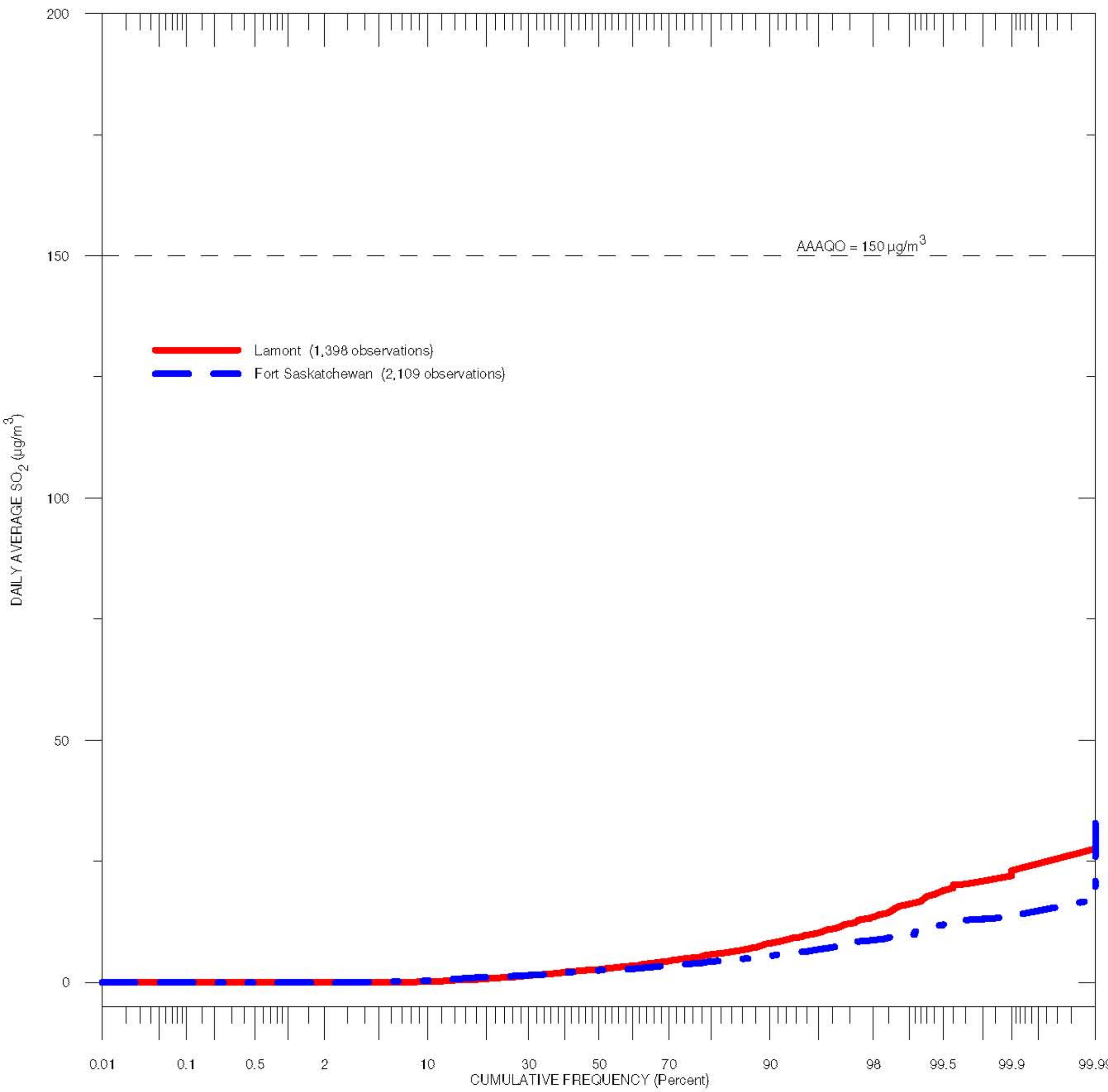
H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/PM25 24-hr.srf



Cumulative Frequency Distributions of Hourly Average SO_2 Concentrations ($\mu g/m^3$) as Observed at the Lamont, and Fort Saskatchewan Air Quality Monitoring Stations.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-11	

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/SO2 1-hr.srf



Cumulative Frequency Distributions of Daily Average SO_2 Concentrations (µg/m^3) as Observed at the Lamont, and Fort Saskatchewan Air Quality Monitoring Stations.

DRAWN BY:	EDITED BY:	DATE
AF	LH	Apr 10/07
APPROVED		FIGURE: 2.4-12

H:/1019043/d9043aqa/Grapher Plots/All Sites Combined/SO2 24-hr.srf

Table 2.4-2: Summary of Ambient H_2S, NO_2, CO, $PM_{2.5}$ and SO_2 Data Observed at the Lamont, Fort Saskatchewan and Elk Island Air Quality Monitoring Stations

Air Contaminant	Averaging Period	Parameter	Concentration (µg/m³)		
			Lamont	Fort Saskatchewan	Elk Island
CO	One-Hour	Maximum	-	5,800.00	-
		98th percentile	-	1,259.00	-
		50th percentile	-	229.00	-
	8-Hour	Maximum	-	3,300.00	-
		98th percentile	-	1,102.00	-
		50th percentile	-	286.00	-
H_2S [1]	One-Hour	Maximum	8.00	5.70	-
		98th percentile	1.40	2.00	-
		50th percentile	0.70	0.70	-
	24-Hour	Maximum	2.30	3.00	-
		98th percentile	1.10	1.30	-
		50th percentile	0.10	0.10	-
NO_2	One-Hour	Maximum	101.60	154.20	39.50
		98th percentile	39.50	78.99	18.81
		50th percentile	1.88	15.05	1.88
	24-Hour	Maximum	42.40	103.60	19.00
		98th percentile	27.50	65.60	13.20
		50th percentile	3.40	18.10	3.10
$PM_{2.5}$	24-Hour	Maximum	51.20	64.40	37.10
		98th percentile	20.70	17.50	15.00
		50th percentile	5.30	4.20	3.50
SO_2	One-Hour	Maximum	120.40	327.10	-
		98th percentile	23.55	13.08	-
		50th percentile	2.62	2.62	-
	24-Hour	Maximum	27.60	35.40	-
		98th percentile	13.50	8.70	-
		50th percentile	2.70	2.50	-

Notes:
[1] July 01, 2005–October 31, 2006.
- Not Monitored.

2.4.4 Predicted Air Quality and Acid Deposition within the Local Study Area

Plume dispersion calculations were performed to estimate ground-level concentrations of criteria and non-criteria air emissions that might occur in the study area as a result of existing conditions.

A regularly spaced, nested Cartesian receptor grid was created for the CALPUFF model to determine the maximum ground-level concentration associated with emissions from the Canexus Sodium Chlorate Plant which lies adjacent to the Project. The receptor grid is more densely spaced near the facility where maximum impacts are expected. The receptor spacing followed the guidance of AENV (2003):

- 20 m in the general area of maximum impact and the property boundary
- 50 m within 0.5 km of the source
- 250 m within 2 km of the sources of interest
- 500 m within 5 km of the sources of interest
- 1,000 m beyond 5 km
- 5,000 m beyond 10 km

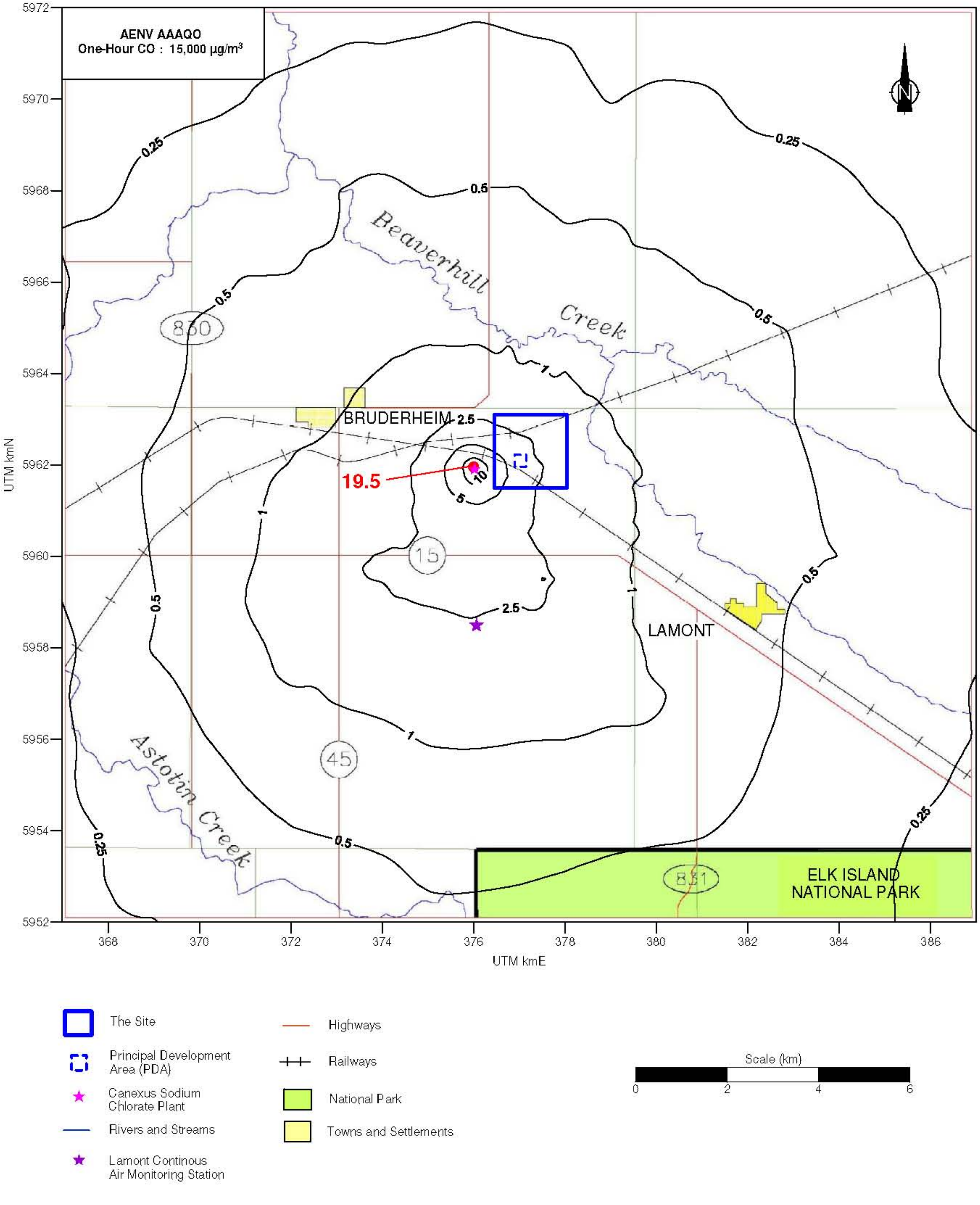
The nested grid had a total of 5,264 receptor locations. These locations are illustrated in Figure I-1 of Appendix I. At each grid location the terrain height was interpolated from topographical data with a grid spacing of about 25 m. Dispersion modelling results are presented in the following sections.

2.4.4.1 Criteria Pollutants

Air quality dispersion calculations were performed to estimate the ground-level consequences of air emissions within the study area associated with emissions from the Canexus Sodium Chlorate Plant together with background values. A summary of the baseline air quality predictions associated with emissions from the Canexus Plant is provided in Table 2.4-3 and a discussion of the modelling results for criteria air contaminants is provided in the following sections. Isopleths of predicted concentrations are presented for each air contaminant and averaging period in Figure 2.4-13, Figure 2.4-14, Figure 2.4-15, Figure 2.4-16, Figure 2.4-17 and Figure 2.4-18.

Table 2.4-3: Summary of Baseline Air Quality Predictions for Criteria Air Contaminants

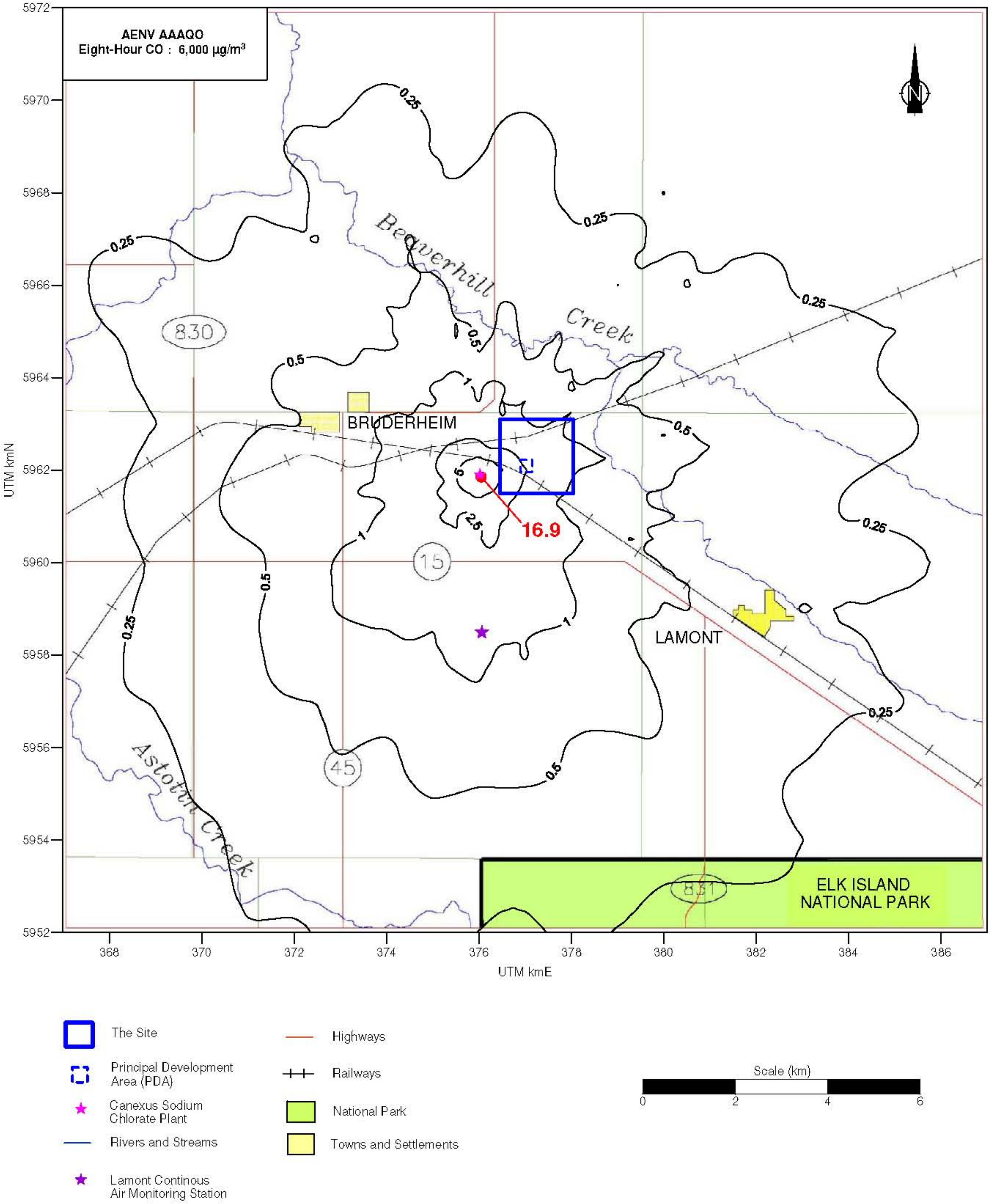
Air Contaminant	Maximum Predicted Concentration ($\mu g/m^3$)	Objective/Standard ($\mu g/m^3$)	Averaging Period
CO	19.5	15,000	1 h
	16.9	6,000	8 h
NO_2	23.2	400	1 h
	14.4	200	24 h
	1.0	60	Annual
$PM_{2.5}$	1.5	30	98th percentile, 24 h, 3-year average



Isopleths of Maximum Predicted Hourly Average Ground-level CO Concentrations (µg/m³) Associated with Emissions from the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED		FIGURE: 2.4-13

H:/1019043/d9043srf/cp2/CO_h.srf



Isopleths of Maximum Predicted 8-hour Average Ground-level CO Concentrations (µg/m³) Associated with Emissions from the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED	FIGURE: 2.4-14	

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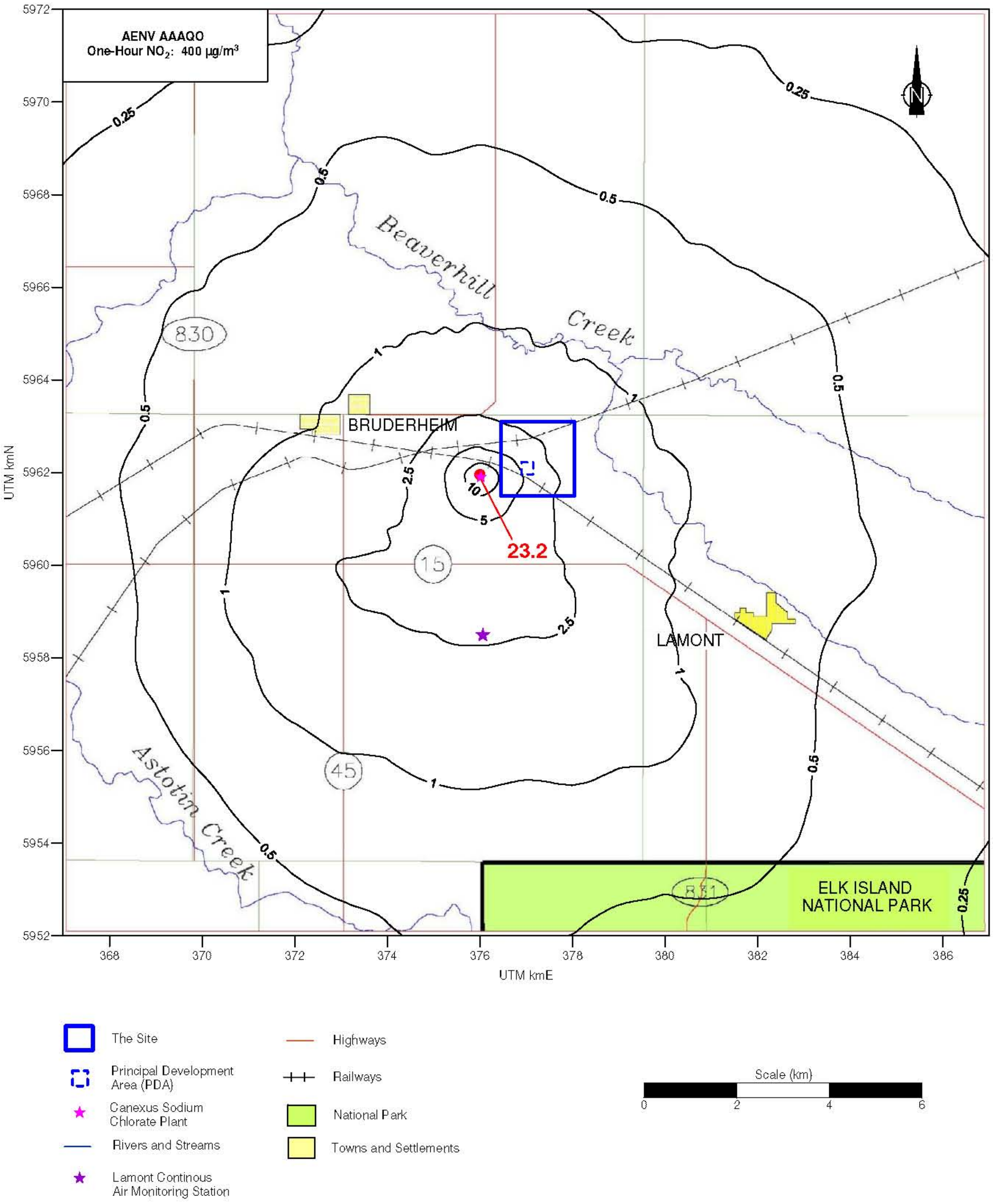

Isopleths of Maximum Predicted Hourly Average Ground-level NO_2 Concentrations (µg/m³) Associated with Emissions from the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED	FIGURE: 2.4-15	

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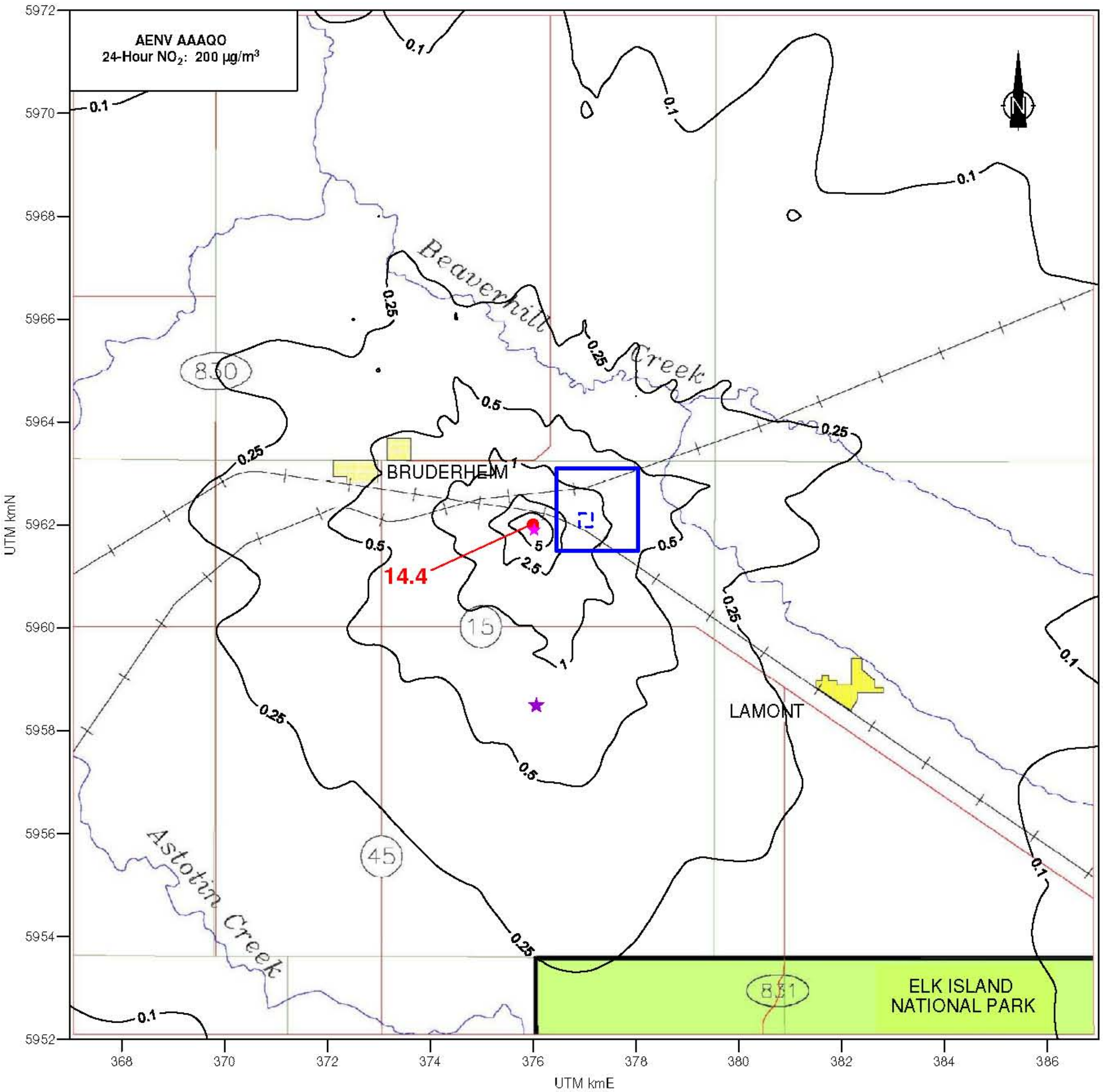


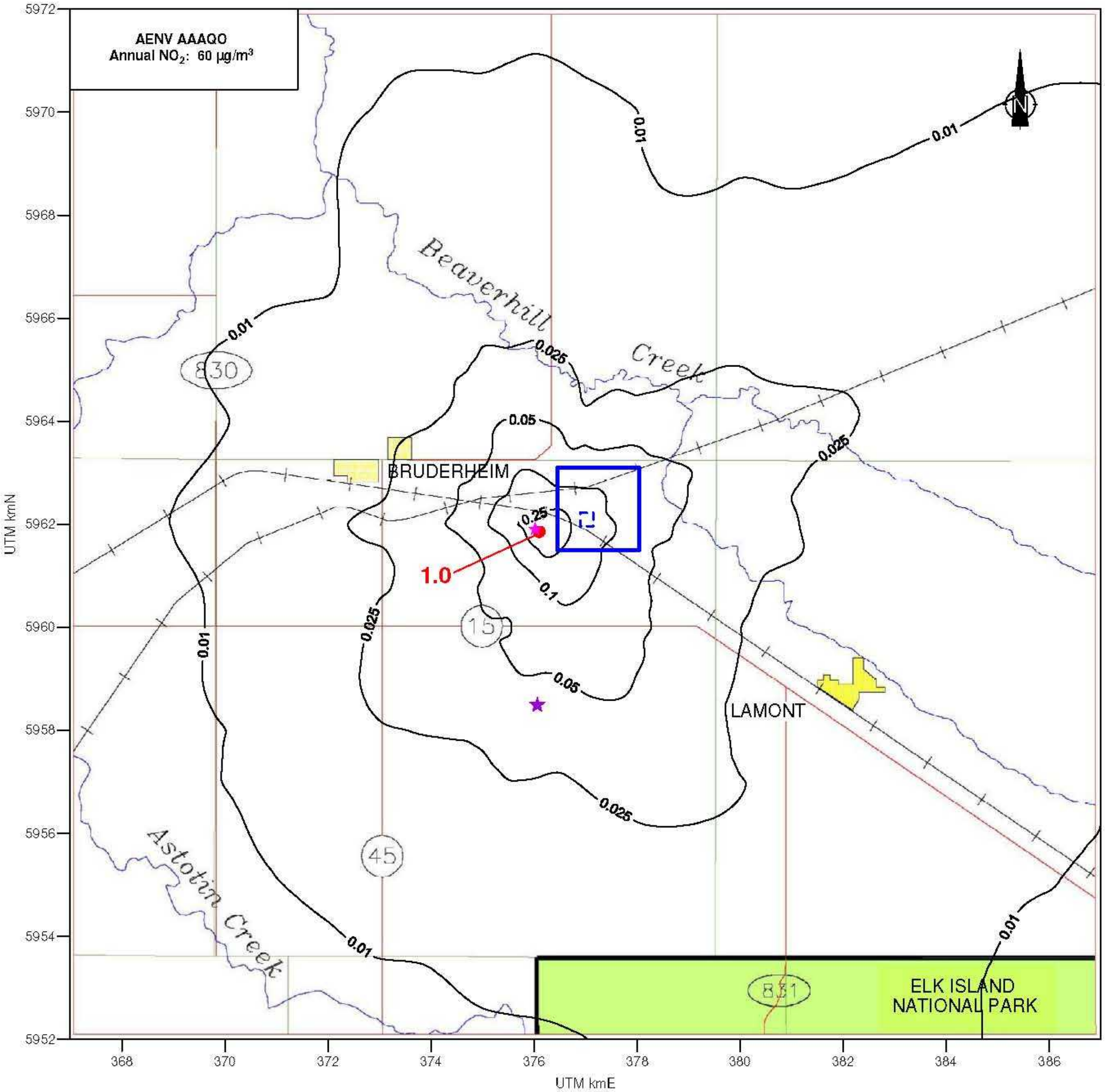
The Site
Principal Development Area (PDA)
Canexus Sodium Chlorate Plant
Rivers and Streams
Lamont Continous Air Monitoring Station
Highways
Railways
National Park
Towns and Settlements

Scale (km) 0 2 4 6

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED	FIGURE: 2.4-16	

Isopleths of Maximum Predicted Daily Average Ground-level NO_2 Concentrations (µg/m³) Associated with Emissions from the Canexus Sodium Chlorate Plant.

H:/1019043/d9043srf/cp2/NO2_d.srf

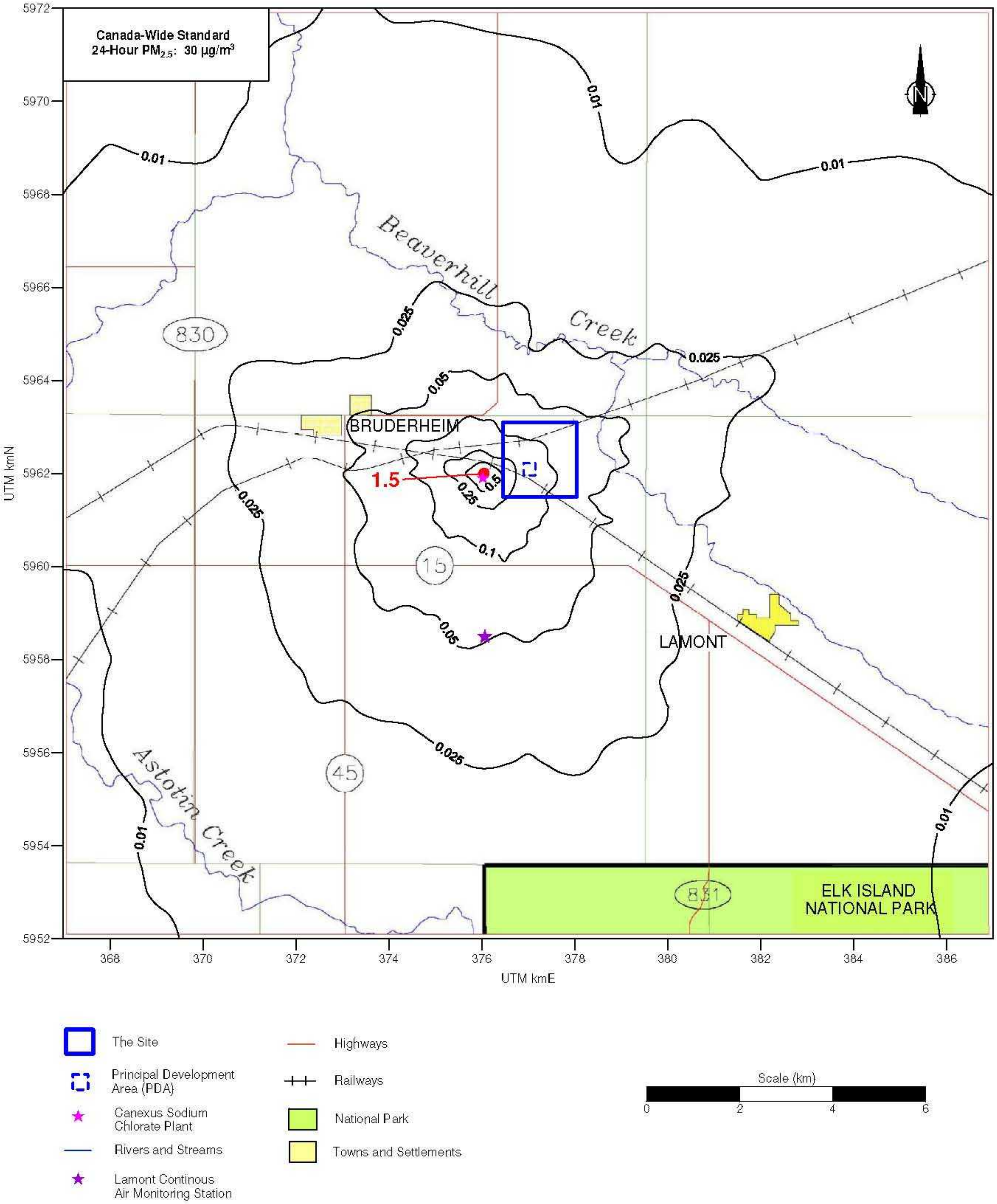


Isopleths of Maximum Predicted Annual Average Ground-level NO_2 Concentrations ($\mu g/m^3$) Associated with Emissions from the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07

APPROVED	FIGURE:
	2.4-17

H:/1019043/d9043srf/cp2/NO2_a.srf



DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED		FIGURE: 2.4-18

Isopleths of the 98th Percentile of Daily Average Ground-level $PM_{2.5}$ Concentrations (µg/m^3) Averaged Over a Three Year Period Associated with Emissions from the Canexus Sodium Chlorate Plant.

H:/1019043/d9043srf/cp2/PM25_d.srf

2.4.4.1.1 Carbon Monoxide

The highest predicted hourly and 8-hourly concentrations occur in the immediate vicinity of the Canexus Plant outside the fenceline surrounding the Site. Maximum predicted concentrations are of negligible importance being less than 0.5% of the relevant AAAQO.

2.4.4.1.2 Nitrogen Dioxide

The highest predictions for all three time averaging periods (hourly, daily and annual) are predicted to occur in the immediate vicinity of the Canexus Plant. All predicted concentrations are less than 10% of the respective AAAQO of 400, 200 and 60 µg/m^3.

The predicted 98^{th} daily average concentrations of $PM_{2.5}$ values averaged over a three year period include both primary and secondary particulates. Primary particulates are emitted directly from the source, whereas secondary particulates are formed as the result of chemical reactions involving SO_2 and NO_2. All predicted concentrations are much less than 10% of the CWS of 30 µg/m^3. This is especially true for values predicted for the region of the Lamont monitoring station where the CWS is to be applied.

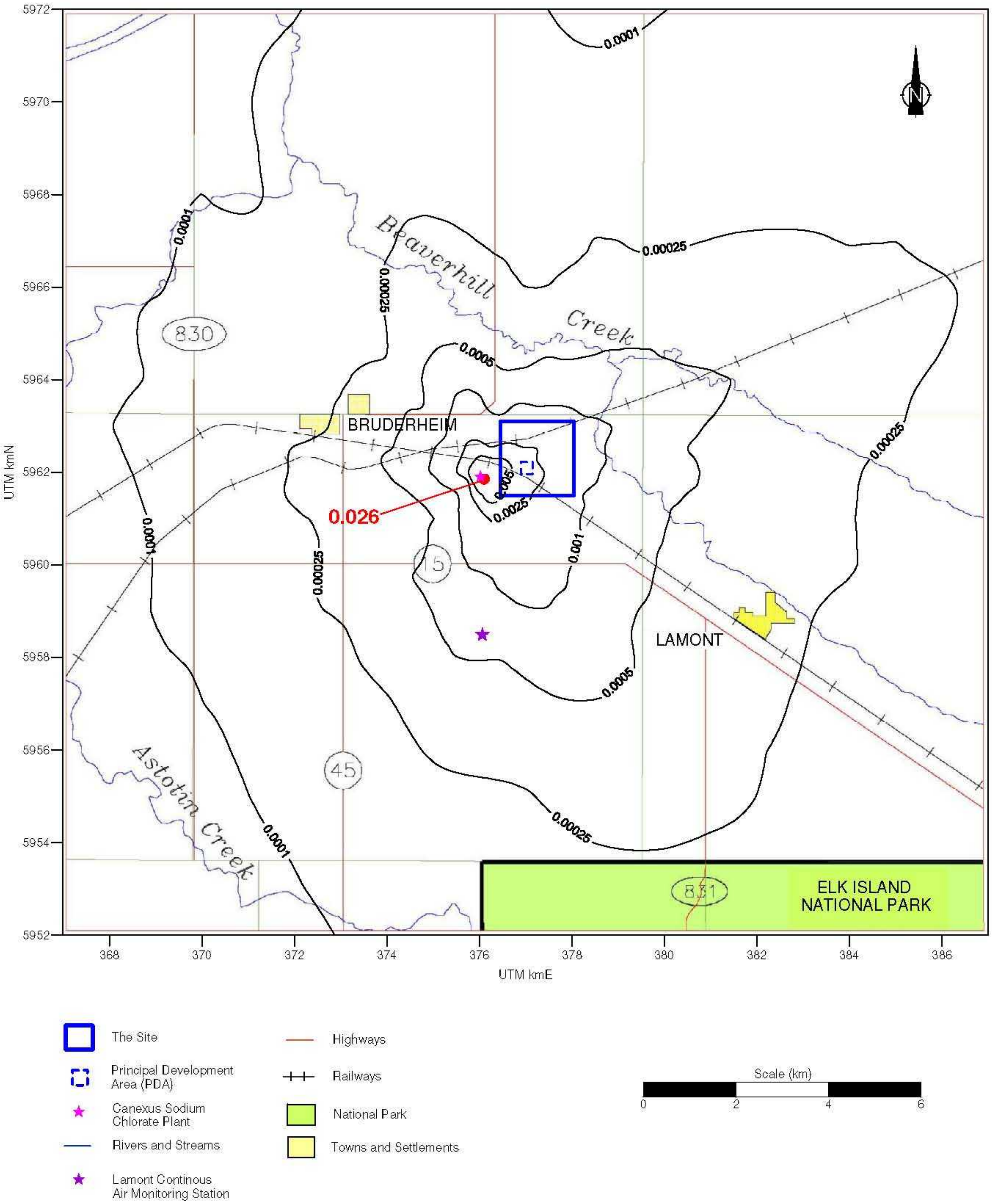
2.4.4.2 <u>Acid Deposition</u>

The current PAI predictions from RELAD for the cell containing the Project indicate a deposition value of about 0.09 keq H^+/(ha•y), which is less than the monitoring load criteria of 0.17 keq H^+/(ha•y). This means that all receptors near the plant are adequately protected against adverse effects associated with acid deposition. In consequence there should be no need for a monitoring program to measure acidifying effects of acid deposition on neighboring soils or water.

The CALPUFF model has been used to provide predictions of acid deposition within the study area as required by the Terms of Reference (TOR) (AENV 2007). In the context of the provincial acid deposition management framework (CASA and AENV 1999), deposition values obtained using this model may be useful in determining where monitoring efforts, if required, should be best directed.

Figure 2.4-19 shows isopleths of predicted PAI attributable to emissions from the Canexus Sodium Chlorate Plant. The maximum predicted PAI value of 0.026 keq H^+/(ha•y) occurs in the immediate vicinity of the facility. Predicted values decrease rapidly with distance from the Site. With an assumed background value of 0.09 keq H^+/(ha•y) based on estimates presented by CASA and AENV (1999) the overall maximum predicted PAI is only about 0.116 keq H^+/(ha•y).

The modelling shows that the highest predictions of acid deposition are localized near the facility. If deemed desirable, a monitoring program designed to ascertain the degree of acidification on soils and water from current operations could be conducted within this localized area.



Isopleths of Maximum Predicted PAI Values (keq H^+/ha/yr) Associated with Emission from the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED	FIGURE:	
	2.4-19	

H:/1019043/d9043srf/cp2/PAI_a.srf

2.4.5 Baseline Case Summary

Warm, short summers and long, cold winters characterize the climate of the region surrounding the Project. About 355 mm of rain and 105 cm of snow fall annually. About half of the precipitation occurs during June, July and August.

Meteorological conditions within the LSA are such that NO_x emissions result in the scavenging rather than the creation of ozone. The observational evidence supports this conclusion. Therefore, emissions of NO_x associated with the Project should not have a negative impact with respect to ambient ozone concentrations. Air monitoring data indicate the impacts of regional emissions for criteria air contaminants such as H_2S, NO_2 and SO_2 are small. Maximum observed ground-level concentrations are much less than the ambient air quality objectives.

Plume dispersion calculations demonstrate that maximum ground-level concentrations of CO, NO_2, SO_2 and $PM_{2.5}$ attributable to the emissions from the adjacent Canexus facility are less than 10% of relative AAAQO. They will, therefore, not have any significant effects on air quality within the region of the Project. Results under the Acid Deposition Management Framework (CASA and AENV 1999) indicate that acid deposition in the LSA is appreciably less than the monitoring load. Additionally, acid deposition modelling using the CALPUFF dispersion model demonstrates that the best locations for making observations relating to acid deposition effects would be immediately adjacent to the Canexus facility.

The final estimated ground-level concentrations of criteria pollutants for the Project area as based on observational data and plume dispersion calculations are presented in Table 2.4-4. Ambient background concentrations are based on maximum observed data. Estimated background concentrations of CO are very much larger than will likely occur because they are based on Fort Saskatchewan values. The table illustrates that existing air quality within the study area is very much within acceptable limits.

Table 2.4-4: Maximum Ground-level Concentrations of Criteria Pollutants Predicted for the Study Area (Baseline Case)

Air Contaminant	Averaging Period	Ambient Background Concentration ($\mu g/m^3$)	Maximum Predicted Ground-level Concentration ($\mu g/m^3$)	Total Ground-level Concentration, Including Background ($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
CO	One-hour	5,800.0	19.5	5,820.0	15,000
	8-hour	3,300.0	16.9	3,317.0	6,000
H_2S	One-hour	8.0	-	8.0	14
	24-hour	2.3	-	2.3	4
NO_2	One-hour	102.0	23.2	125.2	400
	24-hour	42.0	14.4	56.4	200
	Annual	4.0	1.1	5.1	60
$PM_{2.5}$	24-hour	20.5*	1.5*	22.0*	30**
SO_2	One-hour	120.0	-	120.0	450
	24-hour	28.0	-	28.0	150
	Annual	3.0	-	3.0	30

Notes:
* 98th percentile value.
** CWS applies to representative regional locations and not to maximum predicted impacts.
- Not associated with emissions from Canexus Sodium Chlorate Plant.

2.5 Application Case

An assessment was done on ambient air quality expected as the result of emissions from the Project. Figure 2.5-1 shows a plot plan of the Principal Development Area (PDA) for the proposed Project and locations of point sources and area sources associated with its operations. The portion of the facility associated with the expansion from 3,000–6,000 t/d capacity is highlighted.

There will be six point sources: four rotoform stacks and two boiler stacks. Emissions associated with trucks, locomotive, trackmobile, storage tanks and front end loader will comprise area sources. Four trucks will be simultaneously unloading liquid sulphur with motors running about 10% of the time. The Trackmobile, locomotive and front end loaders were assumed to act as area sources because they will be in motion over defined spaces. Emissions due to resuspension of dust from the asphalt pavement transversed by the front end loader will occur within the area of loading activity.

Table 2.5-1 presents emission parameters associated with the point sources. They were based on stack survey results obtained from facilities similar to those being proposed by AST. Emissions of fine particulates are assumed to comprise sulphur particles.

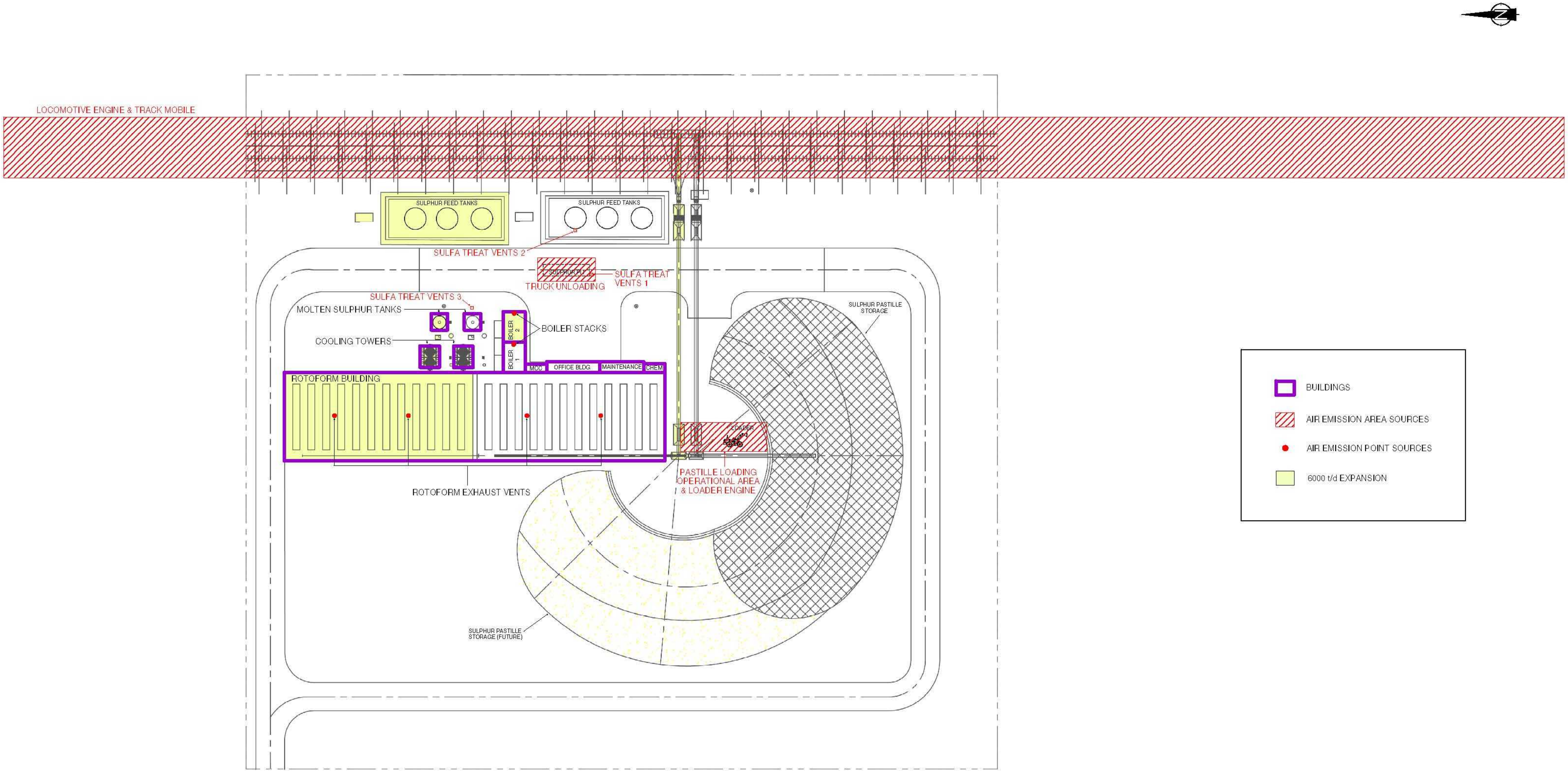
Table 2.5-2 presents emission parameters associated with area sources. Emissions from the trucks, locomotives, trackmobile and front end loader were based on exhaust specifications. Sulphur content for the diesel fuel consumed by the locomotive engine was assumed to be 500 ppm while that consumed by trucks and front end loader was assumed to be only 15 ppm. Emissions from the asphalt pavement were obtained from estimation methods recommended by the United States Environmental Protection Agency (USEPA 2006, Internet site) with the assumption that the silt covering the asphalt would be similar to that found in areas of sand and gravel operations. This is a conservative assumption because it does not allow for AST's commitment to sweep the area on a daily basis.

Estimates of H_2S emissions from the storage tanks as shown in Table 2.5-2 were made on the assumption that head space in the storage tanks would be displaced at a rate consistent with the daily supply of 6,000 t of liquid sulphur to the Project. Exhausts from the storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed 1 ppm by volume.

Daily average emissions shown in Table 2.5-2 for the mobile sources are less than hourly average values. This is because they were estimated on the assumption that activities for trucks, front-end loader and Trackmobile at the sulphur forming site would be limited to a 17 hour day. The locomotive will be present only for two hours a day.

Table 2.5-1 and Table 2.5-2 do not show emissions for the pastille storage pile or for transfer points associated with conveyor belt activity. The conveyor belt, itself, will be covered. The transfer points should not create any significant sources of wind borne dust:

- measurements have shown that 99.8% of the sulphur particles associated with the pastille forming process retain diameters of greater than 2 mm. Particles of these diameters are non-erodible (non-suspendable) by the wind (Watson et al. 2000).
- large non-erodible particles will shield finer suspendable dust from actions by the wind
- dust suppression chemicals will be sprayed on the pastilles at all conveyor transfer points



NOT TO SCALE

PDA for the Proposed Bruderheim Sulphur Forming and Shipping Facility.

DRAWN BY:	EDITED BY:	DATE
SH	SH	Apr 16/07

APPROVED	FIGURE:
	2.5-1

H:/1019043/d9043bpr/Buildings Plot.srf

Table 2.5-1: Estimated Emissions from Point Sources at the Proposed AST Sulphur Forming and Shipping Facility

Parameter		Rotoform Stack #1	Rotoform Stack #2	Rotoform Stack #3	Rotoform Stack #4	Boiler #1 150 HP	Boiler #2 150 HP
Stack height (m)		18.3	18.3	18.3	18.3	16.76	16.76
Stack diameter (m)		0.390	0.390	0.390	0.390	0.406	0.406
Exit temperature	^{o}C	36	36	36	36	228	228
	K	309	309	309	309	501	501
Exit velocity (m s^{-1})		16.7	16.7	16.7	16.7	7.5	7.5
Actual exhaust volume flow rate (m^3 h^{-1})		7,170	7,170	7,170	7,170	3,523	3,523
Exhaust mass flow rate (kg s^{-1})		2.10	2.10	2.10	2.10	0.69	0.69
Emission rates (g s^{-1})	CO	-	-	-	-	0.123	0.123
	H_2S	0.012	0.012	0.012	0.012	-	-
	NO_x[a]	-	-	-	-	0.101	0.101
	$PM_{2.5}$	0.105	0.105	0.105	0.105	0.011	0.011
	SO_2	-	-	-	-	0.001	0.001

Notes:
[a] NO_x as NO_2 equivalent.

Table 2.5-2: Estimated Emissions from Area Sources at the Proposed AST Sulphur Forming and Shipping Facility

Parameter		Trucks	Underground Molten Sulphur Storage Tank	Molten Sulphur Storage Tanks	Molten Sulphur Feed Tank	Locomotive	Trackmobile	Front End Loader	Loading Area
Release height (m)		4.5	2.5	2.5	2.5	5.0	1.5	3.6	1.0
Length (m)		8.0	1.0	1.0	1.0	21.0	21.0	10	10
Width (m)		20.0	1.0	1.0	1.0	542.0	542.0	30	30
Area (m^2)		160	1.0	1.0	1.0	11382	11382	300	300
Maximum hourly emission rates ($g\ s^{-1}$)	CO	2.75×10^{-1}	-	-	-	5.77×10^{-1}	1.12×10^{-1}	2.57×10^{-1}	-
	H_2S	-	5.40×10^{-5}	5.40×10^{-5}	5.40×10^{-5}	-	-	-	-
	NO_x	2.11×10^{-2}	-	-	-	5.53	6.42×10^{-3}	1.47×10^{-2}	-
	$PM_{2.5}$	1.06×10^{-3}	-	-	-	1.96×10^{-1}	3.21×10^{-4}	7.35×10^{-4}	4.00×10^{-2}
	PM_{10}	1.06×10^{-3}	-	-	-	1.96×10^{-1}	3.21×10^{-4}	7.35×10^{-4}	2.79×10^{-1}
	SO_2	2.54×10^{-4}	-	-	-	9.81×10^{-2}	1.04×10^{-4}	2.37×10^{-4}	-
Daily/annual emission rates ($g\ s^{-1}$)	CO	1.38×10^{-1}	-	-	-	4.81×10^{-2}	1.12×10^{-1}	1.82×10^{-1}	-
	H_2S	-	-	-	-	-	-	-	-
	NOx	1.06×10^{-2}	-	-	-	$4.61 \mathrm{X} 10^{-1}$	6.42×10^{-3}	1.04×10^{-2}	-
	$PM_{2.5}$	5.28×10^{-4}	-	-	-	1.64×10^{-2}	3.21×10^{-4}	5.21×10^{-4}	4.00×10^{-2}
	PM_{10}	5.28×10^{-4}	-	-	-	1.64×10^{-2}	3.21×10^{-4}	5.21×10^{-4}	2.79×10^{-1}
	SO_2	1.27×10^{-4}	-	-	-	8.17×10^{-3}	1.04×10^{-4}	1.68×10^{-4}	-

2.5.1 Criteria Pollutants

2.5.1.1 Project Plus the Canexus Sodium Chlorate Plant

A summary of air quality predictions of criteria pollutants associated with emissions from the Project plus the Canexus Sodium Chlorate Plant is provided in Table 2.5-3 and a discussion of each criteria air contaminant is provided in the sections that follow. Isopleths of predicted concentrations are presented below for each air contaminant and averaging period. The AAAQO apply only to those areas beyond the fenceline. Acceptable air quality levels within the plant boundary are governed by occupational health standards.

2.5.1.1.1 Carbon Monoxide

The highest predicted hourly average concentrations of 238 µg/m^3 occur on the southern portion of the Project fenceline (Figure 2.5-2), whereas the highest predicted 8-hour concentrations of 51.4 µg/m^3 occur along the western portion (Figure 2.5-3). Maximum predicted concentrations are less
than 2% of the relevant AAAQO of 15,000 µg/m^3 (hourly average concentrations) and 6,000 µg/m^3 (8-hourly concentrations).

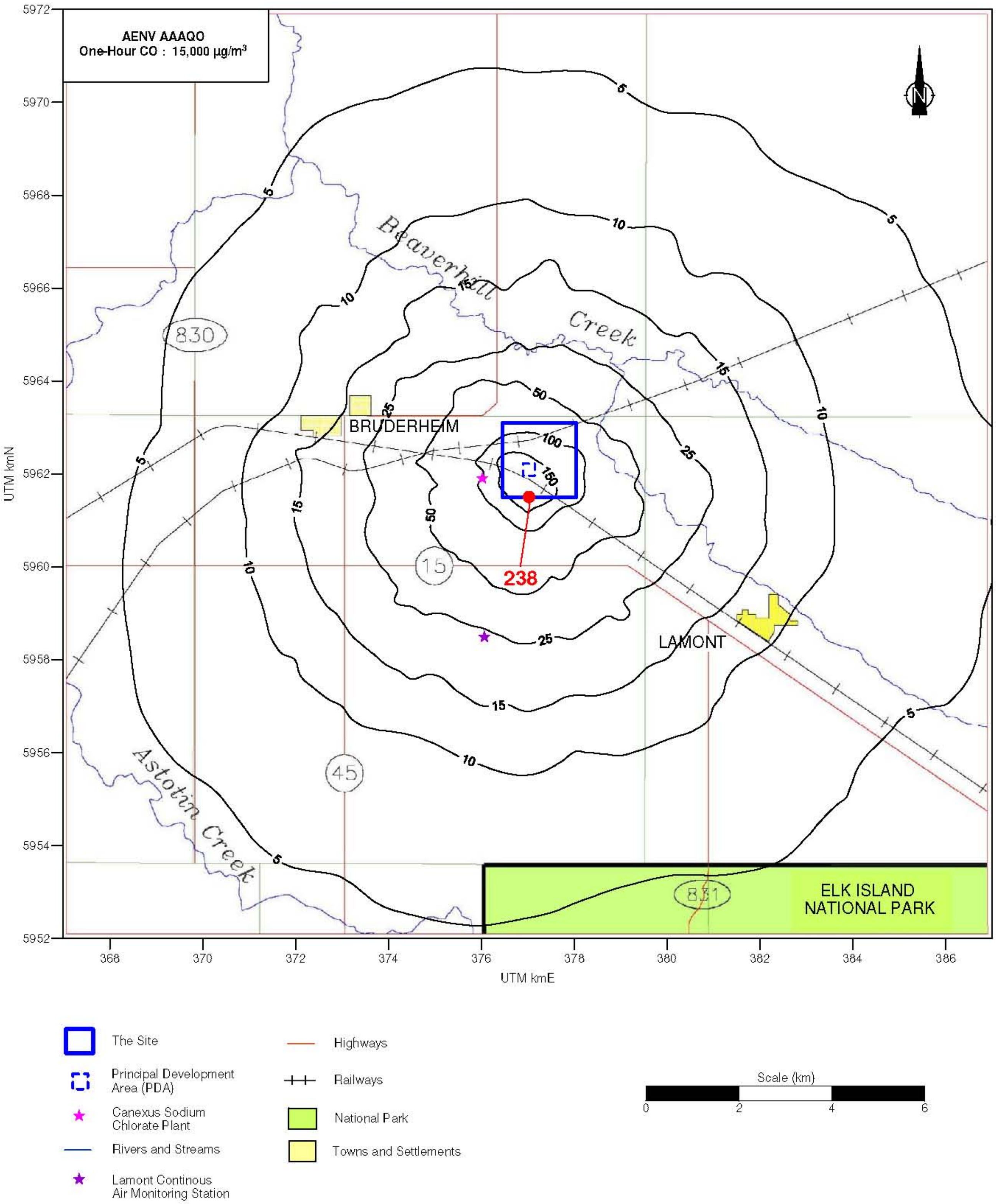
2.5.1.1.2 Hydrogen Sulphide

Maximum predicted hourly and daily average concentrations are respectively 2.2 and 1.0 µg/m^3 (Figure 2.5-4). Hourly averages beyond the fenceline are less than 10% of the AAAQO except within a narrow band extending along the southwestern portion of the Project fenceline. Daily average values are similarly less than 10% of the relevant AAAQO except in a narrow band along the west and south plant boundaries (Figure 2.5-5).

Table 2.5-3: Maximum Predicted Ground-level Concentrations of Pollutants Associated with Emissions from the Project Plus the Canexus Sodium Chlorate Plant

Air Contaminant	Averaging Period	Maximum Predicted Ground-level Concentration (µg/m^3)	AAAQO (µg/m^3)
CO	One-hour	238.00	15,000
	8-hour	51.40	6,000
H_2S	One-hour	2.20	14
	24-hour	1.00	4
NO_2	One-hour	209.00	400
	24-hour	39.00	200
	Annual	2.20	60
$PM_{2.5}$	24-hour	6.00	30*
SO_2	One-hour	19.40	450
	24-hour	0.60	150
	Annual	0.03	30

Note:
* CWS based on 98th percentile ambient measurement annually, averaged over three consecutive years.



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SH	LH	Apr 10/07

Isopleths of Maximum Predicted Hourly Average Ground-level CO Concentrations (µg/m³) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

APPROVED

FIGURE: 2.5-2

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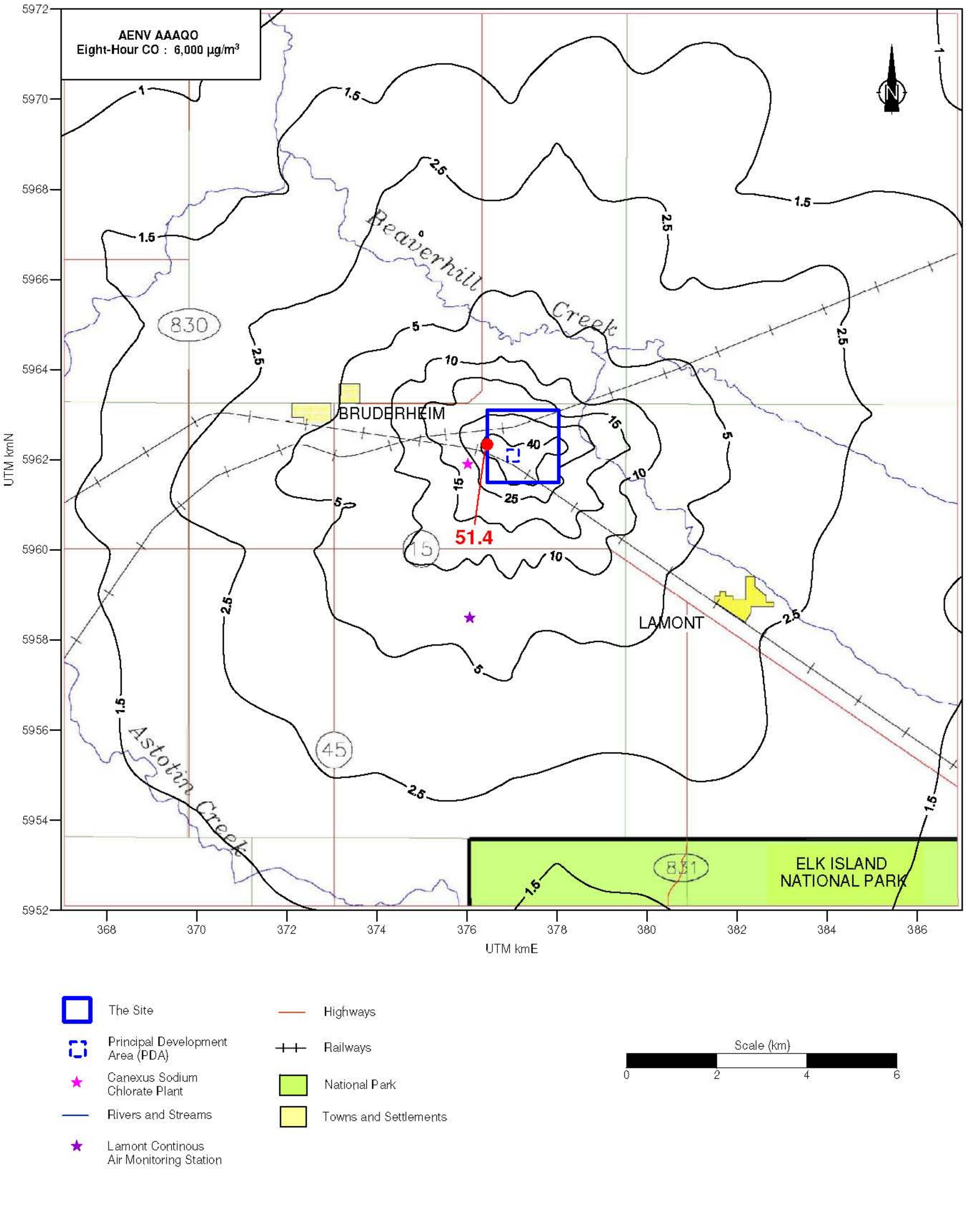

Isopleths of Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

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SH	LH	Apr 10/07
APPROVED	FIGURE:	
	2.5-3	

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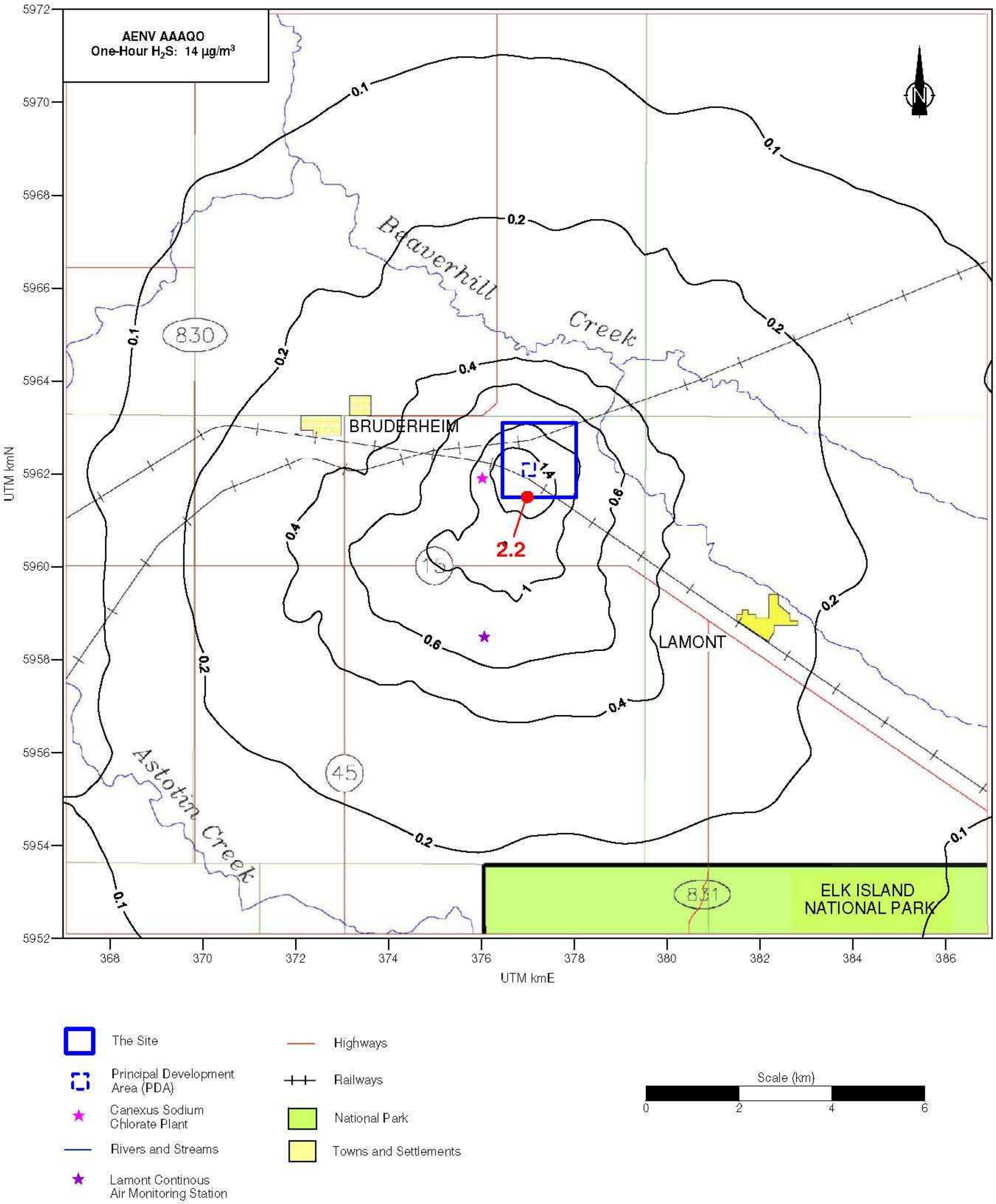

Isopleths of Maximum Predicted Hourly Average Ground-level H_2S Concentrations (µg/m^3) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED	FIGURE:	
	2.5-4	

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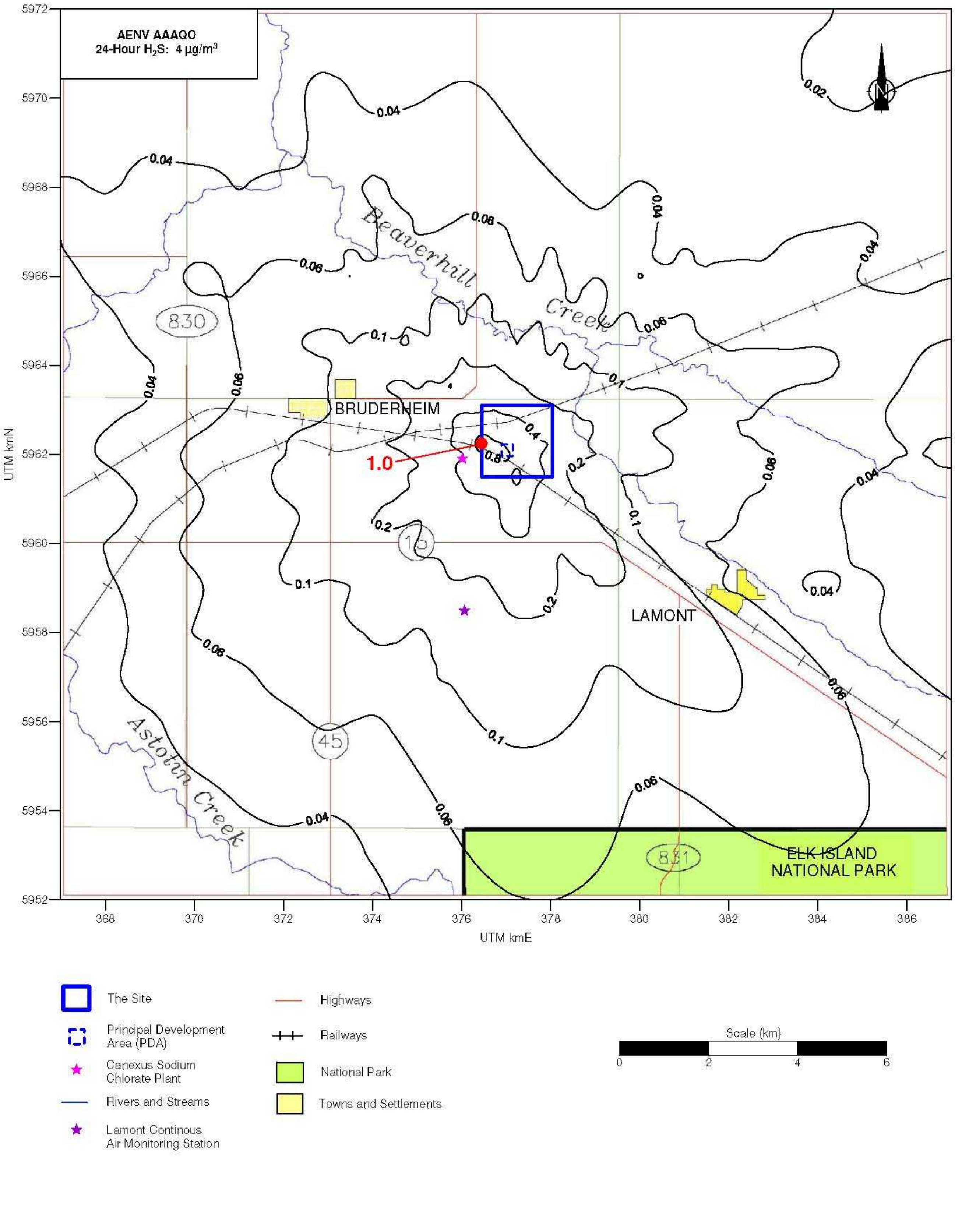

Isopleths of Maximum Predicted Daily Average Ground-level H_2S Concentrations (µg/m³) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

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SH	LH	Apr 10/07
APPROVED	FIGURE: 2.5-5	

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2.5.1.1.3 Nitrogen Dioxide

The highest predicted hourly average concentration of 209 µg/m^3 occurs on the southern portion of the Site boundary (Figure 2.5-6). It is less than the ambient air quality objective of 400 µg/m^3. Locomotive emissions were the main contributor to the predicted values. Predicted daily average values are comparatively small because the locomotive was assumed to be present for a maximum of two hours a day (Figure 2.5-7). The largest predicted annual average NO_2 concentrations occur along the south plant boundary (Figure 2.5-8). The largest predicted value of 2.2 µg/m^3 is much less than the AAAQO of 60 µg/m^3.

2.5.1.1.4 Sulphur Dioxide

The highest predicted hourly average concentration of 19.4 µg/m^3 occurs on the southern boundary of the Project (Figure 2.5-9) while the maximum predicted daily average concentration of 0.6 µg/m^3 occurs on the eastern boundary (Figure 2.5-10). Both predicted values are much less than 10% of the relevant AAAQO. The maximum predicted annual average concentration of 0.03 µg/m^3 is only 0.1% of the AAAQO value of 30 µg/m^3 (Figure 2.5-11).

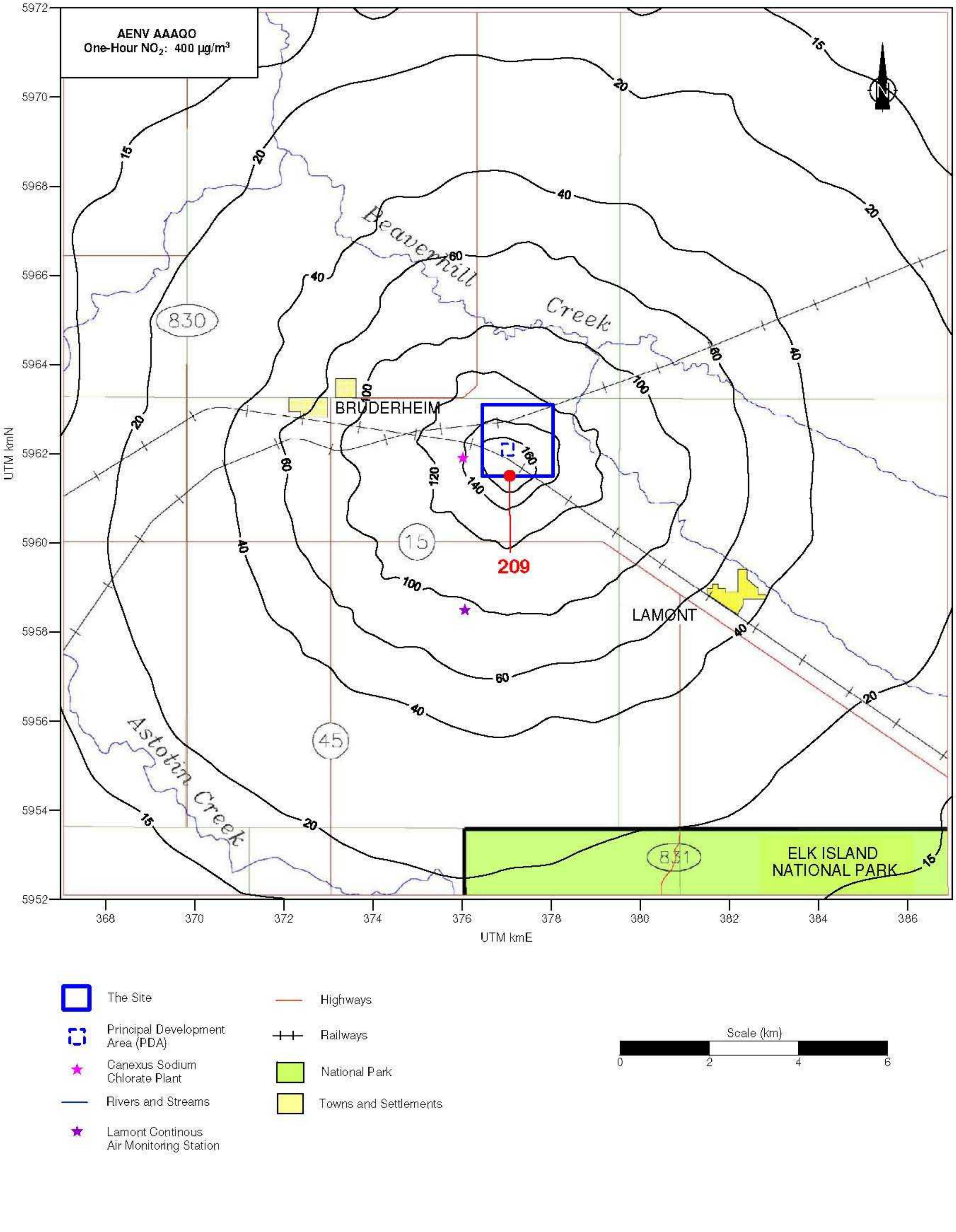
2.5.1.1.5 Particulate Matter

The predicted 98th daily average concentrations of $PM_{2.5}$ values averaged over a three year period include both primary and secondary particulates (Figure 2.5-12). The largest predicted concentration of 6.0 µg/m^3 should not be compared to the CWS value of 30 µg/m^3. This CWS pertains to the regional background concentrations as measured at the Lamont monitoring site. The maximum predicted concentration for that location being only 0.8 µg/m^3 is much less than the CWS value.

2.5.1.2 <u>Project Plus the Canexus Sodium Chlorate Plant and Background Regional Emission Sources</u>

Table 2.5-4 presents estimated maximum background concentrations of criteria pollutants (Jacques Whitford–AXYS 2006). It shows that future predicted maximum background concentrations of NO_2, SO_2 and $PM_{2.5}$ tend to be similar in magnitude to the existing values measured at the Lamont monitoring station (Table 2.4-5). This seems reasonable in-so-far as the newly approved industrial facilities tend to be located at distances 14 km or greater from the Site. Their emissions, should therefore, have little effect on air quality impacts at the Site. Maximum predicted background values for CO and H_2S are less than assumed existing values. Existing background values for CO, as was previously discussed, were very conservatively assumed to be equal to existing values observed at Fort Saskatchewan. The high observed values for H_2S may be associated with anomalous upset conditions which were not modelled.

Table 2.5-5 presents the final application predictions of maximum concentrations of criteria pollutants that will occur in the Bruderheim area as a result of emissions from the Project. They were obtained by adding maximum predicted background values to maximum predicted concentrations shown in Figure 2.5-2, Figure 2.5-3, Figure 2.5-4, Figure 2.5-5, Figure 2.5-6, Figure 2.5-7, Figure 2.5-8, Figure 2.5-9, Figure 2.5-10, Figure 2.5-11 and Figure 2.5-12. Existing background concentration values are given in Table 2.5-5 when predicted future values are of less magnitude. This is a very conservative procedure because it assumes that maximum background values will occur under the same meteorological conditions as those associated with Project emissions. The table shows that operation of the Project, when existing and approved industrial sources are taken into consideration, should result in maximum ground-level concentrations of criteria pollutants which are less than AAAQO.



Isopleths of Maximum Predicted Hourly Average Ground-level NO_2 Concentrations (µg/m³) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED		FIGURE: 2.5-6

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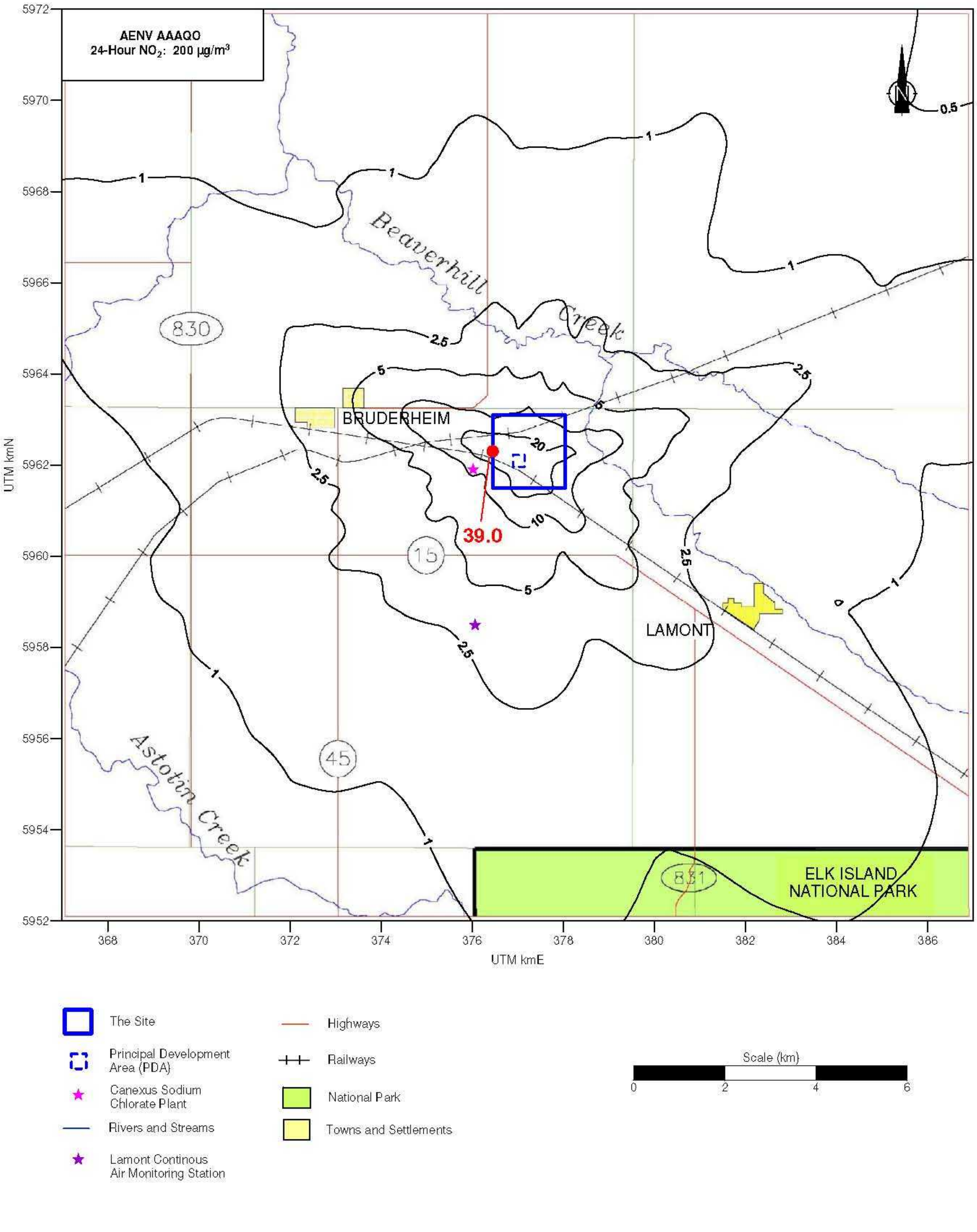

Isopleths of Maximum Predicted Daily Average Ground-level NO_2 Concentrations (µg/m³) Associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant.

DRAWN BY:	EDITED BY:	DATE
SH	LH	Apr 10/07
APPROVED		FIGURE: 2.5-7

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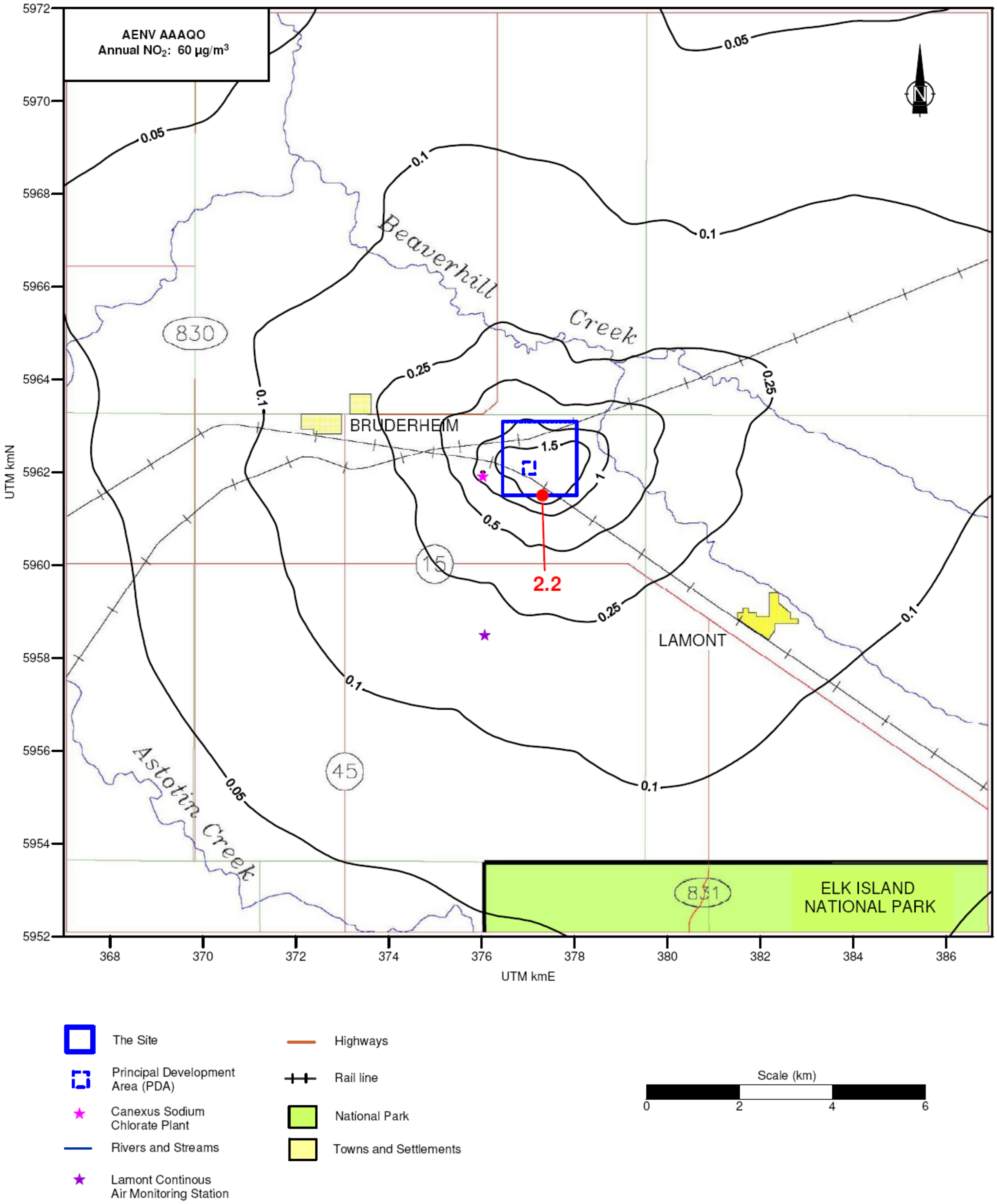

Figure 2.5-8: Isopleths of Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m^3) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

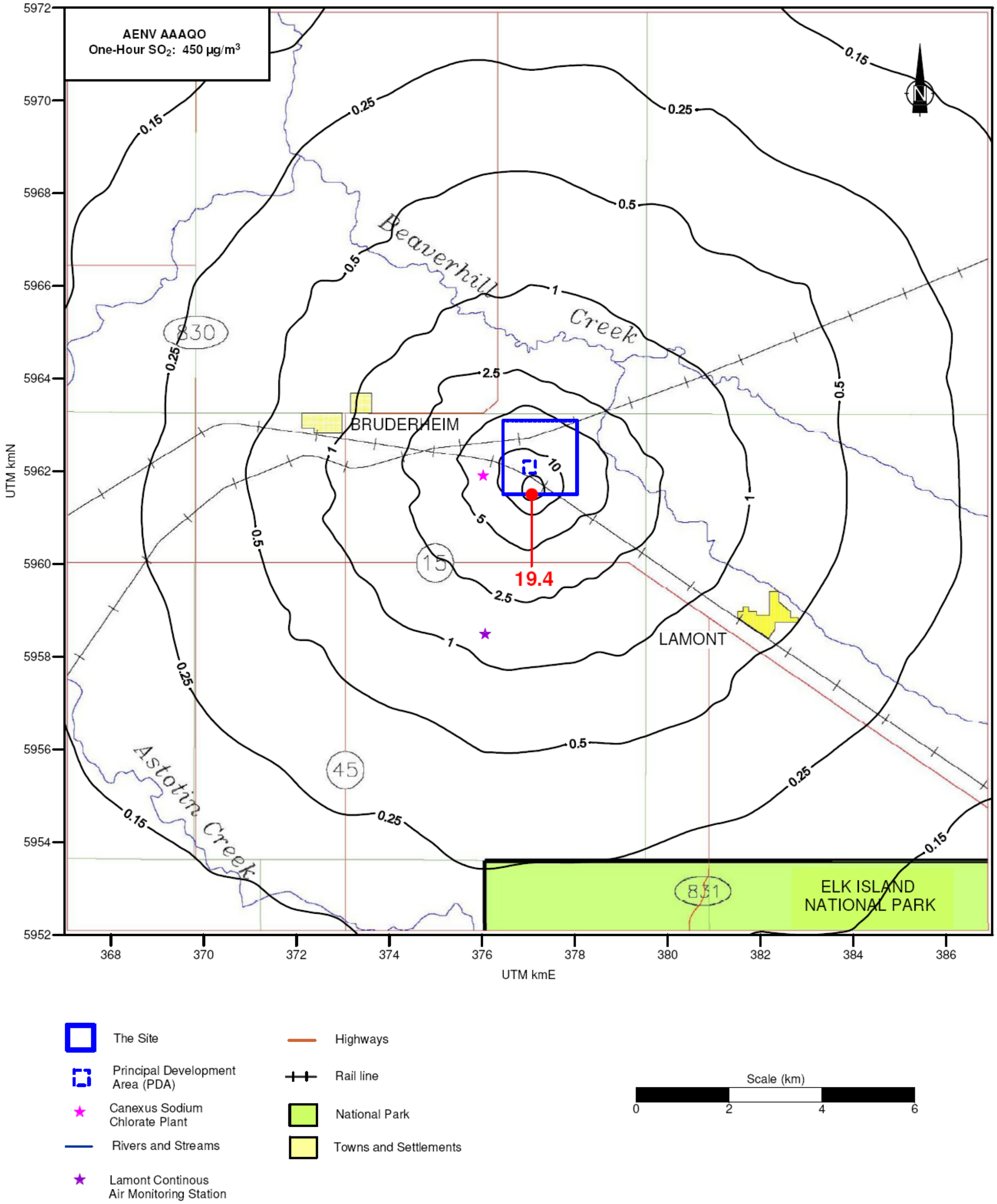

Figure 2.5-9: Isopleths of Maximum Predicted Hourly Average Ground-level SO_2 Concentrations (µg/m^3) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

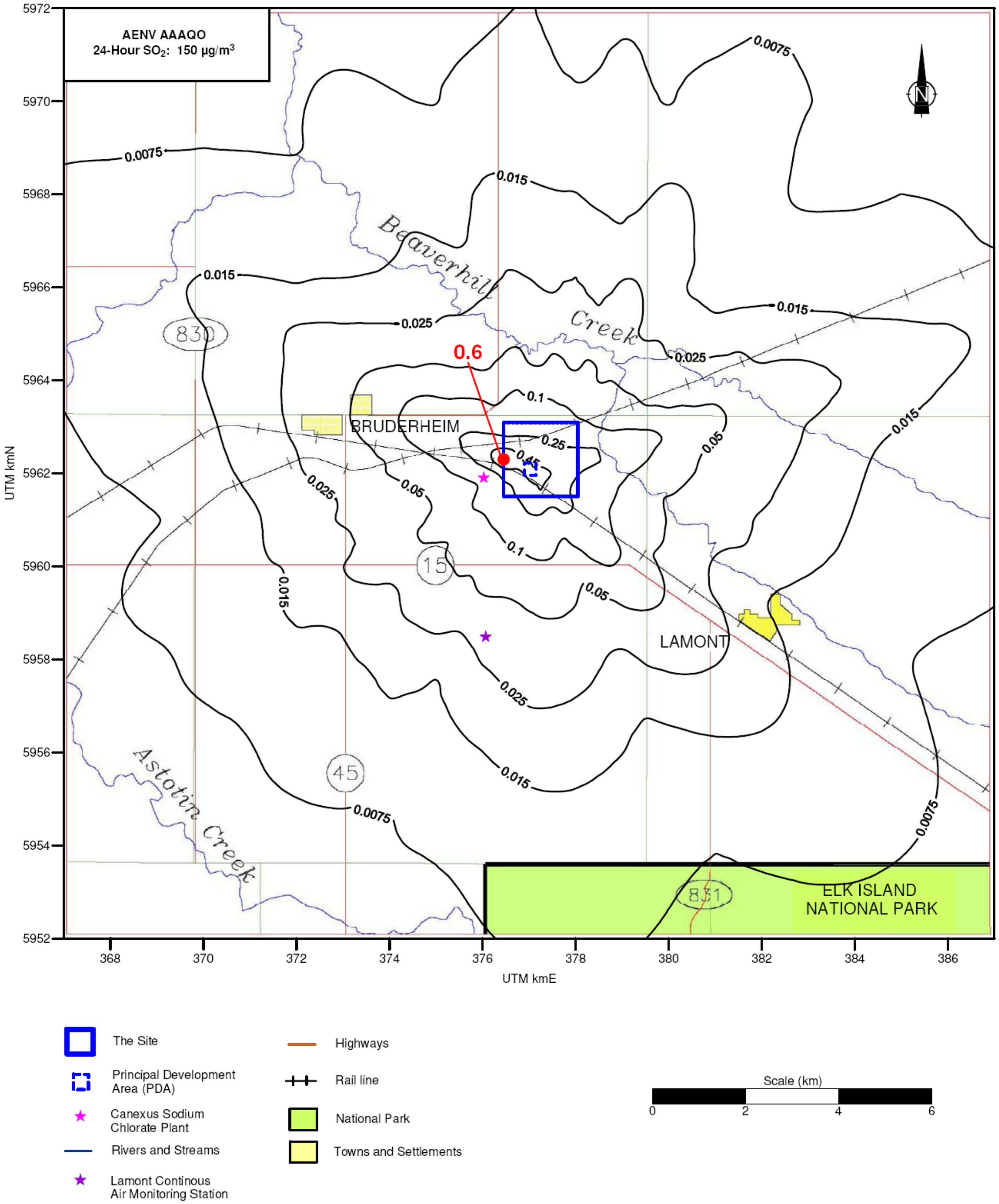

Figure 2.5-10: Isopleths of Maximum Predicted Daily Average Ground-level SO_2 Concentrations (µg/m³) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

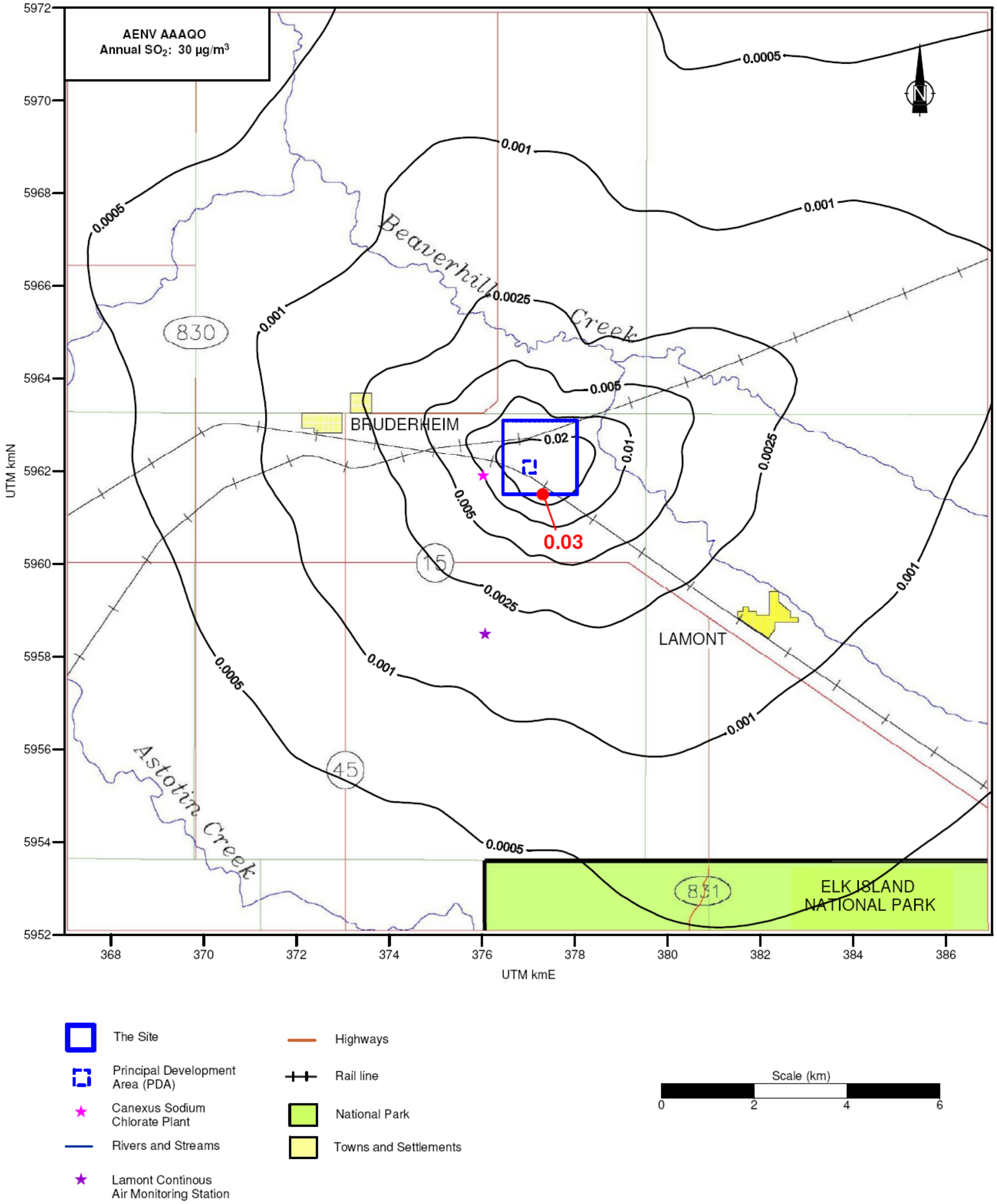

Figure 2.5-11: Isopleths of Maximum Predicted Annual Average Ground-level SO_2 Concentrations (µg/m³) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

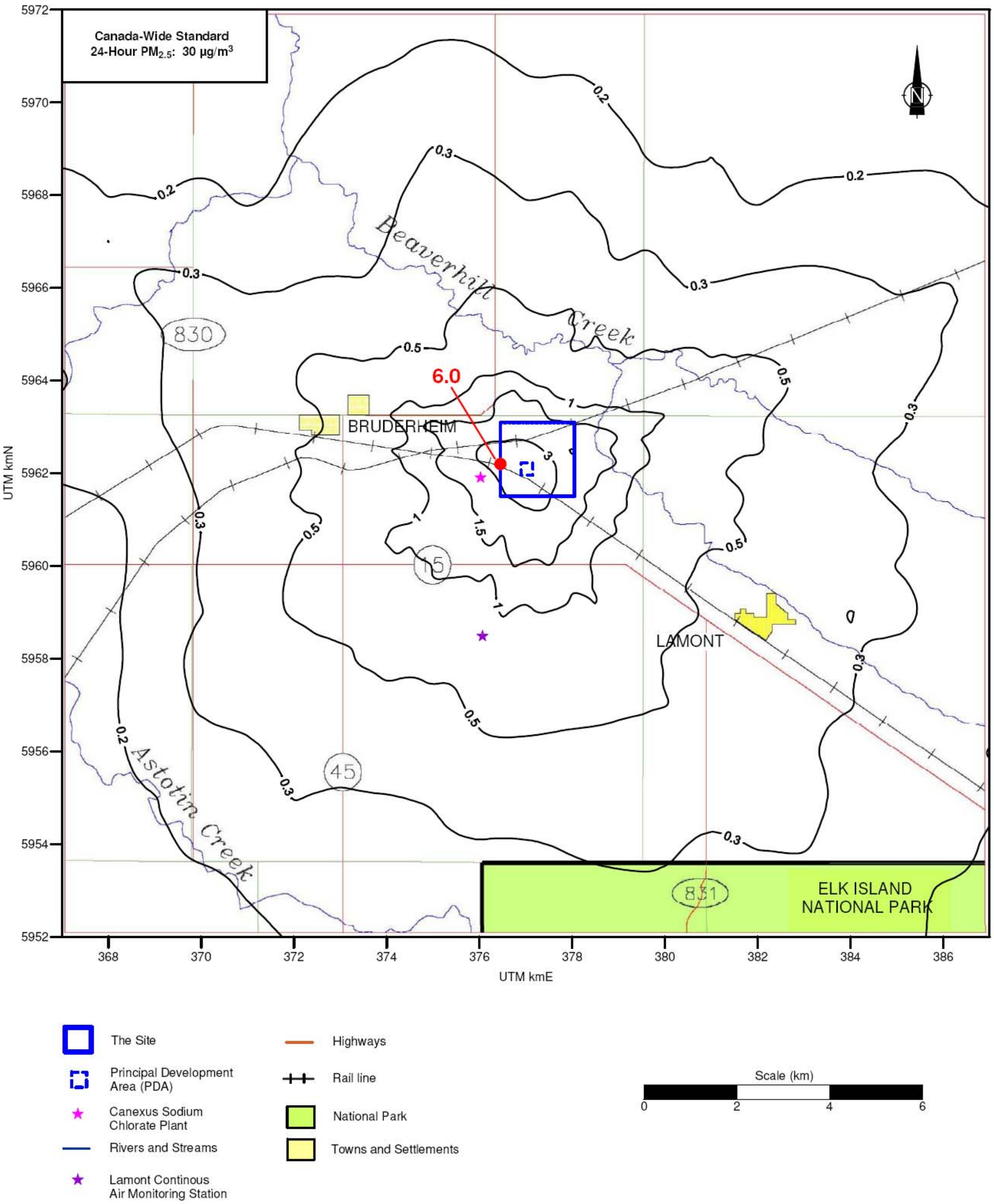

Figure 2.5-12: Isopleths of 98th Percentile Daily Average $PM_{2.5}$ Concentrations ($\mu g/m^3$) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

Table 2.5-4: Maximum Predicted Ground-level Background Concentrations of Criteria Pollutants Associated with Emissions from Existing and Approved Industrial and Urban Sources

Air Contaminant	Averaging Period	Ambient Background Concentration ($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
CO	One-hour	1.1	15,000
	8-hour	1.0	6,000
H_2S	One-hour	1.3	14
	24-hour	0.5	4
NO_2	One-hour	90.0	400
	24-hour	55.0	200
	Annual	15.0	60
$PM_{2.5}$	24-hour	20.0[1]	30[2]
SO_2	One-hour	100.0	450
	24-hour	35.0	150
	Annual	7.0	30

Notes:
1 98th percentile value.
2 CWS based on the 98th percentile ambient measurement annually, averaged over three consecutive years.

Table 2.5-5: Maximum Ground-level Concentrations of Criteria Pollutants Predicted for the Study Area (Application Case)

Air Contaminant	Averaging Period	Observed Ambient Background Concentration ($\mu g/m^3$)	Maximum Predicted Ground-level Concentration ($\mu g/m^3$)	Total Ground-level Concentration, Including Background ($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
CO	One-hour	5800.0	238.0	6038.0	15,000
	8-hour	3300.0	51.4	3663.0	6,000
H_2S	One-hour	8.0	2.2	10.2	14
	24-hour	2.3	1.0	3.3	4
NO_2	One-hour	102.0	209.0	311.0	400
	24-hour	55.0	39.0	99.0	200
	Annual	15.0	2.2	16.2	60
$PM_{2.5}$	24-hour	20.5*	6.0	26.5	30**
SO_2	One-hour	120.0	19.4	139.4	450
	24-hour	35.0	0.6	35.6	150
	Annual	7.0	0.03	7.0	30

Notes:
* 98th percentile value.
** CWS applies to community centres and not to maximum predicted impacts.

2.5.2 Acid Deposition

The background value for acid deposition in the Project area for the application case as predicted through use of the CALPUFF model is 0.17 keq H^+/(ha•y) (Jacques Whitford-AXYS 2006). Isopleths of predicted annual average ground-level PAI values (keq H^+/(ha•y)) associated with emissions from the Project and Canexus Sodium Chlorate Plant are presented in Figure 2.5-13. These values, predicted by the CALPUFF plume dispersion model, are comparatively small. Areas within the 0.017 keq H^+/(ha•y) isopleth are enclosed in a region that extends very short distances beyond the Project fenceline. Beyond this small enclosed area, acid deposition should be essentially the same with or without the Project.

2.5.3 Sulphur Deposition

The rotoform stacks and facility loading area will be sources of particulate emissions of sulphur. Figure 2.5-14 presents maximum predicted annual average sulphur deposition values (kg $ha^{-1}yr^{-1}$) associated with Project emissions. They were estimated through use of the CALPUFF model (see Appendix I). The highest value of 1.1 kg/ha/y occurs on the south Site boundary. Values tend to decrease to less than 0.1 kg/ha/y within about 4 km from the boundary. There are no existing guidelines relating to sulphur deposition values.

2.5.4 Upset Conditions

A sulphur fire may occur during an upset condition relating to a fire in the pastille storage pile. but is likely to be small and of short duration. Project facilities will be supplemented by a network of SO_2 monitors that will quickly detect any incipient fire. Any fire should be small, slow in progressing and short lived. Figure 2.5-15 presents isopleths of predicted maximum hourly average ground-level SO_2 concentrations (µg/m^3) which would accompany a sulphur fire at the top of the pastille storage pile which burns at the rate of 4 kg/10 minutes. The maximum predicted hourly average concentration of 433 µg/m^3 occurs on the south plant boundary. This value is less than the relevant AAAQO of 450 µg/m^3.

2.5.5 Mitigation

AST will implement a dust suppression program within operating areas where pastilles are exposed to wind actions. This includes all conveyor transfer points and the loading bin associated with front end loading operations. The asphalt pavement within the loading area will be swept and washed on a daily basis. Exhausts from the storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed 1 ppm by volume.

2.5.6 Residual Impacts

2.5.6.1 Criteria Pollutants

The residual impacts from criteria air pollutants are negative in direction, local in effect, negligible in magnitude and long term in duration. The confidence level in these predictions is high. Therefore, the impact rating is Class 4.

2.5.6.2 Acid Deposition

The residual impacts from acid deposition are negative in direction, local in effect, negligible in magnitude and long term in effect. The confidence level in these predictions is high. Therefore, the impact rating is Class 4.

Figure 2.5-13: Isopleths of Predicted Annual Average PAI Values (keq H^+/(ha•y)) associated with Emissions from the Project plus the Canexus Sodium Chlorate Plant

Figure 2.5-14: Isopleths of Maximum Predicted Annual Average Sulphur Deposition Values (kg/ha/y) Associated with Project Emissions

Figure 2.5-15: Isopleths of Maximum Predicted Hourly Average Ground-level SO_2 Concentrations (µg/m^3) Associated with Emissions from the Project during Upset Conditions (4 kg S per 10 minute event)

2.5.6.3 ***Ozone***

Observational data collected within the general region of the Project area has shown the presence of O_3 scavenging by NO_x emissions. AST will work with regulatory agencies within the Particulate and Ozone Management Framework (AENV 2006b, Internet site) to ensure that the CWS is not exceeded.

2.5.7 Application Case Summary

Impacts predicted in the application case for Project emissions with respect to criteria pollutants, acid deposition and O_3 creation are all concluded to be acceptable and will not result in exceedances of the air quality objectives or standards used in this assessment.

2.6 Cumulative Effects Case

A cumulative effects case differs from an application case assessment by considering the air quality impacts from other proposed emission sources. As previously indicated in Table 2.3-1 seven significant industries are being planned for the general Project region. These industries and their distance from the Project as given in brackets are:

- Access Pipeline, Redwater Trim Blending Facility (18 km)
- Aux Sable Canada, Heartland Offgas Project (14 km)
- North West Upgrading Inc., NorthWest Upgrader Project (18 km)
- Petro-Canada Oilsands Inc., Sturgeon Upgrader Project (24 km)
- Sherritt International Corporation, Fort Saskatchewan Fertilizer Plant (24 km)
- Synenco Energy Ltd., Northern Lights Upgrader Project (18 km)
- Terasen Pipelines, Heartland Storage Tank Terminal (14 km)

Estimates of ground-level concentrations of criteria pollutants and PAI that might occur within the Project area as a result of the additional seven sources were calculated by Jacques Whitford-AXYS (2006) using the CALPUFF dispersion model in the manner described in Section 2.3.1.4 and Section 2.4.3 of this report.

2.6.1 Criteria Pollutants

Predicted maximum background concentrations for the Project area following construction and operation of the planned industries are shown in Table 2.6-1.

An examination of Table 2.6-1 shows that maximum background concentrations for criteria pollutants after the planned industry facilities come on stream are predicted to be similar to existing values (see Table 2.4-3). This is again not unexpected, given that the planned industries tend to be at distances of greater than 15 km from the Site.

The maximum ground-level concentrations of criteria substances predicted for the Site for the cumulative case were very conservatively estimated by adding the maximum concentration associated with emissions from the Project and Canexus Plant with maximum estimated background values. Results of the estimating procedure are shown in Table 2.6-2. Existing background concentration values are given in Table 2.5-5 when predicted future values are of less magnitude. They are the same as for the application case (Table 2.5-5).

Table 2.6-1: Maximum Predicted Ground-level Background Concentrations of Criteria Pollutants Associated with Emissions from Existing, Approved and Planned Industrial and Urban Sources

Air Contaminant	Averaging Period	Predicted Ambient Background Concentrations ($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
CO	One-hour	1.10	15,000
	8-hour	1.00	6,000
H_2S	One-hour	1.30	14
	24-hour	0.50	4
NO_2	One-hour	90.00	400
	24-hour	55.00	200
	Annual	15.00	60
$PM_{2.5}$	24-hour	20.0[1]	30[2]
SO_2	One-hour	100.00	450
	24-hour	35.00	150
	Annual	7.00	30

Notes:
1 98th percentile value.
2 CWS based on the 98th percentile ambient measurement annually, averaged over three consecutive years.

Table 2.6-2: Maximum Ground-level Concentrations of Criteria Pollutants Predicted for the Study Area (Cumulative Case)

Air Contaminant	Averaging Period	Observed Ambient Background Concentration ($\mu g/m^3$)	Maximum Predicted Ground-level Concentration ($\mu g/m^3$)	Total Ground-level Concentration, Including Background ($\mu g/m^3$)	AAAQO ($\mu g/m^3$)
CO	One-hour	5,800.0	238.00	6,038.0	15,000
	8-hour	3,300.0	51.40	3,663.0	6,000
H_2S	One-hour	8.0	2.20	10.2	14
	24-hour	2.3	1.00	3.3	4
NO_2	One-hour	102.0	209.00	311.0	400
	24-hour	55.0	39.00	99.0	200
	Annual	15.0	2.20	16.2	60
$PM_{2.5}$	24-hour	20.5*	6.00	26.5	30**
SO_2	One-hour	120.0	19.40	139.4	450
	24-hour	35.0	0.60	35.6	150
	Annual	7.0	0.03	7.0	30

Notes:
* 98th percentile value.
** The CWS applies to community centres and not to maximum predicted impacts.

2.6.2 Acid Deposition

Background values of PAI as predicted through application of the CALPUFF model for the cumulative case is 0.25 keq $H^+/(ha \cdot y)$ (Jacques Whitford-AXYS 2006). As illustrated in

Figure 2.5-13, any significant influence of Project emissions should be localized to within about 1 km of the Site boundary.

2.6.3 Sulphur Deposition

There will be no other regional sources of sulphur deposition. Maximum estimated values for the cumulative case are the same as for the application case.

2.6.4 Mitigation

AST will implement a dust suppression program within areas of plant operations where pastilles are exposed to wind actions. This includes all conveyor transfer points and the loading bin associated with front end loading operations. The asphalt pavement within the loading area will be swept and washed on a daily basis. Exhausts from the storage tanks will be subject to the SulfaTreat process to ensure that H_2S concentrations do not exceed 1 ppm by volume.

2.6.5 Residual Impacts

2.6.5.1 Criteria Pollutants

The residual impacts from criteria air pollutants are negative in direction, local in effect, negligible in magnitude and long term in duration. The confidence level in these predictions is high. Therefore, the impact rating is Class 4.

2.6.5.2 Acid Deposition

The residual impacts from acid deposition are negative in direction, local in effect, negligible in magnitude and long term in effect. The confidence level in these predictions is high. Therefore, the impact rating is Class 4.

2.6.5.3 Ozone

As indicated in the baseline case, O_3 within the LSA as observed at stationary monitors appears to be scavenged by NO_x emissions. Ozone has not been further assessed in the application case. AST will work with regulatory agencies within the Particulate and Ozone Management Framework (AENV 2006b, Internet site) to ensure that issues relating to O_3 are satisfactorily addressed.

2.6.6 Cumulative Effects Case Summary

Impacts predicted for the cumulative effects case for emissions associated with the Project and other regional existing and proposed air emission sources are similar to those predicted for the application case. Impacts with respect to criteria pollutants, acid deposition and O_3 creation are, therefore, concluded to be acceptable. They will not result in exceedances of air quality objectives or acid deposition criteria.

2.6.7 Management and Monitoring

AST will continue to implement dust suppression measures with respect to conveyor transfer points and within the sulphur loading area. AST will maintain observational programs with respect to fine particulates and H_2S. Furthermore, AST will continue to participate in regional initiatives relative to air quality issues.

2.6.8 Conclusions

All residual impacts were assessed in terms of direction, extent, magnitude, duration and confidence. A qualitative descriptor for each attribute has been used to determine an overall impact class numerical ranking from 1–4 for each indicator. The rankings presuppose that the mitigative actions are implemented and effective. Table 2.6-3 summarizes the impacts for all the chosen air quality indicators. This assessment of air emissions associated with the Project has shown they should not have any adverse effects on the environment with respect to harmful ground-level pollutant concentrations, soil and water acidification or O_3 creation.

Table 2.6-3: Final Impact Rating Summary Table

Issue	Geographic Extent	Magnitude	Direction	Duration	Confidence	Rating
Criteria pollutants	Local	Negligible	Negative	Long term	High	4
Non-criteria substances	Local	Negligible	Negative	Long term	High	4
Ozone	Local	Negligible	Uncertain	Long term	High	4
Acid deposition	Local	Negligible	Negative	Long term	High	4

2.7 Potential Impacts of Climate Change and Project Adaptation and Mitigation

Climate change refers to a significant shift from one climate regime to another. Concern is growing because average global temperatures are rising, and measurable increases in temperatures and changes in precipitation patterns have been observed in Alberta. These changes appear to be related to an increase in greenhouse gases that trap heat in the atmosphere. For example, CO_2 levels are increasing and it is estimated that atmospheric CO_2 concentration will double by approximately 2050. The Project itself will not have a measurable impact on influencing regional or local climate because greenhouse gas emissions associated with the Project are minimal.

2.7.1 Climate Change Predictions

The Canadian Climate Centre's most recent diagnostic tool for climate modelling is the CGCM3 global climate model, which is the third version of the Canadian Centre for Climate Modelling and Analysis Coupled Global Climate Model. This model makes use of the same ocean component as that was used in the earlier models, but includes a substantially updated atmospheric component. For the purposes of this report, data generated by the CGCM3 model is driven by the Intergovernmental Panel on Climate Change (IPCC) scenario IS92a. This scenario predicted temperature and precipitation over Western Canada for the time-slice simulation between 2040 and 2049 (CCCma 2007, Internet site). A 45 km horizontal grid-size mesh with 18 vertical levels of modelling was employed. The IS92a scenario assumes that effective CO_2 concentrations in the atmosphere increase at 1% per year after 1990. In the model, the concentrations are specified by linear interpolation between specified values at 2000, 2025 and 2050. The assumed atmospheric CO_2 concentration for this scenario in 2049 is 865 ppm. The estimated variance in temperature for the project area is illustrated in Figure 2.7-1, and the estimated variance in precipitation is illustrated in Figure 2.7-2.

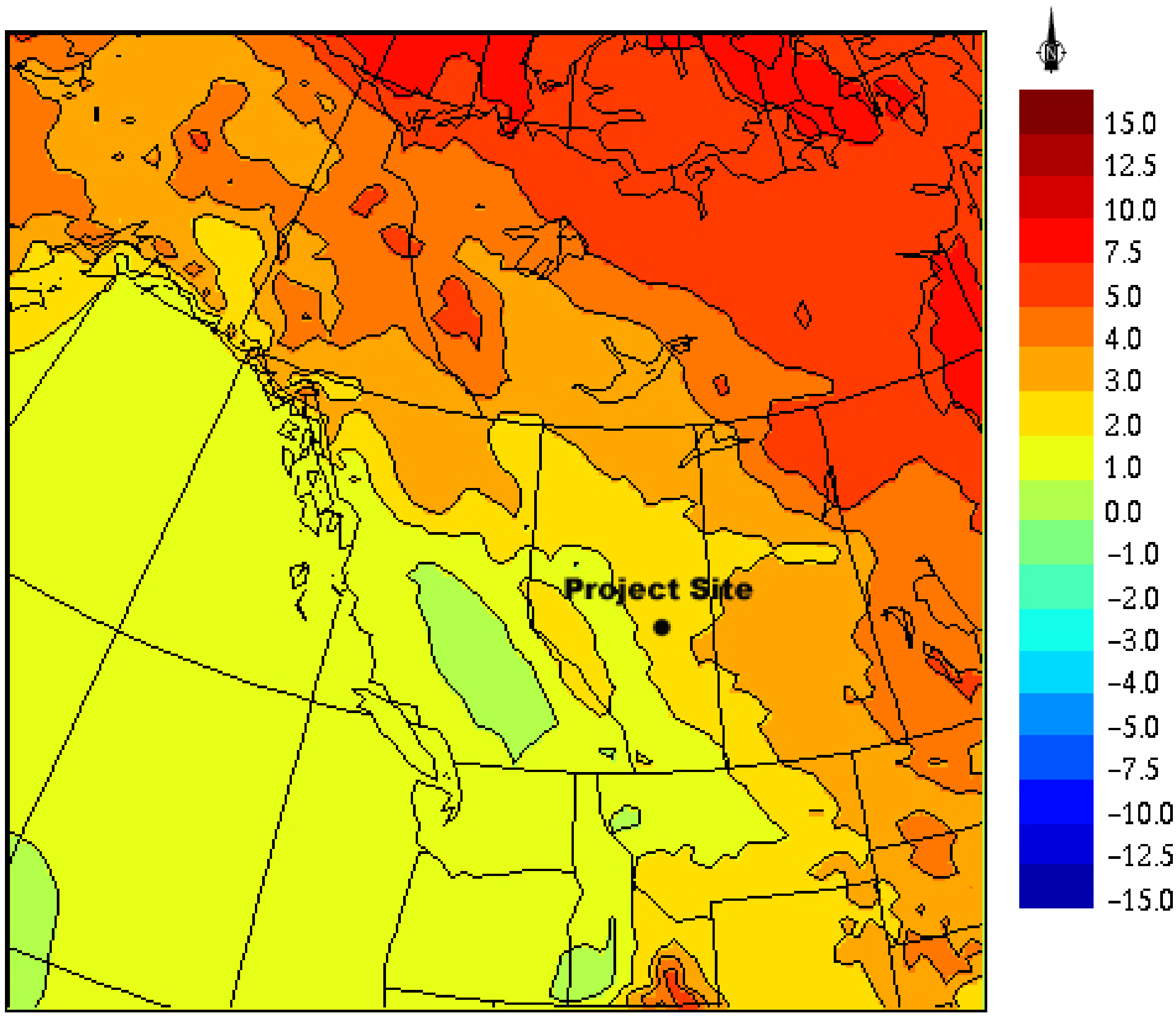

Figure 2.7-1: Estimated Surface Temperature Variance (2 m) in the Project Area (ºC): 1975–1984 vs. 2040–2049 Generated by CGCM3 Assuming IPCC Scenario IS92a

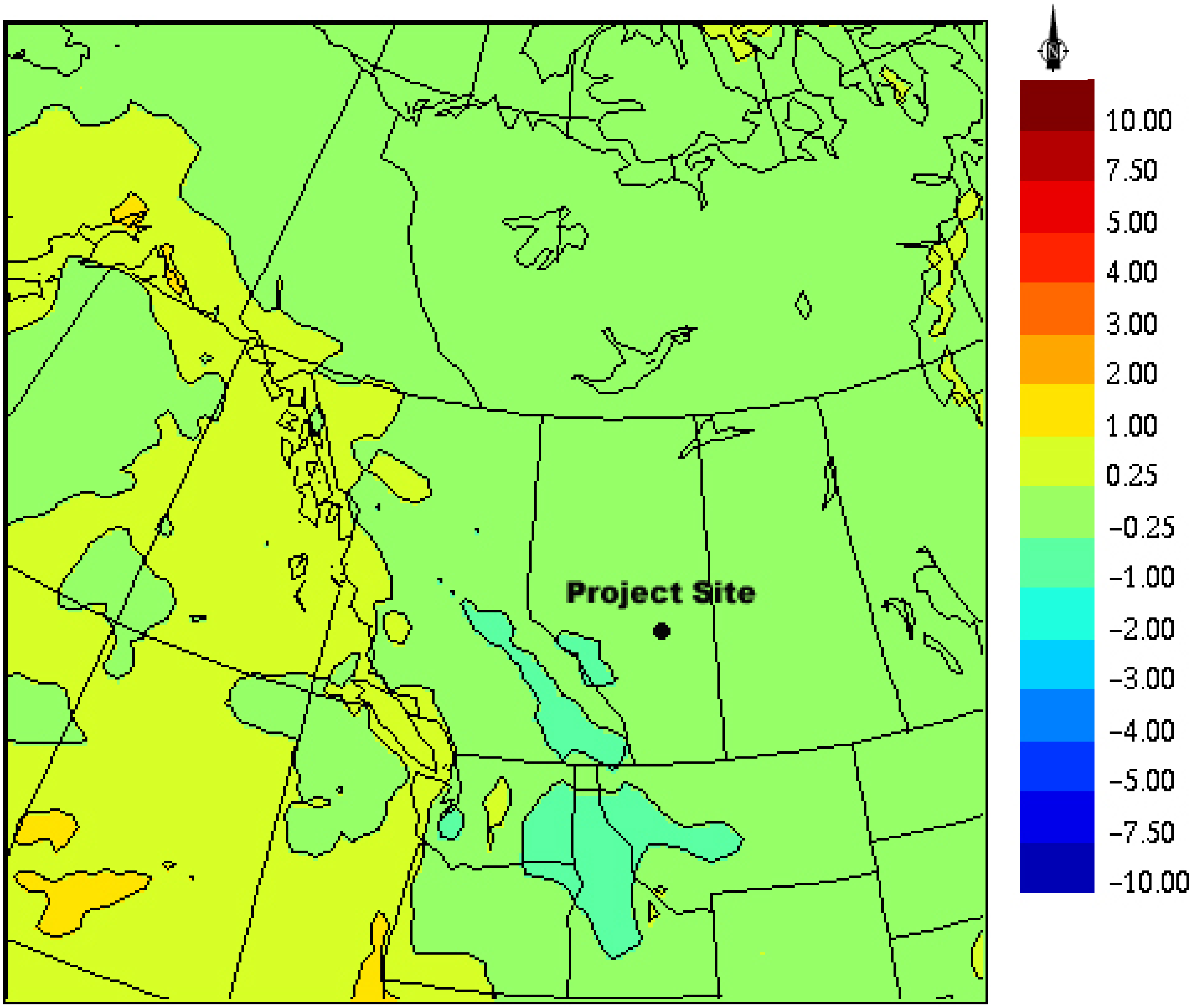

Figure 2.7-2: Estimated Variance in Precipitation (mm/d) in the Project Area: 1975–1984 and 2040–2049 Generated by CGCM3 Assuming IPCC Scenario IS92a

Under the IS92a climate scenario, the Project area is expected to warm by approximately 2–3°C by 2050 relative to the 1975–1984 mean. Precipitation is expected to decrease by up to 0.25 mm/d (91 mm per year, or approximately 25%) relative to the 1975–1984 mean. Precipitation estimates are highly uncertain, and there is little agreement across climate scenarios regarding changes in total annual runoff across North America. Important factors to note when using these predictions include the following:

- changes in precipitation are highly uncertain. There is little agreement across climate scenarios regarding changes in total annual runoff across North America. Arid environments are characterized by highly nonlinear relationships between precipitation and runoff. Thus, stream flows in the moisture-deficit project area will be particularly sensitive to any changes in temperature and precipitation.
- seasonal shifts in runoff are likely, with a larger proportion of runoff occurring in winter (earlier snowmelt), together with possible reductions in summer flows (high confidence). Earlier melt-off in combination with either lower or higher snow pack will tend to increase winter or spring flows and reduce summer flows. Warmer temperatures could increase the number of rain-on-snow events in some river basins, increasing the risk of winter and spring floods.
- where lower summer flows and higher water temperatures occur, there may be reduced water quality and increased stress on aquatic ecosystems (medium confidence)
- possible changes in the frequency/intensity/duration of heavy precipitation events may require changes in land-use planning and infrastructure design to avoid increased damage arising from flooding, landslides, sewerage overflows, and releases of contaminants to natural waterbodies

2.7.2 Project Impacts and Mitigation

The sulphur forming and shipping activities are essentially insensitive to changes in atmospheric temperature and precipitation. Given these climatic predictions, it is anticipated that the vulnerable aspects of the Project to climatic change are related to water supply and stormwater runoff. Specifically:

- more intense storm events may lead to localized flooding
- an overall decrease in the regional water balance (including groundwater recharge), may potentially impact the available cooling water supply

Both of these potential impacts can be mitigated by increasing the capacity of the stormwater retention pond, and perhaps by diverting additional drainage to the pond from adjacent areas. Additional pond capacity will reduce the probability of a forced discharge event during flooding, and will also allow for storage of additional water for cooling. This change, if required, may be implemented at any time in the future as the retention pond and stormwater controls are designed to support the proposed development and are entirely manmade. Further, the stormwater retention pond as it is currently designed is significantly oversized because this pond also provides a reservoir for cooling water and fire fighting.

2.8 References

2.8.1 Literature Cited

Alberta Environment (AENV). 2003. *Air Quality Model Guideline Science and Technology Branch, Environmental Sciences Division,* AENV. Edmonton, AB.

Alberta Environment (AENV). 2007. *Final Terms of Reference, Environmental Impact Assessment (EIA) Report for the Proposed AST Sulphur Forming and Shipping Facility.* March 13, 2007. Edmonton, AB.

Baumgardner, R.E. and E. S. Edgerton. 1998. Rural Ozone Across the United States: Analysis of CASTNet Data 1988-1995. J. *Air & Waste Management Assoc*. 48 674-688.

Cheng, L., K. McDonald, D. Fox, R. Angle. 1997. *Total Potential Acid Input in Alberta.* Alberta Environment Protection, Edmonton, AB.

Cheng, L., R.P. Angle, E. Peake and H.S. Sandhu. 1995. Effective Acidity Modelling to Establish Acidic Deposition Objectives and Manage Emissions. *Atmospheric Environment* 29: 383-392.

Clean Air Strategic Alliance (CASA) and Alberta Environment (AENV). 1999. *Application of Critical, Target and Monitoring Loads for the Evaluation and Management of Acid Deposition.* Calgary, AB.

Environment Canada. 1999. *National Ambient Air Quality Objectives for Particulate Matter Part 1: Science Assessment Document ,* Minister, Public Works and Government Services, ISBN 0-662–26715-X Cat. No. H46-2/98-220-1E.

Furmanczyk, T. 1994. *National Urban Air Quality Trends: 1981–1990.* Pollution Data Branch, Environment Protection Service, Environment Canada. Report EPS 7/UP/4.

Jacques Whitford-AXYS. 2006. *Application for Approval of the Sturgeon Upgrader Prepared for Fort Hills Energy L.P.* (FHELP). Calgary, AB.

Leahey, D.M. and B.K. Morrow. 1999*. Observations in Alberta of Ozone Depletion by Nitric Oxide*. Presented at Ozone Experts Forum sponsored by Shell Canada Limited. Calgary, AB.

Maxxam Analytics Inc. 2005. *Analytical Report on Particle Size Distributions.* Report to DM Leahey & Associates. Maxxam Analytics Inc., Calgary, AB T2E 6P2. August 3, 2005.

Mulholland, J.A., A.J. Butler, J.G. Wilkinson and A.G. Russell. 1998. *Temporal and Spatial Distributions of Ozone in Atlanta: Regulatory and Epidemiologic Implications.* Journal of the Air & Waste Management Association 48 418-426.

Scire, J.S., D.G. Strimatis and R.J. Yamartino. 1999. A User's Guide for the CALPUFF Dispersion Model (Version 5.0). Concord, MA: Earth Tech Inc.

Strimaitis, D.G., J.S. Scire and J.C. Cheng. 1998. Evaluation of the CALPUFF Dispersion Model with Two Power Plant Data Sets. 10th Joint Conference on the Applications of Air Pollution Meteorology. January 11–16, 1998. Phoenix, AZ.

Watson J.G., J.C. Chow and T.G. Pace. 2000/ *Fugitive Dust Emissions Air Pollution Engineering Manual* (2nd Edition) Air & Waste Management Assoc. John Wiley & Sons Inc. New York, Brisbane, Toronto. pp 886

2.8.2 Internet Sites

Alberta Environment (AENV). 2006a. Existing Ambient Air Quality Objectives. Available at: http://www3.gov.ab.ca/env/air/OGS/objexisting. Accessed July 28, 2006.

Alberta Environment (AENV). 2006b. Particulate Matter and Ozone Management Framework. Available at: http://www3.gov.ab.ca/env/air/OGS/pmozone.html. Accessed March 15, 2007.

Alberta Environment (AENV). 2002. Alberta & Climate Change: Taking Action. Available at: http://environment.gov.ab.ca/info/library/6123.pdf. Accessed February 27, 2007. Environment Canada. 2004.

Canadian Centre for Climate Modelling and Analysis (CCCma). 2007. Available at: www.cccma.ec.gc.ca/data/cgcm/cgcm_forcing.shtml. Accessed February 16, 2007.

Canadian Climate Normals 1971-2000: Edmonton International Airport. Available at: http://www.climate.weatheroffice.ec.gc.ca/climate_normals. Accessed July 24, 2006.

Clean Air Strategic Alliance (CASA). 2006. Online Data Warehouse. Available at: http://www.casadata.org/. Accessed 2006.

Fort Air Partnership (FAP). 2006. Data Reports. Available at: http://www.fortair.org/historical_data.php. Accessed November 30, 2006.

Health Canada. 2005. Regulations Related to Health and Air Quality. Available at: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/reg_e.html#2. Accessed February 15, 2007.

United States Environmental Protection Agency (USEPA). 2006. Emission Factors & AP-42. Available at: http://www.epa.gov/ttn/chief/ap42/. Accessed January 25, 2007.

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Appendix I: Dispersion Modelling Approach

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1. Introduction

Ambient air quality models are used to predict air quality changes (i.e., changes to ambient concentrations or deposition) associated with current and future emission scenarios. This section discusses the application of the CALPUFF dispersion model that was used to evaluate the proposed Project.

2. CALPUFF Dispersion Model

CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model, which can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and deposition. Several options are provided in CALPUFF for the computation of dispersion coefficients, including the use of turbulence measurements (σv and σw), the use of similarity theory to estimate σv and σw from modeled surface heat and momentum fluxes, or the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model. Options are provided to apply an averaging time correction or surface roughness length adjustment to the PG coefficients. For this assessment, the single meteorological station mode was applied and dispersion coefficients were determined from internally calculated σv and σw using micrometeorological variables.

CALPUFF contains algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, as well as longer-range effects such as chemical transformation, and pollutant removal (wet scavenging and dry deposition). It can accommodate arbitrarily varying point source and area source emissions. Most of the algorithms contain options to treat the physical processes at differing levels of detail depending on the requirements for the particular model application.

3. CALPUFF Modelling Methodology

The following sections discuss CALPUFF modelling options and input data (i.e., meteorological data, receptor grids and terrain) that were applied in CALPUFF dispersion modelling for this air quality assessment.

3.1 Model Options

Table I-1 provides a detailed summary of all CALPUFF model user options selected for one of the CALPUFF simulations done for this assessment. Model default values, as recommended by the United States Environmental Protection Agency (US EPA 1998), are presented for comparative purposes. In most cases, these default values were used.

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility

Input Group	Parameter	US EPA Default	AST Bruderheim	Description
Group 1: General Run Control Parameters	METRUN	0	1	Run all period in met file
	IBYR	-	2002	Used only if METRUN=0
	IBMO	-	0	Used only if METRUN=0
	IBDY	-	0	Used only if METRUN=0
	IBHR	-	0	Used only if METRUN=0
	IBYR	-	2005	Used only if METRUN=0
	IBMO	-	0	Used only if METRUN=0
	IBDY	-	0	Used only if METRUN=0
	IBHR	-	0	Used only if METRUN=0
	XBTZ	-	7	Time Zone, Mountain Standard Time
	NSECDT	3600	3600	Length of modelling time-step (s)
	NSPEC	5	5	Number of chemical species modelled
	NSE	3	5	Number of chemical species emitted
	ITEST	2	2	Continue with model execution after setup
	MRESTART	0	0	Do not write a restart file
	NRESPD	0	0	Write restart file only at last period
	METFM	1	2	ISC ASCII file
	MPRFFM	1	1	CTDM plus tower file
	AVET	60	60	Averaging time is 60 minutes
	PGTIME	60	60	PG Averaging time is 60 minutes
Group 2: Technical Options	MGAUSS	1	1	Gaussian distribution used in the near field
	MCTADJ	3	3	Partial Plume Path Adjustment Method of terrain adjustment
	MCTSG	0	0	Subgrid-scale complex terrain not modelled
	MSLUG	0	0	Near field puffs not elongated
	MTRANS	1	1	Transitional plume rise applied
	MTIP	1	1	Stack tip downwash applied
	MBDW	1	2	PRIME method is applied
	MSHEAR	0	0	Vertical wind shear modelled
	MSPLIT	0	0	No puff splitting allowed
	MCHEM	1	0	Chemical transformation not modelled
	MAQCHEM	0	0	Aqueous phase transformation not modelled
	MWET	1	0	Wet removal not modelled
	MDRY	1	0	Dry removal not modelled
	MDISP	3	2	Dispersion coefficients calculated from CALMET micrometeorological variables
	MTURBVW	3	3	Use direct turbulence measurements to estimate dispersion (Not Used)
	MDISP2	3	3	Use PG coefficients when turbulence measurements not available
	MTAULY	0	0	Draxler default 617.284s
	MTAUADV	0	0	No turbulence advection is applied
	MCTURB	1	1	Standard CALPUFF subroutines is applied
	MROUGH	0	0	Sigma Y and Z are not adjusted for roughness
	MPARTL	1	1	Model partial plume penetration of elevated inversion
	MTINV	0	0	Strength of temperature inversion is computed from default gradients
	MPDF	0	0	Use PDF to compute near-field dispersion under convective conditions
	MSGTIBL	0	0	Sub-grid TIBL module is not used
	MBCON	0	0	Boundary conditions are not modelled
	MFOG	0	0	Not configured for fog model output
	MREG	1	0	Do not test options against defaults

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility (Cont'd)

Input Group	Parameter	US EPA Default	AST Bruderheim	Description
Group 3: Species List	CSPEC	-	NO_x, CO, $PM_{2.5}$, H_2S, PM_{10}	List of chemical species
	-	NO_X		Modelled, Emitted
		CO		Modelled, Emitted
		$PM_{2.5}$		Modelled, Emitted
		H_2S		Modelled, Emitted
	-	PM_{10}		Modelled, Emitted
Group 4: Grid Control Parameters	PMAP	UTM	UTM	Universal Transverse Mercator for Projection of all X, Y
	FEAST	0	0	False Easting (Not Used)
	FNORTH	0	0	False Northing (Not Used)
	IUTMZN	-	12	UTM Zone
	UTMHEM	N	N	Northern Hemisphere
	RLAT0	-	0N	Latitude of Projection Origin (Not Used)
	RLON0	-	0E	Longitude of Projection Origin (Not Used)
	XLAT1	-	0N	Latitude of 1st Parallel (Not Used)
	XLAT2	-	0N	Latitude of 2nd Parallel (Not Used)
	DATUM	WGS-84	NAS-C	North American 1983 GRS 80 Spheriod, Mean for Conus, NAD83
	NX	-	10	Number of X grid cells
	NY	-	10	Number of Y grid cells
	NZ	-	1	Number of vertical grid cells
	DGRIDKM	-	10.	Grid spacing in X and Y directions (km)
	ZFACE	-	0, 5000	Vertical cell face heights of the NZ vertical layers
	XORIGKM	-	327	Reference Easting of SW corner of SW grid cell in UTM (km)
	YORIGKM	-	5910	Reference Northing of SW corner of SW grid cell in UTM (km)
	IBCOMP	-	1	X index of lower left grid cell for computation
	JBCOMP	-	1	Y index of lower left grid cell for computation
	IECOMP	-	10	X index of upper right grid cell for computation
	JECOMP	-	10	Y index of upper right grid cell for computation
	LSAMP	T	F	Sampling grid is not used
	IBSAMP	-	0	X index of lower left grid cell for sampling
	JBSAMP	-	0	Y index of lower left grid cell for sampling
	IESAMP	-	0	X index of upper right grid cell for sampling
	JESAMP	-	0	Y index of upper right grid cell for sampling
	MESHDN	1	1	Nesting factor of sampling grid
Group 5: Output Options	ICON	1	1	Create binary concentration output file
	IDRY	1	0	Binary dry flux output file is not created
	IWET	1	0	Binary wet flux output file is not created
	IVIS	1	0	Output file containing relative humidity is not created
	IQAPLOT	1	1	Create a standard series of output files suitable for plotting
	IMFLX	0	0	Diagnostic mass flux option not applied
	IMBAL	0	0	Do not report hourly mass balance for each species
	ICPRT	0	0	Do not print concentrations to list file
	IDPRT	0	0	Do not print dry fluxes to list file
	IWPRT	0	0	Do not print wet fluxes to list file
	ICFRQ	1	1	Concentration print interval in hours
	IDFRQ	1	1	Dry flux print interval in hours

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility (Cont'd)

<table>
<tr><th>Input Group</th><th>Parameter</th><th>US EPA Default</th><th>AST Bruderheim</th><th colspan="3">Description</th></tr>
<tr><td rowspan="15">Group 5: Output Options (Cont'd)</td><td>IWFRQ</td><td>1</td><td>1</td><td colspan="3">Wet flux print interval in hours</td></tr>
<tr><td>IPRTU</td><td>1</td><td>3</td><td colspan="3">Output units are µg m^{-3} for concentration and µg m^{-2} s^{-1} for fluxes</td></tr>
<tr><td>IMESG</td><td>2</td><td>2</td><td colspan="3">Track progress of run on screen</td></tr>
<tr><td>-</td><td colspan="2">NO_X</td><td colspan="3" rowspan="5">Concentrations are saved to the hard disk. Concentrations, dry and wet fluxes are not printed hourly.</td></tr>
<tr><td>-</td><td colspan="2">CO</td></tr>
<tr><td>-</td><td colspan="2">$PM_{2.5}$</td></tr>
<tr><td>-</td><td colspan="2">H_2S</td></tr>
<tr><td>-</td><td colspan="2">PM_{10}</td></tr>
<tr><td>LDEBUG</td><td>F</td><td>F</td><td colspan="3">Do not print debug data</td></tr>
<tr><td>IPFDEB</td><td>1</td><td>1</td><td colspan="3">Debug options - First puff to track</td></tr>
<tr><td>NPFDEB</td><td>1</td><td>1</td><td colspan="3">Debug options - Number of puffs to track</td></tr>
<tr><td>NN1</td><td>1</td><td>1</td><td colspan="3">Debug options - Met period to start output</td></tr>
<tr><td>NN2</td><td>10</td><td>10</td><td colspan="3">Debug options - Met period to end output</td></tr>
<tr><td rowspan="7">Group 6: Subgrid Scale Complex Terrain Inputs</td><td>NHILL</td><td>0</td><td>0</td><td colspan="3">Number of terrain features</td></tr>
<tr><td>NCTREC</td><td>0</td><td>0</td><td colspan="3">Number of complex terrain receptors</td></tr>
<tr><td>MHILL</td><td>-</td><td>2</td><td colspan="3">Hill data created by OPTHILL (Not Used)</td></tr>
<tr><td>XHILL2M</td><td>1</td><td>1</td><td colspan="3">Horizontal conversion factor to meters</td></tr>
<tr><td>ZHILL2M</td><td>1</td><td>1</td><td colspan="3">Vertical conversion factor to meters</td></tr>
<tr><td>XCTDMKM</td><td>-</td><td>0</td><td colspan="3">CTDM X origin relative to CALPUFF grid</td></tr>
<tr><td>YCTDMKM</td><td>-</td><td>0</td><td colspan="3">CTDM Y origin relative to CALPUFF grid</td></tr>
<tr><td rowspan="2">Group 7: Chemical Parameters for Dry Deposition of Gases</td><td></td><td>Diffusivity</td><td>Alpha Star</td><td>Reactivity</td><td>Mesophyll Resistance</td><td>Henry's Law Coefficient</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Group 8: Size Parameters for Dry Deposition of Particles</td><td></td><td colspan="2">Geometric Mass Mean</td><td colspan="3">Geometric Standard Deviation</td></tr>
<tr><td>-</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td rowspan="5">Group 9: Miscellaneous Dry Deposition Parameters</td><td>RCUTR</td><td>30</td><td>30</td><td colspan="3">Reference cuticle resistance</td></tr>
<tr><td>RGR</td><td>10</td><td>10</td><td colspan="3">Reference ground resistance</td></tr>
<tr><td>REACTR</td><td>8</td><td>8</td><td colspan="3">Reference pollutant reactivity</td></tr>
<tr><td>NINT</td><td>9</td><td>9</td><td colspan="3">Number of particle size intervals used to evaluate effective particle deposition velocity</td></tr>
<tr><td>IVEG</td><td>1</td><td>1</td><td colspan="3">Vegetation in unirrigated areas is active and unstressed</td></tr>
<tr><td rowspan="2">Group 10: Wet Deposition Parameters</td><td></td><td colspan="2">Liquid Precip Coef.</td><td colspan="3">Frozen Precip Coef.</td></tr>
<tr><td>-</td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td rowspan="10">Group 11: Chemistry Parameters</td><td>MOZ</td><td>1</td><td>0</td><td colspan="3">Monthly ozone values are used in chemistry</td></tr>
<tr><td>BCKO3</td><td>12*80</td><td>12*80</td><td colspan="3">Monthly ozone values are used in chemistry</td></tr>
<tr><td>BCKNH3</td><td>12*10</td><td>12*10</td><td colspan="3">Constant background concentration in ppb</td></tr>
<tr><td>RNITE1</td><td>0.2</td><td>0.2</td><td colspan="3">Night time SO_2 loss rate (% per hour)</td></tr>
<tr><td>RNITE2</td><td>2</td><td>2</td><td colspan="3">Night time NO_x loss rate (% per hour)</td></tr>
<tr><td>RNITE3</td><td>2</td><td>2</td><td colspan="3">Night time HNO_3 formation rate (% per hour)</td></tr>
<tr><td>BCKH2O2</td><td>12*1</td><td>12*1</td><td colspan="3">Background H_2O_2 (Not Used)</td></tr>
<tr><td>BCKPMF</td><td>12*1</td><td>12*1</td><td colspan="3">Background fine particulate matter (Not Used)</td></tr>
<tr><td>OFRAC</td><td>12*0.20</td><td>0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15</td><td colspan="3">Organic fraction of fine particulate matter (Not Used)</td></tr>
<tr><td>VCNX</td><td>12*50</td><td>12*50</td><td colspan="3">VOC/NO_x ratio for chemistry (Not Used)</td></tr>
</table>

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility (Cont'd)

Input Group	Parameter	US EPA Default	AST Bruderheim	Description
Group 12: Miscellaneous Dispersion and Computational Parameters	SYTDEP	550	550	Horizontal size of puff in meters beyond which Heffer dispersion is applied
	MHFTSZ	0	0	Do not use Heffer formulas for sigma Z
	JSUP	5	5	Stability class used to determine plume growth rates for puff above the boundary layer
	CONK1	0.01	0.01	Vertical dispersion constant for stable conditions
	CONK2	0.1	0.1	Vertical dispersion constant for neutral/unstable conditions
	TBD	0.5	0.5	ISC Transition-point
	IURB1	10	10	Lower range of land use categories for which urban dispersion is assumed
	IURB2	19	19	Upper range of land use categories for which urban dispersion is assumed
	ILANDUIN	20	20	Land use category for modelling domain
	ZOIN	0.25	0.25	Roughness length in meters for domain
	XLAIIN	3	3	Leaf area index for domain
	ELEVIN	0	722	Elevation above sea level in meters
	XLATIN	-999	45.614	Latitude of met location in degrees
	XLONIN	-999	52.803	Longitude of met location in degrees
	ANEMHT	10	10	Anemometer height in meters
	ISIGMAV	1	1	Read sigma-v from profile file (Not Used)
	IMIXCTDM	0	0	Predicted mixing heights are used (Not Used)
	XMXLEN	1	1	Maximum slug length
	XSAMLEN	1	1	Maximum travel distance of a puff in grid units during one sampling step
	MXNEW	99	99	Maximum number of puffs released from one source during one sampling step
	MXSAM	99	99	Maximum number of sampling steps during one time step for a puff
	NCOUNT	2	2	Number of iterations used when computing the transport wind for a sampling step that includes transitional plume rise
	SYMIN	1	1	Minimum sigma Y (m) for a new puff
	SZMIN	1	1	Minimum sigma Z (m) for a new puff
	SVMIN	0.5,0.5,0.5 0.5, 0.5, 0.5	0.5,0.5,0.5 0.5, 0.5, 0.5	Default minimum turbulence velocities for each stability class (Sigma-V)
	SWMIN	0.2, 0.12 0.08, 0.06 0.03, 0.016	0.2, 0.12, 0.08, 0.06 0.03, 0.016	Default minimum turbulence velocities for each stability class (Sigma-W)
	WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions in m s^{-1}
	XMAXZI	3000	3000	Maximum mixing height in meters
	XMINZI	50	50	Minimum mixing height in meters
	CDIV	0, 0	0, 0	Divergence criteria for dw dz^{-1} in meters
	WSCAT	1.54, 3.09, 5.14, 8.23, 10.8	1.54, 3.09, 5.14, 8.23, 10.8	Default wind speed classes - 5 upper bounds (m s^{-1}) are entered; the 6th class has no upper limit
	PLX0	0.15, 0.15, 0.20, 0.25, 0.30, 0.30	0.08, 0.09, 0.11, 0.16, 0.32, 0.54	Wind speed profile power-law exponents for stabilities 1 to 6 for 10 centimeter roughness length
	PTG0	0.02, 0.035	0.02, 0.035	Potential temperature gradient for stable classes
	PPC	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	0.5, 0.5, 0.5, 0.5, 0.35, 0.35	Plume path coefficients for partial plume path adjustment terrain method.
	SL2PF	10	10	Slug to puff transition factor (Not used)

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility (Cont'd)

Input Group	Parameter	US EPA Default	AST Bruderheim	Description
Group 12: Miscellaneous Dispersion and Computational Parameters (Cont'd)	NSPLIT	3	3	Number of puffs that result every time a puff is split (Not used)
	IRESPLIT	0,0,0,0,0,0,0 0,0,0,0,0,0,0 0,0,0,1,0,0,0 0,0,0	0,0,0,0,0,0,0 0,0,0,0,0,0,0 0,0,0,1,0,0,0 0,0,0	Times of day when puff can be split after being split previously (Not used)
	ZISPLIT	100	100	Puff split only occurs if previous hours mixing height exceeds this value (Not used)
	ROLDMAX	0.25	0.25	Maximum allowable ratio previous hour mixing height to maximum mixing height experience by puff (Not used)
	NSPLITH	5	5	Number of puffs that result from each split (Not used)
	SYSPLITH	1	1	Minimum sigma-y off puff before it may be split (Not used)
	SHSPLITH	2	2	Minimum puff elongation rate due to wind shear, before it may be split (Not used)
	CNSPLITH	$1e^{-7}$	$1e^{-7}$	Minimum concentration (g m^{-3}) of each species in puff before it may be split (Not used)
	EPSSLUG	$1e^{-4}$	$1e^{-4}$	Fraction convergence criterion for numerical slug sampling integration
	EPSAREA	$1e^{-6}$	$1e^{-6}$	Fraction convergence criterion for numerical area sources integration
	DSRISE	1	1	Trajectory step-length (m) used for numerical rise integration
	HTMINBC	500	500	Minimum height to mix boundary condition puffs (m)
	RSAMPBC	10	10	Search radius (BC length segments) about a receptor for sampling nearest BC puff.
	NDEPBC	1	1	Near surface depletion adjustment when sampling BC puffs
Group 13: Point Source Parameters	NPT1	-	13	Number of point sources modelled (Application Case)
	IPTU	1	1	Units used for emissions (g s^{-1})
	NSPT1	0	0	Number of source-species combinations with variable emissions scaling factors
	NPT2	-	0	Number of point sources with variable emissions
Group 14: Area Source Parameters	NAR1	-	7	Number of polygon area sources modelled
	IARU	1	1	Units used for emissions (g m^{-2} s^{-1})
	NSAR1	0	0	Number of source-species combinations with variable emissions scaling factors
	NAR2	-	0	Number of area sources with variable emissions
Group 15: Line Source Parameters	NLN2	-	0	Number of buoyant line sources with variable location and emission parameters
	NLINES	-	0	Number of buoyant line sources
	ILNU	1	1	Units for line source emission rates is g s^{-1}
	NSLN1	0	0	Number of source-species combinations with variable emission scaling factors
	MXNSEG	7	7	Maximum number of segments used to model each line
	NLRISE	6	6	Number of distances at which transitional rise computed

Table I-1: CALPUFF Options Used for the AST Bruderheim Sulphur Forming Facility (Cont'd)

Input Group	Parameter	US EPA Default	AST Bruderheim	Description
Group 15: Line Source Parameters (Cont'd)	XL	-	0	Average building length
	HBL	-	0	Average building height
	WBL	-	0	Average building width
	WML	-	0	Average line sources width
	DXL	-	0	Average separation between buildings
	FPRIMEL	-	0	Average buoyancy parameter
Group 16: Volume Source Parameters	NVL1	-	0	Number of volume sources applied
	IVLU	1	1	Units used for volume sources (g s^{-1})
	NSVL1	0	0	Number of source-species combinations with variable emission scaling factors
	NSVL2	-	0	Number of volume sources with variable location and emission parameters
Group 17: Non-Girded Receptor Information	NREC	-	5264	Number of non-girded discrete receptors that compose the series of nested grids, and property boundary.

3.1.1 Model Options Specific to Sulphur Deposition

A full resistance model is provided in CALPUFF for the computation of dry deposition rates of gases and particulate matter as a function of geophysical parameters, meteorological conditions, and pollutant species. Options are provided to allow user-specified, diurnally-varying deposition velocities to be used for one or more pollutants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely.

An empirical scavenging coefficient approach is used in CALPUFF to compute the depletion and wet deposition fluxes due to precipitation scavenging. The scavenging coefficients are specified as a function of the pollutant and precipitation type (i.e., frozen versus liquid precipitation).

Specific CALPUFF options for the sulphur deposition modelling are provided in Table I-2.

Table I-2: CALPUFF Options Used for the Sulphur Deposition Modelling

Model Options	Source	
	Rotoformer Stacks	**Loading Area**
Geometric Mass Mean Diameter (µm)	13.9	8.0
Geometric Standard Deviation (µm)	3.2	3.2
Liquid Scavenging Coefficient (s^{-1})	6×10^{-4}	6×10^{-4}
Frozen Scavenging Coefficient (s^{-1})	2×10^{-4}	2×10^{-4}

3.2 Modelled Receptors and Terrain

A regularly spaced, nested Cartesian receptor grid was created for the CALPUFF model to determine the maximum ground-level concentrations. The receptor grid is more densely spaced near the facility where maximum impacts are expected. The receptor spacing was based on the recommendations of AENV (2003) and included the following:

- 20 m in the general area of maximum impact and the property boundary
- 50 m within 0.5 km of the source

- 250 m within 2 km of the sources of interest
- 500 m within 5 km of the sources of interest
- 1,000 m beyond 5 km
- 5,000 m beyond 10 km

The nested grid had a total of 5,264 receptor locations. These locations are illustrated in Figure I-1.

At each grid location the terrain height was interpolated from topographical data with a grid spacing of about 25 m.

3.3 Meteorological Data

For this assessment, CALPUFF was run using data for the four-year period of 2002–2005 as obtained from the Fort Air Partnership's (FAP) Lamont monitoring station. Further information regarding meteorology and climate conditions within the study area of the Project can be found in Appendix II.

3.3.1 Mixing Heights

Mixing height is the depth of the unstable air in the atmospheric boundary layer and is used for forecasting pollutant dispersion. Strong solar heating or strong winds can create a two-layered atmosphere. The lower layer is well mixed and characterized by either neutral or unstable conditions; the upper layer is characterized by stable conditions (elevated temperature inversion). Vertical motions in the upper layer are damped, which effectively prevents the transfer of air between the two layers. Thus, emissions injected into the mixing layer may become trapped if they do not have enough buoyancy or momentum to penetrate the elevated stable layer. This leads to the classical trapping situation that is often associated with poor air quality.

Mechanical interactions result in mixing of air by roughness at the surface of the earth. Surface roughness can be due to topography, forests or buildings. Heights of the mechanically mixed layer are location dependent and proportional to wind speed.

Atmospheric thermal interactions are caused by the effects of solar radiation. During the day, unstable conditions are created by radiation from the sun. This creates warmer, less dense air that rises; cooler, more dense air from above sinks to ground level. As air rises, it expands and cools. Upward motion ceases at the height where rising air reaches the same temperature as surrounding air. This height is called the convective mixing height. It is dependent on the intensity of solar radiation and vertical temperature characteristics of the air mass.

The hourly distribution of median mixing layer heights for meteorological data applied in dispersion modelling (as recorded at the Lamont and Stony Plain Monitoring Stations from January 1, 2002–December 31, 2005) are presented in Figure I-2. Mixing heights vary from several meters to several thousand meters, depending on the intensity of solar radiation reaching the earth's surface and wind speed. Mixing heights are much greater during the summer than the winter. Maximum mixing heights usually occur during mid-afternoon hours when the effects of solar heating are greatest, while minimum heights occur at night.

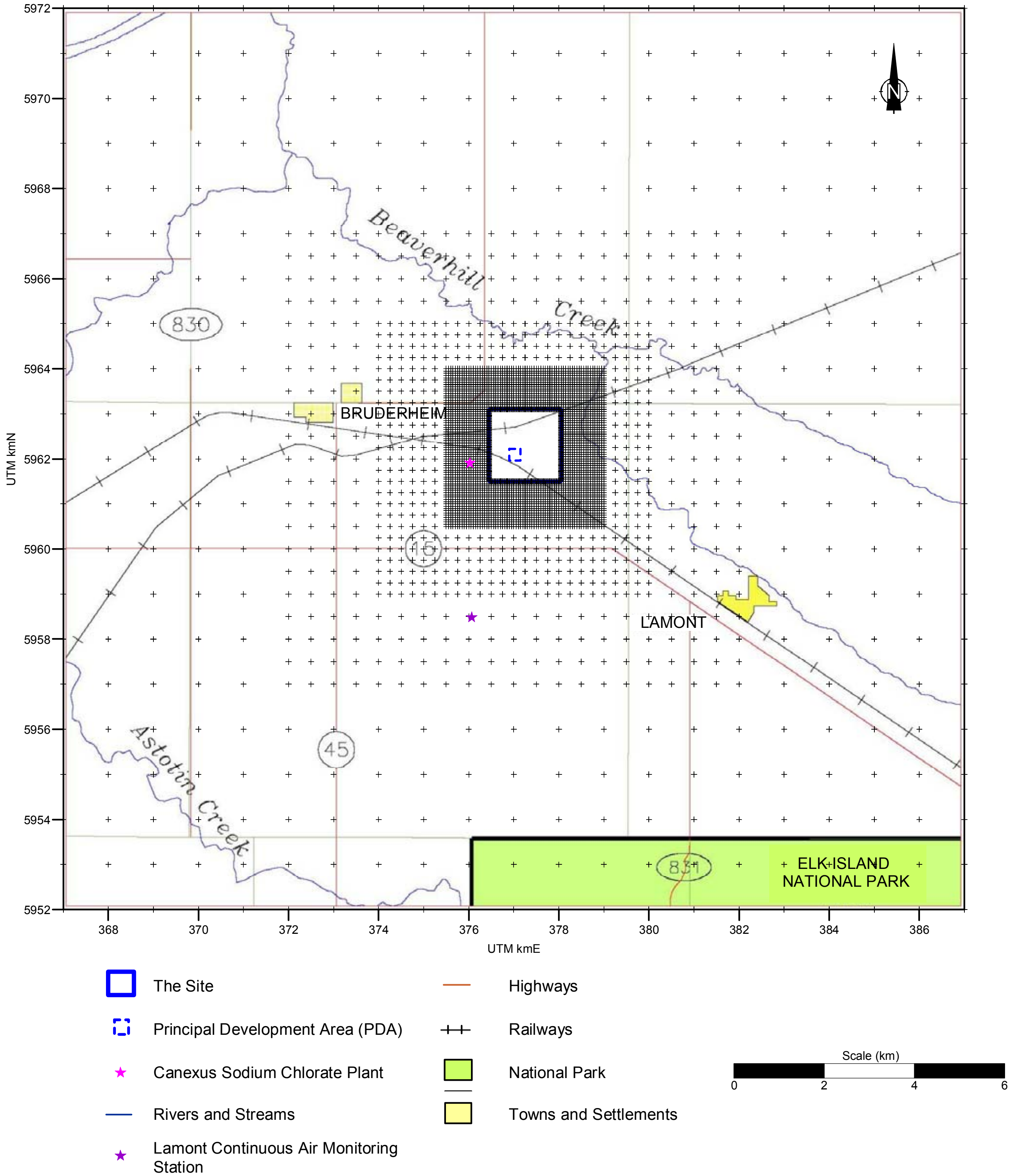

Figure I-1: Receptors Applied in Dispersion Modelling of the Project

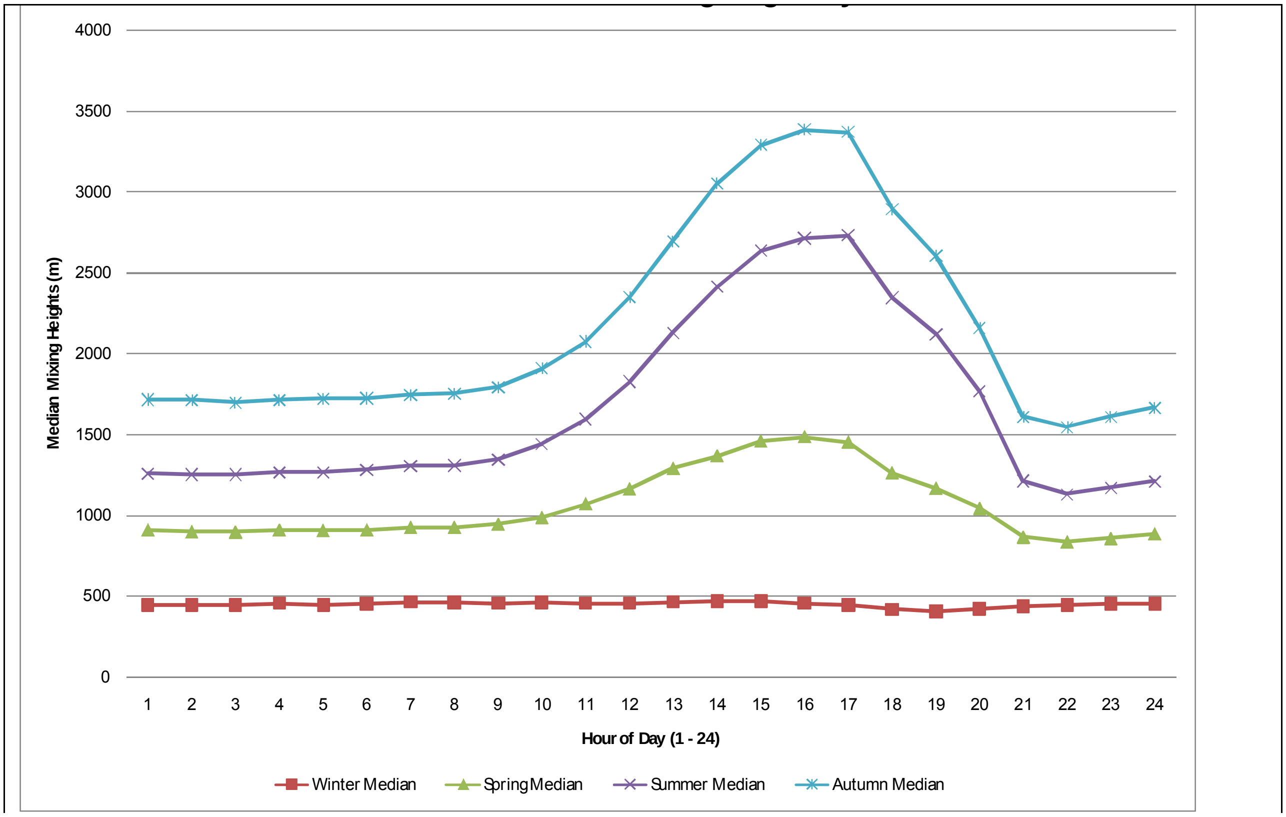

Figure I-2: Diurnal Distribution of Median Mixing Layer Heights by Season

3.3.2 Atmospheric Stability

Atmospheric turbulence near the earth's surface is a function of atmospheric stability, which is governed by thermal and mechanical influences. The atmosphere can be broadly described as being stable, neutral or unstable. During night-time hours the earth's surface emits thermal radiation and cools. Air in contact with the ground thus becomes cooler and denser than the air aloft. This phenomenon is referred to as a ground-based temperature inversion. Vertical motions of the atmosphere are suppressed and the atmosphere is described as stable. This contrasts with daytime situations when the sun heats the ground. Air in contact with the ground becomes warmer and less dense than the air aloft. Vertical motions of the atmosphere are enhanced and the atmosphere is said to be unstable. When a balance exists between incoming and outgoing radiation, there is no net heating or cooling of the air in contact with the ground and vertical motions of the atmosphere are neither enhanced nor suppressed. Such an atmosphere is described as neutral and exists during overcast skies or in transition from unstable to stable conditions. Mechanical mixing may also create neutral atmospheres generated by strong winds.

Meteorologists define six stability classes (referred to as the Pasquill-Gifford (PG) classes):

- Stability classes A, B and C occur during the day, when the earth is heated by solar radiation. The air next to the earth is heated and tends to rise, enhancing vertical motions. This is referred to as an unstable atmosphere.
- Stability classes E and F occur during the night, when the earth cools due to long-wave radiation losses. The air next to the earth cools, suppressing vertical motions. This is referred to as a stable atmosphere.

- Stability class D is associated with completely overcast conditions (day or night) when there is no net heating or cooling of the earth, transitional periods between stable and unstable conditions, or during high wind speed periods (winds greater than 6 ms^{-1} (or 22 km h^{-1}). This is referred to as a neutral atmosphere.

Stability classes undergo significant daily variation, and they also have a seasonal dependence. Stability classes can be determined from routine airport observations using the US EPA RAMMET meteorological processor. Table **I**-3 presents the stability class frequency distributions based on the RAMMET approach.

Table I-3: Atmospheric Stability Frequencies for the Project Area

Pasquill Stability Category	**Frequency[1] (%)**			
	Winter	**Spring**	**Summer**	**Autumn**
A	0.00	0.01	0.05	0.00
B	0.47	5.96	12.91	2.23
C	5.62	14.80	19.69	10.14
D	58.74	53.93	38.29	53.70
E	21.84	14.63	14.82	20.76
F	13.33	10.68	14.24	13.16

Note:
[1] Based on data from the Edmonton Namao Airport and the FAP Lamont monitoring station for the period January 1, 2002 to December 31, 2005.

3.3.3 Winds

Wind roses are an efficient and convenient means of presenting wind data. The length of the radial barbs gives the total percent frequency of winds from the indicated direction, while portions of the barbs of different widths indicate the frequency of associated wind speed categories. Figure **I**-3 presents the annual wind speed and direction frequency distributions of hourly average wind speed for meteorological data applied in dispersion modelling (as recorded at the Lamont Monitoring Station from January 1, 2002– December 31, 2005). Figure **I**-4 presents the associated frequency distribution of the various wind speed categories.

The mean and maximum hourly wind speeds are equal to 3.8 and 15.8 m s^{-1} (13.7 and 56.9 km h^{-1}), respectively. The predominant winds are from the southwest. Over 53% of winds are less than 3.6 m s^{-1} (13.0 km h^{-1}) while just 1.6% of winds are greater than 8.8 m s^{-1} (31.7 km h^{-1}).

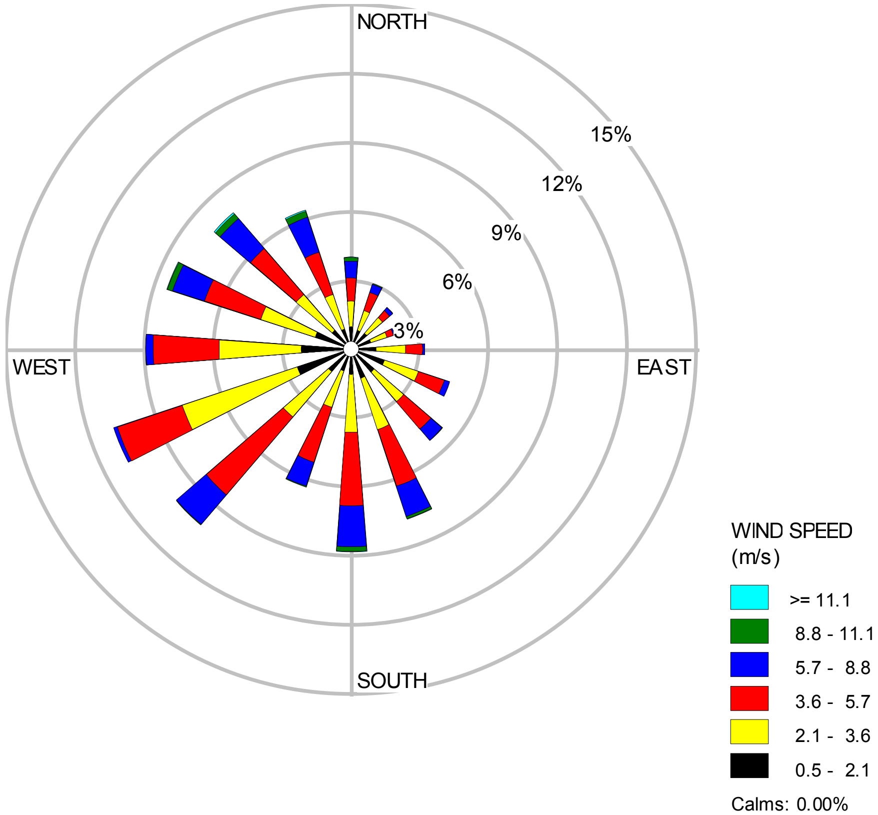

Figure I-3: Wind Rose of Hourly Wind Speed and Direction Frequency Distributions for Meteorological Data Applied in Dispersion Modelling

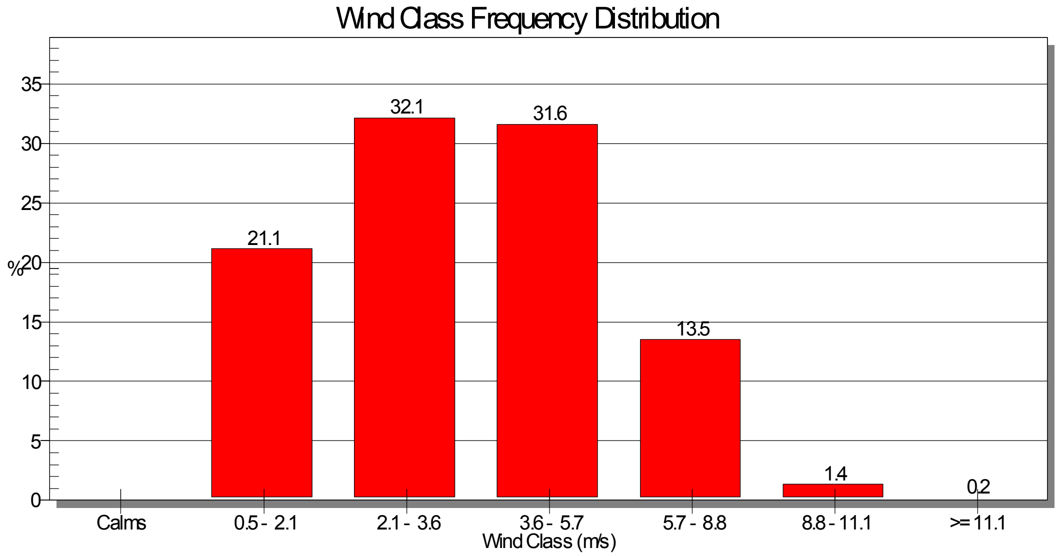

Figure I-4: Frequency Distribution of Wind Speed Classes for Meteorological Data Applied in Dispersion Modelling

4. References

4.1 Literature Cited

Alberta Environment (AENV). 2003. *Air Quality Model Guideline Science and Technology Branch,* Environmental Sciences Division, AENV. Edmonton, AB.

United States Environmental Protection Agency (US EPA). 1998. *A User's Guide for the CALPUFF Dispersion Model.* Prepared by Earth Tech, Inc. 196 Baker Avenue, Concord, MA.

4.2 Internet Sites

United States National Oceanic and Atmospheric Administration (NOAA). 2006. ROAB Data Access. Online. Available: http://raob.fsl.noaa.gov/. Accessed February 15, 2007.

Volume IIA: Climate and Air Quality

Appendix II: Climate of the Study Area

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1. Climate and Meteorology of the Study Area

An analysis has been done of climatological data collected in the general region of Bruderheim in the vicinity of the proposed Alberta Sulphur Terminals (the Project). The data concerns a range of phenomena including ambient air temperature, precipitation, relative humidity, visibility, and wind. Most of the information presented herein, with the exception of that relating to wind, was obtained from 30 years of data (1971-2000) collected by Environment Canada at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports (Environment Canada 2006, Internet Site). Information relating to wind was obtained from continuous hourly monitoring data at the Fort Air Partnership's (FAP) Fort Saskatchewan and Lamont monitoring stations for the period of January 1, 2001 to October 31, 2006 (Clean Air Strategic Alliance (CASA) 2006, Internet Site).

1.1 Ambient Air Temperature

Monthly mean temperatures, as recorded at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports from 1971–2000, are shown in Figure II-1. A summary of the seasonal and annual ambient temperatures is presented in Table II-1. July is the warmest month in the Bruderheim region with a mean daily temperature of about 16.7°C. The coldest month of the year is January with a mean daily temperature of -12.7°C. The annual mean daily temperature for the study area is 3.1°C.

Table II-1: Mean Seasonal Daily Temperatures at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports (1971–2000)

Season	Mean Daily Temperature (°C)				
	Fort Saskatchewan	Edmonton International Airport	Edmonton City Centre Airport	Edmonton Namao Airport	Average
Winter[1]	-11.7	-11.8	-9.9	-10.9	-11.1
Spring[2]	4.1	3.4	4.9	4.1	4.1
Summer[3]	15.8	15.0	16.5	15.6	15.7
Fall[4]	3.3	2.9	4.3	3.5	3.5
Annual	2.9	2.4	3.9	3.1	3.1

Notes:

[1] Winter months: December, January, February.

[2] Spring months: March, April, May.

[3] Summer months: June, July, August.

[4] Fall months: September, October, November.

Source: Environment Canada (2006).

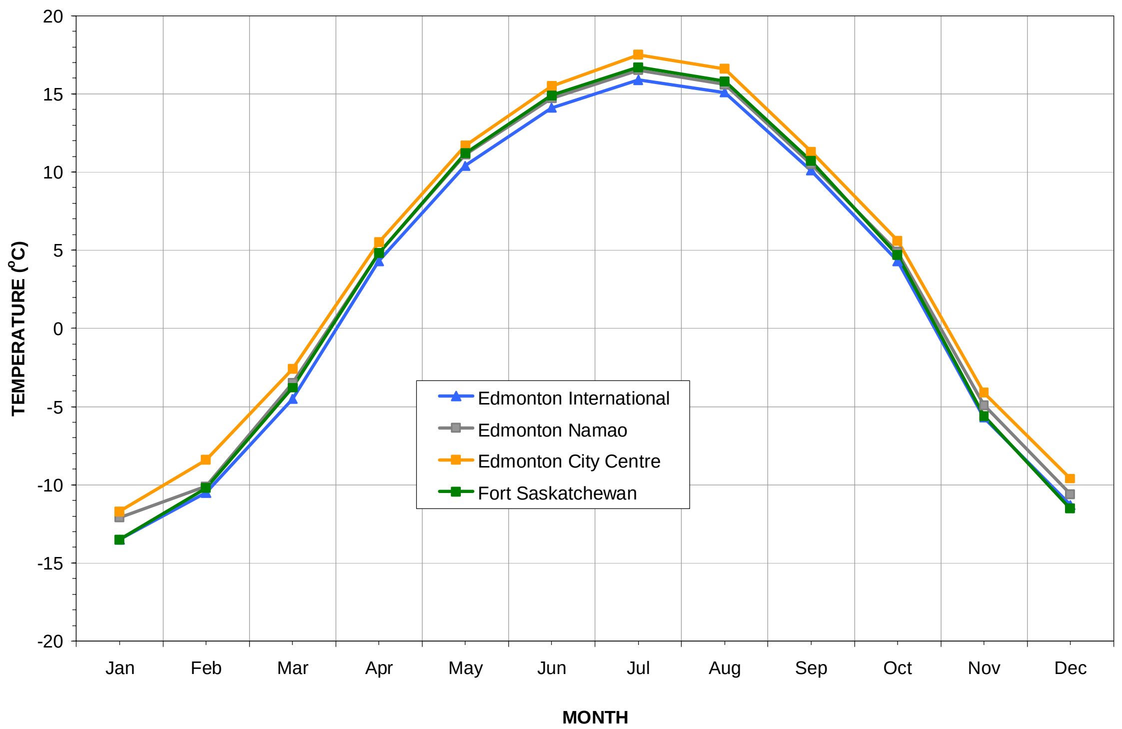


Figure II-1: Monthly Mean Temperatures at Fort Saskatchewan and the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)

1.2 Precipitation

Monthly mean total precipitation, rainfall, and snowfall are illustrated in Figure II-2, Figure II-3 and Figure II-4 respectively.

The annual average total precipitation is approximately 471.4 mm. The majority of the annual precipitation occurs from May–September. The driest month is February, with average total precipitation of 13.8 mm. The wettest month is July when the total daily rainfall is 91.4 mm. Mean snowfalls shown in Figure II-4 for the months of December through March are 22.0, 23.1, 15.2 and 16.1 cm. Measurable snowfall amounts occur in all months except June and July.

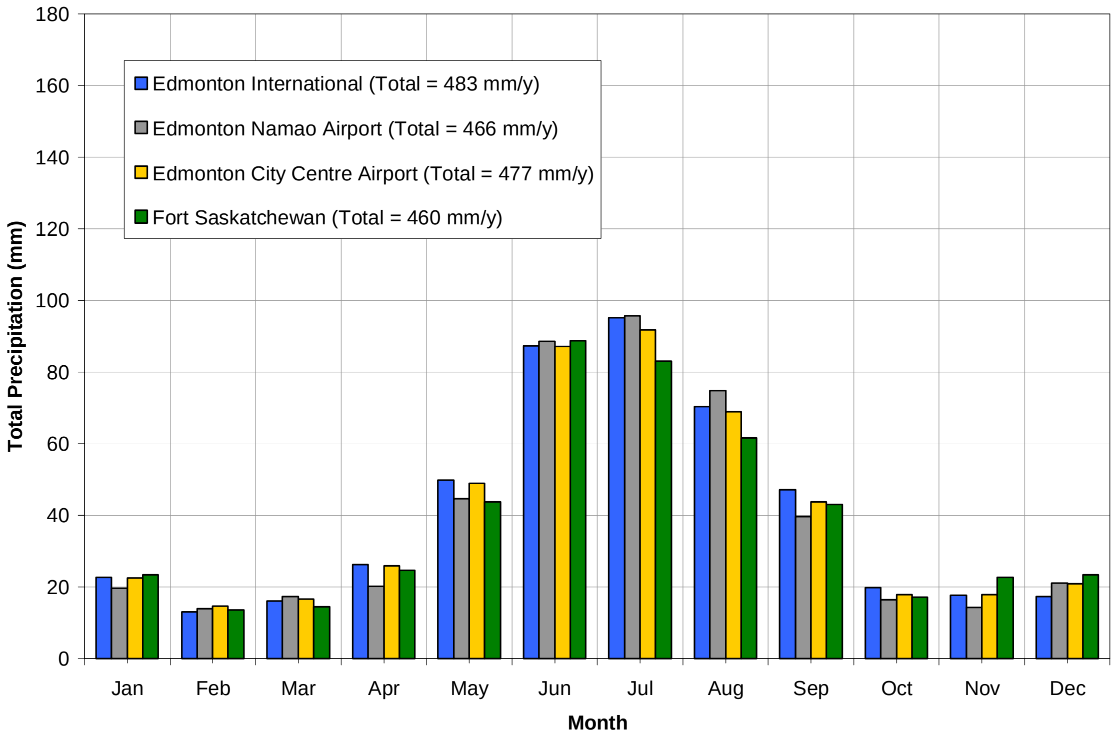


Figure II-2: Monthly Mean Total Precipitation at Fort Saskatchewan and the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971-2000)

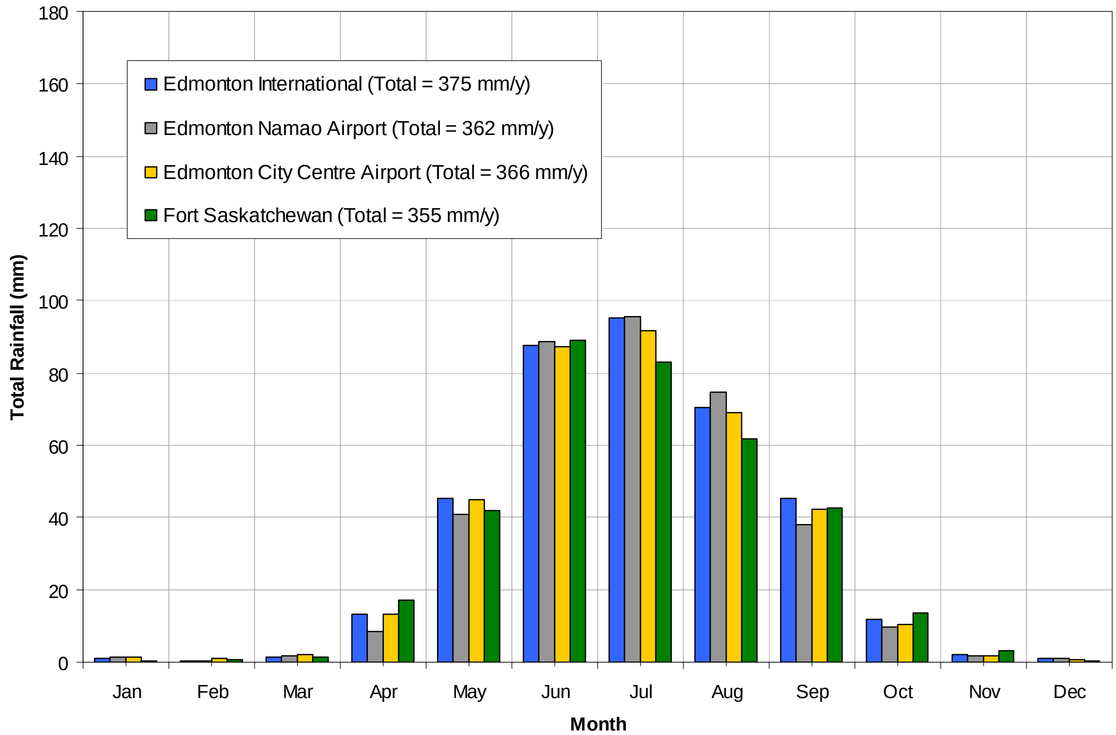


Figure II-3: Monthly Mean Rainfall at Fort Saskatchewan and the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)

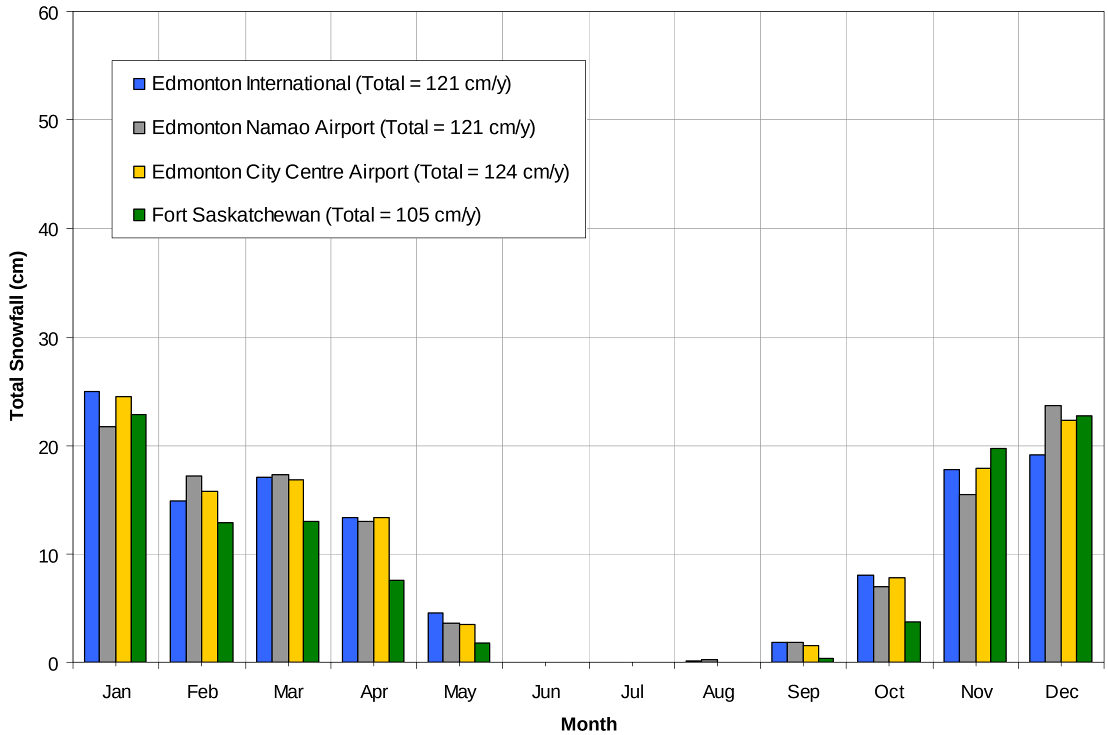


Figure II-4: Monthly Mean Snow Fall at Fort Saskatchewan and the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)

1.3 Relative Humidity

Relative humidity is the ratio of the amount of water vapour actually in the air compared to the maximum amount of water vapour required for saturation at a particular temperature. It is therefore the ratio (usually expressed as percent) of the air's water vapour content to its capacity.

Relative Humidity = (Water Vapour Content)/ (Water Vapour Capacity)

Table II-2 shows the mean relative humidity for each month at 6:00 and 15:00 Local Standard Time (LST), as recorded at the Edmonton International, Edmonton Namao and Edmonton City Center Airports from 1971–2000. The mean 6:00 LST annual relative humidity of approximately 79% at the International and Namao Airports fluctuates to its lowest point in late spring and its highest in late summer and early fall. The mean 15:00 LST annual relative humidity of 56% at the International and Namao Airports fluctuates to its lowest point in late spring and its highest in early winter.

Table II–2: Monthly Mean Relative Humidity at the Edmonton International, Edmonton Namao and Edmonton City Center Airports (1971–2000)

Month	Relative Humidity (%)					
	Edmonton International Airport		Edmonton City Center Airport		Edmonton Namao Airport	
	6:00 LST	15:00 LST	6:00 LST	15:00 LST	6:00 LST	15:00 LST
January	71.2	67.0	74.3	66.6	74.1	68
February	72.6	65.1	75.1	62.5	75.0	64.6
March	77.1	62.1	76.3	57.7	79.3	61.4
April	77.3	46.3	72.5	43.4	76.1	45.5
May	74.7	41.9	69.9	40.8	73.7	41.1
June	80.9	50.3	76.1	48.0	80.6	49.3
July	87.7	55.8	81.0	52.3	86.0	54.6
August	89.7	54.6	84.2	52.8	88.3	54.5
September	85.9	51.6	82.4	51.9	85.9	53.3
October	79.5	49.9	75.0	49.6	77.4	50.2
November	79.1	66.8	77.6	64.5	79.8	66.8
December	73.4	68.4	74.5	67.2	76.2	70.3

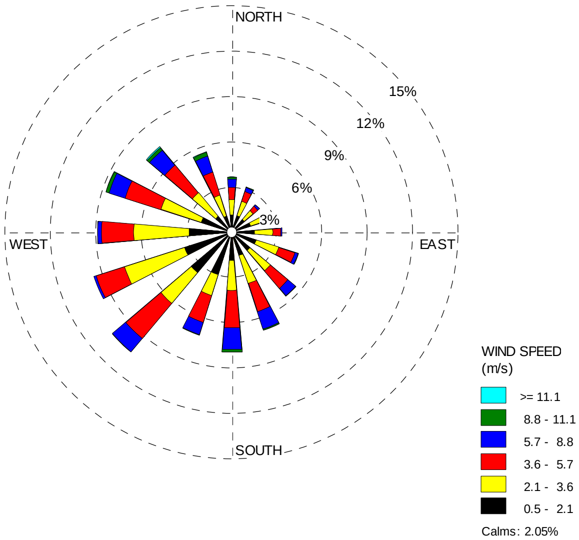
1.4 Wind

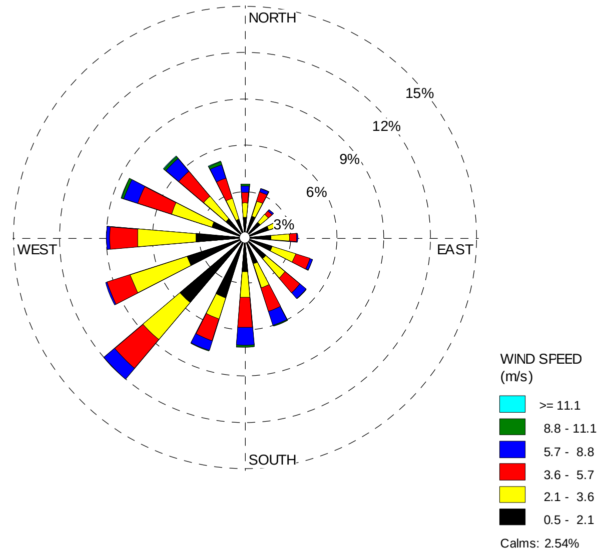
At the Fort Saskatchewan station, wind data were analyzed for a five-year period from January 1, 2001–October 31, 2006. The wind data collected at the Lamont station were analyzed for the complete data collection period, which was from January 1, 2003–October 31, 2006.

Wind roses are an efficient and convenient means of presenting wind data. The length of the radial barbs gives the total percent frequency of winds from the indicated direction, while portions of the barbs of different widths indicate the frequency of associated wind speed categories. Figure II-5 presents the seasonal wind speed and direction frequency distributions of hourly average wind speed at the Fort Saskatchewan station, while Figure II-6 presents the seasonal wind speed and direction frequency distributions of hourly average wind speed at the Lamont station. Figure II-7 presents the annual wind speed and direction frequency distributions for both locations.

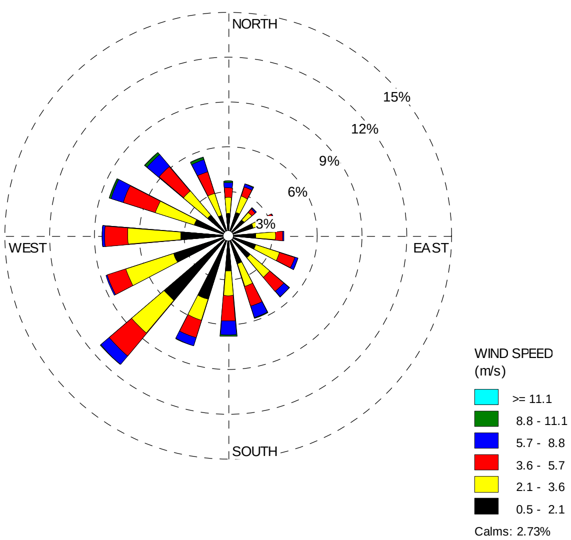
The Fort Saskatchewan station has mean and maximum annual wind speeds of 2.0 and 11.0 m s^{-1} (7.2 and 39.7 km h^{-1}). The predominant winds are from the southwest and calms are relatively frequent (4.98%). Approximately 62.8% of winds are less than 2 m s^{-1} and 1.3% of winds are greater than 6 m s^{-1}.

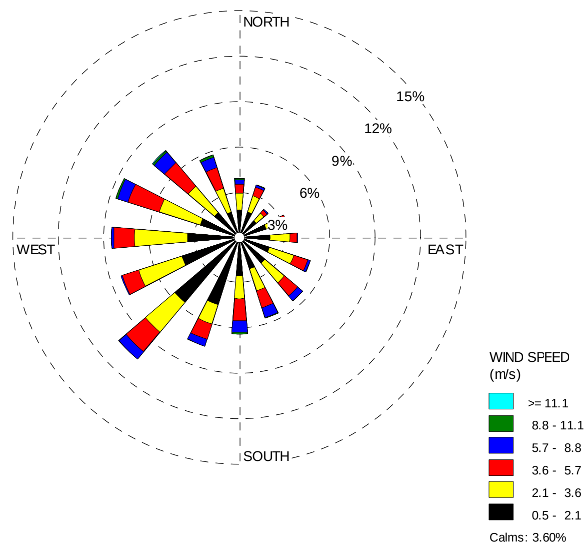
Winds at the Lamont station originate most often from the west-southwest. The strongest recorded wind speed is 15.8 m s^{-1} (57.0 km h^{-1}) and the mean annual wind speed is 3.8 m s^{-1} (13.7 km h^{-1}). Calms are infrequent, occurring 1.5% of the time. Approximately 21.3% of winds are less than 2 m s^{-1} while 15.6% are greater than 6 m s^{-1}.





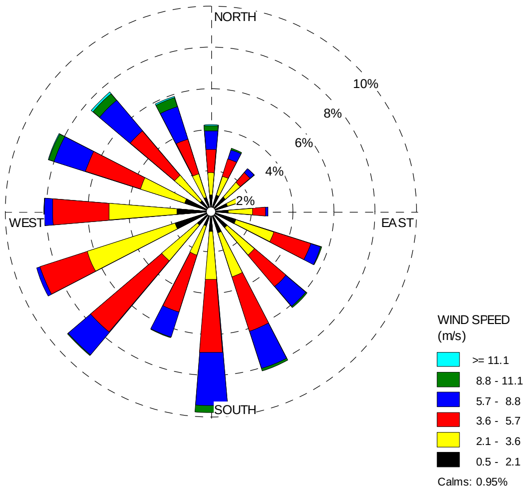
Fall **Winter**



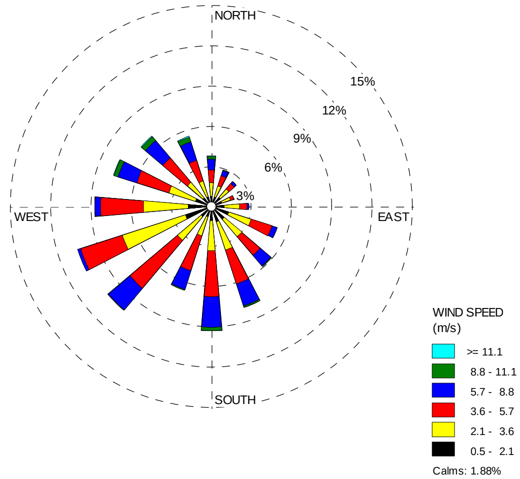


Spring **Summer**

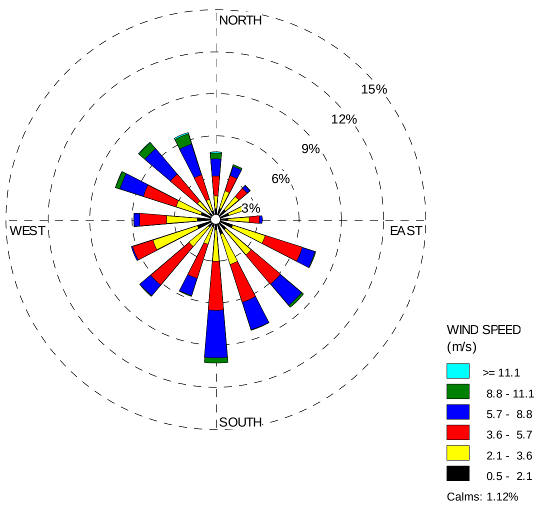
Figure II-5: Seasonal Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as observed at the Fort Saskatchewan Air Quality Monitoring Station



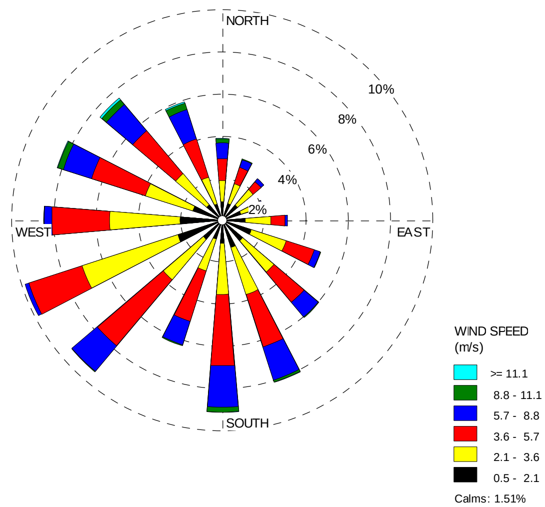
Fall



Winter

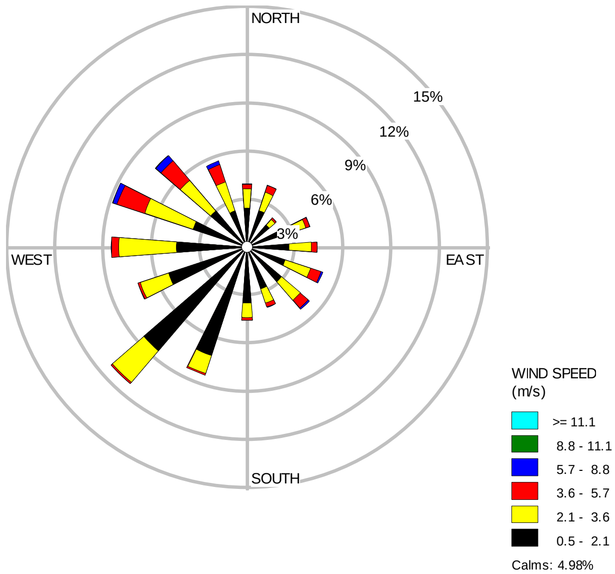


Spring

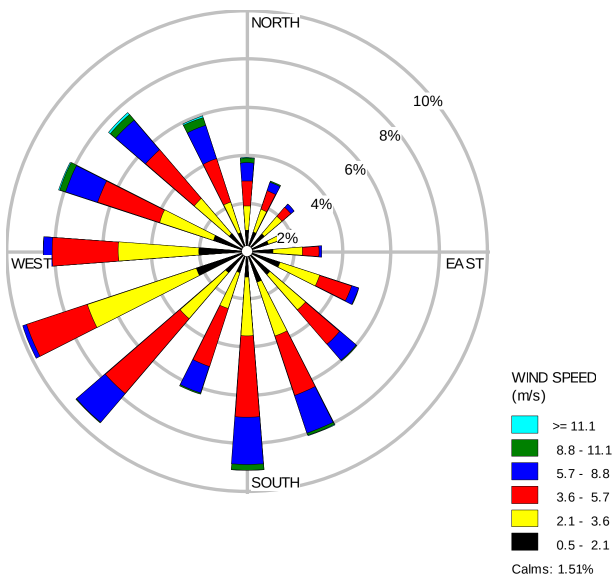


Summer

Figure II-6: Seasonal Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as Observed at the Lamont Air Quality Monitoring Station



Fort Saskatchewan (50,874 hours)



Lamont (33,465 hours)

Figure II-7: Annual Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as Observed at the Fort Saskatchewan and Lamont Air Quality Monitoring Stations

1.5 Severe Weather

Severe weather is characterized by such phenomena as thunderstorms, freezing rain and hail. Table II-3 summarizes the mean number of days during each month that these types of weather have been observed at the Edmonton City Center Airport (Environment Canada 1990). An average of eight thunderstorms occurs during the month of July. Freezing rain has occurred in all months except July and August. Hail occurs most often in July.

Tornadoes represent another severe weather phenomenon. They are relatively rare in the Fort Saskatchewan area, occurring at an annual frequency of about 4 per 10,000 km^2 (Environment Canada 1994, Internet Site).

Table II-3: Mean Number of Days per Year Severe Weather Observed at Edmonton City Center Airport (1951–1980)

Month	Thunderstorms	Freezing Rain	Hail
January	0	1	< 0.5
February	0	1	0
March	0	1	0
April	< 0.5	1	0
May	2	< 0.5	< 0.5
June	5	< 0.5	1
July	8	0	1
August	6	0	1
September	1	< 0.5	< 0.5
October	< 0.5	< 0.5	< 0.5
November	0	2	< 0.5
December	0	2	0
Annual	**23**	**10**	**5.5**

1.6 Visibility

Visibility in the study area is usually greater than 10 km.

Figure II-8 presents the mean number of hours in each month during which relatively poor visibility occurred. They are shown for two categories: visibilities less than 1 km and visibilities between 1 and 9 km. Poor visibilities tend to be relatively common during winter months when snow storms are most frequent.

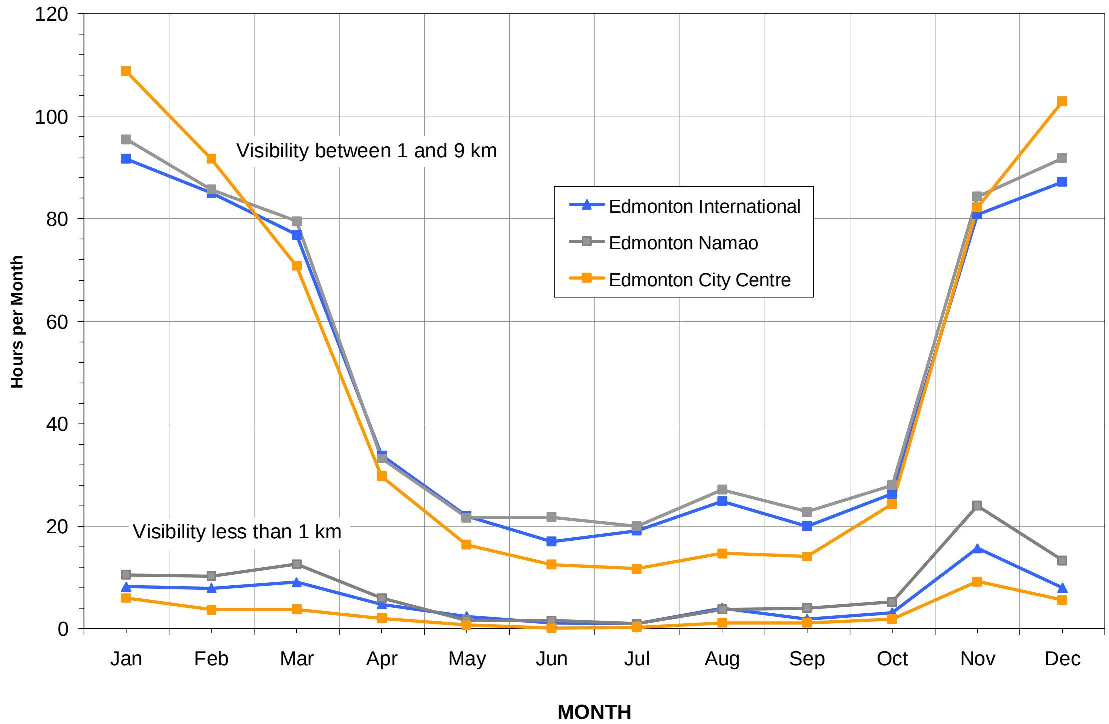


Figure II-8: Summary of Monthly Mean Visibility at the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)

2. References

2.1.1 Literature Cited

Environment Canada. 1990. *The Climate of Canada.* Canadian Publishing Centre. ISSNO-660-13459-4.

2.2 Internet Sites

Clean Air Strategic Alliance (CASA). 2006. Data Warehouse. Data Reports. Available at: http://www.casadata.org. Accessed: 2006.

Environment Canada. 1994. Map of the Annual Number of Tornados in Canada. Accessed: 2006 available at: http://atlas.gc.ca/site/english/maps/environment/naturalhazards/number_tornadoes_per_year.gif/image_view

Environment Canada. 2006. Canadian Climate Normals on Averages 1971–2000. Available at: http://climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html. Accessed: 2006.

Volume IIA: Climate and Air Quality

Appendix II: Climate of the Study Area

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1. Climate and Meteorology of the Study Area

An analysis has been done of climatological data collected in the general region of Bruderheim in the vicinity of the proposed Alberta Sulphur Terminals (the Project). The data concerns a range of phenomena including ambient air temperature, precipitation, relative humidity, visibility, and wind. Most of the information presented herein, with the exception of that relating to wind, was obtained from 30 years of data (1971-2000) collected by Environment Canada at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports (Environment Canada 2006, Internet Site). Information relating to wind was obtained from continuous hourly monitoring data at the Fort Air Partnership's (FAP) Fort Saskatchewan and Lamont monitoring stations for the period of January 1, 2001 to October 31, 2006 (Clean Air Strategic Alliance (CASA) 2006, Internet Site).

1.1 Ambient Air Temperature

Monthly mean temperatures, as recorded at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports from 1971–2000, are shown in Figure II-1. A summary of the seasonal and annual ambient temperatures is presented in Table II-1. July is the warmest month in the Bruderheim region with a mean daily temperature of about 16.7°C. The coldest month of the year is January with a mean daily temperature of -12.7°C. The annual mean daily temperature for the study area is 3.1°C.

Table II-1: Mean Seasonal Daily Temperatures at Fort Saskatchewan and the Edmonton International, Edmonton Namao and Edmonton City Center Airports (1971–2000)

Season	Mean Daily Temperature (°C)				
	Fort Saskatchewan	Edmonton International Airport	Edmonton City Centre Airport	Edmonton Namao Airport	Average
Winter[1]	-11.7	-11.8	-9.9	-10.9	-11.1
Spring[2]	4.1	3.4	4.9	4.1	4.1
Summer[3]	15.8	15.0	16.5	15.6	15.7
Fall[4]	3.3	2.9	4.3	3.5	3.5
Annual	2.9	2.4	3.9	3.1	3.1

Notes:
[1] Winter months: December, January, February.
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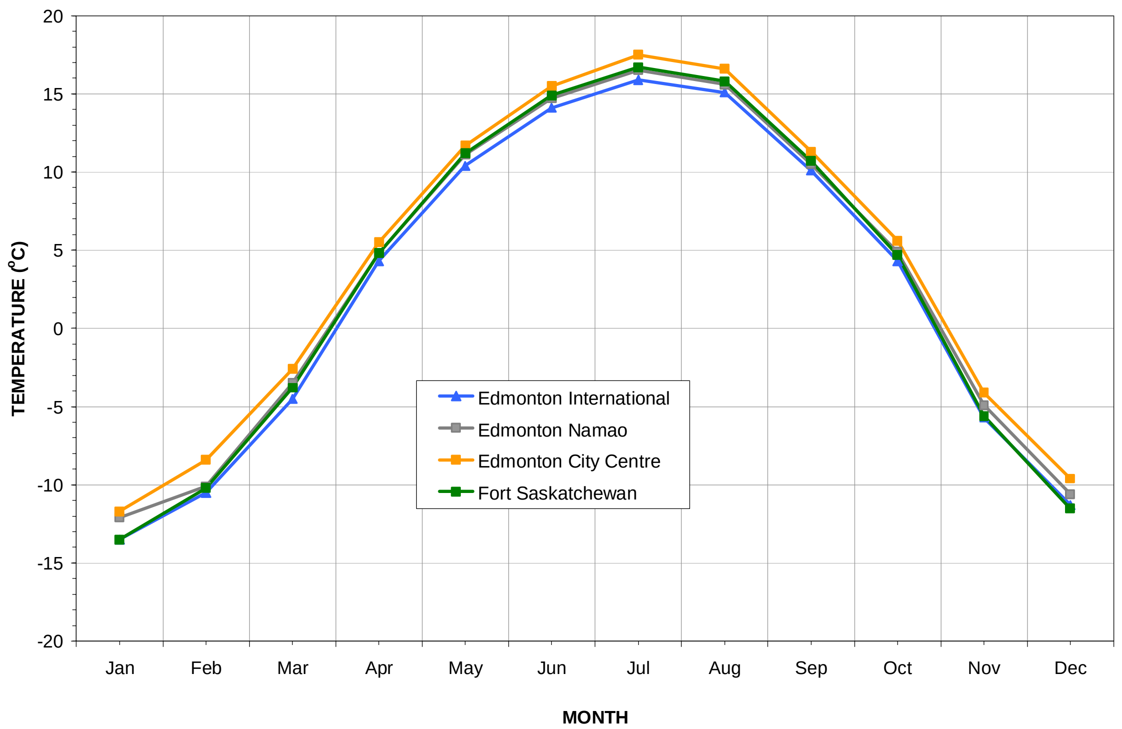
Source: Environment Canada (2006).



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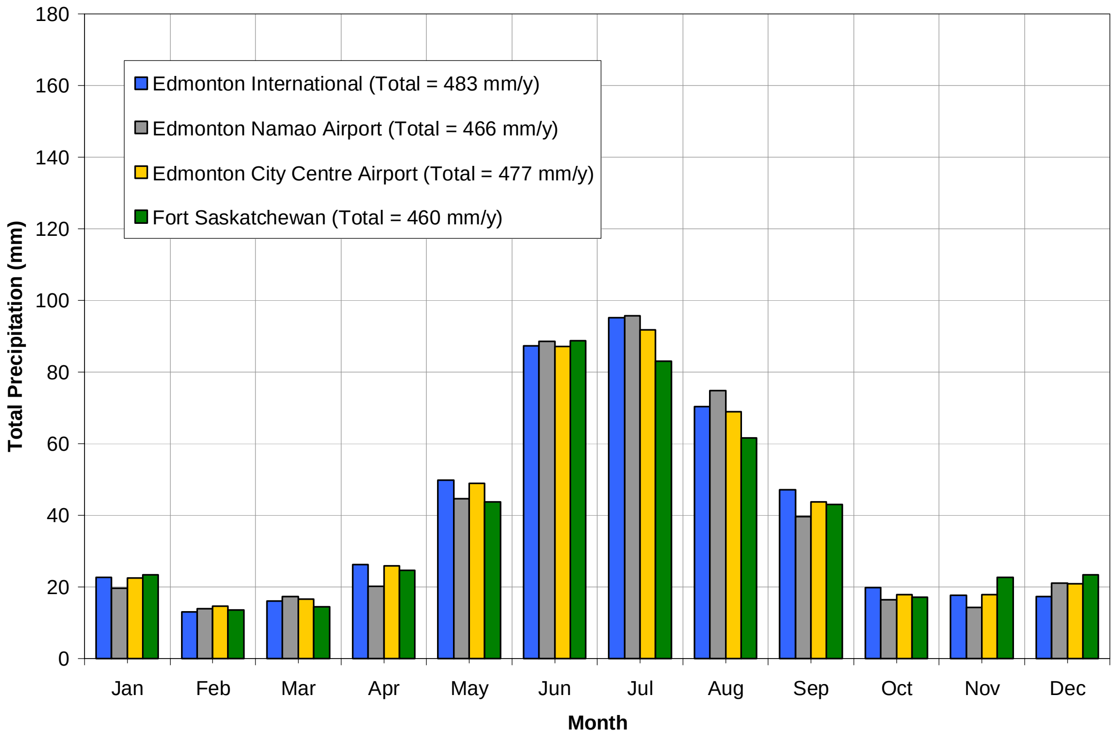
1.2 Precipitation

Monthly mean total precipitation, rainfall, and snowfall are illustrated in Figure II-2, Figure II-3 and Figure II-4 respectively.

The annual average total precipitation is approximately 471.4 mm. The majority of the annual precipitation occurs from May–September. The driest month is February, with average total precipitation of 13.8 mm. The wettest month is July when the total daily rainfall is 91.4 mm. Mean snowfalls shown in Figure II-4 for the months of December through March are 22.0, 23.1, 15.2 and 16.1 cm. Measurable snowfall amounts occur in all months except June and July.



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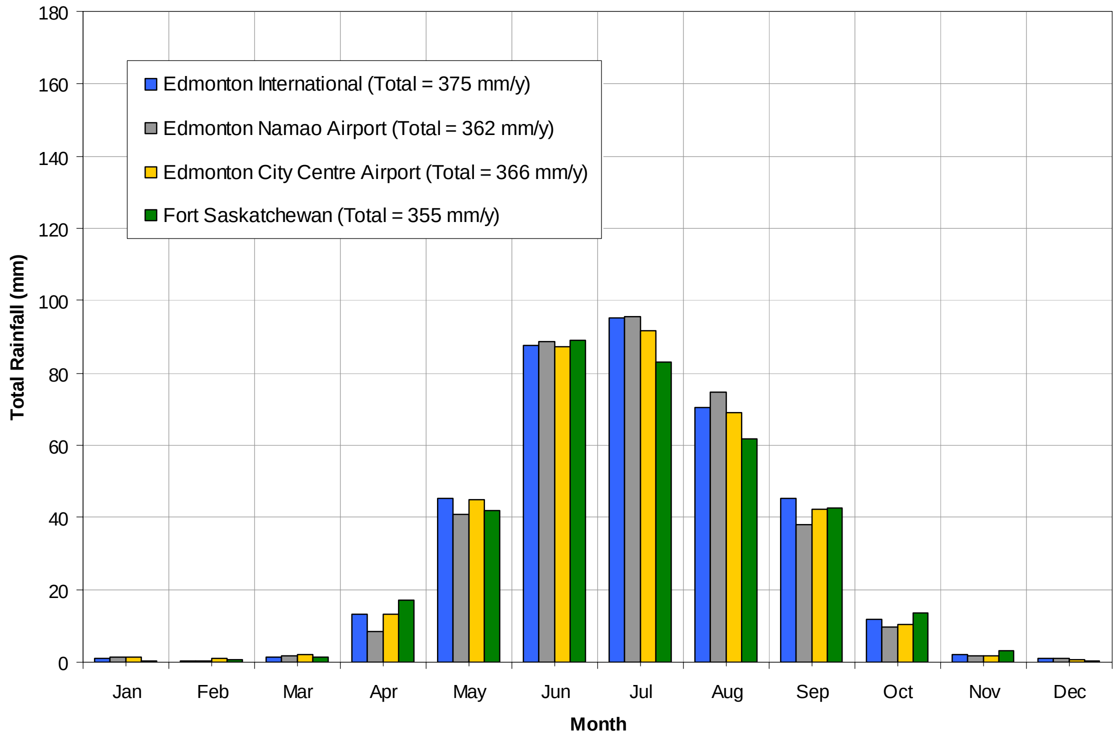
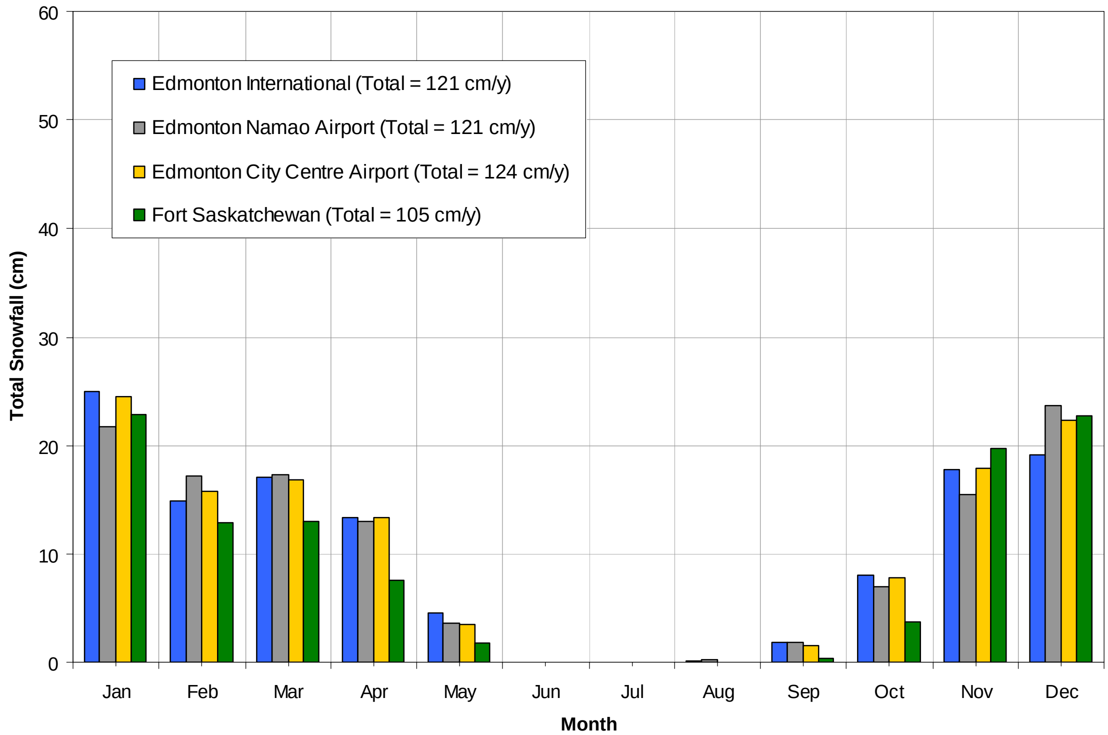


Figure II-3: Monthly Mean Rainfall at Fort Saskatchewan and the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)



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Relative humidity is the ratio of the amount of water vapour actually in the air compared to the maximum amount of water vapour required for saturation at a particular temperature. It is therefore the ratio (usually expressed as percent) of the air's water vapour content to its capacity.

Relative Humidity = (Water Vapour Content)/ (Water Vapour Capacity)

Table II-2 shows the mean relative humidity for each month at 6:00 and 15:00 Local Standard Time (LST), as recorded at the Edmonton International, Edmonton Namao and Edmonton City Center Airports from 1971–2000. The mean 6:00 LST annual relative humidity of approximately 79% at the International and Namao Airports fluctuates to its lowest point in late spring and its highest in late summer and early fall. The mean 15:00 LST annual relative humidity of 56% at the International and Namao Airports fluctuates to its lowest point in late spring and its highest in early winter.

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Month	Relative Humidity (%)					
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The Fort Saskatchewan station has mean and maximum annual wind speeds of 2.0 and 11.0 m s^{-1} (7.2 and 39.7 km h^{-1}). The predominant winds are from the southwest and calms are relatively frequent (4.98%). Approximately 62.8% of winds are less than 2 m s^{-1} and 1.3% of winds are greater than 6 m s^{-1}.

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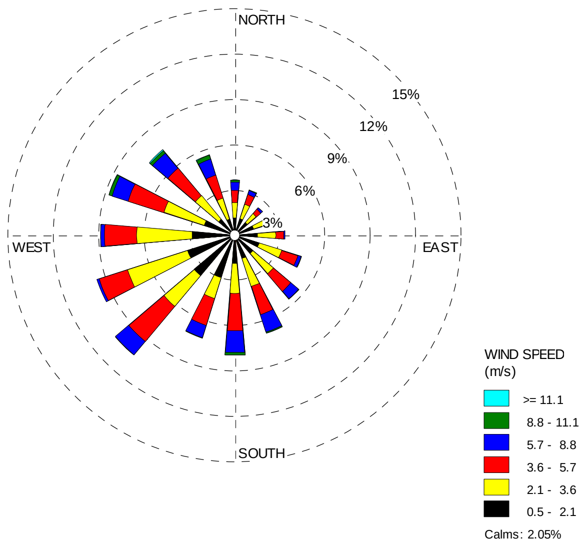
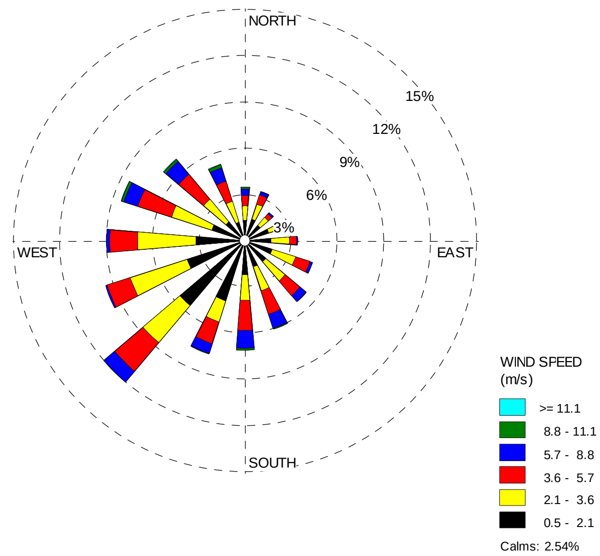
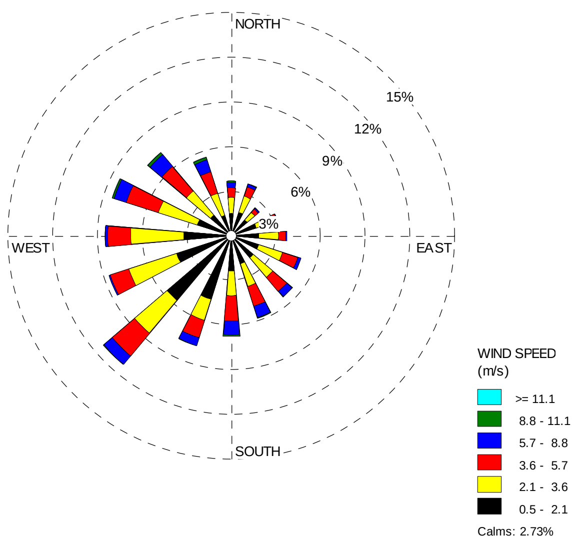


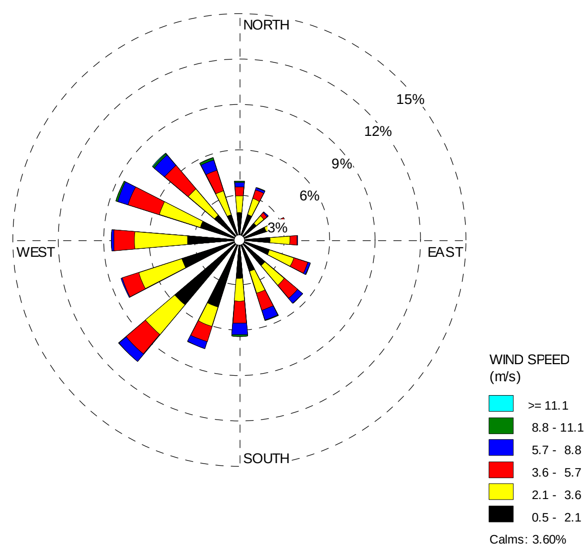
Fall



Winter

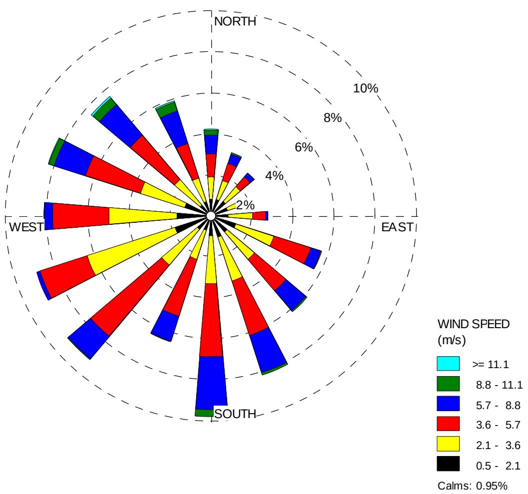


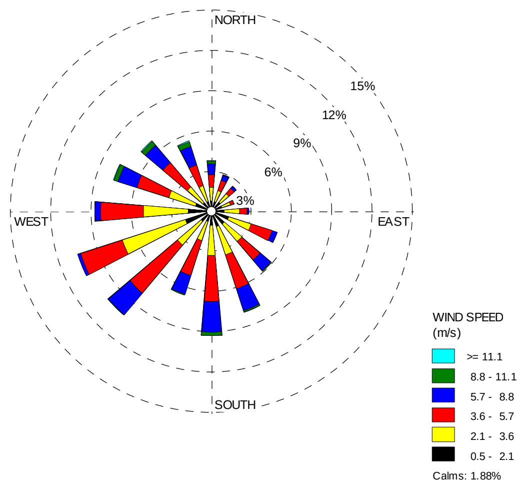
Spring



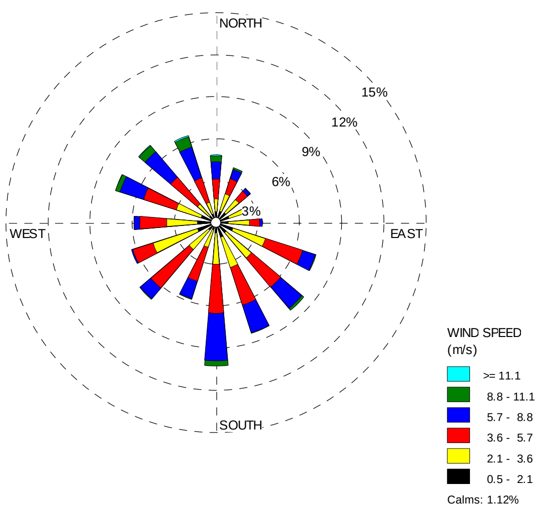
Summer

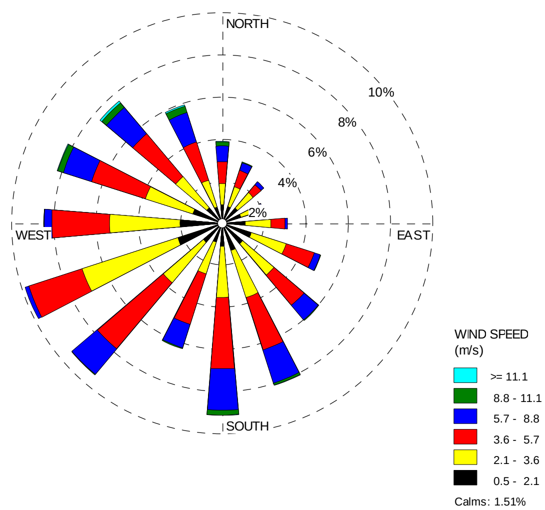
Figure II-5: Seasonal Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as observed at the Fort Saskatchewan Air Quality Monitoring Station





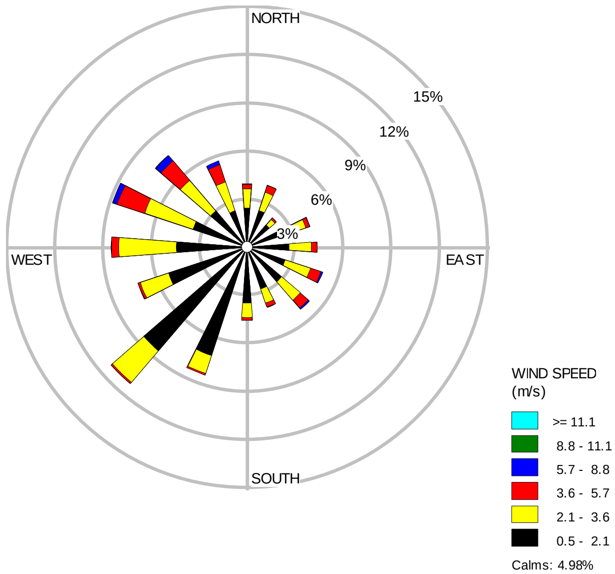
Fall **Winter**



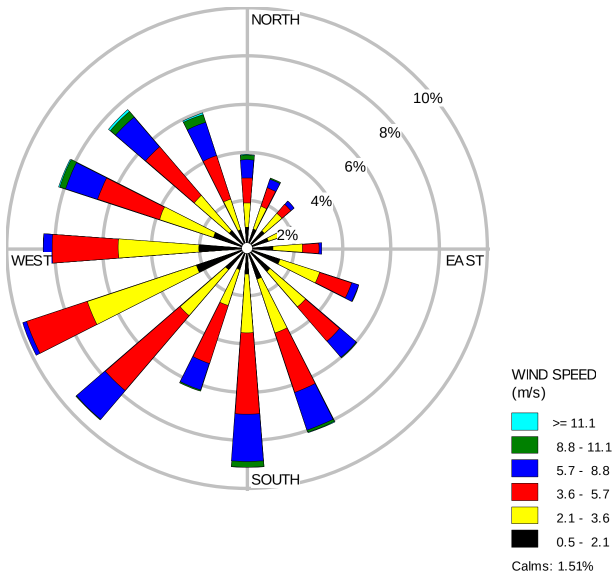


Spring **Summer**

Figure II-6: Seasonal Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as Observed at the Lamont Air Quality Monitoring Station



Fort Saskatchewan (50,874 hours)



Lamont (33,465 hours)

Figure II-7: Annual Wind Roses of Hourly Wind Speed and Direction Frequency Distributions as Observed at the Fort Saskatchewan and Lamont Air Quality Monitoring Stations

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Severe weather is characterized by such phenomena as thunderstorms, freezing rain and hail. Table II-3 summarizes the mean number of days during each month that these types of weather have been observed at the Edmonton City Center Airport (Environment Canada 1990). An average of eight thunderstorms occurs during the month of July. Freezing rain has occurred in all months except July and August. Hail occurs most often in July.

Tornadoes represent another severe weather phenomenon. They are relatively rare in the Fort Saskatchewan area, occurring at an annual frequency of about 4 per 10,000 km^2 (Environment Canada 1994, Internet Site).

Table II-3: Mean Number of Days per Year Severe Weather Observed at Edmonton City Center Airport (1951–1980)

Month	Thunderstorms	Freezing Rain	Hail
January	0	1	< 0.5
February	0	1	0
March	0	1	0
April	< 0.5	1	0
May	2	< 0.5	< 0.5
June	5	< 0.5	1
July	8	0	1
August	6	0	1
September	1	< 0.5	< 0.5
October	< 0.5	< 0.5	< 0.5
November	0	2	< 0.5
December	0	2	0
Annual	**23**	**10**	**5.5**

1.6 Visibility

Visibility in the study area is usually greater than 10 km.

Figure II-8 presents the mean number of hours in each month during which relatively poor visibility occurred. They are shown for two categories: visibilities less than 1 km and visibilities between 1 and 9 km. Poor visibilities tend to be relatively common during winter months when snow storms are most frequent.

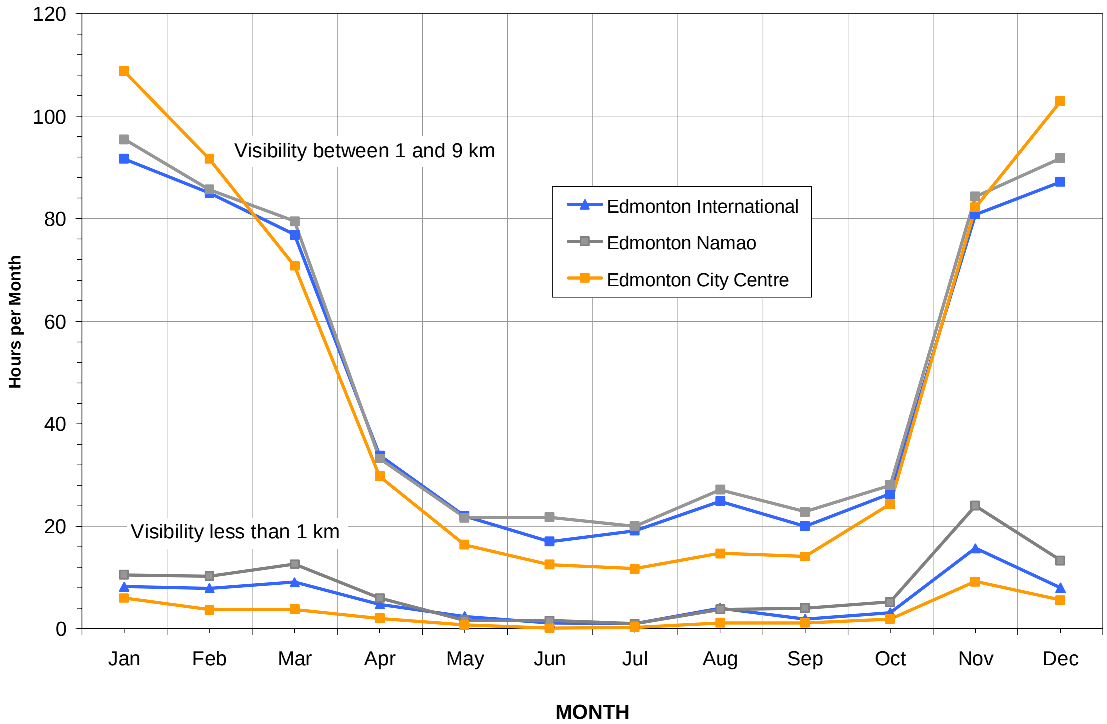

Figure II-8: Summary of Monthly Mean Visibility at the Edmonton International, Edmonton Namao, and Edmonton City Center Airports (1971–2000)

2. References

2.1.1 Literature Cited

Environment Canada. 1990. *The Climate of Canada.* Canadian Publishing Centre. ISSNO-660-13459-4.

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Clean Air Strategic Alliance (CASA). 2006. Data Warehouse. Data Reports. Available at: http://www.casadata.org. Accessed: 2006.

Environment Canada. 1994. Map of the Annual Number of Tornados in Canada. Accessed: 2006 available at: http://atlas.gc.ca/site/english/maps/environment/naturalhazards/number_tornadoes_per_year.gif/image_view

Environment Canada. 2006. Canadian Climate Normals on Averages 1971–2000. Available at: http://climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html. Accessed: 2006.

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resources & energy

Alberta Sulphur Terminals Ltd.
Bruderheim Sulphur Forming and Shipping Facility

Volume IIA – Air, Noise and Public Health

3. Noise and Light

Project Number 62720000
June 2007

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APPENDICES

Executive Summary

Alberta Sulphur Terminals Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), retained HFP Acoustical Consultants (HFP) to conduct a Noise Impact Assessment (NIA) for the proposed AST Sulphur Forming and Shipping Facility (the Project) near Bruderheim to determine compliance with the following components of the Terms of Reference (TOR) (AENV 2007):

Discuss baseline noise and light level conditions. Identify components of the Project that will affect noise and light level, and:

a) *present the results of a noise assessment based upon existing conditions as specified by EUB ID 98-08* [sic 99-08]*, Noise Control Directive, including:*

   i) *an estimate of the potential for increased noise resulting from the Project*

   ii) *the identification of potentially-affected people and wildlife; and*

   iii) *the implications of any increased noise levels*

   The Noise Control Directive was recently re-issued on February 16, 2007 as Directive 038. The sound level requirements within Directive 038 remain unchanged.

   This NIA focused on determining the impact on selected residential locations in the immediate vicinity of the proposed Project. The assessment evaluated:

   - current sound environment including the contribution from existing sound sources such as the nearby highways (Highway 15 and Highway 45) and two rail lines
   - contribution of the Project, associated truck traffic and associated rail traffic alone
   - cumulative effect of the addition of the proposed Bruderheim facility and associated truck and rail traffic to the existing sound levels

   Alberta Environment (AENV) has no specific noise regulations applicable to the Bruderheim facility. The Alberta Energy and Utilities Board (EUB) Noise Control Directive (ID 99-08) is applicable to energy industry facilities similar to the AST facility. It specifies maximum allowable outdoor sound levels for noise from operation of energy industry facilities. Sound levels for noise from the Bruderheim facility were determined for identified residences in accordance with the Directive's requirements.

   Noise from the proposed facility, noise sources and associated transportation were evaluated by computer modelling to determine predicted sound level contributions at five residential locations. The modelling assumed standard noise mitigation measures in the facility design and also included conservative assumptions which will make the predicted facility contributions conservative (i.e., high).

   Table ES-1 and ES-2 summarize existing or baseline sound levels, predicted sound levels, combined sound levels and EUB permissible sound levels (PSLs) for daytime (first table) and nighttime (second table). The predictions have been split out to present facility sources alone and facility and transportation sources together. Facility sources alone represent the continuous sound level emanating from the facility and would be representative of the usual noise impact from the facility. The facility and transportation sources together scenario includes additional sound energy from associated truck and rail traffic and would be representative of the maximum noise impact from the facility.

Table ES-1: Daytime Sound Levels

Residence	Baseline Daytime Sound Level (dBA L_{eq})	Predicted Daytime Sound Level Contribution (dBA L_{eq})		Combined Daytime Sound Levels (dBA L_{eq})		Daytime EUB PSLs (dBA L_{eq})
		Facility Sources Only	Facility and Transportation Sources Together	Facility Sources Only	Facility and Transportation Sources Together	
Residence 1	53.0	39.0	44.6	53.2	53.6	55
Residence 2	48.1	32.3	37.0	48.2	48.4	55
Residence 3	44.6	34.4	38.9	45.0	45.6	55
Residence 4	48.7	31.4	38.2	48.8	49.1	50
Residence 5	48.7	31.8	39.6	48.8	49.2	55

Table ES-2: Nighttime Sound Levels

Residence	Baseline Nighttime Sound Level (dBA L_{eq})	Predicted Nighttime Sound Level Contribution (dBA L_{eq})		Combined Nighttime Sound Levels (dBA L_{eq})		Nighttime EUB PSLs (dBA L_{eq})
		Facility Sources Only	Facility and Transportation Sources Together	Facility Sources Only	Facility and Transportation Sources Together	
Residence 1	46.7	39.0	41.1	47.4	47.8	45
Residence 2	43.8	32.3	34.9	44.1	44.3	45
Residence 3	40.7	34.4	37.4	41.6	42.4	45
Residence 4	44.4	31.4	36.6	44.6	45.1	40
Residence 5	44.4	31.8	37.9	44.6	45.3	45

The measured baseline noise conditions are shown in the second column of both tables. They include contributions from Highway 15 and Highway 45 road traffic, the Canadian National Railway (CNR) and Canadian Pacific Railway (CPR) rail lines, the Canexus Chemicals Canada plant in Section 34, local traffic, residential activities and natural sounds.

The predicted sound level contributions from the Bruderheim facility alone, or the Bruderheim facility and associated transportation together, are at least 3 dBA below the existing sound levels, resulting in incremental sound level increases of no more than 1.7 dB. The predicted sound level contributions from the Bruderheim facility and associated truck traffic together are at least 3 dBA below EUB PSLs.

While there are no applicable regulations or guidelines for noise emissions resulting from construction activities, the EUB Directive specifies construction noise must be considered. Predictions of construction noise impact at the residential locations have been calculated and the excavation and steel erection phases are expected to be the noisiest construction phase. The predicted sound level contribution due to construction activity alone ranges from 47–55 dBA, depending on the distance each residence is from the Bruderheim facility. AST has also indicated that most construction activities will be confined to daytime hours. Predicted noise levels are within acceptable levels cited in other provincial legislation.

The cumulative predicted sound level of the proposed Project and the existing sound level are below EUB nighttime requirements at two of the five residences. For two residences (Residence 1 and Residence 4), the current measured nighttime sound levels already exceed EUB PSLs. It is, therefore, impossible for the cumulative sound level to be below EUB requirements. In this case, it is more appropriate to determine the incremental impact. For Residence 1, the incremental impact is 1.1 dB and for Residence 4 the incremental impact is 0.7 dB, which can be considered an insignificant impact. For Residence 5, the cumulative predicted sound level is 0.3 dB above the nighttime PSL. The major contributor to the cumulative predicted sound level is the measured sound level, rather than the Project. HFP, therefore, believes it is more appropriate to determine the incremental impact. For Residence 5, the incremental impact is 0.9 dB. Again, this can be considered an insignificant impact. Table ES-3 presents a summary of impacts for noise.

Table ES-3: Noise Impacts

	Geographic Extent	Magnitude	Direction	Duration	Confidence	Reversibility	Rating
Noise from normal operations	Local	Low to moderate	Negative	Mid-term	High	Reversible	Class 3
Construction noise	Local	Low to moderate	Negative	Short-term	High	Reversible	Class 3
Transportation noise	Local	Low to moderate	Negative	Mid-term	High	Reversible	Class 3
Non-routine operations (e.g., blowdown of steam, emergency power generators)	Local	Low to moderate	Negative	Short-term	Moderate	Reversible	Class 3

It can be concluded that an acceptable minimum impact scenario will occur as a result of the proposed AST Bruderheim facility, as the predicted sound levels are all below the EUB PSLs or have a minimal incremental impact.

Based on the very small increases in noise that are predicted, and the developed nature of the lands in the Bruderheim area, no impacts to wildlife related to noise are anticipated. No incremental increase in noise levels at the north extreme of Elk Island Park is predicted.

b) identify facilities that will affect light levels at night and evaluate the potential effects of increased light on affected residents; and

The sulphur receiving, forming and shipping facilities will operate 24 hours per day and will be lit to allow nighttime operation. Consistent with provincial regulations for the petroleum, petro-chemical and chemical facilities, the level of lighting will be maintained at 5 foot-candles (50 Lux) outside of all active receiving, processing and shipping facilities. This will result in a light impact that is similar in nature to the Canexus chlorate plant that is located to the southwest of the facilities component of the PDA.

Light associated with the proposed Project will diminish with distance away from the source area through adsorption and dissipation. A conservative estimate of the light intensity with distance from the source can be made assuming that the light dissipates in proportion to the square of the distance from the light source. Assuming that the lighting intensity of 5 foot-candles is generated by a light source 100 m away, the intensity of the light 600 m away would be less than 0.15 foot-candles. This level of light is not expected to distract nearby residences but would be noticeable.

The actual level of light at the property boundary will be less than this estimate because facility lighting will be directed into the process area (rather than the surrounding ground), vegetation and buildings will act as barriers to light travel and a portion of the light will be adsorbed into the air.

It is noted that the sulphur forming and shipping facilities are relatively low-lying, with most buildings and facilities being no higher than an equivalent two- story building.

c) *discuss the effects and mitigative measures to be utilized to minimize the production of noise and light.*

Mitigating measures to reduce noise impact would include restricting transportation activities to daytime periods only.

Light impacts will be mitigated by implementing the following:

- wherever practical, facility lighting will be directed away from adjacent residences
- light sources will be situated above the facilities and will be directed downwards and inwards to reduce the area outside of the facilities area that is effected by lighting
- trees and shrubs around the perimeter of the Site will be left in place and will establish a visual barrier to light propagation

Additional trees can be planted around the perimeter of the plant to mitigate light impacts, should the level of light be a nuisance to adjacent neighbours.

3. Noise and Light

3.1 Introduction

Alberta Environment (AENV) has no specific noise regulations applicable to the Bruderheim facility. In the absence of Natural Resources Conservation Board (NRCB) or AENV guidance, the Alberta Energy and Utilities Board (EUB) Noise Control Directive (ID 99-08) (EUB 1999) was used as a guideline. The Directive is applicable to energy industry facilities similar to the proposed Alberta Sulphur Terminals Ltd. (AST) facility (the Project). The Directive was re-issued on February 16, 2007 as Directive 038; sound level requirements remain unchanged.

3.2 Scope of Work

The main purpose for conducting the Noise Impact Analysis (NIA) for the proposed Project was to satisfy the specific conditions of the TOR for an Environmental Impact Assessment (EIA) issued by AENV. The NIA was also completed to properly address concerns raised by local residents. The elements of the Terms of Reference (TOR) that specifically deal with noise issues are summarized as follows:

Discuss baseline noise and light level conditions. Identify components of the Project that will affect noise and light level, and:

a) present the results of a noise assessment based on existing conditions as specified by EUB ID 98-08, Noise Control Directive, including:
    i) an estimate of the potential for increased noise resulting from the Project;
    ii) the identification of potentially-affected people and wildlife, and
    iii) the implications of any increased noise levels;

b) identify facilities that will affect light levels at night and evaluate the potential effects of increased light on affected residents; and

c) discuss the effects and mitigative measures to be utilized to minimize the production of noise and light.

3.2.1 Description of Project

The Project includes plans for the following facilities as they relate to elemental sulphur forming and shipping:

- rail and road access for receiving molten sulphur
- molten sulphur unloading and transfer facilities
- sulphur forming facilities to produce sulphur pastilles
- loading and shipping facilities for formed sulphur
- a sulphur pastilles temporary storage area

3.3 Environmental Noise Description

Environmental noise typically is not steady and continuous in nature, but varies constantly over time. In the case of environmental noise near an industrial facility, there is usually a steady background sound level due to noise from the facility that varies slowly over time because of changes in atmospheric and terrain conditions. Along with facility noise, there are also short-term, continuously varying, higher-level noises. The most common noises in this area are the sounds of Highways 15 and 45, the Canadian National (CN) and Canadian Pacific Railway (CPR) rail lines, Canexus Chemicals Canada (Canexus) plant in Section 34, traffic on local roads, residential activities and natural sounds.

To account for the time-varying nature of environmental noise, a single-number descriptor known as the "energy equivalent sound level" or L_{eq} is used. This descriptor, which quantifies sound that varies over time such as noise commonly occurring in outdoor environments, is generally accepted and used for environmental noise measurements and criteria. It is defined as the steady, continuous sound level over a specified time period, that has the same acoustic energy as the actual fluctuating sound levels occurring over the same time period. Time periods commonly used for L_{eq} noise measurements and criteria are the daytime (0700–2200 hours) and nighttime (2200–0700 hours) periods.

L_{eq} values for compiling environmental noise over time are normally based on measurement of "A-weighted sound levels," expressed in units of dBA. The A-weighting of sound measurement accounts for the frequency content of the sound and assesses it with a frequency response similar to that of the human ear. Thus, measurements and criteria for environmental noise are normally quantified in units of dBA L_{eq}. This measurement unit is applicable to environmental noise criteria, as specified in the EUB Directive.

Measurements of environmental noise are comprehensive in nature, in that noise from all sources affecting a measurement location are included in the sound measurement. This means that measurement of environmental noise from an industrial facility would normally include noise from other sources, such as road or rail traffic and community activity. However, criteria for noise from industrial facilities in general and criteria contained in the EUB Directive in particular, are based on environmental noise effects of the facility only; that is, the contribution of the facility noise to the overall environmental noise at a noise-sensitive location. Therefore, in assessing the noise impact of an industrial facility at a noise-sensitive location in its vicinity, the sound level contribution of facility noise relative to the overall or comprehensive sound level at the location must be quantified. This contribution may be dominant, such as when noise from a facility is audible above most other sources, or it may be weak such as when noise from a facility is barely audible or not at all audible, or it may be in between these two extremes.

3.4 Study Areas

The study areas were selected by evaluating the region around Section 35-55-20-W4M (the Site) that may reasonably be expected to be impacted by airborne noise emanating from the facility. Outdoor sound propagation is affected by a number of sound attenuation mechanisms, whereby their cumulative effect will generally reduce sound pressure levels from outdoor noise sources with increasing distance from the source. At relatively large receiver distances from noise sources, the noise contribution of distant sources will become less than the existing ambient noise from sources closer to the receiver. In the region around the Site, other sources contributing to the current sound level would be noise from Highways 15 and 45, CN and CPR rail lines, the Canexus plant in Section 34, Triton Fabrication in Section 26, local road traffic, residential activities, natural sounds and so on. The extent of the study areas were, therefore, defined as a region around the Site where a non-negligible contribution of facility noise to the existing ambient noise may be expected to occur.

The Principal Development Area (PDA) is defined as the Project footprint. The Noise and Light Local Study Area (LSA) is defined as the Site plus an area that includes the nearest permanent residences and the local roadways. The LSA extends out to an area approximately 1,500 m around the Site. The Noise and Light Regional Study Area (RSA) is the Site plus a radius of 3,000 m.

These study areas are shown in Figure 3.5-1 which identifies the Site and a number of nearby residential locations. Five residential locations were selected for this NIA and are listed in Table 3.4-1, along with the orientation of each location relative to the Site and the distance between each residential location and the mid point location of the Project. The five residential locations are labeled on Figure 3.5-1.

Table 3.4-1: Residential Locations in the LSA

Residence	Orientation from Facility	Approximate Distance to Project (m)
Residence 1	WNW	725
Residence 2	NNW	1,275
Residence 3	NNE	1,100
Residence 4	ESE	1,200
Residence 5	SE	1,100

When conducting noise impact assessments, an effort is made to identify the potentially most affected dwelling. In many cases, this is the closest residence, however, sometimes a residence further away than the closest dwelling unit may actually receive a greater noise impact. This may occur when the closest residence has buildings or landforms interposed between the residence and the facility, which could effectively shield the residence from facility noise and may result in higher sound levels at a more distant residence. In other cases, the predominant wind direction may enhance sound propagation towards a more distant residence and cause sound levels to be greater there than at the closest residence. Therefore, the noise impact assessment is usually conducted for a group of residences in the site vicinity, in an effort to determine the single most affected residence. All noise control designs for the proposed facility would then be done for this most affected residential location. Residences at distances greater than the most affected residence will then be less affected by noise from the facility and residential locations beyond the study area would be largely unaffected.

3.5 Standards and Methods

The proposed Project will be regulated by AENV and the NRCB and neither regulatory body has published regulations or guidelines pertaining to noise levels. In the absence of specific regulatory standards, the EUB Noise Control Directive (EUB 1999) was used as a guideline for evaluating noise impacts as per the TOR. The Directive is applicable to facilities associated with the energy industry that are similar to the Project.

Historically, two methods have been used to assess environmental noise impact:

- achieving absolute sound level limits
- minimizing the extent of increase of existing sound level values

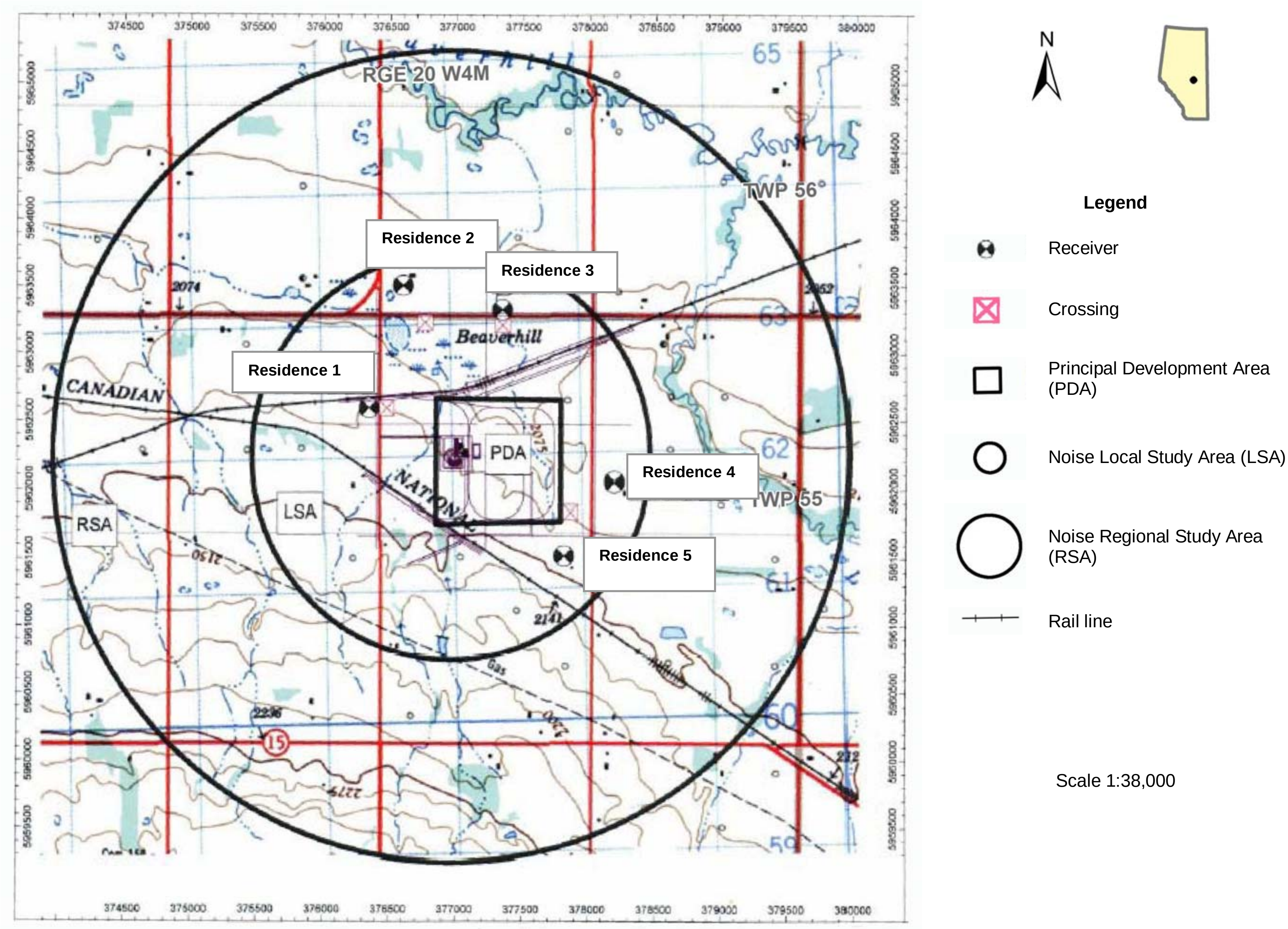

Figure 3.5-1: Noise Study Areas and Monitoring Locations

The absolute value method infers that a maximum level of acceptable noise has been established, typically by means of regulatory requirements. The advantage of this method is that a noise ceiling is ultimately established, so that a gradual increase of community sound levels over the years is prevented. If the regulatory values are achieved, it is assumed that an acceptable minimum noise impact scenario is achieved.

The other method of determining potential environmental noise impact is based upon the increase of existing values. This process infers that the sound from a new or expanded facility will be considered acceptable as long as it does not noticeably increase existing sound levels at noise-sensitive locations in its vicinity. In other words, presuming that people are accustomed to the sound environment that presently exists and provided the change does not increase the existing sound environment, people would not sense the change and not be significantly impacted.

An overall approach to assessing noise impact was utilized to provide a complete assessment of noise impact for the Project. This approach includes:

- assessment of compliance to applicable EUB requirements
- assessment of the extent of increase of sound levels at selected residential locations

While the EUB Directive is not directly applicable to the Project, it is applicable to all energy industry facilities under the EUB's jurisdiction, including facilities similar to the Project. The Directive incorporates both methods for determining potential environmental noise impacts in that it:

- specifies absolute sound level values that directly apply to energy industry facilities
- incorporates consideration of ambient sound environment values that are deemed to be typical of the type of location being assessed and then allows a minimal acceptable increase of that ambient value

In summary, both impact assessment methods are incorporated in this one approach. Compliance with this Directive infers that an adverse environmental noise impact is not likely to occur.

The extent of noise impact is directly related to an increase in sound levels and the intent of the Directive is to keep noise impacts to an acceptable minimum. Furthermore, an acceptable minimum impact is anticipated if predicted sound level contributions due to operation of the Project do not exceed the Directive's specified absolute sound level values. Its focus is to specify a maximum level of noise contribution from a facility at a residential property.

3.6 Potential Environment Interaction and Issues

For noise, the potential environmental interaction is with neighbouring residences, rather than any biophysical effect upon the environment itself. The interaction with the residences consists of annoyance due to disturbance in the quiet enjoyment of their residence and may take the form of sleep disturbance or decreased outdoor activities due to noise contributions from the industrial facility.

3.7 Baseline Case

Sound levels were measured for 24 hours at four locations near the closest residences. HFP attempted to conduct baseline monitoring at four of the five residences chosen for the assessment. However, some residents were opposed to having monitoring conducted in their yards. As a result, noise monitoring locations were chosen on the Site opposite the residences. The monitoring locations were chosen to be an equal distance from the local roads, highways or rail lines as much as possible, so that an equivalent noise impact would be measured. The 24-hour sound surveys were conducted on November 8–9, 2005 by HFP. Table 3.7-1 shows the four 24-hour monitoring locations.

Isolation analysis was not required as unusual noise events had not occurred during the baseline sound monitoring survey. The results of the baseline sound surveys are presented in Table 3.7-1 and are split into daytime (07:00–22:00) and nighttime (22:00–07:00) components, according to the EUB Directive. Nighttime L_{eq} values ranged from 40.7–46.7 dBA L_{eq} and daytime L_{eq} values ranged from 44.6–53.0 dBA L_{eq}.

The current sound environment at all monitoring locations is affected by road traffic on Highway 15 and Highway 45, rail traffic and the Canexus plant in Section 34. Details of the baseline sound surveys are presented in Appendix I.

Table 3.7-1: 24 Hour Baseline Sound Survey Results at Locations near Project

Location	Baseline Sound Level (dBA L_{eq}) November 8–9, 2005	
	Daytime	Nighttime
Opposite Residence 1	53.0	46.7
Opposite Residence 2	48.1	43.8
Opposite Residence 3	44.6	40.7
Opposite Residences 4 and 5	48.7	44.4

3.7.1 Predicted Sound Levels

The major mechanical equipment noise sources for the Project were identified by AST and their engineering consultant, WorleyParsons MEG. The ultimate expanded capacity of the facility (6,000 t/d) was modelled including the following facility sources:

- 22 Rotoformer units
- 2 product feed conveyor motors
- 2 radial stacking conveyor motors
- 2 load-out conveyor motors
- 2 steam boilers
- 2 steam boiler exhausts
- 4 exhaust fans for the Sulfatreat H_2S scavenging system
- 4 Rotoformer building exhaust fans
- 4–12' diameter cooling tower fans in 2 separate cooling towers
- 4 water-splash sides of cooling tower in 2 separate cooling towers

- 4 ends of cooling tower in 2 separate cooling towers
- 18 pump and motor units located at various positions within the facility

All sound sources modelled were assumed to be outdoors, which is a conservative estimate, because the Rotoformers are actually enclosed. As well, it was assumed all pumps run continuously rather than intermittently, which should be conservative.

There will also be truck and rail traffic associated with the facility's operation. According to AST, the truck noise sources would be:

- 45 trucks per day accessing the Site from Highway 15 to the south
- 30 trucks per day accessing the Site from Highway 45 to the north and west

All truck traffic will arrive during daytime hours (0700–2200).

Train noise sources would be:

- a 30-car train will arrive daily dropping off full liquid sulphur cars using the CN rail line
- once every 2–3 days, a unit train of up to 110 rail cars will be loaded between 0600 and 0000 and removed from site using the CPR rail line

3.7.1.1 *Predicted Sound Level Contributions (Construction Phase)*

Construction activities will proceed through a number of phases. Each construction phase will have both generic and phase-specific noise sources. Construction noise emissions are expected to occur during the following activities:

- leveling and grading
- pile driving
- excavation
- concrete pouring
- steel erection
- mechanical installation

Sound level predictions for construction noise at the residential locations were calculated using a general prediction method for determining noise emissions from large industrial construction sites. The construction site is not large and predictions of construction noise should be conservative. Predictions were done for the noisiest phases of the construction period, which includes the excavation and steel erection phases. Worst-case predicted sound level contributions during these phases are shown in Table 3.7-2. Sound level contributions from the other phases will be lower.

It should be noted that there are presently no regulations or guidelines applicable to noise emissions from construction sites located within the Province of Alberta or within the jurisdiction of the EUB. The predicted sound level contributions listed in Table 3.7-2 are within acceptable limits for construction noise during daytime hours as specified in other jurisdictions, such as the Nova Scotia Department of the Environment.

Table 3.7-2: Predicted Sound Level Contributions at Residential Locations from Construction Noise – Excavation and Steel Erection Phases

Residence	Predicted Sound Level Contribution (dBA L_{eq}) Excavation and Steel Erection Phases
Residence 1	55.0
Residence 2	47.3
Residence 3	49.4
Residence 4	48.2
Residence 5	49.4

Construction activities shall be confined to daytime hours. Furthermore, AST shall consider appropriate mitigative measures to minimize the effect of construction noise at nearby residential locations in close proximity to the Site and keep these residents informed of abnormal noise causing activities, including noise during commissioning and startup.

3.7.1.2 *Predicted Sound Level Contributions (Normal Operations – Project Alone)*

This section describes the noise contribution that will be generated by the operation of the Project alone. This scenario represents the continuous sound level emanating from the Project and is representative of its usual noise impact.

HFP utilized the Canada Environmental Noise Program, as developed by DataKustik GmbH, in Germany. The model considers the following aspects of sound attenuation:

- distance dissipation – the effect of sound attenuation with distance
- ground absorption – the effect of sound absorption by terrain situated between source and receiver
- atmospheric attenuation – the effect of sound absorption by moisture in the air
- barrier diffraction – the effect of an acoustical shadow created by interposed buildings and landforms
- the effects of wind and thermal gradients

The modelling was done using the ISO 9613 Standard, a temperature of 10°C and relative humidity of 70%. The ISO Standard assumes moderately downwind conditions and represents a conservative, worst-case condition.

Figure 3.7-1 shows the predicted sound level contribution from the proposed Bruderheim facility alone within approximately a 3 km radius of the proposed facility. As all the facility sound sources are assumed to be running continuously, this figure represents the sound contributions during both the daytime and nighttime periods. Table 3.7-3 presents the existing and predicted sound level contribution from the proposed facility alone, at each of the residential locations.

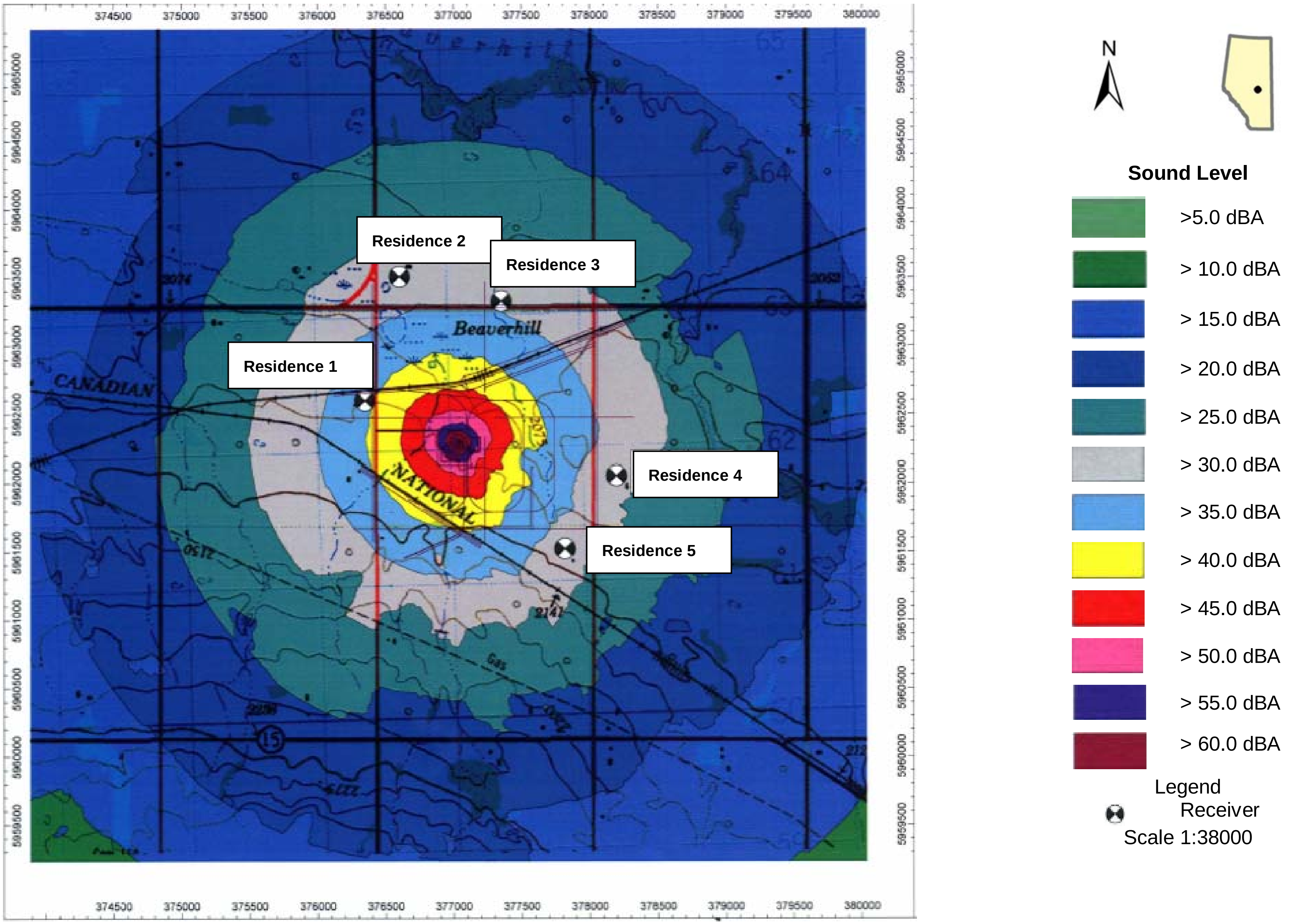

Figure 3.7-1: Predicted Daytime and Nighttime Sound Level Contribution from Project Alone

Table 3.7-3: Predicted Sound Level Contribution of Project Alone at Residential Locations

Residence	Predicted Sound Level Contribution of Project Alone at Residential Locations (dBA L_{eq})	
	Daytime	Nighttime
Residence 1	39.0	39.0
Residence 2	32.3	32.3
Residence 3	34.4	34.4
Residence 4	31.4	31.4
Residence 5	31.8	31.8

The daytime and nighttime predictions are the same because all facility equipment is assumed to run continuously. The predictions in Table 3.7-3 are for moderately downwind conditions. Under other weather conditions less favourable to sound transmission (e.g., residence upwind from the facility), the predicted facility contributions will be lower.

3.7.1.3 *Predicted Sound Level Contributions (Normal Operations – Project and Associated Transportation Sources Together)*

This section describes the noise contribution that will be generated by the operation of the Project and associated transportation sources together. This scenario includes the sound energy from the associated truck and rail traffic and is representative of the maximum noise impact from the facility.

Truck traffic modelling was done using the German RLS-90 Standard that allows input values for:

- number of vehicles per hour for daytime and nighttime
- percentage of heavy trucks during daytime and nighttime periods
- speed of vehicles

The rail traffic modelling was done by creating line noise sources for each train activity. Rail standards in the computer model are designed for mainline rail activities with multiple trains per day and higher speeds than would be found within the facility site. Therefore, HFP determined it would be more appropriate to model train activities using line noise sources.

Figure 3.7-2 shows the predicted daytime sound level contribution from the Project and associated transportation sources together within approximately a 3 km radius of the facility. Figure 3.7-3 shows the predicted nighttime sound level contribution. Table 3.7-4 presents the predicted sound level contribution from the Project and transportation sources at each of the residential locations. At all residences, the transportation noise sources are the loudest contributors during the daytime and generally are at least as loud as facility sources during the nighttime.

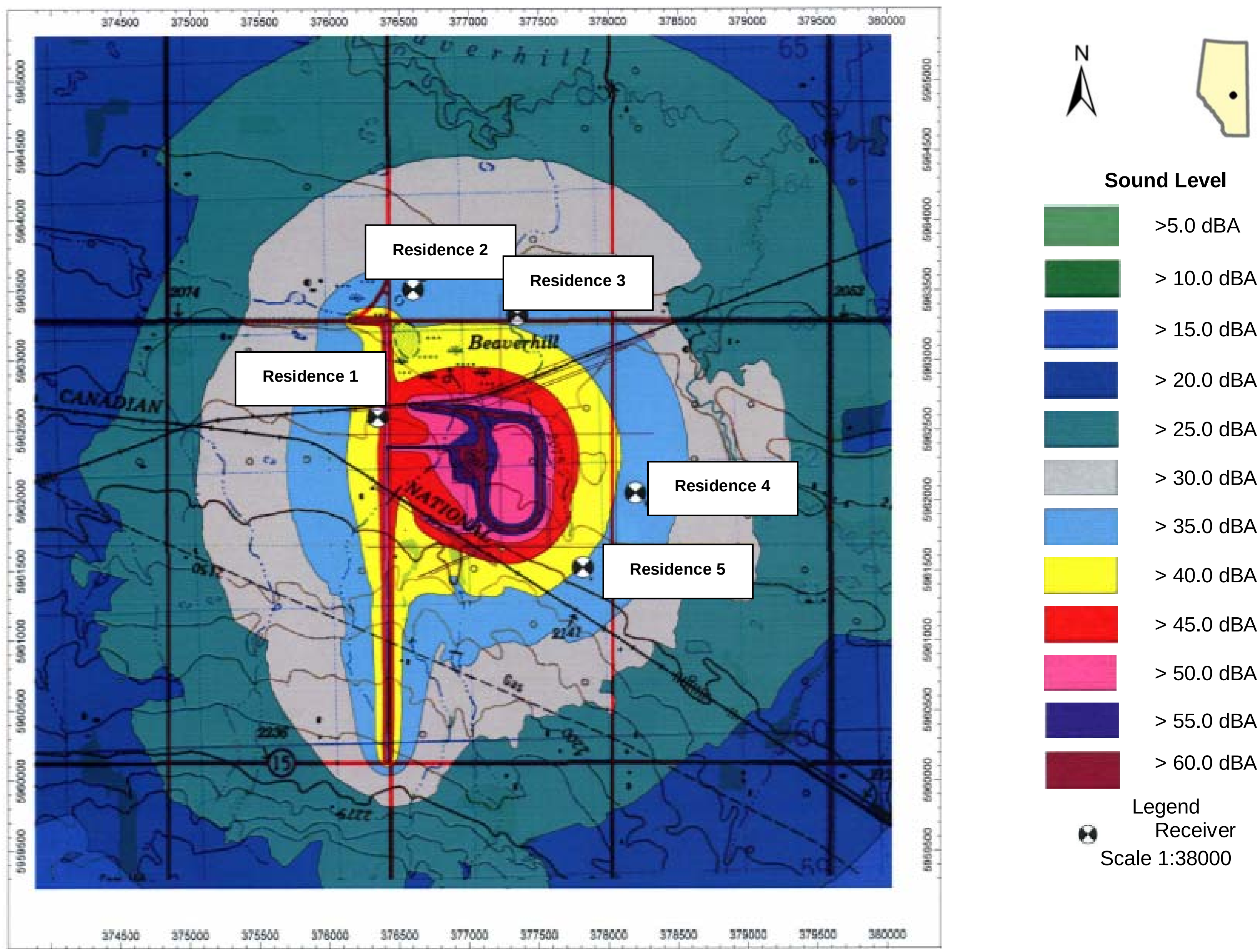

Figure 3.7-2: Predicted Daytime Sound Level Contribution from Project and Transportation Sources

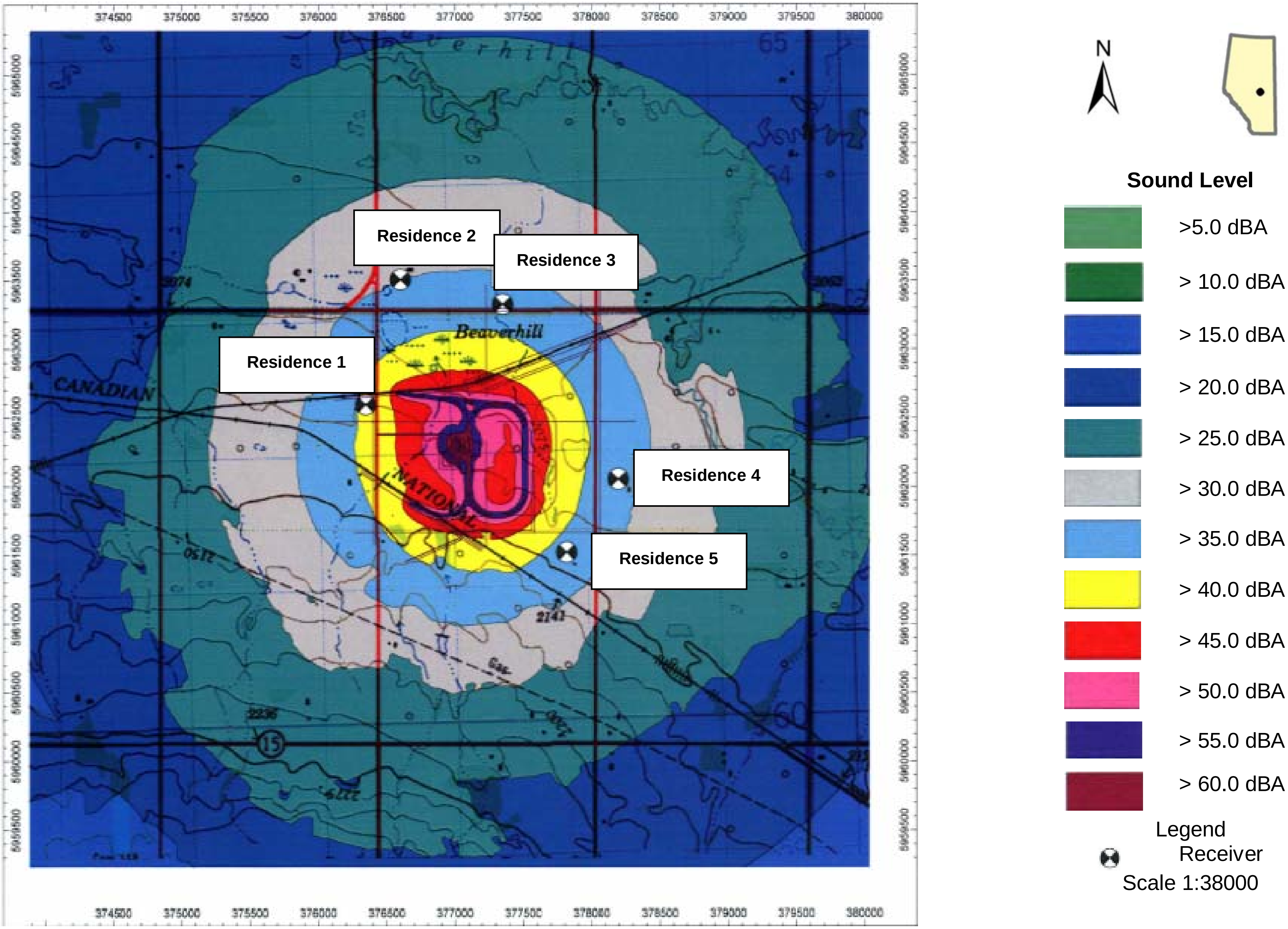

Figure 3.7-3: Predicted Nighttime Sound Level Contribution from Project and Transportation Sources

Table 3.7-4: Predicted Sound Level Contribution of Project and Associated Transportation Sources at Residential Locations

Residence	Predicted Sound Level Contribution of Project and Associated Transportation Sources at Residential Locations ($dBA\ L_{eq}$)	
	Daytime	Nighttime
Residence 1	44.6	41.1
Residence 2	37.0	34.9
Residence 3	38.9	37.4
Residence 4	38.2	36.6
Residence 5	39.6	37.9

Separate predictions for daytime and nighttime are provided, as different truck volumes and rail traffic occur during these periods.

Mitigating measures to reduce the noise impact would include restricting transportation activities to daytime periods only.

3.7.1.4 *Predicted Combined Sound Level Contributions (Normal Operations – Project Alone and Existing Sound Levels)*

This section describes the predicted overall noise levels expected when the Bruderheim facility is operating, but without the inclusion of transportation sources. This scenario represents the usual overall noise levels expected.

An overall predicted sound level can be estimated by adding the existing measured sound levels with the predicted contributions for the Project. As the sound levels were not measured at the residences, HFP has assumed the sound levels measured at an adjacent location are representative of the current sound levels at the individual residences. Because these measurement locations are relatively close to the residences, this is not an unreasonable assumption. Table 3.7-5 presents the predicted combined sound levels with the Project alone at each of the residential locations.

Table 3.7-5: Predicted Combined Sound Level Contribution of the Project Alone and Existing Sound Levels

Residence	Measured Existing Sound Level		Predicted Sound Level Contribution of Project Alone		Predicted Combined Sound Level Contribution	
	Daytime ($dBA\ L_{eq}$)	Nighttime ($dBA\ L_{eq}$)	Daytime ($dBA\ L_{eq}$)	Nighttime ($dBA\ L_{eq}$)	Daytime ($dBA\ L_{eq}$)	Nighttime ($dBA\ L_{eq}$)
Residence 1	53.0	46.7	39.0	39.0	53.2	47.4
Residence 2	48.1	43.8	32.3	32.3	48.2	44.1
Residence 3	44.6	40.7	34.4	34.4	45.0	41.6
Residence 4	48.7	44.4	31.4	31.4	48.8	44.6
Residence 5	48.7	44.4	31.8	31.8	48.8	44.6

3.7.1.5 *Predicted Combined Sound Level Contributions (Normal Operations – Project Associated Transportation Sources and Existing Sound Levels)*

This section describes the predicted overall noise levels expected when the Project is operating with the inclusion of transportation sources. This scenario represents the maximum overall noise levels expected. Similar to the previous section, an overall predicted sound level can be estimated by adding the existing measured sound levels with the predicted contributions for the proposed Project, including the transportation sources. Table 3.7-6 presents the predicted combined sound levels with the Project operating plus transportation sources at each of the residential locations.

Table 3.7-6: Predicted Combined Sound Level Contribution of the Project, Associated Transportation Sources and Existing Sound Levels

Residence	Measured Existing Sound Level		Predicted Sound Level Contribution of Project and Associated Transportation Sources		Predicted Combined Sound Level Contribution	
	Daytime (dBA L_{eq})	Nighttime (dBA L_{eq})	Daytime (dBA L_{eq})	Nighttime (dBA L_{eq})	Daytime (dBA L_{eq})	Nighttime (dBA L_{eq})
Residence 1	53.0	46.7	44.6	41.1	53.6	47.8
Residence 2	48.1	43.8	37.0	34.9	48.4	44.3
Residence 3	44.6	40.7	38.9	37.4	45.6	42.4
Residence 4	48.7	44.4	38.2	36.6	49.1	45.1
Residence 5	48.7	44.4	39.6	37.9	49.2	45.3

3.8 Comparison of Project Contributions to EUB Directive

3.8.1 Determination of Permissible Sound Levels

The Directive specifies maximum allowable outdoor sound levels for noise from energy industry facilities. The current Directive considers a receptor viewpoint, in this case the permanently occupied dwellings and not the facility fence-lines. The noise readings or predictions are taken at a point 15 m from the wall of each residential location facing the noise source. Thus all lands between the facility equipment and the residential locations are acceptable as a sound attenuating buffer zone.

To determine the EUB permissible sound level (PSL), the Directive first defines the basic sound level (BSL), which is the typical allowable sound level including a 5 dBA L_{eq} allowance for industrial presence. The BSL is based upon the nearby residence dwelling unit density and the proximity to transportation noise sources. This concept is utilized since typical ambient sounds are usually dominated by the extent of local development and by the effects of transportation in the area. Thus the louder the existing ambient sound environment is due to local transportation noise sources and local activity from neighbors, the louder the industrial component can be. Adjustments are set out within the Directive to account for certain site specific parameters which can affect typical subjective responses to noise. These are additive adjustments to the BSL and can include the following:

- daytime adjustment
- class A adjustments
- seasonal adjustment

- absence of both tonal and impulse/impact noise components adjustments
- ambient noise monitoring adjustment
- class B adjustment
- duration of activity adjustment

An explanation of the intent and applicability of these adjustments is not presented herein; rather the reader is referred to explanations contained within the Directive. However for clarity, an outline of the EUB method for determining the BSL is provided in Table 3.8-1.

Table 3.8-1: BSL Determination

Proximity to Transportation	Dwelling Unit Density per 1/4 Section of Land		
	1–8 Dwellings 22:00–07:00 (nighttime) dBA L_{eq}	9–160 Dwellings 22:00–07:00 (nighttime) dBA L_{eq}	>160 Dwellings 22:00–07:00 (nighttime) dBA L_{eq}
Category 1	40	43	46
Category 2	45	48	51
Category 3	50	53	56

Category 1: Dwelling units more than 500 m from primary or secondary highways and/or rail lines and not subject to frequent aircraft flyovers

Category 2: Dwelling units more than 30 m but less than 500 m from primary or secondary highways and/or rail lines and not subject to frequent aircraft flyovers

Category 3: Dwelling units less than 30 m from primary or secondary highways and/or rail lines and/or subject to frequent aircraft flyovers

The PSL is equal to the BSL plus the prescribed allowable adjustments. The default condition, assuming a typical low dwelling unit density rural area, no proximity to significant transportation noise sources, nighttime operation and no allowance for any other adjustments, would be 40 dBA L_{eq}. Although this value is the most commonly quoted sound level, it is not the pertinent value in this case since all relevant adjustments must be taken into account to determine the appropriate PSL.

For residences within 500 m of Highway 45 or one of the rail lines (Residence 1, Residence 2, Residence 3 and Residence 5), the BSL (=BSL) is 45 dBA L_{eq} during the nighttime and 55 dBA L_{eq} during the daytime. For Residence 4, the BSL is 40 dBA L_{eq} during nighttime and 50 dBA L_{eq} during the daytime as this residence is more than 500 m from a Highway or rail line.

None of the adjustments to the BSLs can be claimed. As a result, the previously described BSLs become the PSLs and are shown in Table 3.8-2.

Table 3.8-2: PSLs – Bruderheim Facility

Residence	PSLs (dBA L_{eq})	
	Daytime	Nighttime
Residence 1	55	45
Residence 2	55	45
Residence 3	55	45
Residence 4	50	40
Residence 5	55	45

In comparing Table 3.8-2 (PSLs) with Table 3.7-1 (Measured Sound Levels), the current measured sound levels already exceed the nighttime PSLs at Residence 1 and Residence 4. Therefore, comparing any cumulative sound levels that include the current measured sound level to the PSL is not appropriate for these two residences.

3.8.2 Comparison of Predicted Contributions from Project Alone to PSLs

The predicted sound level contributions for the Project alone at each residence are compared to the EUB PSLs in Table 3.8-3.

The predicted contributions from the proposed facility alone vary from 6.0–23.2 dBA L_{eq} below the PSLs, as shown in the bolded "margin of safety" columns. It should be noted that these are the predicted industrial contributions and do not include any sound contributions from other sources.

Table 3.8-3: Comparison of Predicted Contributions from Project Alone to PSLs

Residence	Daytime PSL (dBA L_{eq})	Daytime Predicted Sound Level Contribution (dBA L_{eq})	Daytime Margin of Safety (dBA L_{eq})	Nighttime PSL (dBA L_{eq})	Nighttime Predicted Sound Level Contribution (dBA L_{eq})	Nighttime Margin of Safety (dBA L_{eq})
Residence 1	55	39.0	16.0	45	39.0	6.0
Residence 2	55	32.3	22.7	45	32.3	12.7
Residence 3	55	34.4	20.6	45	34.4	10.6
Residence 4	50	31.4	18.6	40	31.4	8.6
Residence 5	55	31.8	23.2	45	31.8	13.2

3.8.3 Comparison of Predicted Contributions from the Project and Associated Transportation Sources to PSLs

The predicted sound level contributions for the Project and associated transportation sources at each residence are compared to the EUB PSLs in Table 3.8-4. The predicted contributions from the proposed facility vary from 3.4–18.0 dBA L_{eq} below the PSLs, as shown in the bolded "margin of safety" columns. Again, it should be noted that these are the predicted industrial contributions and do not include any sound contributions from other sources.

Table 3.8-4: Comparison of Predicted Contributions from the Project and Associated Transportation Sources to PSLs

Residence	Daytime PSL (dBA L_{eq})	Daytime Predicted Sound Level Contribution (dBA L_{eq})	Daytime Margin of Safety (dBA L_{eq})	Nighttime PSL (dBA L_{eq})	Nighttime Predicted Sound Level Contribution (dBA L_{eq})	Nighttime Margin of Safety (dBA L_{eq})
Residence 1	55	44.6	**10.4**	45	41.1	**3.9**
Residence 2	55	37.0	**18.0**	45	34.9	**10.1**
Residence 3	55	38.9	**16.1**	45	37.4	**7.6**
Residence 4	50	38.2	**11.8**	40	36.6	**3.4**
Residence 5	55	39.6	**15.4**	45	37.9	**7.1**

3.8.4 Comparison of Combined Contribution (Project Alone and Existing Sound Levels) to PSLs

The combined sound levels, including only the Project's contributions at each residence, can be compared to the EUB PSLs, as shown in Table 3.8-5.

The predicted combined sound levels are 0.4–10.0 dBA L_{eq} below the PSLs for three of the five residences, as shown in the bolded "Margin of Safety" columns. The nighttime Margin of Safety is negative for Residence 1 and Residence 4. These exceedances are due to the measured sound levels already exceeding the EUB PSL, not due to the contribution from the Project.

Table 3.8-5: Comparison of Combined Sound Levels (Project Alone and Existing Sound Levels) to PSLs

Residence	Daytime PSL (dBA L_{eq})	Daytime Predicted Combined Sound Level (dBA L_{eq})	Daytime Margin of Safety (dBA L_{eq})	Nighttime PSL (dBA L_{eq})	Nighttime Predicted Combined Sound Level (dBA L_{eq})	Nighttime Margin of Safety (dBA L_{eq})
Residence 1	55	53.2	**1.8**	45	47.4	**-2.4**
Residence 2	55	48.2	**6.8**	45	44.1	**0.9**
Residence 3	55	45.0	**10.0**	45	41.6	**3.4**
Residence 4	50	48.8	**1.2**	40	44.6	**-4.6**
Residence 5	55	48.8	**6.2**	45	44.6	**0.4**

3.8.5 Comparison of Combined Contribution (Project, Associated Transportation Sources and Existing Sound Levels) to PSLs

Similar to the previous section, the combined sound levels, including both Project and transportation source contributions at each residence can be compared to the EUB PSLs, as is shown in Table 3.8-6.

The predicted combined sound levels are 0.7–9.4 dBA L_{eq} below the PSLs for two of the five residences, as shown in the bolded "Margin of Safety" columns. The nighttime Margin of Safety is negative for Residence 1 and Residence 4. These exceedances are due to the measured sound levels already exceeding the EUB PSL, not due to the contribution from the Project and associated transportation sources. The margin of safety is -0.3 dB for Resident 5;

however, the major contributor to the cumulative predicted sound level at this location is the measured sound level, rather than the proposed facility.

Table 3.8-6: Comparison of Combined Sound Levels (Project, Associated Transportation Sources and Existing Sound Levels) to PSLs

Residence	Daytime PSL (dBA L_{eq})	Daytime Predicted Combined Sound Level (dBA L_{eq})	Daytime Margin of Safety (dBA L_{eq})	Nighttime PSL (dBA L_{eq})	Nighttime Predicted Combined Sound Level (dBA L_{eq})	Nighttime Margin of Safety (dBA L_{eq})
Residence 1	55	53.6	**1.4**	45	47.8	**-2.8**
Residence 2	55	48.4	**6.6**	45	44.3	**0.7**
Residence 3	55	45.6	**9.4**	45	42.4	**2.6**
Residence 4	50	49.1	**0.9**	40	45.1	**-5.1**
Residence 5	55	49.2	**5.8**	45	45.3	**-0.3**

3.9 Application Case

For noise, the application case effect is the logarithmic addition of the current measured sound levels with the predicted contribution of the Project. This section assesses the application case effects of adding the Project to the existing sound levels. Table 3.9-1 presents the comparison of incremental change in sound levels due to the addition of the Project alone and Table 3.9-2 presents the comparison of the incremental change in sound levels due to the addition of the Project plus transportation sources.

Assessment of the Project's cumulative noise impact is best addressed by the change in existing sound levels, which is shown in the bolded columns. The incremental impact from the Project alone ranges from 0.1–0.9 dBA and the incremental impact from the Project plus transportation sources is 0.3–1.7 dBA. These incremental increases would not be noticeable to the normal human ear and can be considered an insignificant impact. There are no other projects planned in the area that would be anticipated to affect noise levels in the immediate vicinity of the Project. Hence, the projected noise levels are relevant to the application case.

Table 3.9-1: Incremental Impact of Project Alone

Residence	Measured Daytime Sound Level (dBA L_{eq})	Daytime Combined Sound Level (dBA L_{eq})	Daytime Incremental Impact (dBA L_{eq})	Measured Nighttime Sound Level (dBA L_{eq})	Nighttime Combined Sound Level (dBA L_{eq})	Nighttime Incremental Impact (dBA L_{eq})
Residence 1	53.0	53.2	**0.2**	46.7	47.8	**0.7**
Residence 2	48.1	48.2	**0.1**	43.8	44.1	**0.3**
Residence 3	44.6	45.0	**0.4**	40.7	41.6	**0.9**
Residence 4	48.7	48.8	**0.1**	44.4	44.6	**0.2**
Residence 5	48.7	48.8	**0.1**	44.4	44.6	**0.2**

Table 3.9-2: Incremental Impact of Project plus Transportation Sources

Residence	Measured Daytime Sound Level (dBA L_{eq})	Daytime Combined Sound Level (dBA L_{eq})	Daytime Incremental Impact (dBA L_{eq})	Measured Nighttime Sound Level (dBA L_{eq})	Nighttime Combined Sound Level (dBA L_{eq})	Nighttime Incremental Impact (dBA L_{eq})
Residence 1	53.0	53.6	**0.6**	46.7	47.8	**1.1**
Residence 2	48.1	48.4	**0.3**	43.8	44.3	**0.5**
Residence 3	44.6	45.6	**1.0**	40.7	42.4	**1.7**
Residence 4	48.7	49.1	**0.4**	44.4	45.1	**0.7**
Residence 5	48.7	49.2	**0.5**	44.4	45.3	**0.9**

3.10 Summary of Impacts

Given the developed nature of the Bruderheim area, the noise impacts are not expected to affect local wildlife. No measurable increase in noise level is anticipated for the north end of Elk Island National Park, a critical area that is closest to the Project.

Table 3.10-1 presents a summary of the impacts for noise.

Table 3.10-1: Final Impact Rating Summary Table of Noise Impacts

	Geographic Extent	Magnitude	Direction	Duration	Confidence	Reversibility	Rating
Noise from normal operations	Local	Low to moderate	Negative	Mid-term	High	Reversible	Class 3
Construction noise	Local	Low to moderate	Negative	Short-term	High	Reversible	Class 3
Transportation noise	Local	Low to moderate	Negative	Mid-term	High	Reversible	Class 3

3.11 Follow-up and Monitoring

The predicted sound levels of the Project alone are well below the PSLs and remain below the PSLs even when transportation sources are added. When combined with the existing sound levels, the PSLs will still be met at all but one residence where the current sound levels are below the PSLs. The incremental impact is predicted to be no more than 1.7 dBA at all residences, which will not be a noticeable change in sound level. AST will investigate any noise concerns expressed by the surrounding residents.

3.12 Light

The sulphur receiving, forming and shipping facilities will operate 24 hours per day and will be lit to allow nighttime operation. Consistent with provincial regulations for the petroleum, petro-chemical and chemical facilities, the level of lighting will be maintained at 5 foot-candles (50 Lux) outside of all active receiving, processing and shipping facilities. This will result in a light impact that is similar in nature to the Canexus chlorate plant that is located to the southwest of the facilities component of the PDA.

Light associated with the Project will diminish with distance away from the source area through adsorption and dissipation. A conservative estimate of the light intensity with distance from the source can be made assuming that the light dissipates in proportion to the square of the distance from the light source. Assuming that the lighting intensity of 5 foot-candles is generated by a light source 100 m away, the intensity of the light 600 m away would be less than 0.15 foot-candles. This level of light is not expected to distract nearby residences but would be noticeable.

The actual level of light at the property boundary will be less than this estimate because facility lighting will be directed into the process area (rather than the surrounding ground), vegetation and buildings will act as barriers to light travel and a portion of the light will be adsorbed into the air.

It is noted that the sulphur forming and shipping facilities are relatively low-lying, with most buildings and facilities being no higher than an equivalent two-story building.

Mitigating measures to reduce noise impact would include restricting transportation activities to daytime periods only.

Light impacts will be mitigated by implementing the following:

- wherever practical, facility lighting will be directed away from adjacent residences
- light sources will be situated above the facilities and will be directed downwards and inwards to reduce the area outside of the facilities area that is effected by lighting
- trees and shrubs around the perimeter of the Site will be left in place and will establish a visual barrier to light propagation

Additional trees can be planted around the perimeter of the plant to mitigate light impacts, should the level of light be a nuisance to adjacent neighbours.

3.13 References

3.13.1 Literature Cited

Alberta Energy and Utilities Board (EUB). 1999. *Interim Directive (ID) 99-08 Noise Control Directive.* Calgary, AB.

Alberta Environment (AENV). 2007. *Final Terms of Reference, Environmental Impact Assessment (EIA) Report for the Proposed Bruderheim Sulphur Forming and Shipping Facility.* March 13, 2007. Alberta Environment, Edmonton, AB.

Volume IIA, Section 3: Noise and Light

Appendix I: Baseline Noise Assessment

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1. Purpose

Alberta Sulphur Terminal Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), retained HFP Acoustical Consultants Corp. (HFP) to conduct baseline sound monitoring surveys at five locations near the proposed AST facility (the Project). The proposed Project will be located in Section 35-55-20 W4M (the Site), near Bruderheim, Alberta. To address noise concerns and facilitate the application to Alberta Environment (AENV), AST requested that HFP prepare a Noise Impact Assessment (NIA) for the Project. Part of that work involved baseline sound surveys. This report serves as an appendix to Volume IIA, Section 3: Noise and Light of the Environmental Impact Assessment.

2. Measurements Conducted

2.1 Measurement Methodology

AENV has no specific noise regulations applicable to the AST Project. In the absence of specific AENV regulations, HFP recommends using the Alberta Energy and Utilities Board (EUB) Noise Control Directive (ID-99-08). The EUB regulation is applicable to energy industry facilities similar to the proposed Project and serves as a good tool for assessing noise impact.

The Directive is a receptor-oriented noise regulation that may require a continuous noise monitoring survey in the yard of the nearest, most impacted, or a complainant's residence. The measurement methods outlined in the Directive were adhered to during this noise monitoring survey. While baseline noise measurements are not required, many companies wish to have this information before proceeding with new or expanded facilities.

2.2 Monitoring Locations

Mr. Matt Gaskell, C.E.T., of HFP Acoustical Consultants Corp. conducted the baseline sound monitoring surveys at five locations. Typically, residential locations are chosen because the EUB Directive is receptor-based. In this case, some residents were opposed to having baseline noise monitoring conducted in their yards. As a result, noise monitoring locations were chosen on the AST property (the Site) opposite the residences. The monitoring locations were chosen to be an equal distance from local roads, highways or rail lines as much as possible, so that an equivalent noise impact would be measured.

Residence 1 is located to the west of the proposed Project, approximately 115 m south of the CPR rail line. The microphone was placed opposite Residence 1, approximately 61 m east of Range Road (R.R.) 202, as the residence is approximately 61 m west of R.R. 202. This residence will have a clear view towards the proposed Project.

Residence 2 is located approximately 200 m north of Township Road 560 and 200 m east of Highway 45. The microphone was placed at the entrance to an electrical substation located in the northwest corner of the Site. This placed the microphone just south of Township Road 560 and an equivalent distance from Highway 45 as Residence 2. This residence will have a clear view towards the proposed Project. The transformer substation is approximately 75 m south of the microphone location.

Residence 3 is located approximately 35 m north of Township Road 560 in the southeast quarter of Section 2, north of the proposed Project. This residence is also located approximately 500 m north of the CPR rail line. The microphone was located approximately 35 m south of Township Road 560, opposite Residence 3. This residence will have a clear view towards the proposed Project.

Residence 4 is approximately 200 m east of R.R. 201, in the southwest quarter of Section 36, to the east of the proposed Project. Residence 5 is located approximately 250 m south of the south fence of the Site, in the northeast quarter of Section 26. One monitoring location was chosen to represent both these residences. The microphone was located approximately 60 m north of the south fenceline of Section 35 and 100 m west of R.R. 201. This placed the microphone north of Residence 5 and southwest of Residence 4.

The microphones at all locations were mounted on tripods that elevated them to an approximate height of 1.2 m.

Both the CPR and CN rail lines pass through the Site, as shown on Figure I-1. All rail traffic observed by HFP was on the CN rail line, which passes through the southwest quarter of the Site and would affect Residence 1 and Residence 5 the most.

Figure I-1 also shows the four monitoring locations, nearby highways and rail lines and Site.

2.3 Duration of Monitoring

Continuous sound measurements were conducted for 24-hours at all four locations. Monitoring commenced at 14:00 hours on Tuesday, November 8, 2005 and was completed at 14:00 hours on Wednesday, November 9, 2005.

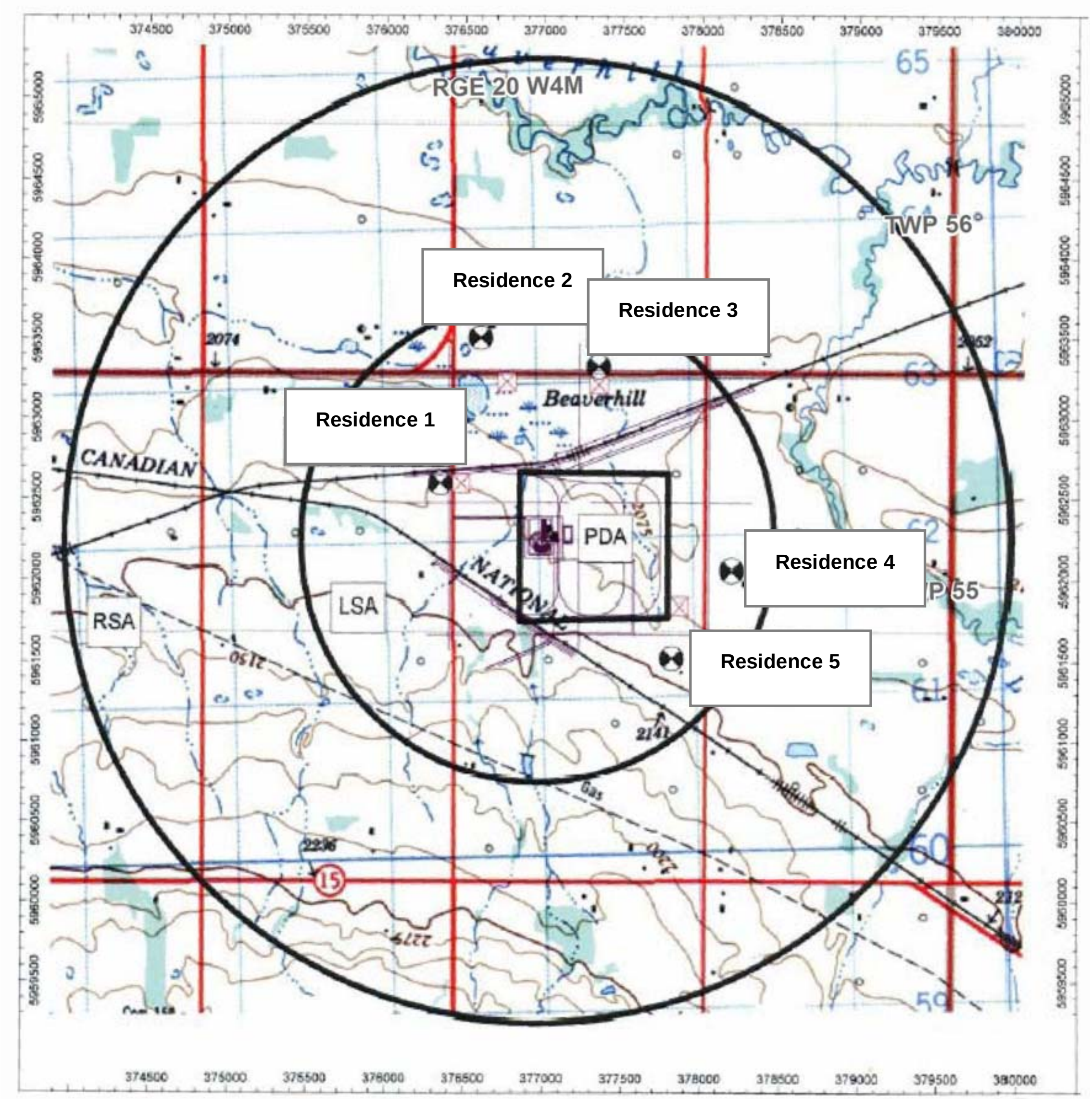
2.4 Measurement Instrumentation

The sound measurement instrumentation used to conduct the continuous noise monitoring survey was as follows:

- Larson Davis 824 Environmental Sound Level Meter (4)
- Larson Davis PRM902 preamplifier (4)
- Modal Shop 40AENV microphone (4)
- Brüel and Kjær UA0237 windscreen (4)
- Archos Jukebox Recorder 20 MP3 recorder (4)
- Brüel and Kjær 4231 calibrator (calibration date March 2005)

The sound measurement system was calibrated at the beginning of the noise monitoring survey and then checked again at the end.

The Larson Davis 824 system is rated as a Type 1 measurement system in reference to ANSI S1.4.1983 Standards and fulfills the instrumentation requirements of the Directive.



Legend

- Receiver
- Crossing
- Principal Development Area (PDA
- Noise Local Study Area (LSA)
- Noise Regional Study Area (RSA)
- Rail line

Scale 1:38,000

Figure I-1: Noise Study Areas and Monitoring Locations

2.5 L_{eq} Sound Level Descriptor

Environmental sound level measurements must contend with noise sources that constantly vary over time. For these measurements, there is a steady-state background sound level that slowly varies over time because of changes in sound propagation efficiencies due to varying atmospheric or terrain cover conditions. There are also short-term, continuously varying higher level noises. The most common are sounds associated with Highway 45, Highway 15, rail traffic, local traffic, residential activities and surrounding rural area. Therefore, when undertaking sound measurements, it is a complex task to describe the sound level at a receptor point as it continuously varies over time. This has led to the development of single number noise descriptors. This allows noise monitoring of a constantly varying noise environment over an extended time period, with the results described as a single number.

The single number descriptor commonly used for environmental noise measurements and the descriptor required by the Directive is the energy equivalent sound level (L_{eq}). The L_{eq} value is the sound energy average over the entire measurement time period. It is defined as a calculated sound level over the measured time period that has the same acoustic energy as the actual fluctuating sound levels that occurred during the same period. The sound level measuring instrumentation used by HFP for this study records continuous 1 minute A-weighted L_{eq} sound levels. These 1 minute L_{eq} values are then used to calculate hourly, daytime and nighttime dBA L_{eq} values as required by the Directive.

The L_{eq} values are based on a measurement of the A-weighted sound levels expressed in units of dBA. The dBA value accounts for the frequency content of the measured sound and assesses it with a frequency response similar to that of the human ear.

2.6 Meteorological Conditions

Table I-1 shows meteorological and ground conditions during the noise monitoring survey:

Table I–1: Meteorological Conditions during Noise Survey

Date and Time	Meteorological Parameter					
	Temperature (°C)	Relative Humidity (%)	Wind Speed (km/h)	Wind Direction	Cloud Cover	Ground Conditions
November 8, 2005						
14:15	0	64	8–9	SW	clear	dry
15:00	0	62	11–15	SSW	clear	dry
19:20	-1	59	12–18	South	clear	little frost
19:55	-1	56	14	South	clear	little frost
November 9, 2005						
00:00	0	55	15–19	South	clear	some frost
00:35	0	53	11–14	South	clear	some frost
08:30	1	49	calm	-	high cloud	dry
09:00	2	49	14–18	SSW	high cloud	dry
14:15	8	42	2	SW	high cloud	dry

Wind speeds during the survey were near the upper end of the acceptable range. The remaining meteorological conditions were in accordance with the requirements of the EUB Directive.

2.7 Effects of Meteorological and Terrain Conditions

Various meteorological and seasonal conditions can affect the sound propagation efficiency between noise sources and a residence. If the residence is located upwind from a distant noise source, a wind gradient could cause greater than normal sound attenuation to occur. This would result in lower sound levels at the residence than would normally occur with no wind. However, if the residence is downwind of a distant noise source, the opposite effect would occur, resulting in higher sound levels than normal at the residence. Crosswinds do not significantly affect sound propagation efficiency in either respect. The maximum acceptable hourly average wind speed for noise monitoring in accordance to the Directive is 15 km/h. However, from HFP's experience, lower wind speeds are usually required to conduct a meaningful noise monitoring survey.

Types of vegetation, ground cover conditions and differing terrain conditions, (i.e., tall grass, snow cover, wet ground, ploughed earth or rocky ground) can also affect the amount of sound absorption that occurs as sound waves pass over the ground. For example, moist soil or soft fresh snow is highly sound absorptive, as opposed to hard-packed ground or crusty snow which is highly sound reflective. The land between the proposed Bruderheim Facility and the surrounding residences is made up of flat, open fields.

The sound monitoring survey was conducted during the fall under mostly clear conditions. The winds were over 10 km/h from the south for most of the survey, with occasional calm to light winds.

2.8 Results of Measurements

2.8.1 Continuous Noise Monitoring Data Presentation

The 1 minute L_{min}, L_{eq} and L_{max} values recorded during the survey opposite Residence 1, Residence 2, Residence 3, Residence 4 and Residence 5 are presented in Figures I-2, I-3, I-4 and I-5, respectively. These figures illustrate the short-term variations in sound levels measured over the 24-hour period at each location. These figures should also be referred to when assessing the sound level that may be attributed to a specific occurrence or event.

The 1 hour L_{eq} sound levels were calculated from the 1 minute values and are presented in Table I-2, Table I-3, Table I-4 Table I-5, Figures I-6, Figure I-7, Figure I-8 and Figure I-9. The calculated daytime (07:00–22:00) and nighttime (22:00–07:00) L_{eq} values are presented at the bottom of each table. The C-weighted (dBC) hourly, daytime and nighttime L_{eq} values are also presented in the tables. The difference between the dBC and dBA values is sometimes used to determine if there are significant low-frequency components.

Hourly L_{eq} values and longer-term L_{eq} values are of more use when describing the sound environment as a single number. It should be understood that the actual sound level may vary considerably over the time period that the L_{eq} value represents.

Figure I-2: Monitored 1-Minute L_{eq} Baseline Sound Values Opposite Residence 1, November 8–9, 2005

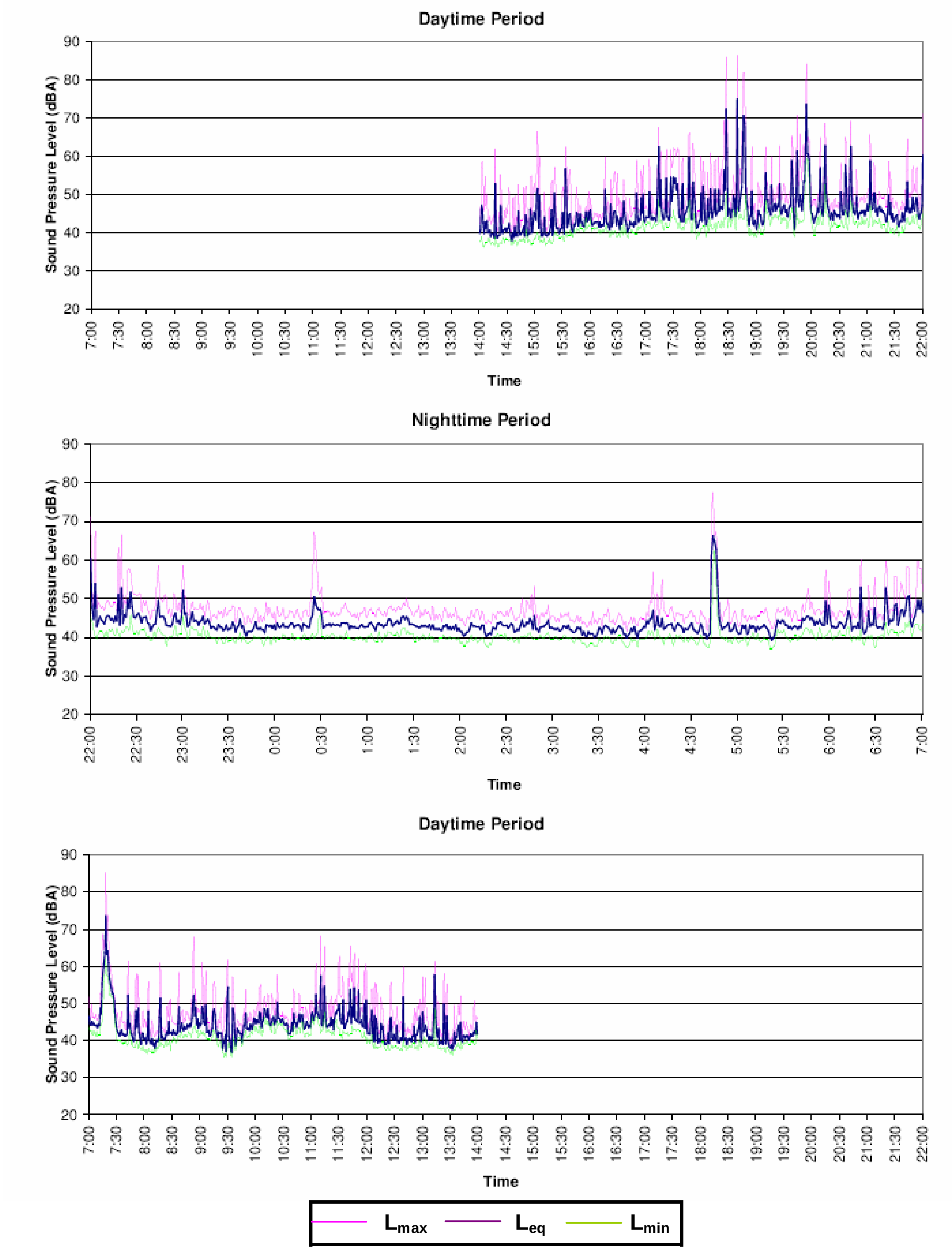


Figure I-3: 1-Minute L_{eq} Baseline Sound Values Opposite Residence 2, November 8–9, 2005

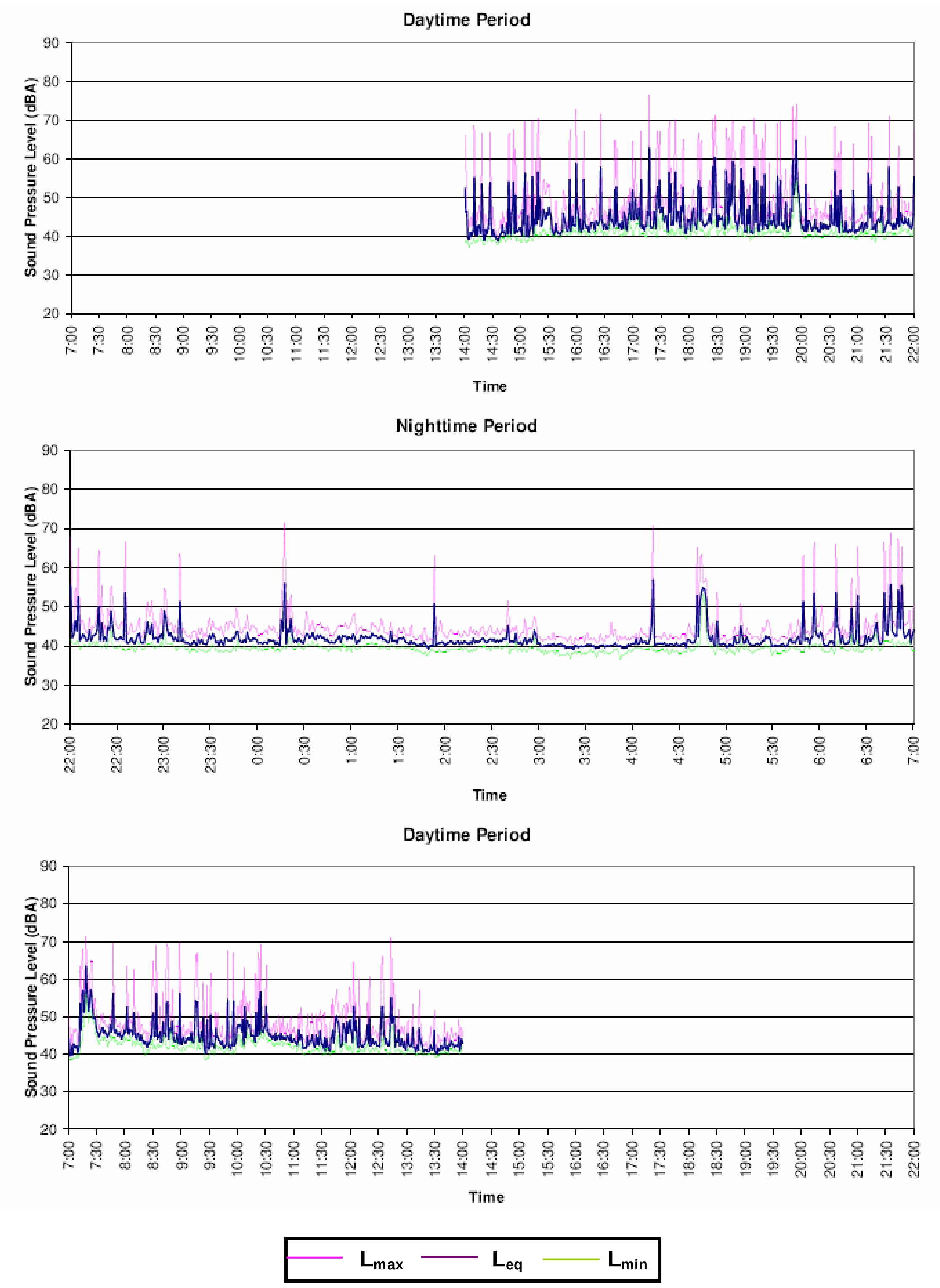


Figure I-4: 1-Minute L_{eq} Baseline Sound Values Opposite Residence 3, November 8–9, 2005

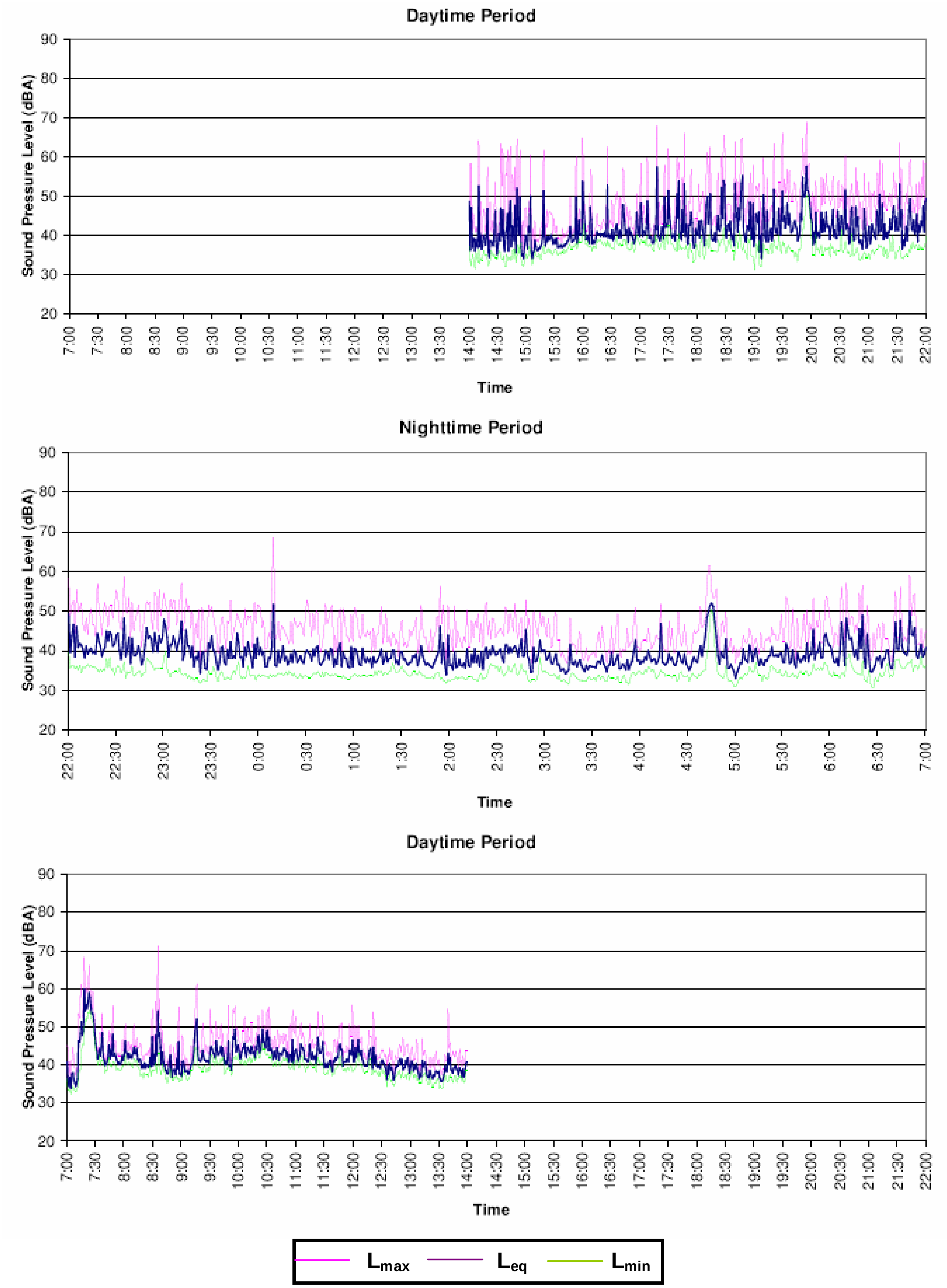


Figure I-5: 1-Minute L_{eq} Baseline Sound Values Opposite Residence 4 and Residence 5, November 8–9, 2005

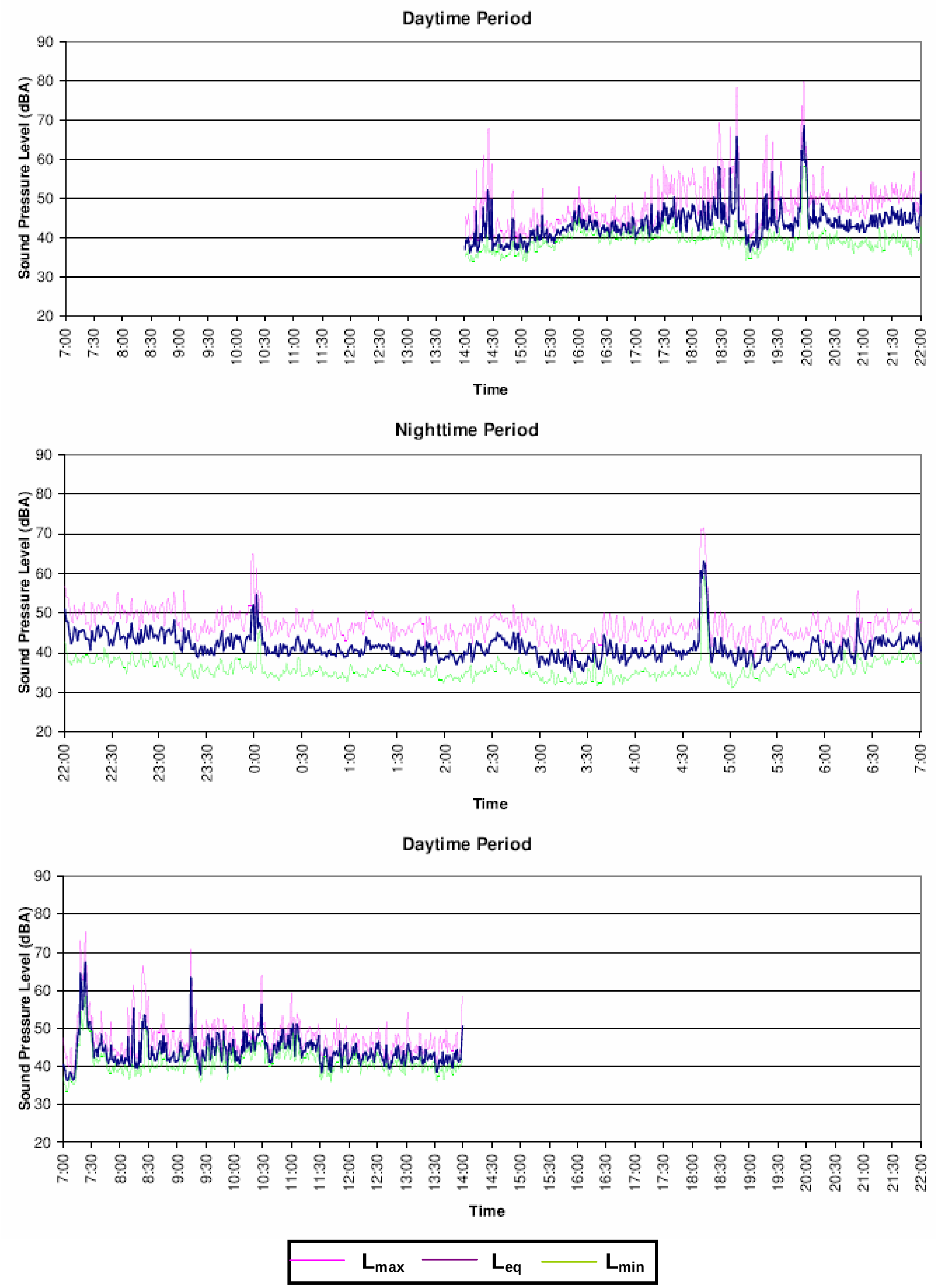


Table I-2: Monitored Hourly L_{eq} Baseline Sound Levels opposite Residence 1, November 8–9, 2005

Time Start Hour	Measured Sound Level	
	dBA L_{eq}	dBC L_{eq}
14:00	42.5	60.4
15:00	45.3	59.9
16:00	44.3	59.0
17:00	50.6	62.0
18:00	60.9	68.2
19:00	57.4	68.7
20:00	51.0	65.7
21:00	47.5	66.2
22:00	47.8	66.6
23:00	43.7	64.7
0:00	43.9	64.2
1:00	43.2	62.8
2:00	42.8	62.9
3:00	41.8	60.2
4:00	52.9	65.4
5:00	43.5	63.0
6:00	45.9	63.1
7:00	57.8	68.6
8:00	44.3	60.6
9:00	44.9	60.4
10:00	45.5	59.5
11:00	48.3	59.8
12:00	42.8	57.6
13:00	44.2	60.3
15 hour daytime L_{eq}	53.0	64.2
9 hour nighttime L_{eq}	46.7	64.0

Table I-3: Monitored Hourly L_{eq} Baseline Sound Levels opposite Residence 2, November 8–9, 2005

Time Start Hour	Measured Sound Level	
	dBA L_{eq}	dBC L_{eq}
14:00	46.0	60.4
15:00	47.8	60.8
16:00	46.6	59.5
17:00	49.7	61.1
18:00	50.9	62.0
19:00	51.5	64.8
20:00	45.5	59.9
21:00	46.5	61.3
22:00	45.1	60.2
23:00	42.6	59.0
0:00	43.5	59.2
1:00	41.9	58.4
2:00	41.4	58.2
3:00	40.1	56.1
4:00	46.2	60.0
5:00	42.7	56.8
6:00	46.4	58.4
7:00	51.3	66.4
8:00	47.6	61.7
9:00	46.5	61.2
10:00	47.4	61.1
11:00	44.9	58.1
12:00	46.2	58.9
13:00	42.5	58.4
15 hour daytime L_{eq}	48.1	61.7
9 hour nighttime L_{eq}	43.8	58.6

Table I-4: Monitored Hourly L_{eq} Baseline Sound Levels opposite Residence 3, November 8–9, 2005

Time Start Hour	Measured Sound Level	
	dBA L_{eq}	dBC L_{eq}
14:00	43.3	59.6
15:00	42.2	57.8
16:00	42.4	56.8
17:00	45.7	59.0
18:00	46.4	60.6
19:00	47.0	63.8
20:00	43.0	62.4
21:00	44.1	62.4
22:00	42.5	61.3
23:00	41.2	60.4
0:00	40.0	58.6
1:00	38.8	57.7
2:00	39.3	58.9
3:00	37.3	56.5
4:00	42.5	59.9
5:00	39.4	58.0
6:00	42.2	58.9
7:00	49.8	66.3
8:00	43.2	58.2
9:00	43.7	60.3
10:00	44.3	58.1
11:00	42.6	56.3
12:00	41.0	56.9
13:00	38.8	57.3
15 hour daytime L_{eq}	44.6	60.8
9 hour nighttime L_{eq}	40.7	59.1

Table I-5: Monitored Hourly L_{eq} Baseline Sound Levels opposite Residence 4 and Residence 5, November 8–9, 2005

Time Start Hour	Measured Sound Level	
	dBA L_{eq}	dBC L_{eq}
14:00	42.0	60.6
15:00	41.7	57.7
16:00	43.1	58.1
17:00	45.1	62.4
18:00	51.9	67.3
19:00	54.9	69.6
20:00	45.0	68.0
21:00	44.9	69.5
22:00	45.1	70.2
23:00	44.0	68.6
0:00	42.8	67.1
1:00	40.9	66.6
2:00	41.6	67.2
3:00	39.3	64.6
4:00	50.4	67.5
5:00	40.4	65.2
6:00	42.4	65.8
7:00	54.1	67.6
8:00	46.1	63.3
9:00	48.2	62.5
10:00	46.9	61.3
11:00	45.1	57.8
12:00	43.0	58.6
13:00	43.0	58.3
15 hour daytime L_{eq}	48.7	65.0
9 hour nighttime L_{eq}	44.4	67.3

Figure I-6: 1-Hour Measured Baseline Values opposite Residence 1, November 8–9, 2005

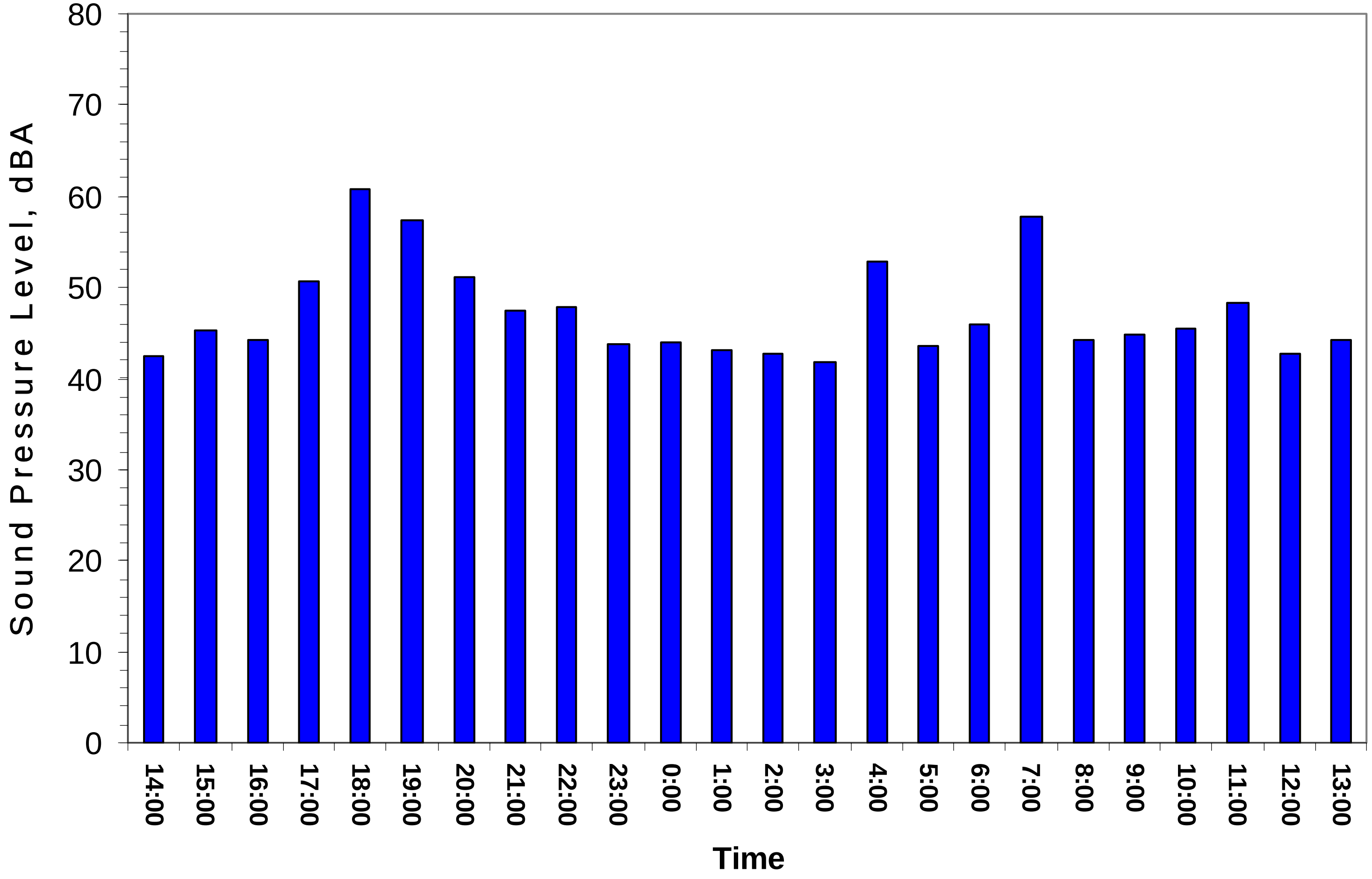


Figure I-7: 1-Hour Measured Baseline Values Opposite Residence 2, November 8–9, 2005

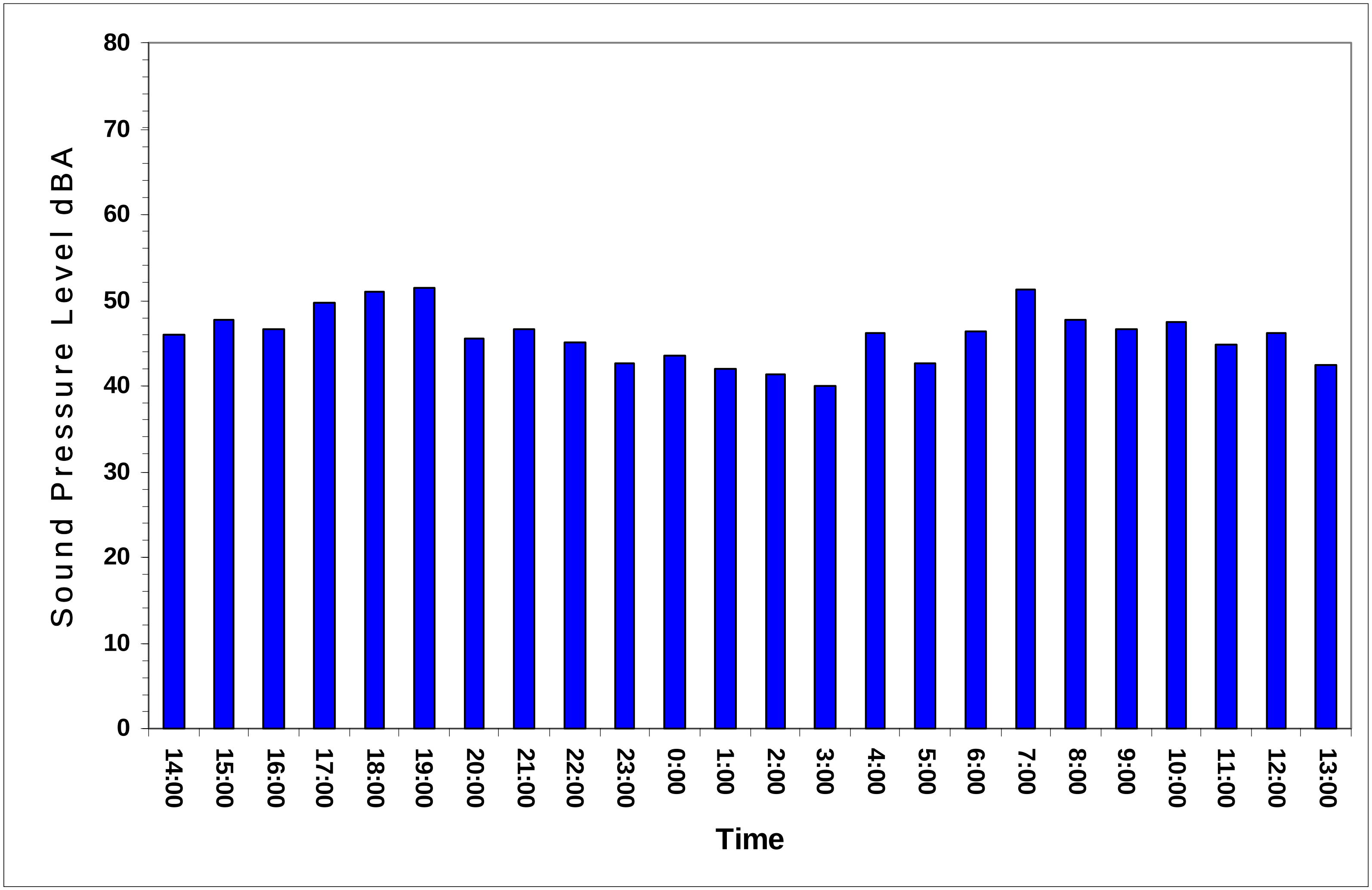


Figure I-8: 1-Hour Measured Baseline Values Opposite Residence 3, November 8–9, 2005

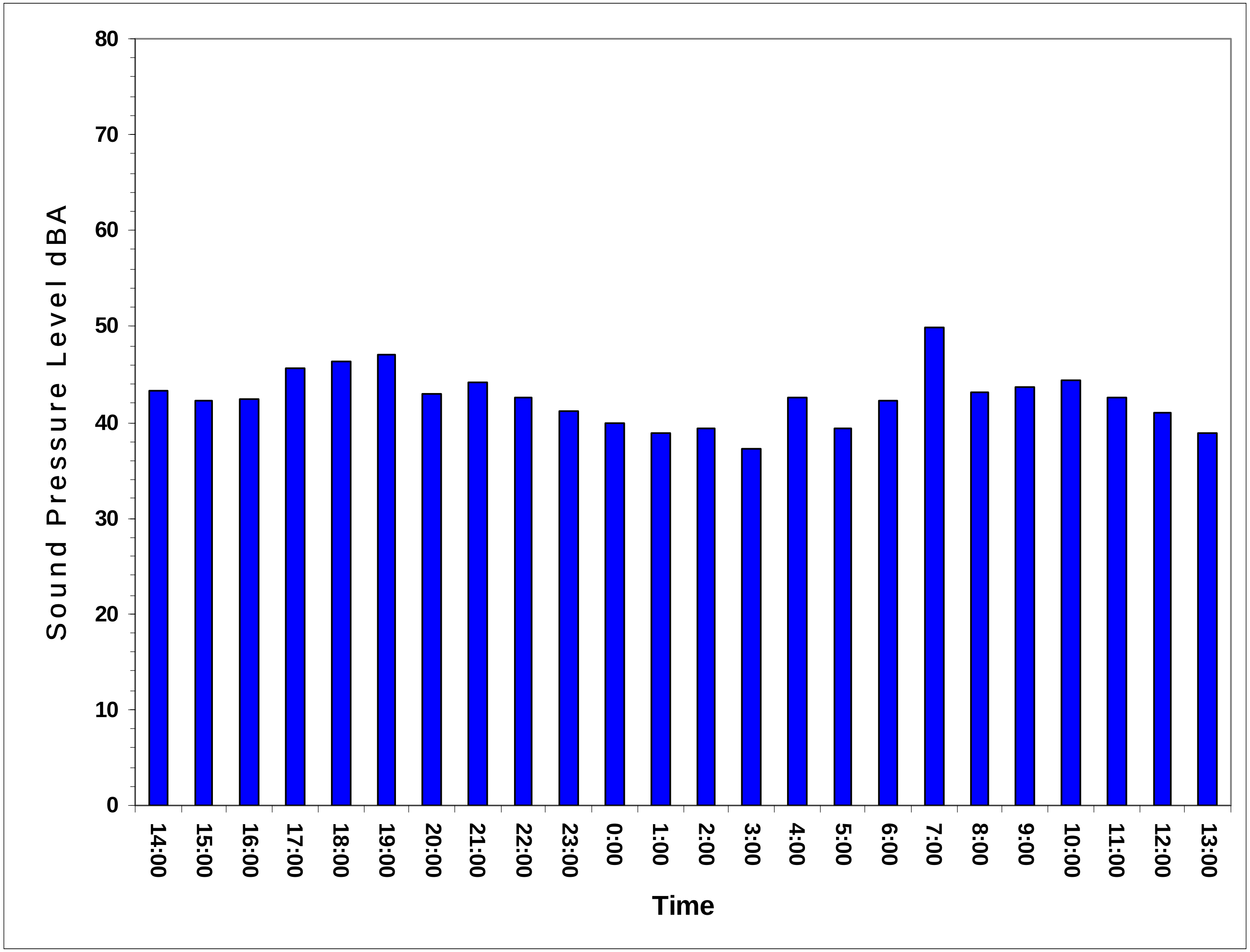
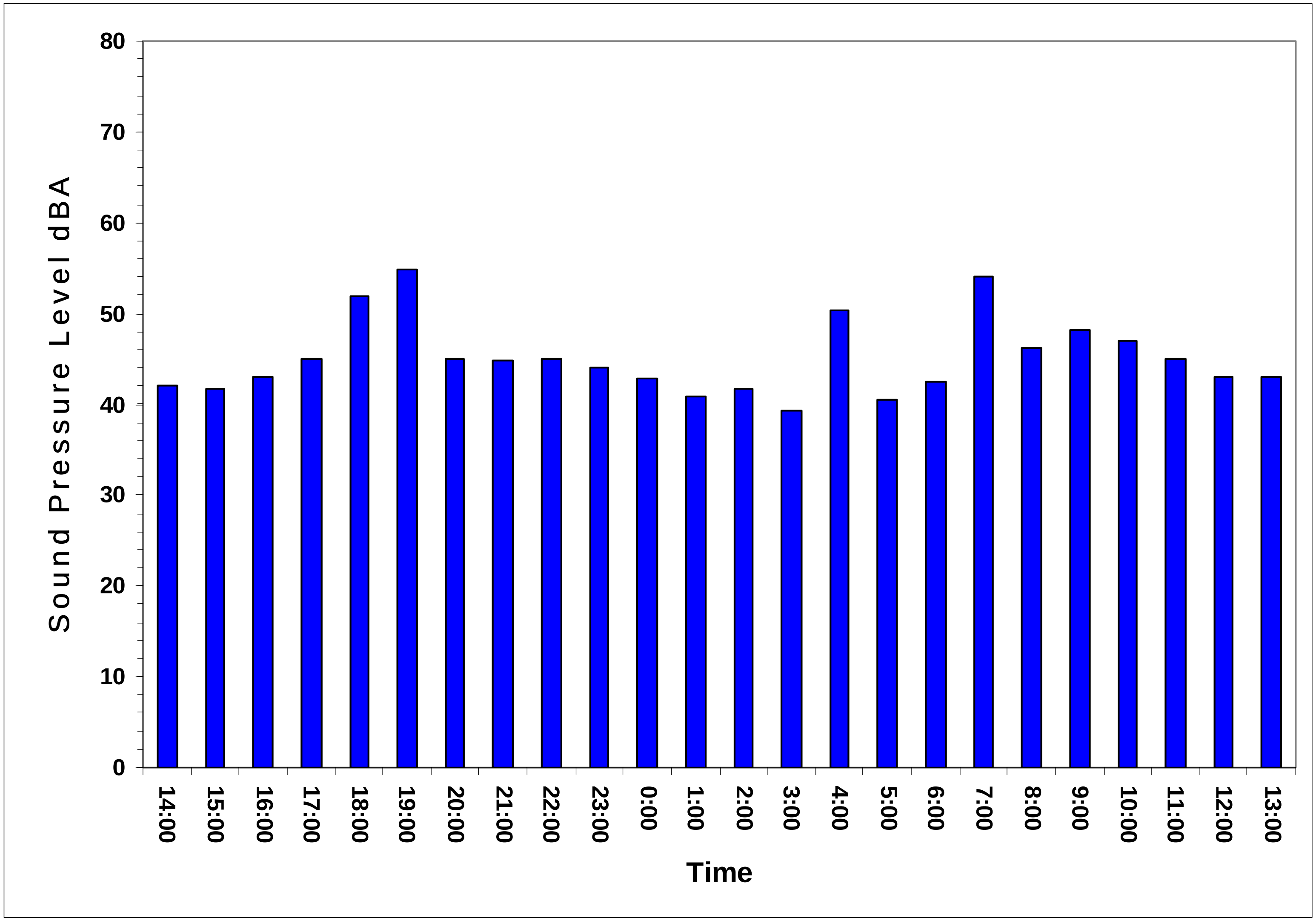


Figure I-9: 1-Hour Measured Baseline Values Opposite Residence 4 and Residence 5, November 8–9, 2005



2.8.2 Assessment of Noise Monitoring Results

Monitored daytime and nighttime L_{eq} values (i.e., baseline sound levels) can often be assumed to be representative of the typical sound environment. However, when the monitored sound levels contain abnormal or invalid noises, the monitored values are not totally representative of the typical sound environment. In such cases, an appropriate "isolation analysis technique" may be used to remove the abnormal events or invalid time periods from the measured overall values. This assessment technique is deemed acceptable to the EUB. Examples of noise that may be isolated in a baseline survey are abnormal events or invalid data due to weather conditions such as rain. No isolation analysis was required as no unusual noise events occurred during the survey.

2.8.2.1 Opposite Residence 1

2.8.2.1.1 Daytime

The results of the survey indicate a daytime sound level of 53.0 dBA L_{eq}. During the daytime period, the main audible sources at this monitoring location were traffic noise from Highway 45 and Highway 15, the Canexus plant to the southwest, occasional train passages, local traffic and cows mooing to the west.

2.8.2.1.2 Nighttime

The results of the survey indicate a nighttime sound level of 46.7 dBA L_{eq}. The main audible sound sources during the nighttime period were the industrial facilities to the southwest (Canexus and Triton) and occasional highway traffic noise from both highways. Train passages and train horns were very audible when they occurred.

2.8.2.2 Opposite Residence 2

2.8.2.2.1 Daytime

The daytime L_{eq} was 48.1 dBA L_{eq}. The main audible sources were Highway 45 traffic, Highway 15 traffic, transformer hum, grass rustling and occasional local traffic or trains. The industrial facilities to the south-southwest were sometimes audible.

2.8.2.2.2 Nighttime

The nighttime L_{eq} was 43.8 dBA L_{eq}. The main audible sound sources were transformer hum and grass rustle. Highway traffic and trains were audible when they passed. The L_{min} values are consistent near 40 dBA, which was due to the transformer hum.

2.8.2.3 Opposite Residence 3

2.8.2.3.1 Daytime

The daytime sound level was 44.6 dBA L_{eq}. During the daytime, the main audible sound sources at this location were Highway 15 and Highway 45 traffic, grass rustling and occasional local traffic or trains. Industrial facilities to the southwest were sometimes audible.

2.8.2.3.2 Nighttime

The nighttime sound level was 40.7 dBA L_{eq}. The main audible noise source during the nighttime period was grass rustle. Train passages and distant highway traffic were audible when they occurred. The industrial facilities to the southwest were audible during HFP's site visit at 00:15.

2.8.2.4 Opposite Residence 4 and Residence 5

2.8.2.4.1 Daytime

The daytime sound level was 48.7 dBA L_{eq}. The main audible sound source was Highway 15 traffic to the south. Other audible sounds included Highway 45 traffic, train passages, the industrial plants to the west, grass rustling and occasional dogs barking to the south.

2.8.2.4.2 Nighttime

The nighttime sound level was 44.4 dBA L_{eq}. The main audible source during the nighttime period was grass rustling. Train passages and highway traffic were audible when they occurred. The industrial facilities became slightly audible during lower wind speeds.

2.9 Representative Conditions

For a baseline sound survey, the Directive indicates that:

> *The survey should be conducted during periods representative of typical days and nights for the area. What is typical depends upon the area being surveyed and should include such tests as:*
>
> - *What is the frequency of this type of activity?*
> - *Do these types of activities normally occur in this area?*

and the Directive defines representative conditions as:

> *Those conditions typical for an area and/or the nature of a complaint. For ASLs (Ambient Sound Levels), these are conditions that portray the typical activities for the area, not the quietest time. For CSLs (Comprehensive Sound Levels), these do not constitute absolute worst-case conditions or the exact conditions the complainant has highlighted if those conditions are not easily duplicated.*

Sound levels must be taken only when representative conditions exist; this may necessitate a survey of extensive duration (two or more consecutive nights).

HFP believes that representative conditions were captured during these baseline sound surveys because the amount of traffic on the highways and number of train passages appeared normal. As well, the industrial facilities to the west appeared to be operating normally. It was windier than HFP would have preferred, which caused more grass rustle than if the winds had been calmer. This increased grass rustle may have elevated the nighttime sound levels slightly, but HFP does not believe the difference would be significant.

While these surveys were not conducted at the residences, they still provide a snapshot of the sound levels in the area.

3. Summary of the Noise Monitoring Results

Table I-6 presents a summary of daytime and nighttime baseline L_{eq} sound levels.

Table I-6: Daytime and Nighttime Baseline L_{eq} Sound Levels

Location	Baseline Sound Level (dBA L_{eq}) November 8–9, 2005	
	Daytime	Nighttime
Opposite Residence 1	53.0	46.7
Opposite Residence 2	48.1	43.8
Opposite Residence 3	44.6	40.7
Opposite Residence 4 and Residence 5	48.7	44.4

4. Conclusions

The 24-hour baseline sound monitoring surveys were completed at four locations near the proposed Project. The sound surveys will serve as a baseline in AST's application for the proposed Project. The results of the sound surveys provide a snapshot of the current sound environment at these locations.

Calibrations results are summarized in Table I-7.

Table I-7: Record of Calibration Results - HFP File: 05-1780-1

Equipment Model	Equipment Serial No.	Calibrator Model	Calibrator Serial No.	Calibration Level (dBA)	Date DD/MM/YY	Time	Calibrated By (Initials)	Notes
Larson Davis 824	A0298	Brüel and Kjær	1795340	94.0	08/11/05	13:47	MG	Pre-calibration
Larson Davis 824	A0298	Brüel and Kjær	1795340	94.1	09/11/05	14:48	MG	Post-calibration
Larson Davis 824	A0301	Brüel and Kjær	1795340	94.0	08/11/05	13:18	MG	Pre-calibration
Larson Davis 824	A0301	Brüel and Kjær	1795340	94.0	09/11/05	15:04	MG	Post-calibration
Larson Davis 824	A0412	Brüel and Kjær	1795340	94.0	08/11/05	12:27	MG	Pre-calibration
Larson Davis 824	A0412	Brüel and Kjær	1795340	94.2	09/11/05	14:04	MG	Post-calibration
Larson Davis 824	A0606	Brüel and Kjær	1795340	94.0	08/11/05	12:56	MG	Pre-calibration
Larson Davis 824	A0606	Brüel and Kjær	1795340	94.0	09/11/05	14:27	MG	Post-calibration

WorleyParsons Komex

resources & energy

Alberta Sulphur Terminals Ltd.
Bruderheim Sulphur Forming and Shipping Facility

Volume IIA – Air, Noise and Public Health

4. Public Health and Safety

Project Number 62720000
June 2007

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APPENDICES

Executive Summary

Alberta Sulphur Terminals Ltd. (AST), a division of HAZCO Environmental Services (HAZCO) which, in turn, is a division of CCS Income Trust (CCS), retained WorleyParsons Komex to complete a Human Health Risk Assessment (HHRA) of the proposed Bruderheim Sulphur Forming and Shipping Facility (the Project) located in Section 35-55-20 W4M (the Site).

The HHRA examined short- and long-term effects associated with Project emissions in combination with existing or approved developments in the region, as well as proposed future developments. It confirmed that overall, the Project is not anticipated to have an adverse effect on human health. The aspects of the Terms of Reference that are relevant to the HHRA and the respective conclusions of the assessment are summarized as follows.

Describe those aspects of the Project that may have implications for public health or the delivery of health care services. Determine whether there may be implications for public health arising from the Project. Specifically:

a) *identify and discuss the data and methods used by AST to assess the impacts of the Project on human health and safety;*

   The air quality assessment considered the impacts of the Project as they relate to ambient air concentrations (hypothetical maximum points of impingement) of carbon monoxide (CO), hydrogen sulphide (H_2S), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and fine particulate matter ($PM_{2.5}$). The HHRA focused on the potential health risks posed by these five COPC. The cumulative ground-level air concentrations (i.e., Project + background sources) were based partially on ambient air data specific to the relevant exposure durations (e.g., hourly vs. annual averages).

b) *assess the potential health implications of the compounds that will be released to the environment from the proposed operation in relation to exposure limits established to prevent acute and chronic adverse effects on human health;*

   All acute inhalation concentration ratios (CRs), with the exception of the respiratory mixture (1-hour) in the application case are less than one. This suggests that the estimated acute inhalation exposures to each of the individual COPC at maximum ground level concentrations are associated with low health risks. The CR for the acute respiratory mixture was slightly above 1. However, this value was based on maximum background levels and maximum predicted ground-level concentrations of the three relevant COPC, as well as conservative assumptions employed in the risk assessment. The health effects associated chronic exposures to the COPC in association with the application case were determined to be negligible.

c) *identify the human health impact of potential contamination of country foods and natural food sources taking into consideration all Project activities;*

   The COPC emitted from the Project are unlikely to bioaccumulate in soil or plants due to their physico-chemical characteristics. Given this lack of accumulation and that soil quality was determined to not be impacted by the Project, food ingestion pathways were determined to be closed with respect to exposure and were not evaluated in the quantitative HHRA.

d) *provide information on samples of selected species of vegetation known to be consumed by humans;*

   Sampling data were not incorporated into the HHRA as the COPC are not anticipated to bioaccumulate due to their physico-chemical characteristics.

e) *discuss the potential to increase human exposure to contaminants from changes to water quality, air quality and soil quality taking into consideration all Project activities;*

Water and soil quality were not quantitatively evaluated in the HHRA, as no adverse impacts were predicted. Air quality is not anticipated to adversely affect human health.

f) *document health concerns identified by Aboriginal stakeholders;*

This was not evaluated as part of the Environmental Impact Assessment (EIA). Please refer to Volume IID, Section 2: Land Use and Reclamation which states:

> *Conversations with the Métis Council of Alberta (Métis Council 2006, pers. comm.) and the Municipality of Lamont (Janssen 2006, pers. comm.) confirmed there were no Aboriginal groups or Aboriginal group activity within the boundaries of the RSA.*

g) *assess cumulative health effects to receptors, that are likely to result from the Project in combination with other existing, approved, and planned projects;*

All acute inhalation CRs, with the exception of the respiratory mixture (1-hour) in the application and CEA cases, are less than 1 for all three assessment cases. Slightly elevated CRs for the respiratory irritant mixture were identified for both the application and CEA cases. However, this value was based on maximum background levels and maximum predicted ground-level concentrations of the three relevant COPC, as well as conservative assumptions employed in the risk assessment. Thus, the impact on human health is likely negligible. No significant risks of adverse chronic health impacts were identified.

h) *as appropriate, identify anticipated follow-up work, including regional cooperative studies. Identify how such work will be implemented and coordinated with ongoing air, soil and water quality initiatives;*

Groundwater will be monitored twice annually to evaluate potential effects to groundwater quantity and quality.

A response plan will be developed to enable prompt courses of action in the event that routine monitoring detects an impact to either groundwater quantity or quality.

As part of the surface water quality monitoring plan, parameters will be monitored during construction activities near surface waterbodies. This will be maintained throughout clearing and construction. Also, intercepted water will be tested to ensure regulatory water quality requirements for surface water release are satisfied.

AST plans to implement dust suppression measures near the conveyor transfer points and within the sulphur loading area. AST will maintain observational programs with respect to fine particulates and H_2S. AST will participate in regional initiatives relative to air quality issues (for more information regarding the response to this TOR, please refer to Section 2.6.7).

i) *identify and discuss potential health and safety impacts due to higher regional traffic volumes and the increased risk of accidental leaks and spills;*

This was not evaluated as part of the HHRA. See Volume I, Appendix III: Traffic Impact Assessment.

j) *document health and safety concerns raised by stakeholders during the consultation on the Project;*

This was not evaluated as part of the HHRA. See Volume IID, Section 5: Public Consultation.

k) *provide a summary of AST's emergency response plan and discuss mitigation plans that will be implemented to ensure workforce and public safety during pre-construction, construction, operation and reclamation of the Project. Include prevention and safety measures for wildfire occurrences,* *accidental release or spill of chemicals to the environment and failures of structures retaining water or fluid wastes;*

This was not evaluated as part of the HHRA. Refer to Volume I, Appendix V: Emergency Response Plan.

l) describe how local residents will be contacted during an emergency and what type of information will be communicated to them;

This was not evaluated as part of the HHRA. Refer to Volume I, Appendix V: Emergency Response Plan.

m) describe existing agreements with area municipalities or industry groups such as, safety co-operatives, emergency response associations and municipal emergency response agencies;

This was not evaluated as part of the HHRA. Refer to Volume I, Appendix V: Emergency Response Plan.

n) describe and discuss the impacts of the proposed Project on potential shortages of affordable housing and the quality of health care services. Identify and discuss the mitigation plans that will be undertaken to address these issues. Provide a summary of any discussions that have taken place with the Municipality and the Regional Health Authority concerning potential housing shortages and health care services respectively.

This was not evaluated as part of the HHRA. See Volume IID, Section 4: Socio-Economic Assessment.

4. Public Health and Safety

4.1 Introduction

Alberta Sulphur Terminals Ltd. (AST) proposes to build and operate a sulphur forming and shipping facility (the Project) about 2.2 km east of the Town of Bruderheim in the Industrial Heartland of Lamont County, Alberta.

4.2 Issues Scoping

The overall scope of the Human Health Risk Assessment (HHRA) was based on provincial regulatory requirements as described within Alberta Environment's Terms of Reference (TOR) (AENV 2007) as follows:

Describe those aspects of the Project that may have implications for public health or the delivery of health care services. Determine whether there may be implications for public health arising from the Project. Specifically:

a) identify and discuss the data and methods used by AST to assess the impacts of the Project on human health and safety;

b) assess the potential health implications of the compounds that will be released to the environment from the proposed operation in relation to exposure limits established to prevent acute and chronic adverse effects on human health;

c) identify the human health impact of potential contamination of country foods and natural food sources taking into consideration all Project activities;

d) provide information on samples of selected species of vegetation known to be consumed by humans;

e) discuss the potential to increase human exposure to contaminants from changes to water quality, air quality and soil quality taking into consideration all Project activities;

f) document health concerns identified by Aboriginal stakeholders;

g) assess cumulative health effects to receptors, that are likely to result from the Project in combination with other existing, approved, and planned projects;

h) as appropriate, identify anticipated follow-up work, including regional cooperative studies. Identify how such work will be implemented and coordinated with ongoing air, soil and water quality initiatives;

i) identify and discuss potential health and safety impacts due to higher regional traffic volumes and the increased risk of accidental leaks and spills;

j) document health and safety concerns raised by stakeholders during the consultation on the Project;

k) provide a summary of AST's emergency response plan and discuss mitigation plans that will be implemented to ensure workforce and public safety during pre-construction, construction, operation and reclamation of the Project. Include prevention and safety measures for wildfire occurrences, accidental release or spill of chemicals to the environment and failures of structures retaining water or fluid wastes;

l) describe how local residents will be contacted during an emergency and what type of information will be communicated to them;

m) describe existing agreements with area municipalities or industry groups such as, safety co-operatives, emergency response associations and municipal emergency response agencies;

n) describe and discuss the impacts of the proposed Project on potential shortages of affordable housing and the quality of health care services. Identify and discuss the mitigation plans that will be undertaken to address these issues. Provide a summary of any discussions that have taken place with the Municipality and the Regional Health Authority concerning potential housing shortages and health care services respectively.

The HHRA addressed these TOR by focusing on potential short- and long-term health implications associated with the Project's emissions, in combination with other existing and approved industrial sources or developments in the region. The remaining Public Health and Safety Issues described in the TOR are addressed in other sections of the Environmental Impact Assessment (EIA) (see Volume I, Concordance Table).

Potential health risks are characterized by comparing the predicted (i.e., modelled) ground-level air concentrations to regulatory exposure guidelines that are protective of human health.

The air quality assessment (see Volume IIA, Section 2: Climate and Air Quality) considered the impacts of the Project as they relate to ambient air concentrations of CO, H_2S, NO_2, SO_2 and $PM_{2.5}$. The HHRA focused on the potential health risks posed by the same five common air contaminants. The cumulative ground-level air concentrations (i.e., Project + background sources) were based, in part, on ambient air data specific to the relevant exposure durations (e.g., hourly vs. annual averages). The HHRA constitutes a "worst-case" analysis in that the conclusions are based on maximum predicted ground-level air concentrations that might occur at locations where people do not reside (i.e., hypothetical maximum points of impingement).

4.3 Methods

Potential human health risks were examined by following a conventional risk assessment paradigm consistent with those developed by Health Canada (2004) and the United States Environmental Protection Agency (USEPA 1991). This methodology has been endorsed by a number of provincial regulatory authorities, including Alberta Environment (AENV), Alberta Health and Wellness (AHW) and the Alberta Energy and Utilities Board (EUB). There are four steps or phases to the risk assessment paradigm (see Figure 4.3-1):

1. Problem formulation: characterization of the Project and Site, characterization of potential human receptors, determination of relevant exposure pathways and identification of COPC associated with Project-related emissions.

2. Toxicity assessment: identification of potential adverse health effects associated with each COPC, the conditions under which these effects are observed and determination of the maximum safe dose for the chemical for the most sensitive subjects following exposure for a prescribed period of time (i.e., identification of acute and chronic exposure limits for COPC).

3. Exposure assessment: quantification of the amount or dose of each COPC received by human receptors via all relevant exposure pathways

4. Risk characterization: comparison of exposure limits (established in step 2) with estimated exposures (established in step 3) to identify potential health risks for the different assessment cases, as well as discussion of sources of uncertainty and how these were addressed in the risk assessment.

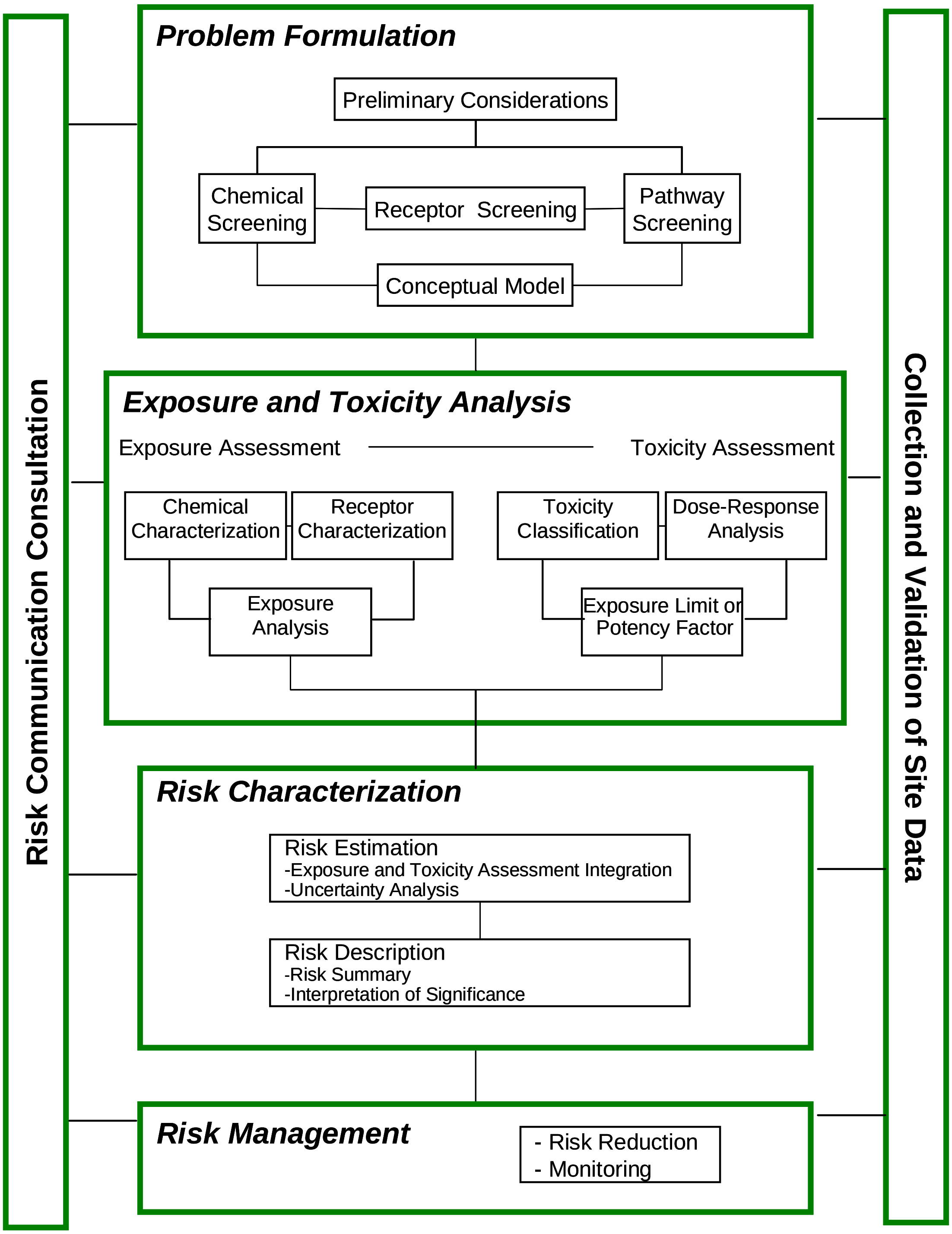

Figure 4.3-1: Risk Assessment Paradigm

The HHRA was conducted based on a number of guiding principles, common to the study of potential health effects of all chemicals regardless of source, that have been proven through years of scientific investigation and observation. These principles are as follows:

- all chemicals, regardless of type or source, possess some degree of intrinsic toxicity (i.e., all chemicals have the capacity to cause some level of harm or injury)
- the health effects produced by any chemical are equally dependent on the intrinsic toxicity of the substance and the exposure, or dose, of the chemical that is received
- with few exceptions, the intrinsic toxicity of a chemical (i.e., the capacity to produce a harmful effect or physiological injury) is only expressed if the exposure exceeds a critical threshold level. Below this threshold dose, injury does not occur and health effects are not observed.
- if the threshold dose is exceeded, health effects can occur. The severity of these effects will depend on the level of exposure received, with more severe effects occurring with increasing dose.
- the health effects produced by a chemical depend on the nature, extent and duration of exposure. It is important to distinguish between the health effects that may result from acute exposures of short duration and effects that may occur following chronic or long-term exposure.

Uncertainty was addressed in the HHRA process by applying conservative assumptions to help ensure potential human health risks were not underestimated.

4.3.1 Spatial Boundaries

The Principal Development Area (PDA) where the Project will be constructed is located on a portion of Section 35-55-20 W4M (the Site) 2.2 km east of Bruderheim. The study area considered was the Climate and Air Quality Local Study Area (LSA) as described in Volume IIA, Section 2: Climate and Air Quality. The Project is directly northeast of the Bruderheim Sodium Chlorate Plant operated by Canexus Chemicals Ltd.

Existing soil and groundwater conditions at the Site indicate that significant natural buffering capacity exists. In addition, surficial soils have a low hydraulic conductivity, reducing the potential for migration of any potential contamination off-site. A number of actions will be taken to reduce emissions from the facility into air and other environmental media such as: state-of-the-art dust controls, double containment systems, runoff control systems, environmental monitoring programs and reliable facility operation practices.

4.3.2 Temporal Boundaries

The temporal boundaries for this report are baseline, application and closure. Baseline refers to current conditions at the time this assessment was performed. Application is assessed at the maximum sulphur pastille production of 6,000 t/d. The Project's operation is predicted to be operational for 25 years. Closure is considered when all Project facilities have been decommissioned and reclamation has taken place. It is assumed that closure occurs five years after decommissioning and reclamation.

4.4 Problem Formulation

The problem formulation is intended to focus the HHRA on the key areas of concern by further defining the overall scope and nature of the work. The problem formulation includes the following tasks:

- project and site description
- receptor characterization: people potentially exposed to emissions from the Project are identified with special consideration given to sensitive and more susceptible individuals (e.g., infants and young children, the elderly, individuals with compromised health)
- identification of exposure pathways: all applicable exposure pathways are identified, with consideration given to the physico-chemical properties of the COPC, their fate and transport, and their persistence in the environment
- identification of COPC: identification of the Project's COPC that may contribute to potential human health risks

These steps are described in detail in Sections 4.4.1 – 4.4.4 below.

4.4.1 Receptor Characterization

In health risk assessments, persons that exhibit the greatest potential to be adversely affected by the release of airborne contaminants are generally selected to represent a "reasonable maximum exposure" scenario (USEPA 1989). The rationale for this approach is that if no unacceptable risks are predicted for the most highly exposed and susceptible individuals, unacceptable risks would not be expected for those individuals that experience less exposure or may be less susceptible.

The use of maximum points of impingement (MPOI) is representative of the described maximum exposure scenario. An MPOI is a hypothetical location in that it could occur anywhere within the Climate and Air Quality LSA. By definition, an MPOI is the location where the maximum ground level air concentration is occurring at any given time. The MPOI does not have to represent an actual place of residence or work. In fact, the likelihood of an individual being at the exact location of a maximum ground-level air concentration event is probably low.

4.4.2 Identification of Exposure Pathways

In order for exposure to take place (and potential health risks to be realized), exposure pathways for chemicals must exist from the point of release into the environment (i.e., from the Project) to the point of contact with humans (Health Canada 1995). As such, the HHRA examines each environmental media that could serve as a conduit between the Project and humans to determine which exposure pathways are applicable to the Project. In accordance with the TOR, the environmental media considered in the HHRA include:

- air
- surface water
- groundwater
- soil
- food

4.4.2.1 *Air*

The proposed Project will emit dusts and gases into the air from various sources. As described in Volume IIA, Section 2: Climate and Air Quality, ambient air concentrations are expected to increase for certain COPC associated with the Project, resulting in changes to local and regional air quality. As people live and work in close proximity to the Project, public health could potentially be affected through exposure to chemicals (gases and particulate matter) emitted by the Project into the air. As such, exposure due to inhalation was included in the HHRA. A detailed discussion on the Project's potential impact on air quality is presented in Volume IIA, Section 2: Climate and Air Quality.

4.4.2.2 *Surface Water*

All surface water that comes in contact with the sulphur handling and pastille storage areas will be collected and stored in a surface water runoff collection pond. This pond will be double-lined and equipped with leak detection monitoring to ensure potentially acidic water is not released to the ground or surrounding watershed. Water contained in the lined pond will be re-used as cooling water for the sulphur forming process. Excess water will be neutralized and monitored prior to being released to the surrounding watershed. As significant surface water releases to the environment are unlikely to occur, exposure via surface water was considered to be a closed exposure pathway, and thus is not of concern to human health.

A detailed discussion on the Project's potential impact on surface water quality is presented in Volume IIB, Section 4: Surface Water Quality.

4.4.2.3 *Groundwater*

As indicated in the groundwater assessment (see Volume IIB, Section 2: Groundwater Quantity and Quality), a search of AENV's water well database identified 53 water well records within 1 km of the Site and 176 wells within 3 km of the Site. Thirty-two of the 53 water wells within the 1 km search radius were listed as domestic. Specifically, six registered water wells were identified downgradient (north) of the Project within several hundred metres from the northern Site boundary.

With the appropriate implementation of the planned mitigation measures, groundwater quality during the Project lifetime will not be significantly affected by Project related activities or surface releases during construction and operations. Further, groundwater travel times to the downgradient (northern) Site boundary are on the order of hundreds of years, indicating ample response time for specific mitigation measures to be implemented should an impact occur.

When considering the long travel time of groundwater to the nearest domestic water wells and the mitigation measures planned for the Project, groundwater quality is not anticipated to be adversely affected. Therefore, groundwater ingestion was not considered to be an operable exposure pathway for the HHRA.

4.4.2.4 *Soil*

In theory, chemicals emitted into the ambient air could be deposited onto the soils surrounding the Project area. However, the chemicals emitted from the Project are sufficiently volatile to prevent them from depositing onto soils in appreciable quantities. Therefore, the quality of nearby soils is not expected to materially change as a result of the Project's emissions. As such, soil-related exposure pathways (e.g., inhalation of dust, incidental ingestion of soil or dermal contact with soil) were excluded from the HHRA.

4.4.2.5 *Food*

Quality of locally grown produce (e.g., crops or private gardens) could theoretically be affected due to chemical uptake from impacted soils and aerial deposition. As described, however, soil quality is not expected to be impacted. Further, the identified COPC emitted from the Project tend not to bioconcentrate in plants or mammals, and the oral route of exposure is not significant to health (ATSDR 1998, WHO 2000, ATSDR 2006). Due to the nature of the compounds the Project will emit into ambient air (i.e., gaseous), no plant samples were analyzed in support of the HHRA. Food quality is not expected to be impacted as a result of the Project and any related ingestion pathways were therefore excluded.

4.4.2.6 *Applicable Exposure Pathways*

None of the COPC has the potential to accumulate in the environment (i.e., soil, vegetation) or be ingested by people as they are all gaseous. Given that that the surface and groundwater pathways were determined to be “closed”, and the lack of bioaccumulative potential of the COPC, a multi-pathway assessment was not conducted. Thus, the HHRA is limited to an inhalation pathway alone.

4.4.3 Identification of Chemicals of Potential Concern

As described in Volume IIA, Section 2: Climate and Air Quality, air emissions associated with pastillation forming, storage and shipping operations include:

- CO
- NO_2
- SO_2
- $PM_{2.5}$
- H_2S

All of these chemicals are considered primary pollutants as they are emitted directly from the source into the environment and are governed by provincial and federal authorities. Ozone is considered to be a secondary pollutant as it is formed in the environment by chemical processes that may result from the interaction of natural ozone, nitrogen oxides, and various volatile organic compounds (VOCs). The air quality assessment determined that the potential for ozone formation is low for the reasons that regional meteorological conditions rarely favour the conditions required for the chemical reactions involved in ozone formation and that NO_2 emissions tend to result in a reduction of atmospheric ozone. Consistent with the air quality assessment, ozone was not identified as a COPC in the HHRA.

There will be six point sources associated with the Project: four Rotoform stacks and two boiler stacks. Locomotive, truck, Trackmobile, storage tanks and front end loader emissions make up area sources. Combustion of fuels associated with the area sources could result in VOC and polycyclic aromatic hydrocarbons (PAH) emission into ambient air. However, taking into account the nature and scope of the Project, and the results of air quality assessments of five recent upgrader applications in the region (BA Energy, Shell Scotford Expansion, North West Upgrader, Petro-Canada Sturgeon Upgrader and Synenco), the Project’s contribution to area VOC and PAH concentrations is considered inconsequential. The air quality assessment (see Volume IIA, Section 2: Climate and Air Quality – Section 2.6.8) concluded that non-criteria substances would have a negligible impact on air quality. For these reasons, VOC and PAH were not in the HHRA. A discussion on the potential health implications associated with the Project’s VOC and PAH emissions will be submitted under separate cover.

For the current HHRA, only CO, NO_2, H_2S, $PM_{2.5}$ and SO_2 were “carried forward” as COPC. Elemental sulphur was not assessed because Climate and Air Quality (see Volume IIA, Section 2: Climate and Air Quality) concluded elemental sulphur deposition would occur at a maximum predicted rate of 1.1 kg/ha/y within the Site boundary, which is below the deposition values that would impact crops or vegetable produce.

4.5 Toxicity Assessment

The toxicity assessment requires understanding of the critical toxicological effects that can be caused by the COPC. Such information is generally obtained from published scientific studies conducted in animals or humans under controlled experimental conditions, or observations from human epidemiological studies that examine the relationship between medical conditions of interest and exposure. Potential health effects associated with excessive exposures to the COPC, along with the basis of the exposure limits, are described in further detail in the Toxicity Profiles contained in Appendix I.

When evaluating a substance’s potential to cause an adverse effect, consideration must be given to the dose to which a receptor is exposed; the dose determines the type and potentially the severity of any adverse effects that may be observed. Specifically, it is the amount of the substance that is absorbed and reaches the toxicological site of interest in the organism that determines the probability of an adverse effect occurring.

Substances may differ greatly with respect to the dosage required to result in an adverse effect, as well as in the mechanism(s) by which the adverse effects are elicited. For most substances (including the ones identified as COPC in the current HHRA), it is necessary to evaluate the available information to identify effect-levels at which either no effects are observed (e.g., a no observed adverse effect level (NOAEL)) or adverse effects are first observed (e.g., a lowest observed adverse effect level (LOAEL)).

The application of uncertainty or safety factors to an effect-level provides an added level of protection, allowing for the derivation of an exposure limit that is expected to be safe to the most sensitive subjects following exposure over a prescribed time period.

4.5.1 Exposure Limits Used in the HHRA

Exposure limits (also known as toxicological reference values) developed by scientific and/or regulatory agencies aimed at the protection of human health were identified for each COPC on both an acute (short-term) and chronic (long-term) basis. Emphasis was given to limits with adequate supporting documentation, and they were reviewed to ensure their basis was relevant and sufficient. The scientific and regulatory authorities that were consulted included:

- Alberta Environment
- Health Canada
- United States Environmental Protection Agency
- World Health Organization
- Canadian Council of Ministers of the Environment
- Agency for Toxic Substances and Disease Registry (ATSDR)

The toxicity of a chemical has been observed to vary between acute and chronic exposure. Thus, it is important to differentiate exposure limits on the basis of duration of exposure.

The two exposure limit durations used in the HHRA can be described as follows:

- acute: the amount or dose of a chemical that can be tolerated without evidence of adverse health effects on a short-term basis; these limits are routinely applied to conditions in which exposures extend over several hours or several days only
- chronic: the amount of a chemical that is expected to be without effect, even when exposure occurs continuously or regularly over extended periods, lasting for periods of at least a month, and possibly extending over an entire lifetime

The criteria used in the determination of exposure limits may differ depending on the responsible scientific authority or regulatory jurisdiction charged with developing the safe level of exposure. The limits also may differ in terms of the primary determinant(s) of concern (e.g., health effects versus nuisance effects such as odour). In addition, the limits may vary depending on the level of protection required.

Separate assessments were completed for both the acute and chronic exposure scenarios in recognition of the fact that the toxic response produced by chemicals and the target tissues affected can change, depending on whether exposure is short-term or long-term.

The exposure limits for the HHRA were selected based on the following criteria:

- selected value is protective of the health of the general public based on current scientific knowledge of the health effects associated with exposure to the COPC
- selected value is adequately protective of sensitive individuals (i.e., children and the elderly) through the incorporation of uncertainty or safety factors
- selected value was derived or recommended by reputable scientific or regulatory authorities
- selected value is supported by adequate and available documentation

When these criteria were satisfied by more than one objective, guideline or standard, the most stringent exposure limit was typically selected. Table 4.5-1 summarizes the selected acute and chronic exposure limits used in the HHRA.

Table 4.5-1: Summary of Selected Exposure Limits

	Averaging Time	Limit (µg/m^3)	Reference
Acute			
CO	1-hour	15,000	AENV 2005
	8-hour	6,000	AENV 2005
H_2S	1-hour	98	ATSDR 2006
NO_2	1-hour	400	AENV 2005
	24-hour	200	AENV 2005
SO_2	10-minute	500	WHO 2000
	1-hour	450	AENV 2005
	24-hour	150	AENV 2005
$PM_{2.5}$	24-hour	30	CCME 2000
Chronic			
H_2S	Annual	2	USEPA 2007, Internet site
NO_2	Annual	60	AENV 2005
SO_2	Annual	30	AENV 2005

4.5.2 Chemical Mixtures

Exposure to chemicals rarely occurs in isolation; thus, health effects associated with chemical mixtures are assessed as part of the HHRA. The interaction between chemicals can take many forms, with additive interactions being assumed for the HHRA. Additive interactions apply most readily to chemicals that are structurally similar, act toxicologically via similar mechanisms or affect that same target tissue in the body (Health Canada 2004, 2006).

Possible additive interactions were identified for those COPC known to cause respiratory effects. The endpoints of the exposure limits used in the HHRA provided the basis for a chemicals inclusion in a chemical mixture. As H_2S, NO_2 and SO_2 are considered potential respiratory irritants, these three COPC were evaluated within the acute and chronic assessments as a mixture in addition to being evaluated independently.

4.6 Exposure Assessment

As part of the exposure assessment, potential exposures to the identified COPC were estimated for the receptors under all of the assessment cases (baseline, application and CEA). For each pathway, exposures were estimated on both an acute (short-term) and chronic (long-term) basis. As described previously, acute exposures were assumed to range from minutes to 24-hours, and long-term exposures were evaluated on an annual basis.

The exposure estimates for the HHRA were determined through a combination of ambient air measurements and predictive modeling results. Determination of the extent of COPC exposure to humans relied on a series of mathematical equations or algorithms that define the movement of each COPC from the source to the receptor. These equations required the input of several important variables which include:

- the physical-chemical properties of the chemical (e.g., vapour pressure, solubility)
- the chemical's behaviour in the environment
- local environmental conditions (e.g., meteorology)
- source characteristics (e.g., emission rates, operational life of the Project)

4.6.1 Assessment Cases

Consistent with Climate and Air Quality (see Volume IIA, Section 2), the potential health risks and odours were assessed based on the following three assessment scenarios:

Baseline case	includes existing ambient air quality from community and traffic sources, as well as approved and existing commercial and industrial projects or activities in the Climate and Air Quality LSA. The approved projects include facilities that have received regulatory approval, but are not yet operating.
Application case	includes existing ambient air quality, existing and approved regional sources, as well as the proposed Project (i.e., baseline case plus the Project)
Cumulative effects assessment (CEA) case	includes existing ambient air quality, existing and approved regional sources, the proposed Project (i.e., application case), as well as all other planned or proposed industrial activities or projects in the Climate and Air Quality LSA

The emission sources included in the three assessment cases are described in full in the air quality assessment (see Volume IIA, Section 2: Climate and Air Quality).

Project-specific potential health risks were evaluated by comparing the application case to the baseline case. Cumulative potential health risks were assessed by comparing the CEA case to the baseline case.

4.6.2 Predicted Air Concentrations

The inhalation exposure estimates were based on the results of air dispersion modeling described in the air quality assessment (see Volume IIA, Section 2: Climate and Air Quality). Maximum predicted ground-level air concentrations were assumed for each of the COPC for all of the assessment cases. The predicted air concentrations were presented at the maximum points of impingement over different averaging periods (i.e., 10-minute, 1-hour, 8-hour, 24-hour and annual) to allow for the assessment of both acute and chronic health risks.

Table 4.6-1 summarizes the maximum predicted air concentrations for the three assessment cases.

Table 4.6-1: Summary of Maximum Predicted Air Concentrations Used in the HHRA

Chemicals of Potential Concern	Averaging Time	Predicted Air Concentration (µg/m^3)		
		Baseline[1]	Application	CEA
CO	1-hour	19.5	238.0	238.0
	8-hour	16.9	51.4	51.4
H_2S	1-hour	–	2.2	2.2
	Annual	–	0.4	0.4
NO_2	1-hour	23.2	209.0	209.0
	24-hour	14.4	39.0	39.0
	Annual	1.1	2.2	2.2
SO_2	10-minute	–	32.0	32.0
	1-hour	–	19.4	19.4
	24-hour	–	0.6	0.6
	Annual	–	0.03	0.03
$PM_{2.5}$	24-hour	1.5	6.0	6.0

Notes:
[1] Maximum ground-level air concentrations associated with emissions from the Canexus Sodium Chlorate Plant which lies adjacent to the Project.
– No baseline case emissions.

There are no apparent differences between the maximum predicted air concentrations for the application and CEA cases. This suggests that the other proposed facilities (described in Volume IIA, Section 2: Climate and Air Quality – Section 2.6) are not expected to have a material impact on air quality in the immediate vicinity of the Project.

4.6.3 Measured "Background" Air Concentrations

Predicted baseline case air concentrations were compared with ambient air concentrations measured in the Lamont, Fort Saskatchewan and Elk Island areas, as presented in Volume IIA, Section 2: Climate and Air Quality. For the application and CEA cases, the higher concentration out of the predicted and observed background values was used in the assessment.

Table 4.6-2 summarizes the background values used in the HHRA, which were adopted from the air quality assessment.

Table 4.6-2: Summary of Measured "Background" Air Concentrations Used in the HHRA

Chemicals of Potential Concern	Averaging Time	Baseline		Application		CEA	
		Background (µg/m^3)	Type	Background (µg/m^3)	Type	Background (µg/m^3)	Type
CO	1-hour	5,800	O	5,800	O	5,800	O
	24-hour	3,300	O	3,300	O	3,300	O
H_2S	1-hour	8	O	8	O	8	O
	Annual	0.3	O	0.3	O	0.3	O
NO_2	1-hour	102	O	102	O	102	O
	24-hour	42	O	55	P	55	P
	Annual	4	O	15	P	15	P
SO_2	10-min	198	C	198	C	198	C
	1-hour	120	O	120	O	120	O
	24-hour	28	O	35	P	35	P
	Annual	3	O	7	P	7	P
$PM_{2.5}$	24-hour	20.5	O	20.5	O	20.5	O

Notes:
O – measured ambient from Lamont County.
P – predicted background from air quality assessment.
C – calculated using OMOE (2005).

The final maximum air concentrations were calculated by adding the measured concentrations to the predicted values for the baseline, application and CEA cases. All health risks are based on these summed air concentrations.

4.7 Uncertainty

As uncertainty is intrinsic to all HHRAs, conservative assumptions are applied to ensure that potential health risks are not underestimated. These conservative assumptions apply to the selection and identification of safe levels of exposure (i.e., exposure limits) and to the estimates of exposure. The following assumptions were incorporated into the HHRA for the proposed Project:

- uncertainty factors were applied by regulatory agencies to exposure limits which were based on exposures in studies at which no adverse effects were observed (i.e., NOAEL)
- it was assumed that health risks are additive for chemicals that have the same exposure limit endpoint (e.g., respiratory irritants)

- air dispersion modeling incorporated meteorological data that represented conditions contributing to maximum ground-level air concentrations
- predicted chronic health risks were based on the assumption that individuals would be at the maximum points of impingement for the durations of their lives

4.8 Results

Risk estimates are presented in terms of Project-specific impacts and cumulative impacts for both acute and chronic exposure scenarios. The potential health impacts associated with inhalation exposures to the identified COPC are expressed as concentration ratios (CRs). The CRs have been calculated by comparing the predicted level of exposure to exposure limits developed by regulatory and scientific authorities. CR values are calculated as follows:

$$\text{Concentration ratio (CR)} = \frac{\text{Air concentration } (\mu g/m^3)}{\text{Exposure limit } (\mu g/m^3)}$$

Interpretation of the predicted risks (i.e., CR and exposure ratio (ER) values) is as follows:

A CR value $\leq$ 1.0	signifies that the estimated exposure is less than or equal to the exposure limit (i.e., the assumed safe level of exposure). This indicates that negligible health risks are predicted. Added assurance of protection is provided by the high degree of conservatism incorporated in the derivation of the exposure limit and exposure estimate.
A CR value > 1.0 and $\leq$ 10	signifies the exposure estimate exceeds the exposure limit. This suggests low to moderate risk, the significance of which must be balanced against the high degree of conservatism incorporated into the risk assessment (i.e., the margin of safety is reduced but not eliminated entirely).
A CR > 10	signifies moderate to high potential health risks. Given the conservative assumptions in the risk assessment, the likelihood of predicted risks should be determined using more realistic exposure assumptions and/or a probabilistic risk assessment approach rather than discreet worst case values. Existence of potential health risks may indicate the need for risk management measures and mitigation to reduce overall health risks.

Assessment of the potential health impacts that could result from additive interactions among the chemical constituents found in the emissions released from the Project also formed part of the HHRA. Details concerning the additive interactions that were examined were described earlier. The CRs for the respiratory irritant mixture were determined by summing the risk estimates for the individual chemical constituents for each averaging period, within each assessment case. The approach is illustrated below:

$$\text{CR for respiratory irritants} = \text{CR for } SO_2 + \text{CR for } NO_2 + \text{CR for } H_2S$$

The potential health impacts associated with short- and long-term inhalation exposure are expressed as CRs in Table 4.8-1 and Table 4.8-2. These risk estimates are presented with “background” exposure included for all three of the assessment cases (baseline, application and CEA).

4.8.1 Acute Health Risks

The acute risk estimates (CRs) are based on exposure periods that last from a few minutes (e.g., 10-minute SO_2) to a few days (e.g., 24-hour $PM_{2.5}$) (see Table 4.8-1).

Table 4.8-1: Summary of Concentration Ratios for Acute Inhalation Assessment

Chemicals of Potential Concern	Averaging Time	Concentration Ratios (unitless)		
		Baseline	**Application**	**CEA**
CO	1-hour	0.4	0.4	0.4
	8-hour	0.6	0.6	0.6
H_2S	1-hour	0.1	0.1	0.1
NO_2	1-hour	0.3	0.8	0.8
	24-hour	0.3	0.5	0.5
SO_2	10-minute	0.4	0.5	0.5
	1-hour	0.3	0.3	0.3
	24-hour	0.2	0.2	0.2
$PM_{2.5}$	24-hour	0.7	0.9	0.9
Mixtures				
Respiratory irritants	1-hour	0.7	**1.2**	**1.2**
	24-hour	0.5	0.7	0.7

All acute inhalation CRs, with the exception of the respiratory mixture (1-hour) in the application and CEA cases, are less than one for all three assessment cases. This suggests that the estimated acute inhalation exposures to each of the individual COPC at maximum ground level concentrations are associated with low health risks.

The CRs for the respiratory irritants mixture slightly exceeded one for the application and CEA cases. The mixture assessment assumed that there is an additive interaction between respiratory irritant chemicals, so the predicted CRs represent the sum of the individual CRs for H_2S, NO_2 and SO_2. All CR values were based on maximum background levels and maximum predicted ground-level concentrations of the three relevant COPC. This risk estimate is based on the assumption that the maximum air concentrations would occur at the same location for all three chemicals at precisely the same time. Thus, the CR estimate of 1.2 for the mixture is based upon worst-case exposure conditions, and is likely over conservative.

It is important to note that the respiratory tissues affected by the three COPC are different. NO_2 may be inhaled deeply into the lungs and as a result tends to act as an irritant to the lower airway. The primary contributor to the respiratory irritant mixture in the application and CEA scenarios appears to be NO_2, given the relative magnitude of difference between the CRs for the baseline, application, and CEA scenarios (i.e., 0.3 in baseline to 0.8 in the application and CEA cases). In contrast to NO_2, SO_2 is more soluble in water and is readily absorbed through the upper respiratory tract, potentially inducing increases in airway resistance higher up in the respiratory tract (Calabrese 1991). Hydrogen sulphide can cause irritation to the upper respiratory tract, including nasal tissue (ATSDR 2006). The dose-response relationships for these chemicals are somewhat independent in that the primary responses occur in different regions of the respiratory tract. For this reason, the assumption of additivity with respect to the irritant mixture likely resulted in the true respiratory risk being overstated.

4.8.2 Chronic Health Risks

As shown in Table 4.8-2, the CRs for the three assessment cases (baseline, application and CEA) were all less than one. As such, exposure to the maximum ground level concentrations of the COPC is associated with negligible health risks.

Table 4.8-2: Summary of Concentration Ratios for the Chronic Inhalation Assessment

Calabrese 1991	Averaging Time	Concentration Ratios (unitless)		
		Baseline	Application	CEA
H_2S	Annual	0.2	0.4	0.4
NO_2	Annual	0.1	0.3	0.3
SO_2	Annual	0.1	0.2	0.2
Respiratory irritants	Annual	0.4	0.9	0.9

4.9 Management and Monitoring

Management and monitoring plans applicable to human health are consistent with those described in the groundwater, surface water and air quality assessments. The planned management and monitoring programs are summarized below.

Groundwater will be monitored twice annually to evaluate potential effects to groundwater quantity (i.e., water levels) and quality. The analytical schedule would include temperature, pH, electrical conductivity and routine potability parameters. Upon Project approval, the design of the monitoring plan would be submitted to AENV for review, comment and approval.

A response plan will be developed to enable prompt courses of action in the event that routine monitoring detects an impact to either groundwater quantity or quality (see Volume IIB, Section 2: Groundwater Quantity and Quality – Section 2.10).

As part of the surface water quality monitoring plan, parameters will be monitored (particularly suspended sediments) during construction activities near surface waterbodies. This will be maintained throughout clearing and construction to ensure that water quality guidelines are not exceeded. Also, intercepted water will be tested to ensure regulatory water quality requirements for surface water release are satisfied during construction works (see Volume IIB, Section 4: Surface Water Quality – Section 4.7).

With respect to air quality, AST plans to implement dust suppression measures near the conveyor transfer points and within the sulphur loading area. As well, AST will maintain observational programs with respect to fine particulates and H_2S. Finally, AST will participate in regional initiatives relative to air quality issues (see Volume IIA, Section 2: Climate and Air Quality – Section 2.6.7).

4.10 Summary

Acute health risks associated with Project air emissions were characterized by comparing predicted maximum short-term air concentrations (including measured or background air concentrations) with health-based exposure limits considered protective of the most sensitive individuals. Slight exceedances (CRs of 1.2) were predicted for the respiratory irritant mixture in the application and CEA cases. These exceedances are not expected to translate into health effects due to the conservative nature of the assessment. The conservatism of the assessment was represented, in part, through the characterization of risks at maximum points of impingement and ensured that potential impacts on health would not be underestimated.

The predicted long-term air concentrations met the health-based guidelines for all COPC, suggesting that chronic health risks were negligible in all cases.

A summary of the residual effects assessments is provided in Table 4.10-1. Consistent with the other sections, residual impacts were assessed in terms of direction, magnitude, geographic extent, duration and confidence, as described in Volume IIA, Section I: Introduction – Section 1.4. The final impact ratings are Class 3 for acute health risks and Class 4 for chronic health risks. The rankings for acute and chronic health risks are based on the assumption that the proposed mitigative actions will be implemented and effective.

The Class 3 rating for the acute health risks is due to the slight exceedances for the respiratory irritant mixture. It is important to note that the slightly elevated risks are not expected to result in an adverse impact on human health. Due to the margin of safety built into the HHRA, the Project should not cause adverse respiratory effects in the area residents.

Table 4.10-1: Final Impact Rating Summary Table for Human Health Risks

Issue	Direction	Magnitude	Geographic Extent	Duration	Confidence	Rating
Acute health risks	Negative	Low	Local	Short term	High	3
Chronic health risks	Negative	Negligible	Local	Long term	High	4

4.11 References

4.11.1 Literature Cited

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological Profile for Sulphur Dioxide. U.S. Department of Health and Human Services.

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for Hydrogen Sulphide*. U.S. Department of Health and Human Services.

Alberta Environment (AENV). 2005. *Alberta Air Quality Objectives*. Government of Alberta.

Alberta Environment (AENV). 2007. *Final Terms of Reference, Environmental Impact Assessment (EIA) Report for the Proposed Bruderheim Sulphur Forming and Shipping Facility.* March 13, 2007. Alberta Environment, Edmonton, AB.

Calabrese, E.J. 1991. *Multiple Chemical Interactions*. Chelsea, MI: Lewis Publishers Inc. Toxicology and Environmental Health Series.

Canadian Council of Ministers of the Environment (CCME). 2000. *Canada-Wide Standards for Particulate Matter (PM) and Ozone.* Accepted November 29, 1999 for endorsement in May 2000.

Health Canada. 1995*. Investigating Human Exposure to Contaminants in the Environment: A Handbook for Exposure Calculations.* Volumes 1-3. Published by the Minister of National Health and Welfare.

Health Canada. 2004. *Federal Contaminated Site Risk Assessment in Canada.* Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Ottawa, ON: Environmental Health Assessment Services Safe Environments Programme. September 2004. ISBN 0-662-38244-7.

Health Canada. 2006. *Federal Contaminated Site Risk Assessment in Canada.* Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Volume 2. Ottawa, ON: Environmental Health Assessment Services Safe Environments Programme. December 2006.

Ontario Ministry of the Environment (OMOE). 2005. *Air Dispersion Modelling Guideline for Ontario.* Version 1.0.

United States Environmental Protection Agency (USEPA). 1989. *Guidance for Risk Assessment.* Environmental Protection Agency. Risk Assessment Council, Washington, D.C.

United States Environmental Protection Agency (USEPA). 1991. Guidance for Risk Assessment. Environmental Protection Agency. Risk Assessment Council, Washington, D.C.

World Health Organization (WHO). 2000. *Air Quality Guidelines for Europe,* Second Edition. World Health Organization, Regional Office for Europe, Copenhagen. WHO Regional Publications, European Series.

4.11.2 Internet Sites

United States Environmental Protection Agency (USEPA). 2007. Integrated Risk Information System. Available at: http://www.epa.gov/iris. Accessed: 03/20/07.

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Appendix I: Toxicological Profiles

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1. Toxicological Profiles

1.1 Carbon Monoxide (CO)

Carbon Monoxide (CO) is a colourless, odourless gas.

The health effects for CO are limited to the inhalation exposure route only, as dermal contact and oral ingestion intake are estimated to be negligible given the physical characteristics of the gas. Approximately 80–90% of CO that is inhaled and absorbed binds blood haemoglobin to form carboxyhemoglobin (COHb) in the blood. COHb reduces the oxygen-carrying capacity of the blood, resulting in tissue hypoxia within tissues with high oxygen demand, such as the brain, heart, skeletal muscle and the fetus. Symptom severity increases with the increasing concentration of COHb in the blood. At higher exposure concentrations, CO will bind other heme-containing molecules, such as myoglobin and cytochrome P450 enzymes (WHO 2000).

Possible health effects may vary from mild headaches and fatigue to dizziness and vomiting. Exposure to more than 40% CO may cause collapse, coma or death (WHO 2000).

The ambient air quality guidelines recommended by AENV (2005) for 1-hour and 8-hour exposures are 15,000 $\mu g/m^3$ and 6,000 $\mu g/m^3$ respectively, which were used in the HHRA. These values are based on the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines (1994) recommended maximum desirable objectives, which were developed to protect the subpopulation sensitive to cardio-respiratory effects. At these air concentrations, individuals are not expected to experience even the mildest of symptoms (e.g., minor headaches). Carbon monoxide is not assessed on a chronic or long-term basis because the formation of COHb in blood reaches a steady-state after six to eight hours of exposure; therefore, COHb is not expected to accumulate in the blood (WHO 2000).

1.2 Hydrogen Sulphide (H_2S)

Hydrogen sulphide is a colourless gas with a distinct rotten-egg odour. Inhalation is the primary pathway of exposure, as dermal contact and oral ingestion intakes are assumed to be negligible given the physical characteristics of the gas. The critical toxicological endpoints for H_2S are associated with irritation. Table I–1 below provides a general summary of these effects in association with approximate exposure concentrations.

Table I–1: Health Effects of Hydrogen Sulphide

Concentration in Air	Description of Potential Health Effects
1 ppm or 1,400 µg/m^3	Noticeable odour, may be considered ‘offensive’ by some individuals. Certain individuals may experience mild symptoms of general discomfort, nausea, headache and irritability in direct response to odour. Possible aggravation of symptoms among asthmatics that may or may not be secondary to odour. Appearance of symptoms will depend on severity of asthmatic condition. Any effects would be transient. No symptoms related to direct toxicity expected among normal individuals.
10 ppm or 14,000 µg/m^3	Obvious offensive odour. Minimum concentration causing eye irritation after a single exposure lasting several hours according to some authorities. Irritation of eyes at this concentration has not been well established. Any irritation of the eyes expected to be transient and fully reversible. Symptoms would be very mild (i.e., possible itchiness, dryness, increased blink reflex, slight watering). No damage or permanent injury to the eyes. Could aggravate pre-existing eye conditions (e.g., conjunctivitis). Odour-related symptoms could include headache, nausea and vomiting depending on the individual and duration of exposure. Possible aggravation of symptoms among individuals with asthma, bronchitis or other forms of chronic respiratory disease.
20 ppm or 28,000 µg/m^3	Obvious offensive odour. Possible irritation of the eyes. Effects would be mild and fully reversible. Effects could include itchiness, dryness, watering and slight redness. The likelihood of effects would increase with increasing duration of exposure. No damage or permanent injury to the eyes would be expected. Could aggravate pre-existing eye conditions (e.g., conjunctivitis). Odour-related symptoms could include headache, nausea and/or vomiting depending on the individual and the duration of exposure. Possible aggravation of symptoms among individuals with asthma, bronchitis or other forms of chronic respiratory disease.
50 ppm or 70,000 µg/m^3	Strong and intense, but not intolerable odour. Possible irritation of the eyes and breathing passages. Eye irritation could present itchiness, stinging, redness of the eye, redness of the eyelids, tearing, increased blink reflex and increased tendency to ‘rub’ eyes. Severity of symptoms will vary with duration of exposure. Possible aggravation of pre-existing eye conditions. Possible eye injury after several days of exposure. Respiratory irritation could present ‘tingling’ or stinging sensation in throat and nasal passages, sore throat, increased tendency to “clear” throat and cough. Likely aggravation of symptoms among asthmatics and individuals with pre-existing respiratory disease. Symptoms expected to be transient and reversible. No permanent injury expected unless exposure is prolonged. Strong possibility of odour-related symptoms, including headache, nausea, vomiting and/or diarrhea among odour-sensitive individuals.
100 ppm or 140,000 µg/m^3	Strong objectionable odour initially, becoming less intense due to olfactory ‘fatigue’ with continued exposure. Increasing possibility of irritation of eyes and breathing passages within one hour of exposure. Symptoms of eye irritation could present as soreness, stinging or burning sensation of eyes, tearing, redness of eyes, redness and swelling of eyelids and possible blurred vision. Symptoms of respiratory irritation could include sore throat, cough, soreness or stinging of breathing passages and possible wheezing. Definite aggravation of symptoms among individuals with asthma, bronchitis or other forms of chronic respiratory disease. Odour could induce headache, nausea, retching and vomiting.
250 ppm or 348,000 µg/m^3	Odour may or may not be distinguishable due to olfactory paralysis. Irritation of eyes and respiratory tract within several minutes of exposure, becoming severe with longer exposure. Eye irritation very likely to present as conjunctivitis with possible corneal involvement (i.e., definite redness of eyes and swelling of eyelids, and soreness of eyes). Immediate and excessive watering and tearing of eyes, with possible blurred vision. Very real possibility of permanent eye injury if exposure is prolonged. Respiratory irritation would present as sore throat, cough, difficulty breathing, soreness of chest and/or possible wheezing. Symptoms might be protracted. Definite aggravation of asthma. Some possibility of ‘systemic’ symptoms, including headache, nausea and vertigo depending on duration of exposure.

Table I–1: Health Effects of Hydrogen Sulphide (Cont'd)

Concentration in Air	Description of Potential Health Effects
500 ppm or 697,000 µg/m^3	Odour is not distinguishable due to olfactory paralysis. Severe irritation, and possible injury, to the eyes and breathing passages within 30 minutes of exposure. Post-exposure 'chemical pneumonia' may appear due to damage to the lungs and breathing passages if exposure is prolonged. 'Systemic' effects with central nervous system involvement may occur within one hour of exposure. Symptoms could include headache, anxiety, dizziness, loss of coordination and slurred speech, progressing to loss of consciousness and/or sudden collapse or 'knock-down'. Death may occur if exposure is prolonged.
750 ppm or 1,045,000 µg/m^3	Odour is not distinguishable due to immediate olfactory paralysis. Signs of nervous system involvement will dominate the clinical picture and could include anxiety, confusion, headache, slurred speech, dizziness, stumbling, loss of coordination and other signs of motor dysfunction, which could progress to abrupt 'knock-down' and loss of consciousness and possibly death, if exposure continues for more than a few minutes. Possibility of chemical pneumonia among survivors of post-exposure from damage to the lungs and breathing passages.
1,000 ppm or 1,394,000 µg/m^3	Immediate 'knock-down' and loss of consciousness. Death within moments to minutes. Immediate resuscitation and medical attention needed if victim is to survive.
Sources: ATSDR (2006); Guidotti (1994); Illinois Institute of Environmental Quality (IIEL) (1974); National Research Council of Canada (NRCC) (1981); National Institute of Occupational Safety and Health (NIOSH) (1977); Milby (1962); Milby and Baselt (1999); U.S. Public Health Service (1964); and WHO (1981).	

Alberta Environment (AENV 2005) recommends 1-hour and 24-hour exposure limits of 14 µg/m^3 and 4 µg/m^3 for H_2S. However, it is important to note that these guidelines are based on odour rather than health effects. As such, an exceedance of these values does not necessarily indicate that health effects would occur. The Agency of Toxic Substances and Disease Registry (ATSDR 2005, 2006) recommends an acute minimal risk limit (MRL) of 98 µg/m^3 based on possible changes in airway resistance, headaches and impaired oxygen metabolism. No significant changes in lung function are expected at this air concentration. The ATSDR MRL of 98 µg/m^3 was used in the acute effects assessment as a 1-hour limit.

The USEPA has developed a chronic inhalation RfC of 2 µg/m^3, based upon nasal lesions within the olfactory mucousa (USEPA 2007, Internet site). This RfC is based on a NOAEL of 13.9 mg/m^3 for olfactory loss in adult male rats following inhalation exposure to H_2S for 6 hours per day, 7 days per week for 10 weeks. The NOAEL was adjusted for intermittent exposure (6 hours/24 hours) to a concentration of 3.48 mg/m^3. The $NOAEL_{ADJ}$ was converted to a human equivalent concentration (HEC) using the regional gas dosimetry ratio (RGDR).

$$RGDR_{ET} = \frac{(V_E/SA_{ET})_A}{(V_E/SA_{ET})_H}$$

$$RGDR_{ET} = \frac{0.19 \text{ litres/minute/15 cm}^2}{13.8 \text{ litres/minute/200 cm}^2}$$

Where:

$RGDR_{ET}$ = regional gas dosimetry ratio in the extrathoracic region

V_E = minute volume in rats $(V_E)_A$ or humans $(V_E)_H$

SA_{ET} = extrathoracic surface area in rats $(SA_{ET})_A$ or humans $(SA_{ET})_H$

The $NOAEL_{ADJ}$ was then multiplied by the $RGDR_{ET}$ to yield a $NOAEL_{HEC}$ of 0.64 mg/m^3:

$$NOAEL_{HEC} = NOAEL_{ADJ} \times RGDR_{ET}$$

$$NOAEL_{HEC} = 3.48 \text{ mg/m}^3 \times 0.184$$

Finally, an uncertainty factor of 300 was applied to the NOAELHEC to account for intra-species variability (10-fold), interspecies extrapolation (3-fold) and for subchronic exposure (10-fold). A 3-fold uncertainty factor was used instead of the 10-fold default value for extrapolation from rats to humans because the calculation of a HEC addresses one of the two areas of uncertainty encompassed in an interspecies uncertainty factor. The HEC adjustment addresses the pharmacokinetic component of the extrapolation factor, leaving the pharmacodynamic area of uncertainty.

This exposure limit was used in the chronic HHRA assessment of hydrogen sulphide H_2S.

1.3 Nitrogen Dioxide (NO_2)

Similar to the other criteria air contaminants, the primary health effects of NO_2 are related to the inhalation exposure route as dermal contact and ingestion exposures are anticipated to be negligible.

Short-term exposures to NO_2 may cause effects on the respiratory system, and people who already have breathing problems may be more sensitive. These short-term effects might include respiratory irritation or difficulties breathing (WHO 2000).

Exposure over a longer period of time may cause effects on the lungs, with more severe emphysema-like effects appearing after long-term exposures to high levels of NO_2. There is some evidence that long-term exposures to high levels may cause respiratory irritation and inflammation, and an increased risk of developing infections (WHO 2000). A general summary of health effects at various exposure levels is presented below.

Table I–2: Health Effects of Nitrogen Dioxide

Exposure Concentration (µg/m^3)	Description of Effects
375–940	Slight reduction in lung function and decreased lung capacity in sensitive individuals during exercise
940–1,880	Reduced lung function, decreased lung capacity, potential for increased airway reactivity in sensitive individuals
>1,880	Potential difficulties breathing in sensitive individuals due to airway resistance
>3,760	Impaired lung function in healthy individuals
188,000	Dry cough, chest tightness, potentially more severe respiratory problems (pulmonary edema)

Sources: WHO (2000) and Cal EPA (1999).

AENV (2005) presents 1-hour and 24-hour values for NO_2 of 400 and 200 µg/m^3 respectively, based upon odour. These values were adopted from the Health Canada NAAQO for NO_2 (Health Canada 2006, Internet site) The NAAQO are developed in three tiers: maximum desirable, acceptable and tolerable objectives. In the event that acute exposure concentrations exceed these values, given that the values are odour-based, adverse health effects will not necessarily occur. The World Health Organization (WHO) has recommended a 1-hour guideline of 200 µg/m^3 and an annual guideline of 40 µg/m^3, both based on the protection of human health (WHO 2000). The United State Environmental Protection Agency (USEPA 2006) has derived a National Ambient Air Quality Standard for $NO_2$of 100 µg/m^3 while the California Environmental Protection Agency (Cal EPA 1999) recommends a 1-hour exposure guideline of 470 µg/m3 that is protective of sensitive individuals.

The exposure limits used for the acute effects assessment of NO_2 were based on AAAQO (AENV 2005). These include a 1-hour objective of 400 µg/m^3 and a 24-hour objective of 200 µg/m^3. The Alberta objectives are based on the maximum acceptable levels, as maximum desirable NAAQO (i.e., the lowest objectives) have not been developed for NO_2 on an acute-basis. The NAAQO are health-based, and rely on controlled studies of the most sensitive population (i.e., asthmatics) to NO_2.

The chronic exposure limit used for the assessment of NO_2 concentrations in air was based on the AAAQO of 60 µg/m^3 (AENV 2005). This value was adopted from the Health Canada NAAQO for NO_2 (Health Canada 2006, Internet site) based on an annual averaging time. As for the acute values, the NAAQO are developed in three tiers: maximum desirable, acceptable and tolerable objectives. The maximum desirable level (i.e., the lowest objective) was adopted as the annual objective in Alberta. This objective is health-based and relies on controlled studies of the most sensitive population (i.e., asthmatics) to NO_2.

1.4 Sulphur Dioxide (SO_2)

The potential health effects resulting from exposure to SO_2 are limited to the inhalation route only, as dermal contact and oral ingestion are assumed to be minimal given the chemical characteristics of the gas.

Potential health effects associated with high concentrations of SO_2 are outlined in Table I–3.

Table I–3: Summary of Health Effects of Sulphur Dioxide

Concentration in Air (µg/m^3)	**Description of Potential Health Effects**
262–1,310	Increased airway resistance and potential bronchoconstriction in asthmatic or sensitive individuals, but typically no effect on lung function in normal individuals
1,310–2,620	Increased resistance in airways and difficulties breathing may be experienced by normal individuals (in addition to asthmatics and sensitive individuals). Sore throat and ability to taste and smell SO_2 may also be apparent. Effects in asthmatics and other sensitive individuals may also include wheezing, dyspnea and bronchoconstriction.
2,620–13,100	Odour is detectable. Increased resistance in airways, decreased lung volume, reduced bronchial clearance and evidence of lung irritation (increased macrophages in lung fluid) have been observed at this exposure level. Headache, coughing, throat irritation, nasal congestion, increased salivation may be evident and some symptoms may persist for several days after exposure. Mucociliary transport in the nasal passages may also be impaired, potentially leading to nasal congestion. Respiratory effects may be more severe in asthmatics and sensitive individuals.

Table I–3: Summary of Health Effects of Sulphur Dioxide (Cont'd)

Concentration in Air (µg/m^3)	Description of Potential Health Effects
13,100–26,200	Increased resistance in airways, decreased respiratory volume, difficulties breathing and lung irritation have been reported at this exposure level. Nasal, throat and eye irritation, nosebleeds, coughing, potentially accompanied by erythema of trachea and bronchi may occur. Respiratory effects may be more severe in asthmatics and sensitive individuals.
26,200–131,000	Symptoms of more severe respiratory irritation may appear, such as burning of nose and throat, sneezing, severe airway obstruction, choking and dyspnea. Exposure may result in damage to airway epithelium that may progress to epithelial hyperplasia, an increased number of secretory goblet cells, and hypertrophy of the sub-mucousal glands. A condition known as Reactive Airway Dysfunction Syndrome (RADS) may arise in the concentration ranges (as well as above) as a result of bronchial epithelial damage. Chronic respiratory effects may develop. Eye irritation, watery eyes and skin eruptions (rashes) may be evident. Respiratory effects may be more severe in asthmatics and sensitive individuals.
131,000–262,000	Symptoms of severe respiratory irritation may occur, such as bronchitis, intolerable irritation of mucous membranes in addition to other effects described above, such as decreased lung capacity and breathing difficulties, runny nose, eye and skin irritation.
> 262,000	Immediately dangerous to life and health. Chemical bronchopneumonia and asphyxia have been reported at high levels of exposure. Death may result from severe respiratory depression at concentrations around 2,620,000 µg/m^3.
Sources: NIOSH (1974); WHO (1979); ATSDR (1998); HSDB (1998, Internet site); Cal EPA (1999); WHO (2000).	

The acute exposure limits used for the assessment of SO_2 concentrations in air were based primarily on AAAQO (AENV 2005). These include a 1-hour objective of 450 µg/m^3 and a 24-hour objective of 150 µg/m^3. The AAAQO were adopted from the Health Canada NAAQO (Health Canada 2006, Internet site) that recommends maximum desirable, acceptable and tolerable objectives for SO_2. The AAAQO are based on the maximum desirable levels (i.e., the lowest or most stringent objective). These guidelines are health-based and rely on controlled studies of the most sensitive population (i.e., asthmatics) to air pollutants such as SO_2.

Sulphur dioxide also was assessed using a 10-minute air quality guideline of 500 µg/m^3 developed by the WHO (2000). This guideline is based on changes in lung function in asthmatics (WHO 2000).

The chronic exposure limit used for the assessment of SO_2 concentrations in air was based on AENV's annual ambient air quality objective for SO_2 of 30 µg/m^3 (AENV 2005). This AAAQO was adopted from the Health Canada annual NAAQO (Health Canada 2006, Internet site) which includes maximum desirable, acceptable and tolerable objectives for SO_2. The Alberta objectives are based on the maximum desirable levels (i.e., lowest objective). This guideline is health-based and relies on controlled studies of the most sensitive population (i.e., asthmatics) to air pollutants such as SO_2.

1.5 Particulate Matter ($PM_{2.5}$)

Particulate matter (PM) is the generic term applied to a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a range of sizes. Particles less than 2.5 micrometers (<2.5 µm) are called "fine" particles (i.e., $PM_{2.5}$), while those larger than 2.5 µm but smaller than 10 µm are known as "coarse" particles (i.e., $PM_{2.5-10}$). When inhaled, these particles can reach the deepest regions of the lungs (USEPA 2006, Internet site).

A significant amount of research on health effects associated with both fine and coarse PM in ambient air is on-going. Short-term exposure to ambient PM in numerous urban areas has been associated with a range of health outcomes including:

- premature death in people with heart and lung disease
- non-fatal heart attacks
- respiratory and cardiovascular hospitalizations
- lung function changes
- adverse respiratory symptoms (e.g., cough, wheeze)
- aggravated asthma
- irregular heartbeats (USEPA 2006, Internet site)

The emphasis of PM research has been shifting in recent years to address the many unanswered questions about how particles cause the health effects observed in epidemiological studies. Primary among these are questions related to:

- the biological mechanisms responsible for the effects observed
- the types and sources of particles most likely causing the effects observed. At present, PM standards are based solely on size fraction (e.g., $PM_{2.5}$, PM_{10}, $PM_{2.5-10}$) but future standards could target the particle components or characteristics that are most toxic.

The Scientific Assessment Document (Part 1) of The National Ambient Air Quality Objectives for Particulate Matter prepared by the *Canadian Environmental Protection Act* and Federal Provincial Advisory Committee Working Group on Air Quality Objectives and Guidelines (CEPA/FPAC 1999) concluded that both the mortality and hospitalization studies support the identification of 15 $\mu g/m^3$ averaged over 24 hours as the reference level for $PM_{2.5}$ (CEPA/FPAC 1999). The reference level was considered an estimate of the lowest ambient particulate matter level at which statistically significant increases in health responses can be detected based on data available up to 1996. It was derived based on the average 24-hour concentrations measured in the cities where these effects were found. The CEPA/FPAC Working Group states that reference levels should not be interpreted as thresholds of effects, or levels at which impacts do not occur. They are defined under Canada's National Ambient Air Quality Objectives as levels above which there are demonstrated effects on human health and/or the environment (CEPA/FPAC 1999).

A Canada-wide Standard (CWS) of 30 $\mu g/m^3$ $PM_{2.5}$ averaged over 24 hours was developed by the CCME under the auspices of the Canadian Environmental Protection Agency (CEPA) (CCME 2000). Under this standard, the government is committed to reduce levels of $PM_{2.5}$ significantly by 2010. Achievement of this standard is based on the 24-hour 98^{th} percentile of the ambient measurement annually, measured over three consecutive years. The CWS is considered to be an important step towards the long-term goal of reducing the health risks of $PM_{2.5}$. It represents a balance between achieving the best health and environmental protection possible, and the feasibility and costs of reducing pollutant emissions that contribute to $PM_{2.5}$ in ambient air.

For the current assessment, predicted 24-hour $PM_{2.5}$ concentrations are compared to the CWS of 30 $\mu g/m^3$ (CCME 2000), which falls within the range of recent standards recommended by the WHO and USEPA.

2. References

2.1 Literature Cited

Agency for Toxic Substances and Disease Registry (ATSDR). 2005. *Minimal Risk Levels for Hazardous Substances (MRLs).* Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. December 2005.

Agency for Toxic Substances and Disease Registry (ATSDR). 2006. *Toxicological Profile for Hydrogen Sulphide*. U.S. Department of Health and Human Services, Public Health Service.

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. *Toxicological Profile for Sulphur Dioxide.* U.S. Department of Health and Human Services.

Alberta Environment (AENV). 2005. *Ambient Air Quality Objectives.* Government of Alberta, Edmonton, AB.

California Environmental Protection Agency (Cal EPA). 1999. *Determination of Acute Reference Exposure Levels for Airborne Toxicants.* Office of Environmental Health Hazard Assessment.

Canadian Council for Ministers of the Environment (CCME). 2000. *Canada-Wide Standards for Particulate Matter (PM) and Ozone*. Accepted November 29, 1999, for endorsement in May 2000.

Canadian Environmental Protection Act/Federal-Provincial Advisory Committee (CEPA/FPAC). 1994. *National Ambient Air Quality Objectives for Carbon Monoxide.* Desirable, Acceptable and Tolerable Levels. Working Group on Air Quality Objectives and Guidelines. *Canadian Environmental Protection Act*. Ottawa, ON.

Canadian Environmental Protection Act/Federal-Provincial Advisory Committee (CEPA/FPAC). 1999. *The National Ambient Air Quality Objectives for Particulate Matter: Part 1: Scientific Assessment Document.* Ottawa, ON: Minister of Public Works and Government Services. ISBN 0-662-26715-X.

Guidotti, T.L. 1994. Occupational exposure to hydrogen sulfide in the sour gas industry: some unresolved issues. *Int. Arch. Occup. Environ. Health* 66:153-160.

Illinois Institute for Environmental Quality (IIEQ). 1974. *Hydrogen Sulfide Health Effects and Recommended Air Quality Standard.* Illinois Institute for Environmental Quality, Chicago, IL. NTIS PB233843.

Milby, T.H. 1962. Hydrogen sulphide intoxication. Review of the literature and report of unusual accident resulting in two cases of nonfatal poisoning. *Journal of Occupational Medicine* 4(8):431-437.

Milby, T.H. and R.C. Baselt. 1999. Hydrogen Sulfide Poisoning: Clarification of some Controversial Issues. *American Journal of Industrial Medicine* 35:192-195.

National Institute for Occupational Health and Safety (NIOSH). 1977. *Criteria for a Recommended Standard. Occupational Exposure to Hydrogen Sulfide.* Stanford Research Institute, Menlo Park, CA. NTIS PB-274196.

National Institute of Occupational Safety and Health (NIOSH). 1974. *Criteria for a Recommended Standard - Occupational Exposure to Sulfur Dioxide.* U.S. Department of Health, Education and Welfare.

NRCC (National Research Council of Canada). 1981. *Hydrogen Sulfide in the Atmospheric Environment: Scientific Criteria for Assessing its Effects on Environmental Quality.* Publication NRCC 18467.

United States Public Health Service. 1964. *The Air Pollution Situation in Terre Haute Indiana with Special Reference to the Hydrogen Sulfide Incident of May-June, 1964.* U.S. Public Health Service, Washington, D.C. NTIS PB227486.

World Health Organization (WHO). 2000. *Air Quality Guidelines–Second Edition. Chapter 7.1 Nitrogen Dioxide.*

World Health Organization (WHO). 1981. *Hydrogen Sulfide. Environmental Health Criteria 19.* World Health Organization, IPCS International Program on Chemical Safety, Geneva.

World Health Organization (WHO). 1979. *International Program for Chemical Safety (IPCS)–Environmental Health Criteria 8–Sulphur Oxides and Suspended Particulate Matter.*

2.2 Internet Sites

Hazardous Substances Data Bank (HSDB). 1998 (Rev.). Sulfur Dioxide. Available at: http://toxnet.nlm.nih.gov/cgI–bin/sis/search/f?./temp/~KUwQRy:2. Accessed January 30, 2007.

Health Canada. 2006. National Ambient Air Quality Objectives. Available at: http://www.hc-sc.gc.ca/ewh-semt/air/out-ext/reg_e.html#3. Accessed March 23, 2007.

United States Environmental Protection Agency (U.S. EPA). 2006. Fact Sheet–Final Revisions to the National Ambient Air Quality Standards for Particle Pollution (Particulate Matter). Available at: http://epa.gov/pm/pdfs/20060921_factsheet.pdf. Accessed March 23, 2007.

United States Environmental Protection Agency (USEPA). 2007. Integrated Risk Information System (IRIS). Available at: http://www.epa.gov/iris. Accessed March 23, 2007.