Appendix 10.1-A

Air Quality Technical Data Report

AJAX PROJECT

Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study

Ajax Mine Project

Air Quality Technical Data Report

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FINAL

August 24, 2015

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Executive Summary

This technical data report describes an assessment of air quality completed to support the Environmental Assessment Certificate (EAC) Application for the KGHM Ajax Mining Inc. (KAM) proposed Ajax Project (the Project). The Project is an open pit copper-gold mine at the historic Afton Mining Camp, south of the City of Kamloops, British Columbia. The air quality assessment was conducted with the US EPA approved CALPUFF dispersion modelling system. It employed a three year CALMET dataset that has been shown to perform well and accurately reproduce dispersion in the Kamloops area. The model has been run in a conservative fashion, and while uncertainty exists in all dispersion modelling, Stantec is confident the actual effects will be lower than the predicted ones.

In addition to the dispersion assessment, this report describes the existing regional conditions in the region around the Project and the Project site. The geographic setting is described, followed by background air quality and local climate and meteorology. Understanding both the existing climate and air quality, and its relationship with the landscape helps establish the link between cause (emissions) and effect (resultant changes in air quality), and supports the Project air quality assessment.

This assessment demonstrates that the CALPUFF model accurately reproduced the existing air quality in Kamloops, both in the predicted magnitudes and the geographic patterns. It also showed that the Project has little effect on the overall air quality in Kamloops.

A City-wide analysis shows that the predicted average annual $PM_{2.5}$ is 6.4 μg/m^3, and that can vary by 14% annually. City wide, the project is predicted to add 2.3%—a sixth of the normal year-to-year variation. Project Operations has a limited effect on air quality in Kamloops. Similarly, an analysis of the predicted change in the Federal Air Quality Health Index (AQHI) demonstrates that the Project has little effect on the overall air quality in Kamloops.

The assessment shows that air quality in upper Aberdeen is predicted to remain good. It is, and will remain better than in most other areas in the City of Kamloops. The Project's predicted effects in upper Sahali, the Downtown core, and the North Shore are such that a discernable change in air quality will not be measurable in future.

This Executive Summary steps through the major sections of the report, with more detail found in the body of the report, supported by nine Appendices. Background air quality is described first to place the Project site in perspective with the City of Kamloops and the larger region surrounding it. The substances of interest selected for study are described, as are the modelling scenarios. Following that are descriptions of the results of modelling the Base Case, Construction and Operations cases (both alone and with the Base Case added), and the Cumulative Effects Assessment Case.

Background Air Quality

The background air quality in the City of Kamloops and the outlying regions is well understood owing to an extensive historic record of air quality measurements. This includes continuous measurements of a suite of gasses and particulate matter, and intermittent monitoring of particulate matter and dustfall. These measurements, when compared to the applicable regulatory criteria, indicate that air quality in Kamloops is good. The term 'good' is arguably a fair descriptor for a location where the measured Federal Air Quality Health Index (AQHI) is in the Low Health Risk category 94.1% of the time.

Measured levels of sulphur dioxide, nitrogen dioxide, and carbon monoxide are low. They are always less than the applicable regulatory criteria. Particulate matter measurements (total, inhalable, and respirable) are generally low, but at times exceed the criteria. These exceedances are episodic, and often driven by external forces (e.g., forest fire). At times they are a consequence of local domestic/industrial emissions that accumulate under periods of poor dispersion to levels that are greater than the criteria.

Health Canada (1999) in their Addendum to the Science Assessment Document for the Particulate Matter National Ambient Air Quality Objectives (NAAQO) studied air quality in 18-Canadian Cities. This work reveals that exposure to ambient respirable particulate matter ($PM_{2.5}$) in Kamloops is better than any of the 18 cities studied.

Substances of Interest

The substances of interest selected for modelling include: Total Dustfall (DF); Total Suspended Particulate Matter (TSP); Inhalable Particulate Matter (PM_{10}); Respirable Particulate Matter ($PM_{2.5}$); Sulphur Dioxide (SO_2); Nitrogen Dioxide (NO_2); and Carbon Monoxide (CO).

The assessment considers both the construction and operations worst-case emissions. It also accounts for existing emissions in the CALPUFF domain through modelling (called the Base Case). The modelling scenarios are as follows:

Base Case: All existing emissions in the CALPUFF domain

For Construction:

- Project Case Construction (only Project Case Construction-related emissions)
- Application Case Construction (Base Case plus Project Case Construction)

For Operations:

- Project Case Operations (only Project Case Operation-related emissions)
- Application Case Operations (Base Case plus Project Case Operations)
- Cumulative Effects Assessment Case

To account for all emission sources outside of the CALPUFF domain that are by definition not included in the modelling assessment, values representative of the Global/Regional background ambient air quality are added to the predicted Base Case concentrations. Doing this fully accounts for the effects of all global, regional, and local emission sources that influence air quality in the Kamloops area.

To assess residual Project effects, both the Construction and Operations Cases (Project and Application) results are compared to the applicable regulatory criteria. The Base Case results are compared to both the criteria and to local measurements to place the predictions in perspective.

Following are the findings of the Base Case, Construction Case, and Operations Case modelling.

Base Case

The Base Case results show good agreement with local measurements, increasing confidence in the CALPUFF model ability to conservatively predict changes in air quality attributable to the Project.

Predicted concentrations of sulphur dioxide, nitrogen dioxide, and carbon monoxide are low. They are always less than the applicable regulatory criteria. Particulate matter predictions (total, inhalable, and respirable) are generally low, but at times exceed the criteria. The frequency of exceedance of these parameters is also consistent with background measurements. Dustfall is greater than the criteria 58% of the year while TSP, PM_{10}, and $PM_{2.5}$ are less than 5% of the year. These exceedances are consequences of local domestic/industrial emissions that accumulate under periods of poor dispersion to levels that are exceed the criteria.

The pattern of maximum predicted concentrations of PM_{10} and $PM_{2.5}$ in the CALPUFF domain shows good agreement with local measurements. The valley bottom locations have consistently higher concentrations than the upper reaches of the valley walls. The plateau region beyond has the lowest predicted concentrations. The maximum predicted concentrations of $PM_{2.5}$ typically occur in winter months. Measurements of $PM_{2.5}$ are typically greater in winter than summer months. Exceptions include periods in summer when forest fires are active locally or regionally. This assessment does not reproduce these conditions are forest fires were not included as sources of emissions.

The modelling and measurements show that the valley bottom is affected both by sources outside the region (the global/regional background) and domestic/industrial sources of emissions in the City. In contrast, the Project site is dominated by the global/regional background, and largely unaffected by domestic/industrial sources in the City.

Construction Case (Alone and with Base Case Added)

The Construction Case alone results show that the maximum predicted concentrations of SO_2, NO_2, and CO are small, and are less than applicable regulatory criteria. The maximum predicted concentrations of Dustfall, TSP, and $PM_{2.5}$ are also less than the criteria. The maximum predicted 24-hour concentration of PM_{10} does exceed the criteria. PM_{10} is predicted to exceed the objective twice annually. They occur in January on the northeast plant boundary, largely in undeveloped grasslands.

Generally, the Project Construction has little effect on air quality in the built-up urban area of Kamloops. Exceedances are predicted to occur in undeveloped grasslands.

The Application Case – Construction (the sum of the Construction Case and the Base Case) demonstrates that the Project Construction has a small effect on existing air quality in the City. The Application Case – Construction results are nearly indistinguishable from Base Case results. The addition of the Base Case exacerbates the PM_{10} exceedance on the northeast plant boundary, and causes TSP to exceed the criteria.

Operations Case (Alone and with Base Case Added)

The Operations Case alone results show that the maximum predicted concentrations of SO_2, NO_2, CO, and dustfall are small, and are less than applicable regulatory criteria. The maximum predicted 24-hour concentrations of TSP, PM_{10} and $PM_{2.5}$ are greater than the criteria. These exceedances are predicted to occur less than 7% of the year, generally in winter months. The areas where concentrations above the criteria are predicted to occur are off the northeast plant boundary, largely in undeveloped grasslands. The exceedance area for TSP and PM_{10} extend northeast past the City Development Boundary and cover parts of upper Aberdeen. The exceedance area for $PM_{2.5}$ does not extend past the City Development Boundary.

The Application Case – Operations (the sum of the Operations Case and the Base Case) demonstrates that the Project operations have a limited effect on existing air quality in the City. The Application Case – Operations results are nearly indistinguishable from Base Case results beyond upper Aberdeen. The addition of the Base Case exacerbates the exceedances on and beyond the northeast plant boundary, increasing the predicted concentration and the frequency of exceedance.

Despite the Projects effects in the Application Case Operations, air quality in upper Aberdeen is predicted to remain good. Air quality there remains better than in most other areas in the City of Kamloops. The Projects predicted effects in upper Sahali, the Downtown core, and the North Shore are such that a discernable change in air quality will not be measurable in future.

City-wide, the predicted average annual $PM_{2.5}$ is 6.4 $\mu g/m^3$. The Project Operation Case contributes 0.15 $\mu g/m^3$ to this region, a 2.3% increase. The long-term year to year variability in annual average $PM_{2.5}$ is $\pm$ 0.92 $\mu g/m^3$ (the value of one standard deviation of the annual average $PM_{2.5}$ collected at Brocklehurst between 1998 and 2011). Given this high variability, and the fact that the increase attributed to the project is a factor of six less, the increase in annual average is insubstantial. It is dwarfed by the long-term year to year variability in annual average $PM_{2.5}$.

For the Application Case Operations the Federal Air Quality Health Index (AQHI) is predicted to be in the Low Health Risk category for more than 90% of the time at the location where the predicted effects of the Project are most evident (northeast plant boundary). In upper Aberdeen it is in the Low Health Risk category for 97.1% of the time, which is similar to that observed in the remainder of the City. Comparing the measured and predicted Federal AQHI before and after the Project demonstrates that the Project has little effect on the overall air quality in Kamloops.

Considering the conservative nature of the dispersion assessment, concentrations in excess of the applicable regulatory criteria attributable to the Project Operations will likely be limited to northeast plant boundary, nearby undeveloped grasslands, and to a lesser extent in upper Aberdeen. The remainder of the City is largely unaffected by Project Operations.

Cumulative Effects Assessment Case

To determine if it was necessary to perform a Cumulative Effects Assessment (CEA) the project inclusion list was searched for i) any approved, announced or foreseeable future projects within the CALPUFF domain (called the Regional Study Area or RSA in the EA section) that have the potential to interact with the Project in a cumulative manner; and/or ii) are any approved, announced or foreseeable future projects outside the CALPUFF domain that have the potential to interact with the Project in a cumulative manner. This review determined that there are no approved, announced or foreseeable future projects either within or outside the CALPUFF domain that have the potential to interact with the Project in a cumulative manner.

This review determined that are four proposed projects on the project inclusion list that need be considered. All four are well outside of the CALPUFF domain. These proposed projects have been deemed through application of professional judgement to be incapable of resulting in a potentially deleterious effect in the CALPUFF domain in combination with the Project. They were discounted based upon the quantities emitted (whether large or small) and previous experience with similar projects.

The cumulative air quality effects assessment for future projects was completed and it was determined that there was no Project interactions with approved, announced or foreseeable future projects.

Abbreviations

AAQO	Ambient Air Quality Objective
AN	ammonium nitrate
ANFO	ammonium nitrate fuel oil
AQHI	Air Quality Health Index
BAM	Beta Attenuation Mass Monitor
B(a)P	Benzo(a)Pyrene
BC	British Columbia
BCFS	British Columbia Forest Service
BC MOE	British Columbia Ministry of Environment
BC MOT	British Columbia Ministry of Transportation
°C	degree Celsius
CAC	criteria air contaminants
CAAQS	Canadian Ambient Air Quality Standards
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of Environment
CCN	Canadian Climate Normals
CCNS	Canadian Climate Normals Station
CDED	Canadian Digital Elevation Data
CEC	Commission for Environmental Cooperation
cm	centimetre
CMS	Continuous Monitoring Station
CO	carbon monoxide
COC	Contaminants of Concern
CO_2	carbon dioxide
CWS	Canada-wide Standard
EA	Environmental Assessment
EAC	Environmental Assessment Certificate
EC	Environment Canada

EIA	Environmental Impact Assessment
EMRSF	East Mine Rock Storage Facility
EPA	Environmental Protection Agency
EU	European Union
DF	dustfall
DFS	dustfall station
GHG	greenhouse gas
g/s	grams per second
HAP	Hazardous Air Pollutant
HHERA	Human Health and Ecological Risk Assessment
ha	hectare
hr	hour
H_2S	Hydrogen Sulphide
HP	horse power
ICP-MS	inductively coupled plasma mass spectrometry
JWA	Jacques Whitford Axys
K	Degrees Kelvin
KAM	KGHM Ajax Mining Inc.
KAPA	Kamloops Area Preservation Association
km	kilometre
km^2	square kilometre
Kt/d	thousand tonnes per day
kW	kilowatt
LAI	leaf area index
LOD	Limit of Detection
LSD	Legal Site Description
LST	Local Standard Time
m	metres
masl	metres above sea level
mE	metres east
$mg/dm^2/d$	milligrams per decimetre squared per day

MEG	monoethelyne glycol
mm	millimetres
MM5	Mesoscale Model v5
mN	metres north
MPOI	Maximum Point of Impingement
MRSF	Mine Rock Storage Facility
Mt	million tonnes
m/s	metre per second
NAAQO	National Ambient Air Quality Objectives
NAD	North American Datum
NALCMS	North American Land Change Monitoring System
NAPS	National Air Pollution Surveillance
NASA	National Aeronautics and Space Administration
NGTL	NOVA Gas Transmission Ltd.
No.	number
NO	nitric oxide
NO_2	nitrogen dioxide
NOAEL	No Observable Adverse Effect Level
NO_X	nitrogen oxides
MPOI	Maximum Point of Impingement
OLM	Ozone Limiting Method
PAH	polynuclear aromatic hydrocarbon
PCO	Pollution Control Objectives
PM	particulate matter
PM_{10}	inhalable particulate matter
$PM_{2.5}$	respirable particulate matter
QA/QC	quality assurance/quality control
SO_2	sulphur dioxide
SOI	Substance of Interest
SMRSF	South Mine Rock Storage Facility
SRTM	Shuttle Radar Topography Mission

TEOM	Tapered Element Oscillating Microbalance
TRU	Thompson Rivers University
TRV	Toxicity reference value
TSF	Tailings Storage Facility
TSP	total suspended particulates
t/y	tonnes per year
UCLM	upper confidence limit for mean
UTM	Universal Transverse Mercator
$\mu g/m^3$	microgram per cubic metre
µm	micrometre or micron
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

Glossary

Air dispersion modelling (or modelling)	It is the mathematical simulation of how particles and gases disperse in the atmosphere. It also includes simulation of transport and deposition processes.
Applicable regulatory criteria	Provincial and/or Federal ambient air quality objectives that have been established to protect human health and the environment, collectively referred to as 'applicable regulatory criteria' or 'criteria'.
Background	Atmospheric air quality conditions for the assessment area that are measured at monitoring stations. The "background" is the concentration due to emissions from all natural and human-caused sources, including all sources that are modelled.
Global/regional background	Accounts for the effect of all global, regional, and local sources of air contaminants that affect the assessment area that are not captured by the Base Case modelling. It accounts for all emission sources outside of the assessment area that are, by definition, not included in the modelling.
CALPUFF assessment area	A 30 km long x 30 km wide sub-set of the CALPUFF domain centered on the open-pit mine site used to depict the modelling results.
CALPUFF domain	The CALPUFF computational domain covers a 70 km x 55 km area sized to capture the emission sources that make up the Base Case modelling scenario. This is also the size of the CALMET meteorological domain. For simplicity sake this is referred to as the CALPUFF domain.
Exceedance	A concentration (predicted or measured) that is greater than the applicable regulatory criteria.

Errata

The following summarizes changes made to mine plan terminology between the time of the modelling assessment and the completion of the final report. Terminology used in this report relates to earlier versions of the mine General Arrangement, called “TDR Terminology”. Current terminology relating to the most recent version of the General Arrangement is called “Updated Terminology”.

TDR Terminology	Updated Terminology
Main Embankment	North Embankment
Tailings Storage Facility Mine Rock Storage Facility (TSF MRSF)	West Mine Rock Storage Facility (West MRSF)

Other

The length of construction in this TDR is assumed to be the four years of development. The worst case year of construction is assumed to be year -1 (the last year of development). See the Project Description in Section 3.0 of the KGHM Ajax Mine Environmental Assessment Certificate for the updated length of construction.

1.0 INTRODUCTION

KGHM Ajax Mining Inc. (KAM) proposes to develop the Ajax Project (Project), an open pit copper-gold mine at the historic Afton Mining Camp, south of the City of Kamloops, British Columbia (BC). The Project is located in the South-Central Interior of British Columbia, southeast of the junction of the Trans-Canada Highway No. 1 and the Coquihalla Highway (No. 5), within the Thompson Nicola Regional District. Figure 1.1-1 shows the general location of the Project in relation to local cultural and geographic features.

1.1 MINE PLAN OVERVIEW

The current mine plan for the proposed Project is based on an average of 65 thousand tonnes of ore milled per day (Kt/d) from the Ajax Pit over a 23 year mine life. Total material movement from the pit during the life of the mine is estimated at 1,554 million tonnes (Mt). This assessment however is based on 70 Kt/d of ore mined to add conservatism to the assessment.

A full description of the mine plan and general arrangement of features is presented in the Project Description in the KGHM Ajax Mine Environmental Assessment Certificate (EAC) Application (Section 3.0). Additional descriptions of mine features are presented in the final approved detailed model plan (**Appendix B**). Note that certain mine feature terminology used in this report differs from updated terminology in use now (see Errata above).

The ore will be delivered from the mine to the outpit primary crusher using haul trucks. The outpit primary crusher will be located south of the ultimate mine pit limit. Ore will be crushed to the size which meets process requirements and will be transferred to the processing plant by a covered conveyor belt. Delivery to the ore stockpile is by haul truck. The ore stockpile (901 metres above sea level or masl) will be located south of the mine pit.

The processing plant (962 masl) will consist of stage-wise crushing and grinding, followed by a flotation process to recover and upgrade copper from the feed material. A gravity circuit will be included within the flotation circuit to enhance gold recovery. The flotation concentrate will be thickened and filtered and shipped by covered trucks to the Port of Vancouver.

The tailings storage facility (TSF) (950–1,000 masl) will be located approximately 2.0 km south of the mine pit. The proposed tailings dams will be built with mine rock from the mining operations. The dams will take advantage of the rolling nature of the local topography. The main and north dams will receive 12 Mt and 168 Mt of mine rock, respectively, by mine life end.

Mine rock will be hauled via haul truck to the mine rock storage facilities (MRSFs). Mine rock will not be crushed by the primary crusher. A dozing and spreading system will fill the proposed MRSF as indicated below:

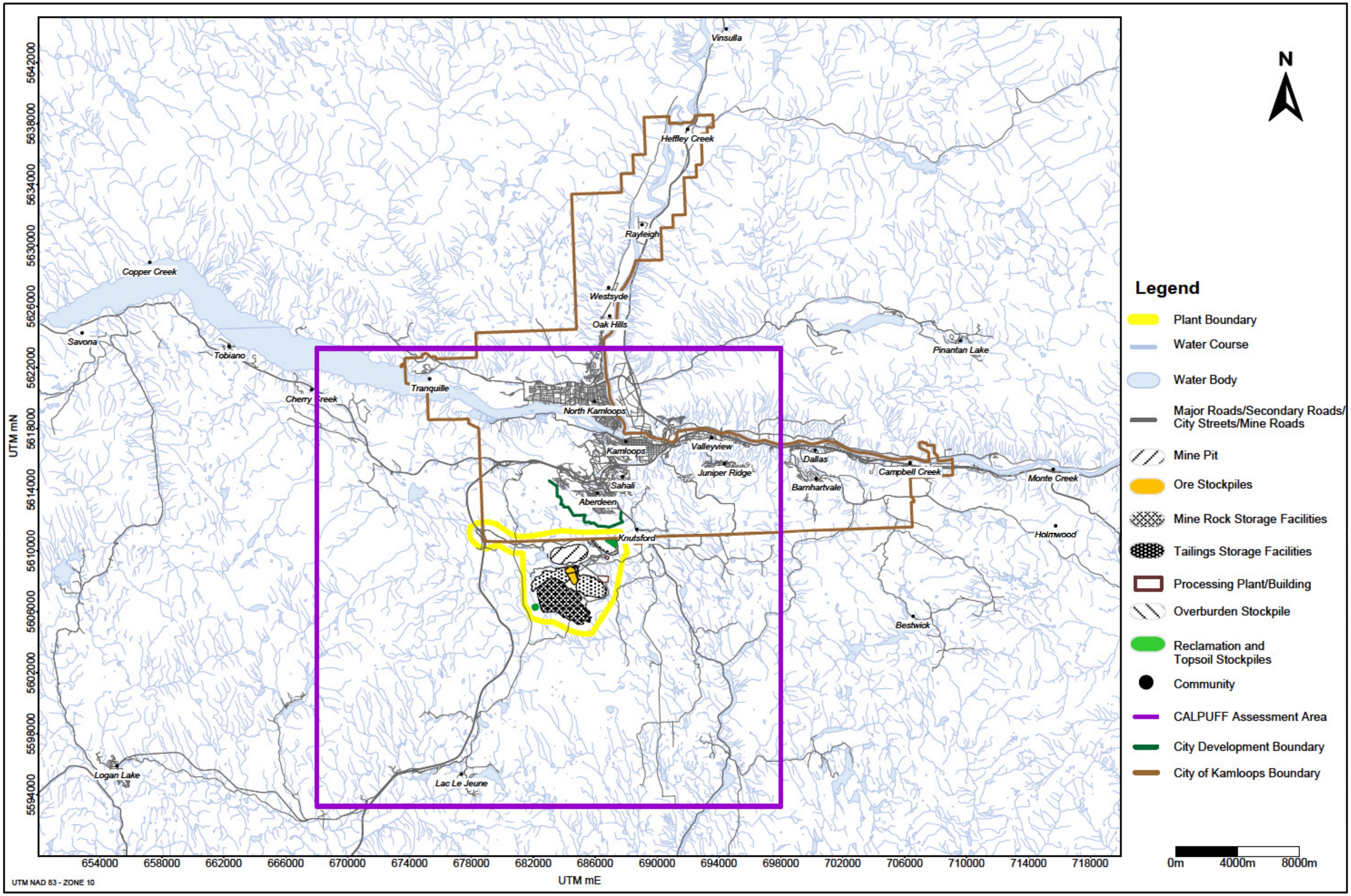
- Main Embankment 1,012 masl (year -2) – 1,060 masl (year 17) – receives a total of 161 Mt
- East Embankment 975 masl (year -1) 1,060 masl (year 8) – receives a total of 17 Mt
- South Embankment
- South MRSF (SMRSF) (421 Mt of mine rock), final elevation 1,235 masl
- East MRSF (EMRSF)(57 Mt of mine rock), final elevation 1,030 masl
- TSF MRSF 915 masl (year -2) – 1,095 masl (year 17) – Receives a total of 226 Mt
- 16 Mt will be in the overburden stock pile on the north side of the EMRSF, final elevation 990 m
- 8 Mt will be at the reclaim stock pile at the northeast edge of the pit

A total of 30 Mt of topsoil will be stored in the Topsoil Stockpile collocated to the southeast of the EMRSF.

The mine plan and general arrangement may be subject to change as work continues.
At present, the Project components assessed in the ongoing single joint harmonized environmental assessment process are included in Section 10.1.4 of the EA. The following are the Project components relevant to the air quality assessment:

- Ajax open mine pit
- Crusher pile
- Primary crusher
- Processing plant
- Ore stockpile
- TSF
- MRSF
- Road and bridge upgrades
- New access and haul roads
- Explosives storage facility
- Concentrate storage and shipping area
- Concentrate transport on access road

Not all Project components result in substantial emissions to the atmosphere, or emit substances from a human or ecological health perspective. Therefore, the air quality assessment only considers those sources and substances of interest for which effects are reasonably contemplated.



KGHM Ajax Air Quality Assessment
Technical Data Report

General Location of the Project

PREPARED BY
Stantec

PREPARED FOR
KGHM

FIGURE NO.
1.1-1

1.2 THE EFFECTS ASSESSMENT APPROACH

The effects assessment approach consists of the following general steps:

- Background atmospheric conditions for the assessment area were assessed using existing information. This included a review of ambient air quality monitoring data and climatological and meteorological data. This is used to determine the global/regional background and to gauge model performance.
- Commitments in the air quality management plan (Section11.7 of the EAC Application) were assessed to determine which proposed mitigations applied to sources of air emissions.
- Dispersion modelling was used to predict concentrations and deposition rates of substances of interest within the CALPUFF domain.
- The modelling considers both the Construction and Operations worst-case emissions. It also accounts for existing emissions through modelling of the Base Case. The modelling scenarios are as follows:
  - Base Case: all existing emissions in the 70 km (W-E) by 55 km (N-S) model domain

  For construction:
  - Project Case Construction (only Project Case Construction-related emissions)
  - Application Case Construction (Base Case plus Project Case Construction)

  For operations:
  - Project Case Operations (only Project Case Operation-related emissions)
  - Application Case Operations (Base Case plus Project Case Operations)
  - Cumulative Effects Assessment Case
- To account for all emission sources outside of the CALPUFF domain that are by definition not included in the modelling, values representative of the global/regional background ambient air quality are added to the predicted Base Case concentrations. Doing this fully accounts for the effect of all global, regional, and local sources of air contaminants that affect the Kamloops area.
- To assess residual Project effects, both the Construction and Project Application Case results are compared to the applicable regulatory criteria.

1.3 TECHNICAL DATA REPORT STRUCTURE

The structure of the technical data report (TDR) generally follows the environmental assessment structure above. Section 2 examines regional conditions including the background air quality and local climate and Project site meteorology. Section 3 details the results of the process to select substances of interest for the air quality and human health risk assessment section of the Ajax environmental assessment. The dispersion modelling methodology is laid out in Section 4. Topics covered include the assessment boundaries, the CALMET and CALPUFF modelling, and the Project emissions inventory. In Section 5 the modelling results for Construction and Operational phases of the Project are presented. Section 6 presents a summary and conclusions. References and Closure statements are presented in Sections 7 and 8 respectively.

There are nine Appendices in the report containing important supplemental reports or information too detailed to include in the report body. The Appendices include:

- Details on 30-Year Climate Normals (**Appendix A**)
- The final approved detailed model plan (**Appendix B**)
- The CALMET modelling (**Appendix C)**
- The CALPUFF modelling and model performance evaluation (**Appendix D**)
- The detailed emission inventory (**Appendix E**)
- Base Case emissions inventory (**Appendix F**)
- Isopleth maps presenting assessment results for Base Case (**Appendix G**), Construction Case (**Appendix H**), and Operations Case (**Appendix I**)

2.0 REGIONAL CONDITIONS

This section describes the existing regional conditions at the Project site. The geographic setting is described, followed by background air quality and local climate and meteorology. Understanding both the existing climate and air quality, and its relationship with the landscape helps establish the link between cause (emissions) and effect (resultant changes in air quality), and supports the Project air quality assessment.

2.1 GEOGRAPHIC SETTING

The Project is situated at the historic Afton Mining Camp to the south of, south of the City of Kamloops. Located in the Thompson Plateau physiographic region of British Columbia, the Project site exhibits drumlins and other remnants indicative of the Laurentide glaciation of the late Tertiary period. The Project site is gently rolling, and covered in a thick, continuous glacial till blanket (Church and Ryder 2010).

The Project site occupies the Interior dryland, an arid rain shadow region to the east of the Coast Mountains. As a result of the climate and physiography the landscape below approximately 900 masl is sparsely forested or is covered in grassland, depending on slope and aspect. Above 900 masl the sparse forest and grassland gives way to a continuous forest cover. The markedly differing physical attributes of the Project site and the valley bottom influence both the local scale meteorology and background air quality.

In contrast to the Project site, which lies between approximately 900 to 1,000 masl, the City of Kamloops itself occupies the valley bottom (345 masl), with neighborhoods extending up the south valley wall towards the Project up to approximately 900 masl. The Thompson River valley is deeply incised into the Thompson Plateau, and once hosted post-glacial Lake Thompson (Johnsen 2004). The valley bottom is, as a result, covered in a thick mantle of fine-grained lacustrine silt/clay. The upper reaches of the valley walls are covered in a thin discontinuous till veneer (Church and Ryder 2010). The fine-grained valley bottom material is more prone to wind erosion when disturbed. All other things being equal, more fugitive dust would be expected to originate from exposed soil surfaces in the valley bottom compared to the Project site.

Physically separating the built-up urban landscape in Kamloops from the Project site is a height of land marked by (from east to west) Coal Hill (1,092 masl), Ironmask Hill (995 masl), and Sugarloaf Mountain (1,130 masl). This feature forms a natural barrier between the Project and the City that will help confine some of the emissions to the Project site (e.g., dustfall), but will have a less pronounced confining effect on others (e.g., $PM_{2.5}$ and gaseous emissions).

2.2 BACKGROUND AIR QUALITY

Section 10.1 of the *Guidelines* (BC MOE 2008) state that although it is useful to know the predicted incremental contribution from modelled emission sources, it is the cumulative air quality that is of importance. The cumulative air quality is given by:

Cumulative air quality= Background + Predicted Increment (contribution from modelled emission)

"Background" values are usually derived from ambient air quality measurements and are added to modelled concentrations to approximate the additive effects of a modelled source and sources not included in the modelling (e.g., other industries, traffic emissions, natural sources).

Choosing the appropriate background concentration can be critical in assessing overall air quality. In order of priority, the information sources used to establish the background concentration level are:

- A network of long-term ambient monitoring stations near the source under study
- Long-term ambient monitoring at a different location that is adequately representative
- Modelled background

As described in Section 2.1.1 of the final approved detailed model plan (**Appendix B**), Stantec's approach in this assessment is to model background air quality (called the Base Case) consistent with bullet three in Section 10.1 of the *Guidelines* (BC MOE 2008). A value representative of the global/regional Background is added to the Base Case predictions. The global/regional background is based on a low-percentile value of the measured background to eliminate the influence of local sources (i.e., the maximum and high-percentile values) which are by definition included in the Base Case modelling.

The measured background consistent with the *Guidelines* is discussed in Section 2.2.1, and the measured global/regional background is discussed in Section 2.2.2.

2.2.1 Measured Background Consistent with the Guidelines

Table 2-1 lists the station location, parameters measured, and other information. Figure 2.2-1 illustrates the locations of both the permanent and intermittent monitoring locations. Table 2-2 presents background values based upon continuous gas and particulate matter measurements taken at three permanent Kamloops air quality monitoring stations. Background values are listed only for averaging intervals employed in the ambient air quality objectives (Table 3-1).

Figure 2.2-1 also includes the location of the newly installed air quality and meteorological monitoring station (named "the Ajax Upwind Station"). The Ajax Upwind station measures NO_X, O_3, PM_{10}, and $PM_{2.5}$ as well as meteorological parameters (wind speed and direction, temperature, pressure, precipitation, relative humidity, and solar radiation). The Ajax Upwind station has less than a year of data (collection started in August 2014) and is therefore not included in the background air quality analysis.

Table 2-1 Continuous Gas and Particulate Matter Monitoring Stations in Kamloops

Station Name	Parameters						Location (UTM Zone 10)		Elevation	Sampling Dates	
	PM_{10}	$PM_{2.5}$	NO_X	O_3	SO_2	H_2S	mE	mN	(masl)	Start	End
Fire Station #2		X	X	X	X	X	684,743	5,620,037	348	Jun-11	Ongoing
Brocklehurst	X	X	X	X	X	X	683,826	5,619,425	345	Pre-98	Sep-12
Federal Building		X			X	X	688,358	5,617,046	362	Pre-98	Ongoing
NOTE: mE = UTM metres East, mN = UTM metres North											

Table 2-2 Background or Reference Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

Substance and Monitoring Station	Averaging Period	Background Concentration	Applicable Regulatory Criteria [j]
TSP (µg/m³) [a] Kamloops Federal	24-hours	78.0	120
	Annual	45.0	60
PM_{10} (µg/m³) [b] Brocklehurst	24-hours	**68.7**	50
$PM_{2.5}$ (µg/m³) [c] Brocklehurst R&P TEOM	24-hours	**41.4**	25
	Annual	7.8	8
$PM_{2.5}$ (µg/m³) [d] Brocklehurst BAM	24-hours	21.4	25
	Annual	8.3	8
$PM_{2.5}$ (µg/m³) [e] Kamloops Federal BAM	24-hours	**28.2**	25
	Annual	**9.1**	8
$PM_{2.5}$ (µg/m³) [f] Kamloops Fire Station #2 BAM	24-hours	19.7	25
	Annual	7.5	8
SO_2 (µg/m³) [g] Kamloops Federal	1-hour	16.5	200
	24-hours	10.4	150
	Annual	3.5	30
NO_2 (µg/m³) [h] Brocklehurst	1-hour	65.1	188
	24-hours	55.5	200
	Annual	23.2	60
CO (µg/m³) i Brocklehurst	1-hour	931	15,000
	8-hours	815	6,000

Table 2-2 Background or Reference Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

NOTES:

- Between 1994 and 1998 the 24-h maximum TSP was greater than the AAQO (120 µg/m^3) every year.
- Between 1998 and 2013 the 24-h maximum PM_{10} was greater than the AAQO (50 µg/m^3) in 14 of 16 years. Exceedance frequency is 1.4% or 5 days/year. The average maximum value is 111 µg/m^3.
- Between 1998 and 2013 the maximum $PM_{2.5}$ (Brocklehurst) was greater than the AAQO (25) in 7 of 14 years. Exceedance frequency is 0.8% or 3 days/year. The average maximum daily value is 40.7 µg/m^3.

[a] For TSP the 24-hour background value is the 90th percentile measured concentration. The annual value is the maximum measured annual concentration. All values are for the period from January 1, 1994 to December 31, 1998, measured at the Kamloops Federal Building monitoring station.

[b] For PM_{10} the 24-hour background values are the 98th percentile measured concentrations (2003). All values are for the period from January 1, 1994 to June 18, 2009, measured at the Kamloops Brocklehurst monitoring station.

[c] For $PM_{2.5}$ (TEOM) the 24-hour background values are the 98th percentile measured concentrations (2003). The annual values are the maximum measured annual concentrations (2003). All values are for the period from January 1, 1998 to June 5, 2011, measured at the Kamloops Brocklehurst monitoring station with an R&P TEOM Instrument.

[d] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2011). The annual values are the maximum measured annual concentrations (2011). All values are for the period from September 20, 2010 to September 25, 2012, measured at the Kamloops Brocklehurst monitoring station with a BAM 1020 Instrument.

[e] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2014). The annual values are the maximum measured annual concentrations (2014). All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Federal Building monitoring station with a BAM 1020 Instrument.

[f] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2012 and 2013). The annual values are the maximum measured annual concentrations (2011). All values are for the period from June 27, 2011 to December 31, 2013, measured at the Kamloops Fire Station #2 monitoring station with a BAM 1020 Instrument.

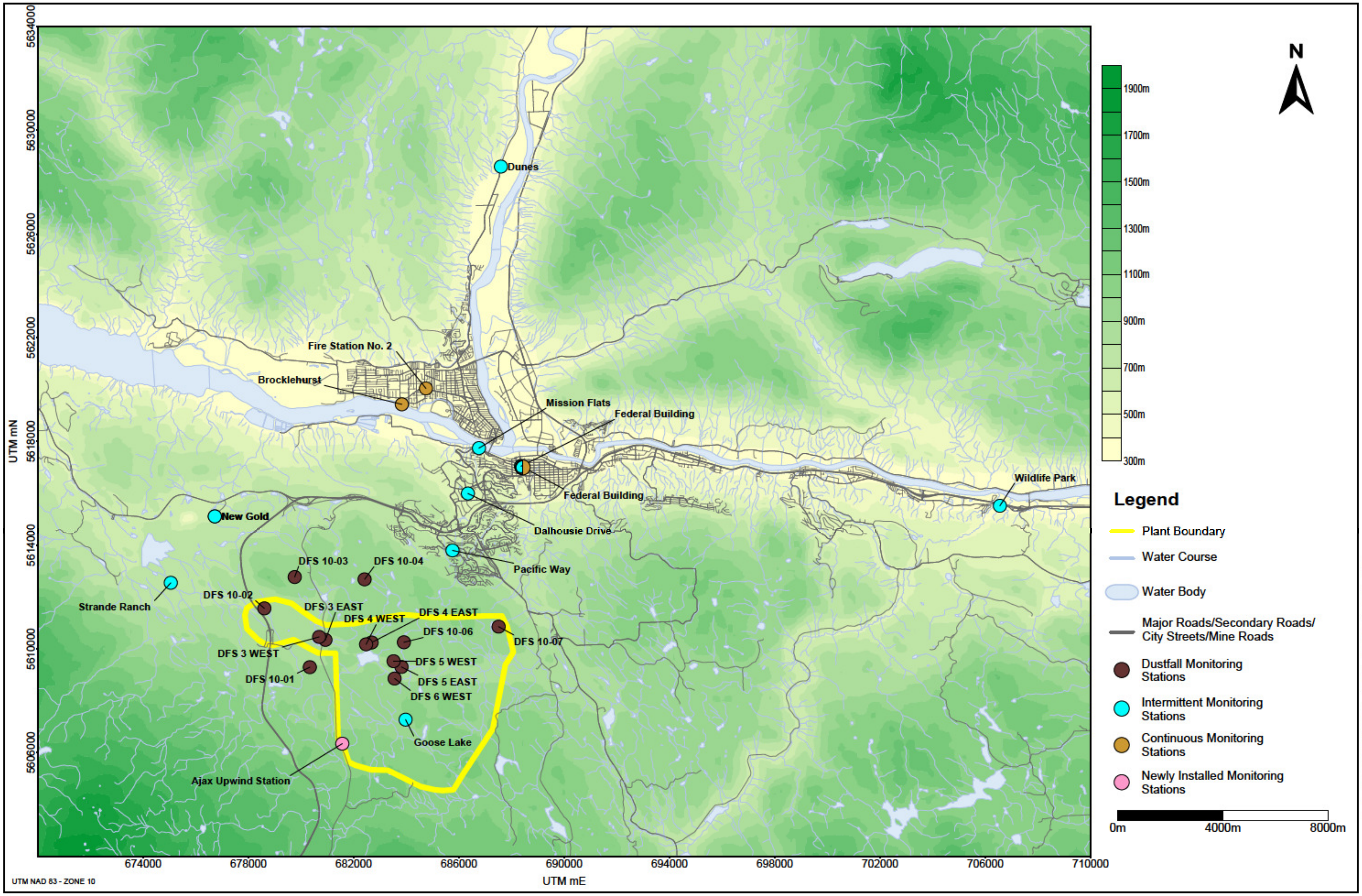
[g] For SO_2 the 1-hour and 24-hour background values are the 98th percentile measured concentrations (2012). The 3-hour background value is equal to the 1-hour value. The annual values are the maximum measured annual concentrations (2012). All values are for the period from January 1, 1998 to December 31, 2013, measured at the Kamloops Federal Building monitoring station.

[h] For NO_2 the 1-hour and 24-hour background values are the 98th percentile measured concentrations (2000). The annual values are the maximum measured annual concentrations (2006). All values are for the period from January 1, 1998 to May 29, 2012, measured at the Kamloops Brocklehurst monitoring station.

[i] For CO the 1-hour and 8-hour CO background values are the 98th percentile measured concentrations (2004).These values are for the period from January 1, 1998 to May 30, 2011, measured at the Kamloops Brocklehurst monitoring station.

[j] Applicable regulatory criteria are described in Table 3-1.

The sources for these data are spreadsheet summaries developed and distributed by the BC MOE annually. Raw data are also available at http://envistaweb.env.gov.bc.ca/ (BC MOE 2013b).



KGHM Ajax Air Quality Assessment
Technical Data Report

Location of Background Air Quality Monitoring Stations

PREPARED BY
Stantec

PREPARED FOR
KGHM

FIGURE NO.
2.2-1

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Last Modified: 05/11/2015 By: KW

Levels of SO_2, NO_2, and CO are always less than the applicable regulatory criteria. Particulate matter concentrations (TSP, PM_{10}, and $PM_{2.5}$) are most often below the criteria. When they are above the criteria external forces are most often the cause (e.g., forest fire, dust storms). At times however local domestic/industrial emissions can accumulate under periods of poor dispersion to levels above the criteria.

It is important to recognize that, consistent with Section 10.1.5 of the *Guidelines* (BC MOE 2008) the background 1-hour, 8-hour, and 24-hour values are the 98th percentile of the measured concentrations. The annual values are the maximum measured annual concentrations. Often these are years dominated by a single event such as a nearby forest fire (e.g., the 2003 Rayleigh fires) or some other phenomenon (e.g., an unusually persistent period of air stagnation, strong winds, or greater than normal emissions from existing sources).

Intermittently measured TSP and dustfall data were requested from the BC MOE. This includes historic Ministry dustfall measurements from the City of Kamloops and surrounding area, and intermittent particulate monitoring undertaken by the Ministry and/or Permit holders in the area. KAM approached the BC MOE seeking these data and were informed that these intermittently-collected data could not be located.

Table 2-3 lists the station location, parameters measured, and other information. Consistent with Section 10.1.5 of the *Guidelines* (BC MOE 2008) the 24-hour background values are represented by the 98th percentile of the measured concentrations. Other statistical metrics are reported for reference purposes. The average values are the period average of all measured concentrations, and is a good proxy for the annual average value.

Table 2-4 presents background values based upon intermittent particulate matter measurements taken at nine Kamloops air quality monitoring stations, one of which is permanent and the remainder of which are temporary. This satisfies a requirement of Interior Health (2012) which "requested that a year of measured background data (specifically $PM_{2.5}$) be provided from residential receptor sites within the immediate study area." The BC MOE have provided suitable data, presented below.

Individual station measurements only represent a one to three year interval in the 11 year record (1994 to 2004). These particulate matter measurements are not directly intercomparable as they are not paired in time, however they do illustrate some important geographic trends. For example, the greater measured values are found at stations that are closer to the City of Kamloops and are at lower elevations. Stations farther away from the city, and at higher elevations, have values less than the measurements near the City (the valley bottom)—approximately one-third of what is measured in the valley bottom.

Table 2-3 Intermittent Particulate Matter Monitoring Stations in Kamloops

Station Name	Parameter	Location (UTM Zone 10)		Elevation	Sampling Dates		24-h Samples	
		(mN)	(mE)	(masl)	Start	End	Possible	Collected
Dunes	$PM_{2.5}$	5,628,598	687,591	353	3-Feb-04	26-Aug-05	96	86
Mission Flats	$PM_{2.5}$	5,617,741	686,757	354	4-Jan-12	31-Aug-12	129	116
Federal Building	$PM_{2.5}$	5,617,046	688,358	362	1-Oct-05	19-Dec-06	75	66
Dalhousie Drive	$PM_{2.5}$	5,615,994	686,337	542	12-Apr-07	10-Oct-09	153	140
Wildlife Park	$PM_{2.5}$	5,615,521	706,554	355	1-Oct-05	27-Nov-09	254	221
New Gold	$PM_{2.5}$	5,615,113	676,719	684	9-Feb-12	30-Jan-15	121	117
	PM_{10}	5,615,113	676,719	684	9-Feb-12	30-Jan-15	121	115
Pacific Way	$PM_{2.5}$	5,613,791	685,753	747	3-Feb-04	26-Aug-05	96	90
Strande Ranch	PM_{10}	5,612,544	675,045	739	3-Jun-13	29-May-14	61	53
Goose Lake	$PM_{2.5}$	5,607,271	683,968	975	3-May-12	28-May-13	66	62
	PM_{10}	5,607,271	683,968	975	3-Jun-13	29-May-14	61	60

Table 2-4 Background or Reference Concentrations of Intermittently Monitored Particulate Matter in Kamloops

Station Name	Parameter	Mean	Maximum	Percentiles						24-h Samples:	
				98th	90th	75th	50th	25th	10th	Missing	@ LOD
Dunes	$PM_{2.5}$	6.5	18.9	15.6	11.7	8.9	7.0	3.3	2.0	10%	15%
Mission Flats	$PM_{2.5}$	6.7	38.5	21.9	12.3	7.7	5.7	4.2	3.2	10%	2%
Federal Building	$PM_{2.5}$	7.8	37.0	24.8	15.5	9.8	6.7	3.3	2.7	12%	8%
Dalhousie Drive	$PM_{2.5}$	6.0	39.2	16.4	11.0	6.8	5.7	3.1	2.1	8%	8%
Wildlife Park	$PM_{2.5}$	6.1	35.0	17.4	12.0	7.3	5.9	3.3	2.0	13%	10%
New Gold	$PM_{2.5}$	5.1	70.4	11.1	8.1	6.2	4.5	2.2	2.0	3.3%	18%
	PM_{10}	12.3	85.0	37.3	22.0	14.2	10.5	6.5	4.1	5.0%	2%
Pacific Way	$PM_{2.5}$	5.8	24.1	19.9	11.3	7.3	5.4	0.0	2.3	6%	20%
Strande Ranch	PM_{10}	6.9	21.2	12.9	10.6	8.6	7.6	4.5	3.2	13%	5%
Goose Lake	$PM_{2.5}$	3.2	10.3	8.2	5.7	3.6	3.0	2.0	2.0	6%	39%
	PM_{10}	4.6	10.8	9.1	7.7	6.0	4.9	2.5	2.0	2%	15%
NOTE: all measurements in micrograms per cubic metre ($\mu g/m^3$)											

Site-specific monitoring of dustfall was undertaken on behalf of KAM. Knight-Piesold (Eagen 2012, pers. comm) established 13 dustfall monitoring stations in August 2007 around the old Afton Mine Site. Dustfall samples were collected monthly between August 2007 and September 2008, after which quarterly sampling was initiated, lasting until October of 2009. Seven of the dustfall stations were then relocated to characterize baseline conditions surrounding the Project footprint. Sampling frequency returned to monthly at that time.

The background rate of deposition of dustfall in Kamloops is presented in Table 2-5. Table 2-6 lists the station locations and the range of dates over which data was collected. Figure 2.2-1 illustrates the location of the background dustfall monitoring stations.

At these sites, total dustfall and 33 metals were measured and the deposition rate (mg/dm^2/day) determined. These data were collected by Knight-Piesold (Eagen 2012, pers. comm), and provided to Stantec. These data were re-analyzed by Stantec to establish a background value for dustfall for the region. These values range from an average of 0.119 mg/dm^2/day (Calcium) to 0.0000006430 mg/dm^2/day (Silver).

For the Human Health and Ecological Risk assessment (HHERA), background metals deposition rates are added to the Base Case metals deposition rates. These are derived from the average of the 33 metals measured coincident with the dustfall rate in Table 2-5.

Table 2-5 Background Dustfall Deposition Rate

Substance	Averaging Period	Background Deposition
Dustfall (mg/dm^2/day) [a]	30 day	0.8

NOTE:

[a] The 30-day dustfall deposition rate is the average of 276 monthly measurements collected at 13 sites on or near the proposed mine for the period from August, 2007 to August 2012 (5 years).

Table 2-6 Stations Employed to Calculate the Deposition of Dustfall in Kamloops

Stations	Date Range		Location (UTM Zone 10)		Elevation
	Start	End	(mE)	(mN)	(masl)
DFS 10-01	11/6/2010	8/27/2012	680,329.03	5,609,293.03	913
DFS 10-02	11/6/2010	8/27/2012	678,601.99	5,611,558.05	822
DFS 10-03	11/6/2010	8/27/2012	679,754.97	5,612,765.99	964
DFS 10-04	11/6/2010	8/27/2012	682,409.99	5,612,677.03	955
DFS 10-06	11/6/2010	8/27/2012	683903.99	5610252.05	942
DFS 10-07	11/6/2010	8/27/2012	687504.02	5610854.05	978
DFS 3 EAST	8/27/2007	10/6/2010	680922.00	5610344.05	865
DFS 3 WEST	8/27/2007	10/6/2010	680683.00	5610459.02	855
DFS 4 EAST	8/27/2007	10/6/2010	682676.98	5610242.98	909
DFS 4 WEST	8/27/2007	10/6/2010	682468.02	5610173.03	903
DFS 5 EAST	8/27/2007	10/6/2010	683813.01	5609302.05	896
DFS 5 WEST	8/27/2007	10/6/2010	683512.02	5609523.03	921
DFS 6 WEST	8/27/2007	10/6/2010	683550.99	5608854.98	898

2.2.2 Measured Global/Regional Background

As discussed in Section 1.2 measured global/regional background concentrations are added to the predicted Base Case concentrations. Since only those sources in the CALPUFF domain are being modelled in the Base Case, background values based on a low percentile of continuously monitored gases and particulate matter in Kamloops are added (the global/regional background). This conservatively accounts for the global and regional background – substances that are already in the air when it enters the CALPUFF domain but are not captured by the modelling.

Table 2-7 presents global/regional background values based upon continuous gas and particulate matter measurements taken at three permanent Kamloops air quality monitoring stations. Background values are listed for averaging intervals employed in the applicable regulatory criteria (Table 3-1). The 1 hour values are 50th percentile measured, the 24-hour values are the 25th percentile measured, and the annual values are the 10th percentile measured 24-hour concentrations.

Table 2-7 Global/Regional Background Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

Substance	Averaging Period	Background Concentration
TSP (µg/m³) [a] Kamloops Federal	24-hours	**25.4**
	Annual	**20**
PM_{10} (µg/m³) [b] Brocklehurst	24-hours	**9.6**
$PM_{2.5}$ (µg/m³) [c] Brocklehurst R&P TEOM	24-hours	2.7
	Annual	1.8
$PM_{2.5}$ (µg/m³) [d] Brocklehurst BAM	24-hours	2.8
	Annual	1.8
$PM_{2.5}$ (µg/m³) [e] Kamloops Federal BAM	24-hours	**5.3**
	Annual	**3.8**
$PM_{2.5}$ (µg/m³) [f] Kamloops Fire Station #2 BAM	24-hours	4.3
	Annual	3.1
SO_2 (µg/m³) [g] Kamloops Federal	1-hour	**1.5**
	24-hours	**1.3**
	Annual	**0.9**
NO_2 (µg/m³) [h] Brocklehurst	1-hour	**15.3**
	24-hours	**10.8**
	Annual	**7.0**
CO (µg/m³) [i] Brocklehurst	1-hour	**208**
	8-hours	**150**

Table 2-7 Global/Regional Background Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

NOTES:

Values in **boldface** identify the selected concentration added to Base Case results.

The Global/Regional rate of dustfall deposition is conservatively assumed to be equal to the Background rate of dustfall deposition depicted in Table 2-5.

[a] For TSP the 24-hour background value is the 5-year average 25th percentile measured concentration. The annual value is the 5-year average measured 10th percentile 24-hour concentration. All values are for the period from January 1, 1994 to December 31, 1998, measured at the Kamloops Federal Building monitoring station.

[b] For PM_{10} the 24-hour background values are the average 25th percentile measured 24-hour concentrations. All values are for the period from January 1, 1994 to June 18, 2009, measured at the Kamloops Brocklehurst monitoring station.

[c] For $PM_{2.5}$ (TEOM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 1998 to June 5, 2011, measured at the Kamloops Brocklehurst monitoring station with an R&P TEOM Instrument.

[d] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Brocklehurst monitoring station with a BAM 1020 Instrument.

[e] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Federal Building monitoring station with a BAM 1020 Instrument.

[f] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from June 27, 2011 to December 31, 2013, measured at the Kamloops Fire Station #2 monitoring station with a BAM 1020 Instrument.

[g] For SO_2 the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 3-hour background value is equal to the 1-hour value. The 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2010 to December 31, 2013, measured at the Kamloops Federal Building monitoring station.

[h] For NO_2 the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 1998 to May 29, 2011, measured at the Kamloops Brocklehurst monitoring station.

[i] For CO the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 8-hour background values are the average 25th percentile measured 8-hour concentrations. These values are for the period from January 1, 1998 to May 30, 2011, measured at the Kamloops Brocklehurst monitoring station.

The sources for these data are spreadsheet summaries developed and distributed by the BC MOE annually. Raw data are also available at http://envistaweb.env.gov.bc.ca/ (BC MOE 2013b).

2.2.3 Respirable Particulate Matter ($PM_{2.5}$) Trends

Since particulate matter concentrations greater than the ambient criteria have been measured in the region, the temporal trends associated with $PM_{2.5}$ concentration are further expanded. Since ambient SO_2, NO_2, and CO are less than the respective ambient criteria, the associated temporal analysis has not been conducted.

Temporal trends of ambient levels of $PM_{2.5}$ in Kamloops and compliance with the Canadian Ambient Air Quality Standards (CAAQS – See Section 3.1.1) plus the Health Canada SUM15 metric are described in this section.

The CAAQS for 24-hour $PM_{2.5}$ is referenced to the annual 98th percentile of daily 24-hour average concentrations, averaged over three years. The CAAQS for annual $PM_{2.5}$ is referenced to the 3-year mean of annual average concentrations. The CAAQS of 28 µg/m^3 (first shown in Table 3-1) is the standard effective in 2015 (Environment Canada 2013).

The Health Canada SUM15 metric facilitates a comparison of effects attributable to current $PM_{2.5}$ concentrations between a number of Canadian Cities. The SUM15 metric is estimated by initially summing all 24-hour concentrations above 15 µg/m^3, the $PM_{2.5}$ Reference Level or "No Observable Adverse Effect Level" (NOAEL). On an annual basis this metric, referred to as SUM15, is calculated as follows:

$$\text{SUM15 } (\mu g/m^3\text{-days}) = \Sigma([PM_{2.5}]\text{daily - 15})$$

The annual SUM15 is then multiplied by the risk associated with a 1 µg/m^3 increase in $PM_{2.5}$ and then multiplied by the baseline incidence rate for a given health endpoint (Health Canada 1999).

The 15 µg/m^3 Reference Level is derived statistically and should be interpreted as levels above which there is statistical confidence in the concentration-response relationship and a subsequent ability to provide quantification of adverse effects. The Reference Levels should not be interpreted as a threshold of effects. Below the Reference Levels, a statistically significant confidence interval cannot be established for the relationships between ambient $PM_{2.5}$ and the observed health effects (Health Canada 1999).

Table 2-8 includes summary statistics for $PM_{2.5}$ by year, and calculated CWS and SUM15 statistics for Kamloops Brocklehurst. Many of the metrics in this data series peak in 2003. The 98th percentile 24-hour averages are above average, as are the SUM15 metrics. Unprecedented wildfire activity within Kamloops City limits had an appreciable effect on particulate air quality in 2003 (the Rayleigh fire). In 2002 and 2010 high annual average $PM_{2.5}$ values were observed, and wildfires are again suspected as the cause. In 2011 to 2014 high $PM_{2.5}$ concentrations were also observed. During this time $PM_{2.5}$ was measured by the BAM1020 which often reports higher concentrations than the TEOM (EC 2014).

Table 2-8 Annual Summary Statistics for $PM_{2.5}$ CAAQS and SUM15 Thresholds in Kamloops

	Annual Average	Maximum 24-hour	98th Percentile 24-hour	3-year Rolling Average [b]	Days above 15 µg/m³	SUM15 metric (annual)
Year	(µg/m³)	(µg/m³)	(µg/m³)	(µg/m³)	(No.)	(µg/m³)
1997[a]	5.8	17.6	10.9	-	1	2.6
1998 [a]	5.6	35.4	15.7	-	11	57.5
1999 [a]	4.7	18.1	11.0	13.2	3	7.9
2000 [a]	5.6	18.2	14.4	14.4	8	11.3
2001 [a]	5.3	15.3	12.6	13.6	1	0.3
2002 [a]	6.7	28.2	18.8	16.2	23	108.6
2003 [a]	7.9	140.1	30.4	25.0	30	569.7
2004 [a]	5.7	29.5	15.9	26.4	14	63.1
2005 [a]	4.7	16.0	12.7	24.0	3	2.2
2006 [b]	5.1	31.9	16	18.4	8	36.9
2007 [b]	4.9	18.2	14	19.3	6	5.0
2008 [b]	5.0	19.3	14.1	21.3	6	11.9
2009 [b]	5.7	61.8	24.6	28.2	16	196.9
2010 [c]	10.0	92.9	43.3	-	26	449.2
2011 [d]	7.7	23.5	18.4	-	21	66.3
2012 [d]	8.0	32.6	19.3	19	21	76.7
2013 [d]	8.9	25.8	21.3	20	39	142.3
2014 [d]	9.1	61.4	28.2	23	35	289.1
Average	5.6	33.1	15.2	18.3	15.9	123.2
Maximum	7.9	140.1	30.4	26.4	39	569.7
Minimum	4.4	12.6	9.3	13.2	1	0.3

NOTES:

[a] 1997-2005 data from BC MOE ADAMS System – Brocklehurst PM25_R&P_TEOM

[b] 2006-2009 data from BC MOE Data Summaries (source below) – Brocklehurst PM25_R&P_TEOM

[c] 2010 data from BC MOE Data Summaries (source below) – Brocklehurst PM25_R&P_TEOM to May 31, then Federal Building BAM1020 to Dec 31.

[d] 2011-2014 data from BC MOE Data Summaries (source below) – Federal Building BAM1020

The sources for these post 2005 data are spreadsheet summaries developed and distributed by the BC MOE annually. Raw data are also available at http://envistaweb.env.gov.bc.ca/ (BC MOE 2013b).

In the Health Canada study (1999, Table 4) the maximum SUM15 values observed in a three-year period (January 1992 through December 1994) are presented for eighteen Canadian cities. The SUM15 values range between 179 (Sutton, near Montreal, Quebec) and 3,474 (Walpole Island, near Windsor, Ontario). Table 2-9 presents the rank-ordered SUM15 data from Health Canada (1999) and includes the average SUM15 metric for Kamloops from Table 2-8.

Table 2-9 Annual SUM15 Metric for 18 Canadian Cites (after Health Canada, 1999) compared to the Average for Kamloops

Station ID	Location	Annual SUM15
61901	Walpole Is.	3,474
60512	Hamilton	2,442
60211	Windsor	2,006
60424	Toronto	1,728
50109	Montreal	1,661
60204	Windsor	1,350
50104	Montreal	946
64401	Egbert	714
60104	Ottawa	709
100111	Vancouver	662
70119	Winnipeg	396
30501	Kejimkujic	375
90130	Edmonton	321
40203	Saint John	309
30118	Halifax	303
100303	Victoria	291
90227	Calgary	214
54101	Sutton	179
Various	Kamloops	123

NOTES:

For the eight Health Canada (1999) locations SUM15 represents average values observed over a three year period (January 1992 through December 1994),

For Kamloops SUM15 represents average values observed over an eighteen year period (January 1997 through December 2014). From Jan 1 1997 to May 31 2010 data collected at Brocklehurst was employed, and the Federal Building data was employed thereafter.

The maximum annual SUM15 value in Kamloops is 569.7 (2003–the year of the Rayleigh fire). The minimum annual SUM15 value in Kamloops is 0.3 (2001). The 1997-2014 average SUM15 is 123.2. Using this latter value for comparison to the SUM15 values in Health Canada (1999) Kamloops ranks below the lowest of the eighteen Cities cited (Sutton at 179).

There is an increase in the SUM15 metric from 2010 onward that is attributable in part to a change in monitoring technology that year. 2010 is the year that $PM_{2.5}$ monitoring in Kamloops transitioned from an R&P TEOM to a BAM 1020 monitor. It's well known the R&P TEOM under predicts $PM_{2.5}$ as compared to the BAM $PM_{2.5}$ measurement– particularly in winter (EC, 2014). This is attributable to the semi-volatile fraction being lost by the TEOM as a result of sample stream heating—a necessary action to eliminate moisture from the TEOM gravimetric sensor. The BAM relies on a Beta attenuation technology and does not require sample stream heating; hence it captures the semi-volatile fraction of $PM_{2.5}$ that the TEOM eliminates by heating the sample stream.

This work reveals that exposure to ambient respirable particulate matter ($PM_{2.5}$) in Kamloops is better than any of the 18 cities studied (Health Canada 1999). Forest fires appear to be a major factor in elevating the SUM15 and other $PM_{2.5}$ metrics above the typical background concentrations.

2.3 CLIMATE AND METEOROLOGY

Climate

Climate is defined as the weather conditions prevailing in an area over a long time period. The region's climate is continental, with cold winters, and warm, sometimes hot summers. Precipitation is sparse and distributed relatively evenly throughout the year, excepting summer when showers and thunderstorms give an edge to the summer (Phillips 1990).

It is important to understand the local climate, as it has an influence on many aspects of the Project. Snow, rain and evaporation dictate the water balance of the site and therefore the moisture content of non-vegetated surfaces such as roadways. This has a direct bearing on the potential of roadways and other features to generate dust, and therefore the need for watering as mitigation.

The climate of the Project site was characterized using the 30-year Canadian Climate Normals (1971-2000) for two stations: Kamloops Airport and Kamloops Afton Mines (Environment Canada 2010). The Kamloops Airport Canadian Climate Normals Station (CCNS) is in the Thompson River valley at an elevation of 345 masl. The Kamloops Afton Mines CCNS is out of the valley, on the gently rolling Thompson Plateau at an elevation of 701 masl. The complete CCN summaries for these two stations are presented in **Appendix A**. The temperature and precipitation data are described below briefly.

Air Temperature

The daily average temperature at Kamloops Airport is 8.9°C. January is the coldest month, and July is the warmest (-4.2°C and 21.0°C daily average temperature). Extreme temperatures vary from -37.2°C (Jan 29, 1969) to 40.6°C (July 31, 1971).

The daily average temperature at Kamloops Afton Mines is 7.0°C. January is the coldest month, and July is the warmest (-5.9°C and 19.1°C daily average temperature). Extreme temperatures vary from -34.0°C (Dec 29, 1990) to 39.0°C (July 19, 1979).

The temperature patterns are similar, but exhibit differences attributable to the elevation change of 356 metres between stations. The daily average temperature decreases by 1.9°C from Kamloops Airport to Kamloops Afton Mines or 0.53°C/100 m elevation gained.

Precipitation

The annual precipitation at Kamloops Airport is 27.9 cm, of which 78% falls as rain. June is the wettest month (3.52 cm), and March is the driest (1.17 cm). The extreme daily precipitation is 4.8 cm (August 16, 1976).

The annual precipitation at Kamloops Afton Mines is 30.5 cm, of which 75% falls as rain. June is the wettest month (3.94 cm), and March is the driest (1.08 cm). The extreme daily precipitation is 3.44 cm (November 25, 1977).

Precipitation patterns are similar, but exhibit differences attributable to the elevation change of 355.7 metres between stations. Marginally more precipitation falls at higher elevation, although more falls as rain at lower elevation. More snow is observed at Kamloops Afton Mines.

Meteorology

Meteorology, on the other hand, is the study of the changes in wind speed and direction, temperature, air pressure, humidity and other parameters in the atmosphere. Local meteorological conditions influence the transport and dispersion of Project air emissions. Wind speed, wind direction, and atmospheric turbulence are major meteorological elements that influence the transport and dispersion of particulate and gaseous emissions.

Hourly-averaged meteorological data from surface stations for the modelling period was provided by Environment Canada (EC), British Columbia Ministry of the Environment (BC MOE), BC Forest Service (BCFS) and BC Ministry of Transportation (BC MOT). These meteorological data were utilized specifically in dispersion modelling, and are discussed in detail in Section 4.2 and the CALMET Appendix (**Appendix C**).

Of specific interest in the air quality assessment are patterns of wind direction and wind speed. Specifically, the BC MOE (Adams 2013, pers. comm.) have requested that windroses be generated using CALMET output for seven locations in the modelling domain. The locations are listed in Table 4-2, and the windroses are presented in Section 4.3.

3.0 SUBSTANCES OF INTEREST SELECTION

The substances of interest (SOI) that are considered in the Air Quality Assessment are discussed in Section 3.1. The SOI for the Air Quality Assessment are modelled for gridded receptors in the CALPUFF domain. The results of this work are discussed in Section 5.

The contaminants of concern (COCs) that are considered in the HHERA are discussed in Section 3.2. The COCs for the HHERA are modelled at discrete 'special receptors' in the CALPUFF domain. The results of this work are discussed in the HHERA (Appendix 10.4-A of the EAC Application).

3.1 SUBSTANCES OF INTEREST SELECTED FOR THE AIR QUALITY ASSESSMENT

The substances of interest emitted by the Project that are considered in this air quality assessment are discussed in this section. They include substances deemed through application of professional judgement to be potentially capable of resulting in a deleterious effect in the receiving environment. They were selected based upon the quantities emitted (whether large or small) and previous experience with similar projects. The selected substances were vetted by the Ajax Project Health Sub-Committee and approved by the BC Ministry of Environment as part of the detailed model plan (**Appendix B**).

These substances are included in the modelling of both gridded and special receptors. The gridded receptors, special receptors, and the domain sizes are described in Sub-Section 4.4.1. These substances are commonly known as criteria air contaminants (CAC – see Section 3.1.1). They include:

- Total dustfall (DF)
- Total suspended particulates (TSP)
- Inhalable particulate matter (10 microns or less in aerodynamic diameter or PM_{10})
- Respirable particulate matter (5 microns or less in aerodynamic diameter or $PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Oxides of nitrogen (NO_X)
- Carbon monoxide (CO)

Details on each of the selected SOI are discussed below. Section 3.1.1 describes the regulatory criteria applicable to the selected SOIs.

Dustfall refers to the surface accumulation of large particulate matter, generally larger than 40 μm in diameter. Nearly all Project activities that result in emissions of particulate matter (PM) emit some fraction larger than 40 μm, resulting in the deposition of dustfall. Dustfall also originates from natural sources and processes such as the erosion of soils and other crustal materials. The chemical composition of dustfall varies widely.

The Project's dustfall is mainly the result of PM emissions from both unpaved road vehicle travel and mining activities. While combustion sources like heavy equipment generates PM emissions, these emissions are mainly is the respirable range ($PM_{2.5}$). Fine particles remain airborne for much longer periods of time and are dispersed much further afield. Combustion sources are therefore a small portion of dustfall predictions. For this assessment dustfall is assumed equivalent to TSP wet and dry deposition predicted by CALPUFF.

The BC dustfall objective is averaged over 30 days. Daily TSP emission rates were used in the dispersion simulations, and the wet and dry deposition results were block-averaged over 30 days to produce the dustfall predictions.

Particulate Matter (PM) is characterized based on the diameter of the particle and includes TSP, PM_{10} and $PM_{2.5}$, Depending on their size and aerodynamic properties particles may remain suspended in the air for a few seconds or indefinitely. Generally, large particles settle out close to the source. TSP is generally defined as particles less than 40 µm in diameter, PM_{10} is less than 10 µm, and $PM_{2.5}$ is defined to be equal or less than 2.5 µm.

In recent years, the air quality and epidemiological communities have shifted their research interests from TSP to PM_{10} and then to $PM_{2.5}$ as a result of concerns related to human health effects. Very fine particles can penetrate deep into the respiratory tract where removal processes are not efficient. Large particles are trapped in the nose and throat and are efficiently removed.

Short-term exposure to above normal concentrations of $PM_{2.5}$ can irritate the lungs and cause lung constriction, producing shortness of breath and coughing. Long-term exposure can lead to asthma, lung disease, decreased lung function, and cardiovascular problems (American Lung Association 2006).

During construction, PM emissions are caused mostly by site clearing and grubbing, soil salvaging and stockpiling, site grading, borrow area development, camp and haul road construction, and surface disruption from vehicle movement. Combustion-related PM emissions are generated mainly by heavy equipment exhaust.

In the Operations Case dust related TSP, PM_{10} and $PM_{2.5}$ emissions as a result of open pit mining, ore processing activities, and surface disruption from vehicle movement. Combustion-related PM emissions are generated mainly by heavy equipment exhaust.

Sulphur Dioxide (SO_2) is a colourless gas with a distinctive pungent sulphur odour at high concentrations. It is produced in combustion processes by the oxidation of diesel fuel containing sulphur. At high enough concentrations, SO_2 can have negative effects on plant and animal health, particularly with respect to their respiratory systems. In addition, SO_2 can be further oxidized and may combine with water to form sulphuric acid, another constituent of acid rain. Project SO_2 emissions result from internal combustion of diesel fuel by heavy equipment. Diesel fuel contains trace amounts of sulphur.

Nitrogen Dioxide (NO_2) is produced in most combustion processes including in the operation of internal combustion engines. NO_2 is an orange to brown gas that is corrosive, and irritating at high concentrations. Most NO_2 in the atmosphere is formed by the oxidation of nitric oxide (NO), which is emitted directly by diesel fuel combustion processes in internal combustion engines. The levels of NO and NO_2, and the ratio of the two gases, together with the presence of hydrocarbons and sunlight, are the most important factors in the formation of ground-level ozone and other oxidants. Oxidation in combination with atmospheric water forms nitric acid, a constituent of acid rain.

Project-related NO_X emissions result from the operation of heavy equipment required during ore handling, and from blasting.

Carbon Monoxide (CO) is a colourless, odourless gas and is a product of incomplete combustion from internal combustion engines. Project CO emissions result from the operation of vehicles and additional support equipment required during ore handling, and from blasting. As an air contaminant, CO is regulated by both BC and Canada. The regulatory criteria for CO permit relatively high concentrations, a reflection of its low toxicity at ambient concentrations.

Project-related CO emissions result from the operation of heavy equipment required during ore handling.

Ozone (O_3) and Secondary $PM_{2.5}$ formation is not be modelled in this assessment. Further information on this subject is available in the detailed dispersion modelling plan (**Appendix B**).

3.1.1 Ambient Air Quality Objectives and Standards

The effect of the Project on air quality is determined in part by comparing predicted concentrations to ambient air quality objectives that have been established to protect human health and the environment.

The province of BC uses a suite of ambient air quality criteria that have been developed provincially and nationally to inform decisions on the management of air contaminants. These include Provincial Air Quality Objectives (AQOs), the former Pollution Control Objectives (PCOs), National Ambient Air Quality Objectives (NAAQOs) and Canadian Ambient Air Quality Standards (CAAQS) (BC MOE 2014). These are collectively referred to as 'applicable regulatory criteria' or 'criteria'.

The Canada (Federal) and BC Ambient Air Quality Objectives (AAQO) are shown in Table 3-1. The Canada objectives are denoted as Desirable, Acceptable and Tolerable. The BC objectives are denoted as Levels A, B and C. Note that the Canada and BC AAQO for some substances are similar.

The Canada AAQOs are defined as follows:

- The **Maximum Desirable Level** is the long-term goal for air quality and provides a basis for anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.
- The **Maximum Acceptable Level** is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.
- The **Maximum Tolerable Level** denotes time- based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population.

The BC AAQOs are defined as follows:

- **Level A** is set as the objective for new and proposed discharges and, within the limits of best practicable technology, to existing discharges by planned staged improvements for these operations.
- **Level B** is set as the intermediate objective for all existing discharges to meet within a period of time specified by the Director (BC MOE), and as an immediate objective for existing discharges which may be increasing in quantity or altered in quality as a result of process expansion or modification.
- **Level C** is set as the immediate objective for all existing chemical and petroleum industries to reach within a minimum technically feasible period of time.

In 1979 BC established pollution control objectives (PCOs) for the mining, smelting, and related industries (BC MOE 1979). Table 3-1 lists objectives for dustfall that are derived from this document. It specifies a range in values that have been portrayed as Level A and Level B. While the PCOs themselves have been rescinded the dustfall objectives continue to be employed.

In 1995, BC established an Interim Level B 24-hour Objective for PM_{10} of 50 µg/m^3 (BC MOE 2014). In 2009 BC adopted AAQO for respirable particulate matter ($PM_{2.5}$) set at 25 µg/m^3 for a 24-hour averaging period (as a 98th percentile value over one year) and 8 µg/m^3 for the annual averaging period (BC MOE 2014). BC also listed a planning goal of 6 µg/m^3 for the annual averaging period.

The CAAQS for 2015 and 2020 were adopted by the Canadian Council of Ministers of the Environment (Environment Canada 2013). The new CAAQS replace the Canada-wide Standards for $PM_{2.5}$ and ozone (O_3). A review of the 2020 CAAQS is expected in 2015.

It is important to note that the original Canada-wide Standards (CWS) were not intended to be used as a standard for predicted concentrations at facility fencelines (CASA 2003). They are intended to be employed as a means of determining potential health effects in a large census metropolitan area (population >100,000). As such, the stations to which the CWS were applied were intended to be representative of the community as a whole. These stations are carefully selected to be free of interference from nearby sources such as highways or industrial facilities (CCME 2000).

It is expected that this same principle applies to the CAAQS, as the present CAAQS are essentially the CWS renamed. This caveat applies to all objectives and standards to some extent. At a location where predicted concentrations are greater than an objective or standard, there needs be a receptor (e.g., resident population, sensitive ecosystem) capable of being affected by that substance for an adverse effect to occur.

Table 3-1 Provincial and Federal Ambient Air Quality Objectives and Standards

Substance (Units)	Averaging Period	Provincial (BC)			National (Canada)		
		AAQO			NAAQO & CAAQS [c d]		
		Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
Dustfall ($mg/dm^2/day$)	24-hour	**1.7** [e]	2.9 [e]	—	—	—	—
TSP (µg/m^3)	24-hour	**120**	200	260	—	120	400
	Annual	**60**	70	75	60	70	—
PM_{10} (µg/m^3)	24-hour	—	**50**	—	—	—	—
$PM_{2.5}$ (µg/m^3)	24-hour	**25** [a]			28 (27) [b]		
	Annual	**8** [a]			10 (8.8) [c]		
SO_2 (µg/m^3)	1-hour	**200** [f]			**450**	900	—
	24-hour [h]	—			**150**	300	800
	Annual [h]	—			**30**	60	—
NO_2 (µg/m^3)	1-hour	**188** [g]			—	**400**	1,000
	24-hour [h]	—			—	**200**	300
	Annual	**60**			60	100	—
CO (µg/m^3)	1-hour	**14,300**	28,000	35,000	15,000	35,000	—
	8-hour	**5,500**	11,000	14,300	6,000	15,000	20,000

Table 3-1 Provincial and Federal Ambient Air Quality Objectives and Standards

NOTES:

[a] The $PM_{2.5}$ 24-hour average is based on the 98th percentile value for one year.

[b] The CAAQS for 24-hour $PM_{2.5}$ is referenced to the annual 98th percentile of daily 24-hour average concentrations, averaged over three years. The first CAAQS is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).

[c] The CAAQS for annual $PM_{2.5}$ is referenced to the 3-year mean of annual average concentrations. The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).

[d] National Ambient Air Quality Objectives, or NAAQO, summarized in (CCME 1999).

[e] BC MOE 1979 Pollution Control Objectives for the Mining, Smelting, and Related Industries (BC MOE 1979). As the dustfall Objective is a daily rate referenced to a 30 day sampling interval, the Objective is referenced to the monthly averaging interval, not the daily.

[f] Achievement is based on the annual 99th percentile of daily 1-hour maxima, averaged over one year. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values.

[g] Achievement is based on the annual 98th percentile of daily 1-hour maxima, averaged over one year. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values.

[h] The BC MOE has not specified objectives for the 24-hour intervals for SO_2 or NO_2, nor has it specified an annual average objective for NO_2.

- - Indicates no applicable objective or standard specified for this Jurisdiction

Values in **boldface** identify the most stringent objectives adopted to evaluate the Project.

3.1.2 $PM_{2.5}$ Criteria from Other Jurisdictions

Table 3-2 lists criteria from the US Environmental Protection Agency (US EPA), the World Health Organization (WHO), and the European Commission (EC) $PM_{2.5}$ criteria. While not strictly applicable, goals, objectives, or standards (criteria) from other jurisdictions are often raised as a counterpoint to the applicable regulatory criteria. It's important to note that the BC AAQO for annual average $PM_{2.5}$ (8 $\mu g/m^3$) is far more stringent than the WHO (2005), US EPA (2012) and EU (EC, 2000) criteria (10, 12, and 20 $\mu g/m^3$ respectively).

Table 3-2 $PM_{2.5}$ Criteria from Other Jurisdictions

Jurisdiction	Averaging Period	Criteria (µg/m³)
US EPA	24-hour [a]	35.0
	Annual [b]	15.0
	Annual [c]	12.0
WHO	24-hour [d]	25
	Annual [e]	10
EU	Annual [f]	25
	Annual [g]	20

NOTES:

[a] The US EPA Primary Standard for 24-hour $PM_{2.5}$ was brought into existence in 2006. An area meets the 24-hour standard if the 98th percentile of 24-hour $PM_{2.5}$ concentrations in one year, averaged over three years, is less than or equal to 35 µg/m³.

[b] The US EPA Primary Standard for annual average $PM_{2.5}$ was brought into existence in 1997. An area meets the standard if the three-year average of its annual average $PM_{2.5}$ concentration (at each monitoring site in the area) is less than or equal to 15.0 µg/m³.

[c] The revised US EPA Primary Standard for annual average $PM_{2.5}$ was brought into existence in 2012. An area meets the standard if the three-year average of its annual average $PM_{2.5}$ concentration (at each monitoring site in the area) is less than or equal to 12.0 µg/m³.

[d] The WHO air quality guideline for $PM_{2.5}$ for the 24-hour average was updated in 2005. Achievement is determined based on the 99th percentile of the daily value (three 24-hour exceedances per year allowed). In addition to the guideline the WHO offer three interim targets for 24-hour average $PM_{2.5}$ (IT-1; IT-2; IT-3) that are 75, 50, and 37.5 µg/m³ respectively.

[e] The WHO air quality guideline for $PM_{2.5}$ for the annual average was updated in 2005. In addition to the guideline the WHO offer three interim targets for annual average $PM_{2.5}$ (IT-1; IT02; IT03) that are 35, 25, and 15 µg/m³ respectively.

[f] The EU Annual Standard for $PM_{2.5}$ entered into force on 01-Jan-2010.

[g] The EU Annual Limit Value for $PM_{2.5}$ becomes legally binding in 2015. Achievement is determined based on a three-year average of the annual average for 2013, 2014, and 2015.

SOURCES: US EPA 2012; WHO 2005, EC 2000

3.1.3 Air Quality Health Index

The BC MOE has implemented an Air Quality Health Index (AQHI) in BC. It is used to communicate the health risks posed by air pollution across Canada (BC MOE 2010). The AQHI is based on continuously measured concentrations of NO_2, O_3, and $PM_{2.5}$. The following equation is used to calculate the AQHI. The NO_2, O_3, and $PM_{2.5}$ concentrations are averaged over three consecutive hours. The equation requires NO_2 and O_3 concentrations to be in ppb and $PM_{2.5}$ to be expressed as µg/m³.

$$AQHI = \frac{10}{10.4} \times \left(100 \times (e^{0.000817 \times NO_2} - 1 + e^{0.000537 \times O_3} - 1 + e^{0.000487 \times PM_{2.5}} - 1)\right)$$

The AQHI has been divided into four Health Risk Categories:

- Low Health Risk – AQHI values from 1 to 3
- Moderate Health Risk – AQHI values from 4 to 6
- High Health Risk – AQHI values from 7 to 10
- Very High Health Risk – AQHI values above 10

Note that the AQHI is rounded to the nearest whole number, not truncated (i.e., 3.5 is 4).

3.2 SUBSTANCES SELECTED FOR THE HUMAN AND ECOLOGICAL HEALTH RISK ASSESSMENT

The HHERA discipline refers to their substances of interest as contaminants of concern (COCs). The COCs released by Project emission sources that are considered in the HHERA are discussed in this section. These substances are included in modelling only at discrete 'special receptors'. The discrete 'special receptors' are described in Section 4.4.1. Special receptors are also described in detail in the final dispersion modelling plan (**Appendix B**). The modelling results specific to the HHERA are not presented in this report, but contained in the HHERA Appendix 10.4-A.

The Stantec Senior Toxicologist selected the COCs based on laboratory results provided by KAM. The COCs include trace elements in the ore, mine rock, and tailings. The selection process is governed by the toxicity of the mobile portion of each substance that represents a potential human exposure or possibility for uptake into plants.

From the perspective of the HHERA assessment, the priority is the individual elements and their potential long term deposition. The toxicological benchmarks for humans and ecological receptors are based on trace element concentrations. The final identification of the COCs for the HHERA assessment depends on the concentrations of the individual elements in soil, surface water and/or sediments. The HHERA methodology is fully explained in the HHERA Detailed Modelling Plan for the KAM Ajax Mine Project (Stantec 2014).

Stantec has completed a statistical analysis of the results of ore and mine rock samples plus tailings samples to develop a list of metals and several non-metals present at low concentrations. These were derived from inductively coupled plasma mass spectrometry (ICP MS) test performed for and supplied by KAM. A total of 58 elements were detected.

For the ore samples and mine rock samples, the upper 95% confidence limit for mean (95% UCLM) of all individual species from ore assay results were employed as a basis for emission calculations. The 95% UCLM was obtained using the US EPAs ProUCL statistics package as per US EPA guidance (http://www.epa.gov/osp/hstl/tsc/software.htm).

A Step 1 and Step 2 Screening of the elements has been conducted by the Stantec Senior Toxicologist to eliminate the elements that do not represent a concern for human or ecological health based on the use of toxicity reference values (TRV) and techniques discussed in Richardson and Wilson (BC MOE 2013a). These substances can include essential nutrients such as magnesium and phosphorus.

The COCs for the HHERA assessment (Table 3-3) include 14 metals in dustfall as a rate of deposition per unit area, they include:

Table 3-3 Fourteen Selected Metal COCs for the HHERA

Antimony (Sb)	Mercury (Hg)
Arsenic (As)	Molybdenum (Mo)
Cadmium (Cd)	Nickel (Ni)
Cobalt (Co)	Selenium (Se)
Chromium (Cr)	Tin (Sn)
Copper (Cu)	Vanadium (V)
Lead (Pb)	Uranium (U)

As well as ore, mine rock, and tailings, diesel emissions are known to contain some metals. These metals are included in the dispersion assessment where emission factors are available.

Each source on the mine site has one of these metals profiles associated with it. For example, roadways are assumed to have the mine rock metals profile; the pit is assigned the ore profile; the TSF is assigned the tailings profile. The air quality discipline hands off to the HHERA team total dustfall broken down into four rates of deposition to which they apply the pertinent metals profile to calculate total metals deposition.

Metals and several non-metals indicated in the data provided by KAM, but have been screened out of the assessment by the Stantec Senior Toxicologist (Table 3-4). The screening process is outlined in the final dispersion modelling plan (**Appendix B**).

Table 3-4 Metal and Non Metals Screened out of the HHERA Assessment

Aluminum (Al)	Gold (Au)	Phosphorus (P)	Tantalum (Ta)
Barium (Ba)	Hafnium (Hf)	Platinum (Pt)	Tellurium (Te)
Beryllium (Be)	Indium (In)	Potassium (K)	Terbium (Tb)
Bismuth (Bi)	Iron (Fe)	Rhenium (Re)	Thallium (Tl)
Boron (B)	Lanthanum (La)	Rubidium (Rb)	Thorium (Th)
Caesium (Cs)	Lithium (Li)	Scandium (Sc)	Titanium (Ti)
Calcium (Ca)	Lutetium (Lu)	Silicon (Si)	Tungsten (W)
Cerium (Ce)	Magnesium (Mg)	Silver (Ag)	Ytterbium (Yb)
Fluorine (F)	Manganese (Mn)	Sodium (Na)	Yttrium (Y)
Gallium (Ga)	Niobium (Nb)	Strontium (Sr)	Zinc (Zn)
Germanium (Ge)	Palladium (Pd)	Sulphur (S)	Zirconium (Zr)

The COCs for the HHERA also includes:

i. The following CACs:

- Total dustfall (DF)
- Total suspended particulates (TSP)
- Inhalable particulate matter (10 microns or less in aerodynamic diameter or PM_{10})
- Respirable particulate matter (5 microns or less in aerodynamic diameter or $PM_{2.5}$)

ii. The following Hazardous Air Pollutant (HAP):

- Polynuclear Aromatic Hydrocarbon species (PAH) expressed as Benzo (a) Pyrene (B(a)P) equivalent (as a mass concentration in air). B(a)P equivalent is a proxy for 'diesel particulate matter' for which there are no applicable criteria. Diesel particulate matter' is a complex mixture of various organic carbon species, of which PAHs represent the group of compounds of greatest concern. All PAH species have an associated toxicity factor, expressed as a ratio of their toxicity compared to B(a)P. PAH are assessed as a single COC by expressing all PAH species as a B(a)P equivalent.

Other substances screened out of the HHERA following consideration include crystalline silica plus four reagents employed in the process of isolating minerals from the ore. They are discussed in detail in the final dispersion modelling plan (**Appendix B**).

Assessment of Project Greenhouse Gas (GHG) emissions generated by the Project is not within the scope of this report, and is considered elsewhere in the Application (Section 6.1 of the EAC Application).

4.0 DISPERSION MODELLING

Dispersion simulations, including transport, transformation, and deposition, predict the interactions between the emissions and the meteorology for any given hour and determine how concentrations and depositions vary across the assessment area in response to terrain and other surface factors. The location and magnitude of the maximum CAC concentrations within the modelling domain are of particular importance. The quantified effects provide basic information required to assess the predicted change in air quality with respect to the applicable regulatory criteria (Section 3.1).

4.1 DISPERSION MODEL SELECTION

The CALPUFF dispersion model system was used for this assessment. It is a refined model that applies terrain and meteorological data, and employs improved plume rise (improved upon from other available models), dispersion and terrain algorithms. The CALPUFF model is a non-steady-state Gaussian puff dispersion model that incorporates simple chemical transformation mechanisms, complex terrain algorithms and building downwash. It is suitable for estimating ground-level air quality concentrations on local and regional scales, from tens of metres to hundreds of kilometres. The CALPUFF model system is recommended in the *Guidelines* (BC MOE 2008).

In Section 3.6 of the *Guidelines* (2008) the BC MOE recommends that proponents submit a dispersion modelling plan for review and acceptance. The plan provides an overview of the planned air quality assessment so that the general modelling approach is agreed to before work is started. They note that such a plan is especially important when an extensive air quality assessment is planned and considerable resources are required for collecting the input data, running the models, and organizing the output in a way that is meaningful to both the public and decision makers. A detailed model plan was submitted for the Ministry consideration, and it was subsequently approved. Section 7.0, page 7.1, of **Appendix B** outlines the revision and submission process and timeline of the dispersion modelling plan.

The final dispersion modelling plan is in **Appendix B** for reference. Technical details and assumptions regarding the CALPUFF modelling are in **Appendix D**.

4.2 DISPERSION ASSESSMENT BOUNDARIES

4.2.1 Temporal Boundaries

Based on the proposed Project schedule the temporal boundaries for the assessment are construction and operations: Project effects were predicted employing averaging time periods consistent with the applicable regulatory criteria. Hourly (one-hour), daily (24-hour) and annual emissions rates were developed for both construction and operations phase.

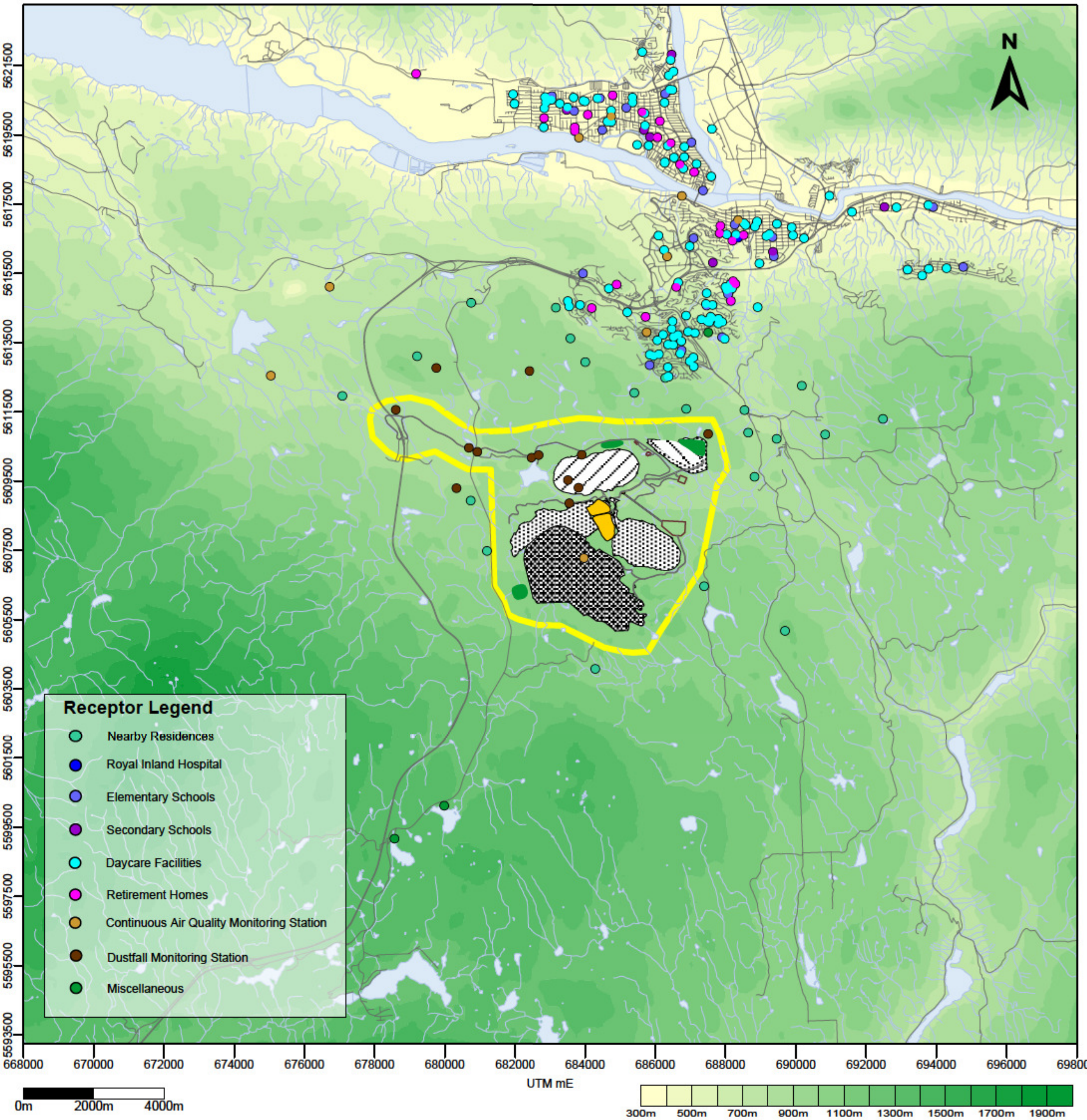
4.2.2 Spatial Boundaries

Study area boundaries were established to focus the spatial extents of the assessment. These are referred to in this report as the CALPUFF domain and the CALPUFF assessment area.

The CALPUFF domain is an area sized to capture all values of interest as per the *Guidelines* (BC MOE 2008; Sub-Section 6.1). For this assessment the CALPUFF computational domain covers a 70 km x 55 km area, which is also the size of the CALMET meteorological domain). The CALPUFF domain is sized to capture the emission sources that make up the Base Case modelling scenario.

The CALPUFF assessment area is a 30 km long x 30 km wide sub-set of the CALPUFF domain centered on the open-pit mine site. The CALPUFF result analysis focusses on effects in this area, although predictions are available for the entire CALPUFF domain. It is sized to capture all values of interest (e.g., predicted concentrations greater than 10% of the applicable ambient air quality objective). It includes most of the City of Kamloops except the Westsyde and Rayleigh developments to the north in the North Thompson valley, and the Dallas and Barhartvale districts to the east in the South Thompson valley.

The CALPUFF assessment area is presented in Figure 4.2-1 along with the mine plant boundary and other features of interest within and outside the plant boundary. In Section 1.1 both of these areas are depicted on a larger-scale map (Figure 5.7-1).



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles

UTM NAD 83 - ZONE 10

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Last Modified: 03/24/2015 By: sbanholzer

YT NWT BC AB Ajax USA

KGHM Ajax Air Quality Assessment
Technical Data Report

CALPUFF Assessment Area, Mine Features, and Special Receptors

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **4.2-1**

4.3 CALMET METEOROLOGICAL MODELLING

4.3.1 Original CALMET Modelling

Levelton Consultants Ltd. was retained in 2008 by BC MOE to conduct the CALMET modelling work. Their report (Levelton 2008) provides detailed modelling setup and results analysis at selected locations within the CALMET domain. To better understand the model performance, quality assurance/quality control (QA/QC) was performed for the full three year, 2003-2005, CALMET dataset. This QA/QC is provided in full in **Appendix D** of JWA (2009).

4.3.2 Updated CALMET Modelling

Working for the Kamloops Area Preservation Association (KAPA) Dr. Douw Steyn and Dr. Bruce Ainslie prepared questions for KAPA to submit to the Ajax environmental assessment process (Steyn & Ainslie 2012). This letter is included in **Appendix B** in the Atmospheric Modelling Methodology section. Steyn & Ainslie (2012; page 3) recommend the following steps be undertaken for the atmospheric modelling:

- Because of the complex terrain surrounding the proposed mine and City, we recommend a minimum 250 m resolution be used in the modelling.
- The modelling domain should extend a minimum 20 km away from the proposed site in all directions.

Following discussions with KAM and the BC MOE, Stantec undertook a rework of the Levelton (2008) CALMET dataset to address the recommendation of Steyn & Ainslie (2012). Details can be found in the CALMET Modelling Description Appendix (**Appendix C**).

The spatial grid resolution in the Levelton (2008) CALMET dataset is 500 m. Stantec achieved the recommended 250 m resolution by re-compiling CALMET from the original MM5 observations. This allows CALMET to better resolve features like Sugarloaf Mountain, Coal Hill, and the undulations in the terrain around the site.

The Levelton (2008) CALMET domain ends 9 km south of the pit. To address the second recommendation Stantec extended that to 19 km, giving more than the minimum distance recommended by Steyn & Ainslie (2012). A 70 km by 55 km (3,850 km^2) CALMET domain was used for this assessment. Within the CALMET domain, a resolution of 250 m was used. Ten vertical levels were used to model the atmosphere up to a maximum cell face height of 3,000 m above ground-level. Cell mid-points were chosen at heights of 10, 30, 60, 120, 230, 400, 750, 1,250, 1,750 and 2,500 m above ground to allow for higher resolution in the layers nearest to the earth's surface than in the levels aloft.

For this revised CALMET dataset the North American land-cover data (CEC 2010) were used to initialize land use categories in the CALMET model. The 2005 North American land-cover dataset was produced as part of the North American Land Change Monitoring System (NALCMS), a trilateral effort between the Canada Centre for Remote Sensing, the United States Geological Survey, and three Mexican organizations including the National Institute of Statistics and Geography, National Commission for the Knowledge and Use of the Biodiversity, and the National Forestry Commission of Mexico. The 2005 North American land-cover dataset is at a resolution of 250 m, consistent with that of the CALMET receptor grid spacing. This land-cover information was then converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor.

In the GEO.DAT file (an input file for CALMET), Stantec applied seasonal values for surface roughness (z0), albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and leaf area index (LAI) as defined in the *Guidelines* (BC MOE 2008) and the CALMET User Guide (Scire et al. 2000).

The CALMET model requires the input of surface and upper air meteorological fields. For this application, Levelton (2008) initialized CALMET with surface station information from four surface weather stations in the domain and with upper air data from the MM5 meteorological model. While this model initialization approach allows for a more accurate depiction of mesoscale wind circulations in the layers aloft than would be provided by using radiosonde data, it simultaneously permits data from surface weather stations to provide valuable localized information and correct the biases that prognostic data often exhibits in the lower layers.

Hourly output from the MM5 model at 12 km resolution was provided for Levelton’s use by the BC MOE. The data were prepared for use in CALMET by using the CALMM5 pre-processor. Observed hourly-averaged meteorological data from surface stations during the modelling period were provided by Environment Canada (EC), British Columbia Ministry of the Environment (BC MOE), BC Forest Service (BCFS) and BC Ministry of transportation (BC MOT). Table 4-1 provides a summary of the surface stations used as input. The EC weather station at the Kamloops Airport contained all fields necessary to initialize CALMET over the period of interest. Thus, the Kamloops Airport Station was the primary surface weather input used for modelling, while the other three stations were used to provide additional weather information closer to the Project location.

In addition to hourly surface data, hourly precipitation data at the Kamloops airport, Afton and Walloper stations and upper air data from the nearest station (i.e., Kelowna Airport) were used in CALMET modelling, as depicted in Table 4-1.

Based on sensitivity tests conducted for each of the meteorological years 2003, 2004, and 2005, year 2003 produced the highest results on the plant boundary therefore this year was selected to take forward into the detailed analysis.

Table 4-1 Input Surface Meteorological Parameters

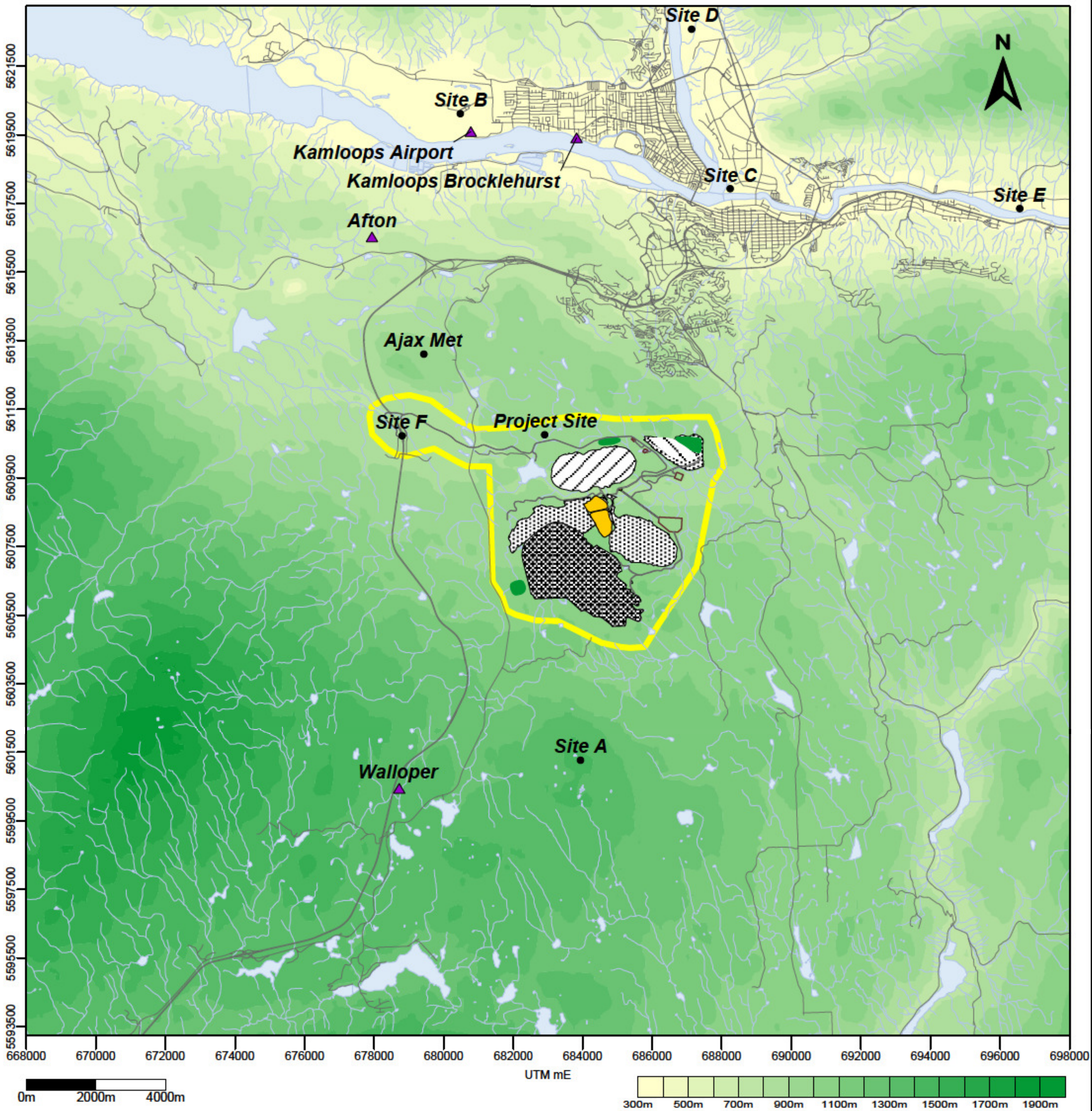
Station Name	Type	UTM mE	UTM mN	Elevation (masl)	Surface Input Data Used
Kamloops Airport	EC	680,778	5,619,591	345	Wind Speed & Direction, Temperature, Relative Humidity, Cloud Cover & Ceiling Height, Station Pressure, Precipitation
Kamloops Brocklehurst	MOE	683,828	5,619,419	347	Wind Speed & Direction, Temperature, Relative Humidity
Afton	BCFS	677,937	5,616,525	780	Wind Speed & Direction, Temperature, Relative Humidity, precipitation
Walloper	MOT	678,720	5,600,444	1,300	Wind Speed & Direction, Temperature, Relative Humidity, Station Pressure, Precipitation

Extracted CALMET Modelled Windroses

Of specific interest in the air quality assessment are patterns of wind direction and wind speed. Specifically, the BC MOE (Adams 2013) requested that windroses be generated using CALMET output for various locations in the CALMET domain. These requested locations are indicated in Table 4-2 and presented in map form in Figure 4.3-1. The seven requested extracted windroses and an eighth representing the Project Site are presented in Figure 4.3-2.

Table 4-2 Location and Description of Windroses Extracted from CALMET

Site	UTM mE	UTM mN	Elevation (masl)	Location Description (After MOE, 2012)
A	683941	5601264	1,446	A location between the proposed pit and the southern boundary of the domain
B	680476	5620113	345	A location near the airport
C	688243	5617936	353	A location near the confluence of the North and South Thompson rivers
D	687135	5622581	353	A location in the North Thompson valley near the northern boundary of the domain
E	696567	5617356	360	A location in South Thompson valley near the eastern Boundary of the domain
F	678803	5610725	835	At the Inks Lake Interchange on the Coquihalla Highway
Ajax Met	679428	5613105	952	Ajax Met Station: At the site of the climate station installed by the proponent on the Northwest side of Sugarloaf Hill.
Project Site	682910	5610750	915	A location arbitrarily selected to represent the center of the Project Site



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Location of Windrose Extractions
- Location of Meteorological Stations

UTM NAD 83 - ZONE 10

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Location of Meteorological Stations and Windroses Extracted from CALMET

PREPARED BY
Stantec

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KGHM

FIGURE NO.
4.3-1

Last Modified: 04/28/2015 By: KW

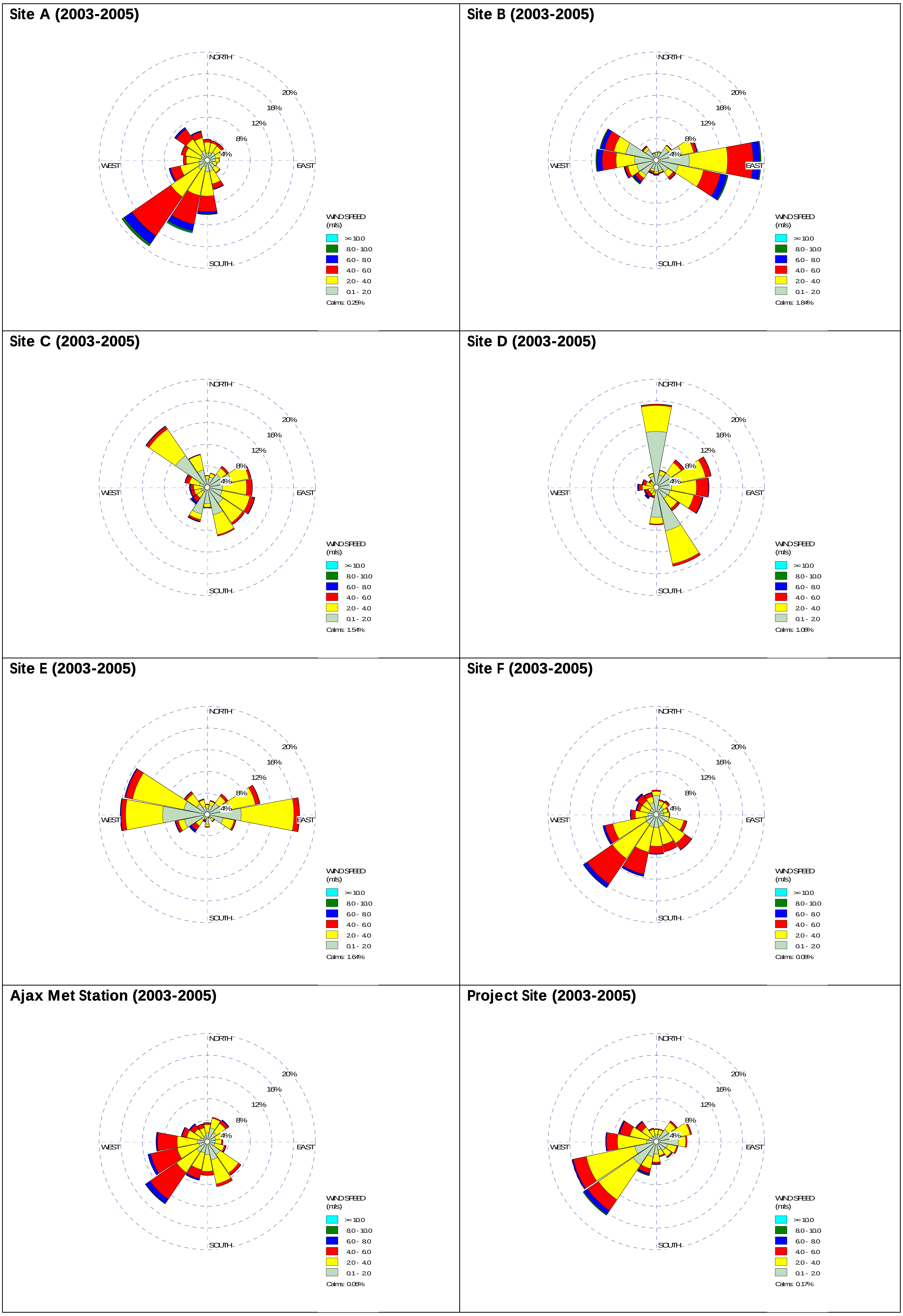


Figure 4.3-2 Windroses Extracted from CALMET

Wind roses are an efficient and convenient means of presenting wind data. The length of the radial barbs gives the total percent frequency of hourly winds from the indicated direction, while portions of the barbs of different widths indicate the frequency associated with each wind speed category.

In Figure 4.3-2the wind characteristics at the eight sites are illustrated. The wind roses depict surface meteorology consistent with expectations given the topographic controls imposed by the landscape on prevailing southwesterly synoptic scale winds. While most locations have prevalent SW winds as a common feature they diverge in some important ways.

Following is a brief summary of the major distinguishing features of the wind regimes:

The valley bottom: The Thompson River valley has windroses that display the control imposed on them by the east-west valley orientation, and blocking features such as the bluffs to the immediate east and west of the downtown. Windroses B, C, and E display prevailing winds from the east-west, infrequent south winds and less northerly winds. Site B (the Airport) is more strongly oriented east-west than Site C (Downtown), which shows the local influence of the bluffs. Site E is similar to Site B, being in a similar setting. Site D shows the influence of the north-south orientation of the North Thompson River valley, with infrequent westerly winds, and a strong north-south wind orientation.

The Project site: Represented by Site F, the Project Site and Ajax Met Station wind roses, this open grassland at mid-elevation shows more synoptic control in the form of winds uniformly distributed throughout the southwest quadrant. Easterly and northerly winds are infrequent. The Ajax Met Station shows the blocking influence of Sugarloaf Mountain to the southwest of the site.

The uplands south of the Project: Site A is in a closed forest setting above the mid-elevation mine site. It is exposed fully to synoptic-scale southwesterly winds. There are some northwesterly winds. Easterly winds are infrequent.

This suite of wind roses demonstrates that the CALMET meteorological model has performed well and faithfully depicts known features of the local wind regime. This increases confidence in overall CALPUFF model performance.

4.4 CALPUFF DISPERSION MODELLING

Air emissions sources identified during the construction and operations phases are the subject of this dispersion modelling exercise. All of the sources are mobile or surface-based (fugitive) emissions, and these are treated as occurring within defined areas. The extents of these area emission sources are characterized by area polygons specified by four vertices, each with unique set of UTM coordinates. The emissions are characterized by specifying an effective emission height, the source base elevation, an initial height of the plume and a discharge rate. The plume is assumed to be initially spread over the polygon area. **Appendix E** contains the specific plume parameters for each polygon area as well as parameters unique to the stationary sources. **Appendix D** provides technical details and assumptions regarding the CALPUFF modelling.

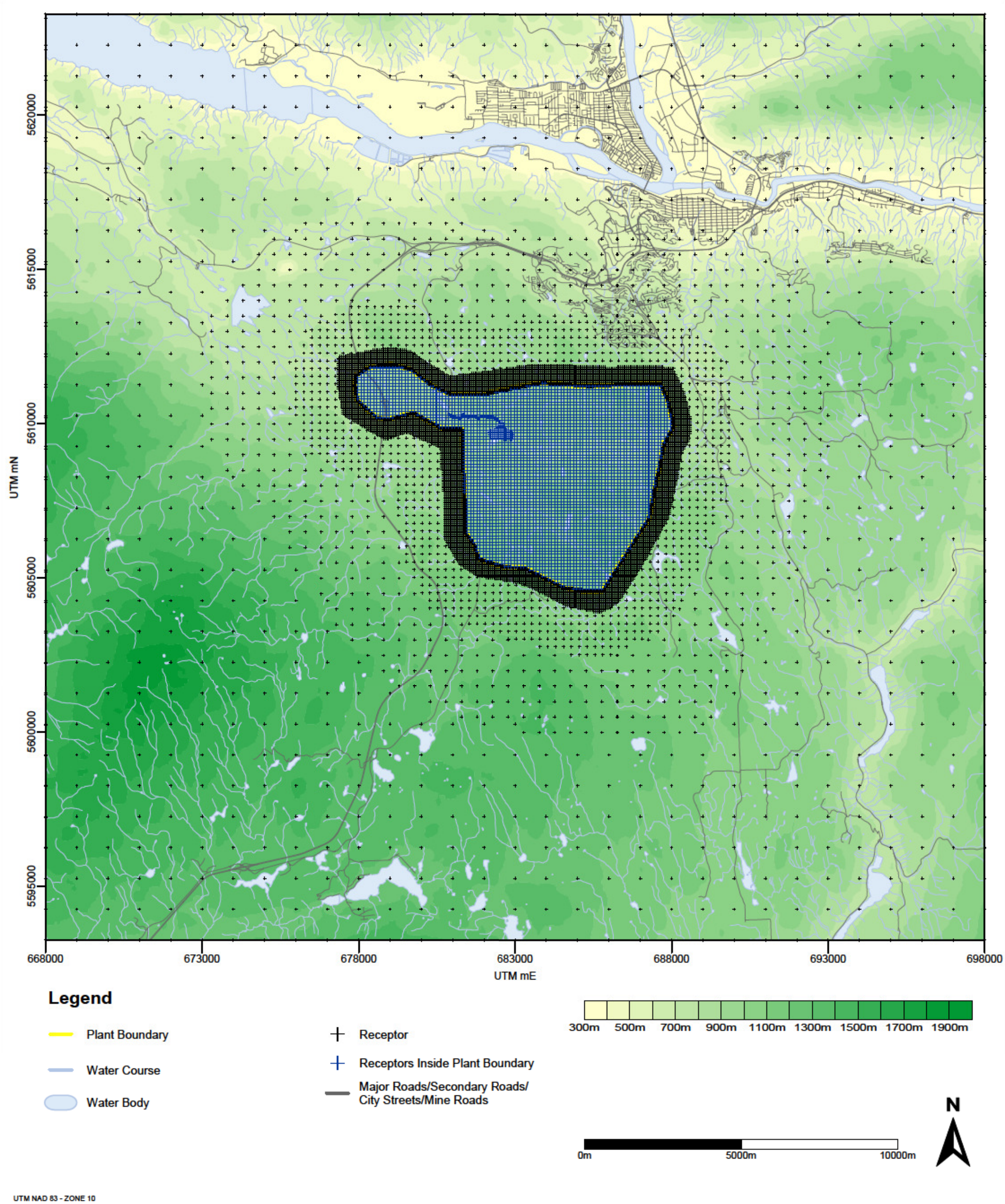
4.4.1 Receptor Grids and Terrain

Gridded Receptors

Within the modelling domain, calculations of ground-level air concentrations were made using a series of nested Cartesian grids with increasing receptor density with proximity to the Project sites. Table 4-3 identifies the receptor grids used in the modelling. Figure 4.4-1shows the grid used in the modelling. The general receptor grids and their corresponding spacing were developed consistent with the *Guidelines* (BC MOE, 2008). Actual terrain elevations are applied to all receptors used in modelling based on the Canadian Digital Elevation Data (CDED 2012). The definition of the plant boundary and specific method by which the plant boundary was defined is summarized below.

The gridded receptors are as follows:

- 20 m spacing along the facility boundary
- 50 m spacing within 1.5 km of the plant boundary
- 250 m spacing within 5 km of the plant boundary
- 500 m spacing within 10 km of the plant boundary
- 1,000 m spacing within 25 km of the plant boundary



KGHM Ajax Air Quality Assessment
Technical Data Report

Receptor Grid in the CALPUFF Assessment Area

PREPARED BY
Stantec

PREPARED FOR
KGHM

FIGURE NO.
4.4-1

Plant Boundary

The plant boundary, as defined in Section 6.3 of the *Guidelines* (BC MOE 2008) is a line of receptors that demarcates the areas governed by public versus worker exposure criteria. Often the highest predicted offsite concentrations and/or deposition rates are on the plant boundary. Within the plant boundary, meeting occupational health and safety criteria are of primary importance. BC AAQO are often applied to areas where there is public access (e.g., on and outside the plant boundary). Section 6.3 of the *Guidelines* (BC MOE 2008) describes the criteria used to determine the plant boundary.

Setting the plant boundary for a mine is more subjective than for a fenced facility such as a pulp mill. In the instance of a fenced mill, the facility fenceline defines where public access is restricted. Mines are not generally fenced; however public access is often discouraged or prohibited due to safety concerns. The plant boundary is based on the guidance in Section 6.3 of the *Guidelines* (BC MOE 2008). Specifically, the plant boundary is defined by:

- The perimeter of disturbed area that defines where public access is restricted
- The perimeter along a road allowance if a public access road passes through the plant

The west plant boundary is defined by the road allowance of Lac Le Jeune Road except where the access road joins Highway 5. The southern and eastern plant boundaries are defined as the perimeter of the existing mine and proposed disturbed area. Generally this includes a buffer of approximately 500 m from the edge of features that include the mine pit, MRSF ore stockpiles, tailings impoundment, and access road.

The area inside the plant boundary is covered by a grid of receptors with 100 m spacing, except over Jacko Lake where the receptor spacing is 50 m. The Goose Lake road is terminated at the southern and eastern edges of the plant boundary. There are predicted concentrations for the receptors within the plant boundary and over Jacko Lake. The model predictions at these receptors were provided to HHERA to consider exposures from the mine site to the public (Appendix 10.4-A of the EAC Application).

Special Receptors

The HHERA assessed only requires deposition and concentration data at selected locations. In a study of this magnitude there are over 14,000 receptors in a CALPUFF domain and over 200 discrete ‘special receptors’.

Special receptors are locations of human and ecological importance: sensitive ecosystems (e.g., a lake), nearby homes, and places frequented by sensitive sub-populations of the community (e.g., children, the elderly, and those under medical care). These latter locations include schools, medical treatment facilities, daycare facilities, and retirement homes.

The deposition and concentration data for the point of maximum impingement is also captured for the HHERA; the logic being that ecological receptors or sensitive populations may also be present at that location, despite being unanticipated.

A list of 209 special receptors for modelling metals and other chemical species is presented in the final detailed model plan (**Appendix B**). They include 21 nearby residences (also designated as noise receptors), the Royal Inland Hospital, 21 elementary schools, 6 secondary schools, and 110 daycare facilities, 23 retirement homes, 3 miscellaneous receptors, 11 air quality monitoring stations, and 13 dustfall monitoring stations. These receptors are shown in Figure 4.2-1. They are also listed in Table D-4 (**Appendix D**).

Workplaces, office and residential buildings, shopping centers, arenas, and other places frequented by Kamloops residents are not listed as special receptors. Thompson Rivers University (TRU) is not designated a special receptor as the students and staff are not considered a sensitive sub-population (e.g., do not differ substantially from the general population). However, the TRU daycare is listed as a daycare facility.

Along with the 209 special receptors there are also 841 HHERA special receptors on a 1 km x 1 km grid across a 30 km x 30 km domain, the CALPUFF assessment area (31 x 31 receptors = 961 – 120 receptors on the domain border = 841). All receptor grids are described in Table 4-3.

Table 4-3 Receptor Grids

Grid Name	Receptor Grid Description	Distance Relative to Mine Boundary	Spacing (m)
Air quality	Outside plant boundary	Beyond 5 km	1,000
		Within 5 km	500
		Within 2 km	250
		Within 500m	50
	Along plant boundary	Inside	20
Special	Inside plant boundary	Inside	100
	Along Jacko Lake Road	Inside	20
	Jacko Lake area	Inside	50
	HHERA	30 km from center of mine boundary	100
	209 Discrete special receptors	Throughout the regional assessment area	—

4.4.2 NO_X to NO_2 Conversion

Oxides of nitrogen (NO_X) are comprised of NO and NO_2. Only NO_2 concentrations are regulated by the BC AAQO. Therefore, it is important to be able to estimate the portion of predicted ground-level concentrations of NO_X comprised of NO_2. For this current study, the Ozone Limiting Method (OLM) (BC MOE 2008) was applied. The OLM is the alternative if adequate monitoring data of NO/NO_2 ratios are not available. This method requires O_3 values based on a nearby monitoring station that is representative of the region. The OLM equation is shown below:

$$[NO_2] = 0.1[NO_x] + the\ lesser\ of\ ([O_3]\ or\ 0.9[NO_x]) + Background\ [NO_2]$$

The OLM assumes that the conversion of NO to NO_2 in the atmosphere is limited by the ambient O_3 concentration in the atmosphere. The approach assumes that 10 percent (on a volume basis) of the NO_X is converted to NO_2 prior to discharge into the atmosphere. For the remaining NO_X, the following is adopted:

- If 0.9 (NO_X) is greater than the ambient O_3 concentration then NO_2 = 0.1 (NO_X) + O_3. For this case, the conversion is not complete.
- If 0.9 (NO_X) is less than the ambient O_3 concentration then NO_2 = 0.1 (NO_X) + 0.9 (NO_X) =NO_X. This is equivalent to the total conversion approach, since there is sufficient O_3 to effect the complete conversion.

In the application of the OLM, the above relationships assume the concentrations are expressed on a volumetric (i.e., ppb) basis. The hourly O_3 values used in the assessment are based on ambient air quality monitoring data at the Kamloops Brocklehurst station for 2003 to 2005

4.4.3 Air Quality Health Index Calculation

The air quality health index (AQHI) was calculated using predicted concentrations at six locations in the CALPUFF assessment area. These are the same six locations using in Figure 5.1-2 and Figure 5.6-1 (Attribution Figures). The AQHI calculations were based on the equation in Section 3.1.3.

The predicted AQHI is based on 3-hour average predicted concentrations of NO_2 and $PM_{2.5}$. Since O_3 is not an SOC, O_3 predicted concentrations were not available; therefore the measured 3-hour average O_3 concentrations from the Brocklehurst monitoring station were used in the AQHI calculation. Global/Regional background was added to the 1-hour predictions before the AQHI calculation. The 1-hour global/regional NO_2 concentration is in Table 2-7 (15.3 µg/m^3). The Global/Regional 1-hour $PM_{2.5}$ concentration of 7.0 µg/m^3 is based on the 50th percentile measured 1-hour concentration at the Kamloops Brocklehurst R&P TEOM monitoring station.

The measured AQHI from the Kamloops Brocklehurst monitoring station data is based on measured 3-hour average NO_2, O_3, and $PM_{2.5}$ concentrations from 2003. This year was chosen to be consistent with the meteorology employed in the modelling. $PM_{2.5}$ was measured with an R&P TEOM Instrument, which is biased to under predict in the winter (Environment Canada 2014). During August 2003 there were high measurements of $PM_{2.5}$ due to forest fires in the region.

4.4.4 Dispersion Modelling Output

CALPUFF produced air contaminant concentrations (in µg/m^3) at every grid point for each hour of the assessment period. Post processing determined the maximum predicted concentrations for all averaging periods to compare with the applicable regulatory criteria. For pattern visualization and to locate the maximum point of impingement, isopleth maps are included (**Appendix G** to **Appendix I**).

4.5 BASE CASE EMISSIONS

Modelling the Base Case for all substances of interest involves an inventory of emissions within the CALPUFF domain from existing sources of information. By source type, these include:

- **Industrial Emissions** from Tolko Industries Ltd, Savona Specialty Plywood, Spectra Energy Transmission, Thompson River Veneer Products, Absorbent Products, Domtar Pulp Mill, Lafarge Cement Plant, New Gold, and Kamloops Terminal.
- **Transportation Emissions** from on-road mobile sources due to light duty gasoline vehicles and trucks, light duty diesel vehicles and trucks, heavy duty gasoline and diesel vehicles, motorcycles, brake lining, tire wear, and railway sources.
- **Heating Emissions** from commercial fuel combustion, residential fuel combustion, and residential fuel wood combustion.
- **Paved and Unpaved Roads** include fugitive dust from major roads, including the Trans-Canada Highway, the Yellowhead Highway (Hwy 5), Highway 5A, and the Lac Le Jeune Road. Unpaved road dust was not included because it constitutes a 3% of the total Base Case $PM_{2.5}$ annual emissions. Unpaved road dust emissions occur outside of the City of Kamloops and do not have a strong influence in the Project area..
- **Disturbed Lands** or fugitive dust from all land where vegetation is absent for all of the year. This includes the historic Afton and New Gold tailings beaches and local landfills. Agricultural lands, industrial sites, and seasonally exposed river beds are not included.

Where appropriate emissions were varied on monthly to hourly time scales (detailed in **Appendix F**).

Background air quality values reflective of global/regional background concentrations derived from local measurements are added to the Base Case predictions. This is described in Section 2.2.2 and presented in Table 2-7.

The Base Case assessment results are added to the Construction Case and Operations Case results on a receptor-by-receptor, hour-by-hour basis such that cumulative results are portrayed in a more robust manner than could be achieved by adding measured background values representative of worst-case measurements to the Construction Case and Operations Case predicted concentrations.

Table 4-4 contains a summary of the Base Case emissions from the categories listed above. Detail on the Base Case emissions is contained in **Appendix F**.

Table 4-4 Base Case Total Emission Rates (tonnes/year)

Source Group or Activity	Emission Rates (tonnes/year)					
	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_X	CO
Industrial Emissions	1,024	576.3	339.8	69.4	2248	1,792
Transportation Emissions	23.3	23.1	16.1	3.5	815.7	7,575
Heating Emissions	176.2	166.6	165.4	34.6	110.3	1,043
Paved Roads	3,201	618.8	156.6	-	-	-
Disturbed Lands	35.9	16.3	2.6	-	-	-
Total	**4,460**	**1,401**	**680.5**	**107.5**	**3,174**	**10,410**

4.6 PROJECT EMISSIONS

Two Project modelling scenarios are considered, each with differing emission profiles to determine how the various Project phases affect air quality. These include both construction and operations. Note that certain mine feature terminology used in this report differs from updated terminology in use now (see Errata section).

In order to determine the emission profiles for construction and operations a year from mine development was chosen to represent construction and a year from mine operations was chosen to represent operations. Emissions associated with year -1 are used in the Construction Case and emissions associated with the combination of year 4 and year 8 (year 4/8) are used in the Operations Case.

Year -1 of the mine development was selected for the Construction Case. Because it represents the year with the greatest amount of surface disturbance, the construction year just before operations start (year -1) was chosen for assessment.

For the Operations Case, a combination operations year, which consists of aspects from year 4 and year 8 of the mine life, was chosen for assessment because the mine plan predicts that the combination of these two years will experience the greatest amount of machine activity, blasting, earth moving and resulting air emissions.

All emissions associated with mine equipment and processes were modelled. This includes diesel exhaust from haul trucks and other heavy equipment and fugitive dust created by the equipment, mining processes, and wind erosion. The sources of fugitive dust include dust mechanically induced by heavy equipment on haul and access roads, fugitive dust from movement and distribution of material on land and mine features such as the mine pit, access and haul roads, the tailings facility, and the MRSFs. Fugitive dust created by wind erosion of the land and mine features is also included. Modelling also includes dust emissions from blasting and emissions associated with explosives detonation.

Project emissions from the above sources are calculated using published emission factors and facility engineering design estimates. The modelling exercise includes filterable and condensable particulate fractions when they are included in the published emission factors. **Appendix E** contains a description of the emission factors and calculations used to determine the emission rates from each source associated with the Project Case Construction (year -1) and Project Case Operations (year 4/8) scenarios.

Mobile diesel engine emission sources can be disaggregated into on-road (e.g., cars, trucks, and motorcycles) and non-road emission categories (heavy equipment). Because of the substantial contribution of non-road diesel engine emission sources to the total mobile source emission inventory, it has become critical over the past several years for the US EPA to provide accurate, reproducible inventories of non-road emissions. Generally, the US EPA air emission factors for non-road mobile equipment are also applicable in Canada for environmental assessments because the Canadian equipment emissions legislation closely matches that of the USA. Non-road diesel emission sources result from the use of fuel in a diverse collection of vehicles and equipment. **Appendix E** describes the emission factors used for the non-road diesel engine emissions.

There are no emissions from on-site generation of electricity commonly associated with mining projects. A 1,000 kW diesel generator will be available for emergency standby power generation. It is not included as a point source in the modelling as it only runs a few hours per month for testing.

The Project does not include cooling towers or near-saturated discharges of water vapour (e.g., wet scrubbers) and therefore the potential for fogging and icing due to discharges of water vapour are not modelled. Water consumption on site is limited to normal evaporation from water storage facilities and wetted surfaces (e.g., portions of the TSF surface, roadways sprayed with water for dust control). As such, fogging and icing episodes attributable to water evaporation associated with Project activities are not contemplated to occur more those instances where fogging and icing is already occurring naturally.

The emissions discussed in the following sections were modelled as either area sources or volume sources. An area source is a two-dimensional source of diffuse air pollutant emissions. A volume source is a three-dimensional source of diffuse air pollutant emissions; it is an area source with a height dimension. Although point sources are not used in this assessment, for comparison, a point source is a single identifiable source of air pollutant emissions such as a stack or roof vent.

The following is a list of mitigations and assumptions that applies to both construction and operations. **Appendix E** has more detail on the mitigations and assumptions.

- All activities, except for basting, assume constant emission rates. For blasting, emissions are assumed to occur only during mid-day.
- All diesel equipment is assumed to have tier 3 emissions.
- The hourly emission rates are the worst case hour. They assume no road watering or natural mitigation and that a blast is occurring.
- The daily emission rates are the worst case day. They assume a blast is occurring twice in the day, all roads are watered to a moisture ratio of 4, which is 90% dust suppression by watering, and they assume it is a dry day with no precipitation (rain or snow).
- The annual emission rates assume there is one blast per day, there is 90% dust suppression watering of all roadways, and there is 42% natural mitigation (assuming 42% of the year there is snow or rain on the roads further suppressing dust).

4.6.1 Construction

The Construction Case represents a year with a great deal of earth moving and handling, and therefore emissions. Generally the mine construction air emissions are vehicle exhaust from the mobile construction equipment and the fugitive dust emissions generated by preparation of the site for building foundations and roads, or pre-stripping of overburden for ore mining. For this assessment the Construction Case also includes emissions from the first small scale mining activities (which include blasting activities) which begin in construction in order for the mine to build up to full production by the first year of operations.

The emission sources included in the Construction Case are:

- Diesel engine running
- Blasting
- Drilling
- Pre stripping
- Grading/Road building
- Truck loading
- Truck unloading
- Unpaved road dust
- Dozing
- Wind erosion
- Crushing
- Conveyor transfer point
- Backhoe digging
- Trenching

Each of the above emission types are distributed into specific areas over the Mine Site. The main emission area categories are:

- Open pit
- Ore storage and processing
- MRSF/overburden/reclamation stockpiles
- Roads (haul roads and access road)

Each of these area categories consist of various area and volume sources associated with emissions from vehicle exhaust and fugitive dust, depending on what types of activities are typical for the area. In the mine pit there are also blasting emissions. **Appendix E** contains a description of allocation of emission types over the Mine Site.

The Construction Case emission totals are summarized in Table 4-5. Vehicle exhaust emissions were calculated on hourly, daily, and annual time scales and fugitive dust emissions are calculated on daily and annual time scales. The particulate matter presented in Table 4-5 is the total particulate from both vehicle exhaust and fugitive dust. **Appendix E** contains a break-down of the particulate matter emissions by type. Daily and annual control mitigation is applied to the fugitive dust emissions. Based on the guidance outlined in US EPA AP-42 (Chapter 13.2.2 Figure 13.2.2-2), the control mitigation is assumed to be a minimum of 90% dust suppression through unpaved road surface dust management (US EPA 2006). Annually, a minimum of 45% natural dust suppression is also applied. In reality during periods of frozen ground and precipitation, the natural dust suppression will be closer to 100% and the PM emissions will be less than the stated estimates.

Table 4-5 Construction Hourly, Daily and Annual Total Emission Rates (tonnes/year)

Source Group or Activity	Time Duration	Emission Rates (tonnes/year)					
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_X	CO
Open Pit	Hourly	-	-	-	0.3	169.3	116.5
	Daily	99.0	54.8	12.1	0.2	168.4	112.7
	Annual	54.4	25.8	6.0	0.1	89.9	60.7
Ore Storage/ Processing	Hourly	-	-	-	0.1	50.5	45.0
	Daily	88.7	56.0	10.6	0.1	50.5	45.0
	Annual	66.6	39.6	7.3	0.06	31.3	27.8
MRSF/ Overburden/ Reclamation Stockpiles	Hourly	-	-	-	0.2	101.1	90.0
	Daily	84.5	47.2	11.7	0.2	101.1	90.0
	Annual	74.7	39.7	8.9	0.1	62.7	55.6
Roads	Hourly	-	-	-	0.6	307.5	259.2
	Daily	332.5	94.2	19.9	0.4	242.4	193.8
	Annual	193.4	55.2	12.0	0.3	143.2	119.3
Total	**Hourly**	**-**	**-**	**-**	**1.2**	**628.5**	**510.7**
	Daily	**604.6**	**252.2**	**54.3**	**1.0**	**562.5**	**441.5**
	Annual	**389.2**	**160.2**	**34.2**	**0.6**	**327.2**	**263.3**

NOTES:
"-" = not applicable
All emission rates presented here are based on rates in grams per second (see **Appendix E**). For averaging periods less that 24-hour the hourly emission rates are used, for the 24-hour averaging period the daily emission rates are used, for the annual averaging period the annual emission rates are used.

4.6.2 Operations

A combination operations year consisting of aspects from year 4 and year 8 was chosen. This combination year represents the peak production in the mine life, the greatest fuel use, greatest amount of earth moving, and therefore a year that represents the greatest emissions. From the mine plan, all other mine operation years have lesser emission qualities compared to the combination of year 4 and year 8. Selecting this combination year to represent all years in the assessment adds conservatism to the resultant predictions.

A simplified process flow diagram that summarizes the various air emissions from the Ajax mine is presented in the final dispersion modelling plan (Stantec 2015b: **Appendix B**) as Figure 2-1.

Mobile diesel engine emissions, explosive detonation emissions, and fugitive dust emissions make up the emission sources for operations. The general mining activities during operations that create the different types of emissions are:

- Diesel engine running
- Blasting
- Drilling
- Truck loading
- Truck unloading
- Unpaved road dust
- Dozing
- Wind erosion
- Crushing
- Conveyor transfer point
- Ore processing

Each of the emissions associated with the above mining activities occur within specific areas and are defined as area or volume sources. These areas are described in **Appendix E**. The main emission area categories are:

- Open pit
- Ore storage and processing
- MRSF/overburden/reclamation stockpiles
- Tailings beach
- Roads (haul roads and access road)

The following four sections describe the mobile diesel engine emissions, explosive detonation emissions, and fugitive dust emissions during operations.

Operations Diesel Emissions from Mobile Sources

Mobile diesel equipment is used during operations for extraction of ore and mine rock from the open pit and hauling to the crusher. As in construction, various pieces of diesel mobile equipment are used to drill the ore body and overburden, for explosives, and loading the broken material into haul trucks. There are several types of main mining equipment such as haul trucks, shovels, loaders, drills, dozers, graders, and water trucks. There is also a large fleet of support equipment. All main and support equipment is assumed to have diesel engines.
A complete list of diesel equipment and the equipment specifications and operating hours is summarized in **Appendix E**. The mobile diesel emissions are distributed over several area sources (e.g., mine pit, the various MRSFs, ore storage piles, and haul roads).

Operations Explosive Detonation Emissions

The explosives used in the in-pit blasting consist of an ANFO and emulsion blend (heavy ANFO). The fugitive and gas emissions from blasting occur within the mine pit only. Both ANFO and emulsion contain ammonium nitrate (AN) products. Therefore the total amount of explosive used in the emission rate calculation is ANFO plus the emulsion. It is assumed that the duration of the blast is one hour and there are at most 2 blasts a day but those blasts occur every other day. Information concerning the amount of ANFO and emulsion used, blasting time durations, and frequency of blasts is in **Appendix E**.

Operations Fugitive Dust Emissions

All of the fugitive dust emissions from unpaved roads and the various mining activities occur within multiple area sources. The main areas are the mine pit, MRSFs, the ore stockpiles, the processing plant, and the haul roads and access road.

Fugitive dust emissions from unpaved haul roads and access road are incorporated into area and volume emissions. There are six haul roads that are incorporated as a collection of area sources along the length of the road and one access road which is a collection of volume sources along the length of the access road. The haul roads and access road are as follows:

- Haul road 1: from the pit edge to the crusher
- Haul road 2: from the pit edge to the ore stockpiles
- Haul road 3: from the pit edge to the SMRSF
- Haul road 4: from the pit edge to the TSF MRSF and north TSF dam
- Haul Road C: from the pit edge to the EMRSF
- In pit haul road: From the active area of the pit to the pit edge
- Access road: from the center of the Mine Site near the crusher to Highway 5

The emission rates are calculated as a function of equipment used and the total material handled during operations. Most of the emissions are those of fugitive dust producing PM concentrations. Gaseous emissions constitute a smaller portion of total Project emissions, and are generated by Project mine fleet and explosives detonation.

Project activities identified as sources of fugitive dust emissions are blasting, drilling, truck loading, truck unloading, road dust, dozing, wind erosion, crushing, conveying, and ore processing.
The crusher and conveyor drop points are both modelled as volumes and not point sources. Similarly the point sources associated with the various dust collectors and the baghouse on the processing plant are modelled as an area source. The emission factors used to estimate the fugitive dust emission rates for each activity were obtained from the US EPA AP42 guidelines and are discussed in detail in **Appendix E**.

A number of material handling activities occur within the open pit, including drilling, blasting, haul truck loading and unloading, and material hauling. Since these activities occur at the pit floor, often deep within the pit, it is reasonable to expect that only a fraction of the fugitive dust emissions escape to the surface where it then may be transported to the plant boundary. The magnitude of the Ajax open pit retention was calculated as a function of the depth of the pit (Winges 1986).

Wind erosion for each active storage pile is also considered. At the Ajax mine, the Ore Stockpiles, SMRSF, Overburden/EMRSF, tailings beach, and TSF MRSF were identified as sources of wind fugitive dust emissions. A detailed description of the different methods of wind erosion emission calculation is available in **Appendix E.**

The emissions associated with ore processing are assumed to all occur within the processing plant. This processing plant has various dust collectors and the emissions from these dust collectors are all captured by a bag-house on the roof of the facility. The emissions escaping from the baghouse are then modelled as an area source over the whole area of the processing plant. A description of the individual point sources making up the total emissions of the processing plant is in **Appendix E**.

Total Emissions

Table 4-6 summarizes hourly, daily and annual emission rates resulting from operations. Hourly rates characterize sources that are assumed to operate continuously and are only presented for gas emissions. Daily rates are a 24-hour average of emission rates which include inactive periods. Annual emission estimates include annual inactive periods. Natural and control dust mitigation measures are applied. Daily and annual emission rates incorporate the control dust mitigation of 90% on all roads, including the access road. Annual rates incorporate 45% natural mitigation.

Table 4-6 Operations Hourly, Daily and Annual Emission Rates (tonnes/year)

Source Group or Activity	Time Duration	Emission Rates (tonnes/year)					
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_X	CO
Open Pit	Hourly	-	-	-	1.3	665.9	444.4
	Daily	524.0	339.6	63.3	0.8	662.4	429.5
	Annual	301.8	193.2	40.7	0.7	517.3	331.8
Ore Storage/ Processing	Hourly	-	-	-	0.1	58.9	50.7
	Daily	143.7	78.3	15.0	0.1	58.9	50.7
	Annual	117.0	60.1	9.2	0.08	42.5	37.5
MRSF/ Overburden/ Reclamation Stockpiles	Hourly	-	-	-	0.2	118.1	101.7
	Daily	80.0	46.5	12.3	0.2	118.1	101.7
	Annual	69.1	38.3	9.8	0.2	85.2	75.2
Tailings Beach	Hourly	-	-	-	0.0	0.0	0.0
	Daily	77.6	36.6	5.6	0.0	0.0	0.0
	Annual	32.2	15.3	2.3	0.0	0.0	0.0
Roads	Hourly	-	-	-	1.1	797.5	561.8
	Daily	1189.9	329.3	60.7	1.0	732.2	495.9
	Annual	697.2	197.5	41.7	0.8	577.7	392.2
Total	**Hourly**	**-**	**-**	**-**	**2.7**	**1,640**	**1,159**
	Daily	**2,015**	**830.3**	**156.9**	**2.2**	**1,572**	**1,078**
	Annual	**1,217**	**504.4**	**103.6**	**1.7**	**1,223**	**836.8**

NOTES:
"-" = not applicable
All emission rates presented here are based on rates in grams per second (see **Appendix E**). For averaging periods less that 24-hour the hourly emission rates are used, for the 24-hour averaging period the daily emission rates are used, for the annual averaging period the annual emission rates are used.

4.7 APPLICATION CASE EMISSIONS

The Application Case emissions are the sum of the total Base Case emissions to the Project Case emissions. The total emissions from the Base Case and the Construction and Operations Cases are presented to illustrate the relative contribution the Project Construction and Project Operations has to the total emissions. The following two sub-sections describe the Application Case Construction emissions and the Application Case Operations Emissions.

The Base Case emissions are presented as total average emissions and therefore are not classified as hourly, daily, and annual. Using an average emission rate is a standard procedure for baseline modelling. The same Base Case average emission rate is used in the total Application Case emission sum for hourly, daily, and annual.

4.7.1 Application Case—Construction

Overall, the highest percent contribution of the construction emissions on a daily and annual basis are observed in PM_{10} and NO_X and lowest percent contribution in SO_2. Table 4-7contains a summary of the total Application Case Construction hourly, daily, and annual emission rates in tonnes per year.

On the hourly time scale, the percent contribution of the construction emissions to the total Application Case Construction emissions ranges from 1.1 % (SO_2) to 16.5% (NO_X).

On the daily time scale, the percent contribution of the construction emissions to the total Application Case Construction emissions ranges from 0.9% (SO_2) to 15.3 % (PM_{10}). Contributions of PM are generally greater than for the gases (SO_2, NO_X, and CO).

On the annual time scale, the percent contribution of the construction emissions to the total Application Case Construction emissions ranges from 0.5% (SO_2) to 10.3% (PM_{10}). Contributions of PM are generally greater than for the gases (SO_2, NO_X, and CO).

Overall, the highest percent contribution of the construction emissions on a daily and annual basis are observed in PM_{10} and NO_X and lowest percent contribution in SO_2.

Table 4-7 Application Case Construction Hourly, Daily and Annual Emission Rates (tonnes/year)

Time Duration	Modelling Case Total Emissions	Emission Rates (tonnes/year) and Percent Contribution (%)					
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_X	CO
Hourly	Base Case	4,460	1,401	680.5	107.5	3174	10,410
	Project Case Construction	—	—	—	1.2	628.5	510.7
	Application Case Construction	—	—	—	109	3,803	10,920
	Construction (%)	—	—	—	1.1%	16.5%	4.7%
Daily	Base Case	4,460	1,401	680.5	107.5	3174	10,410
	Project Case Construction	604.6	252.2	54.3	1.0	562.5	441.5
	Application Case Construction	5,065	1,653	734.7	108.5	3,737	10,851
	Construction (%)	11.9%	15.3%	7.4%	0.9%	15.1%	4.1%
Annual	Base Case	4,460	1,401	680.5	107.5	3,174	10,410
	Project Case Construction	389.2	160.2	34.2	0.6	327.2	263.3
	Application Case Construction	4850	1561	714.6	108.1	3,502	10,673
	Construction (%)	8.0%	10.3%	4.8%	0.5%	9.3%	2.5%

NOTES:
"-" = not applicable
All emission rates presented here are based on rates in grams per second (see **Appendix E**). For averaging periods less that 24-hour the hourly emission rates are used, for the 24-hour averaging period the daily emission rates are used, for the annual averaging period the annual emission rates are used.

4.7.2 Application Case—Operations

Table 4-8 contains a summary of the total Application Case Operations hourly, daily, and annual emission rates in tonnes per year. The Application Case emission rates are the sum of the total Base Case emissions (Table 4-4) plus the total Project Case Operations emissions (Table 4-6). The percent contribution of the Project Case Operations to the total Application Case Operations emissions is also summarized in Table 4-8.

On the hourly time scale, the project contribution ranges from 2.5 % (SO_2) to 34.1% (NO_X) or the Application Case Operations emissions.

On the daily time scale, the percent contribution of the operations emissions to the total Application Case Operations emissions ranges from 2.0% (SO_2) to 37.2% (PM_{10}). Contributions of PM are generally greater than for the gases (SO_2, NO_X, and CO).

On the annual time scale, the percent contribution of the operations emissions to the total Application Case Operations emissions ranges from 1.5% (SO_2) to 27.8% (NO_X). Contributions of PM are generally greater than for the gases (SO_2, NO_X, and CO).

Overall, the highest percent contribution of the operations emissions on a daily and annual basis are observed in PM_{10} and NO_X and lowest percent contribution in SO_2.

Table 4-8 Operation Application Case Hourly, Daily and Annual Emission Rates (tonnes/year)

Time Duration	Modelling Case Total Emissions	Emission Rates (tonnes/year) and Percent Contribution (%)					
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_X	CO
Hourly	Base Case	4,460	1,401	680.5	107.5	3174	10,410
	Project Case Operations	-	-	-	2.7	1,640	1,159
	Application Case Operations	-	-	-	110.3	4815	11,568
	Operations (%)	**-**	**-**	**-**	**2.5%**	**34.1%**	**10.0%**
Daily	Base Case	4,460	1,401	680.5	107.5	3174	10,410
	Project Case Operations	2,015	830.3	156.9	2.2	1,572	1,078
	Application Case Operations	6,476	2231	837.3	109.7	4,746	11,488
	Operations (%)	**31.1%**	**37.2%**	**18.7%**	**2.0%**	**33.1%**	**9.4%**
Annual	Base Case	4,460	1,401	680.5	107.5	3174	10,410
	Project Case Operations	1,217	504.4	103.6	1.7	1,223	836.8
	Application Case Operations	5,678	1,905	784.1	109.2	4,397	11,246
	Operations (%)	**21.4%**	**26.5%**	**13.2%**	**1.5%**	**27.8%**	**7.4%**

NOTES:
"-" = not applicable
All emission rates presented here are based on rates in grams per second (see **Appendix E**). For averaging periods less that 24-hour the hourly emission rates are used, for the 24-hour averaging period the daily emission rates are used, for the annual averaging period the annual emission rates are used.

5.0 ASSESSMENT RESULTS

To determine the potential effects on local ambient air quality associated with the Project air emissions, dispersion modelling was conducted for TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_X and CO. The results of the modelling is a suite of predicted concentrations for each receptor in the domain. From these data the maximum predicted concentrations at the maximum point of impingement (MPOI) for each substance of concern and for each time-averaging interval are determined for receptors lying on and outside of the plant boundary (Table 5-1 to Table 5-12). These data are also used to develop isopleth maps illustrating the maximum predicted concentrations at each receptor in the domain (**Appendix G** to **Appendix I**).

Three emission scenarios were considered: Base Case, Project Case, and Application Case. The Project Case (and therefore the Application Case) consists of construction and operations; therefore there are two Project and two Application Cases:

- Project Case Construction and Project Case Operations
- Application Case Construction and Application Case Operations

The Project Cases are based on emissions from the project activities in isolation (Section 4.6). The Application Cases are the sum of the Base Case modelling results and the Project Case (Construction and Operations) modelling results. Section 4.5, Section 4.6, and Section 4.7 describe the emissions profiles that characterize the Base, Project, and Application modelling cases respectively.

The following sections present the results for each of the cases. Base Case results are in Section 5.1, Project Case Construction results are in Section 5.2, Project Case Operations results are in Section 5.3, Application Case Construction results are in Section 5.40, and Application Case Operations results are in Section 5.5.

Section 5.6 discusses the attribution of effects between the Base and Project cases in the Application cases. It also includes an analysis of predicted exceedances. Section 5.7 discusses the Cumulative Effects Assessment Case.

Total monthly dustfall and NO_2 predictions were developed by post-processing the modelling output. Predicted concentrations of NO_2 were developed employing the Ozone Limiting Method (OLM) conversion of NO_X to NO_2 (Section 4.4.2).

As discussed in Section 2.2, a measured global/regional background concentration is added to the predicted Base Case concentrations. Since the Application Case is the addition of the Base Case and the Project Case, the Application Case also includes the global/regional background concentration.

Results relating to both the Provincial AAQO and CAAQS are presented, though the discussion on the results is limited to the Provincial AAQO as the Project is in British Columbia. As discussed in Section 3.1.1 and Section 3.1.2 the BC Provincial AAQO are more stringent than the CAAQS and criteria from other jurisdictions.

5.1 BASE CASE

Table 5-1 summarizes the maximum predicted concentrations associated with the Base Case. Global/regional background is included in the results. Within the assessment area the maximum predicted concentrations for SO_2, NO_2, and CO for all time-averaging intervals are less than the applicable regulatory criteria. The maximum predicted concentrations for annual TSP are also less than the criteria. Dustfall, 24-hour TSP, PM_{10}, and $PM_{2.5}$ are predicted to be greater than the criteria. Areas where concentrations above the criteria are predicted to occur are over North Kamloops and Downtown Kamloops. Isopleth maps illustrating the Base Case results are in **Appendix G**.

Table 5-1 Maximum Predicted CAC Concentrations Associated with the Base Case

Substance	Averaging Interval	Maximum Predicted Rate/Concentration	Applicable Regulatory Criteria [a]
DF ($mg/dm^2/d$)	30-day	**2.0**	1.7
TSP ($\mu g/m^3$)	24-hour	**151.6**	120
	Annual	44	60
PM_{10} ($\mu g/m^3$)	24-hour	**89.3**	50
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [b]	**34.7**	25
	24-hour [c]	**36.5**	28 (27) [e]
	Annual	**10.9**	8
	Annual [d]	**11.0**	10 (8.8) [e]
SO_2 ($\mu g/m^3$)	1-hour[f]	15.8	200
	1-hour	20.1	450
	24-hour	12.7	150
	Annual	2.1	30
NO_2 ($\mu g/m^3$) [g]	1-hour [h]	77.5	188
	1-hour	117.5	400
	24-hour	49.5	200
	Annual	15.3	60
CO ($\mu g/m^3$)	1-hour	2,088	14,300
	8-hour	1,105	5,500

Table 5-1 Maximum Predicted CAC Concentrations Associated with the Base Case

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
Maximum predicted concentrations include global/regional background (see Section 2.2.2).

[a] Applicable AAQO and CAAQS from Table 3-1
[b] Based on the 98th percentile for one year
[c] Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
[d] Based on the 3-year mean of annual average concentrations
[e] The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
[f] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[g] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[h] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Base Case

The maximum predicted monthly dustfall associated with the Base Case is 2.0 mg/dm^2/d, which is greater than the BC dustfall objective of 1.7 mg/dm^2/d. Figure G-1 in **Appendix G** illustrates the area of exceedance is over the east side of Downtown Kamloops.

The maximum predicted monthly dustfall rate over Downtown Kamloops has a frequency of exceedance of 58% (7 months of the year). The months when the exceedance occurs are primarily the spring, summer, and early fall months (February, March, and June through September). The area where the exceedance occurs covers 6.3 ha over Downtown Kamloops (Figure G-1).

TSP/Base Case

The maximum predicted 24-hour and annual average ground level TSP concentrations for the Base Case are 151.6 and 44.0 µg/m^3, respectively. The 24-hour maximum (151.6 µg/m^3) is greater than the applicable regulatory criteria (120 µg/m^3). An isopleth map of 24-hour TSP concentrations is available in **Appendix G** (Figure G-2). This map illustrates that the maximum predicted concentrations and a potential exceedance occur over North Kamloops.

The maximum predicted 24-hour TSP concentration over the City of Kamloops has a frequency of exceedance of 0.8% (3 days of the year). The days when the exceedance occurs are primarily in the winter months (December and January) when dispersion is frequently poorer than in summer months. The area where the exceedance occurs covers a total of 593 ha over North Kamloops, Downtown Kamloops, and west of the City (Figure G-2).

PM_{10}/Base Case

The maximum predicted 24-hour average PM_{10} concentrations associated with the Base Case is 89.3 µg/m^3. The 24-hour maximum (89.3 µg/m^3) is greater than the applicable regulatory criteria (50 µg/m^3). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix G**, (Figure G-4). This map illustrates that the maximum predicted concentrations occurs over North Kamloops.

The maximum predicted 24-hour PM_{10} concentration over the City of Kamloops has a frequency of exceedance of 1.6% (6 days of the year). The days when the exceedance occurs are primarily in the winter months (December, January, and February) when dispersion is frequently poorer than in summer months. The area where the exceedance occurs covers a total of 2,755 ha over North Kamloops and Downtown Kamloops (Figure G-4).

$PM_{2.5}$/Base Case

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations associated with the Base Case are 34.7 and 10.9 µg/m^3, respectively. The predicted concentrations are greater than the applicable regulatory criteria (25 µg/m^3 and 8 µg/m^3 respectively).

Figure G-5 in **Appendix G** illustrates the area of 24-hour $PM_{2.5}$ exceedance within the modelling domain. This figure shows that the area of 24-hour $PM_{2.5}$ exceedance occurs over North Kamloops, Downtown Kamloops, and extends west of Downtown Kamloops.

Figure G-6 (**Appendix G**) illustrates the area of annual $PM_{2.5}$ exceedance within the modelling domain. This map shows the area of annual $PM_{2.5}$ exceedance occurs primarily over North Kamloops with a small area over the western side of Downtown Kamloops.

The maximum predicted 98th percentile 24-hour $PM_{2.5}$ concentration over the City of Kamloops has a frequency of exceedance of 4.4% (16 days of the year). The days when the 24-hour exceedance occurs are primarily in the fall and winter months (November, December, January, and February). The area where the 24-hour exceedance occurs covers a total of 1,003 ha over North Kamloops and Downtown Kamloops (Figure G-5).

Figure 5.1-1 shows that the maximum predicted concentration of annual average $PM_{2.5}$ over most of the City of Kamloops is more than the Planning Goal of 6 µg/m^3 but less than the BC AAQO of 8 µg/m^3. Areas where the annual average are greater than the BC AAQO covers an area of 763 ha in North Kamloops (Figure 5.1-1 and Figure G-6).

SO_2/Base Case

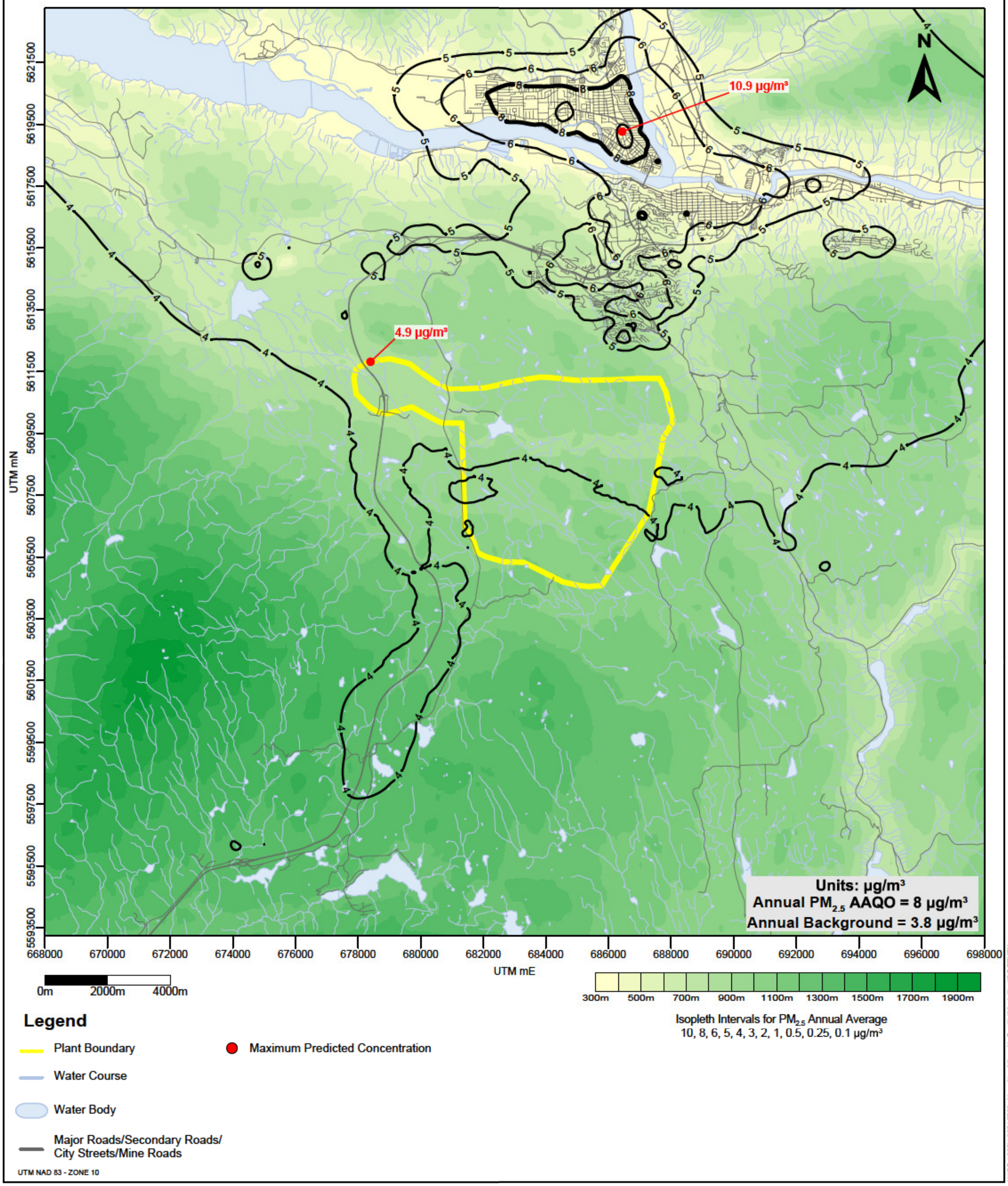
The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations associated with the Base Case are 15.8, 12.7, and 2.1 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Base Case

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations for the Base Case are 77.5, 49.5, and 15.3 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Base Case

The maximum predicted one-hour and eight-hour CO concentrations associated with the Base Case are 2,088 and 1,105 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.



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KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. 5.1-1

Last Modified: 04/27/2015 By: KW

Attribution: Base Case

Figure 5.1-2 and Table 5-2 depict the percent contribution of the four source groupings to Base Case predictions for annual average $PM_{2.5}$. This includes i) Industrial emissions (Permitted); ii) Transportation emissions (on-road mobile sources), paved road emissions (fugitive dust), and rail emissions; iii) Heating emissions (commercial, residential, and wood combustion); and iv) Global/Regional background.

Table 5-2 Annual $PM_{2.5}$ Base Case Source Contributions to Locations in the Modelling Domain

Site #	Total Predicted Annual Concentration (μg/m³)	Contribution from Source Types in μg/m³ and (%)			
		Industrial	Road/Rail	Heating	Global/Regional Background
1 (Plant boundary)	4.1	0.1 (1.8%)	0.1 (2.9%)	0.1 (3.1%)	3.8 (92.6%)
2 (City Development Boundary)	4.2	0.1 (2.0%)	0.2 (3.7%)	0.2 (5.2%)	3.8 (89.7%)
3 (Upper Aberdeen)	5.7	0.1 (1.5%)	0.5 (8.3%)	1.3 (23.6%)	3.8 (67.2%)
4 (Upper Sahali)	7.7	0.1 (1.5%)	1.3 (17.0%)	2.6 (33.5%)	3.8 (49.1%)
5 (West End)	6.4	0.2 (2.8%)	0.6 (9.0%)	1.9 (29.3%)	3.8 (59.4%)
6 (North Kamloops)	10.9	0.1 (1.3%)	1.4 (13.0%)	5.6 (51.4%)	3.8 (34.9%)

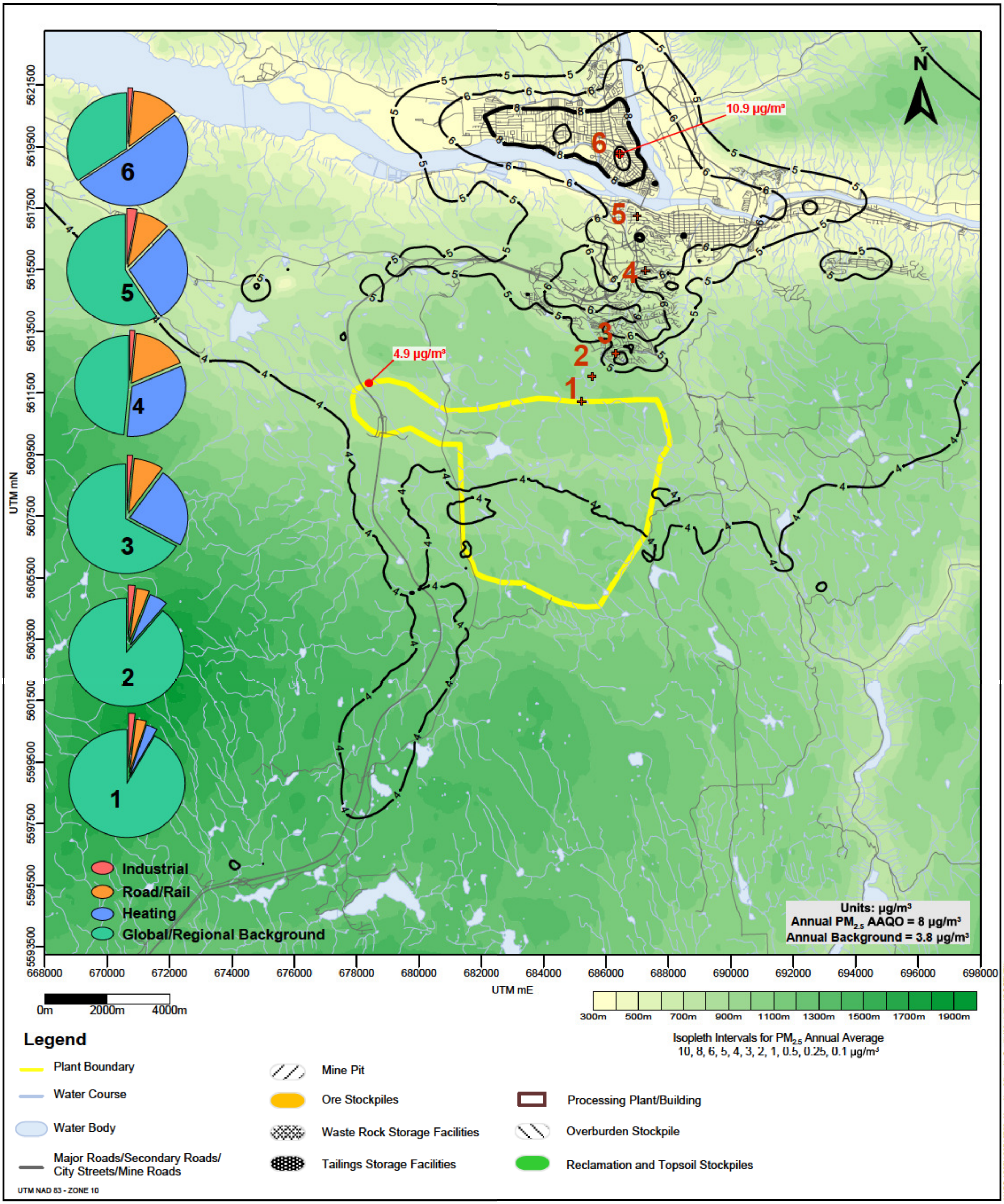
Figure 5.1-2 shows that at locations near the City of Kamloops, the air quality associated with the four Base Case source groupings is primarily dominated by the global/regional background, heating emissions, and transportation emissions.

On the plant boundary (Site 1), the air quality associated with industrial, heating, and transportation (road/rail) sources is less than 8% combined. The largest contribution is the global/regional background (92.6%). The maximum predicted concentration is 4.1 μg/m³. This is less than the BC AAQO of 8 μg/m³ and the BC Planning Goal of 6 μg/m³.

On the City Development Boundary (Site 2), air quality associated with the addition of the global/regional background is the largest contribution (89.7%). There is an increase in the contribution from heating from Site 1 to Site 2 due to the closer proximity to residential areas. The maximum predicted concentration is 4.2 μg/m³. This is less than the BC AAQO of 8 μg/m³ and the BC Planning Goal of 6 μg/m³.

In upper Aberdeen (Site 3), the contribution from heating is larger than at Site 1 or Site 2 at 23.6%. However, the global/regional background (67.2%) contributes two-thirds of the total. The maximum predicted concentration is 5.7 μg/m³. This is less than the BC AAQO of 8 μg/m³ and the BC Planning Goal of 6 μg/m³.

The contribution in the remainder of the City from industrial and transportation sources is similar at Sites 4, 5, and 6. In upper Sahali (Site 4), the contribution from heating accounts for 33.5% of the total. In the West End (Site 5) heating accounts for 29.3%. On the North Shore (Site 6) it accounts for 51.4% of the total. Predicted concentrations at sites 4 and 5 are above the BC Planning Goal (6 µg/m^3). At site 6 the predicted concentration is greater than both the annual AAQO (8 µg/m^3) and the BC Planning Goal (6 µg/m^3).



KGHM Ajax Air Quality Assessment

PREPARED BY Stantec

PREPARED FOR KGHM

Base Case Contributions to Locations in the Modelling Domain for the Maximum Predicted Annual Average Ground-Level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

FIGURE NO. 5.1-2

Air Quality Health Index: Base Case

The AQHI was calculated using Base Case predicted concentrations at six locations in the CALPUFF assessment area (Figure 5.1-2 and Figure 5.6-1). The calculation follows the methodology outlined in Section 3.1.3 and 4.4.3.

Table 5-3 contains the Base Case AQHI at the six locations and the measured AQHI from the Kamloops Brocklehurst monitoring station.

The AQHI at all sites (including the Brocklehurst monitoring station) is in the Low Health Risk range (1 to 3) most of the time. At all six sites the Base Case AQHI is in the Low Health Risk range more than 95% of the year. At Sites 1 through 5 the Base Case AQHI is not predicted to be in the High Health Risk or Very High Health Risk Range. At Site 6, the Base Case AQHI is predicted to be in the High Health Risk range 0.1% of the year and is never predicted to be in the Very High Health Risk range. Due to the forest fire event in August 2003 the measured AQHI at Brocklehurst is in the High Health Risk range 0.6% of the year and in the Very High Health Risk range 0.2% of the year. The predicted AQHI does not replicate the High and Very High categories because the 2003 forest fires were not included in the modelling.

Ozone (O_3) is consistently the greatest contributor to the AQHI at all six sites and Brocklehurst. Nitrogen dioxide (NO_2) and $PM_{2.5}$ have similar but minor contributions to the AQHI at all six sites. At the Brocklehurst monitoring station NO_2 contributes more to the measured AQHI than $PM_{2.5}$.

Table 5-3 Predicted Base Case Air Quality Health Index and Measured Air Quality Health Index at the Kamloops Brocklehurst Monitoring Station for 2003

Location:	Site 1 (Pant Boundary)	Site 2 (City Development Boundary	Site 3 (Upper Aberdeen)	Site 4 (Upper Sahali)	Site 5 (West End)	Site 6 (North Kamloops)	Brocklehurst Station (measurement)
Average AQHI	1	1	1	2	1	2	2
% of year in **Low Health Risk** range	99.7	99.7	99.4	97.6	98.5	96.3	94.1
% of year in **Moderate Health Risk** range	0.3	0.3	0.6	2.4	1.5	3.6	5.1
% of year in **High Health Risk** range	0.0	0.0	0.0	0.0	0.0	0.1	0.6
% of year in **Very High Health Risk** range	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Average % contribution of NO_2 to total AQHI	5.5	6.1	11.3	19.2	14.2	18.8	36.8
Average % contribution of $PM_{2.5}$ to total AQHI	3.6	4.2	11.1	15.5	12.5	21.1	12.6
Average % contribution of O_3 to total AQHI	90.9	89.8	77.5	65.2	73.3	60.1	50.6

NOTES:
Site 1-6 AQHI are based on Base Case predicted concentrations.
AQHI at Brocklehurst Station is based on monitoring data from 2003.

Figure 5.1-2 shows the six locations where AQHI was calculated.
Low Health Risk: AQHI values from 1 to 3
Moderate Health Risk: AQHI values from 4 to 6
High Health Risk: AQHI values from 7 to 10
Very High Health Risk: AQHI values above 10

The AQHI results for Brocklehurst (year 2003) are consistent with those presented in the BC MOE (2010) publication "Air Quality Health Index Variation across British Columbia", which examined AQHI data in the 2000 to 2006 timeframe at nineteen communities in BC. Ozone and NO_2 dominate the AQHI in Kamloops, as it does in the Interior stations examined, with $PM_{2.5}$ contributing approximately 12% to the AQHI.

5.2 PROJECT CASE—CONSTRUCTION

Table 5-4 summarizes the maximum predicted concentrations associated with the Project Case Construction. Global/regional background is not included in the results presented for this modelling case. The maximum predicted concentrations for all substances except for PM_{10} are less than the applicable regulatory criteria. PM_{10} is predicted to be greater than the criteria on the northeast plant boundary. Areas where concentrations above the criteria are predicted to occur are largely uninhabited regions in the assessment area. Isopleth maps illustrating the Project Case Construction results are in **Appendix H**.

Table 5-4 Maximum Predicted CAC Concentrations Associated with the Project Case Construction

Substance	Averaging Interval	Maximum Predicted Rate/Concentration on the Plant Boundary	Applicable Regulatory Criteria [a]
DF (mg/dm^2/d)	30-day	0.2	1.7
TSP (µg/m^3)	24-hour	97.8	120
	Annual	5.5	60
PM_{10} (µg/m^3)	24-hour	**78.4**	50
$PM_{2.5}$ (µg/m^3)	24-hour [b]	9.3	25
	24-hour [c]	6.1	28 (27) [e]
	Annual	0.6	8
	Annual [d]	0.5	10 (8.8) [e]
SO_2 (µg/m^3)	1-hour[f]	0.6	200
	1-hour	0.7	450
	24-hour	0.4	150
	Annual	0.01	30
NO_2 (µg/m^3) [g]	1-hour [h]	84.6	188
	1-hour	107.7	400
	24-hour	58.3	200
	Annual	4.2	60
CO (µg/m^3)	1-hour	341.1	14,300
	8-hour	274.6	5,500

Table 5-4 Maximum Predicted CAC Concentrations Associated with the Project Case Construction

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
[a] Applicable AAQO and CAAQS from Table 3-1
[b] Based on the 98th percentile for one year
[c] Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
[d] Based on the 3-year mean of annual average concentrations
[e] The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
[f] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[g] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[h] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Construction

The maximum predicted monthly dustfall associated with construction is 0.2 milligrams per decimetre squared per day (mg/dm^2/d), which is below the BC dustfall objective of 1.7 mg/dm^2/d.

TSP/Construction

The maximum predicted 24-hour and annual average ground level TSP concentrations for construction are 97.8 and 5.5 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for TSP.

PM_{10}/Construction

The maximum predicted 24-hour average PM_{10} concentrations associated with construction is 78.4 µg/m^3. The 24-hour maximum (78.4 µg/m^3) is greater than the applicable regulatory criteria (50 µg/m^3). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix H**, (Figure H-4). This map illustrates that the maximum predicted concentrations occurs on the northeast plant boundary. Areas where concentrations above the criteria are predicted to occur when background is added are uninhabited regions in the modelling domain.

The maximum predicted 24-hour PM_{10} concentration at the plant boundary has a frequency of exceedance of 0.5% (2 days of the year). The days when the exceedance occurs are primarily in the winter months (January) when dispersion is frequently poorer than in summer months. The area where the exceedance occurs covers 138 ha extending from the northeast plant boundary (Figure H-4). This area largely covers undeveloped grasslands and does not extend into the build-up urban area of Kamloops.

$PM_{2.5}$/Construction

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations associated with construction are 9.3 and 0.6 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for $PM_{2.5}$. Figure 5.2-1 illustrates the annual $PM_{2.5}$ concentrations for the Project Case Construction.

SO_2/Construction

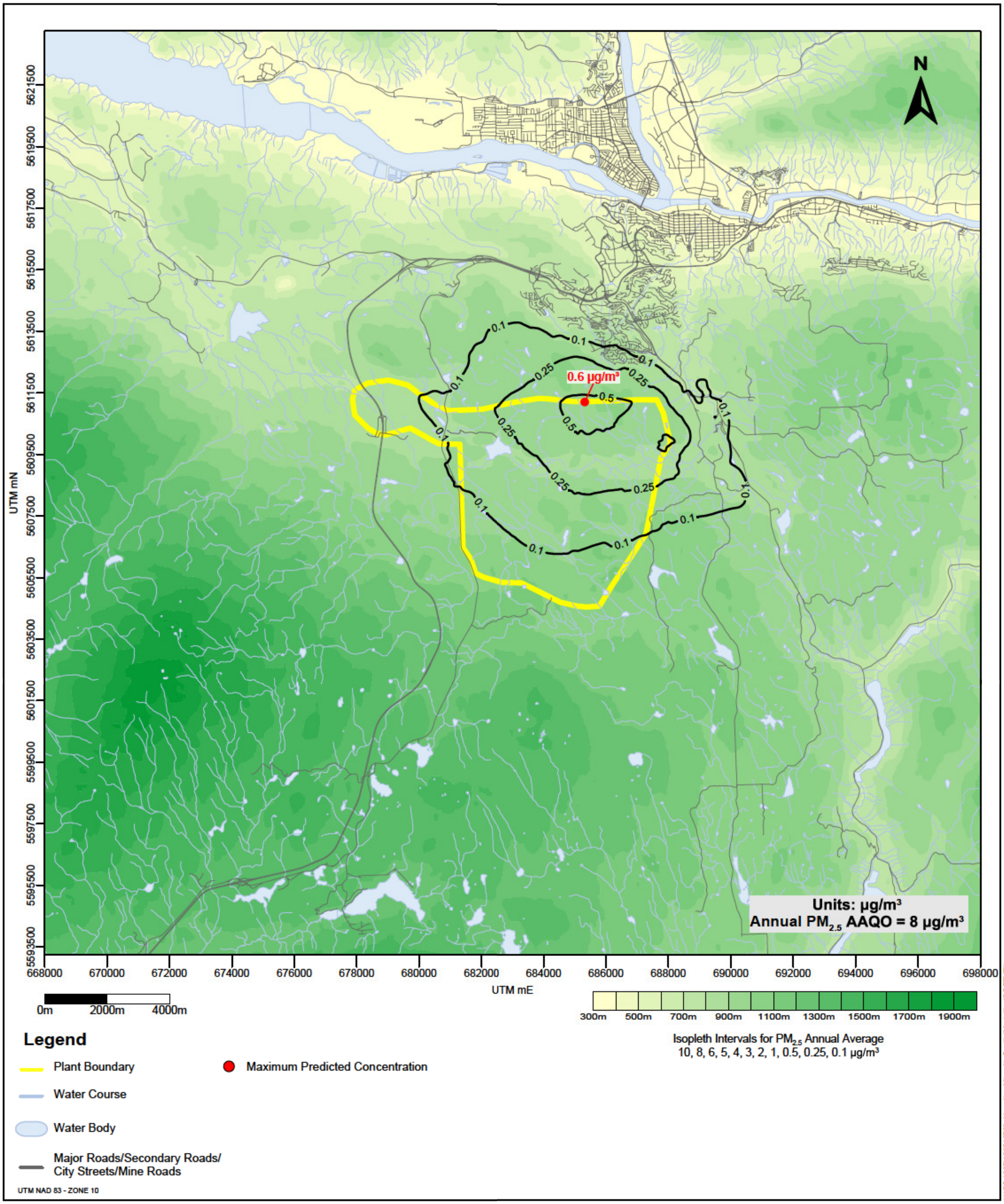
The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations associated with construction are 0.6, 0.4, and 0.01 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Construction

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations for construction are 84.6, 58.3, and 4.2 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Construction

The maximum predicted one-hour and eight-hour CO concentrations associated with construction are 341.1 and 274.6 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted Annual Average Ground-level PM$_{2.5}$ Concentrations (µg/m³) Without Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **5.2-1**

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Last Modified: 04/27/2015 By: KW

5.3 PROJECT CASE—OPERATIONS

The effect of operations emissions on ambient air quality was evaluated using the results obtained from the modelling. Table 5-5 summarizes the maximum predicted concentrations associated with operations. Global/regional background is not included in the results presented for this modelling case. Within the modelling domain all maximum predicted concentrations of dustfall, NO_2, SO_2, and CO are less than the applicable regulatory criteria. Annual TSP and annual $PM_{2.5}$ are also less than the criteria. Twenty-four-hour TSP, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ are predicted to be greater than the criteria on the northeast plant boundary. Isopleth maps illustrating the Project Case Operations are in **Appendix I**.

Table 5-5 Maximum Predicted CAC Concentrations Associated with the Project Case Operations

Substance	Averaging Interval	Maximum Predicted Rate/Concentration on the Plant Boundary	Applicable Regulatory Criteria [a]
DF (mg/dm^2/d)	30-day	0.4	1.7
TSP (µg/m^3)	24-hour	**406.0**	120
	Annual	13.5	60
PM_{10} (µg/m^3)	24-hour	**332.9**	50
$PM_{2.5}$ (µg/m^3)	24-hour [b]	**31.4**	25
	24-hour [c]	19.2	28 (27) [e]
	Annual	2.1	8
	Annual [d]	1.6	10 (8.8) [e]
SO_2 (µg/m^3)	1-hour[f]	1.6	200
	1-hour	1.8	450
	24-hour	1.1	150
	Annual	0.04	30
NO_2 (µg/m^3) [g]	1-hour [h]	142.4	188
	1-hour	171.1	400
	24-hour	117.4	200
	Annual	9.5	60
CO (µg/m^3)	1-hour	926.5	14,300
	8-hour	744.3	5,500

Table 5-5 Maximum Predicted CAC Concentrations Associated with the Project Case Operations

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
[a] Applicable AAQO and CAAQS from Table 3-1
[b] Based on the 98th percentile for one year
[c] Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
[d] Based on the 3-year mean of annual average concentrations
[e] The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
[f] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[g] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[h] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Operations

The maximum predicted monthly dustfall associated with operations is 0.4 mg/dm^2/d, which is below the BC dustfall objective of 1.7 mg/dm^2/d.

TSP/Operations

The maximum predicted 24-hour and annual average ground level TSP concentrations for operations are 406.0 and 13.5 µg/m^3, respectively. The 24-hour predicted concentrations exceed the applicable regulatory criteria (120 µg/m^3).

Figure I-2 in **Appendix I** illustrates the area of 24-hour TSP exceedance within the modelling domain. This map illustrates the area of 24-hour TSP exceedance extends less than 2 km to the northeast of the plant boundary.

The maximum predicted 24-hour TSP concentration at the plant boundary has a frequency of exceedance of 3.3% (12 days of the year). The days when the exceedance occurs are primarily in the winter months (December and January) when dispersion is frequently poorer than in summer months. The area where the exceedance occurs covers 474 ha extending from the northeast plant boundary (Figure I-2). This area largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary and covers parts of upper Aberdeen.

PM_{10}/Operations

The maximum predicted 24-hour average PM_{10} concentrations associated with operations is 332.9 µg/m^3. The predicted concentration is greater than the applicable regulatory criteria (50 µg/m^3).

Figure I-4 in **Appendix I** illustrates the area of 24-hour PM_{10} exceedance within the modelling domain. This map illustrates the area of 24-hour PM_{10} exceedance extends less than 3 km from the north of the plant boundary, less than 2 km from the northeast of the plant boundary, and less than 1 km from the west and east edges of the plant boundary, a largely uninhabited region in the modelling domain.

The maximum predicted 24-hour PM_{10} concentration at the plant boundary has a frequency of exceedance of 6.6% (24 days of the year). The days when the exceedance occurs are primarily in the winter and spring months (November through April) when dispersion is frequently poorer than in summer months. The area where the exceedance occurs covers 1,050 ha extending from the west, northeast, and east plant boundaries (Figure I-4). This area largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary and covers parts of upper Aberdeen.

$PM_{2.5}$/Operations

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations associated with operations are 31.4 and 2.1 μg/m^3, respectively. The 24-hour predicted concentrations are greater than the applicable regulatory criteria (25 μg/m^3).

Figure I-5 in **Appendix I** illustrates the area of 24-hour $PM_{2.5}$ exceedance within the modelling domain. This map illustrates the area of 24-hour $PM_{2.5}$ exceedance extends less than 500 m from the northeast of the plant boundary, a largely uninhabited region in the modelling domain.

The maximum predicted 98th percentile 24-hour $PM_{2.5}$ concentration at the plant boundary has a frequency of exceedance of 0.8% (3 days of the year). The days when the 24-hour exceedance occurs are primarily in the winter months (December and January). The area where the 24-hour exceedance occurs covers 24 ha at the northeast plant boundary (Figure I-5). This area largely covers undeveloped grasslands does not extend into the build-up urban area of Kamloops.

Figure 5.3-1 illustrates the annual average $PM_{2.5}$ concentrations over the modelling domain.

SO_2/Operations

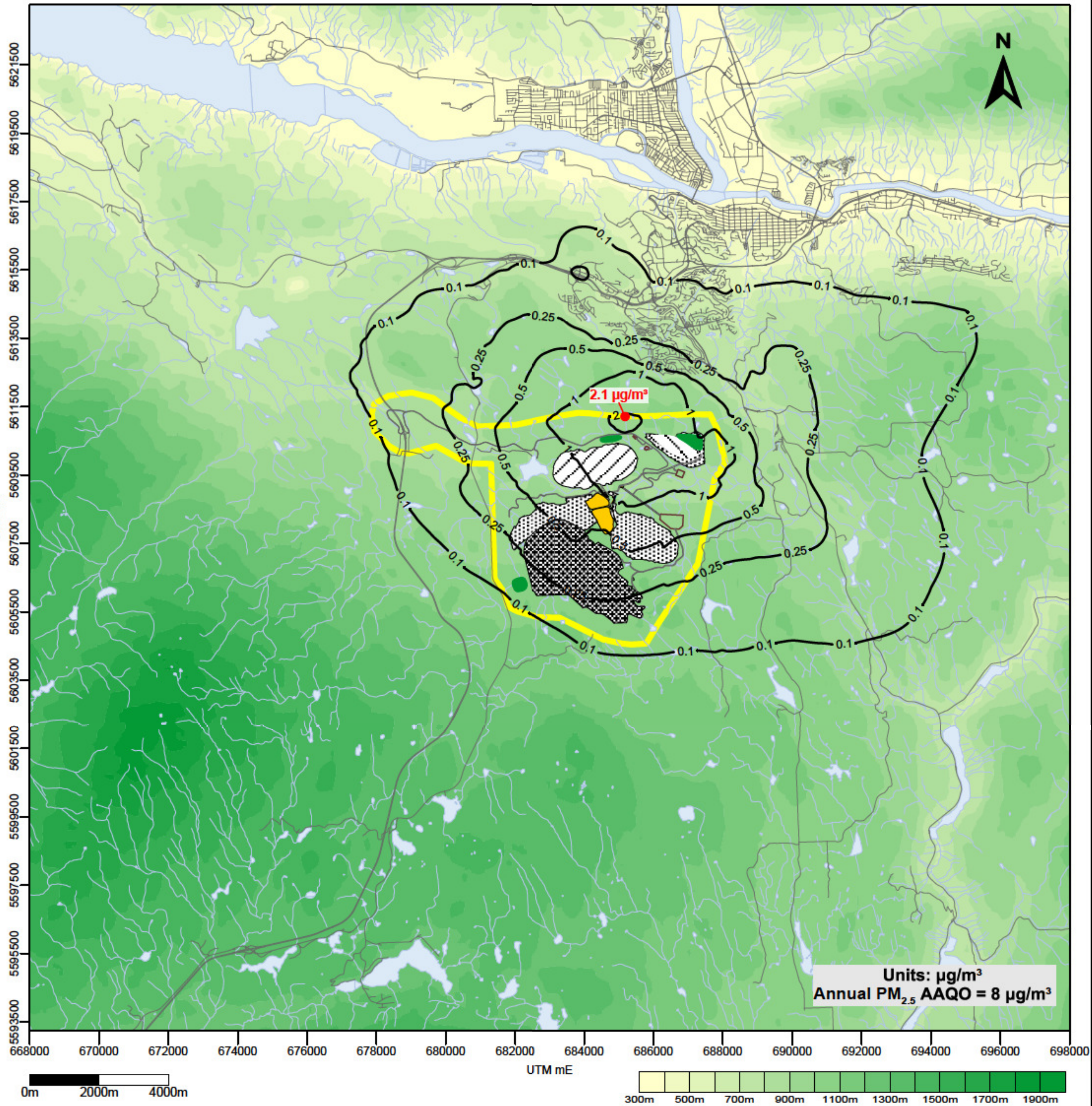
The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations associated with operations are 1.6, 1.1, and 0.04 μg/m^3, respectively. These maxima are much less than the applicable objective for ambient air quality.

NO_2/Operations

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations for operations are 142.4, 117.4, and 9.5 μg/m^3, respectively. The predicted concentrations are less than then applicable regulatory criteria.

CO/Operations

The maximum predicted one-hour and eight-hour CO concentrations associated with operations are 926.5 and 744.3 μg/m^3, respectively. These concentrations are much less than the applicable one hour (14,300 μg/m^3) and eight-hour (5,500 μg/m^3) regulatory criteria for CO.



Isopleth Intervals for $PM_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

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KGHM Ajax Air Quality Assessment

PREPARED BY
Stantec

PREPARED FOR
KGHM

Project Case Operations Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Without Global/Regional Background Added

FIGURE NO.
5.3-1

Last Modified: 04/28/2015 By: KW

5.4 APPLICATION CASE—CONSTRUCTION

The Application Case Construction is the sum of the Base Case (which includes the addition of global/regional background) and the Project Case Construction.

Section 5.4.1 summarizes the maximum predicted concentrations associated with the Application Case Construction in the City of Kamloops. Section 5.4.2 summarizes the maximum predicted concentrations at the plant boundary. Section 5.4.3 summarizes the maximum predicted concentrations over the assessment area.

5.4.1 City of Kamloops Predictions

Table 5-6 summarizes the maximum predicted concentrations associated with Application Case Construction in the City of Kamloops. Over the City of Kamloops the maximum predicted concentrations for SO_2, NO_2, and CO for all time-averaging intervals are less than the applicable regulatory criteria. The maximum predicted concentrations for annual TSP are also less than the criteria. Dustfall, 24-hour TSP, PM_{10}, and $PM_{2.5}$ are predicted to be greater than the criteria. Areas where concentrations above the criteria are predicted to occur are over North Kamloops and Downtown Kamloops. Isopleth maps illustrating the Application Case Construction results are in **Appendix H**.

Section 5.6.1 contains an analysis of the attribution of effects which indicates how much of a contribution the Base Case has to the Application Case Construction at six locations in the modelling domain. In general, maximums predicted in the City of Kamloops are attributed to the Base Case.

Table 5-6 Maximum Predicted CAC Concentrations in the City of Kamloops Associated with the Application Case Construction

Substance	Averaging Interval	Maximum Predicted Rate/Concentration in the City of Kamloops	Applicable Regulatory Criteria [a]
DF ($mg/dm^2/d$)	30-day	**2.0**	1.7
TSP ($\mu g/m^3$)	24-hour	**151.9**	120
	Annual	44.1	60
PM_{10} ($\mu g/m^3$)	24-hour	**89.6**	50
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [b]	**34.7**	25
	24-hour [c]	**36.6**	28 (27) [e]
	Annual	**10.9**	8
	Annual [d]	**11.0**	10 (8.8) [e]
SO_2 ($\mu g/m^3$)	1-hour[f]	15.8	200
	1-hour	20.2	450
	24-hour	1.3	150
	Annual	0.9	30
NO_2 ($\mu g/m^3$) [g]	1-hour [h]	77.8	188
	1-hour	117.5	400
	24-hour	50.3	200
	Annual	15.4	60
CO ($\mu g/m^3$)	1-hour	2,088	14,300
	8-hour	1,105	5,500

NOTES:

Values in **boldface** identify results greater than the applicable regulatory criteria.

Maximum predicted concentrations include global/regional background (see Section 2.2.2).

a Applicable AAQO and CAAQS from Table 3-1

b Based on the 98th percentile for one year

c Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years

d Based on the 3-year mean of annual average concentrations

e The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).

f Based on 99th percentile of daily 1-hour maxima, averaged over one year.

g NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.

h Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Application Case Construction—at City

The maximum predicted monthly dustfall in the City of Kamloops associated with the Application Case Construction is 2.0 mg/dm^2/d, which is greater than the BC dustfall objective of 1.7 mg/dm^2/d. Figure H-12 in **Appendix H** illustrates the area of exceedance within the modelling domain to be over Downtown Kamloops. The frequency of exceedance is discussed in Section 5.4.4.

TSP/Application Case Construction—at City

The maximum predicted 24-hour and annual average ground level TSP concentrations in the City of Kamloops for the Application Case Construction are 151.9 and 44.1 µg/m^3, respectively. The 24-hour maximum (151.9 µg/m^3) is greater than the applicable regulatory criteria (120 µg/m^3). An isopleth map of 24-hour TSP concentrations is available in **Appendix H** (Figure H-13). This map illustrates that the maximum predicted concentrations in the City of Kamloops occur over North Kamloops, with small areas of exceedance in Downtown Kamloops and west of Downtown. The frequency of the 24-hour TSP exceedance is discussed in Section 5.4.4.

PM_{10}/Application Case Construction—at City

The maximum predicted 24-hour average PM_{10} concentrations in the City of Kamloops associated with the Application Case Construction is 89.6 µg/m^3. The 24-hour maximum (89.6 µg/m^3) is greater than the applicable regulatory criteria (50 µg/m^3). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix H**, (Figure H-15). This map illustrates that the maximum predicted concentrations in the City of Kamloops occur over North Kamloops and extends into Downtown Kamloops and west of Downtown. The frequency of the 24-hour PM_{10} exceedance is discussed in Section 5.4.4.

$PM_{2.5}$/Application Case Construction—at City

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations in the City of Kamloops associated with the Application Case Construction are 34.7 and 10.9 µg/m^3, respectively. The predicted concentrations are greater than the applicable regulatory criteria (25 µg/m^3 and 8 µg/m^3 respectively).

Figure H-16 in **Appendix H** illustrates the area of 24-hour $PM_{2.5}$ exceedance within the modelling domain. This figure shows that the area of 24-hour $PM_{2.5}$ exceedance over the City of Kamloops primarily occurs over North Kamloops with small areas of exceedance over Downtown Kamloops, and west of Downtown Kamloops. The frequency of the 24-hour $PM_{2.5}$ exceedance is discussed in Section 5.4.4.

Figure 5.4-1 and Figure H-17 (**Appendix H**) illustrate the area of annual $PM_{2.5}$ exceedance within the modelling domain. This map shows the area of annual $PM_{2.5}$ exceedance in the City of Kamloops occurs primarily over North Kamloops. The frequency of the annual $PM_{2.5}$ exceedance is discussed in Section 5.4.4.

SO_2/Application Case Construction—at City

The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations in the City of Kamloops associated with the Application Case Construction are 16.7, 12.7, and 2.1 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Application Case Construction—at City

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations in the City of Kamloops for the Application Case Construction are 77.8, 50.3, and 15.4 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Application Case Construction—at City

The maximum predicted one-hour and eight-hour CO concentrations in the City of Kamloops associated with the Application Case Construction are 2,088 and 1,105 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.

5.4.2 Plant Boundary Predictions

Table 5-7 summarizes the maximum predicted concentrations associated with Application Case Construction at the plant boundary. At the plant boundary the maximum predicted concentrations for all substances except for TSP and PM_{10} are less than the applicable regulatory criteria. TSP and PM_{10} are predicted to be greater than the criteria on the northeast plant boundary. Areas where concentrations above the criteria are predicted to occur are largely uninhabited regions in the modelling domain. Isopleth maps illustrating the Application Case Construction results are in **Appendix H**.

Section 5.6.1 contains an analysis of the attribution of effects which indicates how much of a contribution the Base Case has to the Application Case Construction at six locations in the modelling domain. In general, maximums predicted at the plant boundary are attributed to the Project Case Construction.

Table 5-7 Maximum Predicted CAC Concentrations at the Plant Boundary Associated with the Project Case Construction

Substance	Averaging Interval	Maximum Predicted Rate/Concentration at the Plant Boundary	Applicable Regulatory Criteria [a]
DF ($mg/dm^2/d$)	30-day	1.1	1.7
TSP ($\mu g/m^3$)	24-hour	**127.4**	120
	Annual	34.7	60
PM_{10} ($\mu g/m^3$)	24-hour	**91.4**	50
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [b]	15.3	25
	24-hour [c]	12.6	28 (27) [e]
	Annual	5.0	8
	Annual [d]	5.0	10 (8.8) [e]
SO_2 ($\mu g/m^3$)	1-hour[f]	4.2	200
	1-hour	6.9	450
	24-hour	2.5	150
	Annual	1.0	30
NO_2 ($\mu g/m^3$) [g]	1-hour [h]	99.9	188
	1-hour	123.1	400
	24-hour	69.5	200
	Annual	12.3	60
CO ($\mu g/m^3$)	1-hour	826.9	14,300
	8-hour	476.1	5,500

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
Maximum predicted concentrations include global/regional background (see Section 2.2.2).
- a Applicable AAQO and CAAQS from Table 3-1
- b Based on the 98th percentile for one year
- c Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
- d Based on the 3-year mean of annual average concentrations
- e The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
- f Based on 99th percentile of daily 1-hour maxima, averaged over one year.
- g NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
- h Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Application Case Construction—at Plant Boundary

The maximum predicted monthly dustfall at the plant boundary associated with the Application Case Construction is 1.1 milligrams per decimetre squared per day ($mg/dm^2/d$), which is below the BC dustfall objective of 1.7 $mg/dm^2/d$.

TSP/Application Case Construction— at Plant Boundary

The maximum predicted 24-hour and annual average ground level TSP concentrations at the plant boundary for the Application Case Construction are 127.4 and 34.7 µg/m^3, respectively. The 24-hour maximum (127.4 µg/m^3) is greater than the applicable regulatory criteria (120 µg/m^3). An isopleth map of 24-hour TSP concentrations is available in **Appendix H** (Figure H-13). This map illustrates that the maximum predicted concentrations at the plant boundary exceed on the northeast side of the plant boundary. The frequency of the 24-hour TSP exceedance is discussed in Section 5.6.2.

PM_{10}/Application Case Construction— at Plant Boundary

The maximum predicted 24-hour average PM_{10} concentrations at the plant boundary associated with Application Case Construction is 91.4 µg/m^3. The 24-hour maximum (91.4 µg/m^3) is greater than the applicable regulatory criteria (50 µg/m^3). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix H**, (Figure H-15). This map illustrates the maximum predicted concentrations on the northeast plant boundary. Areas where concentrations above the criteria are predicted to occur extend less than 2 km from the boundary. This area is an uninhabited region in the modelling domain. The frequency of the 24-hour PM_{10} exceedance is discussed in Section 5.4.4.

$PM_{2.5}$/Application Case Construction— at Plant Boundary

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations at the plant boundary associated with Application Case Construction are 15.3 and 5.0 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for $PM_{2.5}$. Figure 5.4-1 illustrates the annual average $PM_{2.5}$ concentrations.

SO_2/Application Case Construction— at Plant Boundary

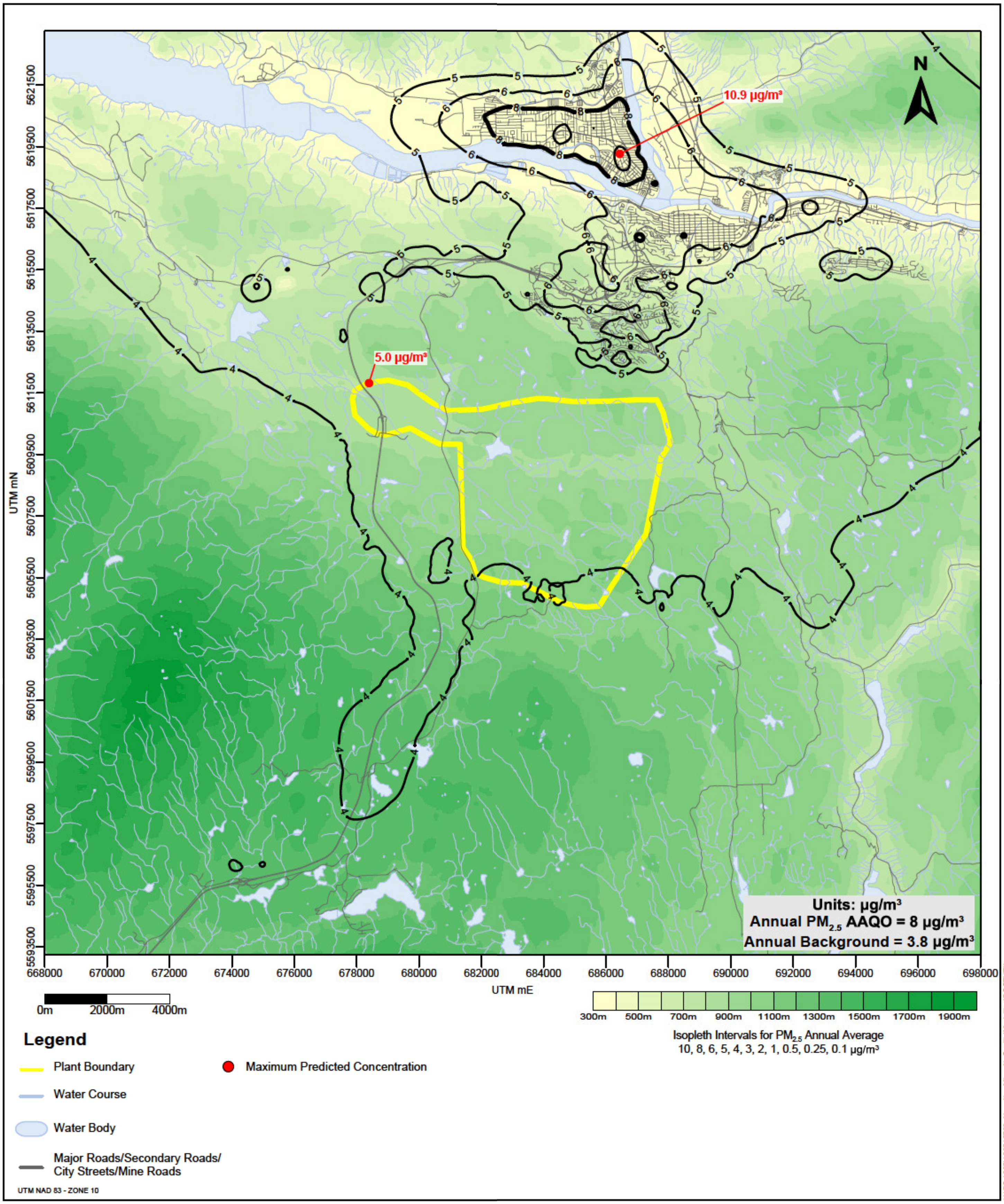
The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations at the plant boundary associated with the Application Case Construction are 4.2, 2.5, and 1.0 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Application Case Construction— at Plant Boundary

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations at the plant boundary for Application Case Construction are 99.9, 69.5, and 12.3 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Application Case Construction— at Plant Boundary

The maximum predicted one-hour and eight-hour CO concentrations at the plant boundary associated with the Application Case Construction are 826.9 and 476.1 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.



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Application Case Construction Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

FIGURE NO. **5.4-1**

5.4.3 CALPUFF Assessment Area Predictions

The maximum predicted concentrations for the Application Case Construction over the entire modelling domain are either located in the City of Kamloops or on the plant boundary. Table 5-8 summarizes the maximum predicted concentrations, the location of the maximum, the description of the maximum, which modelling case is attributed to the maximum location, and which isopleth map in **Appendix H** illustrates the maximums and their locations.

The Application Case Construction maximum predicted 30 day dustfall rate and the maximum predicted concentrations of TSP (24- hour and annual), PM_{10} (24-hour), $PM_{2.5}$ (24-hour and annual), SO_2, (1-hour, 24-hour, and annual), and CO (1-hour and 8-hour) all occur in the City of Kamloops. The maximums in the City are predicted to occur in Downtown Kamloops or North Kamloops. The maximum predicted concentrations of NO_2 (1-hour, 24-hour, and annual) are predicted to occur on the northeast edge of the plant boundary.

Table 5-8 Application Case Construction Maximum Predicted Concentrations over the CALPUFF Assessment Area

Substance	Averaging Interval	Maximum Predicted Rate/Concentration	Location of Maximum Predicted Concentration: Plant Boundary	Location of Maximum Predicted Concentration: City of Kamloops	Description of Location	Effects Attributed to	Isopleth Map (Appendix H)
DF ($mg/dm^2/d$)	30-day	2.0		✓	Southeast side of Downtown Kamloops	Sources in Kamloops (Base Case)	H-12
TSP ($\mu g/m^3$)	24-hour	151.9		✓	North Kamloops	Sources in Kamloops (Base Case)	H-13
	Annual	44.1		✓	Southeast side of Downtown Kamloops	Sources in Kamloops (Base Case)	H-14
PM_{10} ($\mu g/m^3$)	24-hour	89.6		✓	North Kamloops	Sources in Kamloops (Base Case)	H-15
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [a]	34.7		✓	North Kamloops	Sources in Kamloops (Base Case)	H-16
	Annual	10.9		✓	North Kamloops	Sources in Kamloops (Base Case)	H-17
SO_2 ($\mu g/m^3$)	1-hour[b]	15.8		✓	North Kamloops	Sources in Kamloops (Base Case)	H-18
	24-hour	1.3		✓	North Kamloops	Sources in Kamloops (Base Case)	n/a
	Annual	0.9		✓	North Kamloops	Sources in Kamloops (Base Case)	n/a
NO_2 ($\mu g/m^3$) [c]	1-hour [d]	99.9	✓		Northeast edge of the plant boundary	Sources at Project (Project Construction)	H-19
	24-hour	69.5	✓		Northeast edge of the plant boundary	Sources at Project (Project Construction)	n/a
	Annual	15.4		✓	Downtown Kamloops	Sources in Kamloops (Base Case)	H-20
CO ($\mu g/m^3$)	1-hour	2,088		✓	Downtown Kamloops	Sources in Kamloops (Base Case)	H-21
	8-hour	1,105		✓	Downtown Kamloops	Sources in Kamloops (Base Case)	H-22

NOTES:
n/a = not applicable (only isopleth maps for averaging periods that have BC AAQOs are presented)
[a] Based on the 98th percentile for one year
[b] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[c] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[d] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

5.4.4 Predicted Exceedance Analysis

The maximum predicted concentrations of dustfall, 24-hour TSP, 24-hour PM_{10}, 24-hour $PM_{2.5}$, and annual $PM_{2.5}$ are greater than the applicable regulatory criteria. With respect to predicted exceedances in the Application Case Construction, Table 5-9 summarizes the predicted exceedances. Table 5-9 also indicates which figure of **Appendix H** illustrates the exceedance. Section 5.6.2 compares the exceedance analysis for all modelling cases, specifically Table 5-16 summarizes the exceedances in the Base Case, Project Case Construction, and the Application Case Construction.

As illustrated in Table 5-9, the maximum predicted monthly dustfall rate and the maximum predicted 24-hour and annual $PM_{2.5}$ are predicted to be greater than the applicable regulatory criteria only in the City of Kamloops. TSP (24-hour and annual) and 24-hour PM_{10} are predicted to be greater than the criteria in the City as well as on the plant boundary. The maximum predicted dustfall rate is predicted to exceed 58% of the year, covering 6.9 ha over Downtown Kamloops. TSP is predicted to exceed less than 1% of the year covering 622 ha over North Kamloops, Downtown Kamloops, and west of the City. PM_{10} is predicted to exceed less than 2% of the year covering 3,247 ha over North Kamloops, Downtown Kamloops, and the northeast plan boundary. Twenty-four-hour $PM_{2.5}$ is predicted to exceed less than 5% of the year covering 1,051 ha over North Kamloops and Downtown Kamloops. The annual $PM_{2.5}$ exceedance covers 770 ha over North Kamloops.

The predicted exceedances in the City of Kamloops can be attributed to the sources in the City (the Base Case predictions). The exceedances on the plant boundary can be attributed to the Project sources (the Project Case Construction). The exceedances are primarily in the winter when dispersion is frequently poorer than in the summer months.

Table 5-9 Application Case Construction—Exceedance Analysis

Substance	Averaging Interval	Exceedance Location: Plant Boundary	Exceedance Location: City of Kamloops	Maximum Predicted Concentration	Applicable Regulatory Criteria [a]	Frequency of Exceedance	Months	Total Area [b]	Description of Area /Appendix H Figure
DF ($mg/dm^2/d$)	30-day		✓	2.0	1.7	58% (7 months of the year)	February, March, and June through September	6.9 ha	Downtown Kamloops (attributed to the Base Case)/H-12
TSP ($\mu g/m^3$)	24-hour		✓	151.9	120	0.8% (3 days of the year)	December and January	622 ha	North Kamloops, Downtown Kamloops, and west of the city (attributed to the Base Case)/H-13
		✓		127.4		0.3% (1 day of the year)	January		North east plant boundary (attributed to the Project Case Construction)/H-153
PM_{10} ($\mu g/m^3$)	24-hour		✓	89.6	50	1.9% (7 days of the year)	December, January, and February	3,247 ha	North Kamloops, and Downtown Kamloops (attributed to the Base Case)/H-15
		✓		91.4		1.6% (6 days of the year)	December and January		North east plant boundary (attributed to the Project Case Construction)/H-15
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [c]		✓	34.7	25	4.4% (16 days of the year)	November, December, January, and February	1,051 ha	North Kamloops and Downtown Kamloops (attributed to the Base Case)/H-16
	Annual		✓	10.9	8	N/A	N/A	770 ha	North Kamloops (attributed to the Base Case)/H-17

NOTES:
Only substances and averaging periods where concentrations above the criteria are predicted to occur are presented.
N/A = not applicable
[a] Applicable AAQO and CAAQS from Table 3-1
[b] Total are outside of plant boundary
[c] Based on the 98th percentile for one year

5.4.5 Air Quality Health Index: Application Case Construction

The AQHI was calculated using Application Case Construction predicted concentrations at six locations in the CALPUFF assessment area (Figure 5.1-2 and Figure 5.6-1). The calculation follows the methodology outlined in Section 3.1.3 and 4.4.3.

The Application Case Construction AQHI is based on 3-hour average predicted concentrations of NO_2 and $PM_{2.5}$. The 3-hour average NO_2 is based on the hourly NO_2 emission rates. These emission rates conservatively assume there is a blast occurring and that all equipment is in operation and at full load. Therefore the 3-hour average NO_2 used in the AQHI calculation is a highly conservative prediction. The 3-hour average $PM_{2.5}$ is based on $PM_{2.5}$ emission rates that assume 90% control mitigation (road watering). The $PM_{2.5}$ emission rates conservatively assume there is no natural mitigation, a blast is occurring mid-day, and the full equipment fleet is in operation during the day. Therefore the 3-hour average $PM_{2.5}$ used in the AQHI calculation is conservative (an over prediction).

Generally, NO_2 contributes more to the measured AQHI than $PM_{2.5}$. Table 5-10 contains the Application Case Construction AQHI at the six locations. The AQHI at all six sites is in the Low Health Risk range (1 to 3) most of the time. At all 6 sites the Application Case Construction AQHI is in the Low Health Risk range more than 95% of the year. At Site 1 Application Case Construction AQHI is predicted to be in the High Health Risk range 0.1% of the year. At all other sites the Application Case Construction AQHI is not predicted to be in the High Health Risk or Very High Health Risk Range.

At Site 1 (north east plant boundary) the AQHI is predicted to be in the Moderate Health Risk range 3.1% of the year. This can be attributed to the Project Case Construction as the Site 1 Base Case AQHI is predicted to be in the Moderate Health Risk range 0.3% of the year (Table 5-3). At Sites 2, 3, 4, and 5 the AQHI is predicted to be in the Moderate Health Risk range less than 3% of the year. At Site 6, (North Kamloops) the AQHI is predicted to be in the Moderate Health Risk range 3.7% of the year. This is attributed to the Base Case as the Site 6 Base Case AQHI is predicted to be in the Moderate Health Risk range 3.6% of the year (Table 5-3). The AQHI predicted at Site 1, 2, and 3 can be attributed to the Project Case Construction while the predicted AQHIs at Site 4, 5, and 6 can be attributed to the Base Case.

At all six sites, O_3 is the greatest contributor to the AQHI while NO_2 and $PM_{2.5}$ have similar but minor contributions to the AQHI. Generally, NO_2 contributes more to the measured AQHI than $PM_{2.5}$.

Table 5-10 Predicted Application Case Construction Air Quality Health Index

Location:	Site 1 (plant boundary)	Site 2 (City Development Boundary)	Site 3 (upper Aberdeen)	Site 4 (upper Sahali)	Site 5 (West End)	Site 6 (North Kamloops)
Average AQHI	2	1	2	2	2	2
% of year in **Low Health Risk** range	96.8	98.0	99.1	97.5	98.3	96.2
% of year in **Moderate Health Risk** range	3.1	2.0	0.9	2.5	1.6	3.7
% of year in **High Health Risk** range	0.1	0.0	0.0	0.0	0.0	0.1
% of year in **Very High Health Risk** range	0.0	0.0	0.0	0.0	0.0	0.0
Average % contribution of NO_2 to total AQHI	24.3	18.9	20.1	20.1	15.0	19.2
Average % contribution of $PM_{2.5}$ to total AQHI	5.0	5.1	15.4	15.4	12.4	21.1
Average % contribution of O_3 to total AQHI	70.6	76.1	64.5	64.5	72.6	59.8

NOTES:
Site 1-6 AQHI are based on Application Case Construction predicted concentrations.
Figure 5.1-2 and
Figure 5.6-1Figure 5.6-1 show the six locations where AQHI was calculated.
Low Health Risk: AQHI values from 1 to 3
Moderate Health Risk: AQHI values from 4 to 6
High Health Risk: AQHI values from 7 to 10
Very High Health Risk: AQHI values above 10

5.5 APPLICATION CASE—OPERATIONS

The effect of the Application Case Operations emissions on ambient air quality was evaluated using the results obtained from the modelling of the Base Case and Project Case Operations. The Project Application Case is the sum of the Base Case (which includes the addition of global/regional background) and the Project Case Operations.

Section 5.5.1 summarizes the maximum predicted concentrations associated with the Application Case Operations in the City of Kamloops. Section 5.5.2 summarizes the maximum predicted concentrations at the plant boundary. Section 5.5.3 summarizes the maximum predicted concentrations over the entire modelling domain.

5.5.1 City of Kamloops Predictions

Table 5-11 summarizes the maximum predicted concentrations associated with the Application Case Operations in the City of Kamloops. Over the City of Kamloops the maximum predicted concentrations for SO_2, NO_2, and CO for all time-averaging intervals are less than the applicable regulatory criteria. The maximum predicted concentrations for annual TSP are also less than the criteria. Dustfall, 24-hour TSP, PM_{10}, and $PM_{2.5}$ are predicted to exceed the criteria. Areas where concentrations above the criteria are predicted to occur are over North Kamloops and Downtown Kamloops. Isopleth maps illustrating the Application Case Operations results are in **Appendix I**.

Section 5.6.1 contains an analysis of the attribution of effects which indicates how much of a contribution the Base Case has to the Application Case Operations at six locations in the modelling domain. In general, maximums predicted in the City of Kamloops are attributed to the Base Case.

Table 5-11 Maximum Predicted CAC Concentrations in the City of Kamloops Associated with the Application Case Operations

Substance	Averaging Interval	Maximum Predicted Rate/Concentration	Applicable Regulatory Criteria [a]
DF (mg/dm^2/d)	30-day	**2.0**	1.7
TSP (µg/m^3)	24-hour	**152.5**	120
	Annual	44.3	60
PM_{10} (µg/m^3)	24-hour	**94.8 (90.2)** [b]	50
$PM_{2.5}$ (µg/m^3)	24-hour [c]	**34.7**	25
	24-hour [d]	**36.8**	28 (27) [f]
	Annual	**10.9**	8
	Annual [e]	**11.1**	10 (8.8) [f]
SO_2 (µg/m^3)	1-hour [g]	15.8	200
	1-hour	20.2	450
	24-hour	12.7	150
	Annual	2.1	30
NO_2 (µg/m^3) [h]	1-hour [i]	78.7	188
	1-hour	168.5	400
	24-hour	51.4	200
	Annual	15.8	60
CO (µg/m^3)	1-hour	2,088	14,300
	8-hour	1,105	5,500

Table 5-11 Maximum Predicted CAC Concentrations in the City of Kamloops Associated with the Application Case Operations

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
[a] Applicable AAQO and CAAQS from Table 3-1
[b] 94.8 μg/m³ is the maximum over the City of Kamloops, 90.4 μg/m³ is the maximum over the North Shore
[c] Based on the 98th percentile for one year
[d] Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
[e] Based on the 3-year mean of annual average concentrations
[f] The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
[g] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[h] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[i] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Application Case Operations—at City

The maximum predicted monthly dustfall in the City of Kamloops associated with the Application Case Operations is 2.0 mg/dm²/d, which is greater than the BC dustfall objective of 1.7 mg/dm²/d. Figure I-12 in **Appendix I** illustrates the area of exceedance within the modelling domain to be over Downtown Kamloops. The frequency of exceedance is discussed in Section 5.6.2.

TSP/Application Case Operations—at City

The maximum predicted 24-hour and annual average ground level TSP concentrations in the City of Kamloops for the Application Case Operations are 152.5 and 44.3 μg/m³, respectively. The 24-hour maximum (152.5 μg/m³) is greater than the applicable regulatory criteria (120 μg/m³). An isopleth map of 24-hour TSP concentrations is available in **Appendix I** (Figure I-13). This map illustrates that the maximum predicted concentrations in the City of Kamloops occur over North Kamloops, with small areas of exceedance in Downtown Kamloops and west of Downtown. The frequency of the 24-hour TSP exceedance is discussed in Section 5.6.2.

PM_{10}/Application Case Operations—at City

The maximum predicted 24-hour average PM_{10} concentrations in the City of Kamloops associated with the Application Case Operations is 94.8 μg/m³. The maximum over the North Shore is 90.2 μg/m³. The 24-hour maxima (94.8, and 90.2 μg/m³) exceed the applicable regulatory criteria (50 μg/m³). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix I**, (Figure I-15). This map illustrates that the maximum predicted concentrations in the City of Kamloops occur over the south of Aberdeen, North Kamloops, and extends into Downtown Kamloops and west of Downtown. The frequency of the 24-hour PM_{10} exceedance is discussed in Section 5.6.2.

$PM_{2.5}$/Application Case Operations—at City

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations in the City of Kamloops associated with the Application Case Operations are 34.7 and 10.9 µg/m^3, respectively. The predicted concentrations are greater than the applicable regulatory criteria (25 µg/m^3 and 8 µg/m^3 respectively).

Figure I-16 in **Appendix I** illustrates the area of 24-hour $PM_{2.5}$ exceedance within the modelling domain. This figure shows that the area of 24-hour $PM_{2.5}$ exceedance occurs over North Kamloops, Downtown Kamloops, and extends west of Downtown Kamloops. The frequency of the 24-hour $PM_{2.5}$ exceedance is discussed in Section 5.6.2.

Figure 5.5-1 and Figure I-17 (**Appendix I**) illustrate the area of annual $PM_{2.5}$ exceedance within the modelling domain. This map shows the area of annual $PM_{2.5}$ exceedance occurs primarily over North Kamloops with a small area over the western side of Downtown Kamloops. The frequency of the annual $PM_{2.5}$ exceedance is discussed in Section 5.6.2.

SO_2/Application Case Operations—at City

The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations in the City of Kamloops associated with the Application Case Operations are 15.8, 12.7, and 2.1 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Application Case Operations—at City

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations in the City of Kamloops for the Application Case Operations are 78.7, 51.4, and 15.8 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Application Case Operations—at City

The maximum predicted one-hour and eight-hour CO concentrations in the City of Kamloops associated with the Application Case Operations are 2,088 and 1,105 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.

5.5.2 Plant Boundary Predictions

Table 5-12 summarizes the maximum predicted concentrations associated with the Application Case Operations at the plant boundary. At the plant boundary the maximum predicted concentrations for SO_2, NO_2, and CO for all time-averaging intervals are less than the applicable regulatory criteria. The maximum predicted concentrations for annual TSP and Annual $PM_{2.5}$ are also less than the criteria. TSP and PM_{10} are predicted to exceed the criteria on the northeast plant boundary. Areas where concentrations above the criteria are predicted to occur are largely uninhabited regions in the modelling domain. Isopleth maps illustrating the Application Case Construction results are in **Appendix I**.

Section 5.6.1 contains an analysis of the attribution of effects which indicates how much of a contribution the Base Case has to the Application Case Operations at six locations in the modelling domain. In general, maximums predicted at the plant boundary are attributed to the Project Case Operations.

Table 5-12 Maximum Predicted CAC Concentrations at the Plant Boundary Associated with the Application Case Operations

Substance	Averaging Interval	Maximum Predicted Concentration	Applicable Regulatory Criteria [a]
DF ($mg/dm^2/d$)	30-day	1.2	1.7
TSP ($\mu g/m^3$)	24-hour	**435.6**	120
	Annual	35.4	60
PM_{10} ($\mu g/m^3$)	24-hour	**345.9**	50
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [b]	**37.8**	25
	24-hour [c]	25.4	28 (27) [e]
	Annual	6.2	8
	Annual [d]	5.7	10 (8.8) [e]
SO_2 ($\mu g/m^3$)	1-hour[f]	4.3	200
	1-hour	6.9	450
	24-hour	2.9	150
	Annual	1.0	30
NO_2 ($\mu g/m^3$) [g]	1-hour [h]	158.3	188
	1-hour	187.0	400
	24-hour	128.7	200
	Annual	17.2	60
CO ($\mu g/m^3$)	1-hour	1,142	14,300
	8-hour	945.5	5,500

NOTES:
Values in **boldface** identify results greater than the applicable regulatory criteria.
[a] Applicable AAQO and CAAQS from Table 3-1
[b] Based on the 98th percentile for one year
[c] Base on the annual 98th percentile of daily 24-hour average concentrations, averaged over three years
[d] Based on the 3-year mean of annual average concentrations
[e] The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).
[f] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[g] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[h] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

Dustfall/Application Case Operations—at Plant Boundary

The maximum predicted monthly dustfall at the plant boundary associated with the Application Case Operations is 1.2 milligrams per decimetre squared per day (mg/dm^2/d), which is below the BC dustfall objective of 1.7 mg/dm^2/d.

TSP/Application Case Operations— at Plant Boundary

The maximum predicted 24-hour and annual average ground level TSP concentrations at the plant boundary for the Application Case Operations are 435.6 and 35.4 µg/m^3, respectively. The 24-hour maximum (435.6µg/m^3) is greater than the applicable regulatory criteria (120 µg/m^3). An isopleth map of 24-hour TSP concentrations is available in **Appendix I** (Figure I-13). This map illustrates that the maximum predicted concentrations at the plant boundary occur on the northeast side with small areas of exceedance on the east and west sides of the plant boundary. The frequency of the 24-hour TSP exceedance is discussed in Section 5.6.2

PM_{10}/Application Case Operations— at Plant Boundary

The maximum predicted 24-hour average PM_{10} concentrations at the plant boundary associated with Application Case Operations is 345.9 µg/m^3. The 24-hour maximum (345.9 µg/m^3) is greater than the applicable regulatory criteria (50 µg/m^3). An isopleth map of 24-hour PM_{10} concentrations is available in **Appendix I**, (Figure I-15). This map illustrates the maximum predicted concentrations on the northeast plant boundary extend less than 3 km from the boundary. There are also areas with potential exceedance on the east and west sides of the plant boundary. The frequency of the 24-hour PM_{10} exceedance is discussed in Section 5.6.2.

$PM_{2.5}$/Application Case Operations— at Plant Boundary

The maximum predicted 98th percentile 24-hour and annual average $PM_{2.5}$ concentrations at the plant boundary associated with Application Case Operations are 37.8 and 6.2 µg/m^3, respectively. The 24-hour predicted concentrations are greater than the applicable regulatory criteria (25 µg/m^3).

Figure 5.5-1 and Figure I-16 (**Appendix I**) illustrate the area of 24-hour $PM_{2.5}$ exceedance on the plant boundary. This map illustrates the area of 24-hour $PM_{2.5}$ exceedance extends less than 2 km from the northeast of the plant boundary, a largely uninhabited region in the modelling domain. The frequency of exceedance is discussed in Section 5.6.2.

SO_2/Application Case Operations— at Plant Boundary

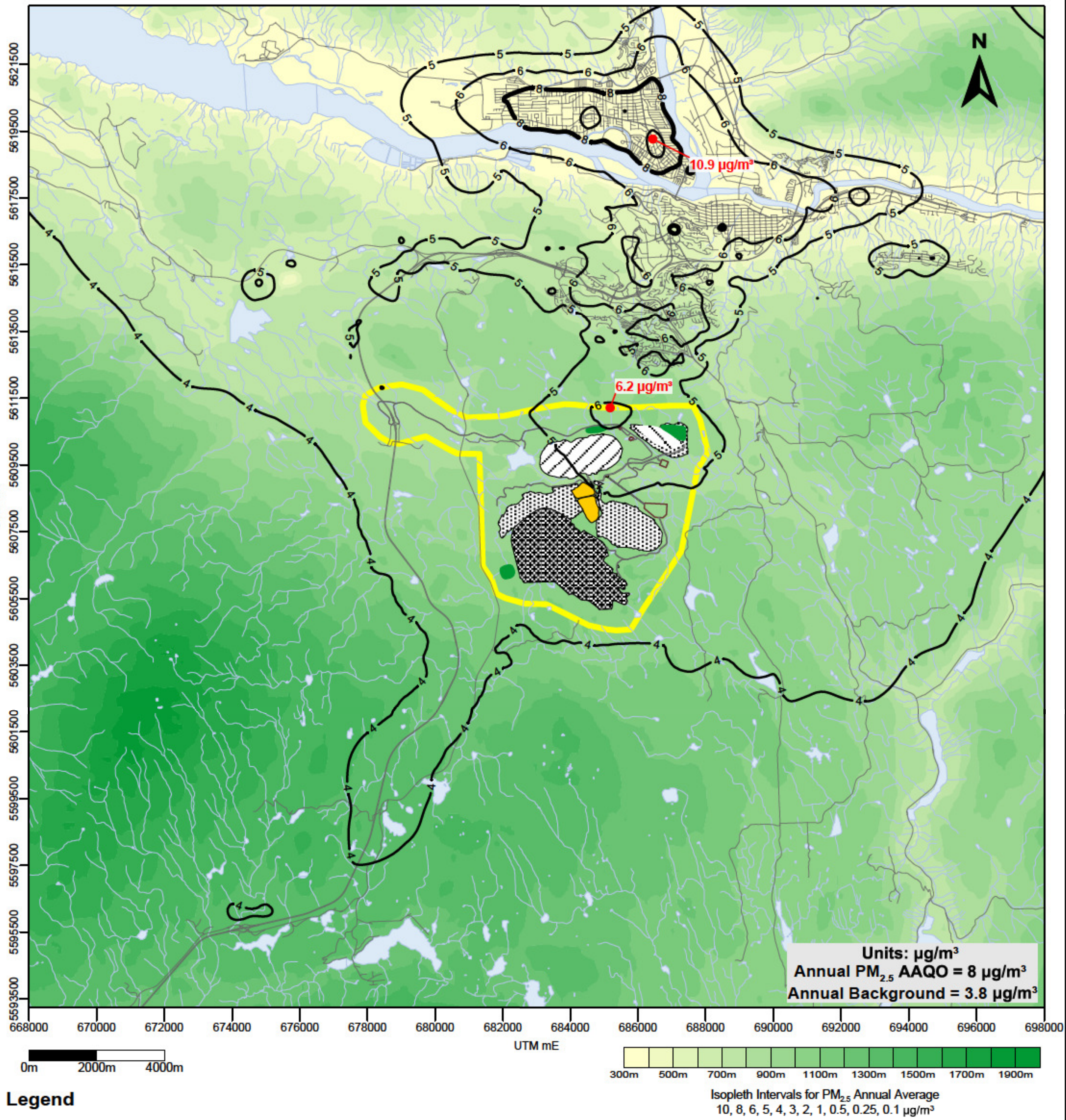
The maximum predicted one-hour, 24-hour, and annual ground level SO_2 concentrations at the plant boundary associated with the Application Case Operations are 4.3, 2.9, and 1.0 µg/m^3, respectively. These maxima are much less than the applicable regulatory criteria for SO_2.

NO_2/Application Case Operations— at Plant Boundary

The maximum predicted one-hour, 24-hour, and annual NO_2 concentrations at the plant boundary for Application Case Operations are 158.3, 128.7, and 17.2 µg/m^3, respectively. These concentrations are less than the applicable regulatory criteria for NO_2.

CO/Application Case Operations— at Plant Boundary

The maximum predicted one-hour and eight-hour CO concentrations at the plant boundary associated with the Application Case Operations are 1,142 and 945.6 µg/m^3, respectively. These concentrations are less than the applicable one hour (14,300 µg/m^3) and eight-hour (5,500 µg/m^3) regulatory criteria for CO.



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

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KGHM Ajax Air Quality Assessment

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Application Case Operations Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

FIGURE NO. 5.5-1

Last Modified: 04/28/2015 By: KW

5.5.3 CALPUFF Assessment Area Predictions

The maximum predicted concentrations for the Application Case Operations over the entire modelling domain are either located in the City of Kamloops or on the plant boundary. Table 5-13 summarizes the maximum predicted concentrations, the location of the maximum, the description of the maximum, which modelling case is attributed to the maximum location, and which isopleth map in **Appendix I** illustrates the maximums and their locations.

The Application Case Operations maximum predicted 30 day dustfall rate and the maximum predicted concentrations of annual TSP, annual $PM_{2.5}$, SO_2 (1-hour, 24-hour, and annual), and CO (1-hour and 8-hour) all occur in the City of Kamloops. The maximums in the City are predicted to occur in Downtown Kamloops or North Kamloops. The maximum predicted concentrations of 24-hour TSP, 24-hour PM_{10}, and NO_2 (1-hour, 24-hour, and annual) are predicted to occur on the northeast edge of the plant boundary.

Table 5-13 Application Case Operations Maximum Predicted Concentrations over the CALPUFF Assessment Area

Substance	Averaging Interval	Maximum Predicted Concentration	Location of Maximum Predicted Concentration		Description of Location	Effects Attributed to	Isopleth Map (Appendix I)
			Plant Boundary	City of Kamloops			
DF (mg/dm^2/d)	30-day	2.0		✓	South-east side of Downtown Kamloops	Sources in Kamloops (Base Case)	I-12
TSP (µg/m^3)	24-hour	435.6	✓		North-east edge of the plant boundary	Sources at Project (Project Operations)	I-13
	Annual	44.3		✓	South-east side of Downtown Kamloops	Sources in Kamloops (Base Case)	I-14
PM_{10} (µg/m^3)	24-hour	345.9	✓		North-east edge of the plant boundary	Sources at Project (Project Operations)	I-15
$PM_{2.5}$ (µg/m^3)	24-hour [a]	34.7	✓				I-16
	Annual	10.9		✓	North Kamloops	Sources in Kamloops (Base Case)	I-17
SO_2 (µg/m^3)	1-hour[b]	15.8		✓			I-18
	24-hour	12.7		✓			n/a
	Annual	2.1		✓			n/a
NO_2 (µg/m^3) [c]	1-hour [d]	158.3	✓		North-east edge of the plant boundary	Sources at Project (Project Operations)	I-19
	24-hour	128.7	✓				n/a
	Annual	17.2	✓				I-20
CO (µg/m^3)	1-hour	2,088		✓	Downtown Kamloops	Sources in Kamloops (Base Case)	I-21
	8-hour	1,105		✓			I-22

NOTES:
n/a = not applicable (only isopleth maps for averaging periods that have BC AAQOs are presented)
[a] Based on the 98th percentile for one year
[b] Based on 99th percentile of daily 1-hour maxima, averaged over one year.
[c] NO_2 based on the Ozone Limiting Method conversion of NO_X to NO_2.
[d] Based on the 98th percentile of daily 1-hour maxima, averaged over one year

5.5.4 Predicted Exceedance Analysis

The maximum predicted concentrations of dustfall, 24-hour TSP, 24-hour PM_{10}, 24-hour $PM_{2.5}$, and annual $PM_{2.5}$ are greater than the applicable regulatory criteria. With respect to predicted exceedances in the Application Case Operations, Table 5-14 summarizes the predicted exceedances. Table 5-14 also indicates which figure of **Appendix I** illustrates the predicted exceedance. Section 5.6.2 compares the exceedance analysis for all modelling cases, specifically Table 5-17 summarizes the exceedances in the Base Case, Project Case Operations, and the Application Case Operations.

As illustrated in Table 5-14, the maximum predicted monthly dustfall rate and the maximum predicted annual $PM_{2.5}$ are predicted to exceed the applicable regulatory criteria only in the City of Kamloops. TSP (24-hour and annual) and 24-hour PM_{10}, and 24-hour $PM_{2.5}$ are predicted to be greater than the criteria in the City as well as on the plant boundary. The maximum predicted dustfall rate is predicted to exceed 58% of the year, covering 6.9 ha over Downtown Kamloops. TSP is predicted to exceed less than 5% of the year covering 1,344 ha over North Kamloops, Downtown Kamloops, west of the City, and at the west, north, northeast, and east edges of the plant boundary. PM_{10} is predicted to exceed less than 10% of the year covering 4,760 ha over North Kamloops, Downtown Kamloops, and at the west, north, northeast, and east edges of the plant boundary. Twenty-four-hour $PM_{2.5}$ is predicted to exceed less than 5% of the year covering 1,274 ha over North Kamloops and Downtown Kamloops. The annual $PM_{2.5}$ exceedance covers 786 ha over North Kamloops.

The exceedances in the City of Kamloops can be attributed to the sources in the City (the Base Case predictions). The exceedances on the plant boundary can be attributed to the Project sources (the Project Case Operations). The exceedances are primarily in the winter when dispersion is frequently poorer than in the summer months.

Table 5-14 Application Case Operations—Exceedance Analysis

Substance	Averaging Interval	Exceedance Location		Maximum Predicted Concentration	Applicable Regulatory Criteria	Frequency of Exceedance	Months	Total Area[b]	Description of Area Appendix I Figure
		Plant Boundary	City of Kamloops						
DF ($mg/dm^2/d$)	30-day		✓	2.0	1.7	58% (7 months of the year)	February, March, and June through September	6.9 ha	Downtown Kamloops (attributed to the Base Case)/I-12
TSP ($\mu g/m^3$)	24-hour		✓	151.9	120	0.8% (3 days of the year)	December and January	1,344 ha	North Kamloops, Downtown Kamloops, and west of the city (attributed to the Base Case)/I-13
		✓		435.6		4.4% (16 days of the year)	December and January		West, north, northeast, and east plant boundary (attributed to the Project Case Operations)/I-13
PM_{10} ($\mu g/m^3$)	24-hour		✓	90.2	50	1.9% (7 days of the year)	December, January, and February	4,760 ha	North Kamloops, and Downtown Kamloops (attributed to the Base Case)/I-15
		✓		345.9		9.3% (34 days of the year)	November, December, January, and February		West, north, northeast, and east plant boundary (attributed to the Project Case Operations)/I-15
$PM_{2.5}$ ($\mu g/m^3$)	24-hour [c]		✓	34.7	25	4.4% (16 days of the year)	November, December, January, and February	1,274 ha	North Kamloops and Downtown Kamloops (attributed to the Base Case)
	24-hour [c]	✓		37.8		0.8% (3 days of the year)	December and January		Northeast plant boundary (attributed to the Project Case Operations)/I-16
	Annual		✓	10.9	8	N/A	N/A	786 ha	North Kamloops (attributed to the Base Case)/I-17

NOTES:

Only substances and averaging periods where concentrations above the criteria are predicted to occur are presented.

N/A = not applicable

[a] Applicable AAQO and CAAQS from Table 3-1

[b] Total are outside of plant boundary

[c] Based on the 98th percentile for one year

5.5.5 Air Quality Health Index: Application Case Operations

The AQHI was calculated using Application Case Operations predicted concentrations at six locations in the CALPUFF assessment area (Figure 5.1-2 and Figure 5.6-1). The calculation follows the methodology outlined in Section 3.1.3 and 4.4.3.

The Application Case Construction AQHI is based on 3-hour average predicted concentrations of NO_2 and $PM_{2.5}$. The 3-hour average NO_2 is based on the hourly NO_2 emission rates. These emission rates assume there is a blast occurring and that all equipment is in operation and at full load. Therefore the 3-hour average NO_2 used in the AQHI calculation is an over-estimate. The 3-hour average $PM_{2.5}$ is based on $PM_{2.5}$ emission rates that assume 90% control mitigation (road watering). The $PM_{2.5}$ emission rates assume there is no natural mitigation, a blast is occurring mid-day, and the full equipment fleet is in operation during the day. Therefore the 3-hour average $PM_{2.5}$ used in the AQHI calculation is likely an over prediction.

Table 5-15 contains the Application Case Operations AQHI at the six locations in the assessment area. The AQHI at all six sites is in the Low Health Risk range (1 to 3) most of the time. At all 6 sites the Application Case Operations AQHI is in the Low Health Risk range more than 90% of the year.

At Site 1 (northeast plant boundary) the AQHI is predicted to be in the Moderate Health Risk range, High Health Risk range, and Very High Health Risk range 7.9%, 1.5%, and 0.3% of the year, respectively. The 0.3% of the year that is in the Very High Risk Health range occurs during the winter months (primarily December and January) when dispersion is low. During these months the greatest contributor to the AQHI is $PM_{2.5}$. This is attributed to the Project Case Operations as the Site 1 Base Case AQHI (Table 5-3) is never predicted to be in the Very High Health Risk range.

At Site 2 (City Development Boundary) the AQHI is predicted to be in the Moderate Health Risk range, High Health Risk range, and Very High Health Risk range, 4.5%, 0.8%, and 0.1% of the year, respectively. The 0.1% of the year that the AQHI is in the Very High Health Risk range occurs during the winter months (primarily December and January) when dispersion is low. During these months the greatest contributor to the AQHI is $PM_{2.5}$. This can be attributed to the Project Case Operations as the Site 1 Base Case AQHI (Table 5-3) is never predicted to be in the Very High Health Risk range.

At Sites 3, 4, and 5 the AQHI is predicted to be in the Moderate Health Risk range less than 3% of the year. The AQHI at these sites is never predicted to be in the High Health Risk range and Very High Health Risk range. At Site 6, (North Kamloops) the AQHI is predicted to be in the Moderate Health Risk range 4.0% of the year and in the High Health Risk Range 0.1% of the year. This is primarily attributed to the Base Case as the Site 6 Base Case AQHI (Table 5-3) is predicted to be in the Moderate Health Risk range 3.6% of the year and in the High Health Risk range 0.1% of the year.

The predicted AQHI at Site 1 and 2 can be primarily attributed to the Project Case Operations while the predicted AQHIs at Sites 4, 5, and 6 can be primarily attributed to the Base Case.

At all six sites, O_3 is the greatest contributor to the AQHI while NO_2 and $PM_{2.5}$ have similar but minor contributions to the AQHI. Generally, NO_2 contributes more to the measured AQHI than $PM_{2.5}$.

Table 5-15 Predicted Application Case Operations Air Quality Health Index

Location:	**Site 1 (Plant Boundary)**	**Site 2 (City Development Boundary)**	**Site 3 (Upper Aberdeen)**	**Site 4 (Upper Sahali)**	**Site 5 (West End)**	**Site 6 (North Kamloops)**
Average AQHI	2	2	2	2	2	2
% of year in **Low Health Risk** range	90.4	94.6	97.1	97.1	98.2	95.9
% of year in **Moderate Health Risk** range	7.9	4.5	2.9	2.9	1.8	4.0
% of year in **High Health Risk** range	1.5	0.8	0.0	0.0	0.0	0.1
% of year in **Very High Health Risk** range	0.3	0.1	0.0	0.0	0.0	0.0
Average % contribution of NO_2 to total AQHI	27.3	21.8	19.1	21.0	15.9	19.6
Average % contribution of $PM_{2.5}$ to total AQHI	7.1	6.5	11.2	15.4	12.4	21.0
Average % contribution of O_3 to total AQHI	65.6	71.7	69.7	63.6	71.7	59.4

NOTES:
Site 1-6 AQHI are based on Application Case Operations predicted concentrations.
Figure 5.1-2 and Figure 5.6-1 show the six locations where AQHI was calculated.
Low Health Risk: AQHI values from 1 to 3
Moderate Health Risk: AQHI values from 4 to 6
High Health Risk: AQHI values from 7 to 10
Very High Health Risk: AQHI values above 10

5.6 ATTRIBUTION OF EFFECTS, CITY-WIDE AVERAGES, AND EXCEEDANCE SUMMARY

5.6.1 Attribution of Effects and City-Wide Averages

Figure 5.6-1 and Figure 5.6-2 depict the percent contribution the Project Operations predictions have on the total predictions of annual $PM_{2.5}$.

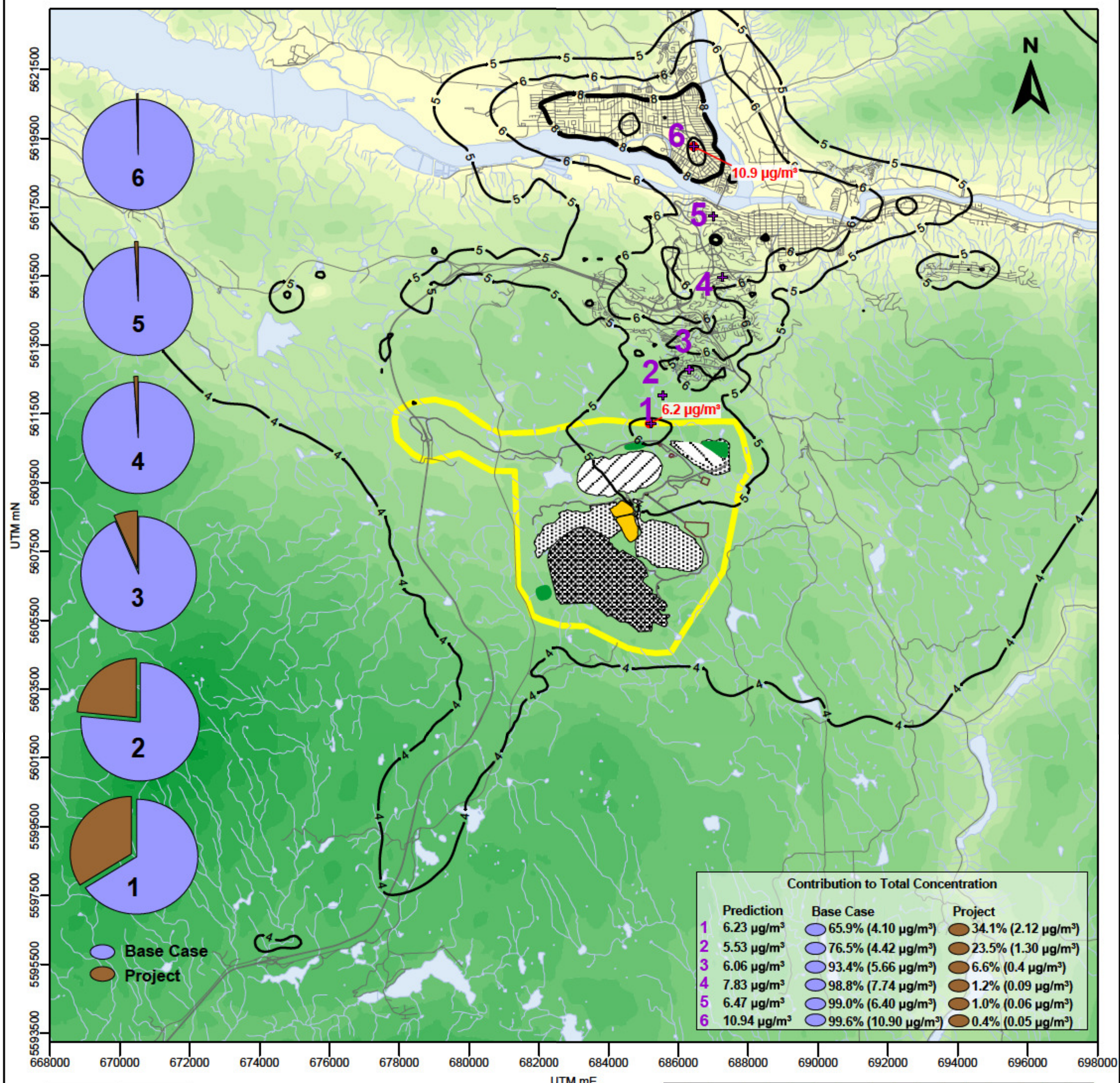
Figure 5.6-1 shows that the air quality associated with Project Operations in upper Aberdeen or Site 3 remains among the best in the City, with an increase in the annual average $PM_{2.5}$ of 6.6%. The maximum predicted concentration is 6.06 µg/m^3. This is less than the BC AAQO of 8 µg/m^3, but greater than the BC Planning Goal of 6 µg/m^3.

On the City Development Boundary or Site 2 air quality associated with Project Operations remains good, despite an increase in the annual average $PM_{2.5}$ of 23.5%. The maximum predicted concentration is 5.53 µg/m^3. This is less than the BC AAQO of 8 µg/m^3 and the BC Planning Goal of 6 µg/m^3.

On the Plant Boundary or Site 1 air quality associated with Project Operations remains good, despite an increase in the annual average $PM_{2.5}$ of 34.1%. The maximum predicted concentration is 6.23 µg/m^3. This is less than the BC AAQO of 8 µg/m^3, but greater than the BC Planning Goal of 6 µg/m^3).

The remainder of the City is relatively unaffected by the Project. In upper Sahali or Site 4 this increase is 1.2%. In the West End or Site 5 this increase is 1%. On the North Shore or Site 6 this increase is 0.4%. Predicted concentrations at sites 4 and 5 are above the BC Planning Goal (6 µg/m^3). At site 6 the predicted concentration is greater than both the annual AAQO (8 µg/m^3) and the BC Planning Goal (6 µg/m^3). This situation is unchanged from the Base Case (Section 5.1).

Figure 5.6-2 identifies the built up urban area and the average $PM_{2.5}$ concentrations for this region is 6.4 µg/m^3. The Project Operation Case contributes 0.15 µg/m^3 to this region, a 2.3% increase. The long-term year to year variability in annual average $PM_{2.5}$ is ± 0.92 µg/m^3 (the value of one standard deviation of the annual average $PM_{2.5}$ collected at Brocklehurst between 1998 and 2011). Given this high variability, and the fact that the increase attributed to the project is a factor of six less, the increase in annual average is insubstantial. It is dwarfed by the long-term year to year variability in annual average $PM_{2.5}$.



Contribution to Total Concentration

	Prediction	Base Case	Project
1	6.23 µg/m³	65.9% (4.10 µg/m³)	34.1% (2.12 µg/m³)
2	5.53 µg/m³	76.5% (4.42 µg/m³)	23.5% (1.30 µg/m³)
3	6.06 µg/m³	93.4% (5.66 µg/m³)	6.6% (0.4 µg/m³)
4	7.83 µg/m³	98.8% (7.74 µg/m³)	1.2% (0.09 µg/m³)
5	6.47 µg/m³	99.0% (6.40 µg/m³)	1.0% (0.06 µg/m³)
6	10.94 µg/m³	99.6% (10.90 µg/m³)	0.4% (0.05 µg/m³)

0m 2000m 4000m

Units: µg/m³
Annual $PM_{2.5}$ AAQO = 8 µg/m³
Annual Background = 3.8 µg/m³
Isoplth contours are for Appliction Case Operations

300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for $PM_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

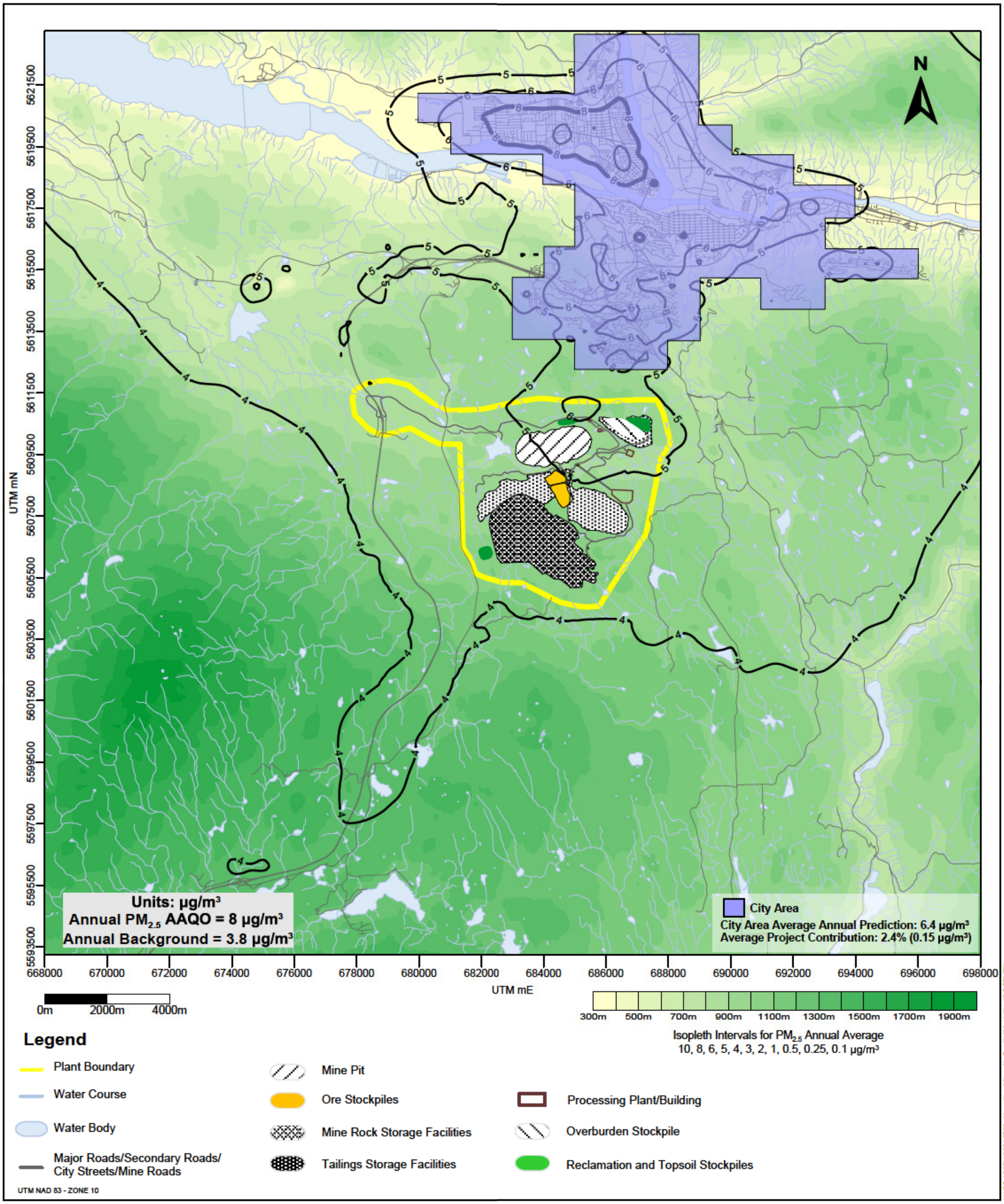
KGHM Ajax Air Quality Assessment

Project Contribution to Locations in the Modelling Domain for the Application Case Operations Maximum Predicted Annual Average Ground-Level $PM_{2.5}$ Concentrations (µg/m3) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. 5.6-1



KGHM Ajax Air Quality Assessment

PREPARED BY Stantec

PREPARED FOR KGHM

Project Contribution to the City of Kamloops for the Maximum Predicted Annual Average Ground-Level $PM_{2.5}$ Concentrations (μg/m³) With Global/Regional Background Added

FIGURE NO. 5.6-2

Last Modified: 04/28/2015 By: KW

5.6.2 Predicted Exceedance Analysis Summary

The area of exceedance is the area which has receptors with maximum predicted concentrations above the applicable regulatory criteria. The frequency of exceedance at a receptor within the exceedance area is the frequency a given receptor has predicted concentrations above the regulatory criteria within the year. The maximum at an exceeding receptor only occurs once and counts towards one of the exceedances making up the frequency of exceedance. For example, the highest predicted 24-hour average PM_{10} concentration within Aberdeen is 71.8 µg/m^3. The frequency of exceedance at this receptor is 0.5% of the year (2 days). At this receptor there is one 24-hour period during the year when the PM_{10} concentration is 71.8 µg/m^3 (e.g., the maximum) and there is one 24-hour period when the PM_{10} concentration is less than the maximum but exceeding the regulatory criteria (50 µg/m^3). For the remaining 363 days of the year the predicted 24-hour PM_{10} concentrations are below the regulatory criteria.

Table 5-16 summarizes the exceedance analysis for the Base Case, Project Case Construction, and Application Case Construction. The maximum predicted concentrations of dustfall, TSP, PM_{10}, and $PM_{2.5}$ are predicted to exceed the applicable regulatory criteria in the Application Case Construction. From Table 5-16 the predicted exceedances of dustfall, TSP (in the City of Kamloops), PM_{10} (in the City), and $PM_{2.5}$ can be attributed to the Base Case as the maximum predicted concentrations are the same. The predicted exceedances on the plant boundary of PM_{10} on and TSP can be attributed to the Project Construction Case.

Table 5-16 Construction Exceedance Analysis

CAC	Base Case	Project Case Construction	Application Case Construction	Change Resulting from the Addition of the Base Case to the Project Case Construction
30-day DF	The maximum monthly dustfall rate over Downtown Kamloops is2.0 mg/dm²/day. The dustfall AAQO is predicted to be exceeded 58% of the year (7 months) over Downtown Kamloops. The high values are predicted to occur in spring, summer, and early fall (February, March, and June through September). The area where the exceedance occurs covers 0.063 km² over Downtown Kamloops (Figure G-1).	No exceedance	The maximum monthly dustfall rate over Downtown Kamloops is2.0 mg/dm²/day. The dustfall AAQO is predicted to be exceeded 58% of the year (7 months). The high values are predicted to occur in spring, summer, and early fall (February, March, and June through September). The area where the exceedance occurs covers 0.065 km² over Downtown Kamloops (Figure H-12). The primary contributor to the dustfall exceedance is the Base Case.	Change in maximum deposition rate: 0.0 mg/dm²/day Change in months > AAQO: 0% Change in area greater than AAQO: 0.002 km² (+3%)
24-hour TSP	The maximum 24-hour TSP concentration over the City of Kamloops is 151.6 µg/m³. The TSP AAQO is predicted to be exceeded 0.8% of the year (3 days)). The high values are predicted to occur in winter (December and January). The area where the exceedance occurs covers a total of 5.93 km² over North Kamloops, Downtown Kamloops, and west of the City (Figure G-2).	No exceedance	The maximum 24-hour TSP concentration over the City of Kamloops is151.9 µg/m³. The TSP AAQO is predicted to be exceeded 0.8% of the year (3 days). The high values are predicted to occur in winter (December and January). The 24-hour TSP concentration at the plant boundary is 127 µg/m³.. At the plant boundary, the TSP AAQO is predicted to be exceeded 0.3% of the year (1 day). The high values are predicted to occur in January. The total area where the exceedance occurs covers a total of 6.22 km² over North Kamloops, Downtown Kamloops, west of the City, and at the northeast edge of the plant boundary (Figure H-13). The primary contributor to the exceedance over the City is the Base Case while the primary contributor to the exceedance at the plant boundary is the Project Case Construction.	Change in maximum concentration: +0.3 µg/m³ (+0.2%) Change in days > AAQO: 0% Change in area greater than AAQO: +0.29 km² (+4.8%)
24-hour PM_{10}	The maximum 24-hour PM_{10} concentration over the City of Kamloops is 89.3 µg/m³. The PM_{10} AAQO is predicted to be exceeded1.6% of the year (6 days). The high values are predicted to occur in winter (December, January, and February) The area where the exceedance occurs covers a total of 27.6 km² over North Kamloops and Downtown Kamloops (Figure G-4).	The maximum 24-hour PM_{10} concentration at the plant boundary is 78.4 µg/m³. The PM_{10} AAQO is predicted to be exceeded 0.5% of the year (2 days). The high values are predicted to occur in January. The area where the exceedance occurs covers 1.38 km² extending from the northeast plant boundary (Figure H-4). This area largely covers undeveloped grasslands and does not extend into the build-up urban area of Kamloops.	The maximum 24-hour PM_{10} concentration over the City of Kamloops is 89.6 µg/m³. The PM_{10} AAQO is predicted to be exceeded 1.9% of the year (7 days). The high values are predicted to be in winter (December, January, and February) The 24-hour PM_{10} concentration at the plant boundary is 91.4 µg/m³. At the plant boundary, the PM_{10} AAQO is predicted to be exceeded 1.6% of the year (6 days). The high values are predicted to be in winter (January and December). The total area where the exceedance occurs covers a total of 32.5 km² over North Kamloops, Downtown Kamloops, and the northeast plant boundary (Figure H-15). The area northeast of the plant boundary largely covers undeveloped grasslands.	Change in maximum concentration over the City of Kamloops: +0.3 µg/m³ (+0.3%) Change in maximum concentration at the plant boundary: +13 µg/m³ (+15%) Change in days > AAQO over the City of Kamloops: +1 day a year (+0.3%) Change in days > AAQO at the plant boundary: +4 days a year (+1.1%) Change in area greater than AAQO: +4.87 km² (+16%)
24-hour $PM_{2.5}$	The maximum 98th percentile 24-hour $PM_{2.5}$ concentration over the City of Kamloops is 34.7 µg/m³. The $PM_{2.5}$ AAQO is predicted to be exceeded 4.4% of the year (16 days). The high values are predicted to be in fall and winter (November, December, January, and February). The area where the 24-hour exceedance occurs covers a total of 10.0 km² over North Kamloops and Downtown Kamloops (Figure G-5).	No exceedance	The maximum 98th percentile 24-hour $PM_{2.5}$ concentration over the City of Kamloops is34.7 µg/m³. The $PM_{2.5}$ AAQO is predicted to be exceeded 4.4% of the year (16 days). The high values are predicted to be in fall and winter (November, December, January, and February). The area where the 24-hour exceedance occurs covers a total of 10.5 km² over North Kamloops and Downtown Kamloops (Figure H-16). The primary contributor is the Base Case	Change in maximum concentration: 0.0 µg/m³ (0%) Change in days > AAQO: 0% Change in area greater than AAQO: +0.5 km² (+4.9%)
Annual $PM_{2.5}$	The maximum annual $PM_{2.5}$ concentration over the City of Kamloops is10.9 µg/m³. The area in exceedance is predicted to cover an area of 7.63 km² over North Kamloops (Figure G-6).	No exceedance	The maximum annual $PM_{2.5}$ concentration over the City of Kamloops is 10.9 µg/m³. The area in exceedance is predicted to cover an area of 7.70 km² over North Kamloops (Figure H-17).	Change in maximum concentration: 0.0 µg/m³ (0%) Change in area greater than AAQO: +0.07 km² (+0.9%)

Table 5-17 summaries the exceedance analysis for the Base Case, Project Case Operations, and Application Case Operations. The maximum predicted concentrations of dustfall, TSP, PM_{10}, and $PM_{2.5}$ are predicted to exceed the applicable regulatory criteria in the Application Case Operations. From Table 5-17 the predicted exceedances in the City of Kamloops can be attributed to the Base Case, while the predicted exceedances on the Plant Boundary can be attributed to the Project Case Operations. Dustfall and annual $PM_{2.5}$ are predicted to be greater than the applicable regulatory criteria in the City of Kamloops but are not predicted to be greater than the criteria on the plant boundary. TSP, PM_{10}, and 24-hour $PM_{2.5}$ are predicted to be greater than the criteria both in the City of Kamloops and on the plant boundary.

Table 5-17 Operations Exceedance Analysis

CAC	Base Case	Project Case Operations	Application Case Operations	Change Resulting from the Addition of the Base Case to the Project Case Operations
30-day DF	The maximum monthly dustfall rate over Downtown Kamloops is2.0 mg/dm^2/day. The dustfall AAQO is predicted to be exceeded 58% of the year (7 months) over Downtown Kamloops. The high values are predicted to occur in spring, summer, and early fall (February, March, and June through September). The area where the exceedance occurs covers 0.063 km^2 over Downtown Kamloops (Figure G-1).	No exceedance	The maximum monthly dustfall rate over Downtown Kamloops is2.0 mg/dm^2/day. The dustfall AAQO is predicted to be exceeded 58% of the year (7 months). The high values are predicted to be in the spring, summer, and early fall (February, March, and June through September). The area where the exceedance occurs covers 0.069 km^2 over Downtown Kamloops (Figure I-12).	Change in maximum deposition rate: 0.0 mg/dm^2/day Change in months > AAQO: 0% Change in area greater than AAQO: +9% (0.006 km^2)
24-hour TSP	The maximum 24-hour TSP concentration over the City of Kamloops is 151.6 µg/m^3. The TSP AAQO is predicted to be exceeded 0.8% of the year (3 days)). The high values are predicted to occur in winter (December and January). The area where the exceedance occurs covers a total of 5.93 km^2 over North Kamloops, Downtown Kamloops, and west of the City (Figure G-2).	The maximum 24-hour TSP concentration at the plant boundary is 406.0 µg/m^3. The TSP AAQO is predicted to be exceeded 3.3% of the year (12 days). The high values are predicted to be in winter (December and January) The area where the exceedance occurs covers 4.74 km^2 extending from the northeast plant boundary (Figure I-2). This area largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary. The predicted exceedance area stops approximately 180 m to the southwest of Aberdeen and there are no predicted exceedances of TSP within Aberdeen. The frequency of exceedance at the City Development Boundary (location 2 on Figure 5.6-2) is 1.6% of the year (6 days). The closest receptor with a predicted TSP exceedance is above the AAQO 0.8% of the year (3 days).	The maximum 24-hour TSP concentration over the City of Kamloops is 152.5 µg/m^3. The TSP AAQO is predicted to be exceeded 0.8% of the year (3 days). The high values are predicted to be in winter (December and January). The 24-hour TSP concentration at the plant boundary is 435.6 µg/m^3. At the plant boundary, the TSP AAQO is predicted to be exceeded 4.4% of the year (16 days). The high values are predicted to be in winter (December and January). The total area where the exceedance occurs covers a total of 13.4 km^2 over North Kamloops, Downtown Kamloops, west of the City, and at the west, north, northeast, and east edges of the plant boundary (Figure I-13). The area northeast of the plant boundary largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary and extends 150m into upper Aberdeen. The frequency of exceedance at the City Development Boundary (location 2 on Figure 5.6-2) is 1.9%of the year (7 days). The frequency of exceedance at the location of the maximum predicted 24-hour TSP concentration within Aberdeen is 0.3% of the year (1 day). The Aberdeen maximum occurs near the intersection of Abbeyglen Way and Pacific Way. One other receptor near the southern portion of Abbeyglen Way is predicted to exceed the TSP regulatory criteria 0.3% of the year (1 day).	Change in maximum concentration over the City of Kamloops: +0.9 µg/m^3 (+0.6%) Change in maximum concentration at the plant boundary: +29.6 µg/m^3 (+7%) Change in days > AAQO over the City of Kamloops: 0 day a year (0%) Change in days > AAQO at the plant boundary: +4 days a year (+1.1%) Change in area greater than AAQO: +7.47 km^2 (+77%)

Table 5-17 Operations Exceedance Analysis

CAC	Base Case	Project Case Operations	Application Case Operations	Change Resulting from the Addition of the Base Case to the Project Case Operations
24-hour PM_{10}	The maximum 24-hour PM_{10} concentration over the City of Kamloops is 89.3 µg/m³. The PM_{10} AAQO is predicted to be exceeded1.6% of the year (6 days). The high values are predicted to occur in winter (December, January, and February) The area where the exceedance occurs covers a total of 27.6 km² over North Kamloops and Downtown Kamloops (Figure G-4).	The maximum 24-hour PM_{10} concentration at the plant boundary is 332.9 µg/m³. The PM_{10} AAQO is predicted to be exceeded 606% of the year (24 days). The high values are predicted to be in winter and spring (November through April). The area where the exceedance occurs covers 10.5 km² extending from the west, northeast, and east plant boundaries (Figure I-4). This area largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary and extends 200m into upper Aberdeen. The PM_{10} AAQO is exceeded is 3.0% of the year (11 days) at the City Development Boundary (location 2 on Figure 5.6-2). The highest predicted PM_{10} concentration within Aberdeen is 71.8 µg/m³. The location of the Aberdeen maximum has a frequency of exceedance of 0.5% of the year (2 days). The location of the Aberdeen maximum is near the intersection of Abbeyglen Way and Pacific Way. Three other receptors near the southern portion of Abbeyglen Way are predicted to exceed the PM_{10} regulatory criteria 0.3% of the year (1 day).	The maximum 24-hour PM_{10} concentrations over the City of Kamloops are94.8 µg/m³ and 90.2 µg/m³. The PM_{10} AAQO is predicted to be exceeded 1.9% of the year (7 days). The high values are predicted to be in winter (December, January, and February). The 24-hour PM_{10} concentration at the plant boundary is 345.9 µg/m³. At the plant boundary, the PM_{10} AAQO is predicted to be exceeded 9.3% of the year (34 days). The high values are predicted to be in winter months (November, December, January, and February) and spring (March and April). The area where the exceedance occurs covers a total of 47.9 km² over North Kamloops, Downtown Kamloops, and at the west, north, northeast, and east edges of the plant boundary (Figure I-15). The area northeast of the plant boundary largely covers undeveloped grasslands, however some of this area extends northeast past the City Development Boundary and extends 600m into upper Aberdeen (where the 94.8 µg/m³ maximum occurs). The PM_{10} AAQO is exceeded 1.9% of the year (7 days) at the City Development Boundary (location 2 on Figure 5.6-2). The location of the Aberdeen maximum is near the intersection of Abbeyglen Way and Pacific Way. The receptor that is in exceedance that extends furthest into Aberdeen exceeds the PM_{10} regulatory criteria 0.3% of the year (1 day).	Change in maximum concentration over the City of Kamloops: +5.5 µg/m³ (+6.0%) Change in maximum concentration at the plant boundary: +13 µg/m³ (+4%) Change in days > AAQO over the City of Kamloops: +1 day a year (+0.3%) Change in days > AAQO at the plant boundary: +10 days a year (+3%) Change in area greater than AAQO: +20.3 km² (+54%)
24-hour $PM_{2.5}$	The maximum 98th percentile 24-hour $PM_{2.5}$ concentration over the City of Kamloops is 34.7 µg/m³. The $PM_{2.5}$ AAQO is predicted to be exceeded 4.4% of the year (16 days). The high values are predicted to be in fall and winter (November, December, January, and February). The area where the 24-hour exceedance occurs covers a total of 10.0 km² over North Kamloops and Downtown Kamloops (Figure G-5).	The maximum 98th percentile 24-hour $PM_{2.5}$ concentration at the plant boundary is 31.4 µg/m³. The $PM_{2.5}$ AAQO is predicted to be exceeded 0.8% of the year (3 days). The high values are predicted to be in winter (December and January). The area where the 24-hour exceedance occurs covers 0.24 km² at the northeast plant boundary (Figure I-5). This area largely covers undeveloped grasslands does not extend into the build-up urban area of Kamloops.	The maximum 98th percentile 24-hour $PM_{2.5}$ concentration over the City of Kamloops is34.7 µg/m³. The $PM_{2.5}$ AAQO is predicted to be exceeded 4.4% of the year (16 days). The high values are predicted to be in fall and winter (November, December, January, and February). The 24-hour $PM_{2.5}$ concentration at the plant boundary (37.8 µg/m³) is predicted to be greater than the AAQO 3 days of the year (0.8% of the year). The high values are predicted to be in winter (December and January). The area where the 24-hour exceedance occurs covers a total of 12.7 km² over North Kamloops, Downtown Kamloops, and the northeast plant boundary (Figure I-16). The area northeast of the plant boundary largely covers undeveloped grasslands.	Change in maximum concentration over the City of Kamloops: 0.0 µg/m³ (0%) Change in maximum concentration at the plant boundary: +6.4 µg/m³ (+18%) Change in days > AAQO over the City of Kamloops: 0 days a year (0%) Change in days > AAQO at the plant boundary: 0 days a year (0%) Change in area greater than AAQO: +2.7 km² (+24%)
Annual $PM_{2.5}$	The maximum annual $PM_{2.5}$ concentration over the City of Kamloops is10.9 µg/m³. The area in exceedance is predicted to cover an area of 7.63 km² over North Kamloops (Figure G-6).	No exceedance	The maximum predicted annual $PM_{2.5}$ concentration over the City of Kamloops is10.9 µg/m³. The area in exceedance covers an area of 7.86 km² over North Kamloops (Figure I-17).	Change in maximum concentration: 0.0 µg/m³ (0%) Change in area greater than AAQO: +0.23 km² (+3%)

5.7 CUMULATIVE EFFECTS ASSESSMENT CASE

A search of the project inclusion list (Section 10.1.6 of the EAC Application) determined that there are no approved, announced or foreseeable future projects within the CALPUFF domain (called the Regional Study area or RSA in the EA section) that have the potential to interact with the Project in a cumulative manner. A review was conducted to determine if there are any approved, announced or foreseeable future projects outside the CALPUFF domain that have the potential to interact with the Project in a cumulative manner.

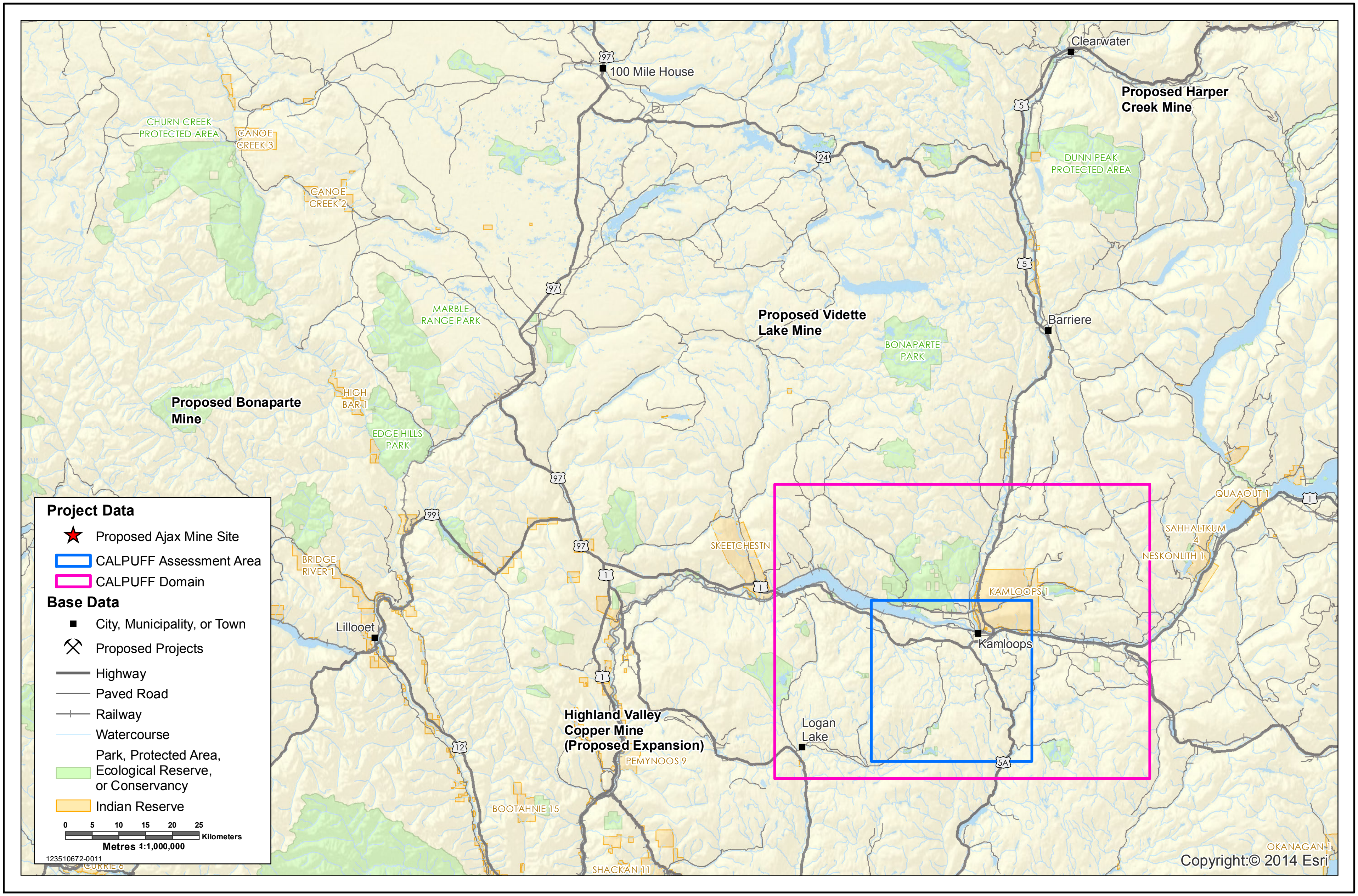
Table 5-18 lists the relevant proposed projects outside the CALPUFF domain and the distance these projects are from the center of the Ajax Mine site. Figure 5.7-1 illustrates the location of these future projects.

The figure shows that proposed projects on the project inclusion list are well outside of the CALPUFF domain. These proposed projects have been deemed through application of professional judgement to be incapable of resulting in a potentially deleterious effect within the CALPUFF domain in combination with the Project. They were discounted based upon the quantities emitted (whether large or small) and previous experience with similar projects. A cumulative air quality effects assessment for future projects is not required and therefore was not completed. The addition of the global/regional background implicitly includes the effects of future operations.

The effect of wildfires on air quality, distant or local, is implicitly accounted for through the addition of the global/regional background. The short-term effect of rare circumstances such as a large forest fire in the RSA was not modelled as part of the Base Case. Nor were accidents or malfunctions (e.g., structural fire, industrial upset), or events caused by severe weather such as an intense wind storm. Such phenomenon, while well within the capability of the CALPUFF model to simulate, are rare events. Their effects are well understood through other means (measurement), and only increase the Base Case contribution. The Projects effects remain unchanged, leading to the conclusion that the Projects proportion of the total effect actually decreases relative to the existing air quality.

Table 5-18 Locations of Proposed Projects in Relation to the Proposed Ajax Mine Site

Project Name	UTM Zone	mE	mN	Distance from Ajax Mine Site
Vidette Lake Mine	10	646,909	5,670,249	72.4 km northwest
Bonaparte Mine		537,397	5,653,667	153.7 km northwest
Highland Valley Copper Mine (proposed expansion)		638,451	5,594,439	47.8 km southwest
Harper Creek Mine	11	297,593	5,712,091	108.5 km northeast



KGHM AJAX AIR QUALITY ASSESSMENT
TECNICAL DATA REPORT

Locations of Proposed Projects in Relation to the Proposed Ajax Mine Site

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. 5.7-1

Last Modified: MAY 14, 2015 By: ROCAMPBELL

6.0 MODEL PREDICTION UNCERTAINTY

Air dispersion modelling (or modelling) is the mathematical simulation of how particles and gases disperse in the atmosphere. It also includes simulation of transport and deposition processes. The models estimate the downwind concentration or rate of deposition of substances resulting from substances emitted by a variety of emission sources. They make use of a great deal of information representative of real-world conditions. To characterize the source they require data representative of emissions quantities, flow rates, temperatures, source locations, heights, and building profiles. They also require inputs representative of atmospheric behavior, terrain, land cover information, and the location of receptors. There are uncertainties associated with all of these data.

The model itself is a computer program that approximates atmospheric behavior based on physical principles and statistical relationships. The goal is to select an appropriate model and produce a prediction of the resultant effects on air quality that over-predicts concentrations. To do this the modeller must be mindful of the inherent uncertainties involved in the input data and the limitations of the model.

In this section, the uncertainties involved in this modelling exercise are discussed. The efforts of the modellers to understand and limit these uncertainties, and produce a robust, conservative prediction are detailed.

General

The ability of a model to predict concentrations and rates of deposition depends on the accuracy of the source and emission inventory, the meteorology, and the assumptions used to represent the atmospheric physics and chemistry processes. The US EPA (2005a) states: "models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of ±10 to ±40% are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models." They also state, "it is desirable to quantify the accuracy or uncertainty associated with concentration estimates used in decision-making. Communications between modellers and decision-makers must be fostered and further developed." The US EPA (2005a) indicates that the application of regulatory dispersion models is viewed as a "best estimate" approach and that this approach should be viewed as acceptable to the decision maker.

The ability of a model is often assessed by comparing model predictions with ambient measurements. The comparison needs to recognize that there may be a level of uncertainty associated with the ambient measurements.

Emission Uncertainty

Generally, the understanding of emissions from industrial point sources (e.g., stacks) is better than the understanding of emissions from sources such as fugitive road dust, wind erosion, and heavy and light vehicle traffic. While the limitations may lead to uncertainties for a specific facility at a given time, the emission factor approach is recognized by regulatory agencies as an accepted method.

A great deal of attention has been paid to adequately characterizing fugitive road dust as it is the largest source of particulate matter associated with the Project. Section 4.0 and **Appendix E** detail this effort. Dust suppression has been applied in the model for both Construction Case and Operations Case to simulate the effect of natural suppression (e.g., frozen ground, precipitation) and mitigation efforts. At times, this suppression is underestimated, adding to the conservatism of the predicted concentrations and deposition rates.

The selection of the combination of operational years 4 and 8 (year 4/8) as the basis for the emissions estimates also adds conservatism to the resultant predictions. All other operational years have lesser emission quantities compared to year 4/8; however the assessment for all years is based on the year with the highest emissions occurring continuously for every year of the mine life.

Meteorological Uncertainty

Meteorological conditions vary systematically and randomly from year-to-year, with season, and with time of day. In addition, the meteorological conditions at any given time can vary with location because of the presence of local tree canopy or terrain influences. It is important to include the wide range of meteorological conditions that can occur into the assessment. The application of three years of prognostic meteorological data provides the opportunity to include a wider range of conditions. From the three years of meteorological data, the year that produced the highest predicted Project-related concentrations (2003) was selected to take forward into the detailed analysis.

The selection of 2003 as the meteorological basis for the modelling adds conservatism to the resultant predictions. The assessment for all years (2003, 2004, and 2003) is based on the meteorological year that produces the highest predicted concentrations and rates of deposition near the Project, and assumes that that is occurring for every year of the mine life. All other meteorological years (2004 and 2005) produce lower predicted concentrations and rates of deposition.

Comparison of Predictions and Measurements

The CALPUFF model predictions associated with existing emissions could not be compared with ambient measurements as there are no existing emissions at the Project site. The existing ambient measurements at the Antoniak Ranch are representative of a near-pristine condition.

In the Steyn & Ainslie (2012) letter prepared for KAPA, the authors recommend that in order to demonstrate that the model "realistically captures dispersion conditions in Kamloops" it should be evaluated "against existing air quality data in the Kamloops Valley, using a known source and pollutant and test bed." To accomplish this Steyn and Ainslie recommend that SO_2 associated with the local Pulp Mill be modelled and the results compared to measurements.

A similar analysis was recently completed in a study for Domtar (JWA 2009). This study employed a lower resolution version of the same CALMET dataset. Section 6 of the Domtar report evaluated the dispersion model performance. After accounting for local sources of SO_2, a comparison of the predicted and observed SO_2 concentrations found that the model performance was within accepted bounds. The correlation of the predicted SO_2 and the observed SO_2 concentrations was close to 1, indicative of good model performance.

Section 6 of JWA (2009) also investigated two unique air quality events at the request of the BC MOE. The first was an unexpected maxima west of the mill, and the second a simulation of unusual concentrations of SO_2 measured on October 13, 2005. It was determined that in both cases, CALPUFF faithfully reproduced 'inversion breakup fumigation' events. These additional investigations increased regulatory confidence in the ability of CALPUFF to accurately reproduce dispersion in the Kamloops area. If CALPUFF can accurately simulate these unique air quality events, it increases confidence that CALPUFF can simulate the majority of air quality events.

For this assessment, a performance evaluation of the CALPUFF model was conducted in order to ascertain the validity of results. A part of this evaluation involved a comparison of Base Case predicted concentrations of $PM_{2.5}$, SO_2, and NO_2 against recent measurements at two continuous ambient air quality stations in the City of Kamloops. This comparison found that model performance was well within what is deemed typical and acceptable by the US EPA (2005a). This full model performance evaluation is found in the CALPUFF Appendix (**Appendix D**).

The two stations employed in Stantec's comparison in **Appendix D** (Kamloops Federal Building and Kamloops Fire Station #2) are located on the valley floor. While there are no continuously monitored stations above the valley floor in Kamloops at present (the Ajax Upwind Station does not have a large enough data set at this time), a number of intermittent (24-hour) monitoring stations exist in the region (listed in Table 2-3, illustrated in Figure 2.2-1). A comparison of the average $PM_{2.5}$ at a number of key stations and the predicted annual average $PM_{2.5}$ in the Base Case (Figure G-6) shows good spatial agreement.

For example:

- The measured $PM_{2.5}$ at the Federal Building is 7.8 μg/m^3 and the figure shows that the region's annual average $PM_{2.5}$ is between 6 and 8 μg/m^3.
- The measured $PM_{2.5}$ at the New Gold site is 5.1 μg/m^3 and the figure shows that region's annual average $PM_{2.5}$ is between 4 and 5 μg/m^3.

- The measured $PM_{2.5}$ at the Goose Lake is 3.2 µg/m^3 and the figure shows that regions annual average $PM_{2.5}$ to be about 4 µg/m^3.
- The Pacific Way measured $PM_{2.5}$ is 5.8 µg/m^3 and the figure shows that regions annual average $PM_{2.5}$ to be between 5 and 6 µg/m^3.
- The Mission Flats measured $PM_{2.5}$ is 6.7 µg/m^3 and the figure shows that regions annual average $PM_{2.5}$ to be in the region of 6 µg/m^3.
- The Dalhousie Drive station measured $PM_{2.5}$ is 6.0 µg/m^3 and the figure shows that regions annual average $PM_{2.5}$ in the region of 6 µg/m^3.

Quality Assurance and Quality Control

The application of a numerical simulation model is one of the key tools to estimate the effect of Project emissions on ambient air quality. The air quality assessment requires the examination of a large amount of numerical data. There are large numerical data sets associated model input that require processing as wells as large numerical datasets associated with model output that require processing. A number of quality assurance/quality control (QA/QC) checks were undertaken for all components of the assessment. These measures are generally described in Section 6 of the model plan (**Appendix B**). These measures include:

Emission Inventory: The emission inventory was developed by an air quality team comprised of five members working together under the direction of the air discipline lead, and in direct consultation with the Project design team. The emission inventory and related input files were reviewed for logical consistency to ensure values were within the range of typical values for each source type. An independent third-party consulting team performed a review of the emissions inventory, and other key aspects of the dispersion assessment. This third-party review resulted is several refinements.

Meteorology: The output of the CALMET model was reviewed extensively by Levelton (2008) following its creation. Subsequently it has been employed in three separate studies in the Kamloops area, each of which involved testing the quality of the meteorological data (JWA 2009; Stantec 2011, Stantec 2012). As a part of the present study, extensive review of the output has been conducted to evaluate meteorology (wind direction, wind speed, temperature, mixing height, stability and precipitation for) at multiple locations for comparison to measured data and to ensure reasonable model performance. This analysis has concluded that CALMET is preforming reasonably well (see **Appendix C**).

Model Application: The development of the CALPUFF model input files was automated to reduce the potential for human errors associated with manually translating the source emission inventory data into model input files. Concentration predictions are rationalized against the emission inventory to ensure that model concentration predictions are logically consistent with the source emission inventory (e.g., high concentrations occur where you expect them to occur). During post-processing, unexpected model results were investigated in detail to ensure consistency with model input.

Model Prediction Confidence

Uncertainty associated with dispersion model predictions stems from two main areas (US EPA 2005b): reducible uncertainty and inherent uncertainty.

Reducible uncertainty results from uncertainties associated with the input values and with the limitations of the model physics and formulations. Reducible uncertainty can be minimized by better (e.g., more accurate and representative) measurements and improved model physics.

Inherent uncertainty is associated with the stochastic nature of the atmosphere and its representation. Models predict concentrations that represent an ensemble average of numerous repetitions for the same nominal event. An individual observed value can deviate significantly from the ensemble value. This uncertainty may be responsible for a ±50% deviation from the measured values.

Generally, models are quoted as having a factor-of-two accuracy (US EPA 2005b). Comparison studies have indicated that models can predict the magnitude of highest concentration occurring sometime and somewhere within an area to within ±10 to ±40%. Predictions for a specific site and time are often poorly correlated with observed values. This poor correlation can often be related to errors in wind direction. For example, an uncertainty of 5° to 10° in the wind direction can produce a concentration error in the 20 to 70% range (US EPA 2005b).

The US EPA (2005b) provides guidance to decision makers relative to model uncertainty. Specifically, they recommend that the model predictions be accepted as a "best estimate", until sufficient technical progress has been made to meaningfully implement concepts dealing with uncertainty.

The above noted sources of error and deficiencies in the assessment procedure result in a certain level of uncertainty in the predicted results, usually biased to the conservative side of possible interpretations. While there may be a high level of uncertainly in the results, there remains a high degree of confidence that the actual effects will be lower than the predicted ones.

7.0 SUMMARY AND CONCLUSIONS

This technical data report describes an assessment of air quality completed to support the EAC Application for the KGHM Ajax Mining Inc. (KAM) proposed Ajax Project (the Project). The Project is an open pit copper-gold mine at the historic Afton Mining Camp, partially within the City of Kamloops, British Columbia. The air quality assessment was conducted with the US EPA approved CALPUFF dispersion modelling system. It employed a three year CALMET dataset that has been shown to perform well and accurately reproduce dispersion in the Kamloops area. While uncertainty exists in all dispersion modelling, Stantec is confident the actual effects will be lower than the predicted ones.

The substances of interest selected for modelling include: Total Dustfall (DF); Total Suspended Particulate Matter (TSP); Inhalable Particulate Matter (PM_{10}); Respirable Particulate Matter ($PM_{2.5}$); Sulphur Dioxide (SO_2); Total Oxides of Nitrogen (NO_X); and Carbon Monoxide (CO).

The dispersion modelling considers both the construction and operations worst-case emissions. It also accounts for existing emissions in the CALPUFF domain through modelling of the Base Case. The modelling scenarios are as follows:

Base Case: All existing emissions in the CALPUFF domain

For construction:

- Project Case Construction (only Project Case Construction-related emissions)
- Application Case Construction (Base Case plus Project Case Construction)

For operations:

- Project Case Operations (only Project Case Operation-related emissions)
- Application Case Operations (Base Case plus Project Case Operations)

To account for all emission sources outside of the CALPUFF domain that are by definition not included in the modelling assessment, values representative of the Global/Regional background ambient air quality are added to the predicted Base Case concentrations. Doing this accounts for the effects of all global, regional, and local emission sources that influence air quality in the study area.

To assess residual Project effects, both the Construction and Operations Cases (Project and Application) results are compared to the applicable regulatory criteria. The Base Case results are compared to both the criteria and to local measurements to place the predictions in perspective.

Following are the findings of the Base Case, Construction Case, and Operations Case modelling.

Base Case

The Base Case results show good agreement with local measurements. The maximum predicted concentrations of SO_2, NO_2, and CO are low. They are always less than applicable regulatory criteria. The maximum predicted concentrations of Dustfall, TSP, PM_{10}, and $PM_{2.5}$ are generally low, but at times are greater than criteria. The frequency of exceedance of these parameters is consistent with background measurements. Dustfall is greater than the criteria 58% of the year while TSP, PM_{10}, and $PM_{2.5}$ are less than 5% of the year. These exceedances are consequences of local domestic/industrial emissions that accumulate under periods of poor dispersion to levels that are exceed the criteria.

The pattern of maximum predicted concentrations of PM_{10} and $PM_{2.5}$ in the CALPUFF domain shows good agreement with local measurements. The valley bottom locations have consistently higher concentrations than the upper reaches of the valley walls. The plateau region beyond has the lowest predicted concentrations. The maximum predicted concentrations of $PM_{2.5}$ typically occur in winter months. Measurements of $PM_{2.5}$ are typically greater in winter than summer months. Exceptions include periods in summer when forest fires are active locally or regionally. This assessment does not reproduce these conditions are forest fires were not included as sources of emissions.

Focusing on $PM_{2.5}$, the Base Case predictions and the emissions inventory give insight into relative importance of sources. In the valley bottom the most important contributors to annual average $PM_{2.5}$. are: i) space heating (51.4%); ii) global/regional background (34.9%); iii) road/rail (13.0%); and iv) industrial (1.3%). At the Project site the most important contributors to annual average $PM_{2.5}$. are: i) global/regional background (92.6%); with ii) space heating (3.1%); iii) road/rail (2.9%); and iv) industrial (1.8%) all contributing a small increment.

The modelling and measurements show that the valley bottom is affected both by sources outside the region (the global/regional background) and domestic/industrial sources of emissions in the City. In contrast, the Project site is dominated by the global/regional background, and largely unaffected by domestic/industrial sources in the City.

Project Case Construction and Application Case Construction

The Construction Case alone results show that the maximum predicted concentrations of SO_2, NO_2, and CO are small, and are less than applicable regulatory criteria. The maximum predicted concentrations of Dustfall, TSP, and $PM_{2.5}$ are also less than the criteria. The maximum predicted 24-hour concentration of PM_{10} does exceed the criteria. PM_{10} is predicted to exceed the objective twice annually. They occur in January on the northeast plant boundary, largely in undeveloped grasslands.

The Application Case – Construction (the sum of the Construction Case and the Base Case) demonstrates that the Project Construction has a small effect on existing air quality in the City. The Application Case – Construction results are nearly indistinguishable from Base Case results. The addition of the Base Case exacerbates the PM_{10} exceedance on the northeast plant boundary, and causes TSP to exceed the criteria.

Project Case Operations and Application Case Operations

The Operations Case alone results show that the maximum predicted concentrations of SO_2, NO_2, and CO are small, and are less than applicable regulatory criteria. The maximum predicted 24-hour concentrations of TSP, PM_{10} and $PM_{2.5}$ are greater than the criteria. These exceedances are predicted to occur less than 7% per year, generally in winter months. The areas where concentrations above the criteria are predicted to occur are off the northeast plant boundary, largely in undeveloped grasslands. The exceedance area for TSP and PM_{10} extend northeast past the City Development Boundary and cover parts of upper Aberdeen. The exceedance area for $PM_{2.5}$ does not extend past the City Development Boundary.

The Application Case–Operations (the sum of the Operations Case and the Base Case demonstrates that the Project operations has a limited effect on existing air quality in the City. The Application Case–Operations results are nearly indistinguishable from Base Case results beyond upper Aberdeen. The addition of the Base Case exacerbates the exceedances on and beyond the northeast plant boundary, increasing the predicted concentration and the frequency of exceedance.

Focusing on $PM_{2.5}$, the Application Case – Operations predictions and the emissions inventory give an insight into relative importance of sources. While Project Operations annually add 13% to the Base Case $PM_{2.5}$ emissions, the modelling shows a different picture in terms of their relevant contribution to annual average $PM_{2.5}$.

In the valley bottom the most important contributors to annual average $PM_{2.5}$ are Base Case sources. The Project Operations adds only between 0.4% (North Shore) and 1.2% (upper Sahali) to the annual average $PM_{2.5}$. In upper Aberdeen the Project Operations adds 6.6% to the annual average $PM_{2.5}$. There is no exceedance of the AAQO there (8 $\mu g/m^3$) but there is a marginal exceedance of the BC Planning Goal (6 $\mu g/m^3$). Despite this, air quality in upper Aberdeen is predicted to remain good. Air quality there remains better than in most other areas in the City of Kamloops.

City-wide, the predicted average annual $PM_{2.5}$ is 6.4 $\mu g/m^3$. The Project Operation Case contributes 0.15 $\mu g/m^3$ to this region, a 2.3% increase. The long-term year to year variability in annual average $PM_{2.5}$ is ± 0.92 $\mu g/m^3$ (the value of one standard deviation of the annual average $PM_{2.5}$ collected at Brocklehurst between 1998 and 2011). Given this high variability, and the fact that the increase attributed to the project is a factor of six less, the increase in annual average is insubstantial. It is dwarfed by the long-term year to year variability in annual average $PM_{2.5}$.

Concentrations in excess of the applicable regulatory criteria attributable to the Project Operations will likely be limited to northeast plant boundary, nearby undeveloped grasslands, and to a lesser extent in upper Aberdeen. The remainder of the City is largely unaffected by Project Operations.

8.0 CLOSURE

This report was prepared for the sole benefit of KGHM Ajax Mining Inc. and their representatives. The report may not be relied upon by any other person or entity without the express written consent of Stantec Consulting Ltd. and KGHM Ajax Mining Inc.

Any uses which a third party makes of this report, or any reliance on decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Should additional information become available, which differs significantly from our understanding of conditions presented in this report, we request that this information be brought to our attention so that we may reassess the conclusions provided herein.

The work was performed and the report prepared by John Spagnol, Senior Air Quality Scientist, Katelyn Wells, Air Quality Scientist, and Dan Jarrett, Air Quality Engineer, and Peter Reid, Principal. John Spagnol and Dan Jarratt were the Project Technical Leads. The report was Technically Reviewed by Peter Reid, the Air Quality Discipline Lead. Senior Principal Mervyn Davies provided the Quality Review. We trust that the above information meets with your present requirements. Should you have any questions or require further information, please contact the undersigned.

Respectfully Submitted,

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APPENDIX A
30-YEAR CANADIAN CLIMATE NORMALS FOR KAMLOOPS AIRPORT AND KAMLOOPS AFTON MINES

Appendix A – 30-Year Canadian Climate Normals for Kamloops Airport and Kamloops Afton Mines

August 21, 2015

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Appendix A 30-YEAR CANADIAN CLIMATE NORMALS FOR KAMLOOPS AIRPORT AND KAMLOOPS AFTON MINES

Table A-1 1971 to 2000 Climate Normals from the Kamloops Airport Canadian Climate Normals Station

Station Name	Province	Latitude	Longitude	Elevation	Climate ID	WMO ID	TC ID
Kamloops A *	BC	50°42'08.000" N	120°26'31.000" W	345.3 m	1163780	71887	YKA

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Temperature														
Daily Average (°C)	-4.2	-0.4	4.8	9.7	14.4	18.1	21	20.5	15.3	8.5	1.8	-3	8.9	A
Standard Deviation	4	3.2	1.5	1.2	1.4	1.4	1.5	1.5	1.6	0.9	2.7	3.3	0.9	A
Daily Maximum (°C)	-0.8	3.6	10.5	16.5	21.3	24.8	28.3	27.8	22	13.7	5.2	0.1	14.4	A
Daily Minimum (°C)	-7.6	-4.4	-0.9	2.9	7.5	11.3	13.7	13.2	8.5	3.2	-1.7	-6.1	3.3	A
Extreme Maximum (°C)	15.9	17	22.8	33	37.2	38.9	40.6	39.6	34.6	31.3	22.8	16.1		
Date (yyyy/dd)	1989/30	1991/19	1994/31	1987/27	1983/29	1961/17	1971/31	1998/04	1998/06	1980/06	1975/03	1958/31		
Extreme Minimum (°C)	-37.2	-28.3	-26.1	-8.8	-5.6	1.1	3.3	0.6	-3.9	-17.1	-28.3	-36.1		
Date (yyyy/dd)	1969/29	1957/02	1955/04	1993/08	1954/01	1962/06	1952/06	1989/23	1972/25	1984/31	1985/28	1968/30		
Precipitation														
Rainfall (mm)	5.4	5.4	8.6	14.4	24.4	35.2	29.5	29.1	28	15.8	13.7	8.3	217.9	A
Snowfall (cm)	21.8	11.3	3.5	0.3	0	0	0	0	0	0.3	12.2	26.1	75.5	A
Precipitation (mm)	22.9	14.4	11.7	14.6	24.4	35.2	29.5	29.1	28	16.2	24.1	28.9	279	A
Average Snow Depth (cm)	10	6	1	0	0	0	0	0	0	0	1	6	2	A
Median Snow Depth (cm)	9	6	0	0	0	0	0	0	0	0	0	5	2	A
Snow Depth at Month-end (cm)	8	3	0	0	0	0	0	0	0	0	2	10	2	A
Extreme Daily Rainfall (mm)	7.8	18	11.2	27.8	20.6	36.8	42.2	48	28.8	20.8	18.8	15.4		
Date (yyyy/dd)	1977/18	1951/09	1958/30	1983/25	1996/17	1986/29	1954/01	1976/16	1985/06	1994/14	1992/04	1997/29		
Extreme Daily Snowfall (cm)	33.8	13	16.8	2.8	0	0	0	0	0	2.8	30.2	23.9		
Date (yyyy/dd)	1962/07	1986/15	1969/05	1972/12	1951/01	1951/01	1951/01	1951/01	1951/01	1957/23	1977/25	1967/21		
Extreme Daily Precipitation (mm)	33.8	20.6	13.5	27.8	20.6	36.8	42.2	48	28.8	20.8	26.5	23.4		
Date (yyyy/dd)	1962/07	1951/09	1969/05	1983/25	1996/17	1986/29	1954/01	1976/16	1985/06	1994/14	1977/25	1971/22		
Extreme Snow Depth (cm)	74	71	43	0	0	0	0	0	0	2	40	81		
Date (yyyy/dd)	1972/21	1972/01	1972/02	1955/01	1955/01	1955/01	1955/01	1955/01	1955/01	1991/31	1977/26	1971/25		
Days with Maximum Temperature														
<= 0 °C	14.7	6.7	0.73	0	0	0	0	0	0	0.11	3.8	13.1	39.1	A
> 0 °C	16.3	21.6	30.3	30	31	30	31	31	30	30.9	26.2	17.9	326.2	A
> 10 °C	0.93	3	17.6	28.7	30.9	30	31	31	29.9	24.9	4.9	0.83	233.6	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
> 20 °C	0	0	0.3	6.6	17	25.5	29.3	29	19.4	2.6	0.07	0	129.6	A
> 30 °C	0	0	0	0.1	1.7	4.2	11.4	10.6	1.2	0.04	0	0	29.3	A
> 35 °C	0	0	0	0	0.17	0.46	2.8	1.9	0	0	0	0	5.4	A
Days with Minimum Temperature														
> 0 °C	4.2	7	13.1	23.4	30.7	30	31	31	29.6	23.5	11.9	4.8	240.1	A
<= 2 °C	30	25.6	23.9	12.1	1.7	0	0	0.03	1.2	12.5	23.4	29.8	160.3	A
<= 0 °C	26.8	21.3	17.9	6.6	0.3	0	0	0	0.43	7.5	18.1	26.2	125.2	A
< -2 °C	22.5	16	11.6	2.7	0	0	0	0	0.1	3.1	12.4	21.1	89.4	A
< -10 °C	10.2	4.8	0.73	0	0	0	0	0	0	0.14	1.8	6.5	24.3	A
< -20 °C	2.2	0.63	0.03	0	0	0	0	0	0	0	0.25	1.3	4.4	A
< - 30 °C	0	0	0	0	0	0	0	0	0	0	0	0.07	0.07	A
Days with Rainfall														
>= 0.2 mm	3.2	3.7	5.3	6.2	9.9	10.6	8.7	8.7	7.5	7.8	6.3	3.9	81.8	A
>= 5 mm	0.27	0.17	0.3	0.73	1.3	2.4	1.9	1.8	2	0.62	0.69	0.48	12.7	A
>= 10 mm	0	0.03	0.03	0.2	0.27	0.57	0.8	0.7	0.63	0.21	0.14	0.07	3.7	A
>= 25 mm	0	0	0	0.03	0	0.07	0.03	0.03	0.03	0	0	0	0.19	A
Days With Snowfall														
>= 0.2 cm	9.2	5.3	2	0.27	0	0	0	0	0	0.38	4.3	9.1	30.5	A
>= 5 cm	1.2	0.57	0.17	0	0	0	0	0	0	0	0.76	1.6	4.3	A
>= 10 cm	0.2	0.17	0.03	0	0	0	0	0	0	0	0.28	0.52	1.2	A
>= 25 cm	0	0	0	0	0	0	0	0	0	0	0.03	0	0.03	A
Days with Precipitation														
>= 0.2 mm	11.1	8	6.6	6.3	9.9	10.6	8.7	8.7	7.5	8.1	9.6	11.9	107.1	A
>= 5 mm	1.3	0.53	0.47	0.73	1.3	2.4	1.9	1.8	2	0.62	1.3	1.6	16	A
>= 10 mm	0.07	0.1	0.03	0.2	0.27	0.57	0.8	0.7	0.63	0.21	0.38	0.45	4.4	A
>= 25 mm	0	0	0	0.03	0	0.07	0.03	0.03	0.03	0	0.03	0	0.22	A
Days with Snow Depth														
>= 1 cm	19.4	10.6	1.7	0	0	0	0	0	0	0.03	3.3	15.9	50.9	A
>= 5 cm	15.6	7.2	1.1	0	0	0	0	0	0	0	1.8	11.2	36.9	A
>= 10 cm	11.9	5.8	0.67	0	0	0	0	0	0	0	1	6.6	26	A
>= 20 cm	6	3.1	0.47	0	0	0	0	0	0	0	0.41	2.6	12.6	A
Wind														
Speed (km/h)	10.4	11.4	11.8	11.6	11.2	10.6	9.7	8.7	8.8	10.4	12.1	11.4	10.7	A
Most Frequent Direction	E	E	E	E	W	W	W	E	E	E	E	E	E	A
Maximum Hourly Speed (km/h)	66	68	93	60	58	61	72	58	68	74	72	67	93	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Date (yyyy/dd)	1965/03	1964/04	1975/30	1972/21	1955/18	1980/08	1970/16	1962/02	1959/03	1975/02	1975/15	1992/17	1975/30	
Direction of Maximum Hourly Speed	W	E	NW	W	S	SW	S	S	S	SW	SW	W	NW	
Maximum Gust Speed (km/h)	117	116	137	97	113	109	100	93	106	119	121	117	137	
Date (yyyy/dd)	1983/12	1972/16	1975/30	1973/05	1971/12	1970/03	1970/16	1990/13	1968/26	1975/02	1975/15	1974/17	1975/30	
Direction of Maximum Gust	SW	N	N	NW	S	S	S	S	W	SW	SW	W	N	
Days with Winds >= 52 km/h	0.8	0.7	0.7	0.8	0.8	0.7	0.5	0.5	0.3	0.9	0.6	1.1	8.3	A
Days with Winds >= 63 km/h	0.3	0.3	0.3	0.1	0.1	0.3	0.1	0.1	0	0.3	0.1	0.3	2.3	A
Degree Days														
Above 24 °C	0	0	0	0	0.1	1.5	10.5	7.4	0.1	0	0	0	19.5	A
Above 18 °C	0	0	0	0.2	10.5	42.4	103.3	92.2	12.3	0.6	0	0	261.4	A
Above 15 °C	0	0	0	2.8	35.6	103	186.5	172.6	46.5	2.3	0.2	0	549.5	A
Above 10 °C	0.1	0	2.1	37.3	140.8	244.7	340.4	326.1	162.3	27.8	2.2	0	1283.7	A
Above 5 °C	2.1	7	41.1	145.1	291.6	394.7	495.4	481.1	308.4	119.6	20.3	2.2	2308.6	A
Above 0 °C	24.8	57.9	159	293	446.6	544.7	650.4	636.1	458.3	264.8	91	30.5	3657.2	A
Below 0 °C	157.7	68.8	9.5	0	0	0	0	0	0	2.1	34.7	119	391.8	A
Below 5 °C	290	159.2	46.6	2.1	0	0	0	0	0.1	11.9	114	245.7	869.6	A
Below 10 °C	443	293.5	162.6	44.4	4.2	0	0	0	4	75.1	245.9	398.5	1671	A
Below 15 °C	597.9	434.9	315.5	159.8	54	8.3	1.1	1.5	38.2	204.6	393.9	553.4	2763.1	A
Below 18 °C	690.9	519.7	408.5	247.3	121.9	37.7	10.9	14	94	295.9	483.8	646.4	3570.8	A
Bright Sunshine														
Total Hours	58.3	91.3	156.8	201.5	250.6	255	310	286.6	212	140	65.2	47.4	2074.6	A
Days with measurable	19.7	23	28.6	28.8	30.1	29	30.5	30.5	28.9	28.4	20.8	18.1	316.2	A
% of possible daylight hours	22.1	32.4	42.7	48.7	52.2	51.8	62.5	63.6	55.8	42	24.1	19	43.1	A
Extreme Daily	7.9	10.1	12.4	13.9	15.8	15.7	15.4	14.5	13.6	10.9	8.6	7		A
Date (yyyy/dd)	1972/27	1996/29	1991/27	1976/26	1995/27	1978/19	1975/01	1974/04	1995/01	1999/01	1981/05	1995/01		
Humidex														
Extreme Humidex	15.8	17	22.4	31.9	36.8	38.6	47.4	40.3	38.4	31.2	22.8	15		
Date (yyyy/dd)	1989/30	1991/19	1994/31	1987/27	1983/29	1961/18	1957/21	1981/11	1988/04	1980/06	1975/04	1958/31		
Days with Humidex >= 30	0	0	0	0.1	1.6	3.9	12.5	11.9	1.9	0	0	0	31.9	A
Days with Humidex >= 35	0	0	0	0	0.3	0.6	3.4	3.5	0.1	0	0	0	7.9	A
Days with Humidex >= 40	0	0	0	0	0	0	0.2	0	0	0	0	0	0.3	A
Wind Chill														
Extreme Wind Chill	-42	-36.7	-33.9	-11.5	-4.6	0.9	4	3	-6.5	-23.2	-39.1	-45.1		
Date (yyyy/dd)	1969/29	1989/01	1955/04	1954/02	1954/01	2002/07	1971/02	1953/25	1972/27	1984/31	1985/26	1968/30		
Days with Wind Chill < -20	5	2.1	0.3	0	0	0	0	0	0	0.1	1.1	3.8	12.5	A

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Days with Wind Chill < -30	1.3	0.3	0	0	0	0	0	0	0	0	0.2	1.1	2.9	A
Days with Wind Chill < -40	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	A
Humidity														
Average Vapour Pressure (kPa)	0.4	0.5	0.5	0.6	0.8	1	1.2	1.2	1	0.7	0.6	0.4	0.7	A
Average Relative Humidity - 0600LST (%)	80.4	79.3	75.9	70.1	67.5	66.4	66.5	70.4	77.9	79.4	80	79	74.4	A
Average Relative Humidity - 1500LST (%)	71.2	61.9	43.7	35.4	35.9	36.4	34.2	35.9	42.2	52.2	65.5	70.7	48.8	A
Pressure														
Average Station Pressure (kPa)	97.7	97.5	97.3	97.3	97.2	97.2	97.4	97.3	97.5	97.6	97.5	97.8	97.5	A
Average Sea Level Pressure (kPa)	102	101.8	101.5	101.5	101.4	101.3	101.4	101.4	101.6	101.8	101.8	102.1	101.6	A
Visibility (hours with)														
< 1 km	14.6	5.7	1.9	0.3	0	0	0	0	0.2	2.2	3.7	5.5	34.1	C
1 to 9 km	85	45.9	10.1	1.2	0.9	1.1	0.4	0.7	2.2	21.4	31.7	67.8	268.4	C
> 9 km	644.4	626.6	732	718.5	743.1	718.9	743.6	743.3	717.7	720.4	684.6	670.7	8463.7	C
Cloud Amount (hours with)														
0 to 2 tenths	94.4	118.6	192.6	182.2	176	147.8	254.6	281.3	258.8	194.7	106.3	86	2093.2	C
3 to 7 tenths	124.4	132.2	185.3	193.7	223.1	233.8	227	228.6	184.7	166.9	123.8	118.2	2141.6	C
8 to 10 tenths	525.3	427.4	366.1	344.2	344.9	338.4	262.4	234.1	276.4	382.5	490	539.8	4531.4	C

NOTES:

* This station meets WMO standards for temperature and precipitation.

A = WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for either temperature or precipitation)

B = At least 25 years

C = At least 20 years

D = At least 15 years

Table A-2 1971 to 2000 Climate Normals from the Kamloops Afton Mines Canadian Climate Normals Station

Station Name	Province	Latitude	Longitude	Elevation	Climate ID	WMO ID	TC ID
Kamloops Afton Mines	BC	50°40'00.000" N	120°30'00.000" W	701.0 m	1163790	n/a	n/a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Temperature														
Daily Average (°C)	-5.9	-2.1	3.4	8	12.6	16.6	19.1	18.8	13.1	7	-0.7	-5.7	7	D
Standard Deviation	4.1	3.3	1.5	1.4	1.6	1.8	1.4	1.4	1.8	1.2	3.5	3.3	1.2	D
Daily Maximum (°C)	-2.5	1.8	8.9	14.4	19.4	23.5	26.5	26.2	19.7	12.2	2.9	-2.5	12.5	D
Daily Minimum (°C)	-9.3	-6.1	-2.1	1.6	5.8	9.7	11.6	11.4	6.6	1.8	-4.3	-8.9	1.5	D
Extreme Maximum (°C)	12	12.5	21	32	35.5	37	39	37	34	28.5	18	12.5		
Date (yyyy/dd)	1981/22	1991/19	1991/31	1987/27	1983/29	1987/30	1979/19	1981/11	1988/03	1980/05	1978/07	1980/26		
Extreme Minimum (°C)	-30	-28	-18	-7	-2.5	-1	3	2	-4	-22	-32	-34		
Date (yyyy/dd)	1979/06	1986/19	1989/03	1979/01	1985/12	1979/06	1984/07	1984/28	1983/28	1984/31	1985/27	1990/29		
Precipitation														
Rainfall (mm)	0.8	4.8	8.2	16.7	29.5	39.4	38.5	29.1	32.5	13.7	10.6	3.7	227.5	D
Snowfall (cm)	20.5	8.4	2.6	0.7	0.4	0	0	0	0	0.4	14.8	29.9	77.6	D
Precipitation (mm)	21.3	13.2	10.8	17.4	29.8	39.4	38.5	29.1	32.5	14.1	25.4	33.6	305.1	D
Extreme Daily Rainfall (mm)	4.5	7.2	7.6	27.2	16	24.8	27.4	23.2	23	10	11	13.9		
Date (yyyy/dd)	1983/26	1980/27	1984/20	1987/30	1989/23	1993/07	1992/07	1989/15	1985/05	1990/15	1992/06	1987/02		
Extreme Daily Snowfall (cm)	18	10	12.5	4	3	0	0	0	0	3	34.4	21		
Date (yyyy/dd)	1993/03	1985/06	1991/01	1983/10	1986/13	1977/01	1977/01	1977/01	1977/01	1991/30	1977/25	1980/03		
Extreme Daily Precipitation (mm)	18	10	12.5	27.2	19	24.8	27.4	23.2	23	10	34.4	21		
Date (yyyy/dd)	1993/03	1985/06	1991/01	1987/30	1989/23	1993/07	1992/07	1989/15	1985/05	1990/15	1977/25	1980/03		
Extreme Snow Depth (cm)	45	44	2	0	0	0	0	0	0	0	16	26		
Date (yyyy/dd)	1982/27	1982/02	1983/02	1981/01	1981/01	1981/01	1981/01	1980/01	1981/01	1981/01	1980/29	1980/04		
Days with Rainfall														
>= 0.2 mm	0.81	2.7	4.3	6.3	10.1	9.9	9.3	8.2	8.4	6.4	4.8	1.1	72.2	D
>= 5 mm	0	0.25	0.31	0.94	1.8	2.7	3	1.9	2.5	0.75	0.71	0.25	15.1	D
>= 10 mm	0	0	0.06	0.31	0.29	1.1	0.75	0.65	0.76	0.06	0.12	0.06	4.1	D
>= 25 mm	0	0	0	0.06	0	0.06	0.06	0	0	0	0	0	0.18	D
Days With Snowfall														
>= 0.2 cm	6.9	2.6	1.3	0.44	0.12	0	0	0	0	0.38	3.9	7.8	23.4	D
>= 5 cm	1.1	0.63	0.06	0	0	0	0	0	0	0	0.76	1.8	4.3	D
>= 10 cm	0.2	0.19	0.06	0	0	0	0	0	0	0	0.35	0.63	1.4	D
>= 25 cm	0	0	0	0	0	0	0	0	0	0	0.06	0	0.06	D

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Days with Precipitation														
>= 0.2 mm	7.2	5	5.3	6.5	10.2	9.9	9.3	8.2	8.4	6.6	7.9	8.8	93.2	D
>= 5 mm	1.1	0.94	0.38	1.1	1.8	2.7	3	1.9	2.5	0.81	1.5	2	19.7	D
>= 10 mm	0.2	0.19	0.13	0.31	0.29	1.1	0.75	0.65	0.76	0.06	0.47	0.69	5.6	D
>= 25 mm	0	0	0	0.06	0	0.06	0.06	0	0	0	0.06	0	0.24	D

NOTES:

A = WMO "3 and 5 rule" (i.e. no more than 3 consecutive and no more than 5 total missing for either temperature or precipitation)

B = At least 25 years

C = At least 20 years

D = At least 15 years

APPENDIX B
AJAX MINING PROJECT FINAL DETAILED MODEL PLAN

AJAX MINING PROJECT
Detailed Model Plan

FINAL

Prepared for:
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615 - 800 W. Pender Street
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Project Number: 123510762

March 4, 2015

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1.0 INTRODUCTION

1.1 THE AJAX MINE PROJECT

KGHM Ajax Mining Inc. (KGHM) proposes to develop the Ajax Project (the Project), an open pit copper-gold mine at the historic Afton Mining Camp, located within the Thompson Nicola Regional District in the south-central interior of British Columbia. The coordinates for the center of the Project area are approximately 50°36' N latitude and 120°24' W longitude. The center of the Project is located approximately 9 km southeast of the junction of the Trans-Canada Highway (No. 1) and the Coquihalla Highway (No. 5). Figure 3-1 in Section 3 shows the general location of the Project.

This FINAL Detailed Model Plan is the third version prepared and approved following regulatory review. Each revision was necessitated by a substantial change in the mine plan and general arrangement. A description of previous Detailed Model Plans is presented in Section 7.

The earlier mine plan and general arrangement had some mine features located within City of Kamloops limits, including the north waste rock management facilities; processing facility and truck shop; thickened tailings plant and emergency pond; process water intake and line; and tailings storage facility. KGHMs revised mine plan and general arrangement has relocated some of these features further to the south and outside the City limits. The major changes include:

Tailings Storage Facility (TSF): The TSF is now located five kilometres southeast of its previously proposed location. The TSF proposed is a conventional wet tailings impoundment.

South Mine Rock Storage Facility (SMRSF): This facility was previously located north of the mine pit, and is now located to the southeast of the mine pit.

Processing Plant, Crushers and Crusher Stockpile: These facilities are proposed to be relocated from the north side of the mine pit to the south side of the mine pit. A covered conveyor belt is proposed between the outpit primary crusher and the processing plant. These two changes substantially lessen haul distances.

East Mine Rock Storage Facility (EMRSF): The proposed EWRSF is not relocated but is smaller than previously planned.

TSF Mine Rock Storage Facility (TSF MRSF): The proposed TSF WRSF is located just south of the mine pit. It will take material previously destined to the EWRSF.

Temporary Ore Stockpile: This proposed stockpile will be moved from the north side of the mine pit to the south side of the mine pit. The ore stockpile will be covered with one open drop point.

The current mine plan for the proposed Project is based on an average of 65 thousand tonnes of ore milled per day (Kt/d) from the Ajax Pit over a 21 year mine life. Total material movement from the pit during the life of the mine is estimated at 1,554 million tonnes (Mt). This assessment however is based on 70 thousand Kt/d to account for possible future increases to the rate of production.

The ore will be delivered from the mine using haul trucks to the outpit primary crusher. The outpit primary crusher will be located southwest of the ultimate mine pit limit and remain in this location until the end of the mine life. Ore will be crushed to the size which meets process requirements and will be transferred to the processing plant by a covered conveyor belt. Delivery to the temporary ore stockpile is by haul truck. The ore stockpile (901 metres above sea level or masl) will be located just south of the mine pit.

The processing plant (962 masl) will consist of stage-wise crushing and grinding, followed by a flotation process to recover and upgrade copper from the feed material. A gravity circuit will be included within the flotation circuit to enhance gold recovery. The flotation concentrate will be thickened and filtered and shipped by covered trucks to the Port of Vancouver.

The TSF (950 - 1,000 masl) will be located approximately 2.0 km south of the mine pit. The proposed tailings dams will be built with waste rock from the mining operations. The dams will take advantage of the rolling nature of the local topography. The main and north dams will receive 12 Mt and 168 Mt of waste rock, respectively, by mine life end.

Waste rock will be hauled via haul truck to the waste rock storage facilities. Waste rock will not be crushed by the primary crusher. A stacking and spreading system will fill the proposed WRSF as indicated below:

Main Embankment 1,012 masl (year -2) – 1,060 masl (year 17) – receives a total of 161 Mt

East Embankment 975 (year -1) 1,060 (year 8) – I don't have any other info about the east dam – receives a total of 17 Mt

- South Embankment – we didn't get any info about this one
- SMRSF (421 Mt of mine rock), final elevation 1,235 masl
- EMRSF (57 Mt of mine rock), final elevation 1,030 masl
- TSF MRSF 915 masl (year -2) – 1,095 masl (year 17) – Receives a total of 226 Mt
- 16 Mt will be in the overburden stock pile on the north side of the EMRS, final elevation 990 m
- 8 Mt will be at the reclaim stock pile at the north east edge of the pit

A total of 30 Mt of topsoil will be stored in the reclamation stockpile collocated to the southeast of the EWRSF.

The mine plan and general arrangement may be subject to change as work continues. At present the Project components to be assessed in the ongoing single joint harmonized environmental assessment process include the following 16 elements:

- Ajax open mine pit
- Crusher pile
- Primary crusher
- Processing plant
- Ore stockpile
- Tailings storage facility
- Waste rock storage facilities
- Water management facilities
- Road and bridge upgrades
- New access and haul roads
- Borrow sources
- Transmission line and transformer upgrades
- Explosives storage facility
- Process and potable water system, including the intake in Kamloops Lake
- Concentrate storage and shipping area
- Concentrate transport to the Port of Vancouver

Not all project components result in substantial emissions to the atmosphere, or emit substances from a human or ecological health perspective. Therefore, the planned air quality assessment only considers those sources and substances of interest for which effects are reasonably contemplated.

1.2 PURPOSE OF THIS DOCUMENT

The proposed Project constitutes a reviewable project under Part 3 of the *Reviewable Projects Regulation* (BC Reg.370/2002), since the production capacity of the proposed project will exceed 75,000 tonnes per year of mineral ore. As specified in the Section 10 Order issued by the British Columbia Environmental Assessment Office (BC EAO) on February 25, 2011, KGHM must complete the provincial environmental assessment process before proceeding with construction and operation of the Project.

In addition to an Environmental Assessment Certificate issued by BC EAO, KGHM will require a number of provincial permits before construction of the Project can begin. KGHM intends to apply for concurrent review of provincial permits in accordance with the *Concurrent Approval Regulation* (BC Reg. 371/2002) of the *BC Environmental Assessment Act*. A decision on these approvals cannot be made until and unless the Environmental Assessment Certificate has been issued.

As the mining industry is listed as a 'prescribed' industry under the *Waste Discharge Regulation* (BC Reg. 263/2010) a Permit is required to authorize the disposition of waste (e.g. air emissions) in compliance with the *Environmental Management Act* ([SBC 2003] Chapter 53). To secure a Permit authorizing emissions to the atmosphere, KGHM must conduct an air quality assessment consistent with the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008). The *Guidelines* (BC MOE 2008) call for the development of a Detailed Model Plan, which is the focus of this report. The Detailed Model Plan and the resultant Air Quality Technical Data Report are integral parts of the environmental assessment.

1.3 LEVEL OF ASSESSMENT

This air quality assessment is intended to evaluate the air quality effects of an industrial development for an environment assessment process. It is providing information to support environmental, human, and economic effects studies. It is potentially evaluating the consequences of air quality management approaches involving multiple sources. As such, Section 2.2.3 of the *Guidelines* (BC MOE 2008) indicates that a Level 3 assessment is required.

1.4 CONTENTS OF THIS DOCUMENT

This document describes an assessment consistent with Level 3 in the *Guidelines* (BC MOE 2008). It considers aspects of emissions (Section 2), the site (Section 3), methodology (Section 4), data presentation (Section 5), the quality management program (Section 6), and the review by regulatory agencies (Section 7).

2.0 EMISSION SOURCES AND SUBSTANCES OF INTEREST

2.1 EMISSION SOURCES

As detailed in Sub-Section 1.1, the Project consists of sixteen components. All emissions associated with mine equipment and process will be evaluated. The emissions include diesel exhaust from haul trucks and other heavy equipment, fugitive dust from haul roads, dust emissions mechanically induced by traffic, fugitive dust from conveyances and transfer points, fugitive dust from land areas such as the Ajax mine pit, access and haul roads, the TSF, and the waste rock storage facilities. Dust and gaseous emissions from blasting will also be modelled.

There will be no continuous emissions from on-site generation of electricity commonly associated with mining projects, as the project will be on the BC Hydro power grid. Diesel generators will be available for emergency standby power generation. Consistent with good modelling practice, the standby power generators will not be included as an emission source. Outside of a power outage, they will be run for testing purposes only (normally one hour per month).

The Project does not include cooling towers or other near-saturated discharges of water vapour (e.g. wet scrubbers). Water emissions to the atmosphere is limited to evaporation from water storage facilities and wetted surfaces (e.g. the TSF surface, roadways sprayed with water for dust control). Fogging and icing episodes attributable to evaporation associated with Project activities are not expected to exceed those instances where fogging and icing is already occurring naturally. The potential for fogging and icing due to the projects emission of water vapour will therefore not be modelled.

Project emissions will be calculated using published emission factors and facility engineering design estimates. Where filterable and condensable particulate fractions are present and included in the published emission factors, they will be considered in the modelling exercise. A summary of mobile emission sources that will be included in assessment are summarized in Table 2-1 (in Sub-Section 2.1.2).

2.1.1 Modelling Scenarios

Good modelling practice dictates that worst cases be characterized and be modelled, understanding that any lesser case has a lesser effect compared to the worst case. Therefore for a lesser case the conclusions of the worst-case assessment hold - with an added measure of conservation.

Two Project scenarios will be considered, each with differing emission profiles to determine how the various project phases affect air quality: They are: Construction (Development year minus 1) and Operations (Operations year 4/8). The operations scenario takes aspects from both year 4 and year 8 of operations that contribute to a worst case possible mine year. This is based on the quantity of the equipment fleet, the haulage lengths, the total amount of material moved, and the location of the active storage facilitates.

The existing air quality in the region will be accounted for by Base Case modelling of the existing sources in the Project area. These three modelling scenarios are described briefly below.

2.1.1.1 Construction Year Assessment

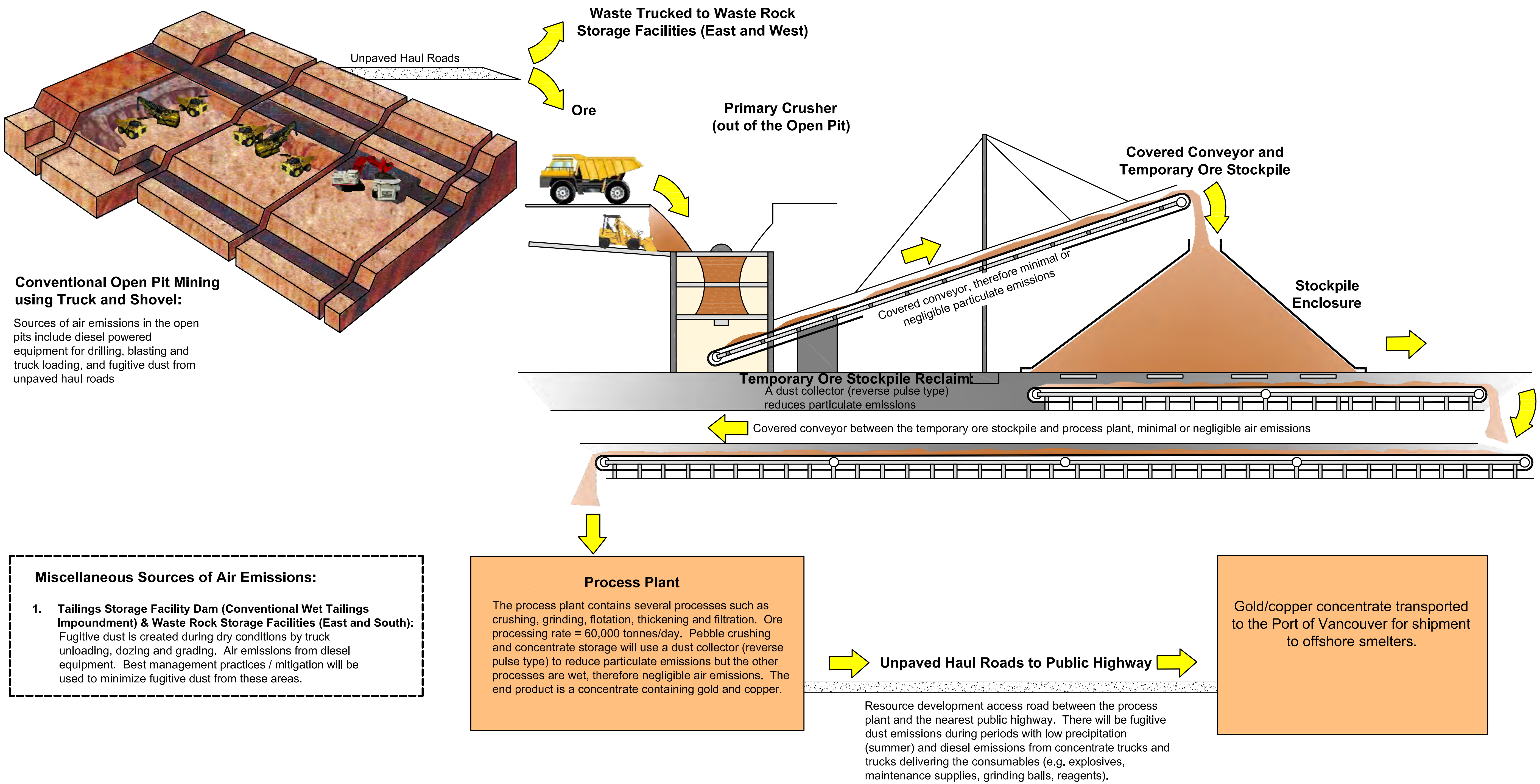
The Construction phase will be assessed because it represents a year with surface disturbances that produce substantial air emissions. Generally the construction air emissions result from the various mobile construction equipment and fugitive dust emissions generated by site preparation for building foundations or pre-stripping for ore mining. Mine development which includes topsoil stripping, clearing and grubbing of the mine area, and mine haul roads construction will begin in 2016 and continue through to 2018. Waste rock from the mine pit will be used to begin construction of the TSF main and north dams. There will be air emissions associated with all of these activities. The construction year just before operations start (Operations minus1) was chosen for assessment because it represents the year with the greatest amount of surface disturbance.

Table 2-1 (in Sub-Section 2.1.2) summarizes mobile air emission sources for the Construction phase. Air emissions from the diesel equipment will be based on the horsepower (hp) rating for each piece of equipment, duration of equipment operation (hours per day) and estimated emission rates from the NONROAD2008 model (US EPA 2005). Generally speaking, anthropogenic emissions can be classified into three broad categories, mobile, stationary (point), and area sources. Mobile source emissions are further disaggregated into on-road (e.g., haul trucks) and nonroad (e.g. track dozers) emission categories.

Because of the contribution of nonroad emission sources to the total mobile source emission inventory, it has become critical over the past several years for the United States Environmental Protection Agency (US EPA) to provide accurate, reproducible inventories of nonroad emissions. Generally, the US EPA air emission factors for nonroad mobile equipment are also applicable in Canada for environmental assessments because the Canadian equipment emissions legislation closely matches that of the US. Nonroad emissions result from the use of fuel in a variety of vehicles and equipment including construction equipment.

2.1.1.2 Operations Assessment

Operations are expected to start in 2019 and continue for 21 years. A combination Operations year, which consists of aspects from year 4 and year 8, was chosen for assessment because the mine plan predicts that the combination of these two years will experience the greatest amount of machine activity, blasting, earth moving and resulting air emissions Figure 2-1 is a simplified process flow diagram that summarizes the various air emission sources.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC REPORT AND MUST NOT BE USED FOR OTHER PURPOSES.

Reference:	Job No.: 123510762 Scale: N.T.S. Date: 23-Sep-14 Dwn. By: SS App'd By: DJ	Client: KGHM INTERNATIONAL Site Address: KAMLOOPS, BC	AJAX OPEN PIT MINE	SIMPLIFIED PROCESS FLOW DIAGRAM SHOWING AIR EMISSIONS	Dwg. No.: 2-1

Stantec

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Waste rock from the mine pit will continue to be added to the waste rock storage facilities and the TSF dams to allow more tailings to be deposited. Fugitive dust emissions from the TSF will be calculated and included in the air dispersion model.

2.1.1.3 Base Case Assessment

Assessment of the existing air quality in the CALPUFF modelling domain (defined in Section 4.2.1) will be done consistent with Section 10.1 of the *Guidelines* (BC MOE 2008). It will be assessed through both dispersion modelling of the Base Case and the addition of background air quality values.

Modelling the Base Case for all substances of interest will involve developing an inventory of emissions within the Kamloops airshed from existing sources of information. By source type, these include:

Permitted Emissions for industrial emissions currently authorized by the Ministry including the Domtar Canada pulp mill, Tolko Industries sawmill, LaFarge Canada cement plant, the Moly-Cop Canada plant, New Gold mine, and the Absorbent Products Ltd. facility.

Transportation Emissions for on and off road vehicle use, including light and heavy duty vehicles, off-road vehicles, and railways.

Home Heating & Other Domestic Sources for home heating with natural gas, oil, or wood. This also encompasses emissions from businesses such as food preparation, light manufacturing, office, and retail.

Paved and Unpaved Roads include fugitive dust from major roads, including the Trans-Canada Highway, the Yellowhead Highway (Hwy 5), Highway 5A, and the Lac Le Juenne road. Unpaved road dust emissions are relatively small and are not included.

Disturbed Lands or fugitive dust from all land where vegetation is absent for all of the year. This includes the historic Afton and New Gold tailings beaches and local landfills. Agricultural lands, industrial sites, and seasonally exposed river beds are not included.

Background air quality values reflective of global and regional background concentrations derived from local measurements will be added to the Base Case predictions. This is described further in Section 3.1.2.

The Base Case assessment results will be added to the Construction and Operations assessment results on a receptor-by-receptor, hour-by-hour basis such that cumulative results are portrayed in a more robust manner than could be achieved by adding measured background values representative of worst-case measurements to the Construction and Operations predicted concentrations.

2.1.2 Source Types

The following section describes the source types included in the assessment. These source types are described for the Construction and Operations phase, however they are generally applicable to the Base Case as well.

2.1.2.1 Point Sources

During operations there will be point sources of particulate emissions; however they will not be modelled as point sources to enhance computational efficiency. These include the primary crusher located south of the mine pit, and baghouses located on the processing plant roof. The primary crusher and drop points are modelled as volume sources. The mill is modelled as a single area source.

A 1,000 kW diesel generator will be available for emergency standby power for the mill and high pressure grinding roller (HPGR) buildings. In their comments, Interior Health (2012) has "recommended including all internal combustion engines, including diesel generators in emissions modelling as worst case scenario." Good modelling practice generally excludes modelling standby or emergency generators unless a compelling argument is made to include them (e.g. an unreliable primary power source). They generally only run an hour per month for testing purposes, and by definition during electrical outages.

Considering the rarity of prolonged electrical outages in Kamloops, the probability of an outage coinciding with worst-case meteorological conditions is unlikely. This is the reasoning behind the exemption of "standby generators from hospitals or other institutions or other industries" from regulation under the *Environmental Management Act - Waste Discharge* Regulation (BC MOE EPD, 2007). As such, Stantec will exclude the 1,000 kW emergency standby diesel generator from the modelling exercise.

2.1.2.2 Mobile Sources

During construction, mobile equipment (largely diesel) will be used to remove the overburden from the mine pit area, then to haul and pile the material at the TSF waste rock facility, cover the haul roads, pile the TSF dam and reclamation stockpiles. Both the dust and exhaust emissions will be modelled as area sources covering the activity areas. Construction equipment is shown in Table 2-1.

During operations, mobile diesel equipment will used to extract ore and waste rock from the mine pit, to haul ore to the primary crusher, and to haul waste rock to the waste rock facilities. Various pieces of diesel mobile equipment will be used to drill the orebody and overburden for the blasting and then loading the broken material into haul trucks (300 t class). Other mobile diesel equipment include dozers, graders, excavators, mobile cranes, general service trucks, fuel and lube trucks, articulated trucks, water trucks, and pickup trucks.

The mobile fleet emissions depend on the power ratings for each piece of equipment and the total net operating hours. The mobile equipment has an operating efficiency of between 45% and 85%. This includes wait periods for meal and rest breaks, blasting and other standbys, shift change, and poor weather.

Table 2-1 Ajax Project Mobile Equipment Used During Construction and Operations

Fleet Summary	Construction Units	Operations Units
Primary Equipment:		
300T Trucks	4	23
76 yard Shovel [a] (58 cubic metres)	1	3
LT1850 Sized Loaders	1	1
311mm Production Drills	1	3
152mm Preshear Drills	0	1
Track Dozers (450 Kw class)	4	6
Rubber Tire Dozers (WD 600)	1	2
Graders (16 foot)	3	4
Water Trucks (20k gallon HD785)	3	5
Ancillary Equipment:		
General service truck	-	3
Boom Truck - 10 t, 9 m reach	-	2
Mobile Crane - 160 t	-	1
Cable Reeler - FEL mounted	-	1
Mobile Cable Repair Station	-	1
Lighting Plant - 20 kW	-	8
Fuel and Lube Truck - 30 kl + 6 tanks	-	1
Pickup Trucks	6	10
Articulated Truck - 40 t class w/ejector	-	1

NOTE:
[a] The electric hydraulic shovels used in the mine pit do not have diesel emissions; they are included here to provide an overall summary of the mining equipment.

SOURCE: KGHM

There will be movement both within and adjacent to the mine pit. As such, the emissions from mobile sources travelling within the mine pit will be represented as an area source for the mine pit. The majority of the mobile equipment moves primarily on unpaved haul roads between the mine pit, the primary crusher, the waste rock storage facilities and the ore stockpiles. Emissions from these mobile sources will be represented by another area source. There is a partially paved access road between the processing plant and the nearest provincial highway (Highway 5A) for concentrate transport. The emissions from the access road sources will be modelled as an unpaved road by a series of volume sources.

A listing of mobile equipment employed during Construction and Operations are presented in Table 2-1.

2.1.2.3 Area Sources

The area sources will include all disturbed open areas such as the mine pit, waste rock storage facilities, reclamation stockpile, and the TSF. Fugitive dust from blasting and emissions from primary truck loading of waste and ore in the mine pit will be included in the mine pit area source. In the mine pit, the primary loading will be done using electric-hydraulic shovels with 58 m^3 buckets; however there will not be diesel emissions from the electric-hydraulic equipment. The mine pit area sources will include the diesel emissions from the drills and the front end loaders with 40.5 m^3 buckets that will be used to load ore and waste into the haul trucks.

Fugitive dust from the TSF area source will be primarily a function of the surface area exposed, the particle size for the surface of the tailings, the moisture content and the prevailing wind speed. Other three-dimensional features such as the waste rock storage facilities will be treated as area sources. Only the newly active surfaces of these features where most of the dust emissions will occur will be modelled as area sources.

2.1.2.4 Line Sources and Volume Sources

Emissions produced by mobile equipment activity on the haul roads south of the mine pit will be modelled by an area source as described above. The only exception is the access road which will be modelled as a series of volume sources. Line sources will not be used as they are computationally inefficient.

The access road should be ready before the construction year that is assessed, so only the dust and exhaust due to travel on the access road will be considered for both Construction and Operations. A summary of the mine features and modelling approach for Construction and Operations are shown in Table 2-2.

Table 2-2 Mine Features Modelling

Modelling Type	Sources during Construction and Operations
Area	Conveyor transfer points Processing plant backhouse Ore stockpiles (low grade and high grad) Mine pit Haul roads between mine pit, crusher, waste rock storage facilities, ore stockpiles Tailings storage facility All waste rock storage facilities, reclamation facilities, and overburden facilities
Volume	Access road Crusher

2.2 SUBSTANCES OF INTEREST

2.2.1 Criteria Air Contaminants Considered in the Air Quality Assessment

The substances of interest emitted by the Project that are considered in this air quality assessment are discussed in this section. These substances will be included in the dispersion modelling of both gridded and special receptors. The gridded receptors, special receptors, and the dispersion modelling domain are described in Sub-Section 4.2.1. These substances are commonly known as criteria air contaminants (CAC – see Sub-Section 3.3). They were selected based upon the quantities emitted and previous experience with similar projects. They include:

- Total dustfall (DF)
- Total suspended particulates (TSP)
- Inhalable particulate matter (10 microns or less in aerodynamic diameter or PM_{10})
- Respirable particulate matter (5 microns or less in aerodynamic diameter or $PM_{2.5}$)
- Sulphur dioxide (SO_2)
- Oxides of nitrogen (NO_X)
- Carbon monoxide (CO)

Ozone and secondary $PM_{2.5}$ formation will not be modelled in this assessment. The BC Ministry of Environment (BC MOE) has stated that ozone and secondary $PM_{2.5}$ formation will occur far outside the City of Kamloops. By that time these substances will be sufficiently dispersed and therefore are of little concern. This issue was revisited by the BC MOE recently (BCMOE 2015a) and a response provided (Stantec 2015). The BC MOE subsequently indicated they consider the issue resolved (BCMOE 2015b).

2.2.2 Substances of Interest for the Human Health and Ecological Risk Assessment

The Human Health and Ecological Risk Assessment (HHERA) discipline refers to their substances of interest (SOIs) as contaminants of concern (COCs). The COCs released by Project emission sources that are considered in the HHERA are discussed in this section. These substances will be included in dispersion modelling only at discrete 'special receptors' located in the dispersion modelling domain. The discrete 'special receptors' are described in Sub-Section 4.2.3.

The Stantec Senior Toxicologist selected the COCs based on laboratory results provided by KGHM. The COCs include trace elements in the ore, waste rock, and tailings. The selection process is governed by the toxicity of the mobile portion of each substance that represents a potential human exposure or possibility for uptake into plants.

From the perspective of the HHERA assessment, the priority is the individual elements and their potential long term deposition. The toxicological benchmarks for humans and ecological receptors are based on trace element concentrations. The final identification of the COCs for the HHERA assessment will depend on the concentrations of the individual elements in soil, surface water and/or sediments. The HHERA methodology is fully explained in the HHERA Detailed Modelling Plan for the KGHM Ajax Mine Project (Stantec 2014).

Stantec has completed a statistical analysis of the results of ore and waste rock samples plus tailings samples to develop a list of metals and several non-metals present at low concentrations. These were derived from inductively coupled plasma mass spectrometry (ICP-MS) test performed for and supplied by KGHM. A total of 58 elements were detected.

For the ore samples and waste rock samples, the upper 95% confidence limit for mean (95% UCLM) of all individual species from ore assay results were employed as a basis for emission calculations. The 95% UCLM was obtained using the US EPAs ProUCL statistics package as per US EPA guidance (http://www.epa.gov/osp/hstl/tsc/software.htm).

A Step 1 and Step 2 Screening of the elements has been conducted by the Stantec Senior Toxicologist to eliminate the elements that do not represent a concern for human or ecological health based on the use of toxicity reference values (TRV) and techniques discussed in Richardson and Wilson (2013). These substances can include essential nutrients such as magnesium and phosphorus.

The COCs for the HHERA assessment include 14 metals in dustfall (as a rate of deposition per unit area) including:

Table 2-3 Fourteen Selected Metal COCs for the HHERA

Antimony (Sb)	Mercury (Hg)
Arsenic (As)	Molybdenum (Mo)
Cadmium (Cd)	Nickel (Ni)
Cobalt (Co)	Selenium (Se)
Chromium (Cr)	Tin (Sn)
Copper (Cu)	Vanadium (V)
Lead (Pb)	Uranium (U)

As well as ore, waste rock, and tailings, diesel emissions are known to contain some metals. These metals will be included in the dispersion assessment where emission factors are available.

Each source on the minesite will have one of these metals profiles associated with it. For example, roadways will be assumed to have the waste rock metals profile; the pit will be assigned the ore profile; the TSF will be assigned the tailings profile. The air quality discipline will hand off to the HHERA team total dustfall broken down into four rates of deposition to which they will apply the pertinent metals profile to calculate total metals deposition.

Metals and several non-metals indicated in the data provided by KGHM, but have been screened out of the assessment by the Stantec Senior Toxicologist (Table 2-4).

Table 2-4 Metal and Non Metals Screened out of the HHERA Assessment

Aluminum (Al)	Gold (Au)	Phosphorus (P)	Tantalum (Ta)
Barium (Ba)	Hafnium (Hf)	Platinum (Pt)	Tellurium (Te)
Beryllium (Be)	Indium (In)	Potassium (K)	Terbium (Tb)
Bismuth (Bi)	Iron (Fe)	Rhenium (Re)	Thallium (Tl)
Boron (B)	Lanthanum (La)	Rubidium (Rb)	Thorium (Th)
Caesium (Cs)	Lithium (Li)	Scandium (Sc)	Titanium (Ti)
Calcium (Ca)	Lutetium (Lu)	Silicon (Si)	Tungsten (W)
Cerium (Ce)	Magnesium (Mg)	Silver (Ag)	Ytterbium (Yb)
Fluorine (F)	Manganese (Mn)	Sodium (Na)	Yttrium (Y)
Gallium (Ga)	Niobium (Nb)	Strontium (Sr)	Zinc (Zn)
Germanium (Ge)	Palladium (Pd)	Sulphur (S)	Zirconium (Zr)

The COCs for the HHERA also includes:

i. The following CACs:

- Total dustfall (DF)
- Total suspended particulates (TSP)
- Inhalable particulate matter (10 microns or less in aerodynamic diameter or PM_{10})
- Respirable particulate matter (5 microns or less in aerodynamic diameter or $PM_{2.5}$)

ii. The following Hazardous Air Pollutant (HAP):

- Polynuclear Aromatic Hydrocarbon species (PAH) expressed as Benzo (a) Pyrene (B(a)P) equivalent (as a mass concentration in air). B(a)P equivalent is a proxy for 'diesel particulate matter' for which there are no applicable criteria

Other substances screened out of the HHERA following consideration include crystalline silica plus four reagents employed in the process of isolating minerals from the ore.

Crystalline silica is the term used to describe a group of minerals composed of silicon and oxygen (SiO_2) where the atoms are arranged in a three-dimensional repeating fashion. Excessive worker exposure to crystalline silica can cause silicosis, a non-cancerous lung disease. It is also classed by the International Agency for Research on Cancer (IARC) as a Group 1 human carcinogen.

Of concern specifically are particles of quartz (the SiO_4 tetrahedron) and cristobalite (a distinct crystalline structure of SiO_2) when they are emitted in the respirable size range (<2.5 µm in diameter). Quartz is so abundant, and the six other polymorphs of silica so rare, that some authors use quartz in place of the term 'crystalline silica'. Amorphous silica (SiO_2 in a non-crystaline form) is not a concern with respect to silicosis and/or cancer.

Crystalline silica forms in igneous rocks only if sufficient silicon (Si) and oxygen (O_2) are left over after silicates (e.g. olivine, pyroxenes, amphiboles, feldspars, and micas) have formed (US DOI 1992). Crystaline silica is therefore present only in igneous rocks that contain excess silica (SiO_2). A detailed description of the mineral content and the microstructures within the rocks at the mine site indicates they are SiO_2 under-saturated, and thus very low in quartz and by extension the six other crystalline silica polymorphs (e.g. cristobalite, tridymite) that are relatively rare (Fee J. 2012).

Given the relative absence of crystalline silica in the Ajax mine site rock, the Stantec Senior Toxicologist has screened SiO_2 out of the HHERA. At the mine site, workers that can potentially be exposed to the small amount of respirable SiO_2 (e.g. drilling activities, crushing activities) will be wearing personal protective equipment. Exposures capable of impacting human health offsite are not possible.

The four reagents employed in the process of isolating minerals from the ore are methyl isobutyl carbinol (MIBC), potassium amyl xanthate (PAX), flocculant (a high molecular weight cationic polymer) and calcium oxide (quicklime). MIBC is in a liquid state and used in process with no dilution. PAX is in solid form and will be mixed with water to a solution containing 20% PAX by weight. As MIBC and PAX are evaporative, ventilation is required in distribution/preparation. They were examined further as a potential COC) for the HHERA.

The flocculants and quicklime are in solid forms and are relatively benign. They will be mixed with water to reach the required strength prior to application. For quicklime, this mixing process creates a lime solution ($Ca(OH)_2$). These two reagents have a very low potential to enter the atmosphere either by evaporation or as a fugitive emission. Flocculants bind with and remain with the solids (tailings and concentrate). Lime solution is used to adjust the pH value in flotation cells. It travels with the tailings to the tailings management facility and returns to the processing plant in the recycled process water.

MIBC and PAX are added in the rougher and cleaner flotation stages, and leave the facility mainly bound to the flotation concentrate. In their pure form both MIBC and PAX evaporate at ambient temperatures. At the proposed Ajax mine facility mitigation is proposed that will minimize the release of MIBC and PAX by evaporation. They may be emitted in small quantities through vents in the process building. Any workers that can potentially be exposed to MIBC and PAX vapours will be wearing personal protective equipment. Meaningful exposures to MIBC and PAX beyond these work environments are not possible.

The fate of MIBC and PAX in the system was examined to determine if any appreciable quantity of MIBC and PAX (or their decomposition products) persists in the water cycle where they may potentially evaporate from open water surfaces on the project site (e.g. from the tailings storage facility). Stantec relied on TetraTech Wardrop (Danon-Schaffer 2012) with respect to the chemistry and decomposition of MIBC and PAX.

MIBC is used as a flotation frother. Its half-life in the environment is approximately 10 hours with a boiling point of 131 °C. Hydrolysis is not considered as a degradation pathway, however it will partition as follows: 3.6% (air), 45% (water), 51% (soil) and <1% (sediment), based on Mackay's Fugacity Model Level III. It has a low bioaccumulation potential and will degrade by approximately 94% in 20 days. Given its biodegradation and photodegradation potential, this compound is not expected to create any environmental exposure. MIBC metabolizes to methyl isobutyl ketone (MIBK) and subsequently to the primary metabolite of MIBK, 4-hydroxy-4-methyl-2-pentanone (HMP). The breakdown product is not expected to cause harm in the environment (Danon-Schaffer 2012).

PAX is used as a flotation collector. It is very soluble in water, approximately 34-46 g/100 g @ 20°C. Its half-life in the environment is approximately 4 days. With first order kinetics to perxanthates 5% degradation occurs in approximately 50 hours @ 20°C and 1% occurs within 24 hours. Degradation is considered a function of pH. Reaction rates vary with temperature.

Therefore, the stability of PAX (and other xanthates) depends on temperature and pH, not exposure to sunlight. Furthermore, the lower the temperature, the more stable the xanthate. Hydrolysis can be accelerated if pH is <8. PAX forms complexes with heavy metals, i.e. it binds with them. It is considered corrosive and volatile. Carbon disulphide is present in the xanthate solution and vapours of carbon disulphide can be produced. These vapours are toxic and flammable (flashpoint 30°C). Evaporation is unlikely. PAX decomposes into xanthic acid: ROC(S)SH (Danon-Schaffer 2012).

The Stantec Senior Toxicologist has examined TetraTech Wardrops information (Danon-Schaffer 2012) and screened both MIBC and PAX, and their decomposition products out of the HHERA.

3.0 REGIONAL SETTING

3.1 BACKGROUND AIR QUALITY

Section 10.1 of the *Guidelines* (BC MOE 2008) state that although it is useful to know the predicted incremental contribution from modelled emission sources, it is the cumulative air quality that is of importance. The cumulative air quality is given by:

Cumulative = Background + Predicted Increment (contribution from modelled emission)

"Background" values are usually derived from ambient air quality measurements and are added to modelled concentrations to approximate the additive effects of a modelled source and sources not included in the modelling (e.g., other industries, traffic emissions, natural sources).

Choosing the appropriate background concentration can be critical in assessing overall air quality. In order of priority, the information sources used to establish the background concentration level are:

- a network of long-term ambient monitoring stations near the source under study
- long-term ambient monitoring at a different location that is adequately representative
- modelled background

As described in Section 2.1.1 Stantecs approach in this assessment is to model background air quality consistent with bullet three in Section 10.1 of the *Guidelines* (BC MOE 2008). Background concentrations based on measurements and consistent with the Guidelines <u>will not be added</u> to the predicted concentrations; however they are provided here both for reference purposes and to provide a point of comparison against modelled background.

What <u>will be added</u> to the modelled background air quality is a figure representative of the Global / Regional Background – and these are derived from measurements in a manner that eliminates the influence of local sources (which are predicted with the background modelling). The measured background consistent with the *Guidelines* is discussed in Section 3.1.1, and the measured global / regional background is discussed in Section 3.1.2.

This issue was revisited by the BC MOE recently (BCMOE 2015a) and a response provided (Stantec 2015). The BC MOE subsequently indicated they consider the issue resolved (BCMOE 2015b).

3.1.1 Measured Background Consistent with the Guidelines

Table 3-1 presents background values based upon continuous gas and particulate matter measurements taken at three permanent Kamloops air quality monitoring stations. Background values are listed only for averaging intervals employed in ambient air quality objectives (Table 3-8). Table 3-2 lists the station location, parameters measured, and other information. Figure 3-1 illustrates the locations of both the permanent and intermittent monitoring locations.

Table 3-1 Background or Reference Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

Substance	Averaging Period	Background Concentration
TSP (µg/m^3) [a] Kamloops Federal	24-hours	78.0
	Annual	45.0
PM_{10} (µg/m^3) [b] Brocklehurst	24-hours	68.7
$PM_{2.5}$ (µg/m^3) [c] Brocklehurst R&P TEOM	24-hours	41.4
	Annual	7.8
$PM_{2.5}$ (µg/m^3) [d] Brocklehurst BAM	24-hours	21.4
	Annual	8.3
$PM_{2.5}$ (µg/m^3) [e] Kamloops Federal BAM	24-hours	28.2
	Annual	9.1
$PM_{2.5}$ (µg/m^3) [f] Kamloops Fire Station #2 BAM	24-hours	19.7
	Annual	7.5
SO_2 (µg/m^3) [g] Kamloops Federal	1-hour	16.5
	3-hour	16.5
	24-hours	10.4
	Annual	3.5
NO_2 (µg/m^3) [h] Brocklehurst	1-hour	65.1
	24-hours	55.5
	Annual	23.2
CO (µg/m^3) i Brocklehurst	1-hour	931
	8-hours	815

NOTES:

- Between 1994 and 1998 the 24-h maximum TSP exceeded the AAQO (120 µg/m^3) every year.
- Between 1998 and 2013 the 24-h maximum PM_{10} exceeded the AAQO (50 µg/m^3) in 14 of 16 years. Exceedance frequency is 1.4% or 5 days/year. The average maximum value is 111 µg/m^3.
- Between 1998 and 2013 the maximum $PM_{2.5}$ (Brocklehurst) exceeded the AAQO (25) in 7 of 14 years. Exceedance frequency is 0.8% or 3 days/year. The average maximum daily value is 40.7 µg/m^3.

Table 3-1 Background or Reference Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

NOTES:

[a] For TSP the 24-hour background value is the 90th percentile measured concentration. The annual value is the maximum measured annual concentration. All values are for the period from January 1, 1994 to December 31, 1998, measured at the Kamloops Federal Building monitoring station.

[b] For PM_{10} the 24-hour background values are the 98th percentile measured concentrations (2003). All values are for the period from January 1, 1994 to June 18, 2009, measured at the Kamloops Brocklehurst monitoring station.

[c] For $PM_{2.5}$ (TEOM) the 24-hour background values are the 98th percentile measured concentrations (2003). The annual values are the maximum measured annual concentrations (2003). All values are for the period from January 1, 1998 to June 5, 2011, measured at the Kamloops Brocklehurst monitoring station with an R&P TEOM Instrument.

[d] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2011). The annual values are the maximum measured annual concentrations (2011). All values are for the period from September 20, 2010 to September 25, 2012, measured at the Kamloops Brocklehurst monitoring station with a BAM 1020 Instrument.

[e] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2014). The annual values are the maximum measured annual concentrations (2014). All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Federal Building monitoring station with a BAM 1020 Instrument.

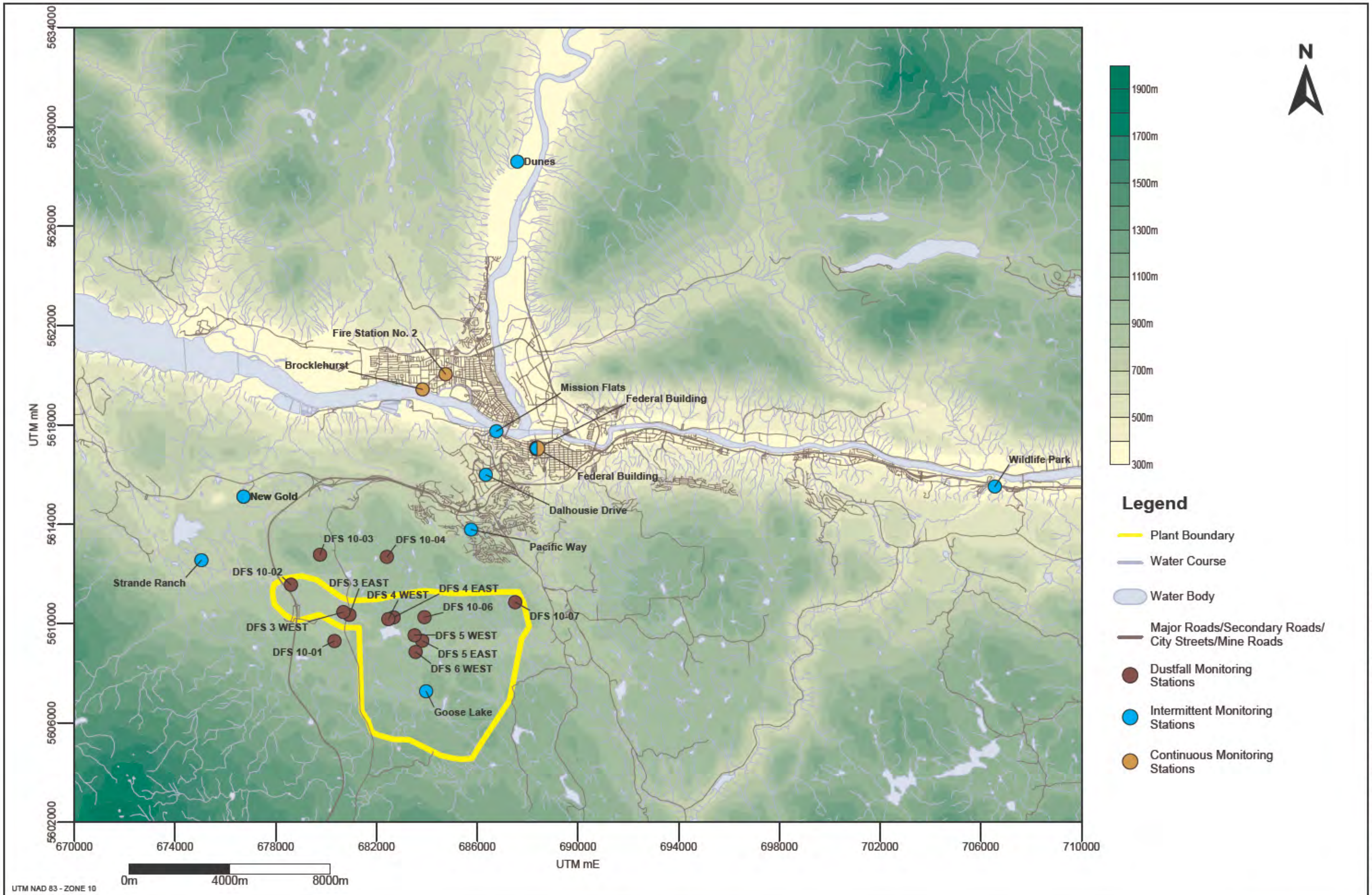
[f] For $PM_{2.5}$ (BAM) the 24-hour background values are the 98th percentile measured concentrations (2012 and 2013). The annual values are the maximum measured annual concentrations (2011). All values are for the period from June 27, 2011 to December 31, 2013, measured at the Kamloops Fire Station #2 monitoring station with a BAM 1020 Instrument.

[g] For SO_2 the 1-hour and 24-hour background values are the 98th percentile measured concentrations (2012). The 3-hour background value is equal to the 1-hour value. The annual values are the maximum measured annual concentrations (2012). All values are for the period from January 1, 1998 to December 31, 2013, measured at the Kamloops Federal Building monitoring station.

[h] For NO_2 the 1-hour and 24-hour background values are the 98th percentile measured concentrations (2000). The annual values are the maximum measured annual concentrations (2006). All values are for the period from January 1, 1998 to May 29, 2012, measured at the Kamloops Brocklehurst monitoring station.

[i] For CO the 1-hour and 8-hour CO background values are the 98th percentile measured concentrations (2004).These values are for the period from January 1, 1998 to May 30, 2011, measured at the Kamloops Brocklehurst monitoring station.

The sources for these data are spreadsheet summaries developed and distributed by the BC MOE annually (BCMOE 2013b). Raw data are also available at http://envistaweb.env.gov.bc.ca/.



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KGHM Ajax Air Quality Assessment
Detailed Model Plan

Location of Background Air Quality Monitoring Stations

PREPARED BY
Stantec
PREPARED FOR
KGHM Ajax
FIGURE NO.
3-1

Last Modified: 02/27/2015 By: kwells

Table 3-2 Continuous Gas and Particulate Matter Monitoring Stations in Kamloops

Station Name	Parameters						Location (UTM Zone 10)		Elevation	Sampling Dates	
	PM_{10}	$PM_{2.5}$	NO_X	O_3	SO_2	H_2S	Northing (m)	Easting (m)	(m asl)	Start	End
Fire Station # 2		X	X	X	X	X	5620037.15	684742.94	348	Jun-11	Ongoing
Brocklehurst	X	X	X	X	X	X	5619425.00	683826.00	345	Pre-98	Sep-12
Federal Building		X			X	X	5617046.00	688358.00	362	Pre-98	Ongoing

It is important to recognize that, consistent with Section 10.1.5 of the *Guidelines* (BC MOE 2008) the 1-hour, 8-hour, and 24-hour values are the 98th percentile of the measured concentrations. The annual values are the maximum measured annual concentrations. Often these are years dominated by a single event such as a nearby forest fire (e.g. the 2003 Rayleigh fires) or some other phenomenon (e.g. an unusually persistent period of air stagnation, an unusually high period of industrial emissions).

Intermittently measured TSP and dustfall data were requested from the BC MOE. This includes historic Ministry dustfall measurements from the City of Kamloops and surrounding area, and intermittent particulate monitoring undertaken by the Ministry and/or Permit holders in the area. These data are unavailable and therefore not included.

Table 3-3 presents background values based upon intermittent particulate matter measurements taken at nine Kamloops air quality monitoring stations, one of which is permanent and the remainder of which are temporary. This satisfies a requirement of Interior Health (2012) which "requested that a year of measured background data (specifically $PM_{2.5}$) be provided from residential receptor sites within the immediate study area." The BC MOE have provided suitable data, presented below.

Table 3-4 lists the station location, parameters measured, and other information. Consistent with Section 10.1.5 of the *Guidelines* (BC MOE 2008) the 24-hour background values are represented by the 98th percentile of the measured concentrations. Other statistical metrics are reported for reference purposes. The average values are the average of all measured concentrations, and is a good proxy for the annual average value.

It is important to note that these measurements are spread over an 11 year period (1994 to 2004), and only represent one to three years of that interval. Particulate air quality varies considerable over that period, as well as from one geographic location to another. These data are not directly intercomparable as they are not paired in time, however they do illustrate some important geographic trends. For example, the highest values are measured in the valley bottom areas. The higher elevation suburban areas are somewhat lower generally. Areas outside the valley have very low values – as little as one-third that found in the valley bottom.

Table 3-3 Background or Reference Concentrations of Intermittently Monitored Particulate Matter in Kamloops

Station Name	Parameter	Mean	Maximum	Percentiles						24-h Samples:	
				98th	90th	75th	50th	25th	10th	Missing	@ LOD
Dunes	$PM_{2.5}$	6.5	18.9	15.6	11.7	8.9	7.0	3.3	2.0	10%	15%
Mission Flats	$PM_{2.5}$	6.7	38.5	21.9	12.3	7.7	5.7	4.2	3.2	10%	2%
Federal Building	$PM_{2.5}$	7.8	37.0	24.8	15.5	9.8	6.7	3.3	2.7	12%	8%
Dalhousie Drive	$PM_{2.5}$	6.0	39.2	16.4	11.0	6.8	5.7	3.1	2.1	8%	8%
Wildlife Park	$PM_{2.5}$	6.1	35.0	17.4	12.0	7.3	5.9	3.3	2.0	13%	10%
New Gold	$PM_{2.5}$	5.1	70.4	11.1	8.1	6.2	4.5	2.2	2.0	3.3%	18%
	PM_{10}	12.3	85.0	37.3	22.0	14.2	10.5	6.5	4.1	5.0%	2%
Pacific Way	$PM_{2.5}$	5.8	24.1	19.9	11.3	7.3	5.4	0.0	2.3	6%	20%
Strande Ranch	PM_{10}	6.9	21.2	12.9	10.6	8.6	7.6	4.5	3.2	13%	5%
Goose Lake	$PM_{2.5}$	3.2	10.3	8.2	5.7	3.6	3.0	2.0	2.0	6%	39%
	PM_{10}	4.6	10.8	9.1	7.7	6.0	4.9	2.5	2.0	2%	15%

Table 3-4 Intermittent Particulate Matter Monitoring Stations in Kamloops

Station Name	Parameter	Location (UTM Zone 10)		Elevation	Sampling Dates		24-h Samples	
		(m N)	(m E)	(m asl)	Start	End	Possible	Collected
Dunes	$PM_{2.5}$	5628597.58	687591.27	353	3-Feb-04	26-Aug-05	96	86
Mission Flats	$PM_{2.5}$	5617741.12	686756.80	354	4-Jan-12	31-Aug-12	129	116
Federal Building	$PM_{2.5}$	5617046.00	688358.00	362	1-Oct-05	19-Dec-06	75	66
Dalhousie Drive	$PM_{2.5}$	5615994.03	686337.14	542	12-Apr-07	10-Oct-09	153	140
Wildlife Park	$PM_{2.5}$	5615520.76	706554.30	355	1-Oct-05	27-Nov-09	254	221
New Gold	$PM_{2.5}$	5615113.34	676718.70	684	9-Feb-12	30-Jan-15	121	117
	PM_{10}	5615113.34	676718.70	684	9-Feb-12	30-Jan-15	121	115
Pacific Way	$PM_{2.5}$	5613791.00	685753.00	747	3-Feb-04	26-Aug-05	96	90
Strande Ranch	PM_{10}	5612543.82	675045.18	739	3-Jun-13	29-May-14	61	53
Goose Lake	$PM_{2.5}$	5607270.96	683968.26	975	3-May-12	28-May-13	66	62
	PM_{10}	5607270.96	683968.26	975	3-Jun-13	29-May-14	61	60

Site-specific monitoring of dustfall was undertaken on behalf of KGHM. Knight-Piesold (2012) established 13 dustfall monitoring stations in August 2007 around the old Afton mine site. Dustfall samples were collected monthly between August 2007 and September 2008, after which quarterly sampling was initiated, lasting until October of 2009. Seven of the dustfall stations were then relocated to characterize baseline conditions surrounding the proposed project footprint. Sampling frequency returned to monthly at that time.

The background rate of deposition of Dustfall in Kamloops is presented in Table 3-5. Table 3-6 lists the station locations and date ranges of data collection. Figure 3-1 also illustrates the locations of both the background dustfall monitoring locations

At these sites, total dustfall and 33 metals were measured and the deposition rate ($mg/dm^2/day$) determined. These data were analyzed by Knight-Piesold (2012), and provided to Stantec. These data were re-analyzed by Stantec to establish a background value for dustfall for the region. These values range from an average of 0.119 $mg/dm^2/day$ (Calcium) to 0.0000006430 $mg/dm^2/day$ (Silver).

For the Human Health and Ecological Risk assessment (HHERA) background metals deposition rates will be added to the Base Case metals deposition rates. These are derived from the average of the 33 metals measured coincident with the Dustfall figure cited in Table 3-5.

Table 3-5 Background Rate of Deposition of Dustfall

Substance	Averaging Period	Background Concentration
Dustfall ($mg/dm^2/day$) [a]	30 day	0.8
NOTE: [a] The 30-day dustfall deposition rate is the average of 276 measurements collected at 13 sites on or near the proposed mine for the period from August, 2007 to August 2012 (5-years).		

For the Human Health and Ecological Risk assessment (HHERA) it will be assumed that the metals profile in the suspended PM is identical to that in the dustfall (DF). Background metals in suspended PM will calculated based on their relative abundance in DF and added to the predicted Base Case suspended PM metals concentrations.

Table 3-6 Stations Employed to Calculate the Deposition of Dustfall in Kamloops

Stations	Date Range		Location (UTM Zone 10)		Elevation
	Start	End	(m E)	(m N)	(m asl)
DFS 10-01	11/6/2010	8/27/2012	680329.03	5609293.03	913
DFS 10-02	11/6/2010	8/27/2012	678601.99	5611558.05	822
DFS 10-03	11/6/2010	8/27/2012	679754.97	5612765.99	964
DFS 10-04	11/6/2010	8/27/2012	682409.99	5612677.03	955
DFS 10-06	11/6/2010	8/27/2012	683903.99	5610252.05	942
DFS 10-07	11/6/2010	8/27/2012	687504.02	5610854.05	978
DFS 3 EAST	8/27/2007	10/6/2010	680922.00	5610344.05	865
DFS 3 WEST	8/27/2007	10/6/2010	680683.00	5610459.02	855
DFS 4 EAST	8/27/2007	10/6/2010	682676.98	5610242.98	909
DFS 4 WEST	8/27/2007	10/6/2010	682468.02	5610173.03	903
DFS 5 EAST	8/27/2007	10/6/2010	683813.01	5609302.05	896
DFS 5 WEST	8/27/2007	10/6/2010	683512.02	5609523.03	921
DFS 6 WEST	8/27/2007	10/6/2010	683550.99	5608854.98	898

3.1.2 Measured Global / Regional Background

As discussed in Section 3.1 a measured global / regional background concentration will be added to the predicted Base Case concentrations. Since only those sources in the CALPUFF modelling domain are being modelled in the Base Case, background based on a low percentile of continuously monitored gases and particulate matter in Kamloops will be added. This will conservatively account for the global and regional background – substances that are already in the air when it enters the CALPUFF modelling domain.

Table 3-7 presents global / regional background values based upon continuous gas and particulate matter measurements taken at three permanent Kamloops air quality monitoring stations. Background values are listed only for averaging intervals employed in ambient air quality objectives (Table 3-8). Generally the 1 hour values are 50th percentile measured, the 24-hour values are the 25th percentile measured, and the annual values are the 10th percentile minimum measured 24-hour concentrations.

Table 3-7 Global / Regional Background Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

Substance	Averaging Period	Background Concentration
TSP (µg/m³) [a] Kamloops Federal	24-hours	**25.4**
	Annual	**20**
PM_{10} (µg/m³) [b] Brocklehurst	24-hours	**9.6**
$PM_{2.5}$ (µg/m³) [c] Brocklehurst R&P TEOM	24-hours	2.7
	Annual	1.8
$PM_{2.5}$ (µg/m³) [d] Brocklehurst BAM	24-hours	2.8
	Annual	1.8
$PM_{2.5}$ (µg/m³) [e] Kamloops Federal BAM	24-hours	**5.3**
	Annual	**3.8**
$PM_{2.5}$ (µg/m³) [f] Kamloops Fire Station #2 BAM	24-hours	4.3
	Annual	3.1
SO_2 (µg/m³) [g] Kamloops Federal	1-hour	**1.5**
	3-hour	**1.5**
	24-hours	**1.3**
	Annual	**0.9**
NO_2 (µg/m³) [h] Brocklehurst	1-hour	**15.3**
	24-hours	**10.8**
	Annual	**7.0**
CO (µg/m³) [i] Brocklehurst	1-hour	**208**
	8-hours	**150**

NOTES:

Values in **boldface** identify the selected concentration added to Base Case results in Tables and isopleth maps.

The Global/Regional rate of dustfall deposition is conservatively assumed to be equal to the Background rate of dustfall deposition depicted in Table 3-5.

Table 3-7 Global / Regional Background Concentrations of Continuously Monitored Gases and Particulate Matter in Kamloops

NOTES:

[a] For TSP the 24-hour background value is the 5-year average 25th percentile measured concentration. The annual value is the 5-year average measured 10th percentile 24-hour concentration. All values are for the period from January 1, 1994 to December 31, 1998, measured at the Kamloops Federal Building monitoring station.

[b] For PM_{10} the 24-hour background values are the average 25th percentile measured 24-hour concentrations. All values are for the period from January 1, 1994 to June 18, 2009, measured at the Kamloops Brocklehurst monitoring station.

[c] For $PM_{2.5}$ (TEOM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 1998 to June 5, 2011, measured at the Kamloops Brocklehurst monitoring station with an R&P TEOM Instrument.

[d] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Brocklehurst monitoring station with a BAM 1020 Instrument.

[e] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2011 to December 31, 2014, measured at the Kamloops Federal Building monitoring station with a BAM 1020 Instrument.

[f] For $PM_{2.5}$ (BAM) the 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from June 27, 2011 to December 31, 2013, measured at the Kamloops Fire Station #2 monitoring station with a BAM 1020 Instrument.

[g] For SO_2 the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 3-hour background value is equal to the 1-hour value. The 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 2010 to December 31, 2013, measured at the Kamloops Federal Building monitoring station.

[h] For NO_2 the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 24-hour background values are the average 25th percentile measured 24-hour concentrations. The annual background values are the average 10th percentile measured 24-hour concentrations. All values are for the period from January 1, 1998 to May 29, 2011, measured at the Kamloops Brocklehurst monitoring station.

[i] For CO the 1-hour background values are the average 50th percentile measured 1-hour concentrations. The 8-hour background values are the average 25th percentile measured 8-hour concentrations. These values are for the period from January 1, 1998 to May 30, 2011, measured at the Kamloops Brocklehurst monitoring station.

The sources for these data are spreadsheet summaries developed and distributed by the BC MOE annually (BCMOE 2013b). Raw data are also available at http://envistaweb.env.gov.bc.ca/.

3.2 APPLICABLE AMBIENT AIR QUALITY OBJECTIVES

3.2.1 British Columbia and Canadian AAQO

The effect of the Project on air quality is determined in part by comparing predicted concentrations to the applicable ambient air quality objectives that have been established to protect human health and the environment.

The province of BC uses a suite of ambient air quality criteria that have been developed provincially and nationally to inform decisions on the management of air contaminants. These include Provincial Air Quality Objectives (AQOs), the former Pollution Control Objectives (PCOs), National Ambient Air Quality Objectives (NAAQOs) and Canadian Ambient Air Quality Standards (CAAQS) (BC MOE, 2014).

The Canada (Federal) and BC Ambient Air Quality Objectives (AAQO) are shown in Table 3-6. The Canada objectives are denoted as Desirable, Acceptable and Tolerable. The BC objectives are denoted as Levels A, B and C. Note that the Canada and BC AAQO for some substances are very similar.

The Canada AAQOs are defined as follows:

- The **Maximum Desirable Level** is the long-term goal for air quality and provides a basis for anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.
- The **Maximum Acceptable Level** is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.
- The **Maximum Tolerable Level** denotes time- based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population.

The BC AAQOs are defined as follows:

- **Level A** is set as the objective for new and proposed discharges and, within the limits of best practicable technology, to existing discharges by planned staged improvements for these operations.
- **Level B** is set as the intermediate objective for all existing discharges to meet within a period of time specified by the Director (BC MOE), and as an immediate objective for existing discharges which may be increasing in quantity or altered in quality as a result of process expansion or modification.
- **Level C** is set as the immediate objective for all existing chemical and petroleum industries to reach within a minimum technically feasible period of time.

In 1979 BC established pollution control objectives (PCOs) for the mining, smelting, and related industries (BC MOE 1979). Table 3-8 lists objectives for dustfall that are derived from this document. It specifies a range in values that have been portrayed as Level A and Level B. While the PCOs themselves have been rescinded the dustfall objectives continue to be employed.

In 1995, BC established an Interim Level B 24-hour Objective for PM_{10} of 50 $\mu g/m^3$ (BC MOE 2006). In 2009 BC adopted AAQO for respirable particulate matter ($PM_{2.5}$) set at 25 $\mu g/m^3$ for a 24-hour averaging period (as a 98th percentile value over one year) and 8 $\mu g/m^3$ for the annual averaging period (BCMOE 2014). BC also listed a planning goal of 6 $\mu g/m^3$ for the annual averaging period. The status of this goal is uncertain given recent changes in $PM_{2.5}$ measurement methodologies, and the uncertainty surrounding historical $PM_{2.5}$ measurements. For the purposes of this assessment, the planning goal will not be considered.

The CAAQS for 2015 and 2020 were adopted by the Canadian Council of Ministers of the Environment (Environment Canada 2013). The new CAAQS replace the Canada-Wide Standards for $PM_{2.5}$ and ozone (O_3). A review of the 2020 CAAQS is expected in 2015.

It is important to note that the original Canada-wide Standards (CWS) were not intended to be used as a standard for predicted concentrations at facility fencelines (CASA 2003). They are intended to be employed as a means of determining potential health effects in a large census metropolitan area (population >100,000). As such, the stations to which the CWS were applied were intended to be representative of the community as a whole. These stations are carefully selected to be free of interference from nearby sources such as highways or industrial facilities (CCME 2000).

It is expected that this same principle applies to the CAAQS. This caveat applies to all objectives and standards to some extent. At a location where predicted concentrations exceed an objective or standard, there needs be a receptor (e.g. resident population, sensitive ecosystem) capable of being affected by that substance for an adverse effect to occur.

Table 3-8 Provincial and Federal Ambient Air Quality Objectives and Standards

Substance (Units)	Averaging Period	Provincial (BC) AAQO			National (Canada) NAAQO & CAAQS [c d]		
		Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable
Dustfall (mg/dm²/day)	24-hour	**1.7** [e]	2.9 [e]	- -	- -	- -	- -
TSP (µg/m³)	24-hour	**120**	200	260	- -	120	400
	Annual	**60**	70	75	60	70	- -
PM_{10} (µg/m³)	24-hour	- -	**50**	- -	- -	- -	- -
$PM_{2.5}$ (µg/m³)	24-hour	**25** [a]			28 (27) [b]		
	Annual	**8** [a]			10 (8.8) [c]		
SO_2 (µg/m³)	1-hour	**200** [f]			**450**	900	- -
	24-hour [h]	- -			**150**	300	800
	Annual [h]	- -			**30**	60	- -
NO_2 (µg/m³)	1-hour	**188** [g]			- -	**400**	1,000
	24-hour [h]	- -			- -	**200**	300
	Annual	**60**			60	100	- -
CO (µg/m³)	1-hour	**14,300**	28,000	35,000	15,000	35,000	- -
	8-hour	**5,500**	11,000	14,300	6,000	15,000	20,000

Table 3-8 Provincial and Federal Ambient Air Quality Objectives and Standards

Substance (Units)	Averaging Period	Provincial (BC) AAQO			National (Canada) NAAQO & CAAQS [c d]		
		Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable

NOTES:

[a] The $PM_{2.5}$ 24-hour average is based on the 98th percentile value for one year.

[b] The CAAQS for 24-hour $PM_{2.5}$ is referenced to the annual 98th percentile of daily 24-hour average concentrations, averaged over three years. The first CAAQS is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).

[c] The CAAQS for annual $PM_{2.5}$ is referenced to the 3-year mean of annual average concentrations. The first CAAQS shown is the standard effective in 2015; the new standard proposed for 2020 is given in brackets (Environment Canada 2013).

[d] National Ambient Air Quality Objectives, or NAAQO, summarized in (CCME 1999).

[e] BC MOE 1979 Pollution Control Objectives for the Mining, Smelting, and Related Industries (BC MOE 1979). As the dustfall Objective is a daily rate referenced to a 30 day sampling interval, the Objective is referenced to the monthly averaging interval, not the daily.

[f] Achievement is based on the annual 99th percentile of daily 1-hour maxima, averaged over one year. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 99th percentile (the fourth highest) of those 365 values.

[g] Achievement is based on the annual 98th percentile of daily 1-hour maxima, averaged over one year. This requires the extraction of the highest predicted 1-hour value at each location for each day, followed by the calculation of the 98th percentile (the eighth highest) of those 365 values.

[h] The BC MOE has not specified objectives for the 24-hour intervals for SO_2 or NO_2, nor has it specified an annual average objective for NO_2.

- - Indicates no applicable objective or standard specified for this Jurisdiction

Values in **boldface** identify the most stringent objectives adopted to evaluate the Project.

3.2.2 $PM_{2.5}$ Criteria from Other Jurisdictions

While not strictly applicable, goals, objectives or standards (criteria) from other jurisdictions are often raised as a counterpoint to those that are applicable. For $PM_{2.5}$ criteria from selected jurisdictions are presented in this section. These will not be considered in the assessment, but are presented for information purposes only. Table 3-9 lists criteria from the US Environmental Protection Agency (US EPA), the World Health Organization (WHO), and the European Commission (EC).

Table 3-9 $PM_{2.5}$ Criteria from Other Jurisdictions

Jurisdiction	Averaging Period	Criteria ($\mu g/m^3$)
US EPA	24-hour [a]	35.0
	Annual [b]	15.0
	Annual [c]	12.0
WHO	24-hour [d]	25
	Annual [e]	10
EU	Annual [f]	25
	Annual [g]	20

NOTES:

[a] The U.S. EPA Primary Standard for 24-hour $PM_{2.5}$ was brought into existence in 2006. An area meets the 24-hour standard if the 98th percentile of 24-hour $PM_{2.5}$ concentrations in one year, averaged over three years, is less than or equal to 35 $\mu g/m^3$.

[b] The U.S. EPA Primary Standard for annual average $PM_{2.5}$ was brought into existence in 1997. An area will meet the standard if the three-year average of its annual average $PM_{2.5}$ concentration (at each monitoring site in the area) is less than or equal to 15.0 $\mu g/m^3$.

[c] The revised U.S. EPA Primary Standard for annual average $PM_{2.5}$ was brought into existence in 2012. An area will meet the standard if the three-year average of its annual average $PM_{2.5}$ concentration (at each monitoring site in the area) is less than or equal to 12.0 $\mu g/m^3$.

[d] The WHO air quality guideline for $PM_{2.5}$ for the 24-hour average was updated in 2005. Achievement is determined based on the 99th percentile of the daily value (three 24-hour exceedances per year allowed). In addition to the guideline the WHO offer three interim targets (IT-1; IT-2; IT-3) that are 35, 25, and 15 $\mu g/m^3$ respectively.

[e] The WHO air quality guideline for $PM_{2.5}$ for the annual average was updated in 2005. In addition to the guideline the WHO offer three interim targets (IT-1; IT02; IT03) that are 75, 50, and 37.5 $\mu g/m^3$ respectively. In addition to the guideline the WHO offer three interim targets (IT-1; IT-2; IT0-) that are 75, 50, and 37.5 $\mu g/m^3$ respectively.

[f] The EU Annual Standard for $PM_{2.5}$ entered into force on 01-Jan-2010.

[g] The EU Annual Limit Value for $PM_{2.5}$ becomes legally binding in 2015. Achievement is determined based on a three-year average of the annual average for 2013, 2014, and 2015.

SOURCES: US EPA 2012; WHO 2005, EC 2000

4.0 MODELLING METHODOLOGY

4.1 SELECTED MODELS

As per Section 2.3.2.3 of the *Guidelines* (BC MOE 2008), the following models and versions will be used:

- CALPUFF version 6.112, an air quality dispersion model
- CALMET version 5.8, a diagnostic 3-dimensional meteorological model

These versions were selected because previous work and test runs have determined that CALPUFF v 6.112 is most compatible with CALMET v 5.8.

Non-guideline models or beta-test versions are not planned for use in this Project. There are no modifications to any of the models planned. More details on CALMET are provided in Sub-Section 4.3.

4.2 CALPUFF DISPERSION MODELLING

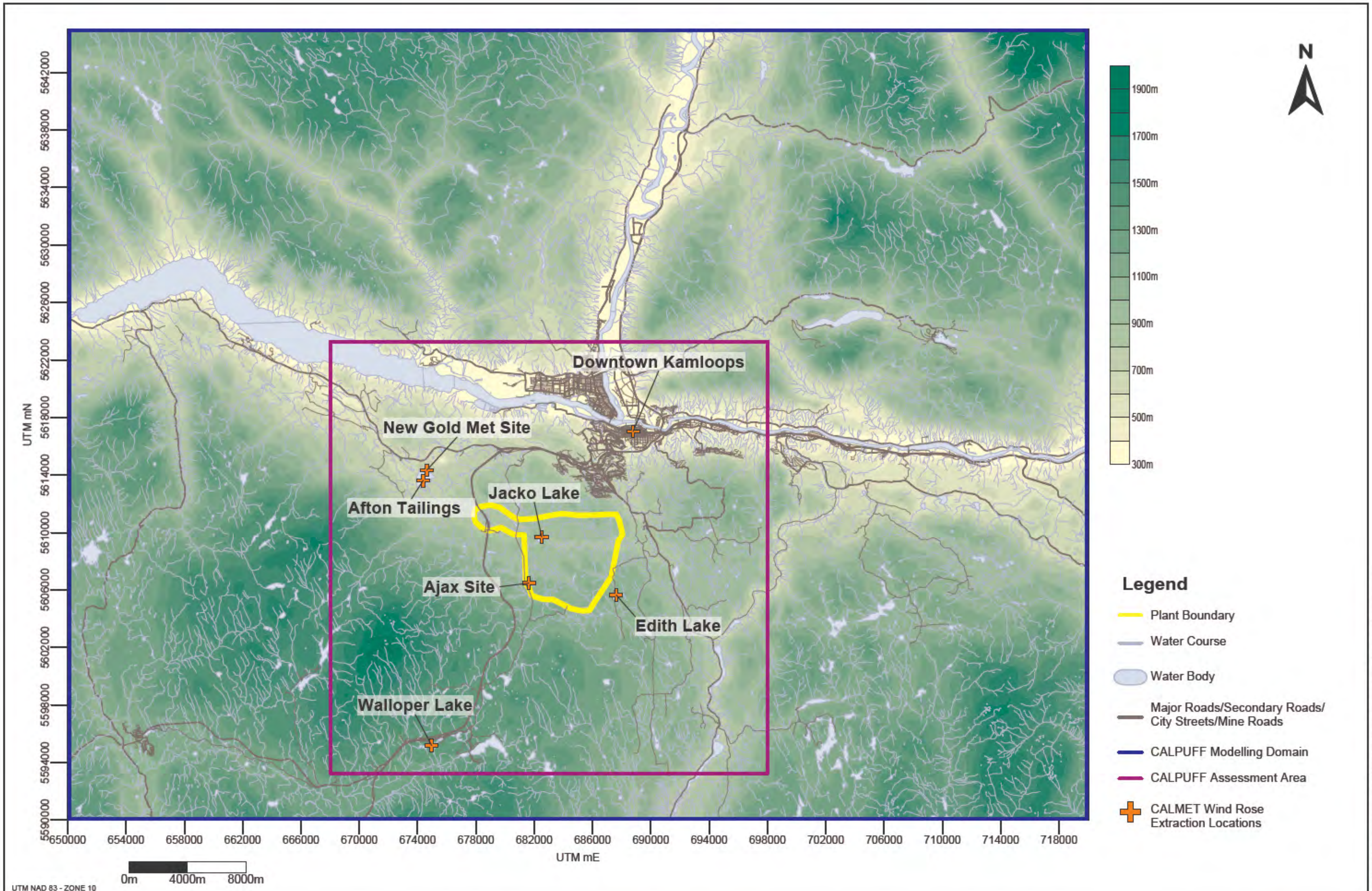
4.2.1 CALPUFF Domain and Receptor Grids for Modelling Substances of Interest

For this assessment a CALPUFF *modelling domain* 70 km (W-E) by 55 km (N-S) and centered on the Project site will be employed to capture all values of interest as per the *Guidelines* (BC MOE 2008; Sub-Section 6.1). All predicted concentrations greater than 10% of the applicable AAQOs will fall within this domain.

From the CALPUFF *modelling domain* a CALPUFF *assessment area* will be depicted in Figures. The CALPUFF assessment area will be 30 km x 30 km square, centered on the Project site (Figure 4-1). It will encompasses the Projects predicted effects and depict them in sufficient detail to illustrate important feature. If necessary, Figures will be prepared at a larger scale to depict finer details.

The CALPUFF *assessment area* includes most of the City of Kamloops excepting the Westsyde and Rayleigh developments in the North Thompson valley. These areas are included in the CALPUFF modelling domain, and information in them can be extracted and reported if necessary.

Figure 4-2 shows features of the operational site plan within the plant boundary. The yellow line encompassing all mine features is the plant boundary. The extents of the domain are defined by the center and four corners shown in Table 4-1.



KGHM Ajax Air Quality Assessment
Detailed Model Plan

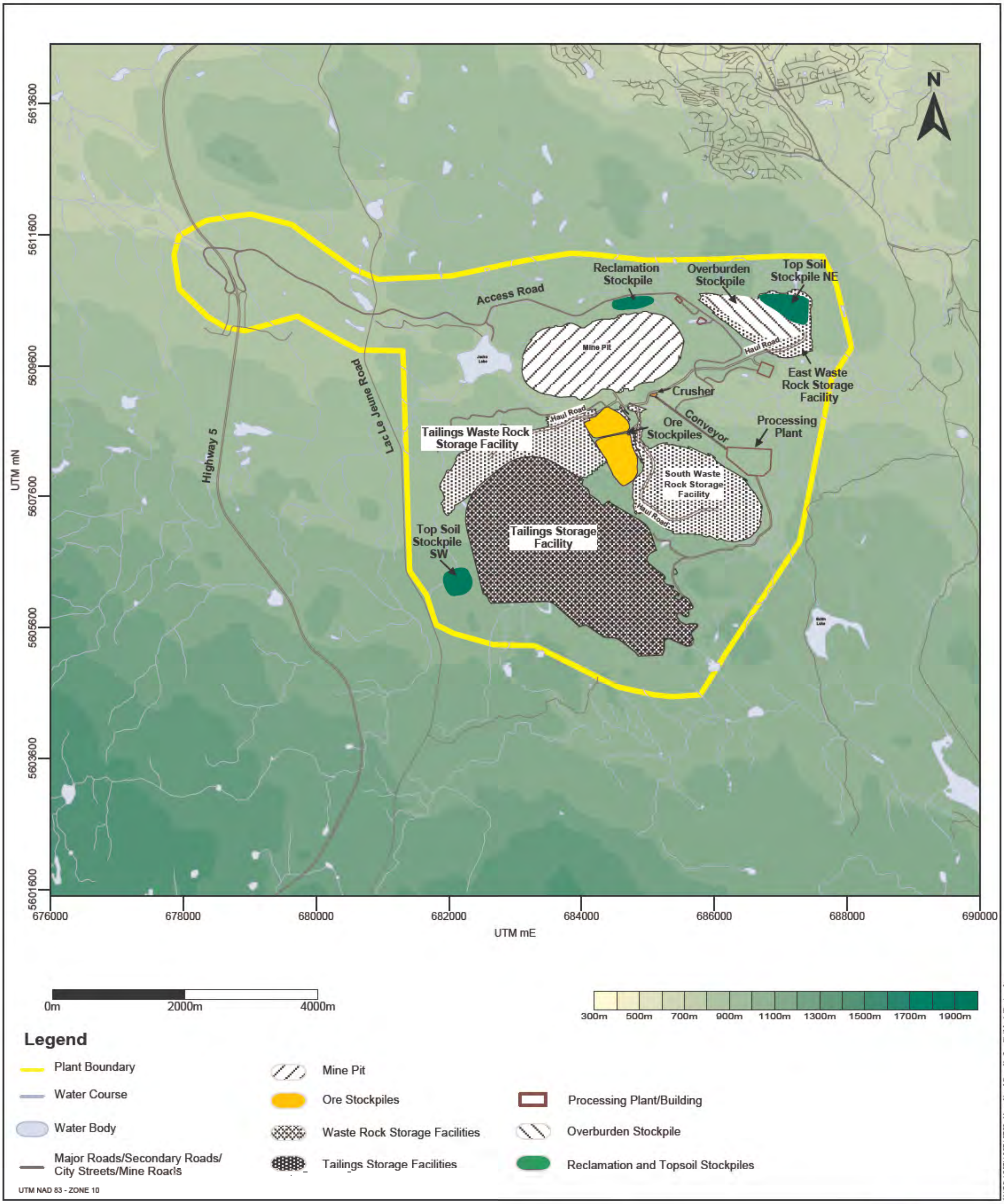
CALPUFF Modelling Domain, Assessment Area, and Wind Rose Extraction Locations

PREPARED BY Stantec

PREPARED FOR KGHM Ajax Mining Inc.

FIGURE NO. 4-1

Last Modified: 02/27/2015 By: kwells



KGHM Ajax Air Quality Assessment
Detailed Model Plan

Proposed Mine Features (End of Mine Life)

PREPARED BY
Stantec

PREPARED FOR
KGHM Ajax

FIGURE NO.
4-2

U:\PC 1235\123510782_New Ajax Mine Air Quality\Modelling\surfer
Last Modified: 02/27/2015 By: kwells

Table 4-1 Extents of CALPUFF Modelling Domain (30 km x 30 km)

CALPUFF Domain location	m East	m North	UTM Zone
CENTER	683000	5608250	10
SW Corner	668000	5593250	10
NW Corner	668000	5623250	10
NE Corner	698000	5623250	10
SE Corner	698000	5593250	10

Within this domain, calculations of ground-level air contaminant concentrations will be made using a series of nested Cartesian grids with increasing receptor density with increasing proximity to the Plant boundary. Receptors are included both inside and outside the Plant boundary (Sub-Section 4.2.2). The receptor grids and their corresponding spacing for each site are as follows:

4.2.1.1 Within the plant boundary:

- 100 m spacing within the Plant boundary

4.2.1.2 On and outside the plant boundary

- 20 m spacing along the plant boundary
- 50 m spacing within 500 m of Project sources
- 250 m spacing within 2,000 m of Project sources
- 500 m spacing within 5,000 m of Project sources
- 1,000 m spacing for the remainder of the 30 km by 30 km domain (the area in excess of 5,000 m from Project sources)

There are 14,656 receptors in the full receptor grid. A special 1 km x 1 km receptor grid for the human health discipline includes 841 receptors. Inside the plant boundary there are 4,316 receptors. There are also 209 special receptors (see Subsection 4.2.3).

Actual terrain elevations based on the Canadian Digital Elevation Data (CDED) will be applied to all receptors used in dispersion modelling.

4.2.2 Plant Boundary

The plant boundary, as defined in Section 6.3 of the *Guidelines* (BC MOE 2008) is a line of receptors that demarcates the areas governed by public versus worker exposure criteria. Often the highest predicted offsite concentrations and/or deposition rates are on the plant boundary. Within the plant boundary, meeting occupational health and safety criteria are of primary importance. BC AAQO are often applied to areas where there is public access (e.g. on and outside the plant boundary). Section 6.3 of the *Guidelines* (BC MOE 2008) describes the criteria used to determine the Plant boundary.

Setting the plant boundary for a mine is more subjective than for a fenced facility such as a pulp mill. In the instance of a fenced mill, the facility fenceline defines where public access is restricted. Mines are not generally fenced; however public access is often discouraged or prohibited due to safety concerns. The plant boundary is based on the guidance in Section 6.3 of the *Guidelines* (BC MOE 2008). Specifically, the plant boundary is defined by:

- the perimeter of disturbed area that defines where public access is restricted
- the perimeter along a road allowance if a public access road passes through the plant

The west plant boundary is defined by the road allowance of Lac Le Jeune Road except where the access road joins Highway 5. The southern and eastern plant boundaries are defined as the perimeter of the mines existing and proposed disturbed area. Generally this includes a buffer of approximately 500 m from the edge of features that include the mine pit, waste rock storage facilities, ore stockpiles, tailings impoundment, and access road.

The area inside the plant boundary is covered by a grid of receptors with 100 m spacing, except over Jacko Lake where the receptor spacing is 50 m. The Goose Lake road will be terminated at the southern and eastern edges of the plant boundary.

4.2.3 Special Receptor for Modelling Metals and other Chemical Species

Sub-Section 2.2 distinguishes between substances of interest (SOI) that are modeled at the gridded receptors in the CALPUFF modelling domain and contaminants of concern (COCs) that are only modeled at discrete 'special receptors'. This is done to produce output suitable for the HHERA and at the same time reducing the computational load. The Toxicologists performing the HHERA only require deposition or air contaminant concentration data at selected locations. In a study of this magnitude there are typically tens of thousands of receptors in a full dispersion modelling domain and less than 100 discrete 'special receptors'.

Special receptors are locations of human and ecological importance: sensitive ecosystems (e.g. a lake), nearby homes, and places frequented by sensitive sub-populations of the community (e.g. children, the elderly, and those under medical care). These later locations include schools, medical treatment facilities, daycare facilities, and retirement homes.

The deposition and air contaminant concentration data for the point of maximum impingement will also be predicted for the HHERA; the logic being that ecological receptors or sensitive populations may also be present at that location, despite being unanticipated.

Stantec prepared a list of 209 special receptors for modelling metals and other chemical species. They include 21 nearby residences (also designated as noise receptors), the Royal Inland Hospital, 21 elementary schools, 6 secondary schools, and 110 daycare facilities, 23 retirement homes, 3 miscellaneous receptors, 11 air quality monitoring stations, and 13 dustfall monitoring stations. They are listed in Table A-1 (**Appendix A**).

Figure 4-3 illustrates the locations of the various special receptors. Labels are not added owing to the density of special receptors. There are also 841 HHERA special receptors on a 1 km x 1 km grid across the 30 km x 30 km domain (31 x 31 receptors = 961 – 120 receptors on the domain border = 841). These receptors are not listed or depicted in a Figure.

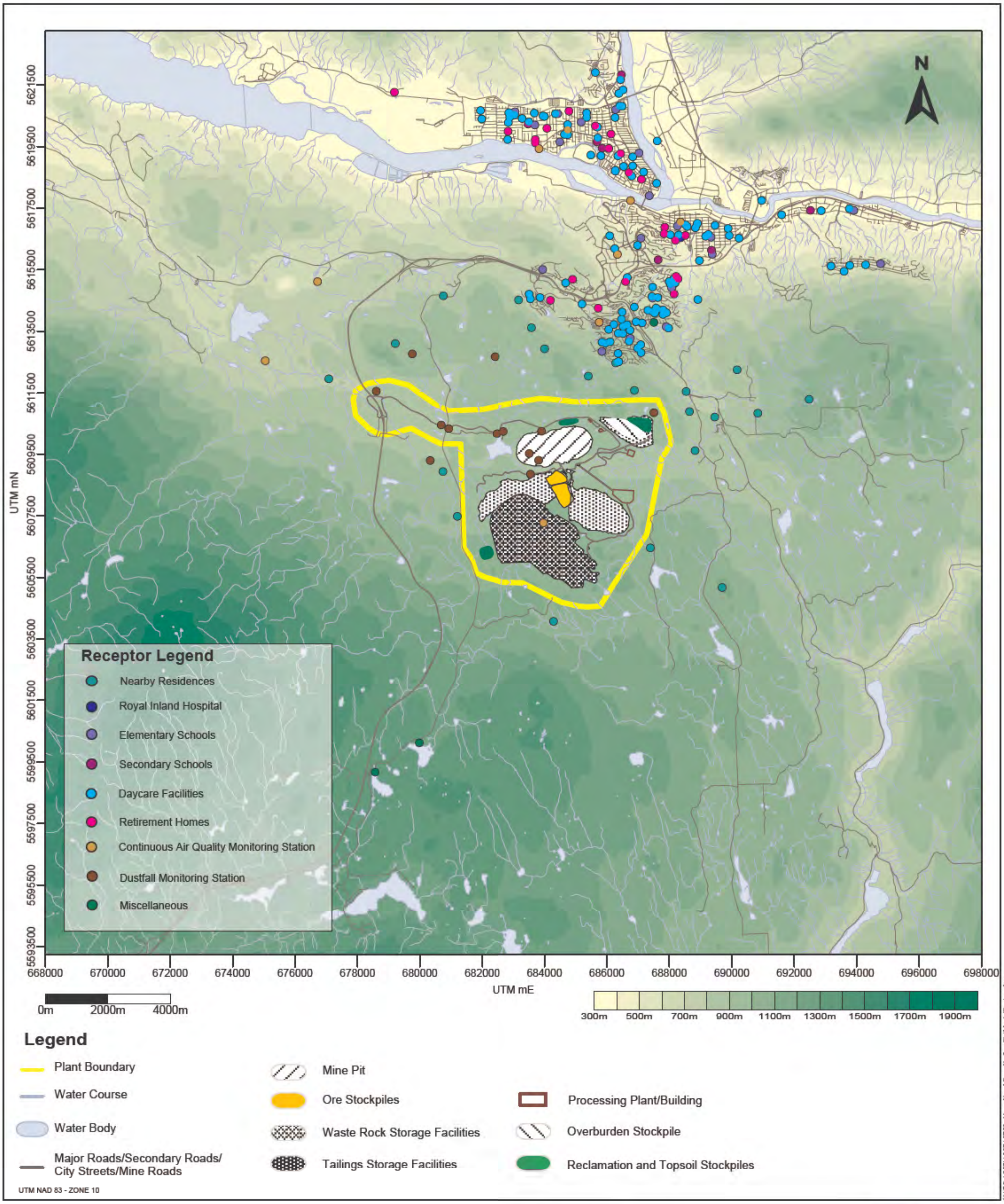
Workplaces, office and residential buildings, shopping centers, arenas, and other places frequented by Kamloops residents are not listed as special receptors. Thompson Rivers University (TRU) is not designated a special receptor as the students and staff are not considered a sensitive sub-population (e.g. do not differ substantially from the general population). However, the TRU daycare is listed as a daycare facility.

4.2.4 NO to NO_2 Conversion

Guidance in Section 11.4 of the *Guidelines* (BC MOE 2008) will be followed. The conversion methods to be considered, in order, are:

- 100% conversion: If the maximum predicted NO_X concentrations are less than the ambient objective for NO_2, then the predicted results for NO_X will be reported as NO_2.
- Ambient ratio method (ARM): If the 100% conversion method results in exceedances of the applicable ambient objective for NO_2, the ARM method will be applied if adequate monitoring data are available to establish a representative NO_2/NO_X relationship over the range of NO_X concentrations.
- Ozone limiting method (OLM): If adequate monitoring data are not available to establish representative NO_2/NO_X ratios for the ARM, then OLM will be applied.

In this assessment the OLM is proposed as neither of the alternative methods are suitable. To achieve a representative depiction of the conversion of NO to NO_2 Stantec proposes to employ an hourly variable ozone concentration file based on actual ozone measurements in Kamloops for the years modelled. This is preferred to assuming ozone is always equal to the maximum hourly measured value, as suggested in the *Guidelines* (BC MOE 2008).



YT NWT BC AB Ajax USA

KGHM Ajax Air Quality Assessment
Detailed Model Plan

Special Discrete Recptors

PREPARED BY
Stantec

PREPARED FOR
KGHM Ajax

FIGURE NO.
4-3

4.2.5 Stack and Building Downwash Effects

For this operational site plan, point sources that are potentially affected by building downwash are located far from the Plant boundary and are small contributors to the overall emissions. The effect of building downwash at the nearest receptors where the applicable AAQO will be applied will have a negligible effect on the predicted concentrations and deposition values. Therefore, the building downwash option will be disabled. For the point sources CALPUFF modelling, the stack tip downwash option will be enabled.

4.3 CALMET METEOROLOGICAL MODELLING

Levelton Consultants Ltd. was retained in 2008 by BC MOE to conduct a Kamloops area CALMET modelling work which covered the three year period Jan 1 2003 through Dec 31 2005. Their report (Levelton 2008) provides detailed modelling setup and results analysis at selected locations within the CALMET domain. To better understand the model performance, quality assurance/quality control (QA/QC) was performed for the full three year CALMET dataset. This QA/QC is reported in full in Appendix D of JWA (2009).

Working with the Kamloops Area Preservation Association (KAPA), Dr. Douw Steyn prepared questions for KAPA to submit to the Ajax Environmental Assessment process (Steyn & Ainslie 2012) In the Atmospheric Modeling Methodology section Steyn & Ainslie (2012; page 3) recommend the following steps be undertaken for the atmospheric modelling:

1. Because of the complex terrain surrounding the proposed mine and city, we recommend a minimum 250 m resolution be used in the modelling.
2. The modelling domain should extend a minimum 20 km away from the proposed site in all directions.

The spatial grid resolution in the Levelton (2008) CALMET data set is 500 m. The recommended 250 m resolution was achieved by re-configuring the CALMET model and rerunning CALMET with the original MM5 data. This increased resolution allows CALMET to better resolve features such as Sugarloaf Mountain, Coal Hill, and the undulations in the terrain around the site.

The Levelton (2008) CALMET domain ends 9 km south of the mine pit. To address the second recommendation Stantec extended the domain to 19 km, more than meeting the minimum distance recommended by Steyn & Ainslie (2012). The CALPUFF domain is expected to meet the Ministry's requirement that the domain enclose all points where the predicted concentrations fall within 10% of the most stringent AAQO. For clarity of presentation only effects within the 30 km x 30 km CALPUFF *assessment area* will be depicted in the isopleth maps.

Stantec applied the CALPUFF model using three years of the CALMET data (2003, 2004, and 2005) for the HHERA (Section 2.2.2). A coarse 1 km x 1 km receptor grid was employed plus all of the special receptors (Section 4.2.3). This work revealed that 2003 is the year when nearly all of the off-site maximum predicted concentrations occur (14 of 15 possible pairings of parameters and averaging intervals). The one maxima that does not occur in 2003 differs from the 2003 maxima by +3%. Given this finding it has been proposed to the BC MOE that the air quality assessment focus only on the year 2003. This approach is consistent with the approach taken in the 2012 Domtar CALPUFF Assessment (JWA 2009) and has been approved in principal by the BC MOE (Adams 2012). The HHERA will continue to employ the three-year CALPUFF output, focusing on the maximum predicted concentrations and deposition rates for that interval.

It was discovered that in 2003 the Walloper Station precipitation data shows daily quantities for the first half of that year up to 10 times the other meteorological sites for the same time period. Given this could potentially over-represent precipitation in the project area and potentially biasing the modelling Stantec developed a new CALMET data set excluding the Walloper Station precipitation data, and ran a test by re-modelling construction emissions for 2003 at all special receptors.

The resulting predictions show a small increase in PM concentrations (0.1% to 1.0%), while dustfall deposition largely remains unchanged. This is a small change, and perhaps indicates that the Walloper meteorological data has only a small influence over precipitation depicted in the CALMET data set near the Project. The Walloper station is 10.7 km southwest of the mine pit. Stantec will use the new 2003 CALMET data set with the Walloper Station precipitation data excluded.

4.3.1 CALMET Domains

The CALMET domain used for this project is summarized below in Table 4-2. For a graphical representation of the 3,850 km^2 area, refer to Figure 4-4.

Table 4-2 Map Projections and Horizontal Grid Parameters for CALMET Domain

Parameter	Value
Map Projection	UTM
UTM Zone	10
Datum	NAR-C
Number of Grid Cells (nx,ny)	280,220
SW Corner (Easting,Northing)	650 km, 5590 km
Grid Spacing	250 m

The CALMET domain extents are presented in Table 4-3. It is the same size as the CALPUFF domain (Figure 4-1). Within the CALMET domain, a resolution of 250 m was used. Ten vertical levels were used to model the atmosphere up to a maximum cell face height of 3,000 m above ground-level. Cell mid-points were chosen at heights of 10, 30, 60, 120, 230, 400, 750, 1,250, 1,750 and 2,500 m above ground to allow for higher resolution in the layers nearest to the earth's surface than in the levels aloft.

Indicated also on this figure are six locations where CALMET winds were extracted for QA/QC proposes (cited in Sub-Section 4.3.4)

Table 4-3 Extents of CALMET Domain

CALMET Domain location	m East	m North	UTM Zone
CENTER	685000	5617500	10
SW Corner	650000	5590000	10
NW Corner	650000	5645000	10
NE Corner	720000	5645000	10
SE Corner	720000	5590000	10

4.3.2 Land Use Categories

For this revised CALMET data set, the North American land-cover data (CEC 2010) was used to initialize land use categories in the CALMET model. The 2005 North American land-cover dataset was produced as part of the North American Land Change Monitoring System (NALCMS), a trilateral effort between the Canada Centre for Remote Sensing, the United States Geological Survey, and three Mexican organizations including the National Institute of Statistics and Geography, National Commission for the Knowledge and Use of the Biodiversity, and the National Forestry Commission of Mexico.

This newer land-cover dataset represents most of new technology and innovative approaches in last decade. Also using a newer land-cover data makes possible to capture those changes attributed to forest fires, insect infestation, urban sprawl and other natural or human-caused events.

The 2005 North American land-cover dataset is at a resolution of 250 m, consistent with that of the CALMET receptor grid spacing. This land-cover information was then converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor.

Stantec used four GEO.DAT files with seasonal values for surface roughness (z_0), albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and leaf area index (LAI) as defined in the *Guidelines* (BC MOE 2008) and the CALMET User Guide (Scire et al. 2000).

The CALMET Appendix in the Air Quality Technical Data Report will include a detailed description and a table showing how the North American land-cover data was converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor.

4.3.3 CALMET Meteorological Inputs

The CALMET model requires the input of surface and upper air meteorological fields. For this application, Levelton (2008) refined the CALMET first guess wind field using with surface station information from four surface weather stations in the CALMET domain and with upper air data from the MM5 meteorological model. While this model initialization approach allows for a more accurate depiction of mesoscale wind circulations in the layers aloft than would be provided by using Kelowna Airport radiosonde data, it simultaneously permits data from surface weather stations to provide valuable localized information and correct the biases that MM5 prognostic data often exhibits in the lower layers.

Hourly output from the MM5 model at 12 km resolution was provided for Levelton use by the BC MOE. These data were prepared for use in CALMET by using the CALMM5 pre-processor. Observed hourly-average meteorological data from surface stations during the modelling period were provided by Environment Canada (EC), British Columbia Ministry of the Environment (BC MOE), BC Forest Service (BCFS) and BC Ministry of transportation (BC MOT). Table 4-4 provides a summary of the surface stations used.

Table 4-4 Input Surface Meteorological Stations

Station Name	Type	UTM Zone 10		Elevation (m asl)	Surface Input Data Used
		m East	M North		
Kamloops Airport	EC	680778	5619591	345	Wind Speed & Direction, Temperature, Relative Humidity, Cloud Cover & Ceiling Height, Station Pressure, Precipitation
Kamloops Brocklehurst	MOE	683828	5619419	347	Wind Speed & Direction, Temperature, Relative Humidity
Afton	BCFS	677937	5616525	780	Wind Speed & Direction, Temperature, Relative Humidity, precipitation
Walloper	MOT	678720	5600444	1,300	Wind Speed & Direction, Temperature, Relative Humidity, Station Pressure, Precipitation* (*see Section 4.4 above)

The EC weather station at the Kamloops Airport contained the data necessary to initialize CALMET over the period of interest. Thus, the Kamloops Airport Station was the primary surface weather data input into the model, while the other three stations were used to provide additional weather information near the site location whenever possible.

In addition to hourly surface data, hourly precipitation data at the Kamloops Airport and Afton stations and upper air data from the nearest station (i.e. Kelowna Airport) were used in CALMET modelling.

4.3.4 Quality Assurance of New CALMET Meteorological Input Data

As a supplement to QA/QC performed in Levelton (2008) and JWA (2009), Stantec has subjected the rework of the Levelton (2008) CALMET to additional QA/QC. Steyn & Ainslie (2012; page 4) made a recommendation to demonstrate that the modelling realistically captures dispersion conditions in Kamloops. The recommendation suggested that the model be evaluated "against existing air quality data in the Kamloops Valley, using a known source and pollutant as a test bed". This test has been performed in the past with a known sulphur dioxide source using the Levelton (2008) 500 m resolution CALMET data (JWA 2009). To test the reworked 250 m resolution CALMET data this same source was re-run with a CALPUFF simulation. The results were compared to the original JWA (2009) results and found to be satisfactory.

Stantec's QA/QC also involved the extraction of wind speed and direction data at six locations of interest to the BC MOE (BCMOE, 2015b) for comparison between the 500 m and 250 m resolution CALMET data sets. This was accomplished through a direct comparison of wind rose diagrams and cumulative frequency histograms of both wind speeds and stability classes. Stability classes are as indicated below:

- 1 or A Extremely Unstable Conditions
- 2 or B Moderately Unstable Conditions
- 3 or C Slightly Unstable Conditions
- 4 or D Neutral Conditions (applicable to heavy overcast day or night)
- 5 or E Slightly Stable Conditions
- 6 or F Moderately Stable Conditions
- 7 or G Extremely Stable

For a location near the junction of the Lac Le Jeune and mine access roads, Figure 4-4 illustrates the wind characteristics for the old (Levelton, 2008) and the reworked CALMET data at one location (Tailings Station). Both old and reworked wind roses show predominantly southerly wind directions, with a strong tendency for the southwest direction. Winds from the northeast are nearly absent. The cumulative frequency histograms of both wind speeds and stability classes are very similar. They are also as expected, with the majority of winds in the lower wind speed classes, and predominantly D class stabilities (neutral). Wind roses depicting the remaining five locations of interest to the MOE will be presented in the CALMET Appendix of the Air Quality Technical Data Report.

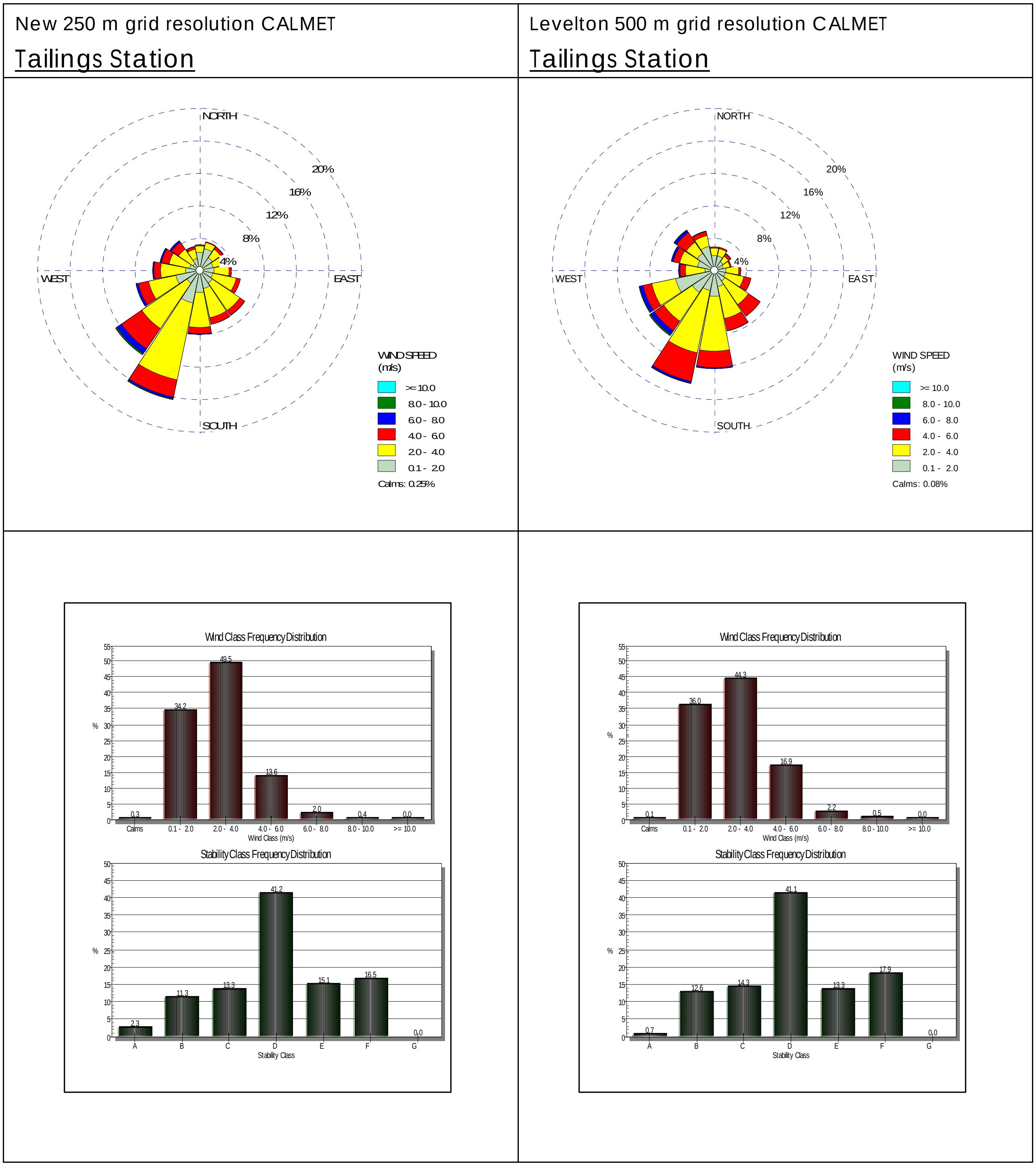


Figure 4-4 Wind Characteristics at Tailings Station: Old vs. Reworked CALMET

5.0 DATA PRESENTATION

5.1 TABLES

Maximum predicted concentrations of each substance of interest will be tabulated and compared to the AAQO. Background or reference values will not be included in the tables. The Base Case results will already include the global/regional background figures depicted in Table 3-7.

5.2 FIGURES

Air contaminant concentration data will be presented graphically for all cases without background or reference values added. Spatial distribution maps for short-term and long-term averaging period over the 30 km by 30 km CALPUFF *assessment area* will be included.

6.0 QUALITY MANAGEMENT PROGRAM

For all levels of the assessment, quality assurance and quality control procedures will be employed to confirm the accuracy of the source inputs, receptors, meteorological data, and the proper behavior of the models. Both input and output files will be subjected to rigorous examination to ensure that they are free of errors. The model output will be studied to ensure that the concentration values and geographic distribution is consistent with expectations. The general approach provided in Section 10.2.1 (BC MOE 2008) will be followed.

In addition, the standard Stantec Quality Management System will be followed in this work. This includes file and version management protocols to avoid erroneous substitution of superseded files, and a series of documented technical and senior reviews by personnel not involved in the day-to-day work on the project.

7.0 REVIEW BY REGULATORY AGENCIES

This FINAL Detailed Model Plan is the third version to be prepared for this Projects regulatory review. Each revision was necessitated by a substantial change in the mine plan and general arrangement.

The first version of the DRAFT Detailed Model Plan (the Plan) was provided to the Ajax Project Health Sub-Committee via e-mail on Monday April 30th 2012. The Sub-Committee reviewed the Plan in a Sub-Committee meeting on May 10th, 2012 and provided input in the form of a four page letter on June 19, 2012 (Interior Health, 2012). The Final Plan (Stantec, 2012) was completed and submitted to the BC MOE on Wednesday August 22, 2012. The Ministry's review of the revised Plan was completed, and the Final Plan approved on Wednesday September 12, 2012.

The second version of the Plan reflected changed modelling assumptions due to a revised mine plan and general arrangement. A revised Plan was submitted to the BC MOE on Tuesday April 30, 2013. The Revised Final Plan was sent to the BC EAO on Tuesday April 30, 2013 for distribution to the Sub-Committee. The Ministry's review of the revised Plan was completed, and the second version of the Plan (Stantec, 2013b) was approved on Wednesday May 22, 2013.

The third version of the Plan was necessitated by a second revised general arrangement and mine plan. This second revised Plan was submitted to the BC MOE on Friday October 3, 2014. This Plan was also sent to the BC EAO. The Ministry's review and approval of the revised Plan was completed on Friday February 27, 2015. The third revised Plan will be sent to the BC MOE on or before Friday March 6, 2015.

Appendix B of this plan contains selected references pertinent to the development and review of the third version of this Plan. This includes the Steyn & Ainslie (2012) letter cited in Section 4.3, the MOE's January 15, 2015 request for clarification (BCMOE, 2015a), Stantecs January 27, 2015 response to the BC MOE (Stantec, 2015), 2015b), and the BC MOE February 27, 2015 approval of the model plan. (BCMOE, 2015b)

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9.0 CLOSURE

We trust that this meets your needs at this time. If you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully Submitted,

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APPENDIX A
LISTING AND DESCRIPTION OF SPECIAL RECEPTORS FOR MODELLING METALS AND OTHER CHEMICAL SPECIES

Appendix A LISTING AND DESCRIPTION OF SPECIAL RECEPTORS FOR MODELLING METALS AND OTHER CHEMICAL SPECIES

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	No.	Name	m East	m North
Noise	1	Residence	677081	5611958
	2	Residence	679209	5613105
	3	Residence	688538	5611542
	4	Residences	688824	5609617
	5	Residence	681197	5607480
	6	Residences	687390	5606458
	7	Residence	689692	5605170
	8	Residence	684290	5604072
	9	Aberdeen Development	686283	5612470
	10	CDB1	683168	5614516
	11	CDB2	683582	5613613
	12	CDB3	684006	5612929
	13	CDB4	685402	5612040
	14	CDB5	686880	5611577
	15	New Noise21 Residence	680734	5608934
	16	New Noise22 Residence	688644	5610892
	17	New Noise23 Residences	689454	5610713
	18	New Noise24 Residence	690170	5612246
	19	New Noise25 Residence	690834	5610838
	20	New Noise26 Residence	692479	5611288
	21	New Noise27 Residences	680747	5614653
Health	22	Royal Inland Hospital	688351	5616532

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	**No.**	**Name**	**m East**	**m North**
Elementary	23	Henry Grube Education Centre	687359	5617899
	24	Twin River Education Centre	684491	5619646
	25	AE Perry Elementary	685173	5620289
	26	Aberdeen Elementary	686751	5613270
	27	Arthur Hatton Elementary	687029	5619288
	28	Beattie School of Arts, McGill Road	687090	5616521
	29	Beattie School of Arts, 9 Ave.	689372	5615998
	30	Bert Edward Science and tech School	686278	5620691
	31	Dufferin Elementary	683939	5615505
	32	George Hilliard Elementary	684423	5620563
	33	Juniper Ridge Elementary	694765	5615690
	34	Kay Bingham Elementary	683689	5620195
	35	Lloyd George Elementary	689335	5616553
	36	Marion Schilling Elementary	693910	5617421
	37	McGowan Park Elementary	687900	5613647
	38	Pacific Way Elementary	685839	5612841
	39	Parkcrest Elementary	683055	5620626
	40	South Sa-hali Elementary	688072	5614905
	41	Stuart wood Elementary	688259	5616915
	42	Summit Elementary	687462	5614575
	43	Westmount Elementary	686463	5621825
Secondary	44	Brocklehurst Secondary	683476	5620224
	45	Norkam Secondary	685679	5619650
	46	Sa-Hali Secondary	687639	5615818
	47	South Kamloops Secondary	689348	5616129
	48	Valleyview Secondary	692522	5617423
	49	Kamloops Christian School	685848	5619446
Daycare	50	Between Friends Out of School Care	688140	5615190
	51	Kiddies Korner & Fun & Learning	693769	5617478
	52	Sixth Avenue Childcare	688834	5616855
	53	Summit Childcare	688183	5615068
	54	TLC Family Daycare	685697	5620127

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	**No.**	**Name**	**m East**	**m North**
Daycare (cont'd)	55	R.M.S. Horticultural Program	685350	5620587
	56	Children's Circle Daycare Society	688297	5616626
	57	Big Adventures After School Care	686797	5618536
	58	Sandy's Family Daycare	687530	5614088
	59	Young Care	688963	5615794
	60	T.J.'S Day Care	686383	5621218
	61	Caroline's Kids Daycare	682839	5620273
	62	Little Munchkins Family Daycare	685842	5613144
	63	Play And Learn Child Care	687129	5613770
	64	Cactus Kidz Play Care	687442	5614623
	65	Chris Rose Therapy Centre for Autism	685707	5619776
	66	Playtime Daycare	692864	5617412
	67	Kamloops Child Development Centre	686269.	5618724
	68	Tots & Teddies	683549	5614551
	69	Treasure Island Family Child Care	687575	5614253
	70	Giggles & Grins Family Daycare	686741	5613531
	71	The Treasure Chest Family Childcare	686645	5613712
	72	Juniper Joyce's Home Away From Home	694289	5615655
	73	Kids Time Childcare Ltd	688032	5616631
	74	Magpie Corners Family Daycare	687477	5614134
	75	Building Blocks Childcare	686263	5620437
	76	Magical Moments Family Daycare	686490	5614123
	77	Brock Kids Care	683953	5620491
	78	Sheila's Family Daycare	690232	5616520
	79	Kamloops Christian School Association / Kamloops	685811	5619197
	80	Janet's Home Daycare	689251	5616642
	81	Small Steps Family Daycare	687591	5618303
	82	Hollyburn Early Learning Centre	687799	5614191
	83	Tender Care Family Daycare	686468	5613887
	84	Aberdeen Adventure Club	686980	5612952
	85	Brock Licensed Family Daycare Play and Learning Academy	683283	5620407

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	No.	Name	m East	m North
Daycare (cont'd)	86	Laugh And Learn Childcare	693597	5615446
	87	Small Blessings Family Childcare Ltd	686516	5621335
	88	Karen's Family Daycare	685352	5620442
	89	Over The Raynebow Family Daycare	686488	5620804
	90	Just Horsin Around Daycare	686435	5621670
	91	Kidz R Us Daycare	689919	5616604
	92	Enriched Daycare	686380	5612508
	93	Little Acorn Childcare	684636	5619890
	94	Everyday Adventures Dayhome	686876	5614286
	95	The Courtyard Child Care	687998	5615113
	96	Cradles To Crayons Licensed Family Childcare	687795	5614044
	97	Lil' Foot Childcare	686651	5615246
	98	Mr. Miller's Learning Adventures	687605	5614212
	99	Little Peeps Daycare	684676	5615071
	100	G's Daycare	682883	5620443
	101	Pitter Patter Daycare	686410	5620812
	102	M & M Family Child Care	683040	5620519
	103	Little Lions Family Child Care	684746	5619880
	104	Cuddlebear Family Daycare	684000	5620472
	105	Happy Faces Family Childcare	683499	5620299
	106	Enriched Daycare Inc.	686980	5616289
	107	Leandra's Lil' Explorers Daycare	685629	5621901
	108	Desert Palms	686357	5612779
	109	Kamloops Village Garden Montessori Early Learning Centre	686933	5613806
	110	Happy Honeybees Child Care	684350	5620561
	111	Le Jardin D'olivia Rose	686519	5613655
	112	Crackerjacks Family Daycare	684743	5620209
	113	Little Lamb Daycare	687314	5614179
	114	Moving Mountains Childcare	687463	5614934
	115	Sunnyside Daycare	683509	5614705
	116	Kamloops Kids Early Learning Center Inc.	688034	5615026
	117	Kid Zone Dayhome	693782	5615636

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	No.	Name	m East	m North
Daycare (cont'd)	118	Destiny's Child	685949	5613109
	119	My World of Discovery Daycare and Preschool	686058	5613558
	120	Creative Beginnings Daycare and Preschool	685202	5614383
	121	TRU daycare	686089	5616597
	122	Children's Circle Childcare and development Society	688897	5617005
	123	Kamloops Montessori Academy	686362	5613436
	124	Sahali Montessori Preschool And Kindergarten	687975	5613599
	125	Fun Learning Out Of School / Kamloops Kidz Early Learning Center/River City Gymnastics	691597	5617280
	126	Kamloops Community YMCA-YWCA Child Care Services	688571	5616900
	127	Kamloops Kidz Early Learning Center (Pineview Campus)	683857	5614592
	128	Kamloops United Church Preschool	688523	5616955
	129	Kim Care	682872	5620596
	130	Aberdeen Hills Montessori Preschool	686709	5613174
	131	Association Francophone De Kamloops	687174	5618669
	132	Bonnie's Daycare	686824	5618865
	133	Boys And Girls Club Of Kamloops - McArthur Island	685485	5619218
	134	Cariboo Child Care Society	686252	5616180
	135	Chris Child Care	683672	5620582
	136	Dolphin Preschool	686351	5619191
	137	Enriched Daycare Phase 2	686362	5612511
	138	Fun And Fancy Free Family Daycare	682822	5619724
	139	Little Ducklings Childcare	689460	5616936
	140	Little Fawn Daycare	690956	5617744
	141	Little League Family Child Care	686103	5613156
	142	Little Learners Preschool	689882	5616836
	143	Little Lions Family Childcare	686826	5619162
	144	Maple Tree Family Daycare	689162	5616580
	145	Mcdonald Avenue Early Childhood Development Centre	686267	5618696
	146	Parkcrest Family Daycare	682855	5620593
	147	Play to Learn Licensed Childcare	693180	5615613
	148	Puddles and Mud Childcare	687629	5614592

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	No.	Name	m East	m North
Daycare (cont'd)	118	Puss N' Boots	687611	5619677
	150	Seed To Apple Tree Learning Centre	687084	5613063
	151	Silly Billies	686509	5613424
	152	St Paul's Early Learning Centre	688896	5616991
	153	Sunhill Montessori Casa	687905	5614099
	154	Sunshine Early Learning Cantre	681940	5620667
	155	The Children's Garden	681978	5620393
	156	Tiny Treasures Family Child Care	686222	5613720
	157	Together We're Better Childminding	686532	5618851
	158	Wee Care Daycare	687094	5612801
	159	YM-YWCA Southwest School Age Care	688913	5614529
Retirement Homes	160	Berwick on the Park Retirement Residence	688279	5615200
	161	Chartwell Select Renaissance Retirement Residence	686438	5619269
	162	Cottonwood Manor Retirement Home	686060	5619433
	163	Kamloops Senior Village	685722	5614250
	164	Ridgepointe at Pineview Retirement Home	684190	5614503
	165	Riverbend Manor Retirement Home	683708	5619617
	166	Riverbend Manor Retirement Home	683708	5619617
	167	The Shores Retirement Residence	686130	5619902
	168	Dufferin Group Home	684898	5615184
	169	Garden Manor Rest Home	687854	5616879
	170	Gaumont Residence	684785	5620647
	171	Hilltop House	686705	5618648
	171	Marjorie Willoughby Snowden Memorial Hospice Home	688213	5615279
	172	McBride Place	682832	5619990
	173	Ord Road Group Home	679181	5621261
	174	Phoenix Centre	688194	5616450
	175	Pine Grove Lodge	687105	5618430
	176	Ponderosa Lodge	688514	5616610
	177	Ridgeview Lodge	684078	5620088
	178	Riverside Retirement Centre	683705	5619724

Table A-1 Listing and Description of Special Receptors for Modelling Metals and other Chemical Species

Receptor			UTM (Zone 10)	
Type	No.	Name	m East	m North
Retirement Homes (cont'd)	179	Sage Health Centre	687832	5616666
	180	Selkirk Family Care Home	685632	5620163
	181	Springridge Group Home	686597	5615113
	182	Waddington Group Home	688151	5614709
Miscellaneous	183	Stake Lake Trailhead	678565	5599165
	184	McConnell Lake Provincial Park	679980	5600117
	185	Hal Rogers Activity Centre	687507	5613786
Monitoring Stations	186	Kamloops Brocklehurst	683826	5619425
	187	Kamloops Federal Building	688358	5617046
	188	Kamloops Dalhousie Drive	686337	5615994
	189	Kamloops Fire Station #2	684743	5620037
	190	Kamloops Wildlife Park	706554	5615521
	191	Kamloops Dunes	687591	5628598
	192	Kamloops Mission Flats	686757	5617741
	193	Kamloops New Gold	676719	5615113
	194	Kamloops Pacific Way	685753	5613791
	195	Kamloops Strande Ranch	675045	5612544
	196	Kamloops Goose Lake	683968	5607271
Dust fall Stations	197	DFS 10-01	680329	5609293
	198	DFS 10-02	678602	5611558
	199	DFS 10-03	679755	5612766
	200	DFS 10-04	682410	5612677
	201	DFS 10-06	683904	5610252
	202	DFS 10-07	687504	5610854
	203	DFS 3 EAST	680922	5610344
	204	DFS 3 WEST	680683	5610459
	205	DFS 4 EAST	682677	5610243
	206	DFS 4 WEST	682468	5610173
	207	DFS 5 EAST	683813	5609302
	208	DFS 5 WEST	683512	5609523
	209	DFS 6 WEST	683551	5608855

APPENDIX B
SELECTED REFERENCES

Appendix B SELECTED REFERENCES

In chronological order (oldest to newest)

1. Steyn, D.G. and Bruce Ainslie. 2012. RE: Preparation of questions for KAPA to submit to Environmental Assessment Process. Letter Report prepared for Don Barz, Kamloops Area Preservation Association. Feb 27, 2012. 4 pages.

2. BCMOE. 2015a. Request for Clarification Regarding Revised Dispersion Modelling Plan . Letter dated January 15, 2015. British Columbia Ministry of Environment. Filename “Stantec_Peter_Reid_questions_re_revised_modelling_plan_20141215.doc”. 4 pages.

3. Stantec, 2015. Request for Clarification Regarding Revised Dispersion Modelling Plan. Stantec filename: 123510762_Clarification Revised Model Plan_27-Jan-2015.pdf. 5 pages.

4. BCMOE. 2015b. Approval of Detailed Dispersion Modelling Plan. Letter dated February 27, 2015. British Columbia Ministry of Environment. Filename “Peter_Reid _20150227_accept_draft_modelling_plan.pdf”. 3 pages.

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Douw G. Steyn, Ph.D.

CMOS accredited consultant in
Air –Pollution Meteorology
Boundary-Layer Meteorology
Meso-Scale Meteorology

2012.02.27

Don Barz
Kamloops Area Preservation Association

RE: Preparation of questions for KAPA to submit to Environmental Assessment Process.

Working with Dr. Bruce Ainslie, I have prepared a set of questions your organization could submit to the to Environmental Assessment Process (EAP) engaged in considering the proposed development of the Ajax mine near the city of Kamloops. The purpose of the questions is to see that the EAP includes a thorough assessment of concerns KAPA has about the possibility of degraded air quality in Kamloops resulting from atmospheric dispersion of dust from proposed uncovered mine tailings piles and other installations on the mine site.

I hope the attached document will serve your needs.

Sincerely

ORIGINAL SIGNED [redacted]

Douw G. Steyn, PhD, ACM.

Approaches to understanding air quality impacts of proposed Ajax Mine development in Kamloops Valley.

Preamble

The proposed development has the potential to add a substantial source of mineral dust to the air pollutant burden of the Kamloops Valley. While the dust is mainly inert mineral material, the possibility of heavy metals contamination of the dust poses a particular concern. We believe that particular care must be exercised in understanding the air quality implications of the proposed development, given the close proximity of the mine installations to residential areas of Kamloops.

There are two major matters that should be dealt with in order to ensure that air quality concerns are appropriately addressed: the quality and representativeness of observational data used to drive the dispersion modeling; and the methodologies used to perform the meteorological and dispersion modeling. Observational data will be needed as inputs for both the atmospheric and the emissions modeling. For the atmospheric modeling, it is essential that the model be capable of capturing the spatially and temporally varying wind fields and associated pollutant dispersion found in the Kamloops Valley. For this task we recommend CALMET be used to calculate meteorological fields and CALPUFF be used to understand pollutant dispersion from the mine site and tailings piles. Emission rates should be calculated using methods appropriate for the task, such as those from the USEPA AP-42 Compilation of Emission

Meteorological Data requirements:

Being a prognostic model, CALMET requires meteorological observations in order to produce 3-D time varying wind fields. In regions of complex terrain like the Kamloops area, wind fields typically show a great deal of spatial variability. Thus, a network of meteorological station data is needed by CALMET in order to capture both the spatial and temporal variability of meteorology in the Kamloops Valley, and in the immediate area of the tailings piles. We believe the following data and analyses will be needed:

1) A tower-mounted anemometer at or near the crest of either Sugarloaf Hill or Coal Hill is needed to characterize valley scale wind speed and direction in the general location of the proposed tailings piles. Decisions as to which site to use must be based on a compromise between logistical and scientific factors.
2) Meteorological measurements at or near the location of the proposed tailings piles are needed in order to understand dust suspension from tailings piles. Such data will also allow an assessment of frequency of occurrence and direction of strong winds over the tailings piles.
3) Long-term meteorological data is needed in order to ensure that seasonal meteorological variations are captured, and that the any data collected at the Ajax mine site is representative of long-term average conditions in the Valley. Thirty years of hourly meteorological data from the Kamloops Airport (YKA) should suffice.
4) To run CALMET, upper-level meteorological data is required. The nearest location where upper air data is regularly recorded is in Kelowna, B.C., approximately 150 km away. The representativeness of Kelowna-observed near-surface and low-level winds (below 2000 m agl) over Kamloops is something that would need to be

investigated, perhaps using ACARS based soundings from the Kamloops airport (if available). As an alternative, the use of prognostically generated 3D wind fields, from a numerical weather prediction model run at high resolution, would be an effective way of introducing above ground meteorological data into CALMET.

5) Addition hourly meteorological data would be useful for initializing the CALMET model especially given the region's complex topography. The potential for additional meteorological data from Ministry of Forests, Lands and Natural Resource Operations forestry stations, Ministry of Transportation highway stations, and Ministry of Environment air quality stations should be explored.

Emissions Data requirements:

Of direct importance to the dispersion modeling is the proper characterizing of emission rates. There are 3 different sources of fugitive emissions from the proposed mine: from vehicle travel on the paved and unpaved roads within the mine industrial area, from handling the mining material and from wind erosion of the tailing piles. Calculating emissions from these sources will require estimates of silt loading and moisture content from both the roadbed material and the tailings themselves. In addition in order to assess wind-assisted erosion rates from the tailing piles, a hand sieving analysis of the tailing structure should be undertaken so that the tailing's threshold friction velocity can be calculated

Atmospheric Modeling Methodology:

We recommend the following steps be undertaken for the atmospheric modeling:

1. Because of the complex terrain surrounding the proposed mine and city, we recommend a minimum 250 m resolution be used in the modeling.
2. The modeling domain should extend a minimum 20km away from the proposed site in all directions.
3. The modeling exercise will have to capture examples of days (via case studies and preferably drawn from both the summer and winter seasons) with poor ventilation associated with light winds and temperature inversions. Accurate temperature profile data will have to be obtained to make these simulations realistic. Modeling atmospheric conditions in regions of complex under such conditions can be quite challenging with small discrepancies in modeled near surface wind speeds or direction spelling the difference between success or failure for the dispersion modeling. As a result, it must be demonstrated that the atmospheric modeling exhibits a fair amount of skill reproducing the hourly observed meteorological conditions during such events. Because CALMET uses meteorological observations to produce its wind fields, direct evaluation of observation against CALMET output is problematic. In regions of complex terrain, without a high density of meteorological stations, a leave-one-out model evaluation does not always reflect model accuracy since withholding data from CALMET can lead the model to produce markedly different wind fields. One possibility is to evaluate the models against existing air quality data in the Kamloops Valley, using a known source and pollutant as a test bed. Because this involves both meteorological and dispersion modeling, this is further discussed in

the section below. At any rate, detailed CALMET output over these events should be presented.

Dispersion Modeling Methodology:

In order to understand suspension of mine tailings dust from tailings piles and estimate the additional PM and other pollution in surrounding communities, the dispersion modeling exercise will require:

1. In order to provide a baseline understanding of the present state of PM pollution in the Kamloops Valley in relation to meteorology, a set of pollution roses should be prepared.
2. The modeling to demonstrate that it realistically captures dispersion conditions in Kamloops. One possibility is to evaluate the model against existing air quality data in the Kamloops Valley, using a known source and pollutant as a test bed. As an example, sulphur dioxide emissions in the Kamloops region are likely limited to a few industrial sources (like the Kamloops pulp mill) with emission rates reasonably well estimated. If SO2 concentrations at the Kamloops Federal building can be well reproduced by CALPUFF on low wind days with high SO2 concentrations, it would suggest the whole modeling train (CALMET + CALPUFF) is capable of capturing dispersion within the Kamloops Valley on low wind days. Detailed output from the CALPUFF model, showing time series plots at various locations and surface concentrations over the entire modeling domain, should be presented for these cases.
3. The modeling exercise will also have to capture high wind days, when PM10 suspension is likely to be a concern. Again, a set of specific case studies is called for, preferably a summer and winter event as well as a springtime event when Kamloops area road dust emissions are likely to be high.
4. The use of dust suppression measures (like watering and the application of chemicals) can greatly affect fugitive dust emission rates, and hence predicted atmospheric concentrations. To gauge the effectiveness of such treatments, it is recommended that dispersion results be presented for all cases with and without such controls.

Ministry of Environment

Environmental Protection and Assurance Division
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MEMORANDUM

To: **Peter Reid**
Principal
Stantec Consulting Ltd.
via email.

File: 44150-20\Ajax
Date:15th January, 2015

From: Ralph Adams
Air Quality Meteorologist
Southern Region

RE: Request for Clarification Regarding Revised Dispersion Modelling Plan.

Dear Mr. Reid:

On November 30th, you supplied a draft of the document *Ajax Mining Project Detailed Dispersion Modelling Plan*, your project number 123510762 dated November 20th 2014, referred to hereafter as the Draft Revised Modelling Plan. This document was also discussed at the meeting held in Kamloops by KGHM, attended by KGHM, Stantec, BCEAO and various members of the working subgroup.

Before I complete my review I would like to ask for clarification, and ask some questions regarding section 3.1 *Background Air Quality* of the Draft Revised Modelling Plan. My request and questions concern three issues: the use of modelled background values rather than the values that have been, and are being measured in the airshed, the choice not to include ozone in the modelling, and the particle density used in the deposition calculations that has been use in preliminary modelling, and the proposed final Modelling.

Modelled Background.

Could you confirm that your proposed method for determining background values of the various air quality parameters is NOT to add values from the historical ambient monitoring that has been conducted in the airshed, but to use modelled background values that would vary through the airshed. The spatially varying background consist of the sum of:

- Modelled values of all parameters; the values for various averaging periods would be based on the results of CALMET/CALPUFF modelling, using estimates of all known sources in the airshed.
- The modelled effects of all sources would be added to a global background levels based on the lower percentiles of the values measured by ambient monitoring in the airshed.

In the meeting held in Kamloops on November 26th, you presented some preliminary results form the background modelling. The results were not distributed, and I am relying on memory and hastily recorded notes, but I believe the results showed that the highest annual average PM2.5 levels were predicted at the valley bottom , with values decreasing with elevation above the valley floor. The highest values were predicted in the area of Brocklehurst between Tranquille and Fortune. I believe the highest value for annual average was shown as 5.6μgm^{-3}. I may be mistaken but I recall the values at the edges of the airshed were below 1μgm^{-3}.

In table 3-7 of the Draft Modelling Plan, values for global baseline PM2.5 annual average, based on the average minimum values vary from 0.5 to 1.6μgm^{-3} for TEOM and BAM based measurements respectively. If I understand your proposal correctly, that would indicate that the background PM2.5 value you propose to use for the location of the highest predicted PM2.5 levels in Kamloops is on the order of 6 to 7μgm^{-3}. That number is well below the values that were measured in Brocklehurst at the Mayfair and Firehall #2 sites, and well below the levels measured at the downtown Federal station over the last four years. I note also that the technique you propose would result in even lower values at the Federal station downtown where the current annual average over the last years has been well above 8μgm^{-3}.

On page 3.1 of the Draft Modelling Report, regarding measured annual averages, that "Often these are years dominated by a single event such as a nearby forest fire (e.g. the 2003 Rayleigh fires) or some other phenomenon (e.g. an unusually persistent period of air stagnation, an unusually high period of industrial emissions)." While I agree that unusual and extreme events can have an effect on the annual average, I do not agree that they should be removed. All of the unusual events you cite constitute part of the exposure of the population to degraded air quality and should be considered in the background values for the airshed.

As you state on page 3.1 of the Draft Modelling Plan, the BC Modelling Guidelines state that modelled background values are appropriate in the absence of representative measurements. "If there is no ambient monitoring data that is representative of the air quality in the area under consideration, a model can be used to estimate the background concentration." In my opinion there is adequate PM2.5 monitoring in the airshed to use as baseline.

My comments above are directed at the PM2.4 background estimates, the proposed modelling includes TSP, PM10, SO2, NO2, and CO. In the case of these parameters, long term measurements are only available at the main air stations at the valley floor (although we now have PM10 measurements form the Goose Lake and New Gold sites as well).

However, I am concerned that, for the same technical reasons as for PM2.5, the modelled background plus estimated global background may also be lower that the values actually observed at the valley bottom air stations.

However, I do agree with the intent of the modelling of background. Due to the proximity of the proposed mine and emission sources to Kamloops (i.e. variation in predicted concentrations due to the operation of the mine would be expected across the Kamloops airshed), and due to the concentration of sources in the valley bottom and the large expected variation in air quality with elevation, it is clearly incorrect to assume that the measured background at the valley floor stations are representative of the levels at higher elevations and at the edge of the airshed. Indeed, I believe this is clearly indicated by the measurements of PM2.5 the Ministry has collected at various locations in the airshed over the years.

One possibility would be to use modelling to interpolate between stations, but use actual measurements as the fixed values between which to interpolate. In the case of PM2.5 I believe we have a good estimate of the range expected, but in the case of other parameters a global background could be estimated using the methods you have described in the Draft Modelling Report.

Ozone.

As we have discussed on many occasions over the last years, it is my opinion, supported by my colleagues in the Air Section in Victoria, that due to the paucity of sources of ozone precursors in the proposed Ajax Mine, and the small size of the domain of interest, there is no need to consider the generation of secondary pollutants like ozone. However, as you know, there has been continued discussion and questions regarding ozone modelling, including from Health Canada and Environment Canada staff.

Could you supply a brief summary of the rationale for not considering ozone in the proposed modelling. It is my intention to meet as soon as possible after I have received the rationale with Health Canada and Environment Canada to discuss the issue and reach a unanimous conclusion.

Particle Density.

I have been informed by my colleagues in Victoria that in the next version of the Modelling Guidelines that is expected to be released in spring 2015, the guidance on the particle density used in the deposition calculations will be changed. The current recommendation is to use the CALPUFF default setting of unity. The in the revised guidelines, this will be changed to a variable density based on particle size distribution. I have attached a document describing a similar system now used in Newfoundland.

Could you supply a brief description of the density settings used in the preliminary modelling, and the you estimates of the effect of changing the density setting (if the default unity has been used) would have on predicted maximum concentrations.

If you wish to discuss these requests in more detail please contact me directly. I will be returning to my office on Monday,19th January.

Sincerely,

Ralph Adams
Air Quality Meteorologist.

cc:

Scott Bailey, BC Environmental Assessment Office, Victoria, BC.
Jason Bourgeois, Environmental protection Division, BC Ministry of Environment, Kamloops, BC.

January 27, 2015
File: 123510762

Attention: Mr. Ralph Adams
1259 Dalhousie Drive
Kamloops BC V2C 5Z5

Dear Mr. Adams,

Reference: Request for Clarification Regarding Revised Dispersion Modelling Plan

Thank you for the letter of January 15th 2015 requesting clarification regarding the Revised Dispersion Modelling Plan, which was submitted to the BC MOE on November 20th, 2014.

This reply addresses the three issues raised in the letter, namely:

i. the use of modelled background values rather than the values that have been, and are being measured in the airshed,
ii. the choice not to include ozone in the modelling, and
iii. the particle density used in the deposition calculations.

i. Modelled Background

The Revised Dispersion Modelling Plan proposes to model a Base Case that includes all nearby sources that substantially interact with the proposed Ajax mine (the Project). This is consistent with most of the EIAs completed in British Columbia recently with an air quality Valued Component. The nearby sources in Kamloops include: 1) on-road vehicles (including rail), 2) on-road road dust (excludes off-road road dust), 3) space heating (including woodstoves), and 4) all industrial activities (permitted and fugitive dust). In aggregate they represent all of the substantial emission sources in the Regional Study Area that could interact with the Project. They therefore warrant inclusion in the Base Case.

Stantec proposes to add to this modelled Base Case background air quality values. The background values proposed accounts for sources in the RSA that have not been modelled (e.g. fugitive dust from seasonally exposed river bottom and disturbed lands), and sources outside the RSA, both regional and global. This background figure will be a single number for each substance and averaging interval based on a low-percentile value derived from the BC MOE monitoring data statistical summaries for Kamloops.

Stantec believes this approach will faithfully portray the Project interacting with exiting air quality both spatially and temporally. It is vastly superior to simply adding to the Project Alone results a single number representative of the highest measurements taken in the valley bottom.

Reference: Request for Clarification Regarding Revised Dispersion Modelling Plan

At the working group meeting in Kamloops on Monday November 24, 2014 Stantec presented preliminary results illustrating predicted annual average $PM_{2.5}$ for the Base Case. Stantec emphasized that the results were preliminary as they were based on a coarse-grid test run, and noted that caution should be exercised in interpreting them.

Since that time the full receptor grid CALPUFF modelling results for the Base Case have been post-processed. As expected the predicted maxima has been more finely resolved through the use of the denser full receptor grid. The results now reveal a maxima over the City of Kamloops that is much more in line with current ambient measurements. Please note that these results too are preliminary and subject to change.

In the FINAL Model Plan Stantec will include revised background numbers for all parameters and all averaging intervals that will achieve the ends you describe in your letter. Stantec will not be able to portray background as varying across the domain however. Stantec cannot envision a defensible means of performing this type of interpolation in the complex terrain encountered locally. Stantec will rely instead on the CALPUFF modelling results alone to portray these patterns. We are confident that the combination of CALPUFF results plus a low-percentile background will portray all of the parameters in all of the time averaging intervals sufficiently well.

ii. Ozone

CEAA defines scoping as an "activity that focuses the assessment on relevant issues and concerns". While there are numerous potential issues at play in this air quality assessment, the scoping exercise is intended to reduce the issues addressed by the assessment to those with a potential to result in a significant adverse effect. Issues that are central to this assessment include the direct effects of emissions of CACs and HAPs by the Project. The potential for the secondary pollutant formation was scoped out of the Project EIA based on professional judgment.

When the selection of substances of interest for the Ajax EIA was first discussed by Stantec and the BC Ministry of Environment it was agreed that secondary pollutants (ozone and secondary $PM_{2.5}$) were scoped out. The quantities of precursors (NO_X, SO_2, and reactive hydrocarbon species) that may be emitted by the Project are not large. It was agreed that any secondary pollutants that did form would form outside of the Regional Study Area (2 to 4 hours downwind) and be well dispersed by that time.

With regards to ozone specifically, Kamloops does not currently, nor has it ever had, measured ozone in excess of the Canadian ambient air quality standards (CAAQS). The Ministry's statistical summary (O3_98_13_FINAL.xls) shows that the fourth highest daily 8-hour maximum, averaged over 2010-2012 and 2011-2013 were 50 and 49 $\mu g/m^3$ respectively. The CAAQS is 63 $\mu g/m^3$. The highest and lowest measured fourth highest daily 8-hour maximum, averaged over three years was 60 $\mu g/m^3$ (2002-2004) and 54 $\mu g/m^3$ (2009-2011) respectively.

Reference: Request for Clarification Regarding Revised Dispersion Modelling Plan

The Project as proposed will emit ozone precursors, namely NO_X and reactive hydrocarbon species from the mine fleet and explosives. Preliminary dispersion modelling shows that the highest concentrations of NO_X are on or near the mine boundary, and concentrations diminish rapidly with increasing distance from the mine. Preliminary dispersion modelling shows that there is limited interaction between NO_X emitted at the mine site and that emitted in the City of Kamloops. Preliminarily, there are no predicted exceedances of the NO_2 AAQO.

Stantec is of the opinion that the net effect of the presence of NO_X from the Project in the RSA will be to *reduce* overall the populations' exposure to existing ozone – which is largely naturally occurring. This is because NO and O_3 readily react to form NO_2 and O_2 in the near field. Enhanced ozone production may occasionally occur in the far field, however it will be well dispersed by that time.

Ozone pollution is a phenomenon that is manifest mainly in large urban/industrial regions. Canada's management of ozone pollution is largely focused on three broad regions: the Lower Fraser Valley, the Windsor-Quebec City Corridor, and the Southern Atlantic Region. Kamloops admittedly has a hot climate that is well suited for the formation of secondary ozone; however the insufficient quantity of precursors will prevent this from becoming an issue. While the Project as proposed will result in an increase in emissions of ozone precursors (NO_X and reactive hydrocarbon species), these emissions have limited interaction with precursors emitted in the valley bottom. Unlike urban/industrial emissions in Kamloops, these emissions cease at the end of the mine life.

iii. Particle Density

Section 5.5 and 5.6 of the current *BC Guidelines* considers emissions of particulate matter, however the *BC Guidelines* are silent on the issue of "particle density". They only mention that the deposition algorithms consider particle size distributions and settling velocities. In that light the modeller is best advised to rely on the CALPUFF default particle density setting of 1 g/cm^3. This is what Stantec has done. The parameters associated with deposition that Stantec has employed are presented in the table on the following page.

Stantec is familiar with the *Government of Newfoundland and Labrador Guideline for Plume Dispersion Modelling* (or "*GNL Guideline*"). Stantecs view is that the particle density adjustments suggested in Section 2.6 (Table 2.6.2) are in nearly all instances technically incorrect. Attempting to 'correct' the aerodynamic diameter for density is ill advised as density is already incorporated into the aerodynamic diameter value.

Particle #	Geometric mass mean diameter (microns)	Geometric standard deviation (microns)	Particle size intervals (NINT)	Effective particle minimum (microns)	Effective particle maximum (microns)
P1 ($PM_{2.5}$)	1.25	0.0	NA	NA	NA
P2 ($PM_{2.5}$ to PM_{10})	6.25	0.0	NA	NA	NA
P3 (PM_{10} to PM_{30})	20.0	0.0	NA	NA	NA
Note: NA- This indicates that a standard deviation of 0.0 is a flag for CALPUFF to assume all particles have the same diameter as the geometric mass mean diameter. The minimum and maximum effective particle diameters are equal to the geometric mass mean diameter. The value for NINT is not used since CALPUFF does not need to calculate an effective deposition velocity across the particle size distribution.					

CALPUFF hard codes the density of particulate as 1 g/cm^3 since information about particle size (geometric mass mean diameter and geometric standard deviation) are provided on an aerodynamic diameter basis. This is consistent with the way emission rates are calculated. For example, the US EPA AP-42 emission rates for unpaved roads provide $PM_{2.5}$ and PM_{10} fractions of total PM on an aerodynamic diameter basis. The deposition resistance model used by CALPUFF relies on the use of aerodynamic diameters.

The aerodynamic diameter is defined as the diameter of a spherical particle having a density of 1 g/cm^3 that has the same inertial properties as the particle of interest. Most particle diameter are described on an aerodynamic diameter basis as it best depicts how particulate behave in the atmosphere. If the particulate in question are very dense, then the aerodynamic diameter of that particulate is larger than the true physical diameter to compensate for the high density. Essentially, the density, along with other properties such as shape of the particle is built into the aerodynamic diameter term. There is therefore no need to “correct” particle density except in the most extreme of cases.

CALPUFF uses the geometric mean diameter and geometric standard deviation descriptors to define the particle size distribution and calculate an effective deposition velocity. The geometric mass mean diameter is the diameter of a particle that has the logarithmic mean for the size distribution. It is the n^{th} root of the product of n terms of the aerodynamic diameters. Stantecs modelling for Ajax simplifies this by assuming that the distribution is broken into three particle sizes with uniform distribution (i.e. we set the standard deviation to 0 to tell CALPUFF that the distribution is uniform). Therefore, the geometric mass mean diameter is exactly equal to the aerodynamic diameter.

In addition, the *GNL Guideline* notes that the hard coded density of 1g/cm^3 is appropriate in most instances. They suggest it is not appropriate for “heavier particulate such as iron which has a density of nearer 5 g/cm^3”. The density of the particulate Stantec is modelling (overburden, ore,

Reference: Request for Clarification Regarding Revised Dispersion Modelling Plan

and tailings) is likely between 2.7 and 3.0 g/cm^3. Stantec is not modelling fugitive emissions of concentrated ore (which is denser than ore by definition) as substantial measures are taken to prevent the loss of valuable product. Actual emissions of concentrated ore are expected to be very small. Therefore, even if Stantec accepted that particle density adjustments are technically correct, one could argue that the *GNL Guideline* advises against considering them in this instance.

References:

BC MOE, 2008. Guidelines for Air Quality Dispersion Modelling in British Columbia. British Columbia Ministry of Environment, March, 2008.

GNL, 2012. Government of Newfoundland and Labrador Guideline for Plume Dispersion Modelling (GD-PPD-019.2), September 18, 2012.

Regards,

Stantec Consulting Ltd.

Peter D. Reid
Principal
Phone: (403) 781-4142
Mobile: (403) 461-5744
peter.reid@stantec.com

Attachment: None

c.

pdr 123510762_clarification revised model plan_27-jan-2015.docx

Ministry of Environment

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Kamloops BC V2C 5Z5

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MEMORANDUM

To: **Peter Reid**
Principal
Stantec Consulting Ltd.
via email.

File: 44150-20\Ajax
Date: 27th February, 2015

From: Ralph Adams
Air Quality Meteorologist
Southern Region
Kamloops

RE: Approval of Detailed Dispersion Modelling Plan.

Dear Mr. Reid:

I have reviewed the Draft Detailed Modelling Plan that you supplied to me in November 2014. The plan meets all the requirements outlined in the Guidelines for Air Quality Dispersion Modelling in British Columbia and will supply the information required to assess the potential impacts of the proposed mine on ambient air quality.

In this memorandum I am referring to three documents:

- A draft of the document *Ajax Mining Project Detailed Dispersion Modelling Plan*, your project number 123510762 dated November 20th 2014, referred to hereafter as the Draft Detailed Modelling Plan. This document was also discussed at the meeting held in Kamloops by KGHM on November 26th, attended by KGHM, Stantec, BCEAO and various members of the working subgroup.
- A memorandum I wrote addressed to you dated 15th January, 2015. File 44150-20\Ajax. The memo requested clarification of several points in the Draft Detailed Modelling Plan. In that memo I requested clarification on the estimation of background ambient concentrations, the choice not to model ozone, and the particle density used in the deposition sub-routines.
- Your response to my request, dated January 27th, 2015, your file 123510762

With regard to the three issues on which I requested clarification:

Ozone. I have discussed your response with my colleagues in the Ministry and other agencies and we have concluded that the choice not to model ozone is justified. Your response and our discussion confirms my original opinion that, due to the small size of the domain, the nature of the additional precursor sources at the proposed mine, and the complexity of modelling existing ozone, little useful information would be provided by attempting to model ozone production.

Background ambient concentrations. Your response and our discussions over the last months indicate that my initial concerns with the proposed method of determining ambient background based on the preliminary data you presented at the November 27th meeting were not warranted, and that the your later results indicate that reasonable estimates of exiting ambient levels will be produced. I do note that there is a typographical error in Table 3-7 point e. It states that the Firehall station ran until December 31st 2013, the station was shut down and sensors moved to the Federal station in fall 2014. As we have discussed, there are now over three years of $PM_{2.5}$ measurements available at the Federal station.

Particle density used in deposition. I have discussed this with my colleague Li Huang in Victoria, and we have reviewed your response to my questions. While we do not necessarily agree with some of your arguments, we agree that there would be little change in modelled concentrations by using the alternative particle densities. The use of the default unity density is acceptable.

The following are some additional requirements that we have discussed in the past. They are, in large part, those I included my approval of the previous 2012 Modelling plan. In order to complete the review of the final modelling report, I will require the following information to be included in addition to that specified in the Draft Detailed Modelling Plan:

1. A description of how the factors used to estimate emissions from the tailings stack impoundment were developed. As we have discussed previously, the final modelling report should include descriptions and documentation regarding the emission factors used for fugitive dust.
2. Windroses generated using CALMET output for a number of locations in the domain: a location between the proposed pit and the southern boundary of the domain; a location near the airport, a location near the confluence of the North and South Thompson rivers, a location in the North Thompson valley near the northern boundary of the domain, a location in South Thompson valley near the eastern Boundary of the domain, at the Inks Lake Interchange on the Coquihalla Highway, and at the site of the climate station installed by the proponent on the Northwest side of Sugarloaf Hill.
3. Details regarding the version of CALMET and CALPUFF used, and a rationale if the latest versions are not used.
4. The reasons for using the North American land-cover data to initialize the revised CALMET data set (Final Modelling Plan, section 4.4.3). Please include a discussion of the advantages of using these data rather than the Baseline Thematic Mapping available from GeoBC. Please also include a table, or other description,

showing how the North American land-cover data was converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor.

5. A copy of the CALPUFF output files (MoE will supply a suitable external drive on request).
6. In addition to our own review of the final modelling report, the Ministry may conduct an outside review of the report. Please include in the final modelling report an appendix listing all parameter and switch settings used in the CALMET and CALPUFF runs (these could be appended as electronic input files).

If you wish to discuss these requests in more detail please contact me directly.

Finally, I note that my comments only refer to the modelling and meteorological components of the Draft Modelling Plan. Part of Section 2.2.2 deals with the meatal contaminants selected for inclusion HHERA (p. 2-10 and 2-11), the comments of those reviewing the HHERA plan may include these contaminants.

Sincerely,

Ralph Adams

Ralph Adams P.Ag.

cc: Scott Bailey, BC Environmental Assessment Office, Victoria, BC.

APPENDIX C
THE CALMET METEOROLOGICAL MODEL

Appendix C–The CALMET Meteorological Model

August 21, 2015

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Appendix C THE CALMET METEOROLOGICAL MODEL

C.1 INTRODUCTION

This appendix provides technical details and assumptions regarding the CALMET meteorological model (CALMET) which were used in conjunction with the CALPUFF dispersion model (CALPUFF) to investigate the proposed KGHM Ajax project (The Project). What follows is an overview of the initialization and parameterization of the CALMET model and a technical description of the model.

C.1.1 THE CALMET MODELLING SYSTEM

The CALMET meteorological model is what is typically used to provide the meteorological data necessary to initialize the CALPUFF dispersion model. This model is initialized with terrain and land use data describing the region of interest, as well as meteorological input from potentially numerous sources. Various user-defined parameters control both how the input meteorological data is interpolated to the grid, as well as which internal algorithms are applied to these input fields. More details regarding these options are provided in the following sections. Output from the CALMET model includes hourly temperature and wind fields on a user-specified three-dimensional domain as well as additional two-dimensional variables used by the CALPUFF dispersion model. **Appendix D** describes the CALPUFF dispersion model in detail.

C.2 CALMET MODELLING

C.2.1 MODEL DESCRIPTION

The following description of the CALMET model’s major model algorithms and options are excerpts from the CALMET model’s user manual (Scire et al. 2000).

The CALMET meteorological model consists of a diagnostic wind field module and micrometeorological modules for overwater and overland boundary layers. The diagnostic wind field module uses a two-step approach to the computation of the wind fields (Douglas and Kessler 1988), as illustrated in Figure C-1.

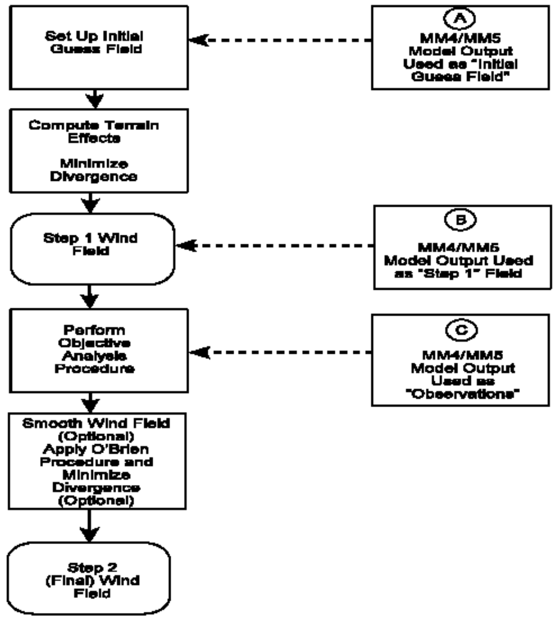


Figure C-1 Flow Diagram of Diagnostic Wind Module in CALMET. (Source: Scire et al. 2000)

In the first step, an initial guess wind field is adjusted for kinematic effects of terrain, slope flows, and terrain blocking effects to produce a Step 1 wind field. The initial guess field is either a uniform field based on available observational data or the output from the NCAR/PSU Mesoscale Modelling System (MM4/MM5). The second step consists of an objective analysis procedure to introduce the effects of observational data into the Step 1 wind field to produce a final wind field. An option is provided to allow gridded meso-meteorological wind fields to be used by CALMET, which may better represent regional flows and certain aspects of sea breeze circulations and slope/valley circulations. Wind fields generated by the meso-meteorological wind field module can be input to CALMET as either the initial guess field or the Step 1 wind field.

C.2.1.1 Diagnostic Wind Field Module – Initial Guess Field

Step 1 Wind Field: The step one wind field is adjusted for kinematic effects of terrain, slope flows, and blocking effects as follows:

- Kinematic Effects of Terrain: The approach of Liu and Yocke (1980) is used to evaluate kinematic terrain effects. The domain scale winds are used to compute a terrain forced vertical velocity, subject to an exponential, stability dependent decay function. The kinematic effects of terrain on the horizontal wind components are evaluated by applying a divergence minimisation scheme to the initial guess wind field. The divergence minimisation scheme is applied iteratively until the three dimensional divergence is less than a threshold value.

- Slope Flows: An empirical scheme based on Allwine and Whiteman (1985) is used to estimate the magnitude of slope flows in complex terrain. The slope flow is parameterised in terms of the terrain slope, terrain height, domain scale lapse rate, and time of day. The slope flow wind components are added to the wind field adjusted for kinematic effects.
- Blocking Effects: The thermodynamic blocking effects of terrain on the wind flow are parameterised in terms of the local Froude number (Allwine and Whiteman 1985). If the Froude number at a particular grid point is less than a critical value and the wind has an uphill component, the wind direction is adjusted to be tangent to the terrain.

Step 2 Wind Field: The second step of the procedure involves the introduction of observational data into the Step 1 wind field through an objective analysis procedure. An inverse distance squared interpolation scheme is used which weighs observational data heavily in the vicinity of the observational station, while the Step 1 wind field dominates the interpolated wind field in regions with no observational data. The resulting wind field is subject to smoothing, an optional adjustment of vertical velocities based on the O'Brien (1970) method, and divergence minimisation to produce a final Step 2 wind field.

C.2.1.2 Micrometeorology Modules

The CALMET model contains two boundary layer models for application to overland and overwater grid cells:

- Overland Boundary Layer Model: Over land surfaces, the energy balance method of Holtslag and van Ulden (1983) is used to compute hourly gridded fields of the sensible heat flux, surface friction velocity, Monin Obukhov length, and convective velocity scale. Mixing heights are determined from the computed hourly surface heat fluxes and observed temperature soundings using a modified Carson (1973) method based on Maul (1980). The model also determines gridded fields of PGT stability class and optional hourly precipitation rates.
- Overwater Boundary Layer Model: The aerodynamic and thermal properties of water surfaces suggest that a different method is best suited for calculating the boundary layer parameters in the marine environment. A profile technique (Garratt 1977; Hanna et al. 1985), using air sea temperature differences, is used in CALMET to compute the micrometeorological parameters in the marine boundary layer.

The Over Land Boundary Layer Model is applied for the Ajax Project air quality assessment.

C.2.2 CALMET APPLICATION

The CALMET model is available from the model developer (i.e., Exponent Inc.). The current U.S. EPA version of CALMET is Version 5.8, level 070623. For consistency with previous Levelton CALMET runs, same version CALMET 5.8 was adopted for this assessment.

A horizontal grid spacing of 250 m was selected for the CALMET simulation. With this grid spacing, it is possible to maximize run time and file size efficiencies while still capturing local complex terrain feature influences on wind flow patterns.

C.2.3 METEOROLOGICAL DOMAIN

The CALMET meteorological domain adopted for this project is summarized below in Table C-1. For a graphical representation of the 3,850 km^2 area, refer to Figure C-2.

Table C-1 Map Projections and Horizontal Grid Parameters

Parameter	Value
Map Projection	UTM
UTM Zone	10
Datum	NAR-C
Number of Grid Cells (n_x, n_y)	280, 220
SW Corner (Easting, Northing)	650km, 5590km
Grid Spacing	250m

The CALMET domain was selected to encompass the emission sources from the Kamloops airsheds as well as the major topographic features of the area. Within the CALMET domain a resolution of 250 m was used. Ten vertical levels were used to model the atmosphere up to a maximum cell face height of 3000m above ground level. Cell mid-points were chosen at heights of 20, 40, 80, 160, 300, 500, 1000, 1500, 2000 and 3000m above ground to allow for higher resolution in the layers nearest to the earth's surface than in the levels aloft.

C.2.4 STUDY PERIOD

The mesoscale model MM5 meso-meteorological dataset, valid from January 1, 2003 to December 31, 2005, was provided by BC Ministry of Environment (BC MOE). The CALMET meteorological model was run in two modes: MM5 data plus observation data (mm5+obs) and only observation data used (obs only).

C.2.5 TERRAIN AND LAND USE

Terrain data were obtained from Canadian Digital Elevation Data (CDED). The source digital data for CDED at scales of 1:50,000 and 1:250,000 are extracted from the hypsographic and hydrographical elements of the National Topographic Data Base (NTDB) or various scaled positional data acquired from the provinces and territories. These data have a horizontal resolution of approximately 30 m, which is more than sufficient for air quality modelling purposes.

Terrain elevations for the CALMET model area are shown in Figure C-2. Terrain in the region is complex with elevations ranging from 300 m to heights greater than 2,100 meters above sea level (masl). The base elevation at the proposed project site is approximately 913 masl.

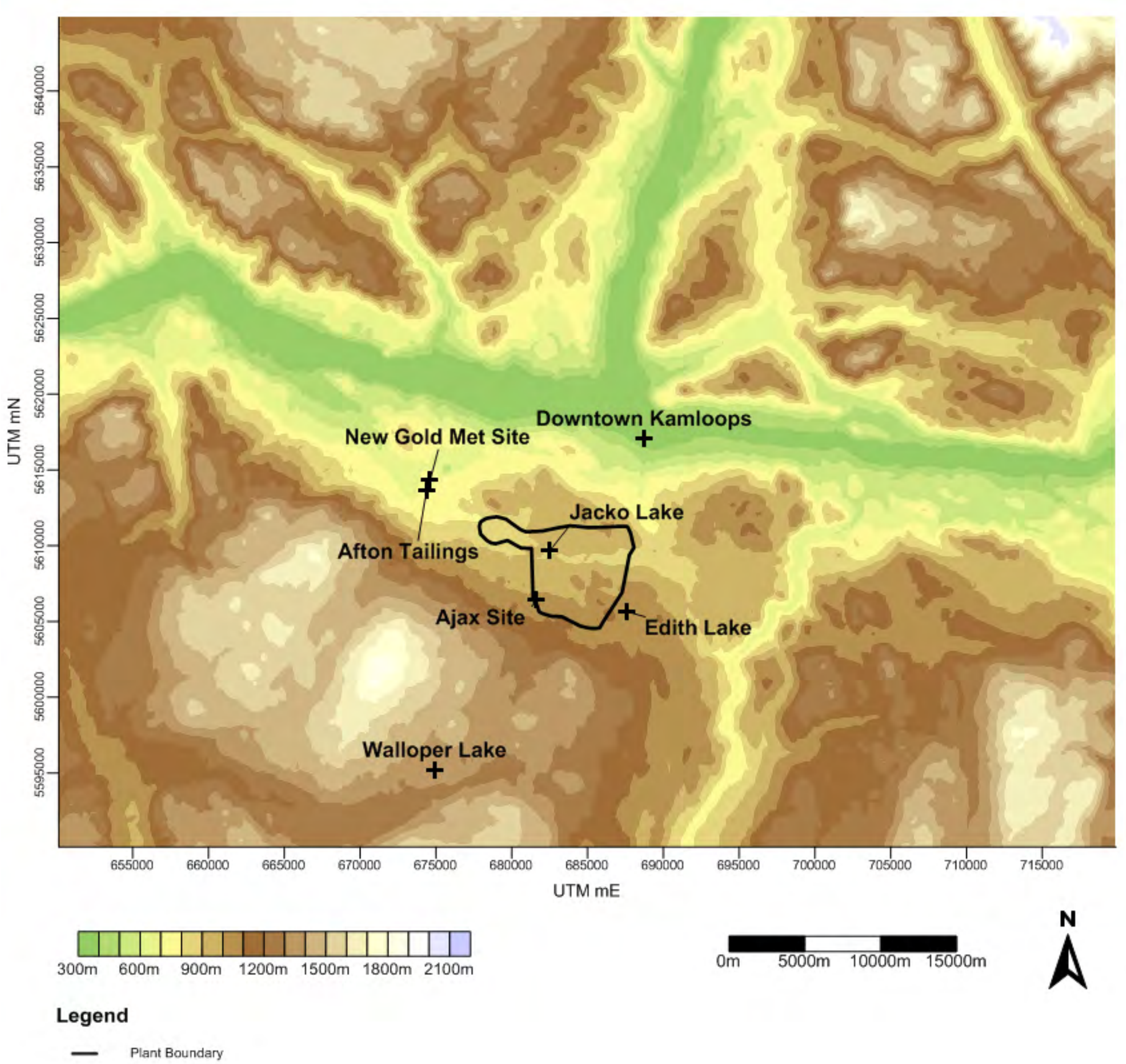


Figure C-2 Terrain Elevations for the CALMET Model Domain

In addition to terrain elevation data, the CALMET model utilizes surface parameters such as surface roughness length, albedo, Bowen ratio, leaf area index, soil heat flux, and anthropogenic heat flux to provide input to important subroutines which, in turn, estimate quantities such as surface heat flux and mechanical turbulence.

For this assessment, the recently published North American land-cover data (Commission for Environmental Cooperation (CEC 2010)) was used to initialize land use categories in the CALMET model. The 2005 North American land-cover dataset was produced as part of the North American Land Change Monitoring System (NALCMS), a trilateral effort between the Canada Centre for Remote Sensing, the United States Geological Survey, and three Mexican organizations including the National Institute of Statistics and Geography, National Commission for the Knowledge and Use of the Biodiversity, and the National Forestry Commission of Mexico. This newer land-cover dataset represents most of new technology and innovative approaches in last decade. Also using a newer land-cover data makes possible to capture those changes attributed to forest fires, insect infestation, urban sprawl and other natural or human-caused events.

The CEC 2010 land use data is at a resolution of 250 m and was published in 2010. This land-cover information was then converted into the fractional land-use format accepted by the CALMET MAKEGEO pre-processor. The extracted fractional land-use file is also at 250 m resolution which is consistent with the CALMET grid resolution. The mapping from the North American land-cover dataset to the CALMET land-use categories is contained in Table C-2. Tables C-3 to C-6 describe the seasonal values for surface roughness (z_0), albedo, Bowen ratio, soil heat flux, anthropogenic heat flux and LAI defined according to the Guidelines for Air Quality Dispersion Modelling in British Columbia (BC MOE 2008) and the CALMET User Guide (Scire et al. 2000).

Table C-2 Mapping from the North American Land-cover Data to CALMET Land-Use Categories

Land Cover Code	Land Cover Type	CALMET Code	CALMET Land Use Category
1	Temperate or sub-polar needleleaf forest	42	Evergreen Forest Land
2	Sub-polar taiga needleleaf forest	42	Evergreen Forest Land
3	Tropical or sub-tropical broadleaf evergreen forest	42	Evergreen Forest Land
4	Tropical or sub-tropical broadleaf deciduous forest	41	Deciduous Forest Land
5	Temperate or sub-polar broadleaf deciduous forest	41	Deciduous Forest Land
6	Mixed forest	43	Mixed Forest Land
7	Tropical or sub-tropical shrubland	32	Shrub Rangeland
8	Temperate or sub-polar shrubland	32	Shrub Rangeland
9	Tropical or sub-tropical grassland	30	Rangeland
10	Temperate or sub-polar grassland	30	Rangeland
11	Sub-polar or polar shrubland-lichen-moss	80	Tundra
12	Sub-polar or polar grassland-lichen-moss	80	Tundra
13	Sub-polar or polar barren-lichen-moss	80	Tundra
14	Wetland	60	Wet Land
15	Cropland	20	Agricultural Land
16	Barren lands	70	Barren Land
17	Urban	10	Urban or Build-up
18	Water	50	Water
19	Snow and Ice	90	Snow or Ice

Table C-3 Land-use Characterization and Associated Geophysical Parameters for the Winter Season

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m²)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.3	0.35	1.5	0.15	0	7	42	Evergreen Forest Land
2	1.3	0.35	1.5	0.15	0	7	42	Evergreen Forest Land
3	1.3	0.35	1.5	0.15	0	7	42	Evergreen Forest Land
4	0.5	0.5	1.5	0.15	0	7	41	Deciduous Forest Land
5	0.5	0.5	1.5	0.15	0	7	41	Deciduous Forest Land
6	1	0.1	1	0.15	0	7	43	Mixed Forest Land
7	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
8	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
9	0.001	0.6	1.5	0.15	0	0.5	30	Rangeland
10	0.001	0.6	1.5	0.15	0	0.5	30	Rangeland
11	0.2	0.3	0.5	0.15	0	0	80	Tundra
12	0.2	0.3	0.5	0.15	0	0	80	Tundra
13	0.2	0.3	0.5	0.15	0	0	80	Tundra
14	0.05	0.3	1.5	0.25	0	2	60	Wet Land
15	0.01	0.6	1.5	0.15	0	3	20	Agricultural Land
16	0.15	0.45	6	0.15	0	0.05	70	Barren Land
17	1	0.35	1.5	0.25	0	0.2	10	Urban or Build-up
18	0.0001	0.2	1.5	1	0	0	50	Water
19	0.2	0.7	0.5	0.15	0	0	90	Snow or Ice

NOTES:
Winter = November, December, January, February and March; Spring = April and May; Summer = June, July and August; Fall = September and October; W/m² = watts per square metre

Table C-4 Land-use Characterization and Associated Geophysical Parameters for the Spring Season

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.3	0.12	0.7	0.15	0	7	42	Evergreen Forest Land
2	1.3	0.12	0.7	0.15	0	7	42	Evergreen Forest Land
3	1.3	0.12	0.7	0.15	0	7	42	Evergreen Forest Land
4	1	0.12	0.7	0.15	0	7	41	Deciduous Forest Land
5	1	0.12	0.7	0.15	0	7	41	Deciduous Forest Land
6	1	0.1	1	0.15	0	7	43	Mixed Forest Land
7	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
8	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
9	0.05	0.18	0.4	0.15	0	0.5	30	Rangeland
10	0.05	0.18	0.4	0.15	0	0.5	30	Rangeland
11	0.2	0.3	0.5	0.15	0	0	80	Tundra
12	0.2	0.3	0.5	0.15	0	0	80	Tundra
13	0.2	0.3	0.5	0.15	0	0	80	Tundra
14	0.2	0.12	0.1	0.25	0	2	60	Wet Land
15	0.03	0.14	0.3	0.15	0	3	20	Agricultural Land
16	0.3	0.3	3	0.15	0	0.05	70	Barren Land
17	1	0.14	1	0.25	0	0.2	10	Urban or Build-up
18	0.0001	0.12	0.1	1	0	0	50	Water
19	0.2	0.7	0.5	0.15	0	0	90	Snow or Ice

NOTES:
Winter = November, December, January, February and March; Spring = April and May; Summer = June, July and August; Fall = September and October; W/m^2 = watts per square metre

Table C-5 Land-use Characterization and Associated Geophysical Parameters for the summer Season

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m²)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.3	0.12	0.3	0.15	0	7	42	Evergreen Forest Land
2	1.3	0.12	0.3	0.15	0	7	42	Evergreen Forest Land
3	1.3	0.12	0.3	0.15	0	7	42	Evergreen Forest Land
4	1.3	0.12	0.3	0.15	0	7	41	Deciduous Forest Land
5	1.3	0.12	0.3	0.15	0	7	41	Deciduous Forest Land
6	1	0.1	1	0.15	0	7	43	Mixed Forest Land
7	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
8	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
9	0.1	0.18	0.8	0.15	0	0.5	30	Rangeland
10	0.1	0.18	0.8	0.15	0	0.5	30	Rangeland
11	0.2	0.3	0.5	0.15	0	0	80	Tundra
12	0.2	0.3	0.5	0.15	0	0	80	Tundra
13	0.2	0.3	0.5	0.15	0	0	80	Tundra
14	0.2	0.14	0.1	0.25	0	2	60	Wet Land
15	0.2	0.2	0.5	0.15	0	3	20	Agricultural Land
16	0.3	0.28	4	0.15	0	0.05	70	Barren Land
17	1	0.16	2	0.25	0	0.2	10	Urban or Build-up
18	0.0001	0.1	0.1	1	0	0	50	Water
19	0.2	0.7	0.5	0.15	0	0	90	Snow or Ice

NOTES:

Winter = November, December, January, February and March; Spring = April and May; Summer = June, July and August; Fall = September and October; W/m² = watts per square metre

Table C-6 Land-use Characterization and Associated Geophysical Parameters for the Fall Season

NALCMS Code	Surface Roughness (m)	Albedo	Bowen Ratio	Soil Heat Flux (fraction)	Anthropogenic Heat Flux (W/m2)	Leaf Area Index	CALMET Code	CALMET Land Cover Type
1	1.3	0.12	0.8	0.15	0	7	42	Evergreen Forest Land
2	1.3	0.12	0.8	0.15	0	7	42	Evergreen Forest Land
3	1.3	0.12	0.8	0.15	0	7	42	Evergreen Forest Land
4	0.8	0.12	1	0.15	0	7	41	Deciduous Forest Land
5	0.8	0.12	1	0.15	0	7	41	Deciduous Forest Land
6	1	0.1	1	0.15	0	7	43	Mixed Forest Land
7	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
8	0.05	0.25	1	0.15	0	0.5	32	Shrub Rangeland
9	0.01	0.2	1	0.15	0	0.5	30	Rangeland
10	0.01	0.2	1	0.15	0	0.5	30	Rangeland
11	0.2	0.3	0.5	0.15	0	0	80	Tundra
12	0.2	0.3	0.5	0.15	0	0	80	Tundra
13	0.2	0.3	0.5	0.15	0	0	80	Tundra
14	0.2	0.16	0.1	0.25	0	2	60	Wet Land
15	0.05	0.18	0.7	0.15	0	3	20	Agricultural Land
16	0.3	0.28	6	0.15	0	0.05	70	Barren Land
17	1	0.18	2	0.25	0	0.2	10	Urban or Build-up
18	0.0001	0.14	0.1	1	0	0	50	Water
19	0.2	0.7	0.5	0.15	0	0	90	Snow or Ice

NOTES:
Winter = November, December, January, February and March; Spring = April and May; Summer = June, July and August; Fall = September and October; W/m^2 = watts per square metre

C.2.6 METEOROLGICAL INPUTS

The CALMET model requires the input of surface and upper air meteorological fields. For this application, CALMET was initialized with surface station information from three surface weather stations in the domain and with upper air data from the MM5 meso-meteorological model. While this model initialization approach allows for a more accurate depiction of mesoscale wind circulations in the layers aloft than would be provided by using radiosonde data, it simultaneously permits data from surface weather stations to provide valuable localized information and correct the biases that meso-meteorological model data often exhibits in the lower layers.

Hourly output from the MM5 model at 12 km resolution was provided for use in this study by BC MOE. The data was prepared for use in CALMET by using the CALMM5 pre-processor. Observed hourly-averaged meteorological data from surface stations during the modelling period was provided by Environment Canada (EC), British Columbia Ministry of the Environment (BC MOE), BC Forest Service (BCFS) and BC Ministry of transportation (BC MOT). Table C-7 provides a summary of the surface stations used as input. The EC weather station at Kamloops Airport contained all fields necessary as input to CALMET over the period of interest. Thus, the Kamloops Airport Station was the primary surface weather input used for modelling, while the other three stations were used to provide additional weather information near the site location whenever possible.

Table C-7 Input Surface Meteorological Stations

Station Name	Type	Easting (km)	Northing (km)	Elevation (masl)	Surface Input Data Used
Kamloops Airport	EC	680.778	5619.591	345	Wind Speed & Direction, Temperature, Relative Humidity, Cloud Cover & Ceiling Height, Station Pressure, Precipitation
Kamloops Brocklehurst	MOE	683.828	5619.419	347	Wind Speed & Direction, Temperature, Relative Humidity
Afton	BCFS	677.937	5616.525	780	Wind Speed & Direction, Temperature, Relative Humidity, precipitation
Wallopt	MOT	678.720	5600.444	1300	Wind Speed & Direction, Temperature, Relative Humidity, Station Pressure, Precipitation

In addition to hourly surface data, hourly precipitation data from the Kamloops airport, Afton, and Wallopt stations and upper air data from the nearest Kelowna airport was used in CALMET modelling.

C.2.7 CALMET DATA QAQC

As a supplement to Quality Assurance/Quality Control (QA/QC) performed by Levelton (2008) and JWA (2009), Stantec subjected the rework of the Levelton (2008) CALMET to additional QA/QC. Steyn & Ainslie (2012) recommend that to demonstrate that the modelling realistically captures dispersion conditions in Kamloops, the model output should be evaluated "against existing air quality data in the Kamloops Valley, using a known source and pollutant as a test bed". This test has been performed in the past with a known sulphur dioxide source using the Levelton (2008) 500 m resolution CALMET data (JWA, 2009). To test the reworked 250 m resolution CALMET data this same source was re-run with CALPUFF. The results were compared to the original JWA (2009) results and found to be satisfactory.

Stantec's QA/QC also involved the extraction of wind speed and direction data at six locations of interest for comparison between the 500 m and 250 m resolution CALMET data sets. These six locations are depicted in Figure C-2. The comparison between the 500 m and 250 m data sets was accomplished through a direct comparison of wind rose diagrams and cumulative frequency histograms of both wind speeds and stability classes. Below are some selected analysis with the CALMET predicted winds, temperature, stability and mixing height for the period of 2003 to 2005. The selected analysis of meteorological conditions for the Project area were extracted from 2003 to 2005 CALMET (mm5+obs) output for a location in the center of the CALMET domain located near the Tailings Facility (679596 mE, 5610769 mN, UTM 10).

C.2.7.1 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 associated with each wind speed category.*

Figure C-3 illustrates the wind characteristics at the Ajax Tailings Facility: for the previous (Levelton, 2008) and the reworked CALMET data. Both previous and reworked wind roses show predominantly southerly wind directions, with a strong tendency to the south-westerly direction. Winds from the northeast are nearly absent. The cumulative frequency histograms of wind speeds are similar. They are also as expected with the majority of winds in the lower wind speed classes.

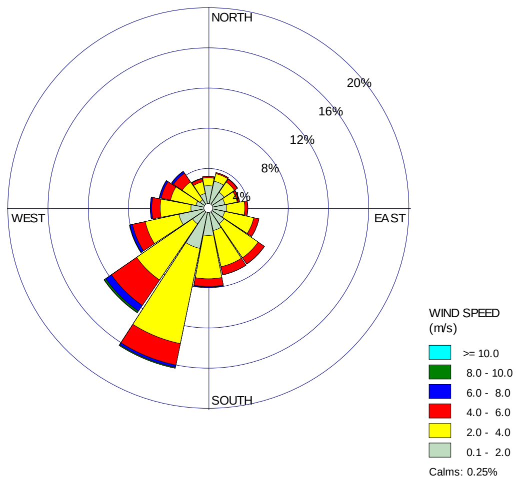
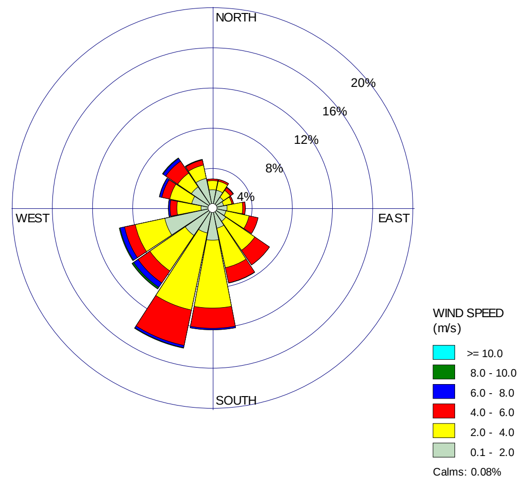
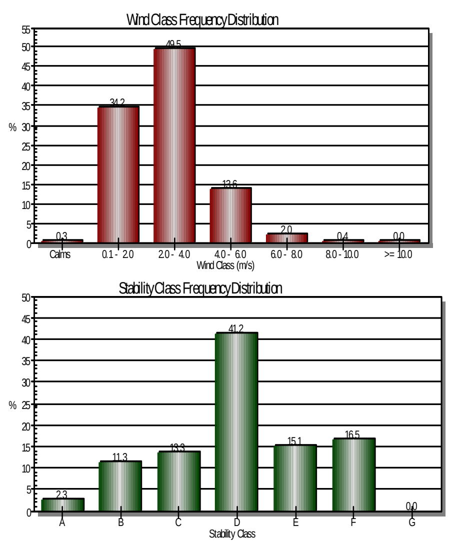
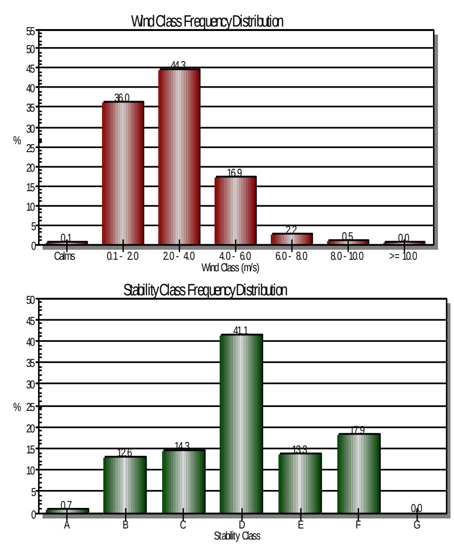
New 250 m grid resolution CALMET Tailings Station (2003–2005)	Levelton 500 m grid resolution CALMET Tailings Station (2003–2005)
	
	

Figure C-3 Comparison of Wind Roses and Wind Speed Frequency Distributions at Tailings Station: New 250 m Grid CALMET vs. Levelton 500 m Grid CALMET

C.2.7.2 Surface Temperature

Figure C-4 shows the modelled monthly average surface temperatures extracted at the project site for the period of 2003 to 2005 along with the monthly climate normal temperature from the Afton Mine Canadian Climate Normals Station (CCNS). The modelled monthly temperatures indicate a reasonable seasonal surface temperature variation and match closely with the climate normal.

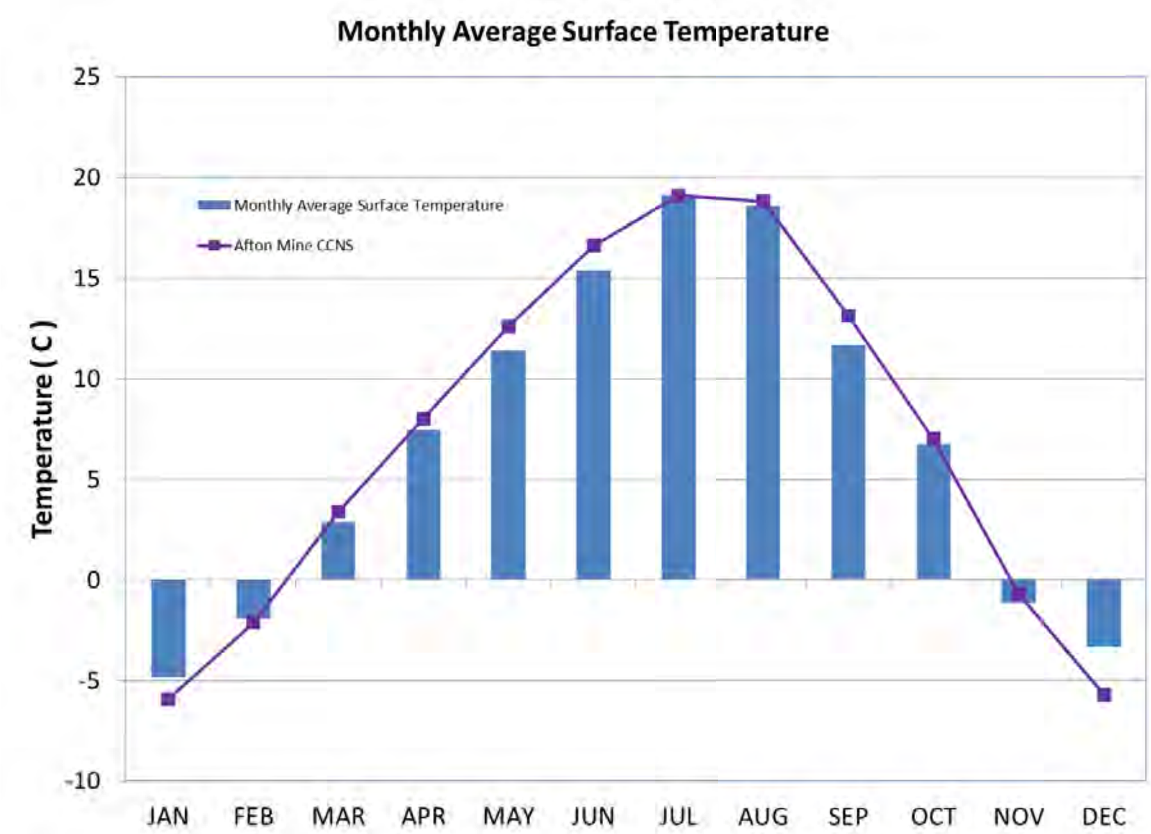


Figure C-4 CALMET Predicted Monthly Average Surface Temperature for the Project Site (2003-2005)

C.2.7.3 Stability and Mixing Heights

Atmospheric turbulence near the earth's surface is often described in terms of atmospheric stability, which is governed by both thermal and mechanical factors. Atmospheric stability can, broadly, be classified as stable, neutral, or unstable.

Stable atmospheric conditions occur when vertical motion in the atmosphere is suppressed. With respect to air quality, this means contaminants emitted near ground-level are not well-dispersed and results in enhanced ambient concentrations. This type of situation frequently occurs at night, when 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 and is often associated with poor air quality conditions.

Unstable atmospheric conditions are also highly dependent on radiation at the earth's surface, and most frequently occur during day-time hours. During such times, as short-wave energy from the sun heats the ground, air in contact with the ground becomes warmer and less dense than the air aloft. Subsequently, vertical motion in the atmosphere is 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 during transition from unstable to stable conditions.

Mechanical mixing, which is mostly a function of lower level wind speeds (and surface roughness), can also influence atmospheric stability. Higher wind speeds (and a greater surface roughness) promote higher levels of turbulence in the region of discussion. This, in turn, leads to more mechanical mixing, which means that the atmosphere becomes more unstable. Mechanical mixing plays a more important role in determining stability during stormy conditions when wind speeds are high and at night, when convective vertical motion is suppressed.

The relative stability of the earth's boundary layer is often expressed in terms of the Pasquill-Gifford-Turner stability classes (Pasquill 1961), as estimated by CALMET at the project site location in Table C-8. The letters A through F each denote a different stability condition and are determined from cloud (or radiation) data as well as wind speeds and time of day. Stability classes are indicated below:

- 1 or A Extremely Unstable Conditions
- 2 or B Moderately Unstable Conditions
- 3 or C Slightly Unstable Conditions
- 4 or D Neutral Conditions (applicable to heavy overcast day or night)
- 5 or E Slightly Stable Conditions
- 6 or F Moderately Stable Conditions

The most frequent stability class is neutral at project site. Moderately stable conditions (class F) occur less frequently in winter than in other seasons due to the strong wind events which occur during this time of year. Unstable conditions occur more frequently during the summer and spring months than during winter and fall as convective conditions are more prominent during summer and spring.

Table C-8 Predicted Seasonal Atmospheric Stability Frequencies (%) for the Project Site for 2003–2005

Pasquill Stability Category	Frequency (%)			
	Winter	Spring	Summer	Fall
A	0.0	2.7	6.7	1.3
B	3.0	11.9	19.0	6.9
C	8.6	16.4	17.7	12.0
D	56.6	35.0	25.4	42.5
E	14.0	13.7	11.4	15.0
F	17.8	20.3	19.9	22.3

The mixing height is the depth of the unstable or neutral air in the atmospheric boundary layer, as influenced by the mechanical and buoyant forces previously described. The height of the mixing layer is an extremely important factor in determining the dispersion of pollution in the atmosphere. Under low mixing heights, a relatively small emission amounts can have a marked effect on local air quality.

The CALMET model calculates a maximum mixing height, as determined by either convective or mechanical forces. The convective mixing height is the height to which an air package will rise under the buoyant forces created by the heating of the earth's surface. The convective mixing height is dependent on solar radiation amount, wind speed, as well as the vertical temperature structure of the atmosphere. Mechanical mixing heights are, similarly, the height to which an air package will rise under the influence of mechanical-invoked turbulence. The mechanical mixing height is proportional to low-level wind speeds and surface roughness.

Diurnal variations of mean mixing height, as estimated by the CALMET model at the project site location are shown for each season in Figure C-5. This figure shows:

- Winter: The mean maximum afternoon values are about 430 m. The mean minimum night values are about 390 m.
- Spring: The mean maximum afternoon values are about 1100 m. The mean minimum night values are about 400 m.
- Summer: The mean maximum afternoon values are about 1250 m. The mean minimum night values are about 400 m
- Fall: The mean maximum afternoon values are about 800 m. The mean minimum night values are about 400 m.

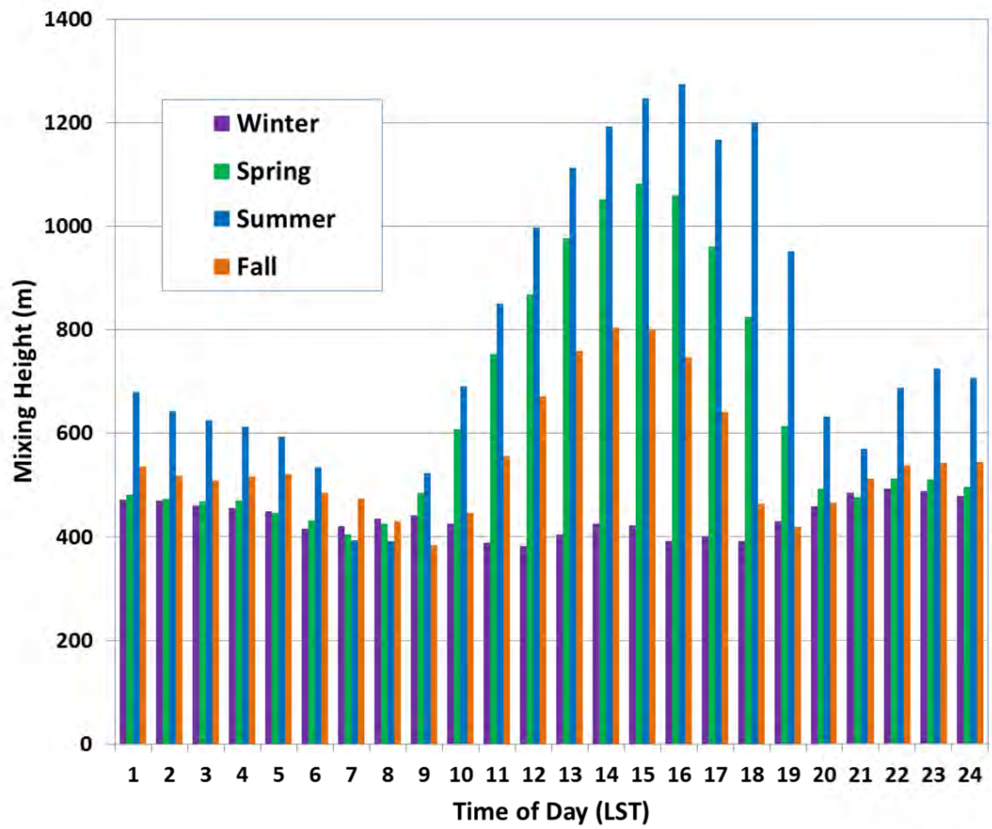


Figure C-5 CALMET Predicted Seasonal Diurnal Mixing Heights at Project Site for 2003 to 2005

C.2.8 CALMET MODEL OPTIONS

Table C-9 provides a detailed summary of all CALMET model user options selected for the mm5+obs modelling done for this study. Model default values, as recommended by the United States Environmental Protection Agency (U.S. EPA 1998), are presented for comparative purposes. In most cases, these default values were used.

Table C-9 CALMET Parameters Used for the KGHM Ajax Project

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 1: General Run Control Parameters	IBYR	–	2003	Starting year
	IBMO	–	1	Starting month
	IBDY	–	1	Starting day
	IBHR	–	0	Starting hour
	IBSEC	–	0	Starting second
	IEYR	–	2005	Ending year
	IEMO	–	12	Ending month
	IEDY	–	31	Ending day
	IEHR	–	22	Ending hour
	IBSEC	–	0	Ending second
	ABTZ	–	8	Time zone
	NSECDT	–	3600	Model Time Step (seconds)
	IRTYPE	1	1	Run type
	LCALGRD	T	T	Special data fields are computer
	ITEST	2	2	Flag to not stop run after setup phase
Group 2: Map Projection and Grid Control Parameters	PMAP	UTM	UTM	Map Projection is UTM
	FEAST	0.0	0.0	False Easting (Not Used)
	FNORTH	0.0	0.0	False Northing (Not Used)
	IUTMZN	–	10	UTM Zone
	UTMHEM	N	N	Northern Hemisphere for UTM Projection
	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	NAR–C	NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
	NX	–	280	Number of X grid cells
	NY	–	220	Number of Y grid cells
	DGRIDKM	–	0.25	Grid spacing in X and Y directions (km)
	XORIGKM	–	650	Reference Easting of SW corner of SW grid cell in UTM (km)
	YORIGKM	–	5590	Reference Northing of SW corner of SW grid cell in UTM (km)
	NZ	–	10	Number of vertical grid cells
	ZFACE	–	0, 20, 40, 80, 160, 300, 500, 1000,1500, 2000,3000	Vertical cell face heights of the NZ vertical layers (m)
Group 3: Output Options	LSAVE	T	T	Save met data in unformatted output files
	IFORMO	1	1	Type of unformatted output file
	LPRINT	F	F	Print meteorological fields
	IPRINF	1	12	Print interval in hours
	IUVOUT	0	0	Do not print u, v wind components
	IWOUT	0	0	Do not print w wind component
	ITOUT	0	0	Do not print 3–D temperature fields
	Specify Meteorological Fields to Print			
	STABILITY	1		Print PGT stability class
	USTAR	0		Do not print friction velocity
	MONIN	0		Do not print Monin–Obukhov length
	MIXHT	1		Print mixing height
	WSTAR	0		Do not print convective velocity scale
	PRECIP	1		Do not print precipitation rate
	SENSHEAT	0		Do not print sensible heat flux
	CONVZI	0		Do not print convective mixing height
	Testing and Debugging Options			
	LDB	F	F	Print input and internal variables
	NN1	1	1	First time step to print data
	NN2	1	1	Last time step to print data
	LDBCST	F	F	Do not print distance to land internal variables
	IOUTD	0	0	Control variable to note write test data to disk
	NZPRN2	1	0	Number of levels to print
	IPR0	0	0	Do not print interpolated wind components

Table C-9 CALMET Parameters Used for the KGHM Ajax Project

Input Group	Parameter	USEPA Default	Value Used	Selection Description
Group 3: Output Options (cont'd)	IPR1	0	0	Do not print the terrain adjusted wind components
	IPR2	0	0	Do not print smoothed wind components and initial divergence fields
	IPR3	0	0	Do not print final wind speed and direction
	IPR4	0	0	Do not print final divergence fields
	IPR5	0	0	Do not print winds after kinematic effects are added
	IPR6	0	0	Do not print winds after the Froude number adjustment
	IPR7	0	0	Do not print wind after slope flow adjustment
	IPR8	0	0	Do not print final wind field components
Group 4: Meteorological Data Options	NOOBS	0	0	Use surface, overwater, and upper air stations
	NSSTA	–	4	Number of surface stations
	NPSTA	–	3	Number of precipitation stations
	ICLOUD	0	0	Gridded cloud data not used
	IFORMS	2	2	Surface meteorological data file format
	IFORMP	2	2	Precipitation data file format
	IFORMC	2	2	Cloud data file format
Group 5: Wind Field Options and Parameters	IWFCOD	1	1	Wind field diagnostic model selected
	IFRADJ	1	1	Use Froude number adjustment
	IKINE	0	0	Do not use Kinematic effects adjustment
	IOBR	0	0	Use O'Brien procedure to adjust vertical velocity
	ISLOPE	1	1	Compute slope flow effects
	IEXTRP	–4	–4	Extrapolate surface wind data to upper layers using similarity theory.
	ICALM	0	0	Do not extrapolate surface winds if calm
	BIAS	10*0	–1,–1,–1,–1,–1,–1, 0.5, 1,1,1	Layer dependent bias in vertical interpolation between surface and upper air data in first guess field. Prognostic data is used, therefore the model ignores this option.
	RMIN2	–1	–1	Minimum distance from nearest upper air station to surface station for which extrapolation of surface winds at surface station be allowed. Not Used if NOOBS=1
	IPROG	0	14	Use gridded prognostic wind field model output as input to the diagnostic wind field model
	ISTEPPG	1	1	Time step (hours) of input prognostic data
	IGFMET	0	0	Use coarse CALMET fields as initial guess fields
	LVARY	F	F	Use varying radius of influence. If no stations are found within RMAX1, RMAX2, or RMAX3, then the closest station will be used.
	RMAX1	–	3	Maximum radius of influence over land in the surface layer (km)
	RMAX2	–	4	Maximum radius of influence over land aloft (km)
	RMAX3	–	0.1	Maximum radius of influence over water (km)
	RMIN	0.1	0.1	Minimum radius of influence used in the wind field interpolation (km)
	TERRAD	15	4	Radius of influence of terrain features (km)
	R1	–	1	Relative weighting of the first guess field and observations in the surface layer (km)
	R2	–	1.5	Relative weighting of the first guess field and observations in the upper layer (km)
	RPROG	–	0	Relative weighting of the prognostic wind field data (km) (Not Used)
	DIVLIM	5 E–6	5 E–6	Maximum acceptable divergence in divergence minimization procedure
	NITER	50	50	Maximum number of iterations in the divergence minimization procedure
	NITER2	99*10	99*10	Maximum number of stations used in each layer for the interpolation of data to a grid point
	NSMTH	2, (nz – 1)*4	2,9*4	Number of passes in the smoothing procedure
	CRITFN	1	1	Critical Froude number
	ALPHA	0.1	0.1	Empirical factor controlling Kinematic effects
	FEXTR2	0*10	0*10	Multiplicative scaling factor for extrapolation of surface observations to upper layers (Not Used)
	NBAR	0	0	Number of barriers to interpolation of wind
	KBAR	NZ	10	Level (1 to NZ) up to which barriers apply
Group 5: Wind Field Options and Parameters (cont'd)	XBBAR	–	0	X coordinate of beginning of barrier (Not Used)
	YBBAR	–	0	Y coordinate of beginning of barrier (Not Used)
	XEBAR	–	0	X coordinate of end of barrier (Not Used)
	YEBAR	–	0	Y coordinate of end of barrier (Not Used)
	IDIOPT1	0	0	Computer surface temperature internally from surface monitoring data for Diagnostic Wind Module

Table C-9 CALMET Parameters Used for the KGHM Ajax Project

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	ISURFT	–	1	Surface meteorological station to use for the surface temperature in Diagnostic Wind Module
	IDIOPT2	0	0	Domain–averaged temperature lapse rate computed internally from upper air soundings
	IUPT	–	1	Upper air station to use for the domain–scale lapse rate (not used).
	ZUPT	200	200	Depth through which the domain–scale lapse rate is computer (m)
	IDIOPT3	0	0	Domain–averaged wind components calculated internally
	IUPWND	–1	–1	Upper air station to use for the domain scale winds
	ZUPWND	1, 1000	1, 1000	Bottom and top of layer through which domain–scale winds are computed (m)
	IDIOPT4	0	0	Observed surface wind components read from surface data file
	IDIOPT5	0	0	Observed upper wind components read from upper air data file
	LLBREZE	F	F	Do not use lake breeze module
	NBOX	–	0	Number of lake breeze regions
	XG1	–	0	X grid line 1 of region of interest
	XG2	–	0	X grid line 2 of region of interest
	YG1	–	0	Y grid line 1 of region of interest
	YG2	–	0	Y grid line 2 of region of interest
	XBCST	–	0	X point defining coast line
	YBCST	–	0	Y point defining coast line
	XECST	–	0	X point defining coast line
	YECST	–	0	Y point defining coast line
	NLB	–	0	Number of station in the region
	METBXID	–	0	Station's ID in the region
Group 6: Mixing Height, Temperature and Precipitation	CONSTB	1.41	1.41	Empirical mixing height equation constant, neutral conditions
	CONSTE	0.15	0.15	Empirical mixing height equation constant, convective conditions
	CONSTN	2400	2400	Empirical mixing height equation constant, stable conditions
	CONSTW	0.16	0.16	Empirical mixing height equation constant, over water conditions
	FCORIO	1.0E–4	1.0E–4	Coriolis Parameters, adjusted for latitude
	IAVEZI	1	1	Use spatial averaging of mixing heights
	MNMDAV	1	2	Maximum search radius (grid cells)
	HAFANG	30	30	Half–angle upwind looking cone for averaging
	ILEVZI	1	1	Layer of winds used in upwind averaging
	IMIXH	1	1	Use the Maul–Carson method for land and water cells to compute convective mixing height
	THRESHL	0.0	0	Threshold buoyancy flux to sustain convective mixing height growth overland (W/m^2)
	THRESHW	0.05	0.05	Threshold buoyancy flux to sustain convective mixing height growth overwater (W/m^2)
	ITWPROG	0	0	Use SEA.DAT to determine overwater lapse rates and deltaT (or assume neutral conditions if missing)
	ILUOC3D	16	16	Land Use category for ocean in 3D.DAT datasets
	DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in the stable layer above the current convective mixing height (K/m)
	DZZI	200	200	Depth of layer above current convective mixing height through which lapse rate is computed (m)
	ZIMIN	50	50	Minimum overland mixing height (m)
	ZIMAX	3000	3000	Maximum overland mixing height (m)
	ZIMINW	50	50	Minimum over water mixing height (m)
	ZIMAXW	3000	3000	Maximum over water mixing height (m)
Group 6: Mixing Height, Temperature and Precipitation (cont'd)	ICOARE	10	10	COARE Method with no wave parameterization used to determine overwater surface flux
	DSHELF	0	0	Coastal/Shallow water length scale (km)
	IWARM	0	0	COARE warm layer computation turned off
	ICOOL	0	0	COARE cool skin layer computation turned off
	IRHPROG	0	0	Relative humidity from surface observations
	ITPROG	0	1	Compute surface temperatures from observed stations, upper air temperatures from MM5 data
	IRAD	1	1	Use 1/R interpolation scheme
	TRADKM	500	500	Radius of influence for temperature interpolation (km)
	NUMTS	5	5	Maximum number of stations to include in interpolation
	IAVET	1	1	Use spatial averaging of temperature data
	TGDEFB	–0.0098	–0.0098	Default temperature gradient below the mixing height, over water (K/m)

Table C-9 CALMET Parameters Used for the KGHM Ajax Project

Input Group	Parameter	USEPA Default	Value Used	Selection Description
	TGDEFA	–0.0045	–0.0045	Default temperature gradient above the mixing height, over water (K/m)
	JWAT1	–	999	Beginning land use category for temperature interpolation over water. Make bigger than largest land use to disable.
	JWAT2	–	999	Ending land use category for temperature interpolation over water. Make bigger than largest land use to disable.
	NFLAGP	2	2	Use 1/R^2 interpolation scheme for precipitation interpolation
	SIGMAP	100	100	Radius of influence for interpolation from precipitation stations (km)
	CUTP	0.01	0.01	Minimum precipitation rate cut off (mm/hr)

Input Group	Surface Meteorological Stations Used					
Group 7: Surface meteorological station parameters	**Name**	**ID**	**X Coordinate (km)**	**Y Coordinate (km)**	**Time Zone**	**Anemometer Height (m)**
	Airp	1111	680.778	5619.591	8	10
	Broc	2222	683.828	5619.419	8	20
	Aftn	3333	677.937	5616.525	8	10
	Wall	4444	678.720	5600.444	8	8

Input Group	Upper Air station Used			
Group 9: Upper Air Meteorological Station Parameters	**Name**	**ID**	**X Coordinate (km)**	**Y Coordinate (km)**
	KELO	94151	759.567	5541.578
	Precipitation Stations Used			
	Name	**ID**	**X Coordinate (km)**	**Y Coordinate (km)**
	Aftn	3333	677.937	5616.525
	Wall	4444	678.720	5600.444
	Airp	1111	680.778	5619.591

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APPENDIX D
THE CALPUFF MODEL AND MODELLING METHODS

Appendix D–The CALPUFF Model and Modelling Methods

August 21, 2015

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Appendix D THE CALPUFF MODEL AND MODELLING METHODS

D.1 INTRODUCTION

This appendix provides technical details and assumptions regarding the application of the CALPUFF modelling system used to investigate the air quality changes due to the proposed KGHM AJAX project (the Project). What follows is an overview of the initialization and parameterization of CALPUFF, a technical description of the model, Project specific information that is applied in CALPUFF, and an analysis of model performance.

D.2 CALPUFF MODELLING

For a Level 3 assessment that involves assessing ambient air quality changes in complex terrain, the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (the *Guidelines*) (BC MOE 2008) recommend a puff air quality simulation model. As per Section 2.3.2.3 of the *Guidelines* (BC MOE 2008), the CALPUFF model system employed in the assessment is as follows:

- CALPUFF Version 6.262 (Level: 080725), an air quality dispersion model

The version of CALPUFF sited in **Appendix B**, the Ajax Mining Project Detailed Model Plan (Stantec, 2015), is incorrect and the correct version used in this modelling assessment is CALPUFF Version 6.262.

All default CALPUFF input model options recommended in the *Guidelines* (BC MOE 2008) are applied.

D.2.1 MODEL DESCRIPTION

The core of the CALPUFF model system consists of a meteorological model CALMET, and a transport and dispersion model CALPUFF. Appendix C discusses the CALMET meteorological model in detail.

The CALMET meteorological model provides the meteorological data necessary to initialize the CALPUFF dispersion model. Terrain and land use data describing the region of interest, as well as meteorological input from numerous sources are used to initialize the model. Various user-defined parameters control the input meteorological data interpolation to the grid, as well as the application of the internal algorithms to the input fields. The following sections provide more details regarding these options. Output from the CALMET model includes hourly temperature and wind fields on a user-specified three-dimensional domain as well as additional two-dimensional variables used by the CALPUFF dispersion model.

CALPUFF is a non-steady-state Gaussian puff dispersion model capable of simulating the effects of time and space-varying meteorological conditions on contaminant transport, dispersion, transformation, and removal (Scire et al. 2000a). This model requires time-variant two- and three-dimensional meteorological data output from CALMET, as well as information regarding the relative location and nature of the emission sources modelled. The following sections provide a discussion of the available and implemented model options. All recommended default CALPUFF model options in the *Guidelines* (BC MOE 2008) are applied. Output from the CALPUFF model includes ground-level concentrations of the contaminant species considered, as well as dry and wet deposition fluxes.

Table D-1 summarizes the major features and options of the CALPUFF model. Some of the technical algorithms are described below. Table D-4 to Table D-8 shows the modelling options enabled for the Project dispersion simulations.

Table D-1 Summary of Major Features of CALPUFF

Source Types • Point sources (constant or variable emissions) • Line sources (constant or variable emissions • Volume sources (constant or variable emissions) • Area sources (constant or variable emissions)
Non-steady-state emissions and meteorological conditions • Gridded 3-D fields of meteorological variables (winds, temperature) • Spatially-variable fields of mixing height, friction velocity, convective velocity scale, Monin-Obukhov length, precipitation rate • Vertically and horizontally-varying turbulence and dispersion rates • Time-dependent source and emissions data
Efficient sampling functions • Integrated puff formulation • Elongated puff (slug) formulation
Dispersion coefficient (σ_y, σ_z) options • Direct measurements of σ_v and σ_w • Estimated values of σ_v and σ_w bases on similarity theory • Pasquill-Gifford (PG) dispersion coefficients (rural areas) • McElroy-Pooler (MP) dispersion coefficients (urban areas) • CTDM dispersion coefficients (neutral/stable)
Vertical wind shear • Puff splitting • Differential advection and dispersion

Table D-1 Summary of Major Features of CALPUFF

Plume rise

- Partial penetration
- Buoyant and momentum rise
- Stack tip effects
- Vertical wind shear
- Building downwash effects

Building downwash

- Huber-Snyder method
- Schulman-Scire method

Subgrid scale complex terrain

- Dividing streamline, H_d:
  - Above H_d, puff flows over the hill and experiences altered diffusion rates
  - Below H_d, puff deflects around the hill, splits, and wraps around the hill

Interface to the Emissions Production Model (EPM)

- Time-varying heat flux and emissions from controlled burns and wildfires

Dry Deposition

- Gases and particulate matter
- Three options:
  - Full treatment of space and time variations of deposition with resistance model
  - User-specified diurnal cycles for each pollutant
  - No dry deposition

Overwater and coastal interaction effects

- Overwater boundary layer parameters
- Abrupt change in meteorological conditions, plume dispersion at coastal boundary
- Plume fumigation
- Option to introduce subgrid scale Thermal Internal Boundary Layers (TIBLs) into coastal grid cells

Chemical transformation options

- Pseudo-first-order chemical mechanism for SO_2, $SO_4^{=}$, NO_x, HNO_3, and NO_3^{-} (MESOPUFF II method)
- User-specified diurnal cycles of transformation rates
- No chemical conversion

Wet Removal

- Scavenging coefficient approach
- Removal rate a function of precipitation intensity and precipitation type

Graphical User Interface

- Point-and-click model setup and data input
- Enhanced error checking of model inputs
- On-line Help files

Chemical Transformation: CALPUFF includes options for parameterizing chemical transformation effects using the five species scheme (SO_2, SO, NO_X, HNO_3, and NO) employed in the MESOPUFF II model, the six species RIVAD/ARM3 scheme, or a set of user-specified, diurnally-varying transformation rates. The RIVAD/ARM3 reactions separately model NO and NO_2 rather than NO_X.

Calculations of chemical transformations require, among other information, knowledge of background concentrations of ozone (O_3) and ammonia.

Subgrid Scale Complex Terrain: The complex terrain module in CALPUFF is based on the approach used in the Complex Terrain Dispersion Model (CTDMPLUS) (Perry et al., 1989). Plume impingement on subgrid scale hills is evaluated using a dividing streamline (Hd) to determine which contaminant material is deflected around the sides of a hill (below Hd) and which material is advected over the hill (above Hd). Individual puffs are split in up to three sections for these calculations.

Puff Sampling Functions: A set of accurate and computationally efficient puff sampling routines are included in CALPUFF, which solve many of the computational difficulties with applying a puff model to near-field releases. For near-field applications during rapidly varying meteorological conditions, an elongated puff (slug) sampling function can be used. An integrated puff approach is used during less demanding conditions. Both techniques reproduce continuous plume results exactly under the appropriate steady state conditions.

Wind Shear Effects: CALPUFF contains an optional puff-splitting algorithm that allows vertical wind shear effects across individual puffs simulated. Differential rates of dispersion and transport occur on the puffs generated from the original puff, which under some conditions can substantially increase the effective rate of horizontal growth of the plume.

Building Downwash: Both the Huber-Snyder and Schulman-Scire downwash models are incorporated into CALPUFF. An option is provided to use either model for all stacks, or make the choice on a stack-by-stack and wind sector-by-wind sector basis. Both algorithms are implemented in such a way as to allow the use of wind direction specific building dimensions.

Overwater and Coastal Interaction Effects: Because the CALMET meteorological model contains overwater and overland boundary layer algorithms, the effects of water bodies on plume transport, dispersion, and deposition can be simulated with CALPUFF. The puff formulation of CALPUFF is designed to handle spatial changes in meteorological and dispersion conditions, including the abrupt changes that occur at the coastline of a major body of water.

Dispersion Coefficients: Several options are provided in CALPUFF for the computation of dispersion coefficients. These include the use of turbulence measurements (σ_v and σ_w), the use of similarity theory to estimate σ_v and σ_w from modelled surface heat and momentum fluxes, the use of Pasquill-Gifford (PG) or McElroy-Pooler (MP) dispersion coefficients, or dispersion equations based on the Complex Terrain Dispersion Model (CTDM). Options for an averaging time correction or surface roughness length adjustment to the PG coefficients are available.

Dry 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 contaminant species. Options are provided to allow user-specified, diurnally varying deposition velocities to be used for one or more contaminants instead of the resistance model (e.g., for sensitivity testing) or to by-pass the dry deposition model completely.

Wet Deposition: 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 contaminant and precipitation type (i.e., frozen vs. liquid precipitation).

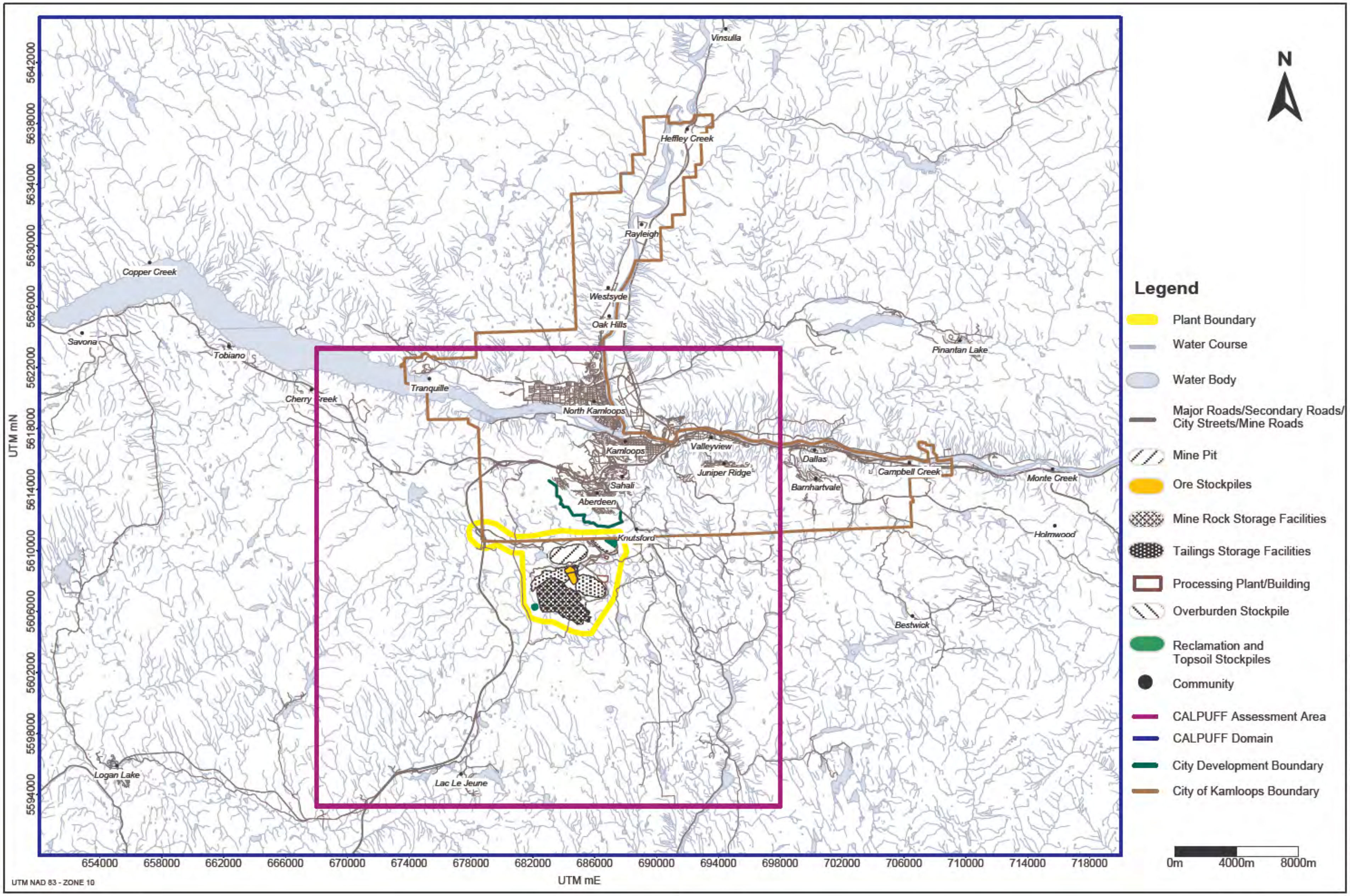
D.2.2 MODEL INITIALIZATION

D.2.2.1 Computational Domain

CALPUFF is used to conduct dispersion modelling over a computational domain that is identical to the CALMET meteorological grid (defined in Appendix C). The CALMET domain covers a 70 km x 55 km area (also called the CALPUFF domain). However, the sub-area 30 km x 30 km centered to the proposed Ajax project was used for conducting CALPUFF modeling results analysis due to available background non-industrial sources (called CALPUFF assessment area). Table D-2 shows CALMET domain and CALPUFF assessment area. Figure D-1 illustrates the computational CALPUFF assessment area as the subset of the meteorological domain.

Table D-2 Location of CALPUFF Assessment Area Relative to the Meteorological CALMET Grid

Location of computation grid	Easting (m)	Northing (m)
CALMET Domain		
Southwest Corner	650000	5590000
Northwest Corner	650000	5645000
Northeast Corner	720000	5645000
Southeast Corner	720000	5590000
CALPUFF Assessment Area		
Southwest Corner	668000	5593250
Northwest Corner	668000	5623250
Northeast Corner	698000	5623250
Southeast Corner	698000	5593250



KGHM Ajax Air Quality Assessment
Technical Data Report

Location of CALPUFF Domain and the CALPUFF Assessment Area

PREPARED BY
Stantec

PREPARED FOR
KGHM

FIGURE NO.
D-1

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D.2.2.2 Meteorological Data

Meteorological data such as mixing heights, stability and winds determine the transport and dispersion of contaminants within the CALPUFF model. To capture puff behavior under a variety of meteorological conditions, three years of modelling was considered for this application. Hourly three-dimensional meteorological fields for the 2003, 2004, and 2005 were prepared using the CALMET model, as described in Appendix C. One year of meteorological data, year 2003, was chosen instead of 3 years of data (2003, 2004, and 2005) based on sensitivity tests that showed that year 2003 predicted greater maximum concentrations for the majority of the contaminants.

D.2.2.3 Emissions and Source Characteristics

CALPUFF was used to model the dispersion of emissions from the source combinations specified for construction and an operations year of the Project. Appendix E discusses rates of emission for each species of concern as well as source characteristics used in the modelling.

D.2.2.4 Plant Boundary

The plant boundary, as defined in Section 6.3 of the *Guidelines* (BC MOE 2008) is a line of receptors that demarcates the areas governed by public versus worker exposure criteria. Often the highest predicted concentrations and/or deposition rates are observed on the plant boundary. Within the plant boundary, meeting occupational health and safety criteria are of primary importance. The British Columbia Ambien Air Quality Objectives (BC AAQO) are often applied to areas where there is public access (e.g., on and beyond the plant boundary). Section 6.3 of the *Guidelines* (BC MOE 2008) describes the criteria used to determine the plant boundary.

Setting the plant boundary for a mine is less straightforward than for a fenced facility such as a pulp mill. In the instance of a fenced mill, the facility fenceline defines where public access is restricted. Mines are not generally fenced; however public access is often discouraged or prohibited due to safety concerns. The plant boundary was determined based on the advice in Section 6.3 of the *Guidelines* (BC MOE 2008). Receptor spacing along the plant boundary is set at 20 m intervals. Specifically, the plant boundary is defined by:

- The perimeter of disturbed area that defines where public access is restricted
- The perimeter along a road allowance if a public access road passes through the plant boundary

The west plant boundary is defined by the road allowance of Lac Le Jeune Road except where the access road joins Highway 5. The southern and eastern project boundaries are defined as the perimeter of the mines existing and proposed disturbed area. Generally this includes a buffer of approximately 500 m from the edge of features like the mine pit, mine rock storage facilities, ore stockpiles, tailings impoundment, and access road.

D.2.2.5 Receptor Grids

For the modelling approach there are two sets of grids. One is the air quality grid consisting of nested Cartesian grids with spacing defined by the *Guidelines* (BC MOE, 2008). Figure D-2 shows the air quality receptor grid at the spacing specified by the *Guidelines*. The nested Cartesian grids have an increasing receptor density with increasing proximity to the Project sites. Receptors are included both inside and outside the plant boundary.

The secondary set of grids is the special receptor grid. Special receptors are locations of human and ecological importance: sensitive ecosystems (e.g., a lake), nearby homes, and places frequented by sensitive sub-populations of the community (e.g., children, the elderly, and those under medical care). These later locations include schools, medical treatment facilities, daycare facilities, and retirement homes.

The deposition and air contaminant concentration data for the point of maximum impingement will also be predicted for the Human Health and Ecological Risk Assessment (HHERA); the logic being that ecological receptors or sensitive populations may also be present at that location, despite being unanticipated.

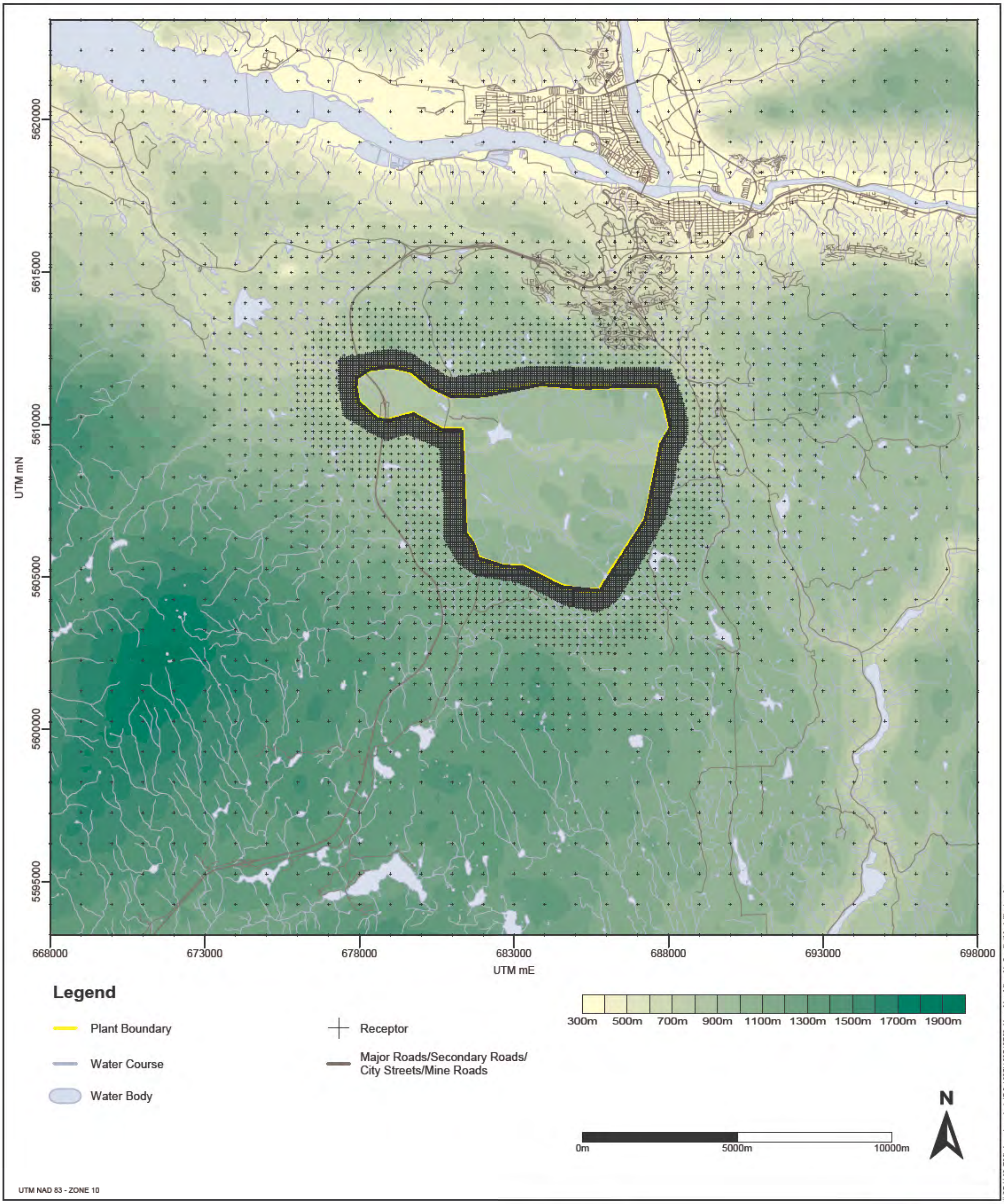
Stantec prepared a list of 209 special discrete receptors for modelling metals and other chemical species. They include 21 nearby residences (also designated as noise receptors), the Royal Inland Hospital, 21 elementary schools, 6 secondary schools, and 110 daycare facilities, 23 retirement homes, 3 miscellaneous receptors, 11 air quality monitoring stations, and 13 dustfall monitoring stations (Figure D-3, Table D-3). There are also 841 HHERA special receptors on a 1 km x 1 km grid across the 30 km x 30 km domain, a 100 m x 100m spaced grid inside the plant boundary, 50 m x 50 m grid across Jack Lake, and a 20 m x 20 m spaced grid along Jacko Lake Road (Figure D-4).

Table D-3 outlines the grids and their corresponding receptor spacing.

Table D-3 Receptor Grids

Grid Name	Receptor Grid Description	Distance Relative to Mine Boundary	Spacing (m)
Air quality	Outside Plant boundary	Beyond 5 km	1000
		Within 5 km	500
		Within 2 km	250
		Within 500m	50
	Along Plant boundary	Inside	20
Special	Inside Mine Boundary	Inside	100
	Along Jacko Lake Road	Inside	20
	Jacko Lake Area	Inside	50
	HHERA	30 km from center of mine boundary	100
	209 Discrete special receptors	Throughout the regional assessment area	—

The above receptor grids result in 14,656 receptors in the air quality grid and 5366 receptors in the special grid.



KGHM Ajax Air Quality Assessment

Air Quality Receptor Grid

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FIGURE NO. D-2

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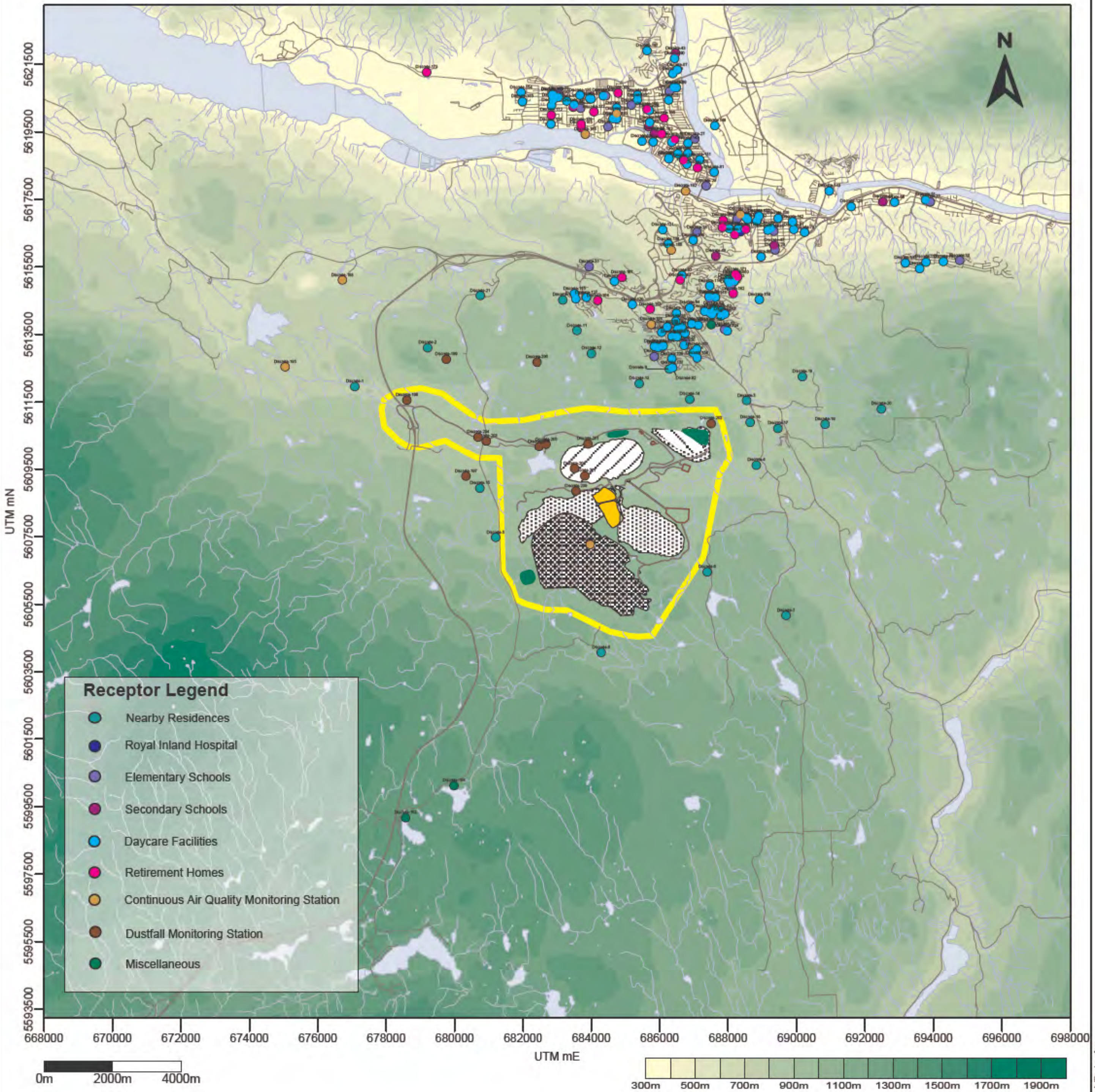
Last Modified: 02/12/2015 By: sbanholzer



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Waste Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Special Discrete Recptors

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FIGURE NO. D-3

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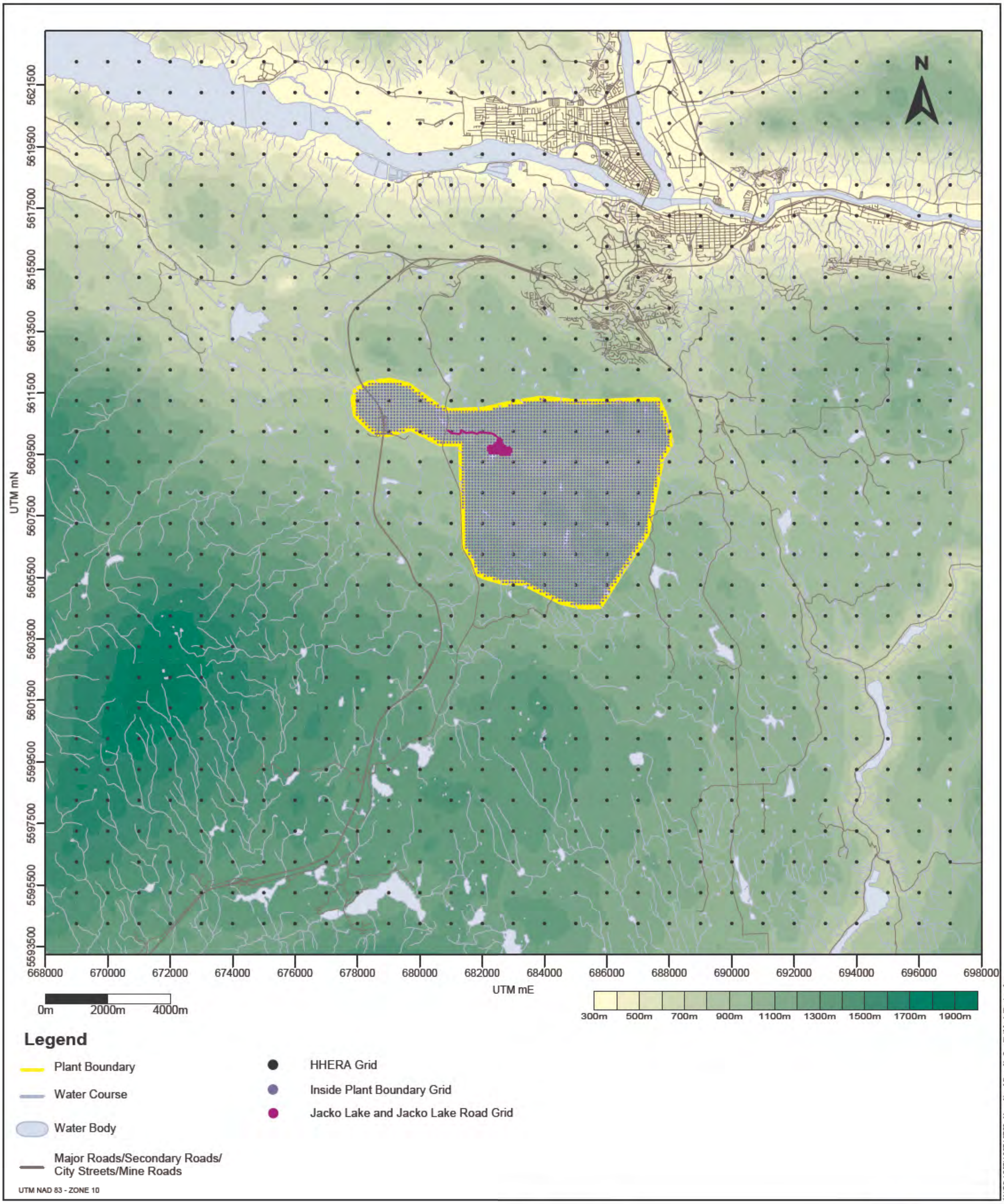

KGHM Ajax Air Quality Assessment

Special HHERA and Inside Plant Boundary Receptor Grids

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FIGURE NO.
D-4

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Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Noise \ Residential	1	Residence	677081	5611958
	2	Residence	679209	5613105
	3	Residence	688538	5611542
	4	Residences	688824	5609617
	5	Residence	681197	5607480
	6	Residences	687390	5606458
	7	Residence	689692	5605170
	8	Residence	684290	5604072
	9	Aberdeen Development	686283	5612470
	10	CDB1	683168	5614516
	11	CDB2	683582	5613613
	12	CDB3	684006	5612929
	13	CDB4	685402	5612040
	14	CDB5	686880	5611577
	15	New Noise21 Residence	680734	5608934
	16	New Noise22 Residence	688644	5610892
	17	New Noise23 Residences	689454	5610713
	18	New Noise24 Residence	690170	5612246
	19	New Noise25 Residence	690834	5610838
	20	New Noise26 Residence	692479	5611288
	21	New Noise27 Residences	680747	5614653
Health	22	Royal Inland Hospital	688351	5616532
Elementary	23	Henry Grube Education Centre	687359	5617899
	24	Twin River Education Centre	684491	5619646
	25	AE Perry Elementary	685173	5620289
	26	Aberdeen Elementary	686751	5613270
	27	Arthur Hatton Elementary	687029	5619288
	28	Beattie School of Arts, McGill Road	687090	5616521
	29	Beattie School of Arts, 9 Ave.	689372	5615998
	30	Bert Edward Science and tech School	686278	5620691
	31	Dufferin Elementary	683939	5615505

Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Elementary (cont'd)	32	George Hilliard Elementary	684423	5620563
	33	Juniper Ridge Elementary	694765	5615690
	34	Kay Bingham Elementary	683689	5620195
	35	Lloyd George Elementary	689335	5616553
	36	Marion Schilling Elementary	693910	5617421
	37	McGowan Park Elementary	687900	5613647
	38	Pacific Way Elementary	685839	5612841
	39	Parkcrest Elementary	683055	5620626
	40	South Sa-hali Elementary	688072	5614905
	41	Stuart wood Elementary	688259	5616915
	42	Summit Elementary	687462	5614575
	43	Westmount Elementary	686463	5621825
Secondary	44	Brocklehurst Secondary	683476	5620224
	45	Norkam Secondary	685679	5619650
	46	Sa-Hali Secondary	687639	5615818
	47	South Kamloops Secondary	689348	5616129
	48	Valleyview Secondary	692522	5617423
	49	Kamloops Christian School	685848	5619446
Daycare	50	Between Friends Out of School Care	688140	5615190
	51	Kiddies Korner & Fun & Learning	693769	5617478
	52	Sixth Avenue Childcare	688834	5616855
	53	Summit Childcare	688183	5615068
	54	TLC Family Daycare	685697	5620127
	55	R.M.S. Horticultural Program	685350	5620587
	56	Children's Circle Daycare Society	688297	5616626
	57	Big Adventures After School Care	686797	5618536
	58	Sandy's Family Daycare	687530	5614088
	59	Young Care	688963	5615794
	60	T.J.'S Day Care	686383	5621218
	61	Caroline's Kids Daycare	682839	5620273
	62	Little Munchkins Family Daycare	685842	5613144
	63	Play And Learn Child Care	687129	5613770
	64	Cactus Kidz Play Care	687442	5614623

Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Daycare (cont'd)	65	Chris Rose Therapy Centre for Autism	685707	5619776
	66	Playtime Daycare	692864	5617412
	67	Kamloops Child Development Centre	686269.	5618724
	68	Tots & Teddies	683549	5614551
	69	Treasure Island Family Child Care	687575	5614253
	70	Giggles & Grins Family Daycare	686741	5613531
	71	The Treasure Chest Family Childcare	686645	5613712
	72	Juniper Joyce's Home Away From Home	694289	5615655
	73	Kids Time Childcare Ltd	688032	5616631
	74	Magpie Corners Family Daycare	687477	5614134
	75	Building Blocks Childcare	686263	5620437
	76	Magical Moments Family Daycare	686490	5614123
	77	Brock Kids Care	683953	5620491
	78	Sheila's Family Daycare	690232	5616520
	79	Kamloops Christian School Association/Kamloops	685811	5619197
	80	Janet's Home Daycare	689251	5616642
	81	Small Steps Family Daycare	687591	5618303
	82	Hollyburn Early Learning Centre	687799	5614191
	83	Tender Care Family Daycare	686468	5613887
	84	Aberdeen Adventure Club	686980	5612952
	85	Brock Licensed Family Daycare Play and Learning Academy	683283	5620407
	86	Laugh And Learn Childcare	693597	5615446
	87	Small Blessings Family Childcare Ltd	686516	5621335
	88	Karen's Family Daycare	685352	5620442
	89	Over The Raynebow Family Daycare	686488	5620804
	90	Just Horsin Around Daycare	686435	5621670
	91	Kidz R Us Daycare	689919	5616604
	92	Enriched Daycare	686380	5612508
	93	Little Acorn Childcare	684636	5619890
	94	Everyday Adventures Dayhome	686876	5614286
	95	The Courtyard Child Care	687998	5615113
	96	Cradles To Crayons Licensed Family Childcare	687795	5614044

Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Daycare (cont'd)	97	Lil' Foot Childcare	686651	5615246
	98	Mr. Miller's Learning Adventures	687605	5614212
	99	Little Peeps Daycare	684676	5615071
	100	G's Daycare	682883	5620443
	101	Pitter Patter Daycare	686410	5620812
	102	M & M Family Child Care	683040	5620519
	103	Little Lions Family Child Care	684746	5619880
	104	Cuddlebear Family Daycare	684000	5620472
	105	Happy Faces Family Childcare	683499	5620299
	106	Enriched Daycare Inc.	686980	5616289
	107	Leandra's Lil' Explorers Daycare	685629	5621901
	108	Desert Palms	686357	5612779
	109	Kamloops Village Garden Montessori Early Learning Centre	686933	5613806
	110	Happy Honeybees Child Care	684350	5620561
	111	Le Jardin D'olivia Rose	686519	5613655
	112	Crackerjacks Family Daycare	684743	5620209
	113	Little Lamb Daycare	687314	5614179
	114	Moving Mountains Childcare	687463	5614934
	115	Sunnyside Daycare	683509	5614705
	116	Kamloops Kids Early Learning Center Inc.	688034	5615026
	117	Kid Zone Dayhome	693782	5615636
	118	Destiny's Child	685949	5613109
	119	My World of Discovery Daycare and Preschool	686058	5613558
	120	Creative Beginnings Daycare and Preschool	685202	5614383
	121	TRU daycare	686089	5616597
	122	Children's Circle Childcare and development Society	688897	5617005
	123	Kamloops Montessori Academy	686362	5613436
	124	Sahali Montessori Preschool And Kindergarten	687975	5613599
	125	Fun Learning Out Of School/Kamloops Kidz Early Learning Center/River City Gymnastics	691597	5617280
	126	Kamloops Community YMCA-YWCA Child Care Services	688571	5616900
	127	Kamloops Kidz Early Learning Center (Pineview Campus)	683857	5614592

Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Daycare (cont'd)	128	Kamloops United Church Preschool	688523	5616955
	129	Kim Care	682872	5620596
	130	Aberdeen Hills Montessori Preschool	686709	5613174
	131	Association Francophone De Kamloops	687174	5618669
	132	Bonnie's Daycare	686824	5618865
	133	Boys And Girls Club Of Kamloops - McArthur Island	685485	5619218
	134	Cariboo Child Care Society	686252	5616180
	135	Chris Child Care	683672	5620582
	136	Dolphin Preschool	686351	5619191
	137	Enriched Daycare Phase 2	686362	5612511
	138	Fun And Fancy Free Family Daycare	682822	5619724
	139	Little Ducklings Childcare	689460	5616936
	140	Little Fawn Daycare	690956	5617744
	141	Little League Family Child Care	686103	5613156
	142	Little Learners Preschool	689882	5616836
	143	Little Lions Family Childcare	686826	5619162
	144	Maple Tree Family Daycare	689162	5616580
	145	Mcdonald Avenue Early Childhood Development Centre	686267	5618696
	146	Parkcrest Family Daycare	682855	5620593
	147	Play to Learn Licensed Childcare	693180	5615613
	148	Puddles and Mud Childcare	687629	5614592
	149	Puss N' Boots	687611	5619677
	150	Seed To Apple Tree Learning Centre	687084	5613063
	151	Silly Billies	686509	5613424
	152	St Paul's Early Learning Centre	688896	5616991
	153	Sunhill Montessori Casa	687905	5614099
	154	Sunshine Early Learning Centre	681940	5620667
	155	The Children's Garden	681978	5620393
	156	Tiny Treasures Family Child Care	686222	5613720
	157	Together We're Better Childminding	686532	5618851
	158	Wee Care Daycare	687094	5612801
	159	YM-YWCA Southwest School Age Care	688913	5614529

Table D-4 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Retirement homes	160	Berwick on the Park Retirement Residence	688279	5615200
	161	Chartwell Select Renaissance Retirement Residence	686438	5619269
	162	Cottonwood Manor Retirement Home	686060	5619433
	163	Kamloops Senior Village	685722	5614250
	164	Ridgepointe at Pineview Retirement Home	684190	5614503
	165	Riverbend Manor Retirement Home	683708	5619617
	166	Riverbend Manor Retirement Home	683708	5619617
	167	The Shores Retirement Residence	686130	5619902
	168	Dufferin Group Home	684898	5615184
	169	Garden Manor Rest Home	687854	5616879
	170	Gaumont Residence	684785	5620647
	171	Hilltop House	686705	5618648
	171	Marjorie Willoughby Snowden Memorial Hospice Home	688213	5615279
	172	McBride Place	682832	5619990
	173	Ord Road Group Home	679181	5621261
	174	Phoenix Centre	688194	5616450
	175	Pine Grove Lodge	687105	5618430
	176	Ponderosa Lodge	688514	5616610
	177	Ridgeview Lodge	684078	5620088
	178	Riverside Retirement Centre	683705	5619724
	179	Sage Health Centre	687832	5616666
	180	Selkirk Family Care Home	685632	5620163
	181	Springridge Group Home	686597	5615113
	182	Waddington Group Home	688151	5614709
Miscellaneous	183	Stake Lake Trailhead	678565	5599165
	184	McConnell Lake Provincial Park	679980	5600117
	185	Hal Rogers Activity Centre	687507	5613786
Monitoring Stations	186	Kamloops Brocklehurst	683826	5619425
	187	Kamloops Federal Building	688358	5617046
	188	Kamloops Dalhousie Drive	686337	5615994
	189	Kamloops Fire Station #2	684743	5620037
	190	Kamloops Wildlife Park	706554	5615521

Table D-5 Listing and Description of 209 Special Discrete Receptors

Type	No	Name	Easting (m)	Northing (m)
Monitoring Stations (cont'd)	191	Kamloops Dunes	687591	5628598
	192	Kamloops Mission Flats	686757	5617741
	193	Kamloops New Gold	676719	5615113
	194	Kamloops Pacific Way	685753	5613791
	195	Kamloops Strande Ranch	675045	5612544
	196	Kamloops Goose Lake	683968	5607271
Dust fall Stations	197	DFS 10-01	680329	5609293
	198	DFS 10-02	678602	5611558
	199	DFS 10-03	679755	5612766
	200	DFS 10-04	682410	5612677
	201	DFS 10-06	683904	5610252
	202	DFS 10-07	687504	5610854
	203	DFS 3 EAST	680922	5610344
	204	DFS 3 WEST	680683	5610459
	205	DFS 4 EAST	682677	5610243
	206	DFS 4 WEST	682468	5610173
	207	DFS 5 EAST	683813	5609302
	208	DFS 5 WEST	683512	5609523
	209	DFS 6 WEST	683551	5608855

D.2.2.6 Terrain Effects

The CALPUFF model was used to estimate concentrations, for each species considered, at each receptor location. Since some of these receptors were located in terrain elevations greater than puff release points, terrain effects were considered at all receptors based on the Canadian Digital Elevation Data (NRCan 2007). To account for the possible distortion of the plume trajectory over elevated terrain, the Partial Plume Path Adjustment Method (PPPAM) was used to modify the height of the plume.

The PPPAM employs a plume path coefficient (PPC) to adjust the height of the plume above the ground. As recommended by the CALPUFF authors, the default PPC values used are 0.5, 0.5, 0.5, 0.5, 0.35, and 0.35 for the corresponding Pasquill-Gifford stability classes A, B, C, D, E, and F (Pasquill, 1961).

Terrain elevations are not adjusted for the topography of the project disturbance area and open pits. Instead, the open pits are modelled as surface based area sources and the effect of the pit depth is accounted for by applying a pit retention algorithm on the fugitive dust emissions released at the surface (see Section D.3).

D.2.2.7 Dispersion Coefficients

A fundamental parameter controlling plume dispersion in a Gaussian model such as CALPUFF are the dispersion coefficients. These values, which must be specified for both the horizontal as well as the vertical directions in the model, can be estimated using several different methods in CALPUFF. For this application, dispersion coefficients were internally computed from turbulence estimates based on micrometeorological data from CALMET (MDISP=2). This method was chosen over the more simplistic default method (MDISP=3) to allow for a better characterization of dispersion in the model. The choice of MDISP=2 is also recommended under the BC Modelling Guidelines where near field (less than 50km) results are required.

D.2.3 MODEL OPTIONS

The CALPUFF model is a very flexible model and provides the user with several optional assessment approaches. The model simulation options are specified in a control input file in the form of user “switches”. To promote consistency with the application of CALPUFF in the BC regulatory framework, the *Guidelines* (BC MOE 2008) requires certain default settings be applied, specifically in Input Group 2 of the control file. For this assessment, the default settings specified by the *Guidelines* are adopted. The selected user “switches” in the CALPUFF control file that are used in one of the CALPUFF simulations are summarized in Table D-5 to Table D-7. The “switches” shown in Table D-84 to Table D-6 represents a specific source-species-receptor combination. Therefore, application-specific model parameters such as the number of sources modelled had different values for different model runs (this is shown by a * in the tables).

Model default options, as recommended by the United States Environmental Protection Agency (US EPA 1998) as well as the BC MOE Guidelines for Air Quality Dispersion Modelling (Group 2) (BC MOE 2008) are presented for comparative purposes. In most cases, these default values were used. When comparing the U.S. EPA default options to the values that are applied, it is important to note the two different distance scales that are associated with each set of options. The U.S. EPA defaults are provided in the context of long range transport which implies source to receptor distances greater than 50 km. The CALPUFF model application in the context of the Ajax air quality assessment and the BC MOE Guidelines focuses primarily on source to receptor distances less than 50 km.

Table D-6 CALPUFF Dispersion Model User Options

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 1: General Run Control Parameters	METRUN	0	0	Run all period in met file
	IBYR	—	2003	Used only if METRUN=0
	IBMO	—	1	Used only if METRUN=0
	IBDY	—	1	Used only if METRUN=0
	IBHR	—	0	Used only if METRUN=0
	IBMIN	—	0	Used only if METRUN=0
	IBSEC	—	0	Used only if METRUN=0
	IEYR	—	2004	Used only if METRUN=0
	IEMO	—	1	Used only if METRUN=0
	IEDY	—	1	Used only if METRUN=0
	IEHR	—	1	Used only if METRUN=0
	IEMIN	—	0	Used only if METRUN=0
	IESEC	—	0	Used only if METRUN=0
	XBTZ	—	8	Time Zone, Pacific Standard Time
	NSECDT	3600	3600	Length of modelling time-step
	NSPEC	5	12	Number of chemical species modelled
	NSE	3	12	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	File written only at last period
	METFM	1	1	CALMET binary type of meteorological file
	MPRFFM	1	1	-
	AVET	60	60	Averaging time is 60 minutes
	PGTIME	60	60	PG Averaging time is 60 minutes

Table D-7 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	BC MOE Default	Selected for Project	Description
Group 2: Technical Options	MGAUSS	1	1	1	Gaussian distribution used in the near field
	MCTADJ	3	3	3	Partial plume path adjustment method of terrain adjustment
	MCTSG	0	0	0	Subgrid-scale complex terrain not modelled
	MSLUG	0	0	0	Near field puffs not elongated
	MTRANS	1	1	1	Transitional plume rise applied
	MTIP	1	1	1	Stack tip downwash applied
	MBDW	1	2	2	PRIME method
	MSHEAR	0	0	0	Vertical wind shear not modelled
	MSPLIT	0	0	0	No puff splitting allowed
	MCHEM	1	1	0	Chemical transformation not modelled
	MAQCHEM	0	0	0	Aqueous phase transformation not modelled
	MWET	1	1	1	Wet removal modelled
	MDRY	1	1	1	Dry removal modelled
	MDISP	3	2 or 3	2	Dispersion coefficients calculated from CALMET micrometeorological variables
	MTILT	0	—	0	Gravitational settling not modelled
	MTURBVW	3	(3)	3	Use direct turbulence measurements to estimate dispersion
	MDISP2	3	(2)	3	Use PG coefficients when turbulence measurements not available
	MTAULY	0	-	0	Draxler default 617.284
	MTAUADV	0	-	0	No turbulence advection
	MCTURB	1	-	1	CALPUFF subroutines used to compute turbulence
	MROUGH	0	0	0	Sigma Y and Z are not adjusted for roughness
	MPARTL	1	1	1	Model partial plume penetration of elevated inversion
	MTINV	0	0	0	Strength of temperature inversion is computed from default gradients

Table D-7 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	BC MOE Default	Selected for Project	Description
Group 2: Technical Options (cont'd)	MPDF	0	0 or 1	1	Use PDF to compute near-field dispersion under convective conditions
	MSGTIBL	0	0	0	Sub-grid TIBL module is not used
	MBCON	0	0	0	Boundary conditions are not modelled
	MSOURCE	0	-	0	Individual source contributions not saved
	MFOG	0	0	0	Not configured for fog model output
	MREG	1	0	0	Do not test options against defaults

NOTES:
a) Colour legend for the recommended technical options in the BC *Guidelines* (BC MOE 2008):

Black	Do not touch
Dark grey	Recommended default
Light grey	Expert judgment required
White	Not used

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 3: Species List	CSPEC	—	SO_2	Sulphur dioxide
			NO_X	Oxides of nitrogen
			CO	Carbon monoxide
			$PM_{0\_2.5}$	Dust particulate matter with particle size less than 2.5 micron
			$PM_{2.5\_10}$	Dust particulate matter with particle size between 2.5 and 10 micron
			PM_{10_30}	Dust particulate matter with particle size between 10 and 30 micron
			$DPM_{0\_2.5}$	Diesel exhaust particulate matter with particle size less than 2.5 micron
			$DPM_{2.5\_10}$	Diesel exhaust particulate matter with particle size between 2.5 and 10 micron

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 3: Species List (cont'd)			DPM_{10_30}	Diesel exhaust particulate matter with particle size between 10 and 30 micron
			$OPM_{0\_2.5}$	Ore particulate matter with particle size less than 2.5 micron
			$OPM_{2.5\_10}$	Ore particulate matter with particle size between 2.5 and 10 micron
			OPM_{10_30}	Ore particulate matter with particle size between 10 and 30 micron
		SO_2		Modelled, Emitted
		NO_X		Modelled, Emitted
		CO		Modelled, Emitted
		$PM_{0\_2.5}$		Modelled, Emitted, Dry Deposited
		$PM_{2.5\_10}$		Modelled, Emitted, Dry Deposited
		PM_{10_30}		Modelled, Emitted, Dry Deposited
		$DPM_{0\_2.5}$		Modelled, Emitted, Dry Deposited
		$DPM_{2.5\_10}$		Modelled, Emitted, Dry Deposited
		DPM_{10_30}		Modelled, Emitted, Dry Deposited
		$OPM_{0\_2.5}$		Modelled, Emitted, Dry Deposited
		$OPM_{2.5\_10}$		Modelled, Emitted, Dry Deposited
		OPM_{10_30}		Modelled, Emitted, Dry Deposited
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	—	10	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	NAR-C	
	NX	—	280	Number of X grid cells
	NY	—	220	Number of Y grid cells

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 4: Grid Control Parameters (cont'd)	NZ	—	10	Number of vertical grid cells
	DGRIDKM	—	0.25	Grid spacing in X and Y directions (km)
	ZFACE	—	0, 20, 40, 80, 160, 300, 500, 1000, 1500, 2000, 3000	Vertical cell face heights of the NZ vertical layers
	XORIGKM	—	650	Reference Easting of SW corner of SW grid cell in UTM (km)
	YORIGKM	—	5590	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	—	280	X index of upper right grid cell for computation
	JECOMP	—	220	Y index of upper right grid cell for computation
	LSAMP	T	F	Sampling grid is not used
	IBSAMP	—	1	X index of lower left grid cell for sampling
	JBSAMP	—	1	Y index of lower left grid cell for sampling
	IESAMP	—	280	X index of upper right grid cell for sampling
	JESAMP	—	220	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	1	Create binary dry flux output file
	IWET	1	1	Create binary wet flux output file
	IT2D	0	0	Do not create 2D temperature output file
	IRHO	0	0	Do not create 2D density output file
	IVIS	1	0	Output file containing relative humidity is not created

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 5: Output Options (cont'd)	LCOMPRS	T	T	Apply data compression
	IQAPLOT	1	1	Create a standard series of output files
	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	730	Concentration print interval in hours
	IDFRQ	1	730	Dry flux print interval in hours
	IWFRQ	1	730	Wet flux print interval in hours
	IPRTU	1	3	Output units are $\mu g/m^3$ for concentration and $\mu g/m^2/s$ for fluxes
	IMESG	2	2	Track progress of run on screen
	—	SO_2		Concentrations, dry fluxes, and wet fluxes are saved to the hard disk. Concentrations, dry fluxes, and wet fluxes are not printed hourly. Mass fluxes are not saved on disk.
		NO_X		
		CO		
		$PM_{0\_2.5}$		
		$PM_{2.5\_10}$		
		PM_{10_30}		
		$DPM_{0\_2.5}$		
		$DPM_{2.5\_10}$		
		DPM_{10_30}		
		$OPM_{0\_2.5}$		
		$OPM_{2.5\_10}$		
		OPM_{10_30}		
	LDEBUG	F	F	Do not print debug data
	IPFDEB	1	1	Debug options–First puff to track
	NPFDEB	1	1	Debug options–Number of puffs to track
	NN1	1	1	Debug options–Met period to start output
	NN2	10	10	Debug options–Met period to end output

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 6: Subgrid Scale Complex Terrain Inputs	NHILL	0	0	Number of terrain features
	NCTREC	0	0	Number of complex terrain receptors
	MHILL	—	2	Hill data created by OPTHILL
	XHILL2M	1	1	Horizontal conversion factor to meters
	ZHILL2M	1	1	Vertical conversion factor to meters
	XCTDMKM	—	0	CTDM X origin relative to CALPUFF grid
	YCTDMKM	—	0	CTDM Y origin relative to CALPUFF grid

Input Group		Diffusivity	Alpha Star	Reactivity	Mesophyll Resistance	Henry's Law Coefficient
Group 7: Chemical Parameters for Dry Deposition of Gases	—	—	—	—	—	—

Input Group	Species	Geometric Mass Mean (microns)	Geometric Standard Deviation (microns)
Group 8: Size Parameters for Dry Deposition of Particles	$PM_{0\_2.5}$	1.25	0.0
	$PM_{2.5\_10}$	6.25	0.0
	PM_{10_30}	20.0	0.0
	$DPM_{0\_2.5}$	1.25	0.0
	$DPM_{2.5\_10}$	6.25	0.0
	DPM_{10_30}	20.0	0.0
	$OPM_{0\_2.5}$	1.25	0.0
	$OPM_{2.5\_10}$	6.25	0.0
	OPM_{10_30}	20.0	0.0

Group 9: Miscellaneous Dry Deposition Parameters	RCUTR	30	30	Reference cuticle resistance
	RGR	10	5	Reference ground resistance
	REACTR	8	8	Reference contaminant reactivity
	NINT	9	9	Number of particle size intervals used to evaluate effective particle deposition velocity
	IVEG	1	1	Vegetation in unirrigated areas is active and unstressed

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 10: Wet Deposition Parameters	Species	Liquid Precipitation Scavenging Coefficient		Frozen Precipitation Scavenging Coefficient
	$PM_{0\_2.5}$	6.0E-05		2.0E-05
	$PM_{2.5\_10}$	4.2E-04		1.4E-04
	PM_{10_30}	6.6E-04		2.2E-04
	$DPM_{0\_2.5}$	6.0E-05		2.0E-05
	$DPM_{2.5\_10}$	4.2E-04		1.4E-04
	DPM_{10_30}	6.6E-04		2.2E-04
	$OPM_{0\_2.5}$	6.0E-05		2.0E-05
	$OPM_{2.5\_10}$	4.2E-04		1.4E-04
	OPM_{10_30}	6.6E-04		2.2E-04
NOTES: Liquid and frozen precipitation scavenging coefficients are based on ISC3 User's Guide, Volume 2, Section 1.4 and Figure 1-11 (US EPA 1995)				
Group 11: Chemistry Parameters	MOZ	1	0	Monthly O_3 values are used in chemistry
	BCKO3	12*80	33, 47, 55, 65, 64, 62, 61, 61, 42, 31, 31, 28	Monthly O_3 values are used in chemistry
	BCKNH3	12*10	12*10	Constant background concentration in ppb
	RNITE1	0.2	0.2	Night time SO_2 loss rate (% per hour)
	RNITE2	2	2	Night time NO_X loss rate (% per hour)
	RNITE3	2	2	Night time HNO_3 formation rate (% per hour)
	BCKH2O2	12*1	12*1	Background H2O2 (Not Used)
	BCKPMF	12*1	12*1	Background fine particulate matter (Not Used)
	OFRAC	12*0.20	9*0.20 3*0.15	Organic fraction of fine particulate matter (Not Used)
	VCNX	12*50	12*50	VOC/NO_X ratio for chemistry (Not Used)

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	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	Transition factor between Huber-Snyder and Schulman-Scire downwash schemes
	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	0	Elevation above sea level in meters
	XLATIN	–999	0	Latitude of met location in degrees
	XLONIN	–999	0	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
	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

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 12: Miscellaneous Dispersion and Computational Parameters (cont'd)	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 in metres for a new puff
	SZMIN	1	1	Minimum sigma Z in metres for a new puff
	SVMIN (Land&Water)	0.5,0.5,0.5 0.5,0.5,0.5, 0.37,0.37, 0.37,0.37, 0.37,0.37	0.5,0.5,0.5 0.5,0.5,0.5, 0.37,0.37, 0.37,0.37, 0.37,0.37	Default minimum turbulence velocities for each stability class (Sigma-V)
	SWMIN (Land&Water)	0.2,0.12, 0.08,0.06, 0.03,0.016, 0.2,0.12 0.08,0.06 0.03,0.016	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)
	CDIV	0, 0	0, 0	Divergence criteria for dw/dz in meters
	WSCALM	0.5	0.5	Minimum wind speed allowed for non-calm conditions in m/s
	XMAXZI	3000	3000	Maximum mixing height in meters
	XMINZI	50	50	Minimum mixing height in meters
	WSCAT	1.54, 3.09, 5.14, 8.23, 10.8	1.54, 3.09, 5.14, 8.23, 10.8	Wind Speed Class
	PLX0	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	0.07, 0.07, 0.10, 0.15, 0.35, 0.55	Wind speed profile power-law exponents for stabilities 1 to 6
	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 D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	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	1.0E–07	1.0E–07	Minimum concentration (g/m3) of each species in puff before it may be split (Not used)
	EPSSLUG	1.0E–04	1.0E–04	Fraction convergence criterion for numerical slug sampling integration
	EPSAREA	1.0E–06	1.0E–06	Fraction convergence criterion for numerical area sources integration
	DSRISE	1	1	Trajectory step-length (m) used for numerical rise integration
	HTMINBC	500	500	Min height to mix boundary condition puffs (m)
	RSAMPBC	10	10	Search radius (BC length segments) about a receptor for sampling nearest BC puff.
	MDEPBC	1	1	Near surface depletion adjustment when sampling BC puffs

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 13: Point Source Parameters	NPT1	—	*	Number of point sources modelled
	IPTU	1	1	Units used for emissions (g/s)
	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	—	*	Number of polygon area sources modelled. This varies with the input files.
	IARU	1	1	Units used for emissions (g/m^2/s)
	NSAR1	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
	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
	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

Table D-8 CALPUFF Dispersion Model User Options (cont'd)

Input Group	Parameter	USEPA Default	Selected for Project	Description
Group 16: Volume Source Parameters	NVL1	—	*	Number of volume sources applied. This varies with the input file.
	IVLU	1	1	Units used for volume sources (g/s)
	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-Gridded Receptor Information	NREC	—	14,656	Number of non-gridded discrete receptors that compose the series of nested grids and plant boundary

D.3 PIT RETENTION

Pit retention is the term used to describe the tendency for particulate matter released inside a surface mine pit to remain inside the pit. Since the CALPUFF model does not have an algorithm to model open pit sources, open pits were modelled as surface area sources with reduced PM emissions to account for pit retention. The fraction of PM emissions retained in the open pits was estimated based on the original Winges equation (Winges 1981). The Winges equation expresses the escape fraction of PM that exits the open pit as a function of pit depth, vertical diffusivity and deposition velocity. The Winges equation uses a number of simplified assumptions including the assumption that the only mechanism for transport of material out of the pit is turbulent diffusion which means that vertical wind speeds are ignored. The equation also does not explicitly include wind speed as a parameter.

The Winges equation has been tested against the results of a pit retention field study conducted by U.S. EPA in 1985 (U.S. EPA 1985). The U.S. EPA field study includes data collection at four Western surface coal mines. Meteorological parameters were measured simultaneously in an out of the mine pits. In addition, a smoke release program was conducted to provide data for the air motion within the pits. The Winges equation was applied independently to each of the smoke release episodes from the field study. The predicted escape fractions calculated with the Winges equation were compared with the escape fractions inferred from the measured field data. The comparison showed that the escape fractions calculated with the Winges equation were in reasonable good agreement with the values inferred by the field study when the data were grouped by Pasquill-Gifford stability class. When the data were grouped by wind speed the agreement between the inferred and calculated escape fractions was not as good which was attributed to the fact that the Winges equation does not explicitly include wind speed

(Winges and Cole 1986). Nevertheless, both the field study and the Winges equation show the same tendency of the escape fraction to increase with unstable and neutral atmospheric conditions and with increasing wind speed.

Appendix E of the AQ TDR Report contains project specific pit retention factors.

D.4 NO_X TO NO_2 CONVERSION

Oxides of nitrogen (NO_X) are comprised of nitric oxide (NO) and nitrogen dioxide (NO_2). Only NO_2 concentrations are regulated by the BC AAQO. Therefore, it is important to be able to estimate the portion of predicted ground-level concentrations of NO_X comprised of NO_2. For this current study, the Ozone Limiting Method (OLM) (BC MOE 2008) was applied. The OLM is the alternative if adequate monitoring data of NO/NO_2 ratios are not available. This method requires O_3 values based on a nearby monitoring station that is representative of the region. The OLM equation is shown below:

$$[\boldsymbol{NO_2}] = \mathbf{0.1}[\boldsymbol{NO_x}] + \textbf{\textit{the lesser of}}\ ([\boldsymbol{O_3}]\ \textbf{\textit{or}}\ \mathbf{0.9}[\boldsymbol{NO_x}]) + \textbf{\textit{Background}}\ [\boldsymbol{NO_2}]$$

The OLM assumes that the conversion of NO to NO_2 in the atmosphere is limited by the ambient O_3 concentration in the atmosphere. The approach assumes that 10 percent (on a volume basis) of the NO_x is converted to NO_2 prior to discharge into the atmosphere. For the remaining NO_x, the following is adopted:

- If 0.9 (NO_x) is greater than the ambient O_3 concentration then NO_2 = 0.1 (NO_x) + O_3. For this case, the conversion is not complete.
- If 0.9 (NO_x) is less than the ambient O_3 concentration then NO_2 = 0.1 (NO_x) + 0.9 (NO_x) =NO_x. This is equivalent to the total conversion approach, since there is sufficient O_3 to effect the complete conversion.

In the application of the OLM, the above relationships assume the concentrations are expressed on a volumetric (i.e., ppb) basis. The hourly O_3 values used in the assessment were based on ambient air quality monitoring data at the Kamloops Brocklehurst station for 2003 to 2005

D.5 PARTICULATE MATTER DEPOSITION

Dry deposition of particulates is the process of settling of particles on the ground due to gravity and micro meteorological and atmospheric processes. Wet deposition is the depletion of particles from the atmosphere by rain or snow. Dry and wet deposition of total particulate matter (PM) are modelled in CALPUFF. PM deposition is also referred to as a dustfall.

Different physical processes govern the settling of particles of different sizes. While for larger particles (greater than 20 µm), dry deposition is caused mainly by gravitational settling, deposition of smaller particles is caused by micro meteorological and atmospheric processes. Wet deposition is proportional to the precipitation rate and a scavenging coefficient which depends on the particle size.

For deposition modelling, total PM is represented with a particle size distribution consisting of the following particle size categories:

- Particles with aerodynamic diameter smaller than 2.5 µm represented with an aerodynamic diameter of 1.25 µm
- Particles with aerodynamic diameter between 2.5 and 10 µm represented with an aerodynamic diameter of 6.25 µm
- Particles with aerodynamic diameter between 10 and 30 µm represented with an aerodynamic diameter of 20 µm

Emission rates for each particle size category are derived from particle size-specific emission factors representative of the various mining activities. The PM generating activities have been grouped into ore related activities, diesel burning equipment and a remaining group of everything else (e.g., road dust). Total dustfall is estimated as the sum of modelled dry and wet deposition for each particle size category.

D.6 ATMOSPHERIC CHEMISTRY AND FORMATION OF SECONDARY PM2.5

The formation of secondary particulate matter is not considered significant compared to fugitive dust generated from mining activities, therefore secondary formation of fine particulate matter ($PM_{2.5}$) from nitrates and sulphates is not modelled.

D.7 BUILDING DOWNWASH

Buildings or other solid facility structures may affect the flow of air in the vicinity of a source and cause building downwash effects due to eddies on the downwind side. These eddies have potential to reduce plume rise and affect dispersion.

For this operational site plan, point sources that are potentially affected by building downwash are located far from the plant boundary and are small contributors to the overall emissions. The effect of building downwash at the nearest receptors where the applicable AAQO will be applied will have a negligible effect on the predicted concentrations and deposition values. Therefore, the building downwash option will be disabled.

D.8 CALPUFF PERFORMANCE

D.8.1 MODEL PREDICTION CONFIDENCE

Uncertainty associated with dispersion model predictions stems from two main areas (U.S. EPA 2005):

- Reducible uncertainty, which results from uncertainties associated with the input values and with the limitations of the model formulations. Reducible uncertainty can be minimized by better (i.e., more accurate and representative) measurements and improved model formulations.
- Inherent uncertainty, which is associated with the stochastic nature of the atmosphere and its representation. Models predict concentrations that represent an ensemble average of numerous repetitions for the same nominal event. An individual observed value can deviate significantly from the ensemble value. This uncertainty may be responsible for a ±50% deviation from the measured values.

Generally, models are quoted as having a factor-of-two accuracy. Comparison studies indicate that models can predict the magnitude of highest concentration occurring sometime and somewhere within an area to within ±10 to ±40%. Predictions for a specific site and time are often poorly correlated with observed values. This poor correlation can often be related to errors in wind direction. For example, an uncertainty of 5º to 10º in the wind direction can produce a concentration error in the 20 to 70% range (U.S. EPA 2005).

The U.S. EPA (2005) provides guidance to decision makers relative to model uncertainty. Specifically, they recommend that the model predictions be accepted as a “best estimate”, until sufficient technical progress has been made to meaningfully implement concepts dealing with uncertainty.

D.8.2 PERFORMANCE APPROACH

The performance of the CALPUFF/CALMET dispersion model predictions was gauged by comparing predictions against ambient air quality measurements from BC Ministry of Environment managed stations in the City of Kamloops. Any comparison should note:

- Existing emission sources in the City are subject to hour-to-hour and day-to-day variability. The model, as applied for this assessment, does not employ variable emission rates, nor does it explicitly account for abnormal emissions (e.g., nearby forest fires, dust storms).
- Ambient air quality measurements are influenced by emissions from existing sources and industrial facilities in the modelling domain and sources outside the modelling domain. The model, as applied for this assessment, includes existing sources and industrial facilities in the modelling domain. It employs a figure representative of global/regional background determined to represent contributions from sources outside the modelling domain.

Model performance is often gauged by comparing the highest predicted values with the highest measured values as the model is often used to determine compliance with ambient air quality objectives. However, the meteorological variability and the emission variability can lead to uncertainties with this type of model performance comparisons. For this assessment, the Top-25 1-hour predicted and measured concentrations are also calculated and compared. The use of the Top-25 concentrations is viewed as a more robust indicator than the single highest value (U.S. EPA 1992).

The fractional bias (FB) has also been used as a model performance indicator (U.S. EPA 1992) that is defined as:

$$FB = 2 \times \left[\frac{PR - OB}{OB + PR}\right]$$

where:

- PR = the average of the Top-25 1-hour concentrations predicted at the same site.
- OB = the average of the Top-25 1-hour concentrations observed at a given site.

The FB has the following properties:

- It is bounded ranging from +2.0 (extreme over prediction) to -2.0 (extreme under prediction).
- FB values corresponding to over predictions and under predictions by a factor of two range from +0.67 to -0.67, respectively.
- A FB value of 0.0 indicates perfect agreement.

The use of the absolute fractional bias (AFB) simplifies the comparison calculations. A model is viewed as acceptable if the AFB is less than 0.67; that is, the model is predicting within a factor of two.

The CALPUFF model comparison was undertaken for the Base Case. The comparison focuses on predicted and measured $PM_{2.5}$, SO_2, and NO_2 concentrations. Because industrial SO_2 emissions originating at the Domtar Pulp Mill dramatically decreased in 2013, ambient measurements for only the most recent years (2013-2014) are used for this comparison. The comparisons were conducted using data from the Kamloops Federal Building and Kamloops Fire Station #2 station, the only ones operational at that time.

D.8.3 $PM_{2.5}$ COMPARISON

The measured $PM_{2.5}$ concentrations include contributions from industrial, traffic and community sources, as well as contributions from other sources (e.g., wildfires, agricultural operations, residential wood burning, and fugitive dust). These other sources are either not implicitly included in the modelling, or the variability in emissions are not faithfully portrayed (constant and not variable emission rates). The global/regional background is portrayed as constant, where in reality it is variable over many time scales (hourly to inter-decadal).

D.8.3.1 Maximum 24-hour $PM_{2.5}$ Comparison

Table D-9 shows the maximum (first highest) predicted 24-hour $PM_{2.5}$ concentrations for each simulation year (2003-2005) and measured 24-hour $PM_{2.5}$ concentrations for years 2013-2014 at the Kamloops Federal Building and Kamloops Fire Station #2 stations.

The concentrations show year-to-year variability. The year-to-year variability between the maximum measured concentrations is much larger than those associated with the predicted values. The larger variability for measured $PM_{2.5}$ is likely because the measured values include wildfire and/or fugitive dust emissions. The predicted values do not consider the variability in this type of source.

Table D-9 also provides the ratio of the predicted-to-measured concentrations. Values greater than unity indicate over prediction, while values less than unity indicate under prediction. Results in Table D-9 indicate that the model slightly under predicts maximum 24-hour $PM_{2.5}$ concentration by 12% at Kamloops Federal Building and over predicts maximum 24-hour $PM_{2.5}$ concentration by 92% at Kamloops Fire Station #2. The under prediction is likely due to not including wildfire and other sources in the modelling. The under prediction and/or over prediction is also likely due to the spatial accuracy of non-industrial emissions (space heating, transportation, road dust) especially for heating and paved road dust emissions.

Table D-9 Comparison of Maximum Measured and Predicted 24-hour Average $PM_{2.5}$ Concentrations

Station	Maximum Predicted 24-hour $PM_{2.5}$ concentration ($\mu g/m^3$)				Maximum Measured 24-hour $PM_{2.5}$ concentration ($\mu g/m^3$)			Predicted divided by Measured
	2003	2004	2005	Average [a]	2013	2014	Average	
Kamloops Federal Building	40.5	23.1	27.1	38.5	25.8	61.4	43.6	0.9
Kamloops Fire Station #2	37.7	47.2	44.7	48.5	25.3 [b]	—	25.3	1.9
Average								1.4

NOTE:
[a] Includes the global/regional background for the 24-hour average $PM_{2.5}$ concentration (5.3 $\mu g/m^3$).
[b] Measurement available for Jan-Oct 2013.

D.8.3.2 Annual Average $PM_{2.5}$ Comparison

Table D-10 compares the long-term measured and predicted $PM_{2.5}$ concentrations at the indicated monitoring sites. An examination of the information in the table indicates the model under predicts annual average $PM_{2.5}$ concentration by 22% at Kamloops Federal Building and over predicts maximum annual average $PM_{2.5}$ concentration by 94% at Kamloops Fire Station #2. The comments regarding the agreement between the measured and predicted $PM_{2.5}$ concentrations for the 24-hour intervals hold.

Table D-10 Comparison of Measured and Predicted Annual Average $PM_{2.5}$ Concentrations

Station	Predicted Annual $PM_{2.5}$ concentration (µg/m³)				Measured Annual $PM_{2.5}$ concentration (µg/m³)			Predicted divided by Measured
	2003	2004	2005	Average [a]	2013	2014	Average	
Kamloops Federal Building	2.99	3.36	2.62	6.79	8.61	8.79	8.70	0.8
Kamloops Fire Station #2	6.49	7.15	6.26	10.4	5.37 [b]	—	5.37	1.9
Average								1.4

NOTE:
Includes the global/regional background for the annual average $PM_{2.5}$ concentration (3.8 µg/m³)
Measurement available for Jan-Oct 2013.

D.8.4 SULPHUR DIOXIDE COMPARISONS

The comparison of measured and predicted SO_2 concentrations often provides the best indication of model performance because:

- The emissions typically originate from a few, well-documented sources.
- Chemical reactions that consume SO_2 do not substantially reduce ambient SO_2 in the City given the associated transport times between source and monitoring station.
- The maximum SO_2 concentrations are relatively large and can be measured with reasonable accuracy in the ambient air.

The model predictions do not account for abnormal events such abnormally high episodic releases of SO_2 and hence may appear to under predict relative to the measurements.

D.8.4.1 Maximum 1-hour SO_2 Comparison

Table D-11 shows the maximum (first highest) predicted 1-hour SO_2 concentrations for the worse year 2003 and measured 1-hour SO_2 concentrations for years 2013-2014 at the monitoring station Kamloops Federal Building. There are no monitoring data available for Kamloops Fire Station #2 for years 2013-2014.

Table 3D-3 also provides the ratio of the predicted-to-measured concentrations. An examination of the information in Table 3D-3 indicates that the model under predicts maximum 1-hour SO_2 concentration by 64% at Kamloops Federal Building. The under prediction is likely due to accuracy of background non-industrial emission spatial distributions especially for heating sources and due to not accounting for industrial upset and abnormal events.

D.8.4.2 Top-25 1-hour SO_2 Comparison

The comparison between the measured and predicted values was repeated by comparing the average of the Top-25 measured 1-hour concentrations with the Top 25 predicted 1-hour concentrations (Table D-12). Table D-11 also provides the ratio of the predicted-to-measured concentrations. Values greater than unity indicate over prediction, while values less than unity indicate under prediction. The absolute fractional bias (AFB) is also shown. AFB values less than 0.67 indicates the model is predicting within a factor of two.

Compared to the maximum 1-hour SO_2 concentrations (Table D-11), the year-to-year variability between the measured values for the Top-25 values become smaller. The results in the table indicates that the model under predicts SO_2 concentrations by 51% (with AFB 0.69) at the Kamloops Federal Building station.

The Top-25 comparison averages out the extreme SO_2 concentrations that are associated with intermittent high SO_2 emission events, providing a more representative indicator of typical peak values. The comparison between the Top-25 average measured and predicted concentrations indicate reasonable model performance.

D.8.4.3 24-hour Average SO_2 Comparison

Table D-13 compares the maximum 24-hour measured and predicted SO_2 concentrations at the Kamloops Federal Building station. Result in the table (prediction/measurement = 1.0) indicates that the model can reproduce the maximum 24-hour average SO_2 concentration.

D.8.4.4 Annual Average SO_2 Comparison

Table D-14 compares the long-term measured and predicted SO_2 concentrations at the Kamloops Federal Building station. The result in the table (prediction/measurement = 1.09) indicates that there is a good model-measurement agreement for the maximum 24-hour average SO_2 concentration.

Table D-11 Comparison of Maximum Measured and Predicted 1-hour Average SO_2 Concentrations

Station	Predicted Annual SO_2 concentration (µg/m³)		Measured Annual SO_2 concentration (µg/m³)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	12.2	13.7	28.3	47.6	37.9	0.4

NOTE:
Includes the global/regional background for the 1-hour average SO_2 concentration (1.5 µg/m³).

Table D-12 Comparison of Measured and Predicted Top-25 1-hour Average SO_2 Concentrations

Station	Predicted Annual SO_2 concentration (µg/m³)		Measured Annual SO_2 concentration (µg/m³)			Predicted divided by Measured	AFB
	2003	With Background [a]	2013	2014	Average		
Kamloops Federal Building	9.65	11.2	20.1	25.8	22.9	0.49	0.7

NOTE:
Includes the global/regional background for the 1-hour average SO_2 concentration (1.5 µg/m³).

Table D-13 Comparison of Maximum Measured and Predicted 24-hour Average SO_2 Concentrations

Station	Predicted Annual SO_2 concentration (µg/m³)		Measured Annual SO_2 concentration (µg/m³)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	7.30	8.60	5.43	11.8	8.62	1.0

NOTE:
Includes the global/regional background for the 24-hour average SO_2 concentration (1.3 µg/m³).

Table D-14 Comparison of Maximum Measured and Predicted Annual Average SO_2 Concentrations

Station	Predicted Annual SO_2 concentration (µg/m³)		Measured Annual SO_2 concentration (µg/m³)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	0.50	1.40	1.32	1.25	1.29	1.1

NOTE:
[a] Includes the global/regional background for the annual average SO_2 concentration (0.9 µg/m³).

D.8.5 NITROGEN DIOXIDE COMPARISON

The NO_2 concentrations are influenced by NOx emissions from industrial and non-industrial sources. The OLM method was applied to convert model predicted NOx concentrations to NO_2 concentrations.

D.8.5.1 Maximum 1-hour NO_2 Comparison

Table D-15 shows the maximum (first highest) predicted 1-hour NO_2 concentrations for the worse year 2003 and measured 1-hour SO_2 concentrations for years 2013-2014 for the monitoring stations Kamloops Federal Building and Kamloops First Station #2.

Table D-15 also provides the ratio of the predicted-to-measured concentrations. Values greater than unity indicate over prediction, while values less than unity indicate under prediction. An examination of the information in Table D-15 indicates that the model over predicts maximum 1-hour NO_2 concentration by 33% at Kamloops Federal Building. There is a good model-measurement agreement at Kamloops First Station #2 with the ratio of prediction to measurement 1.05. The under prediction is likely due spatial distribution accuracy for background non-industrial emission, especially for on-road transportation sources.

D.8.5.2 Top-25 1-hour NO_2 Comparison

The comparisons between the measured and predicted values for the average of the Top-25 1-hour concentrations are shown in Table D-16. Table D-16 also provides the ratio of the predicted-to-measured concentrations. Values greater than unity indicate over prediction, while values less than unity indicate under prediction. The AFB values are also shown. AFB values less than 0.67 indicates the model is predicting within a factor of two.

An examination of the information in the table indicates that the model slightly under predicts NO_2 concentrations by 12% at the Kamloops Federal Building station. The model reproduced the Top-25 1-hour NO_2 concentration at Kamloops Fire Station #2 (prediction/measurement = 1.0).

The Top-25 comparison averages out the extreme NO_2 concentrations that are associated with intermittent high NO_2 emission events, providing a more representative indicator of typical peak values. The comparison between the Top-25 average measured and predicted concentrations indicate reasonable model performance.

D.8.5.3 24-hour Average NO_2 Comparison

Table D-17 compares the 24-hour measured and predicted NO_2 concentrations at the indicated monitoring stations. The results in the table indicate the model, on average, under predicts 24-hour average NO_2 concentration by 17%.

D.8.5.4 Annual Average NO_2 Comparison

Table D-18 compares the long-term measured and predicted NO_2 concentrations at the indicated monitoring stations. The results in the table indicate the model, on average, under predicts annual average NO_2 concentration by 49%. The under prediction is likely due to the accuracy of background non-industrial emission spatial distributions especially for on-road sources.

Table D-15 Comparison of Maximum Measured and Predicted 1-hour Average NO_2 Concentrations

Station	Predicted Annual NO_2 concentration (µg/m³)		Measured Annual NO_2 concentration (µg/m³)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	97.8	113	—	85.0	85.0	1.3
Kamloops Fire Station #2	61.5	76.8	73.2 [b]	—	73.2	1.1
Average						1.2

NOTE:
Includes the global/regional background for the 1-hour average NO_2 concentration (15.3 µg/m³)
Measurement available for Jan-Oct 2013.

Table D-16 Comparison of Measured and Predicted Top-25 1-hour Average NO_2 Concentrations

Station	Predicted Annual NO_2 concentration (µg/m³)		Measured Annual NO_2 concentration (µg/m³)			Predicted divided by Measured	AFB
	2003	With Background [a]	2013	2014	Average		
Kamloops Federal Building	46.9	62.2	—	70.3	70.3	0.88	0.1
Kamloops Fire Station #2	47.6	62.9	62.9 [b]	—	62.9	1.00	0.0
Average						0.94	0.1

NOTE:
Includes the global/regional background for the 1-hour average NO_2 concentration (15.3 µg/m³).
Measurement available for Jan-Oct 2013.

Table D-17 Comparison of Maximum Measured and Predicted 24-hour Average NO_2 Concentrations

Station	Predicted Annual NO_2 concentration (µg/m³)		Measured Annual NO_2 concentration (µg/m³)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	34.7	45.5	—	56.4	56.4	0.8
Kamloops Fire Station #2	30.7	41.5	49.1 [b]	—	49.1	0.8
Average						0.8

NOTE:
Includes the global/regional background for the 24-hour average NO_2 concentration (10.8 µg/m³).
Measurement available for Jan-Oct 2013.

Table D-18 Comparison of Measured and Predicted Annual Average NO_2 Concentrations

Station	Predicted Annual NO_2 concentration ($\mu g/m^3$)		Measured Annual NO_2concentration ($\mu g/m^3$)			Predicted divided by Measured
	2003	With Background [a]	2013	2014	Average	
Kamloops Federal Building	4.24	11.2	—	22.2	22.2	0.5
Kamloops Fire Station #2	6.27	13.3	18.6 [b]	—	18.6	0.7
Average						0.6

NOTE:
[a] Includes the global/regional background for the annual average NO_2 concentration (7.0 $\mu g/m^3$).
[b] Measurement available for Jan-Oct 2013.

D.8.6 CONCULSIONS

A comparison between the model predictions of the maximum 1-hour, the Top-25 1-hour, the maximum 24-hour, and the annual average concentrations and ambient measurements was undertaken. The results of this comparison indicate:

There are considerable year-to-year variations in the measured concentrations that are attributable to emission variations and changing meteorological condition. This variability can be reduced by using the Top-25 1-hour average concentrations as a more robust indicator of ambient measurements.

There is a general tendency for the model to over predict the maximum 24-hour and annual average $PM_{2.5}$ concentration by 40%. The over prediction is likely due to the spatial accuracy of non-industrial emissions (space heating, transportation, road dust) especially for heating and paved road dust emissions.

There is a general tendency for the model to under predict the maximum 1-hour and the Top-25 1-hour SO_2 concentration by 60% and 50%, respectively. The under prediction is likely due to accuracy of background non-industrial emission spatial distributions especially for heating sources and due to not accounting for industrial upset and abnormal events. The model reproduced the maximum 24-hour and annual average SO_2 concentrations faithfully.

There is a general tendency to over predict the maximum 1-hour NO_2 concentration by 20%, under predict the maxim 24-hour average NO_2 concentrations by 20% and annual average NO_2 concentrations by 340%, on average. The under prediction is likely due to the accuracy of background non-industrial emission spatial distributions especially for on-road sources. The model reproduced the Top-25 1-hour NO_2 concentration faithfully.

These comparisons show that the model performs well at predicting $PM_{2.5}$, SO_2 and NO_2 concentrations. The ability of the model to predict concentrations for other parameters depends on the level-of-confidence associated with estimating these other emission rates.

D.9 PREDICTION CONFIDENCE

The evaluation of potential changes in air quality depends primarily upon air dispersion models used to predict the change in expected ambient air concentrations. The predictions by air quality models, such as CALPUFF, are as accurate as the information used to initialize the models.

Emission rates used in the modelling were estimated based on a combination of emission factors, manufacturer specifications, and engineering estimates. In reality, actual emissions vary from hour to hour and day to day. Due to the nature of this approach, there is a high degree of confidence that emissions are over-estimated.

The CALPUFF representation of the atmospheric and dispersion processes only approximates the actual atmospheric processes. CALPUFF employs assumptions to simplify the random behaviour of the atmosphere into short periods of average behaviour. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, one full year of meteorological data was applied to evaluate a wide range of possible conditions. Additionally, regulatory models, such as CALPUFF, are designed to have a bias towards over-estimation of contaminant concentrations predictions (i.e., to be conservative under most conditions).

The predicted results contain a certain level of uncertainty, usually biased to the conservative margin. This bias is carried forward within the subsequent assessment process.

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APPENDIX E
PROJECT CASE CONSTRUCTION AND OPERATIONS EMISSION INVENTORY

Appendix E– Project Case Construction and Operations Emission Inventory

Stantec

August 21, 2015

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Abbreviations

%	percent
AN	ammonium nitrate
ANFO	ammonium nitrate/fuel oil
BSFC	brake specific fuel consumption
CAC	criteria air contaminant
CALPUFF	(California PUFF) air quality dispersion model
CEPA	Canadian Environmental Protection Act
CFR	Code of Federal Regulation
CO	carbon monoxide
DPM	diesel particulate matter
EC	Environment Canada
E_f	emission factor
EOP	end of period
g	gram
gal	gallons
g/kW	gram per kilowatt
g/kW-hr	gram per kilowatt hour
g/L	grams per litre
g/s	gram per second
ha	hectare
hp	horse power
hr	hour
kg	kilogram
kg/Mg	kilogram per megagram
km	kilometre
kW	kilowatt
L	litre
lb	pound
lb/hp-hr	pound per horse power hour
m^3/s	cubic meter per second
masl	metres above sea level
Mg	megagram (tonne)
mg/kg	milligrams per kilogram
mg/m^3	milligrams per cubic metre

NO_2	nitrogen dioxide
NO_x	nitrogen oxides
PM	particulate matter
$PM_{2.5}$	respirable particulate matter (particles with aerodynamic diameter 2.5 microns or smaller)
PM_{10}	inhalable particulate matter (particles with aerodynamic diameter 10 microns or smaller)
s	second
SO_2	sulphur dioxide
TPM	total particulate matter
ton	short ton
t	metric tonnes
US EPA	United States Environmental Protection Agency
VKT	vehicle kilometre travelled
yr	year

Appendix E PROJECT CASE CONSTRUCTION AND OPERATIONS EMISSION INVENTORY

E.1 INTRODUCTION

Appendix E (this appendix) contains the emission factors, assumptions, and emission estimations for year -1 and year 4/8. Year -1 is the last year of mine development before the mine ramps up to full operations. Based on the mine plane, this year is considered to be the highest emission development year. Year -1 is considered as the Construction Case. Year 4/8 is a combination of worst-case activity aspects taken from both year 4 and year 8 of operations. Based on the mine plan, the combination of activities from these two years is assumed to result in the highest emissions when compared to the other years in the mine life. Year 4/8 is considered as the Operations Case.

E.2 EMISSION FACTORS

This section presents the emission factors for heavy duty diesel engines, explosive detonations, and dust emissions as well as the emission rate calculation methodology for point sources associated with the KGHM Ajax (KAM) Project (Project).

E.2.1 HEAVY DUTY DIESEL ENGINES: CRITERIA AIR CONTAMINANT EMISSION FACTORS

Criteria air contaminant (CAC) exhaust emissions from mobile off-road vehicles are estimated based on the Canadian off-road compression-ignition engine emission standards developed under the authority of the Canadian Environmental Protection Act (CEPA). The *Canadian Off-Road Compression-Ignition Engine Emission Regulations* (*CEPA* 2005) mirror the corresponding *US Code of Federal Regulation* (CFR) from the US Environmental Protection Agency (US EPA 2013). Table E-1 contains the heavy duty diesel engine emission factors used to calculate vehicle exhaust nitrogen oxide (NO_x), carbon monoxide (CO), and particulate matter (PM) emissions (USA EPA 2013). Emission standards are set forth in a tiered approach that depends on the year of engine manufacture. Based on the purchasing schedule and to add conservatism the engines of the vehicles to be used by the Project were assumed to be Tier 3.

Table E-1 US EPA/Canada *CEPA* Tier 1, 2, 3 and 4 NO_x, CO and PM Emission Standards for Off-Road Heavy Duty Diesel Engines

Engine Power (kW)	Tier	Model Year	Emission Factors (g/kW-hr)		
			NO_x	CO	PM
≥ 19 to < 37 kW	Tier I	1999–2003	-	5.5	0.8
	Tier II	2004–2007	-	5.5	0.6
	Tier IV transitional	2008–2012	-	5.5	0.3
	Tier IV final	2013+	-	5.5	0.03
≥ 75 to < 130 kW	Tier I	1997–2002	9.2	-	-
	Tier II	2003–2006	-	5	0.3
	Tier III	2007–2011	-	5	0.3
	Tier IV transitional	2012–2013	-	5	0.02
	Tier IV final	2014+	0.4	5	0.02
≥ 130 to < 225 kW	Tier I	1996–2002	9.2	11.4	0.54
	Tier II	2003–2005	-	3.5	0.2
	Tier III	2006–2010	-	3.5	0.2
	Tier IV transitional	2011–2013	-	3.5	0.02
	Tier IV final	2014+	0.4	3.5	0.02

NOTES:
Reference: US EPA 2013
kW = kilowatt
g = gram
hr = hour
"-" = not available

Table E-1 US EPA/Canada *CEPA* Tier 1, 2, 3 and 4 NO_x, CO and PM Emission Standards for Off-Road Heavy Duty Diesel Engines

Engine Power (kW)	Tier	Model Year	Emission Factors (g/kW-hr)		
			NO_x	CO	PM
≥ 225 to < 450 kW	Tier I	1996–2000	9.2	11.4	0.54
	Tier II	2001–2005	-	3.5	0.2
	Tier III	2006–2010	-	3.5	0.2
	Tier IV transitional	2011–2013	-	3.5	0.02
	Tier IV final	2014+	0.4	3.5	0.02
≥ 450 to < 560 kW	Tier I	1996–2001	9.2	11.4	0.54
	Tier II	2002–2005	-	3.5	0.2
	Tier III	2006–2010	-	3.5	0.2
	Tier IV transitional	2011–2013	-	3.5	0.02
	Tier IV final	2014+	0.4	3.5	0.02
≥ 560 to < 900 kW (except generator sets)	Tier I	2000–2005	9.2	11.4	0.54
	Tier II	2006–2010	-	3.5	0.2
	Tier IV transitional	2011–2014	3.5	3.5	0.1
	Tier IV final	2015+	3.5	3.5	0.04
> 900 kW (except generator sets)	Tier I	2000–2005	9.2	11.4	0.54
	Tier II	2006–2010	-	3.5	0.2
	Tier IV transitional	2011–2014	3.5	3.5	0.1
	Tier IV final	2015+	3.5	3.5	0.04

SOURCE:
CEPA Off-Road Compression-Ignition Engine Emission Regulations (*CEPA* 2005)
Nonroad Compression-Ignition Engines - Exhaust Emission Standards (US EPA 2013)

Based on the Environment Canada (EC) sulphur in diesel fuel regulations, the sulphur content was assumed to be 15 milligrams per kilogram (mg/kg) (EC 2013).

Two calculation modes for CAC emission rates in gram per second (g/s) were pursued:

- For CACs other than sulphur dioxide (SO_2):

$$Emission\ Rate(g/s) = [\#units]\left[\begin{matrix}Load\\Factor\end{matrix}\right]\left[\frac{Operational\ \%}{100}\right]\times\left[E_f(g/kW-hr)\right]\left[\frac{1hr}{3600s}\right]\left[\begin{matrix}Engine\\power\ (kW)\end{matrix}\right]\left[\begin{matrix}Deterioration\\Factor\end{matrix}\right]\left[\begin{matrix}Transient\\Adjustment\ Factor\end{matrix}\right]$$

NOTES: E_f = Emission factor — g/kW = gram per kilowatt
hr= hour — s = second

(Equation E-1)

- For SO_2, it is assumed that all diesel sulphur is oxidized during combustion:

$$Emission\ Rate(g/s) = [\#\ units]\left[\frac{Load}{Factor}\right]\left[\frac{Operational\ Percent}{100}\right] \times \left[E_f(g/L)\right][Fuel\ Consumption\ (gallon/hr\ )]\left[\frac{3.7854L}{1gallon}\right]\left[\frac{1hr}{3600s}\right]$$

NOTE: g/L = gram per litre

(Equation E-2)

Terms, variables, and parameters in Equation E-1 and Equation E-2 are defined below.

The **load factor** is defined as the average fraction of rated power (kW) used in a duty cycle. This takes into account that the engines, when turned on, are operating somewhere between idle speed and full power. Load factor values were determined from US EPA NONROAD Engine Emission modeling guide for the all vehicle fleets (US EPA 2010b). Table E-11 and Table E-12 contain the vehicle specific load factors for the mobile equipment during year -1 and year 4/8 respectively.

The **operational percent** (utilization) is defined as the net operating time divided by the gross operating time multiplied by 100. The operating time is the time during which the ignition of the vehicle is turned on. For example, during year -1 the haul truck activity is assumed to occur 11 hours per day, therefore the operational factor is 100% for hourly emission rates (during any giving hour the vehicle is running), 46% for daily (11 hrs/day) emission rates, and annual (4038 hrs/yr) emission rates (see Table E-11). The operational factors for the year -1 and year 4/8 main mining equipment fleet were provided by KAM Ajax (KAM 2015). Table E-11 and Table E-12 contain the total hours used in the operation time calculation for year -1 and year 4/8 respectively.

An E_f is the **emission factor** (Table E-1) in units of g/kW-hr used for CAC emission rate calculations other than SO_2 and in units of g/L for SO_2. The E_f for SO_2 considers the sulphur content of 15 mg/kg (EC 2013) converted to g/L using the density of diesel (0.85 kg/L) (US EPA 1985) and the molecular weight ratio of SO_2 to sulphur (EC Sulphur in Diesel Fuel Regulations (EC 2013) and US EPA AP-42).

The **engine power** (kilowatts) for year -1 and year 4/8 was obtained from the US EPA NONROAD modeling guide (US EPA 2010a) and the CAT performance handbook (CAT 2014). Table E-11 and Table E-12 contain the engine power (engine size) for year -1 and year 4/8 respectively.

The **deterioration factor** (unitless) is applied to the new vehicle emissions and accounts for any increase in emissions over the life of the vehicle. The factor was determined from the US EPA NONROAD modeling guide (US EPA 2010a). Table E-11 and Table E-12 contain the deterioration factor for year -1 and year 4/8 respectively.

The **transient adjustment factor** (unitless) accounts for how the engine speed and load variations affect the emissions. Values were determined from the US EPA NONROAD modeling guide (US EPA 2010a). The values are reported in Table E-11 and Table E-12 for year -1 and year 4/8 respectively.

The **fuel consumption** (gallons/hr) was extracted from the brake specific fuel consumption (BSFC) input file in the US EPA NONROAD model as lb/hp-hr (US EPA 2010a) and converted to gallons/hr using the diesel density (0.85 kg/L) (US EPA 1985) and confirmed by KAM.

For diesel emissions, inhalable particulate matter (PM_{10}, particles with aerodynamic diameter 10 microns or smaller) and respirable particulate matter ($PM_{2.5}$, particles with aerodynamic diameter 2.5 microns or smaller) emission rates are calculated from the total PM emission rate. It is assumed that the diesel particulate diameters are 98% less than 10 microns and 94% less than 2.5 microns. These estimates of the diesel exhaust particulate diameters are based on the Report on Carcinogens (US HHS 2005).

E.2.2 EXPLOSIVE DETONATON EMISSION FACTORS

Explosive detonations during the blasting processes result in emissions. The substances emitted from ammonium nitrate/fuel oil (ANFO) detonation are NO_x, CO, and SO_2. US EPA Explosives Detonation emission factors for the substances considered are listed in Table E-2 in units of kilogram per megagram (kg/Mg) (US EPA 1980).

Table E-2 NO_x, CO and SO_2 Emission Factors for ANFO Detonation

Activity	Emission Factor (kg/Mg)		
	NO_x	CO	SO_2
Explosive Detonation	8	34	1
SOURCE: US EPA AP-42 Table 13.3-1 (1980)			

E.2.3 FUGITIVE DUST EMISSION FACTORS

Table E-3 contains a summary of the emission factors used in calculating the fugitive dust emissions from project activities (e.g., drilling, blasting, unpaved road dust). Emission factors are given for total suspended particulate matter (TSP), inhalable particulate matter (PM_{10}), and respirable particulate matter ($PM_{2.5}$) with the applicable particle size multiplier. The table summarizes applied parameters and mitigations to the individual project activities. The individual parameters and mitigation measures are further detailed in Table E-4.

Table E-3 also presents an emission factor rating. Each emission factor is assigned a confidence rating based on the performance of the estimated values to test data representative of the source of air emission. The ratings suggest the likely variability of the calculated values to actual site conditions. The following list represents the emission factor rating from A to E as described by the US EPA AP-42:

- A — Excellent. Factor is developed from A- and B-rated source test data taken from many randomly chosen facilities in the industry population. The source category population is sufficiently specific to minimize variability.
- B — Above average. Factor is developed from A- or B-rated test data from a "reasonable number" of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with an A rating, the source category population is sufficiently specific to minimize variability.
- C — Average. Factor is developed from A-, B-, and/or C-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As with the A rating, the source category population is sufficiently specific to minimize variability.
- D — Below average. Factor is developed from A-, B- and/or C-rated test data from a small number of facilities, and there may be reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source population.
- E — Poor. Factor is developed from C- and D-rated test data, and there may be reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population.

Table E-3 Emission Factors for Major Sources of Fugitive Dust Emissions

#	Project Activity	Emission Factor				Particle Size Multiplier (k_1, k_2, k_3, k_4)	Parameters	Mitigations (See Table E-4)	Emission Factor Rating	Reference
		TSP	PM_{10}	$PM_{2.5}$	Units					
1	Drilling	$k_1 \times E(PM_{10})$	$4x10^{-5}$	$k_3 \times E(PM_{10})$	kg/Mg	k1 = 2.11 k3 = 0.15	—	Pit retention, natural	E_f(PM10) = E	US EPA AP-42 11.19.2 Crushed Stone Processing and Pulverized Minerals Processing (US EPA 2004)
2	Blasting	$0.00022(A)^{1.5}$	0.52×E(TSP)	0.03×E(TSP)	kg/blast	—	A = area	Pit retention, natural	E_f(TSP) = C E_f(PM10,PM2.5) = D	US EPA AP-42 11.9 Western Surface Coal Mining (US EPA 1998)
3	Truck loading	$k_1 \times E(PM_{10})$	5×10^{-5}	$k_3 \times E(PM_{10})$	kg/Mg	k1 = 2.11 k3 = 0.15	—	Natural	E_f(PM10) = E	US EPA AP-42 11.19.2 Crushed Stone Processing and Pulverized Minerals Processing (US EPA 2004)
4	Truck unloading	$k_1 \times E(PM_{10})$	8×10^{-6}	$k_3 \times E(PM_{10})$	kg/Mg	k1 = 2.11 k3 = 0.15	—	Natural	E_f(TSP, PM10, PM2.5) = B	US EPA AP-42 11.19.2 Crushed Stone Processing and Pulverized Minerals Processing (US EPA 2004)
5	Unpaved roads	$E_f = k1\left(\frac{silt\%}{12}\right)^{0.7}\left(\frac{W}{3}\right)^{0.45}$	$E_f = k2\left(\frac{silt\%}{12}\right)^{0.9}\left(\frac{W}{3}\right)^{0.45}$	$E_f = k3\left(\frac{silt\%}{12}\right)^{0.9}\left(\frac{W}{3}\right)^{0.45}$	kg/VKT	k1 = 1.38 k2 = 0.42 k3 = 0.042	Silt = 5% for haul roads Silt = 4.3% for access road W = mean vehicle weight	Pit retention for in pit haul roads, control (watering), natural	E_f(TSP, PM10, PM2.5) = B	US EPA AP-42 13.2.2 Unpaved Roads (US EPA 2006a) Mean vehicle weight provided by KAM and the CAT Performance Handbook (CAT 2014) Vehicle kilometre travelled (VKT) is based on End of Period (EOP) maps supplied by KAM. Haul road silt content is based on low end of silt content ranges presented in US EPA AP-42 13.2.2 Unpaved Roads as it is assumed the road is gravel surfaced. Access road silt content is based on the mean service road silt content as the access road is considered a typical service road.
7	Primary crusher	0.01	0.004	$k_3 \times E(PM_{2.5})$	kg/Mg	k3 = 0.72	—	Crusher Screen Efficiency = 75%	E_f(TSP, PM10) = C	US EPA AP-42 11.24 Metallic Minerals Processing (US EPA 1995a)
8	Bulldozing	$E_f = 2.6(Silt\%)^{1.2}/(M)^{1.3}$	$k_2 \times E(TSP)$	$k_3 \times E(TSP)$	kg/hr	k2 = 0.75 k3 = 0.105	Silt = 1.3% for rock Silt = 6.9% for ore Silt = 4.1% for pit M = moisture = 4%	Natural	E_f(TSDP, PM10, PM2.5) = B	US EPA AP-42 11.9 Western Surface Coal Mining (US EPA 1998)
9	Wind erosion	$E_f = 1.9\left(\frac{silt\%}{1.5}\right)\times 365 \times\left(\frac{365-p}{235}\right)\times\left(\frac{f(\%)}{15}\right)$	$k_2 \times E(TSP)$	$k_3 \times E(TSP)$	kg/ha/yr	k2 = 0.473 k3 = 0.072	Silt = 1.3% for rock Silt = 11% for tailings Silt = 4% for ore p = 152 (days with precip/snow on ground) f = 17.7 % (wind more than 5.4 m/s)	—	N/A	National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining (NPI 2012)
10	Excavating/trenching	0.025	0.015	$k_3 \times E(TSP)$	Kg/Mg	k3=0.072	—	Natural	C	NPI Emission Estimation Technique Manual for Mining (NPI 2012)
11	Grading	$0.0034(S)^{2.5}$	$0.6x0.0056(S)^{2.0}$	$0.031x0.040(S)^{2.5}$	Kg/VKT	—	S = speed in kph	Pit retention for in pit haul roads, natural	C	US EPA AP-42 11.9 Western Surface Coal Mining (US EPA 1998)
12	Conveyor transfer point (controlled)	0.00007	$2.3x 10^{-5}$	$6.5 x 10^{-6}$	Kg/Mg	—	—	Natural	E(TSP, PM2.5) = E, E(PM10) =D	US EPA AP-42 11.19.2 Crushed Stone Processing and Pulverized Minerals Processing (US EPA 2004)

Table E-4 contains the various parameters and mitigations applied to the Table E-3 emission factors. The individual mitigation measures are explained below.

Pit retention is the term used to describe the tendency for PM released inside a surface mine pit to not be able to escape the pit. The fraction of PM emissions retained in the open pits was estimated based on the original Winges equation (Winges 1981). The Winges equation expresses the escape fraction of PM that exits the open pit as a function of pit depth, vertical diffusivity and deposition velocity. The Winges equation uses a number of simplified assumptions including the assumption that the only mechanism for transport of material out of the pit is turbulent diffusion which means that vertical wind speeds are ignored. The equation also does not explicitly include wind speed as a parameter.

The mass retention fractions of TSP, PM_{10} and $PM_{2.5}$ for the Project, calculated with the Winges equation vary between year -1 and year 4/8 as the pit depth changes throughout the mine life. At the end of year -1 the deepest pit depth is 75 m and the width of the pit is 522 m (the pit at this stage is approximately circular). For year 4/8 the pit dimensions from year 8 were used since the haulage distances from year 8 were used in the emission estimates At the end of year 8 the deepest pit depth is 285 m, the longest horizontal surface length of the pit is 2,320 m, and the width is 1,230 m. These dimensions include any disturbed land feature associated with the mine pit; therefore the active pit dimensions throughout year 8 will be smaller. These dimensions indicate that depth is greater than 10% of the width and therefore the application of the pit retention factor is appropriate (US EPA 1995c).

Activities in the pit are not limited to the deepest pit depth; they are spread out on the different benches of the pit. Based on production information supplied by KAM an average “working” pit depth was calculated. This averaged “working” pit depth is shallower than the deepest pit depth and results in a more conservative retention faction (i.e., the faction of PM escaping will be higher with a shallower pit depth). During year -1, activities occur at an average depth of 63 m. During year4/8, activities occur at an average depth of 168 m. These average “working” depths were used in the pit retention calculation.

The size fractions of TSP, PM_{10}, and $PM_{2.5}$ are different for the material handling and haul roads. To be consistent, size fractions used in calculation of the road dust emission rates are also used for the pit retention factor calculation for the haul road dust emissions within the pit. The values calculated are in reasonable agreement with the prescribed pit retention reduction of 50% for TSP and 5% for PM_{10} found in the Australia National Pollutant Inventory (NPI) Emission Estimation Technique (EET) Manual for Mining Version 2.3 (NPI EET Manual 2001). The Ajax mine pit has two to three active pits in any given year. The active sections of the pits are often at different elevations. The pit depth used in the Wings equation uses the weighted average of each active sections depth based on the amount of material being moved from each section of the pit (Winges 1986).

Crusher screen efficiency is the efficiency of the screen surrounding the crushing activity and not letting dust escape from the crusher area. Since the crusher is not completely enclosed an efficiency of 75% is applied to the crusher.

Control is the dust control efficiency based on the amount of watering on unpaved roads. KAM committed to 90% dust control efficiency on all in-pit and ex-pit roads, including the access road.

Natural is the amount of natural dust suppression induced by rain or snow events. Efficiency by rain is based on 2010–2012 precipitation data recorded at the Ajax meteorological station. Only days with precipitation above 0.254 mm were considered (US EPA 2006a). Dust suppression by snow was determined using the number of days with snow cover as reported in 2010–2012 at the Environment Canada Afton Airport meteorological station.

Table E-4 Mitigations for Fugitive Dust Emission Factors

Mitigation Description	TSP	PM_{10}	$PM_{2.5}$	Reference	Note
Year -1 pit retention: haul roads	0.52	0.95	0.995	Winges (1986)	Fraction escaping from the pit Size fractions for haul roads are different than for the other pit activities
Year -1 pit retention: other activities	0.80	0.97	0.996	Winges (1986)	
Year 4/8 pit retention: haul roads	0.35	0.85	0.99	Winges (1986)	
Year 4/8 pit retention: other activities	0.69	0.92	0.99	Winges (1986)	
Crusher efficiency	75%	75%	75%	US EPA AP-42 (US EPA 2004)and Engineering details supplied by KAM	Applied to hourly, daily, and annual emission rates
Control: dust control efficiency, watering on roads	90% on all roads, including access road	90% on all roads, including access road	90% on all roads, including access road	KAM commitment	Applied to daily and annual emission rates
Natural: natural dust control efficiency, precipitation/snow on ground	0.45	0.45	0.45	2010–2012 Ajax/Afton Airport Meteorological Station days with precip > 0.20mm and snow on ground	Applied only to annual emission rates

E.2.4 POINT SOURCE EMISSION RATE CALCULATION METHODOLGOY

The point sources considered are all engineered dust collectors, thus these equipment result in TSP, PM_{10}, and $PM_{2.5}$ emissions only. The equations for calculating the emission rates from the dust collectors and the corresponding parameters are listed in Table E-5.

Table E-5 Emission Rate Calculation for Point Sources

Daily Emission Rate Equation	Annual Emission Rate Equations	Parameters
$Daily\ TSP = Max\ TSP\ Concentration\ (mg/m^3) \times Max\ Total\ Discharge\ Rate\ (m^3\ /\ s)$	$Annual\ TSP = Daily\ TSP\ \times Daily\ operating\ time\ fraction \times\ Annual\ operating\ time\ fraction$	
$Daily\ PM_{10} = k_2 \times Daily\ TSP$	$Annual\ PM_{10} = Daily\ PM_{10}\ \times Daily\ operating\ time\ fraction \times\ Annual\ operating\ time\ fraction$	k_2 = 0.47
$Daily\ PM_{2.5} = k_3 \times Daily\ TSP$	$Annual\ PM_{2.5} = Daily\ PM_{2.5}\ \times Daily\ operating\ time\ fraction \times\ Annual\ operating\ time\ fraction$	k_3 = 0.072

NOTES: TSP concentration is given in milligram per cubic meter (mg/m^3).
Max total discharge rate is given in cubic meter per second (m^3/s).

SOURCE: The size fraction multiplier reference: US EPA AP-42 13.2.4.

Since there is limited information available concerning the emissions from the point sources during year -1, it is assumed that the emissions from the point sources are the same in year -1 as in year 4/8. The point source emission parameters are specifications of the engineered dust collector and were supplied by KAM. The parameters k_2 and k_3 are the size fraction multiplier from the US EPA AP-42 Table 13.2.4 (US EPA 2006b).

Based on information from KAM, all point sources are inside of a building. On the roof of the building there are bag houses that collect any dust escaping from the building. The fabric filters on these collectors have collection efficiencies typical of fabric filters described in Appendix B.2 of the US EPA AP-42 (US EPA 1995b). Table E-6 contains the control efficiencies applied to the point source emissions.

Since the point sources are all within one building the total emissions are calculated with applied and then modelled as an area source.

Table E-6 Collection Efficiencies of Particulate Control Devices

Code	Type of Collector	Particle Size (µm)		
		0–2.5	2.5–6	6–10
016	Fabric Filter	99% efficiency	99.5% efficiency	99.5% efficiency

E.3 YEAR -1 AND YEAR 4/8 EMISSIONS INVENTORY

E.3.1 WORK DEPLOYMENT AREAS

Work deployment areas are sections of the mine plan that have been identified as areas where certain activities occur or where a specific mine feature is located on the mine plan. These areas are either modelled as area sources or volume sources. During year -1 and year 4/8 the areas include:

Area Sources:

- Blast Area (BA)
- Pit (Pit)
- Ore Drop (OD)
- Ore Storage Pile North (OSN)
- Ore Storage Pile South (OSS)
- Overburden/East Mine Rock Storage Facility (EMRSF)
- Reclamation (Rec)
- South Mine Rock Storage Facility (SMRSF)
- Tailings Beach (Tb)
- Tailings Facility Mike Rock Storage Facility 1 (TSFMRSF 1)
- TSFMRS 2
- Haul Road 1 (HR1)
- Haul Road 2 (HR2)
- Haul Road 3 (HR3)
- Haul Road 4 (HR4)
- Haul Road C (HRC)
- Processing Mill (Mill)

Volume Sources:

- Crusher (Cr)
- Access Road (AR)

The Crusher and the Access Road are both modelled as volume sources. Everything else is modelled as area sources.

The work deployment areas are applied to the equipment fleet as well as the various mine activities to distribute the emission sources into specific areas as percentages. Table E-7 through Table E-10 contain the area and volume source parameters for each of the area and volume sources included in the dispersion modelling during year -1 and 4/8.

Table E-7 Area Sources included in the Air Quality Assessment during Year -1 and Year 4/8

Area	Area Source Location (UTM Zone 10, NAD 83)								Source Parameters			
	Northwest		Northeast		Southwest		Southeast		Effective Height (m)	Base Height (masl)	Initial σ_z (m)	Total area (m^2)
Blast area	683386	5609730	683857	5609730	683857	5609270	683386	5609270	5.0	915.5	4.7	215,054
Pit	683279	5609992	685342	5610273	685080	5609370	683453	5609174	3.3	919.1	3.0	1,577,287
Ore Drop	686191	5608317	686189	5608319	686191	5608320	686192	5608319	1.5	983.1	1.4	7.1
Ore Storage Pile North	684029	5608729	684419	5608962	684807	5608627	684180	5608481	10.0	910.4	9.3	199,203
Ore Storage Pile South	684163	5608465	684755	5608590	684844	5607876	684611	5607746	10.0	954.5	9.3	330,033
Overburden/EMRSF	685785	5610531	686035	5610964	687351	5610204	687101	5609771	20.0	975.3	18.6	757,576
Reclamation	684473	5610409	684440	5610596	685070	5610707	685103	5610520	10.0	953.4	9.3	121,507
SMRSF	685291	5608660	686927	5607630	686360	5606540	684567	5607470	5.0	1135.0	4.7	2,577,320
Tailings Beach	683528	5606001	684897	5606606	685529	5605945	685066	5605177	5.0	1038.0	4.7	1,424,501
TSFMRSF 1	681852	5608010	682608	5608640	683218	5608310	681885	5607310	5.0	1015.0	4.7	800,000
TSFMRS 2	682608	5608640	683928	5608890	684386	5608110	684054	5607850	5.0	1015.0	4.7	884,956
Mill	686193	5608356	686858	5608318	686836	5607909	686500	5607930	10.0	972.8	9.3	230,947

NOTES:
masl = metres above sea level
σ_z = sigma z height

Year -1 and Year 4/8 Emissions Inventory
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Table E-8 Haul Road Sources modelled as Area Sources included in the Air Quality Assessment during Year -1 and Year 4/8

Area	Length of Road (m)	Number of Area Sources	Source Parameters	
			Effective Height (m)	Initial σ_z (m)
Haul Road 1	900	5	3.1	2.9
Haul Road 2	1,500	5	3.1	2.9
Haul Road 3	2,900	16	3.1	2.9
Haul Road 4	2,400	10	3.1	2.9
Haul Road C	4,100	10	3.1	2.9

Table E-9 Access Road Source modelled as Volume Sources included in the Air Quality Assessment during Year -1 and Year 4/8

Volume	Length of Road (m)	Number of Volume Sources	Source Parameters		
			Effective Height (m)	Initial σ_y (m)	Initial σ_z (m)
Access Road	12,200	96	2.1	14.9	1.9

Table E-10 Volume Sources included in the Air Quality Assessment during Year -1 and Year 4/8

Volume	Volume Source Location (UTM Zone 10, NAD 83)		Source Parameters			
	Easting	Northing	Effective Height (m)	Base Height (masl)	Initial σ_y (m)	Initial σ_z (m)
Crusher	685105	5609141	2.1	898.2	3.5	2

E.3.2 CAC EMISSIONS FROM DIESEL ENGINES

The vehicle fleet for year -1 and year 4/8 is sectioned into 3 different groups:

- Main mining equipment
- Support equipment
- Access road vehicles

Table E-11and Table E-12 summarize the vehicle fleet information used in the calculation of CAC emission rates from diesel engines for year -1 and year 4/8, respectively. There are several pieces of equipment that are electric and or considered to be on standby status and therefore have no emissions, however they are included in the inventory for completeness.

Table E-11 Year -1 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

Type	# of Units	Work Deployment (%)	Load Factor	Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
				hrs/day	hrs/year	hrs	(kW)	(gallons/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
Main Mining Equipment															
Haul Trucks 290T	5	50 Pit, 4.5 HR1, 3 HR2, 0.5 HR3, 28 HR4, 14 HRC	0.37	11	4,038	100,000	2,013	150.17	2.0	1.04	1.53	1.47	1.001	1.012	1.038
Shovel - 76 Yard	1	100 Pit	electric	10	3,537	150,000	electric								
Loader LT850 Sized	1	100 Pit	0.37	18	6,658	60,000	1,491	111.24	10.0	1.04	1.53	1.47	1.008	1.151	1.473
Drill-311m Production	1	100 Pit	0.43	1	365	50,000	402	29.66	1.0	1.00	1.00	1.00	1.000	1.001	1.003
Drill-152 mm Preshear Dril (wall control drills)	0	100 Pit	electric	0	0	50,000	electric								
Track Dozer (450 kW class)	4	17 OSN, 17 OSS, 17 EMRSF, 17 SMRSF, 17 TSFMRSF1, 17 TSFMRSF2	0.4	15	5,606	50,000	574	42.83	0.8	1.04	1.53	1.47	1.001	1.013	1.040
Rubber Tire Dozers WD 600	1	98 Pit, 2 Rec	0.43	15	5,475	50,000	389	29.03	0	1.04	1.53	1.47	1.000	1.000	1.000
Grader - 16 ft	3	50 Pit, 10 HR1, 10 HR2, 10 HR3, 10 HR4, 10 HRC	0.43	15	5,606	50,000	224	16.74	0.7	1.04	1.53	1.47	1.001	1.011	1.035
Water trucks HD 785 20k Gallon	3	17 Pit, 17 HR1, 17 HR2, 17 HR3, 17 HR4, 17 HRC	0.21	17	6,329	100,000	895	66.74	0.7	1.04	1.53	1.47	1.000	1.006	1.020
Support Equipment															
Excavator - 4.5m3 bucket CAT374DI	2	8 Pit, 8 OSN, 8 OSS, 8 EMRSF, 8 SMRSF, 8 TSFMRS1, 8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	0.59	15	5,475	50,000	355	26.47	8.0	1.04	1.53	1.47	1.001	1.017	1.052
Cable Reeler – FEL mounted	1		0.59	15	5,475	21,5265	246	18.35	8.0	1.04	1.53	1.47	1.002	1.038	1.120
Truck mounted cable reel c/w hydraulic arm Ground Force	1		0.59	15	5,475	21,526	246	18.35	8.0	1.04	1.53	1.47	1.002	1.038	1.120
Mobile Cable Repair Station	1		0.59	15	5,475	21,526	261	19.47	8.0	1.04	1.53	1.47	1.002	1.038	1.120
Shovel Lube truck	1		0.21	15	5,475	18,388	246	18.35	8.0	1.04	1.53	1.47	1.002	1.045	1.141
Pickup Trucks	35		0.21	15	5,475	10,5120	298	25.97	8.0	1.21	2.57	2.37	1.000	1.008	1.025
Fire truck	1		0.21	2	730	43,800	373	32.46	8.0	1.21	2.57	2.37	1.000	1.003	1.008
Ambulance	1		0.21	2	730	43,800	283	24.67	8.0	1.21	2.57	2.37	1.000	1.003	1.008
100 ton Tow truck and low-bed trailer	1		0.21	15	5,475	43,800	1864	162.29	8.0	1.21	2.57	2.37	1.001	1.019	1.059
Loader for the load-out	2		0.21	15	5,475	43,800	111	8.29	8.0	1.04	1.53	1.47	1.001	1.019	1.059
Extend a-boom loader	1		0.21	15	5,475	43,800	111	8.29	8.0	1.00	1.00	1.00	1.001	1.019	1.059
Crane for the Tailings	1		0.43	15	5,475	52,560	186	13.75	8.0	1.00	1.00	1.00	1.001	1.016	1.049
Dump Truck	1		0.59	15	5,475	43,800	354	26.42	8.0	1.21	2.57	2.37	1.001	1.019	1.059
BACKHOE EXTEND HOE CAT IT420E	1	8 Pit, 8 OSN, 8 OSS, 8 EMRSF, 8 SMRSF, 8 TSFMRS1,	0.21	15	5,475	43,800	71	6.85	8.0	1.21	2.57	2.37	1.001	1.019	1.059

Table E-11 Year -1 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

				Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
Type	# of Units	Work Deployment (%)	Load Factor	hrs/day	hrs/year	hrs	(kW)	(gallons/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
COMPRESSOR, AIR	1	8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	electric												
COMPRESSOR, AIR	1		electric												
FORKLIFT, CAT DP30	1		0.59	15	4,380	105,120	38	3.15	8.0	1.04	1.53	1.47	1.000	1.006	1.020
FORKLIFT CAT DP60	1		0.59	15	4,380	105,120	64	5.29	8.0	1.04	1.53	1.47	1.000	1.006	1.020
FORKLIFT, CAT ELECTRIC NRR30	1		electric												
FORKLIFT DYNALIFT REACHFORK	1		0.59	15	5,475	105,120	86	6.40	8.0	1.04	1.53	1.47	1.000	1.008	1.025
Hyster 80 Forklift	1		0.59	15	5,475	105,120	75	5.56	8.0	1.04	1.53	1.47	1.000	1.008	1.025
CAT MC30 Forklift	3		0.59	15	5,475	105,120	38	3.15	8.0	1.04	1.53	1.47	1.000	1.008	1.025
GENERATOR, CAT	1		standby												
CRANE, MOBILE RT528C, 28 TON	1		0.43	15	5,475	18,826.26	298	22.01	8.0	1.00	1.00	1.00	1.002	1.044	1.138
ALLMAND MAXI-HEATER	1		electric												
WACKER YARD LIGHT MODEL LTC4C	8		0.43	15	4,380	2,688	20	1.64	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Mechanic's Service truck	2		0.59	15	5,475	1,536	246	18.16	8.0	1.04	1.53	1.47	1.008	1.151	1.473
2007 GENIE GS3246 SCISSOR LIFT	1		electric												
CAT SKID STEER 246B	3		0.21	15	5,475	43,800	54	5.26	8.0	1.21	2.57	2.37	1.001	1.019	1.059
BOOM TRUCK 95 FORD	1		0.59	15	5,475	43,800	246	20.38	8.0	1.04	1.53	1.47	1.001	1.019	1.059
BOOM TRUCK FORD W/MANBASKET	1		0.59	15	5,475	43,800	246	18.35	8.0	1.04	1.53	1.47	1.001	1.019	1.059
CRANE, F80 BOOM TRUCK	1		0.43	15	5,475	43,800	246	18.35	8.0	1.00	1.00	1.00	1.001	1.019	1.059
FORD L-8000 BOOM TRUCK	1		0.59	15	5,475	43,800	246	18.35	8.0	1.04	1.53	1.47	1.001	1.019	1.059
CRANE, JLG	1		0.43	15	5,475	52,560	186	13.75	8.0	1.00	1.00	1.00	1.001	1.016	1.049
2008 GENIE 45' MAN LIFT	1		0.59	15	5,475	52,560	186	13.90	8.0	1.04	1.53	1.47	1.001	1.016	1.049
KNUCKLE BOOM, F800, N-50	1		0.59	15	5,475	52,560	186	13.90	8.0	1.04	1.53	1.47	1.001	1.016	1.049
IMT Compressor	2		electric												
Miller Big Blue Air Pac Welder	2		0.21	15	5,475	105,120	242	21.10	8.0	1.21	2.57	2.37	1.000	1.008	1.025
WELDER 400AMP DSL TRLR MTD	1		0.21	15	5,475	105,120	242	21.10	8.0	1.21	2.57	2.37	1.000	1.008	1.025
WELDER 600 AMP	4		0.21	15	5,475	105,120	242	21.10	8.0	1.21	2.57	2.37	1.000	1.008	1.025
Kenworth Lube truck	1	8 Pit, 8 OSN, 8 OSS, 8	0.59	15	5,475	52,560	354	26.42	8.0	1.04	1.53	1.47	1.001	1.016	1.049

Table E-11 Year -1 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

Type	# of Units	Work Deployment (%)	Load Factor	Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
				hrs/day	hrs/year	hrs	(kW)	(gallons/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
GENERATOR, DETROIT DIESEL	1	EMRSF, 8 SMRSF, 8 TSFMRS1, 8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	standby												
Carry Deck Crane 15 ton	1		0.43	15	5,475	52,560	186	13.75	8.0	1.00	1.00	1.00	1.001	1.016	1.049
Loader For Ball Mill Media & Misc Work CAT 966	1		0.21	15	5,475	50,000	188	14.02	8.0	1.00	1.00	1.00	1.001	1.017	1.052
Explosives transport	1	50 Pit, 50 HR1	0.59	1	5,694	105,120	485	36.15	8.0	1.04	1.53	1.47	1.000	1.008	1.026
Access Road Vehicles															
Lime (Hydrated) - 40t payload freight	1	100 AR	0.59	3E-01	121	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.001
MIBC/Dowfroth 40t payload freight	1		0.59	2E-02	6	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
PAX 40t payload freight	1		0.59	1E-02	5	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Flocculent 40t payload freight	1		0.59	3E-04	1	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Gold Promoter 40t payload freight	1		0.59	1E-02	4	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Ball Mill - Balls 40t payload freight	1		0.59	6E-01	231	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Regrind - Balls 40t payload freight	1		0.59	1E-02	4	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Fuel Truck	1		0.59	3	995	105,120	261	19.47	8.0	1.21	2.57	1.97	1.000	1.000	1.001
Bulk Product	1		0.59	1	507	105,120	261	19.47	8.0	1.21	2.57	1.97	1.000	1.000	1.000
Staff Bus	4	50 AR, 50 HR1	0.21	2	887	105,120	261	22.72	8.0	1.21	2.57	2.37	1.000	1.001	1.004
Pickup Truck Traffic	10	50 AR, 50 HR1	0.21	24	7,008	105,120	298	25.97	8.0	1.21	2.57	2.37	1.000	1.001	1.002
Other 20 ton trucks for supplies	2	100 AR	0.59	1	444	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.001	1.004
Concentrate 40 t freight truck	1		0.59	11	3,960	105,120	261	19.47	8.0	1.04	1.53	1.47	1.001	1.010	1.032

NOTES:
BA = Blast Area
OD = Ore Drop
OSN = Ore Storage Pile North
OSS = Ore Storage Pile South
EMRSF = Overburden/East Mine Rock Storage Facility
Rec = Reclamation
SMRSF = South Mine Rock Storage Facility
Tb = Tailings Beach
TSFMRSF 1/2 = Tailings Facility Mike Rock Storage Facility 1/2
HR1 = Haul Road 1
HR2 = Haul Road 2
HR3 = Haul Road 3
HR4 = Haul Road 4
HRC = Haul Road C
Mill = Processing Mill
Cr = Crusher
AR = Access Road

Table E-12 Year 4/8 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

Type	# of Units	Work Deployment (%)	Load Factor	Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
				hrs/day	hrs/year	hours	(kW)	(gallon/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
Main Mining Equipment															
Haul Trucks 290T	28	50 Pit, 10 HR1, 2 HR2, 15 HR3, 22 HR4, 1 HRC	0.37	19	6,935	100,000	2013	150.17	7.2	1.04	1.53	1.47	1.004	1.075	1.235
Shovel - 76 Yard	3	100 Pit	electric	19	7,074	150,000	electric								
Loader LT850 Sized	1	100 Pit	0.37	18	6,658	60,000	1,491	111.24	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Drill-311m Production	3	100 Pit	0.43	15	5,434	50,000	402	29.66	10.0	1.00	1.00	1.00	1.007	1.137	1.428
Drill-152 mm Preshear Dril (wall control drills)	2	100 Pit	electric	17	6,315	50,000	electric								
Track Dozer (450 kW class)	6	17 OSN, 17 OSS, 17 EMRSF, 17 SMRSF, 17 TSFMRSF1, 17 TSFMRSF2	0.4	15	5,606	50,000	574	42.83	7.5	1.04	1.53	1.47	1.003	1.054	1.168
Rubber Tire Dozers WD 600	3	98 Pit, 2 Rec	0.43	15	5,475	50,000	389	29.03	3.2	1.04	1.53	1.47	1.007	1.132	1.414
Grader - 16 ft	4	50 Pit, 10 HR1, 10 HR2, 10 HR3, 10 HR4, 10 HRC	0.43	15	5,606	50,000	224	16.74	8.0	1.04	1.53	1.47	1.004	1.080	1.252
Water trucks HD 785 20k Gallon	5	17 Pit, 17 HR1, 17 HR2, 17 HR3, 17 HR4, 17 HRC	0.21	17	6,329	100,000	895	66.74	4.8	1.04	1.53	1.47	1.004	1.076	1.239
Support Equipment															
Excavator - 4.5m3 bucket CAT374DI	2	8 Pit, 8 OSN, 8 OSS, 8 EMRSF, 8 SMRSF, 8 TSFMRS1, 8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	0.59	19	7,008	50,000	355	26.47	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Cable Reeler – FEL mounted	1		0.59	19	7,008	21,526.15	246	18.35	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Truck mounted cable reel c/w hydraulic arm Ground Force	1		0.59	19	7,008	21,526.15	246	18.35	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Mobile Cable Repair Station	1		0.59	19	7,008	21,526.15	261	19.47	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Shovel Lube truck	1		0.21	19	7,008	18,388.44	246	18.35	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Pickup Trucks	35		0.21	19	7,008	105,120	298	25.97	8.0	1.21	2.57	2.37	1.004	1.081	1.252
Fire truck	1		0.21	2	1,752	43,800	373	32.46	8.0	1.21	2.57	2.37	1.003	1.048	1.151
Ambulance	1		0.21	2	1,752	43,800	283	24.67	8.0	1.21	2.57	2.37	1.003	1.048	1.151
100 ton Tow truck and lowbed trailer	1		0.21	19	7,008	43,800	1864	162.29	8.0	1.21	2.57	2.37	1.008	1.151	1.473
Loader for the load-out	2		0.21	19	7,008	43,800	111	8.29	8.0	1.04	1.53	1.47	1.008	1.151	1.473
Extend a-boom loader	1		0.21	19	7,008	43,800	111	8.29	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Crane for the Tailings	1		0.43	19	7,008	52,560	186	13.75	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Dump Truck	1		0.59	19	7,008	43,800	354	26.42	8.0	1.21	2.57	2.37	1.008	1.151	1.473

Table E-12 Year 4/8 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

Type	# of Units	Work Deployment (%)	Load Factor	Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
				hrs/day	hrs/year	hours	(kW)	(gallon/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
BACKHOE EXTEND HOE CAT IT420E	1	8 Pit, 8 OSN, 8 OSS, 8 EMRSF, 8 SMRSF, 8 TSFMRS1, 8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	0.21	19	7,008	43,800	71	6.85	8.0	1.21	2.57	2.37	1.008	1.151	1.473
COMPRESSOR, AIR	1		electric												
COMPRESSOR, AIR	1		electric												
FORKLIFT, CAT DP30	1		0.59	24	4,380	105,120	38	3.15	8.0	1.04	1.53	1.47	1.003	1.050	1.158
FORKLIFT CAT DP60	1		0.59	24	4,380	105,120	64	5.29	8.0	1.04	1.53	1.47	1.003	1.050	1.158
FORKLIFT, CAT ELECTRIC NRR30	1		electric												
FORKLIFT DYNALIFT REACHFORK	1		0.59	24	7,008	105,120	86	6.40	8.0	1.04	1.53	1.47	1.004	1.081	1.252
Hyster 80 Forklift	1		0.59	24	7,008	105,120	75	5.56	8.0	1.04	1.53	1.47	1.004	1.081	1.252
CAT MC30 Forklift	3		0.59	24	7,008	105,120	38	3.15	8.0	1.04	1.53	1.47	1.004	1.081	1.252
GENERATOR, CAT	1		standby												
CRANE, MOBILE RT528C, 28 TON	1		0.43	24	7,008	18,826.26	298	22.01	8.0	1.00	1.00	1.00	1.008	1.151	1.473
ALLMAND MAXI-HEATER	1		electric												
WACKER YARD LIGHT MODEL LTC4C	8		0.43	24	4,380	2,688	20	1.64	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Mechanic's Service truck	2		0.59	24	7,008	1,536	246	18.16	8.0	1.04	1.53	1.47	1.008	1.151	1.473
2007 GENIE GS3246 SCISSOR LIFT	1		electric												
CAT SKID STEER 246B	3		0.21	24	7,008	43,800	54	5.26	8.0	1.21	2.57	2.37	1.008	1.151	1.473
BOOM TRUCK 95 FORD	1		0.59	24	7,008	43,800	246	20.38	8.0	1.04	1.53	1.47	1.008	1.151	1.473
BOOM TRUCK FORD W/MANBASKET	1		0.59	24	7,008	43,800	246	18.35	8.0	1.04	1.53	1.47	1.008	1.151	1.473
CRANE, F80 BOOM TRUCK	1		0.43	24	7,008	43,800	246	18.35	8.0	1.00	1.00	1.00	1.008	1.151	1.473
FORD L-8000 BOOM TRUCK	1		0.59	24	7,008	43,800	246	18.35	8.0	1.04	1.53	1.47	1.008	1.151	1.473
CRANE, JLG	1		0.43	24	7,008	52,560	186	13.75	8.0	1.00	1.00	1.00	1.008	1.151	1.473
2008 GENIE 45' MAN LIFT	1		0.59	24	7,008	52,560	186	13.90	8.0	1.04	1.53	1.47	1.008	1.151	1.473
KNUCKLE BOOM, F800, N-50	1		0.59	24	7,008	52,560	186	13.90	8.0	1.04	1.53	1.47	1.008	1.151	1.473
IMT Compressor	2		electric												
Miller Big Blue Air Pac Welder	2		0.21	24	7,008	105,120	242	21.10	8.0	1.21	2.57	2.37	1.004	1.081	1.252
WELDER 400AMP DSL TRLR MTD	1		0.21	24	7,008	105,120	242	21.10	8.0	1.21	2.57	2.37	1.004	1.081	1.252
WELDER 600 AMP	4		0.21	24	7,008	105,120	242	21.10	8.0	1.21	2.57	2.37	1.004	1.081	1.252

Table E-12 Year 4/8 Vehicle Fleet and Equipment Parameters for CAC Emission Rate Calculation

Type	# of Units	Work Deployment (%)	Load Factor	Operating time		Lifetime	Engine Size	Diesel Fuel Consumption	Equipment Age	Transient Adjustment Factors			Deterioration Factor		
				hrs/day	hrs/year	hours	(kW)	(gallon/hr)	(Years)	NO_x	CO	PM	NO_x	CO	PM
Kenworth Lube truck	1	8 Pit, 8 OSN, 8 OSS, 8 EMRSF, 8 SMRSF, 8 TSFMRS1, 8 TSFMRS2, 8 HR1, 8 HR2, 8 HR3, 8 HR4, 8 HRC	0.59	24	7,008	52,560	354	26.42	8.0	1.04	1.53	1.47	1.008	1.151	1.473
GENERATOR, DETROIT DIESEL	1		standby												
Carry Deck Crane 15 ton	1		0.43	24	7,008	52,560	186	13.75	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Loader For Ball Mill Media & Misc Work CAT 966	1		0.21	24	7,008	50,000	188	14.02	8.0	1.00	1.00	1.00	1.008	1.151	1.473
Explosives transport	1	50 Pit, 50 HR1	0.59	1	5,694	105,120	485	36.15	8.0	1.04	1.53	1.47	1.003	1.065	1.205
Access Road Vehicles															
Lime (Hydrated) - 40t payload freight	1	100 AR	0.59	3E-01	121	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.001	1.004
MIBC/Dowfroth 40t payload freight	1		0.59	2E-02	6	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
PAX 40t payload freight	1		0.59	1E-02	5	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Flocculent 40t payload freight	1		0.59	3E-04	1	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Gold Promoter 40t payload freight	1		0.59	1E-02	4	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Ball Mill - Balls 40t payload freight	1		0.59	6E-01	231	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.003	1.008
Regrind - Balls 40t payload freight	1		0.59	1E-02	4	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.000	1.000
Fuel Truck	1		0.59	3	995	105,120	261	19.47	8.0	1.21	2.57	1.97	1.001	1.011	1.036
Bulk Product	1		0.59	1	507	105,120	261	19.47	8.0	1.21	2.57	1.97	1.000	1.006	1.018
Staff Bus	4	50 AR, 50 HR1	0.21	2	887	105,120	261	22.72	8.0	1.21	2.57	2.37	1.001	1.010	1.032
Pickup Truck Traffic	10	50 AR, 50 HR1	0.21	24	7,008	105,120	298	25.97	8.0	1.21	2.57	2.37	1.004	1.081	1.252
Other 20 ton trucks for supplies	2	100 AR	0.59	1	444	105,120	261	19.47	8.0	1.04	1.53	1.47	1.000	1.005	1.016
Concentrate 40 t freight truck	1		0.59	11	3,960	105,120	261	19.47	8.0	1.04	1.53	1.47	1.002	1.046	1.143

NOTES:
BA = Blast Area
OD = Ore Drop
OSN = Ore Storage Pile North
OSS = Ore Storage Pile South
EMRSF = Overburden/East Mine Rock Storage Facility
Rec = Reclamation
SMRSF = South Mine Rock Storage Facility
Tb = Tailings Beach
TSFMRSF 1/2 = Tailings Facility Mike Rock Storage Facility 1/2
HR1 = Haul Road 1
HR2 = Haul Road 2
HR3 = Haul Road 3
HR4 = Haul Road 4
HRC = Haul Road C
Mill = Processing Mill
Cr = Crusher
AR = Access Road

Table E-13 and Table E-14 summarize the hourly, daily and annual CAC emission rates during year -1 and year 4/8, respectively. Emission rate totals are given per equipment type. The rates were determined using Equations E-1 (NO_X, CO, and PM) and Equation E-2 (SO_2), the emission factors listed in Table E-3, and the equipment parameters in Table E-12. The PM values in Table E-13 and Table E-14 represent diesel particulate matter (DPM). Only total DPM is shown and not separated into inhalable and or respirable PM. It is assumed that the diesel particulate diameters are 98% less than 10 microns and 94% less than 2.5 microns. These estimates of the diesel exhaust particulate diameters are based on the Report on Carcinogens (US HHS 2005).

Table E-13 CAC Emission Rates for Equipment used during Year -1 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
Main Mining Equipment												
Haul trucks 290t	6.44E+00	3.67E+00	2.15E-01	7.48E-03	6.44E+00	3.67E+00	2.15E-01	7.48E-03	2.97E+00	1.69E+00	9.90E-02	3.45E-03
Shovel - 76 yard												
Loader lt850 sized	9.60E-01	6.17E-01	4.52E-02	1.11E-03	9.60E-01	6.17E-01	4.52E-02	1.11E-03	7.30E-01	4.69E-01	3.43E-02	8.42E-04
Drill-311m Production	1.65E-01	1.68E-01	9.63E-03	3.40E-04	1.65E-01	1.68E-01	9.63E-03	3.40E-04	6.87E-03	7.01E-03	4.01E-04	1.42E-05
Drill-152 mm Preshear Drill (wall control drills)	electric											
Track Dozer (450 kw class)	1.59E+00	9.05E-01	5.31E-02	1.84E-03	1.59E+00	9.05E-01	5.31E-02	1.84E-03	1.02E+00	5.79E-01	3.40E-02	1.18E-03
Rubber tire dozers wd 600	1.60E-01	1.63E-01	9.30E-03	3.36E-04	1.60E-01	1.63E-01	9.30E-03	3.36E-04	9.98E-02	1.02E-01	5.81E-03	2.10E-04
Grader - 16 ft	2.82E-01	2.85E-01	1.67E-02	5.81E-04	2.82E-01	2.85E-01	1.67E-02	5.81E-04	1.81E-01	1.82E-01	1.07E-02	3.72E-04
Water trucks HD 785 20k Gallon	9.74E-01	5.52E-01	3.19E-02	1.13E-03	9.74E-01	5.52E-01	3.19E-02	1.13E-03	7.04E-01	3.99E-01	2.31E-02	8.18E-04
Support Equipment												
Excavator - 4.5m^3 bucket CAT374DI	4.02E-01	4.61E-01	3.29E-02	8.41E-04	4.02E-01	4.61E-01	3.29E-02	8.41E-04	2.52E-01	2.88E-01	2.06E-02	5.26E-04
Cable Reeler – FEL mounted	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	8.90E-02	1.02E-01	7.43E-03	1.82E-04
Truck mounted cable reel c/w hydraulic arm Ground Force	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	8.90E-02	1.02E-01	7.43E-03	1.82E-04
Mobile cable repair station	1.51E-01	1.72E-01	1.26E-02	3.09E-04	1.51E-01	1.72E-01	1.26E-02	3.09E-04	9.44E-02	1.08E-01	7.88E-03	1.93E-04
Shovel Lube truck	5.07E-02	5.78E-02	4.23E-03	1.04E-04	5.07E-02	5.78E-02	4.23E-03	1.04E-04	3.17E-02	3.61E-02	2.64E-03	6.49E-05
Pickup trucks	2.14E+00	2.27E+00	1.46E-01	6.00E-03	2.14E+00	2.27E+00	1.46E-01	6.00E-03	1.34E+00	1.42E+00	9.11E-02	3.75E-03
Fire truck	7.48E-02	7.77E-02	4.62E-03	2.14E-04	7.48E-02	7.77E-02	4.62E-03	2.14E-04	6.23E-03	6.47E-03	3.85E-04	1.79E-05
Ambulance	5.80E-02	5.90E-02	3.51E-03	1.63E-04	5.80E-02	5.90E-02	3.51E-03	1.63E-04	4.83E-03	4.92E-03	2.93E-04	1.36E-05
100 ton Tow truck and lowbed trailer	6.81E-01	4.38E-01	3.20E-02	1.07E-03	6.81E-01	4.38E-01	3.20E-02	1.07E-03	4.26E-01	2.74E-01	2.00E-02	6.70E-04
Loader for the load-out	4.58E-02	5.22E-02	3.82E-03	9.37E-05	4.58E-02	5.22E-02	3.82E-03	9.37E-05	2.86E-02	3.26E-02	2.39E-03	5.86E-05
Extend a-boom loader	2.29E-02	2.61E-02	1.91E-03	4.64E-05	2.29E-02	2.61E-02	1.91E-03	4.64E-05	1.43E-02	1.63E-02	1.19E-03	2.90E-05
Crane for the Tailings	7.86E-02	8.77E-02	6.21E-03	1.58E-04	7.86E-02	8.77E-02	6.21E-03	1.58E-04	4.91E-02	5.48E-02	3.88E-03	9.85E-05
Dump truck	2.01E-01	2.34E-01	1.71E-02	4.90E-04	2.01E-01	2.34E-01	1.71E-02	4.90E-04	1.26E-01	1.46E-01	1.07E-02	3.06E-04
Backhoe extend hoe cat it420e	1.46E-02	1.66E-02	1.22E-03	4.52E-05	1.46E-02	1.66E-02	1.22E-03	4.52E-05	9.12E-03	1.04E-02	7.61E-04	2.83E-05
Compressor, air	electric											
Compressor, air	electric											
Forklift, cat dp30	2.19E-02	2.29E-02	1.44E-03	5.00E-05	2.19E-02	2.29E-02	1.44E-03	5.00E-05	1.09E-02	1.14E-02	7.21E-04	2.50E-05

Table E-13 CAC Emission Rates for Equipment used during Year -1 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
Forklift cat dp60	3.68E-02	3.85E-02	2.42E-03	8.41E-05	3.68E-02	3.85E-02	2.42E-03	8.41E-05	1.84E-02	1.93E-02	1.21E-03	4.20E-05
Forklift, cat electric nrr30	electric											
Forklift dynalift reachfork	4.94E-02	5.23E-02	3.36E-03	1.02E-04	4.94E-02	5.23E-02	3.36E-03	1.02E-04	3.09E-02	3.27E-02	2.10E-03	6.35E-05
Hyster 80 forklift	4.30E-02	4.55E-02	2.93E-03	8.83E-05	4.30E-02	4.55E-02	2.93E-03	8.83E-05	2.69E-02	2.84E-02	1.83E-03	5.52E-05
Cat mc30 forklift	6.57E-02	6.95E-02	4.47E-03	1.50E-04	6.57E-02	6.95E-02	4.47E-03	1.50E-04	4.11E-02	4.34E-02	2.80E-03	9.37E-05
Generator, cat	standby											
Crane, mobile rt528c, 28 ton	1.26E-01	1.44E-01	1.05E-02	2.52E-04	1.26E-01	1.44E-01	1.05E-02	2.52E-04	7.87E-02	8.97E-02	6.56E-03	1.58E-04
Allmand maxi-heater												
Wacker yard light model ltc4c	6.75E-02	7.70E-02	5.63E-03	1.50E-04	6.75E-02	7.70E-02	5.63E-03	1.50E-04	3.38E-02	3.85E-02	2.82E-03	7.52E-05
Mechanic's Service truck	2.85E-01	3.25E-01	2.38E-02	5.77E-04	2.85E-01	3.25E-01	2.38E-02	5.77E-04	1.78E-01	2.03E-01	1.49E-02	3.60E-04
2007 genie gs3246 scissor lift	electric											
Cat skid steer 246b	3.37E-02	3.84E-02	2.81E-03	1.04E-04	3.37E-02	3.84E-02	2.81E-03	1.04E-04	2.10E-02	2.40E-02	1.75E-03	6.52E-05
Boom truck 95 ford	1.42E-01	1.62E-01	1.19E-02	3.24E-04	1.42E-01	1.62E-01	1.19E-02	3.24E-04	8.90E-02	1.02E-01	7.43E-03	2.02E-04
Boom truck ford w/manbasket	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	8.90E-02	1.02E-01	7.43E-03	1.82E-04
Crane, f80 boom truck	1.04E-01	1.18E-01	8.66E-03	2.10E-04	1.04E-01	1.18E-01	8.66E-03	2.10E-04	6.49E-02	7.40E-02	5.41E-03	1.31E-04
Ford l-8000 boom truck	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	8.90E-02	1.02E-01	7.43E-03	1.82E-04
Crane, jlg	7.86E-02	8.77E-02	6.21E-03	1.58E-04	7.86E-02	8.77E-02	6.21E-03	1.58E-04	4.91E-02	5.48E-02	3.88E-03	9.85E-05
2008 genie 45' man lift	1.08E-01	1.20E-01	8.52E-03	2.21E-04	1.08E-01	1.20E-01	8.52E-03	2.21E-04	6.74E-02	7.52E-02	5.32E-03	1.38E-04
Knuckle boom, f800, n-50	1.08E-01	1.20E-01	8.52E-03	2.21E-04	1.08E-01	1.20E-01	8.52E-03	2.21E-04	6.74E-02	7.52E-02	5.32E-03	1.38E-04
Imt compressor	electric											
Miller big blue air pac welder	9.94E-02	1.05E-01	6.77E-03	2.79E-04	9.94E-02	1.05E-01	6.77E-03	2.79E-04	6.21E-02	6.57E-02	4.23E-03	1.74E-04
Welder 400amp dsl trlr mtd	4.97E-02	5.26E-02	3.38E-03	1.39E-04	4.97E-02	5.26E-02	3.38E-03	1.39E-04	3.11E-02	3.29E-02	2.12E-03	8.71E-05
Welder 600 amp	1.99E-01	2.10E-01	1.35E-02	5.57E-04	1.99E-01	2.10E-01	1.35E-02	5.57E-04	1.24E-01	1.31E-01	8.46E-03	3.48E-04
Kenworth Lube truck	2.05E-01	2.29E-01	1.62E-02	4.20E-04	2.05E-01	2.29E-01	1.62E-02	4.20E-04	1.28E-01	1.43E-01	1.01E-02	2.62E-04
Generator, detroit diesel	standby											
Carry Deck Crane 15 ton	7.86E-02	8.77E-02	6.21E-03	1.58E-04	7.86E-02	8.77E-02	6.21E-03	1.58E-04	4.91E-02	5.48E-02	3.88E-03	9.85E-05
Loader for ball mill media & misc work cat 966	3.87E-02	4.34E-02	3.10E-03	7.85E-05	3.87E-02	4.34E-02	3.10E-03	7.85E-05	2.42E-02	2.72E-02	1.94E-03	4.90E-05
Explosives transport	2.74E-01	2.96E-01	1.91E-02	5.74E-04	2.74E-01	2.96E-01	1.91E-02	5.74E-04	1.78E-01	1.93E-01	1.24E-02	3.73E-04
Access Road Vehicles												
Lime (Hydrated) - 40t payload freight	1.50E-01	1.50E-01	8.59E-03	3.09E-04	2.07E-03	2.07E-03	1.19E-04	4.27E-06	2.07E-03	2.07E-03	1.19E-04	4.27E-06
MIBC/Dowfroth 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	9.87E-05	9.86E-05	5.63E-06	2.04E-07	9.87E-05	9.86E-05	5.63E-06	2.04E-07
PAX 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	9.25E-05	9.24E-05	5.28E-06	1.91E-07	9.25E-05	9.24E-05	5.28E-06	1.91E-07

Table E-13 CAC Emission Rates for Equipment used during Year -1 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
Flocculent 40t payload freight	1.50E-01	1.50E-01	8.55E-03	3.09E-04	1.60E-06	1.60E-06	9.15E-08	3.31E-09	1.60E-06	1.60E-06	9.15E-08	3.31E-09
Gold Promoter 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	7.40E-05	7.39E-05	4.22E-06	1.53E-07	7.40E-05	7.39E-05	4.22E-06	1.53E-07
Depressant 40t payload freight	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SAG mill - Balls 40t payload freight	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ball Mill - Balls 40t payload freight	1.50E-01	1.50E-01	8.63E-03	3.09E-04	3.95E-03	3.95E-03	2.27E-04	8.14E-06	3.95E-03	3.95E-03	2.27E-04	8.14E-06
Regrind - Balls 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	6.78E-05	6.78E-05	3.87E-06	1.40E-07	6.78E-05	6.78E-05	3.87E-06	1.40E-07
Fuel truck	1.50E-01	1.51E-01	8.86E-03	3.61E-04	1.70E-02	1.72E-02	1.01E-03	4.10E-05	1.70E-02	1.72E-02	1.01E-03	4.10E-05
Bulk product	1.50E-01	1.51E-01	8.71E-03	3.61E-04	8.67E-03	8.71E-03	5.04E-04	2.09E-05	8.67E-03	8.71E-03	5.04E-04	2.09E-05
Staff bus	2.14E-01	2.15E-01	1.26E-02	6.00E-04	2.16E-02	2.18E-02	1.27E-03	6.08E-05	2.16E-02	2.18E-02	1.27E-03	6.08E-05
Pickup truck traffic	6.12E-01	6.58E-01	4.36E-02	1.72E-03	4.90E-01	5.26E-01	3.49E-02	1.37E-03	4.90E-01	5.26E-01	3.49E-02	1.37E-03
Other 20 ton trucks for supplies	3.00E-01	3.01E-01	1.74E-02	6.18E-04	1.52E-02	1.52E-02	8.80E-04	3.13E-05	1.52E-02	1.52E-02	8.80E-04	3.13E-05
Concentrate 40 t freight truck	1.50E-01	1.50E-01	8.65E-03	3.09E-04	5.54E-03	5.55E-03	3.20E-04	1.14E-05	5.54E-03	5.55E-03	3.20E-04	1.14E-05

Table E-14 CAC Emission Rates for Equipment used during Year 4/8 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
Main Mining Equipment												
Haul Trucks 290T	3.62E+01	2.18E+01	1.43E+00	4.19E-02	3.62E+01	2.18E+01	1.43E+00	4.19E-02	2.86E+01	1.73E+01	1.13E+00	3.32E-02
Shovel - 76 Yard	electric											
Loader LT850 Sized	9.60E-01	6.17E-01	4.52E-02	1.11E-03	9.60E-01	6.17E-01	4.52E-02	1.11E-03	7.30E-01	4.69E-01	3.43E-02	8.42E-04
Drill-311m Production	4.98E-01	5.73E-01	4.11E-02	1.02E-03	4.98E-01	5.73E-01	4.11E-02	1.02E-03	3.09E-01	3.55E-01	2.55E-02	6.33E-04
Drill-152 mm Preshear Drill (wall control drills)	electric											
Track Dozer (450 kW class)	2.39E+00	1.41E+00	8.94E-02	2.77E-03	2.39E+00	1.41E+00	8.94E-02	2.77E-03	1.53E+00	9.03E-01	5.72E-02	1.77E-03
Rubber Tire Dozers WD 600	4.82E-01	5.53E-01	3.95E-02	1.01E-03	4.82E-01	5.53E-01	3.95E-02	1.01E-03	3.02E-01	3.45E-01	2.47E-02	6.30E-04
Grader - 16 ft	3.77E-01	4.06E-01	2.69E-02	7.75E-04	3.77E-01	4.06E-01	2.69E-02	7.75E-04	2.42E-01	2.60E-01	1.72E-02	4.96E-04
Water trucks HD 785 20k Gallon	1.63E+00	9.83E-01	6.47E-02	1.89E-03	1.63E+00	9.83E-01	6.47E-02	1.89E-03	1.18E+00	7.10E-01	4.67E-02	1.36E-03
Support Equipment												
Excavator - 4.5m3 bucket CAT374DI	4.03E-01	4.69E-01	3.43E-02	8.41E-04	4.03E-01	4.69E-01	3.43E-02	8.41E-04	3.22E-01	3.75E-01	2.74E-02	6.73E-04
Cable Reeler – FEL mounted	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.14E-01	1.30E-01	9.50E-03	2.33E-04
Truck mounted cable reel c/w hydraulic arm Ground Force	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.14E-01	1.30E-01	9.50E-03	2.33E-04
Mobile Cable Repair Station	1.51E-01	1.72E-01	1.26E-02	3.09E-04	1.51E-01	1.72E-01	1.26E-02	3.09E-04	1.21E-01	1.38E-01	1.01E-02	2.47E-04
Shovel Lube truck	5.07E-02	5.78E-02	4.23E-03	1.04E-04	5.07E-02	5.78E-02	4.23E-03	1.04E-04	4.06E-02	4.63E-02	3.38E-03	8.30E-05
Pickup Trucks	2.14E+00	2.30E+00	1.53E-01	6.00E-03	2.14E+00	2.30E+00	1.53E-01	6.00E-03	1.71E+00	1.84E+00	1.22E-01	4.80E-03
Fire truck	7.49E-02	7.98E-02	5.01E-03	2.14E-04	7.49E-02	7.98E-02	5.01E-03	2.14E-04	1.50E-02	1.60E-02	1.00E-03	4.29E-05
Ambulance	5.81E-02	6.06E-02	3.81E-03	1.63E-04	5.81E-02	6.06E-02	3.81E-03	1.63E-04	1.16E-02	1.21E-02	7.61E-04	3.26E-05
100 ton Tow truck and lowbed trailer	6.81E-01	4.38E-01	3.20E-02	1.07E-03	6.81E-01	4.38E-01	3.20E-02	1.07E-03	5.45E-01	3.50E-01	2.56E-02	8.58E-04
Loader for the load-out	4.58E-02	5.22E-02	3.82E-03	9.37E-05	4.58E-02	5.22E-02	3.82E-03	9.37E-05	3.66E-02	4.18E-02	3.06E-03	7.50E-05
Extend a-boom loader	2.29E-02	2.61E-02	1.91E-03	4.64E-05	2.29E-02	2.61E-02	1.91E-03	4.64E-05	1.83E-02	2.09E-02	1.53E-03	3.71E-05
Crane for the Tailings	7.87E-02	8.97E-02	6.56E-03	1.58E-04	7.87E-02	8.97E-02	6.56E-03	1.58E-04	6.29E-02	7.18E-02	5.25E-03	1.26E-04
Dump Truck	2.01E-01	2.34E-01	1.71E-02	4.90E-04	2.01E-01	2.34E-01	1.71E-02	4.90E-04	1.61E-01	1.87E-01	1.37E-02	3.92E-04
BACKHOE EXTEND HOE CAT IT420E	1.46E-02	1.66E-02	1.22E-03	4.52E-05	1.46E-02	1.66E-02	1.22E-03	4.52E-05	1.17E-02	1.33E-02	9.74E-04	3.62E-05
COMPRESSOR, AIR	electric											
COMPRESSOR, AIR												
FORKLIFT, CAT DP30	2.19E-02	2.29E-02	1.44E-03	5.00E-05	2.19E-02	2.29E-02	1.44E-03	5.00E-05	1.09E-02	1.14E-02	7.21E-04	2.50E-05
FORKLIFT CAT DP60	3.68E-02	3.85E-02	2.42E-03	8.41E-05	3.68E-02	3.85E-02	2.42E-03	8.41E-05	1.84E-02	1.93E-02	1.21E-03	4.20E-05
FORKLIFT, CAT ELECTRIC NRR30	electric	electric	electric	electric	electric	electric	electric	electric	electric	electric	electric	electric
FORKLIFT DYNALIFT REACHFORK	4.95E-02	5.32E-02	3.52E-03	1.02E-04	4.95E-02	5.32E-02	3.52E-03	1.02E-04	3.96E-02	4.25E-02	2.82E-03	8.13E-05
Hyster 80 Forklift	4.30E-02	4.62E-02	3.06E-03	8.83E-05	4.30E-02	4.62E-02	3.06E-03	8.83E-05	3.44E-02	3.70E-02	2.45E-03	7.07E-05

Table E-14 CAC Emission Rates for Equipment used during Year 4/8 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
CAT MC30 Forklift	6.57E-02	7.06E-02	4.68E-03	1.50E-04	6.57E-02	7.06E-02	4.68E-03	1.50E-04	5.26E-02	5.65E-02	3.74E-03	1.20E-04
GENERATOR, CAT	standby											
CRANE, MOBILE RT528C, 28 TON	1.26E-01	1.44E-01	1.05E-02	2.52E-04	1.26E-01	1.44E-01	1.05E-02	2.52E-04	1.01E-01	1.15E-01	8.40E-03	2.02E-04
ALLMAND MAXI-HEATER	electric											
WACKER YARD LIGHT MODEL LTC4C	6.75E-02	7.70E-02	5.63E-03	1.50E-04	6.75E-02	7.70E-02	5.63E-03	1.50E-04	3.38E-02	3.85E-02	2.82E-03	7.52E-05
Mechanic's Service truck	2.85E-01	3.25E-01	2.38E-02	5.77E-04	2.85E-01	3.25E-01	2.38E-02	5.77E-04	2.28E-01	2.60E-01	1.90E-02	4.61E-04
2007 GENIE GS3246 SCISSOR LIFT	electric											
CAT SKID STEER 246B	3.37E-02	3.84E-02	2.81E-03	1.04E-04	3.37E-02	3.84E-02	2.81E-03	1.04E-04	2.69E-02	3.07E-02	2.25E-03	8.34E-05
BOOM TRUCK 95 FORD	1.42E-01	1.62E-01	1.19E-02	3.24E-04	1.42E-01	1.62E-01	1.19E-02	3.24E-04	1.14E-01	1.30E-01	9.50E-03	2.59E-04
BOOM TRUCK FORD W/MANBASKET	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.14E-01	1.30E-01	9.50E-03	2.33E-04
CRANE, F80 BOOM TRUCK	1.04E-01	1.18E-01	8.66E-03	2.10E-04	1.04E-01	1.18E-01	8.66E-03	2.10E-04	8.31E-02	9.47E-02	6.93E-03	1.68E-04
FORD L-8000 BOOM TRUCK	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.42E-01	1.62E-01	1.19E-02	2.92E-04	1.14E-01	1.30E-01	9.50E-03	2.33E-04
CRANE, JLG	7.87E-02	8.97E-02	6.56E-03	1.58E-04	7.87E-02	8.97E-02	6.56E-03	1.58E-04	6.29E-02	7.18E-02	5.25E-03	1.26E-04
2008 GENIE 45' MAN LIFT	1.08E-01	1.23E-01	9.00E-03	2.21E-04	1.08E-01	1.23E-01	9.00E-03	2.21E-04	8.64E-02	9.85E-02	7.20E-03	1.77E-04
KNUCKLE BOOM, F800, N-50	1.08E-01	1.23E-01	9.00E-03	2.21E-04	1.08E-01	1.23E-01	9.00E-03	2.21E-04	8.64E-02	9.85E-02	7.20E-03	1.77E-04
IMT Compressor	electric											
Miller Big Blue Air Pac Welder	9.95E-02	1.07E-01	7.08E-03	2.79E-04	9.95E-02	1.07E-01	7.08E-03	2.79E-04	7.96E-02	8.55E-02	5.67E-03	2.23E-04
WELDER 400AMP DSL TRLR MTD	4.98E-02	5.35E-02	3.54E-03	1.39E-04	4.98E-02	5.35E-02	3.54E-03	1.39E-04	3.98E-02	4.28E-02	2.83E-03	1.11E-04
WELDER 600 AMP	1.99E-01	2.14E-01	1.42E-02	5.57E-04	1.99E-01	2.14E-01	1.42E-02	5.57E-04	1.59E-01	1.71E-01	1.13E-02	4.46E-04
Kenworth Lube truck	2.05E-01	2.34E-01	1.71E-02	4.20E-04	2.05E-01	2.34E-01	1.71E-02	4.20E-04	1.64E-01	1.87E-01	1.37E-02	3.36E-04
GENERATOR, DETROIT DIESEL	standby											
Carry Deck Crane 15 ton	7.87E-02	8.97E-02	6.56E-03	1.58E-04	7.87E-02	8.97E-02	6.56E-03	1.58E-04	6.29E-02	7.18E-02	5.25E-03	1.26E-04
Loader For Ball Mill Media & Misc Work CAT 966	3.87E-02	4.42E-02	3.23E-03	7.85E-05	3.87E-02	4.42E-02	3.23E-03	7.85E-05	3.10E-02	3.53E-02	2.58E-03	6.28E-05
Explosives transport	2.74E-01	2.96E-01	1.91E-02	5.74E-04	2.74E-01	2.96E-01	1.91E-02	5.74E-04	1.78E-01	1.93E-01	1.24E-02	3.73E-04
Access Road Vehicles												
Lime (Hydrated) - 40t payload freight	1.50E-01	1.50E-01	8.59E-03	3.09E-04	2.07E-03	2.07E-03	1.19E-04	4.27E-06	2.07E-03	2.07E-03	1.19E-04	4.27E-06
MIBC/Dowfroth 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	9.87E-05	9.86E-05	5.63E-06	2.04E-07	9.87E-05	9.86E-05	5.63E-06	2.04E-07
PAX 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	9.25E-05	9.24E-05	5.28E-06	1.91E-07	9.25E-05	9.24E-05	5.28E-06	1.91E-07
Flocculent 40t payload freight	1.50E-01	1.50E-01	8.55E-03	3.09E-04	1.60E-06	1.60E-06	9.15E-08	3.31E-09	1.60E-06	1.60E-06	9.15E-08	3.31E-09
Gold Promoter 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	7.40E-05	7.39E-05	4.22E-06	1.53E-07	7.40E-05	7.39E-05	4.22E-06	1.53E-07
Depressant 40t payload freight	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SAG mill - Balls 40t payload freight	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table E-14 CAC Emission Rates for Equipment used during Year 4/8 of Operations

Equipment Type	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2	NO_X	CO	DPM	SO_2
Ball Mill - Balls 40t payload freight	1.50E-01	1.50E-01	8.63E-03	3.09E-04	3.95E-03	3.95E-03	2.27E-04	8.14E-06	3.95E-03	3.95E-03	2.27E-04	8.14E-06
Regrind - Balls 40t payload freight	1.50E-01	1.50E-01	8.56E-03	3.09E-04	6.78E-05	6.78E-05	3.87E-06	1.40E-07	6.78E-05	6.78E-05	3.87E-06	1.40E-07
Fuel Truck	1.50E-01	1.51E-01	8.86E-03	3.61E-04	1.70E-02	1.72E-02	1.01E-03	4.10E-05	1.70E-02	1.72E-02	1.01E-03	4.10E-05
Bulk Product	1.50E-01	1.51E-01	8.71E-03	3.61E-04	8.67E-03	8.71E-03	5.04E-04	2.09E-05	8.67E-03	8.71E-03	5.04E-04	2.09E-05
Staff Bus	2.14E-01	2.15E-01	1.26E-02	6.00E-04	2.16E-02	2.18E-02	1.27E-03	6.08E-05	2.16E-02	2.18E-02	1.27E-03	6.08E-05
Pickup Truck Traffic	6.12E-01	6.58E-01	4.36E-02	1.72E-03	4.90E-01	5.26E-01	3.49E-02	1.37E-03	4.90E-01	5.26E-01	3.49E-02	1.37E-03
Other 20 ton trucks for supplies	3.00E-01	3.01E-01	1.74E-02	6.18E-04	1.52E-02	1.52E-02	8.80E-04	3.13E-05	1.52E-02	1.52E-02	8.80E-04	3.13E-05
Concentrate 40 t freight truck	1.50E-01	1.57E-01	9.77E-03	3.09E-04	6.79E-02	7.08E-02	4.42E-03	1.40E-04	6.79E-02	7.08E-02	4.42E-03	1.40E-04

E.3.3 EXPLOSIVE DETONATION EMISSIONS

The explosives used in the in-pit blasting consist of an ANFO and emulsion blend (heavy ANFO). Both ANFO and emulsion contain ammonium nitrate products. Therefore the total amount of explosive used in the emission rate calculation is ANFO plus the emulsion. The total amount of explosive used per day in year -1 is 13.2 tonnes and in year 4/8 is 52.1 tonnes. It is assumed that the duration of the blast is for one hour. For daily emission rates it is conservatively assumed that the blast occurs twice a day. On average over a year a blast will only occur once a day, therefore for the annual emission rates there is one blast per day. This assumption is based on information supplied by KAM which states there will be at most two blasts within a day but the blasts occur every other day. Information concerning the amount of ANFO and emulsion used, blasting time durations, and frequency of blasts was supplied by KAM.

Table E-15 summarizes the year -1 and year 4/8 detonation emission rates, as per the emission factors in Table E-2, from explosive detonation.

Table E-15 Year -1 and Year 4/8 Explosive Detonation Emission Rates

Type	Hourly Explosive Emission Rate (g/s)			Daily Explosive Emission Rate (g/s)			Annual Explosive Emission Rate (g/s)		
	NO_X	CO	SO_2	NO_X	CO	SO_2	NO_X	CO	SO_2
Year -1 Explosive Detonation Emission Rates	2.93E-02	1.25E-01	3.67E-03	1.22E-03	5.20E-03	1.53E-04	1.22E-03	5.20E-03	1.53E-04
Year 4/8 Explosive Detonation Emission Rates	1.16E-01	4.92E-01	1.45E-02	4.82E-03	2.05E-02	6.03E-04	4.82E-03	2.05E-02	6.03E-04

E.3.4 PARTICULATE MATTER EMISSIONS

During year -1 and year 4/8 there are various mining activities that create PM emissions. The mining activities during year -1 are summarized into the following categories:

- Blasting
- Drilling
- Pre stripping
- Grading and road building
- Truck loading
- Truck unloading
- Unpaved road dust
- Dozing
- Wind erosion
- Crushing
- Conveyor transfer point
- Backhoe digging
- Trenching

The mining activities during year 4/8 are summarized into the following categories:

- Blasting
- Drilling
- Truck loading
- Truck unloading
- Unpaved road dust
- Dozing
- Wind erosion
- Crushing
- Conveyor transfer point

Daily and annual emission rates from all of the above activities are calculated using the equations in Table E-3 and the applicable parameters in Table E-4. The PM emission rates from the above activities are summarized in Table E-16 and Table E-17 for year -1 and year 4/8, respectively. Table E-16 and Table E-17 also contain other source specific parameters used in the emission rate calculations.

Table E-16 Particulate Matter Emission Rates and Parameters for Equipment during Year -1

Type	Description/Work Deployment Area	Parameter for Emission Rate Calculation		Operating Time Percent	Operating Time Percent	Daily Emission Rates (g/s)			Annual Emission Rates (g/s)		
				Daily	Annual	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Blasting	In pit	**Blasting Area (m²):**	2,400	100	100	2.00E-02	1.25E-02	7.46E-04	2.90E-03	1.82E-03	1.08E-04
Drilling	In pit	**Production (tonnes):**	30,199,995	4	4	2.71E-03	1.55E-03	2.41E-04	1.57E-03	8.96E-04	1.40E-04
Truck loading	In pit	**Production (tonnes):**	30,199,995	100	76	8.12E-02	4.63E-02	7.23E-03	3.58E-02	2.04E-02	3.18E-03
	Trenching (access road)	**Material removed (tonnes):**	8196	100	17	2.75E-05	1.30E-05	1.97E-06	2.66E-06	1.26E-06	1.90E-07
Pre-stripping	In pit	**Hours per day:** 15		64	64	3.25E-01	2.94E-01	4.24E-02	1.21E-01	0.00E+00	0.00E+00
Grading/ haul road building	In pit	**Speed (kph):** 10		64	64	9.89E-02	1.79E-01	5.90E-03	5.73E-02	1.04E-01	3.42E-03
Truck unloading		**Production (metric tonnes)**									
	Ore stockpile north	1,251,038		100	100	6.71E-04	3.17E-04	4.81E-05	3.89E-04	1.84E-04	2.79E-05
	Ore stockpile south	356,472		100	100	1.91E-04	9.04E-05	1.37E-05	1.11E-04	5.24E-05	7.94E-06
	SMRSF	75,600		100	100	4.05E-05	1.92E-05	2.90E-06	2.35E-05	1.11E-05	1.68E-06
	Overburden/EMRSF	7,675,727		100	100	4.12E-03	1.95E-03	2.95E-04	2.39E-03	1.13E-03	1.71E-04
	TSFMRSF 1	7,652,464		100	100	4.10E-03	1.94E-03	2.94E-04	2.38E-03	1.13E-03	1.70E-04
	TSFMRSF 2	7,652,464		100	100	4.10E-03	1.94E-03	2.94E-04	2.38E-03	1.13E-03	1.70E-04
	Crusher	2,463,755		100	92	3.30E-04	1.56E-04	2.37E-05	3.04E-04	1.44E-04	2.18E-05
Road dust		**Total km traveled**	**Mean weight (short tons)**								
	In pit	236,276	348	100	100	2.46E+00	1.16E+00	1.22E-01	1.43E+00	6.71E-01	7.07E-02
	HR1 haul truck	15,002	348	46	46	8.07E-01	2.07E-01	2.07E-02	4.68E-01	1.20E-01	1.20E-02
	HR2 haul truck	17,128	348	46	46	5.26E-01	1.35E-01	1.35E-02	3.05E-01	7.84E-02	7.84E-03
	HR3 haul truck	860	348	46	46	2.47E-02	6.36E-03	6.36E-04	1.44E-02	3.69E-03	3.69E-04
	HR4 haul truck	238,018	348	46	46	5.01E+00	1.29E+00	1.29E-01	2.91E+00	7.47E-01	7.47E-02
	HRC haul truck	169,607	348	46	46	2.51E+00	6.46E-01	6.46E-02	1.46E+00	3.74E-01	3.74E-02
	HR1 support equipment	3,474	29.0	63	63	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR2 support equipment	811	29.0	63	63	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR3 support equipment	4,986	29.0	63	63	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR4 support equipment	7,220	29.0	63	63	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HRC support equipment	173	29.0	63	63	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	Main mobile equipment - main equipment except haul trucks and water trucks	714	273.4	100	100	1.29E-02	3.32E-03	3.32E-04	7.49E-03	1.92E-03	1.92E-04
	Support mobile equipment - on other locations than haul roads	16,664	29.0	100	100	1.10E-01	2.82E-02	2.82E-03	6.37E-02	1.64E-02	1.64E-03

Table E-16 Particulate Matter Emission Rates and Parameters for Equipment during Year -1

Type	Description/Work Deployment Area	Parameter for Emission Rate Calculation		Operating Time Percent	Operating Time Percent	Daily Emission Rates (g/s)			Annual Emission Rates (g/s)		
				Daily	Annual	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
	Access Road -40 t trucks	87,843	30.2	100	100	5.31E-01	1.32E-01	1.32E-02	3.08E-01	7.67E-02	7.67E-03
	Access Road-Pickups	44,355	5.5	100	100	1.24E-01	3.10E-02	3.10E-03	7.22E-02	1.80E-02	1.80E-03
	Access Road-Staff Bus	17,742	11.6	100	100	6.96E-02	1.74E-02	1.74E-03	4.04E-02	1.01E-02	1.01E-03
	Access Road-20 t trucks	8,871	18.0	100	100	4.24E-02	1.06E-02	1.06E-03	2.46E-02	6.13E-03	6.13E-04
Dozing		**Hours per day**									
	Ore stockpile north	15		100	100	7.56E-01	5.67E-01	7.94E-02	4.38E-01	3.29E-01	4.60E-02
	Ore stockpile south			100	100	7.56E-01	5.67E-01	7.94E-02	4.38E-01	3.29E-01	4.60E-02
	SMRSF			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	Overburden/EMRSF			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	TSFMRSF 1			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	TSFMRSF 2			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	Reclamation			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
Wind erosion		**Effective Area (ha)**									
	Ore stockpile north	5		100	100	4.94E-01	2.34E-01	3.54E-02	4.94E-01	2.34E-01	3.54E-02
	Ore stockpile south	4		100	100	4.63E-01	2.19E-01	3.31E-02	4.63E-01	2.19E-01	3.31E-02
	SMRSF	37		100	100	7.52E-01	3.55E-01	5.38E-02	7.52E-01	3.55E-01	5.38E-02
	Overburden/EMRSF	15		100	100	2.98E-01	1.41E-01	2.14E-02	2.98E-01	1.41E-01	2.14E-02
	TSFMRSF 1	17		100	100	3.41E-01	1.61E-01	2.44E-02	3.41E-01	1.61E-01	2.44E-02
	TSFMRSF 2	26		100	100	5.36E-01	2.54E-01	3.84E-02	5.36E-01	2.54E-01	3.84E-02
Crushing	Crusher	**Production (tonnes):**	2,463,755	100	92	1.95E-01	7.81E-02	1.40E-02	1.80E-01	7.19E-02	1.29E-02
Conveyor	Transfer point at mill	**Production (tonnes):**	2,463,755	100	92	5.47E-03	1.80E-03	5.08E-04	2.92E-03	9.59E-04	2.71E-04
Backhoe digging	Access Road	**Material removal (tonnes):**	8196	100	17	3.89E-05	1.87E-05	2.78E-06	3.76E-06	1.80E-06	2.69E-07

Table E-17 Particulate Matter Emission Rates and Parameters for Equipment during Year 4/8

Type	Description/Work Deployment Area	Parameter for Emission Rate Calculation		Operating Time Percent	Operating Time Percent	Daily Emission Rates (g/s)			Annual Emission Rates (g/s)		
				Daily	Annual	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Blasting	In pit	**Blasting Area (m^2):** 13,600		100	100	2.31E-01	1.61E-01	1.00E-02	3.35E-02	2.34E-02	1.45E-03
Drilling	In pit	**Production (tonnes):** 113,985,795		100	62	2.10E-01	1.33E-01	2.17E-02	7.55E-02	4.79E-02	7.81E-03
Truck loading	In pit	**Production (tonnes):** 113,985,795		100	76	2.62E-01	1.66E-01	2.71E-02	1.16E-01	7.33E-02	1.20E-02
Truck unloading		**Production (tonnes)**									
	Ore stockpile north	1,374,683		100	100	7.37E-04	3.49E-04	5.28E-05	4.28E-04	2.02E-04	3.06E-05
	Ore stockpile south	4,166,782		100	100	2.23E-03	1.06E-03	1.60E-04	1.30E-03	6.13E-04	9.28E-05
	SMRSF	34,048,791		100	100	1.83E-02	8.64E-03	1.31E-03	1.06E-02	5.01E-03	7.59E-04
	Overburden/EMRSF	1,179,491		100	100	6.33E-04	2.99E-04	4.53E-05	3.67E-04	1.74E-04	2.63E-05
	TSFMRSF 1	24,650,744		100	100	1.32E-02	6.25E-03	9.47E-04	7.67E-03	3.63E-03	5.49E-04
	TSFMRSF 2	24,650,744		100	100	1.32E-02	6.25E-03	9.47E-04	7.67E-03	3.63E-03	5.49E-04
	Crusher	23,725,000		100	92	3.18E-03	1.50E-03	2.28E-04	2.93E-03	1.38E-03	2.10E-04
Road dust		**Total km traveled**	**Mean weight (tons)**								
	In pit	2,063,570	348	100	100	1.47E+01	9.14E+00	1.06E+00	8.54E+00	5.30E+00	6.12E-01
	HR1 haul truck	144,461	348	79	79	7.20E+00	1.85E+00	1.85E-01	4.18E+00	1.07E+00	1.07E-01
	HR2 haul truck	55,950	348	79	79	1.68E+00	4.32E-01	4.32E-02	9.75E-01	2.51E-01	2.51E-02
	HR3 haul truck	677,219	348	79	79	1.03E+01	2.66E+00	2.66E-01	5.99E+00	1.54E+00	1.54E-01
	HR4 haul truck	802,424	348	79	79	1.50E+01	3.84E+00	3.84E-01	8.68E+00	2.23E+00	2.23E-01
	HRC haul truck	33,384	348	79	79	3.58E-01	9.20E-02	9.20E-03	2.08E-01	5.33E-02	5.33E-03
	HR1 support equipment	3,474	29.0	80	80	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR2 support equipment	811	29.0	80	80	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR3 support equipment	4,986	29.0	80	80	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HR4 support equipment	7,220	29.0	80	80	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	HRC support equipment	173	29.0	80	80	1.01E-01	2.59E-02	2.59E-03	5.84E-02	1.50E-02	1.50E-03
	Main mobile equipment - main equipment except haul trucks and water trucks	714	273.4	100	100	1.29E-02	3.32E-03	3.32E-04	7.49E-03	1.92E-03	1.92E-04
	Support mobile equipment - on other locations than haul roads	16,664	29.0	100	100	1.10E-01	2.82E-02	2.82E-03	6.37E-02	1.64E-02	1.64E-03
	Access Road -40t trucks	233,294	30.2	100	100	1.41E+00	3.51E-01	3.51E-02	8.17E-01	2.04E-01	2.04E-02
	Access Road-Pickups	44,355	5.5	100	100	1.24E-01	3.10E-02	3.10E-03	7.22E-02	1.80E-02	1.80E-03
	Access Road-Staff Bus	17,742	11.6	100	100	6.96E-02	1.74E-02	1.74E-03	4.04E-02	1.01E-02	1.01E-03
	Access Road-20t trucks	8,871	18.0	100	100	4.24E-02	1.06E-02	1.06E-03	2.46E-02	6.13E-03	6.13E-04
Dozing		**Hours per day**									
	In pit	15		100	63	2.78E-01	2.79E-01	4.21E-02	1.01E-01	0.00E+00	0.00E+00

Table E-17 Particulate Matter Emission Rates and Parameters for Equipment during Year 4/8

Type	Description/Work Deployment Area	Parameter for Emission Rate Calculation		Operating Time Percent	Operating Time Percent	Daily Emission Rates (g/s)			Annual Emission Rates (g/s)		
				Daily	Annual	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Dozing	Ore stockpile north	15		100	100	7.56E-01	5.67E-01	7.94E-02	4.38E-01	3.29E-01	4.60E-02
	Ore stockpile south			100	100	7.56E-01	5.67E-01	7.94E-02	4.38E-01	3.29E-01	4.60E-02
	SMRSF			100	100	2.04E-01	1.53E-01	2.14E-02	1.18E-01	8.87E-02	1.24E-02
	Overburden/EMRSF			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	TSFMRSF 1			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	TSFMRSF 2			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
	Reclamation			100	100	1.02E-01	7.65E-02	1.07E-02	5.92E-02	4.44E-02	6.21E-03
Wind erosion		**Effective Area (ha)**									
	Ore stockpile north	5		100	100	4.94E-01	2.34E-01	3.54E-02	4.94E-01	2.34E-01	3.54E-02
	Ore stockpile south	4		100	100	4.63E-01	2.19E-01	3.31E-02	4.63E-01	2.19E-01	3.31E-02
	SMRSF	37		100	100	7.52E-01	3.55E-01	5.38E-02	7.52E-01	3.55E-01	5.38E-02
	Overburden/EMRSF	15		100	100	5.61E-04	2.65E-04	4.01E-05	5.61E-04	2.65E-04	4.01E-05
	TSFMRSF 1	17		100	100	3.41E-01	1.61E-01	2.44E-02	3.41E-01	1.61E-01	2.44E-02
	TSFMRSF 2	26		100	100	5.36E-01	2.54E-01	3.84E-02	5.36E-01	2.54E-01	3.84E-02
	Tailings Beach	14		100	42	2.46E+00	1.16E+00	1.76E-01	1.02E+00	4.85E-01	7.34E-02
Crushing	Crusher	**Production (t):**	23,725,000	100	92	1.88E+00	7.52E-01	1.35E-01	1.73E+00	6.92E-01	1.24E-01
Conveyor	Transfer point at mill	**Production (t):**	23,725,000	100	92	5.27E-02	1.73E-02	4.89E-03	2.81E-02	9.23E-03	2.61E-03

E.3.5 PARTICULATE MATTER EMISSIONS FROM POINT SOURCES

Table E-18 contains point source emission parameters and emissions associated with the processing mill. The emission rates are determined using the equations and parameters in Table E-5 and Table E-6. These values were confirmed with KAM through an information request meeting on October 12, 2012 (KAM 2012). No other information about the processing mill has been provided by KAM. Table E-18 summarizes the maximum total discharge rate and the average TSP concentration for each emission source. The point sources are all located within the processing mill, which is assumed to operate 24 hours a day, 336 hours per year. It is assumed that emissions from the point sources are the same in year -1 and year 4/8 as no other information was provided by KAM. Since the point sources are all located within one building with bag house filters on the roof then it was assumed that the point sources could be blended into one area emissions source.

Table E-18 Point Source Parameters and Emission Rates

Emissions Source	Stack Height (masl)	Base Elevation (masl)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature (K)	Max Total discharge rate (m^3/min)	Maximum TSP concentration (mg/m^3)	Daily Total Emission Rate (g/s)			Annual Total Emission Rate (g/s)		
								TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
Coarse Ore Stockpile reclaim Area D01-COL-011	19.0	922	0.971	15.3	283	11.3	32.0	0.36	0.17	0.026	0.33	0.16	0.024
HPGR Area D04-COL-061	27.0	922	1.314	15.3	283	20.8	32.0	0.66	0.31	0.048	0.61	0.29	0.044
Cone Crusher area E01-COL-060	27.0	922	1.401	15.3	283	23.6	32.0	0.76	0.35	0.054	0.7	0.33	0.05
Cone Crusher and HPGR screen E01-COL-115	48.0	916	1.470	15.3	283	26.0	32.0	0.83	0.39	0.06	0.76	0.36	0.055
Concentrate Area E05-COL-025	24.0	911	1.772	15.3	283	37.8	32.0	1.2	0.57	0.087	1.1	0.52	0.08
Out Pit Crusher total (ore only)	10.0	975	1.398	15.3	283	23.5	32.0	6.9	2.8	0.42	4.9	1.9	0.29
Fine ore stockpile and reclaim area dust collector (HPGR)	19.0	922	0.991	15.3	283	11.8	32.0	0.38	0.18	0.027	0.35	0.16	0.025
Lime silo E06-COL-D65	33.0	911	0.991	15.3	283	11.8	32.0	0.38	0.18	0.027	0.35	0.16	0.025
Lime Area E06-COL-079	33.0	911	0.991	15.3	283	11.8	32.0	0.38	0.18	0.027	0.35	0.16	0.025
Met and Assay Laboratory J04-COL-001	10.0	911	0.627	15.3	283	4.7	32.0	0.15	0.071	0.011	0.14	0.065	0.01
Met and Assay Services Lab Perchloric Screen J04-COL-002	10.0	911	0.313	15.3	283	1.2	32.0	0.038	0.018	0.0027	0.035	0.016	0.0025
Total (after dust control efficiency applied)								**0.026**	**0.012**	**0.004**	**0.0237**	**0.011**	**0.0034**

NOTE: Point source parameters were confirmed with KAM through information request (KAM 2012).
K = Kalvin

E.3.6 EMISSION RATE SUMMARY

The CAC emission rates from diesel engines and explosive detonation and the PM emissions from fugitive dust and point sources for year -1 and year 4/8 are considered to occur within the areas defined in Section E.3.1.

Particulate matter is broken down into categories. PM from diesel sources is referred to as Diesel particulate matter (DPM), PM from ore only sources is referred to as Ore PM (ore storage piles, crusher, etc.), and other PM is everything else other than from diesel and ore sources i.e., from sources such as unpaved road dust, waste, overburden, etc. In year -1, activities that have both ore and waste components, the ore percent is assumed to be 15% and waste percent is assumed to be 85%. In year 4/8, activities that have both ore and waste components the ore percent is assumed to be 26% and waste percent is 74%. These percentages are based on the total ore mined and total waste mined compared to the total material mined.

Each of the emission sources in a given area are summed together to get the total emissions for that area:

- Table E-19 and Table E-20 summarize the total hourly, daily and annual diesel CAC emissions in each of the defined areas for year -1 and year 4/8, respectively. These tables also show the total DPM emissions.
- Table E-21 and Table E-22 summarize the total PM emissions (except DPM emissions) from each of the area sources for year -1 for daily and annual averaging periods, respectively.
- Table E-23 and Table E-24 summarize the total PM emissions (except DPM emissions) from each of the defined areas for year 4/8 for daily and annual averaging periods, respectively.

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Table E-19 Diesel Source Emission Rate Summary for Year -1

Area	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	Diesel PM	SO_2	NO_X	CO	Diesel PM	SO_2	NO_X	CO	Diesel PM	SO_2
Blast area	2.93E-02	1.25E-01	0.00E+00	3.67E-03	1.22E-03	5.20E-03	0.00E+00	1.53E-04	1.22E-03	5.20E-03	0.00E+00	1.53E-04
Pit	5.34E+00	3.57E+00	2.24E-01	7.25E-03	5.34E+00	3.57E+00	2.24E-01	7.25E-03	2.85E+00	1.92E+00	1.23E-01	3.87E-03
Ore Drop	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ore Storage Pile North	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
Ore Storage Pile South	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
Overburden/EMRSF	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
Reclamation	2.82E-03	2.87E-03	1.64E-04	5.92E-06	2.82E-03	2.87E-03	1.64E-04	5.92E-06	1.76E-03	1.79E-03	1.02E-04	3.70E-06
SMRSF	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
Tailings Beach	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
TSFMRS 2	8.01E-01	7.13E-01	4.75E-02	1.56E-03	8.01E-01	7.13E-01	4.75E-02	1.56E-03	4.97E-01	4.40E-01	2.94E-02	9.59E-04
Haul Road 1	1.57E+00	1.43E+00	9.30E-02	3.28E-03	1.41E+00	1.27E+00	8.30E-02	2.84E-03	9.42E-01	8.76E-01	5.74E-02	2.00E-03
Haul Road 2	9.17E-01	7.91E-01	5.20E-02	1.72E-03	9.17E-01	7.91E-01	5.20E-02	1.72E-03	5.51E-01	4.79E-01	3.15E-02	1.04E-03
Haul Road 3	7.35E-01	6.88E-01	4.59E-02	1.51E-03	7.35E-01	6.88E-01	4.59E-02	1.51E-03	4.67E-01	4.31E-01	2.87E-02	9.41E-04
Haul Road 4	2.54E+00	1.72E+00	1.06E-01	3.61E-03	2.54E+00	1.72E+00	1.06E-01	3.61E-03	1.30E+00	9.05E-01	5.65E-02	1.91E-03
Haul Road C	1.64E+00	1.20E+00	7.60E-02	2.56E-03	1.64E+00	1.20E+00	7.60E-02	2.56E-03	8.83E-01	6.68E-01	4.26E-02	1.42E-03
Mill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Access Road	2.35E+00	2.39E+00	1.41E-01	5.26E-03	4.45E-01	4.75E-01	3.07E-02	1.12E-03	3.98E-01	4.23E-01	2.74E-02	1.02E-03
Total	**1.99E+01**	**1.62E+01**	**1.02E+00**	**3.82E-02**	**1.78E+01**	**1.40E+01**	**9.03E-01**	**3.01E-02**	**1.04E+01**	**8.35E+00**	**5.43E-01**	**1.81E-02**

Table E-20 Diesel Source Emission Rate Summary for Year 4/8

Area	Hourly CAC Emission Rates (g/s)				Daily CAC Emission Rates (g/s)				Annual CAC Emission Rates (g/s)			
	NO_X	CO	Diesel PM	SO_2	NO_X	CO	Diesel PM	SO_2	NO_X	CO	Diesel PM	SO_2
Blast area	1.16E-01	4.92E-01	0.00E+00	1.45E-02	4.82E-03	2.05E-02	0.00E+00	6.03E-04	4.82E-03	2.05E-02	0.00E+00	6.03E-04
Pit	2.10E+01	1.36E+01	9.05E-01	2.60E-02	2.10E+01	1.36E+01	9.05E-01	2.60E-02	1.64E+01	1.05E+01	6.98E-01	2.01E-02
Ore Drop	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ore Storage Pile North	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
Ore Storage Pile South	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
Overburden/EMRSF	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
Reclamation	8.50E-03	9.74E-03	6.96E-04	1.78E-05	8.50E-03	9.74E-03	6.96E-04	1.78E-05	5.32E-03	6.09E-03	4.35E-04	1.11E-05
SMRSF	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
Tailings Beach	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
TSFMRS 2	9.34E-01	8.04E-01	5.47E-02	1.71E-03	9.34E-01	8.04E-01	5.47E-02	1.71E-03	6.74E-01	5.95E-01	4.07E-02	1.27E-03
Haul Road 1	5.24E+00	3.71E+00	2.44E-01	7.64E-03	5.01E+00	3.47E+00	2.30E-01	7.02E-03	3.97E+00	2.76E+00	1.83E-01	5.62E-03
Haul Road 2	1.73E+00	1.30E+00	8.81E-02	2.66E-03	1.73E+00	1.30E+00	8.81E-02	2.66E-03	1.34E+00	1.01E+00	6.82E-02	2.06E-03
Haul Road 3	6.26E+00	4.03E+00	2.67E-01	7.91E-03	6.26E+00	4.03E+00	2.67E-01	7.91E-03	4.92E+00	3.17E+00	2.10E-01	6.21E-03
Haul Road 4	8.68E+00	5.50E+00	3.63E-01	1.07E-02	8.68E+00	5.50E+00	3.63E-01	1.07E-02	6.84E+00	4.33E+00	2.86E-01	8.44E-03
Haul Road C	1.03E+00	8.86E-01	6.07E-02	1.86E-03	1.03E+00	8.86E-01	6.07E-02	1.86E-03	7.88E-01	6.78E-01	4.65E-02	1.42E-03
Mill	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Access Road	2.35E+00	2.39E+00	1.42E-01	5.26E-03	5.08E-01	5.40E-01	3.48E-02	1.25E-03	4.60E-01	4.89E-01	3.15E-02	1.15E-03
Total	**5.20E+01**	**3.67E+01**	**2.40E+00**	**8.68E-02**	**4.98E+01**	**3.42E+01**	**2.28E+00**	**6.83E-02**	**3.88E+01**	**2.65E+01**	**1.77E+00**	**5.33E-02**

Table E-21 Daily Particulate Matter Emission Rate Summary for Year -1

Area	Daily Emission Rates (g/s)					
	Other TSP	Other PM_{10}	Other $PM_{2.5}$	Ore TSP	Ore PM_{10}	Ore $PM_{2.5}$
Blast area	1.70E-02	1.07E-02	6.34E-04	3.00E-03	1.88E-03	1.12E-04
Pit	2.46E+00	1.28E+00	1.46E-01	4.34E-01	2.26E-01	2.58E-02
Ore Drop	0.00E+00	0.00E+00	0.00E+00	5.47E-03	1.80E-03	5.08E-04
Ore Storage Pile North	0.00E+00	0.00E+00	0.00E+00	1.26E+00	8.04E-01	1.15E-01
Ore Storage Pile South	0.00E+00	0.00E+00	0.00E+00	1.23E+00	7.88E-01	1.13E-01
Overburden/EMRSF	4.14E-01	2.22E-01	3.26E-02	0.00E+00	0.00E+00	0.00E+00
Reclamation	1.02E-01	7.65E-02	1.07E-02	0.00E+00	0.00E+00	0.00E+00
SMRSF	8.63E-01	4.34E-01	6.48E-02	0.00E+00	0.00E+00	0.00E+00
Tailings Beach	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	4.57E-01	2.42E-01	3.57E-02	0.00E+00	0.00E+00	0.00E+00
TSFMRS 2	6.52E-01	3.35E-01	4.97E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 1	9.09E-01	2.34E-01	2.34E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 2	6.27E-01	1.61E-01	1.61E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 3	1.25E-01	3.22E-02	3.22E-03	0.00E+00	0.00E+00	0.00E+00
Haul Road 4	5.11E+00	1.31E+00	1.31E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road C	2.61E+00	6.72E-01	6.72E-02	0.00E+00	0.00E+00	0.00E+00
Mill	2.57E-02	1.21E-02	3.70E-03	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	1.96E-01	7.83E-02	1.40E-02
Access Road	7.69E-01	1.92E-01	1.92E-02	0.00E+00	0.00E+00	0.00E+00
Total	**1.51E+01**	**5.21E+00**	**6.04E-01**	**3.13E+00**	**1.90E+00**	**2.68E-01**

Table E-22 Annual Particulate Matter Emission Rate Summary for Year -1

Area	Annual Emission Rates (g/s)					
	Other TSP	Other PM_{10}	Other $PM_{2.5}$	Ore TSP	Ore PM_{10}	Ore $PM_{2.5}$
Blast area	2.47E-03	1.55E-03	9.19E-05	4.36E-04	2.73E-04	1.62E-05
Pit	1.36E+00	5.91E-01	6.31E-02	2.40E-01	1.04E-01	1.11E-02
Ore Drop	0.00E+00	0.00E+00	0.00E+00	2.92E-03	9.59E-04	2.71E-04
Ore Storage Pile North	0.00E+00	0.00E+00	0.00E+00	9.39E-01	5.64E-01	8.16E-02
Ore Storage Pile South	0.00E+00	0.00E+00	0.00E+00	9.07E-01	5.49E-01	7.93E-02
Overburden/EMRSF	3.66E-01	1.88E-01	2.79E-02	0.00E+00	0.00E+00	0.00E+00
Reclamation	5.92E-02	4.44E-02	6.21E-03	0.00E+00	0.00E+00	0.00E+00
SMRSF	8.16E-01	4.01E-01	6.02E-02	0.00E+00	0.00E+00	0.00E+00
Tailings Beach	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	4.08E-01	2.08E-01	3.10E-02	0.00E+00	0.00E+00	0.00E+00
TSFMRS 2	6.03E-01	3.01E-01	4.49E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 1	5.27E-01	1.36E-01	1.36E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 2	3.64E-01	9.34E-02	9.34E-03	0.00E+00	0.00E+00	0.00E+00
Haul Road 3	7.27E-02	1.87E-02	1.87E-03	0.00E+00	0.00E+00	0.00E+00
Haul Road 4	2.96E+00	7.62E-01	7.62E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road C	1.52E+00	3.89E-01	3.89E-02	0.00E+00	0.00E+00	0.00E+00
Mill	2.37E-02	1.11E-02	3.41E-03	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	1.80E-01	7.20E-02	1.29E-02
Access Road	4.46E-01	1.11E-01	1.11E-02	0.00E+00	0.00E+00	0.00E+00
Total	**9.53E+00**	**3.26E+00**	**3.88E-01**	**2.27E+00**	**1.29E+00**	**1.85E-01**

Table E-23 Daily Particulate Matter Emission Rate Summary for Year 4/8

Area	Daily Emission Rates (g/s)					
	Other TSP	Other PM_{10}	Other $PM_{2.5}$	Ore TSP	Ore PM_{10}	Ore $PM_{2.5}$
Blast area	1.72E-01	1.20E-01	7.43E-03	5.94E-02	4.14E-02	2.57E-03
Pit	1.15E+01	7.22E+00	8.52E-01	3.98E+00	2.50E+00	2.95E-01
Ore Drop	0.00E+00	0.00E+00	0.00E+00	5.27E-02	1.73E-02	4.89E-03
Ore Storage Pile North	0.00E+00	0.00E+00	0.00E+00	1.26E+00	8.04E-01	1.15E-01
Ore Storage Pile South	0.00E+00	0.00E+00	0.00E+00	1.23E+00	7.89E-01	1.13E-01
Overburden/EMRSF	1.04E-01	7.71E-02	1.08E-02	0.00E+00	0.00E+00	0.00E+00
Reclamation	1.02E-01	7.65E-02	1.07E-02	0.00E+00	0.00E+00	0.00E+00
SMRSF	9.83E-01	5.20E-01	7.68E-02	0.00E+00	0.00E+00	0.00E+00
Tailings Beach	2.46E+00	1.16E+00	1.76E-01	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	4.66E-01	2.47E-01	3.63E-02	0.00E+00	0.00E+00	0.00E+00
TSFMRS 2	6.61E-01	3.39E-01	5.03E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 1	7.30E+00	1.88E+00	1.88E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road 2	1.78E+00	4.58E-01	4.58E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 3	1.04E+01	2.68E+00	2.68E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road 4	1.51E+01	3.87E+00	3.87E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road C	4.59E-01	1.18E-01	1.18E-02	0.00E+00	0.00E+00	0.00E+00
Mill	2.57E-02	1.21E-02	3.70E-03	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	1.88E+00	7.54E-01	1.35E-01
Access Road	1.65E+00	4.11E-01	4.11E-02	0.00E+00	0.00E+00	0.00E+00
Total	**5.32E+01**	**1.92E+01**	**2.17E+00**	**8.47E+00**	**4.90E+00**	**6.65E-01**

Table E-24 Annual Particulate Matter Emission Rate Summary for Year 4/8

Area	Annual Emission Rates (g/s)					
	Other TSP	Other PM_{10}	Other $PM_{2.5}$	Ore TSP	Ore PM_{10}	Ore $PM_{2.5}$
Blast area	2.49E-02	1.73E-02	1.08E-03	8.61E-03	6.01E-03	3.73E-04
Pit	6.57E+00	4.03E+00	4.70E-01	2.27E+00	1.39E+00	1.63E-01
Ore Drop	0.00E+00	0.00E+00	0.00E+00	2.81E-02	9.23E-03	2.61E-03
Ore Storage Pile North	0.00E+00	0.00E+00	0.00E+00	9.39E-01	5.64E-01	8.16E-02
Ore Storage Pile South	0.00E+00	0.00E+00	0.00E+00	9.08E-01	5.50E-01	7.94E-02
Overburden/EMRSF	6.03E-02	4.49E-02	6.28E-03	0.00E+00	0.00E+00	0.00E+00
Reclamation	5.92E-02	4.44E-02	6.21E-03	0.00E+00	0.00E+00	0.00E+00
SMRSF	8.86E-01	4.51E-01	6.72E-02	0.00E+00	0.00E+00	0.00E+00
Tailings Beach	1.02E+00	4.85E-01	7.34E-02	0.00E+00	0.00E+00	0.00E+00
TSFMRSF 1	4.14E-01	2.11E-01	3.13E-02	0.00E+00	0.00E+00	0.00E+00
TSFMRS 2	6.09E-01	3.03E-01	4.53E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 1	4.24E+00	1.09E+00	1.09E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road 2	1.03E+00	2.66E-01	2.66E-02	0.00E+00	0.00E+00	0.00E+00
Haul Road 3	6.05E+00	1.55E+00	1.55E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road 4	8.74E+00	2.24E+00	2.24E-01	0.00E+00	0.00E+00	0.00E+00
Haul Road C	2.66E-01	6.83E-02	6.83E-03	0.00E+00	0.00E+00	0.00E+00
Mill	2.37E-02	1.11E-02	3.41E-03	0.00E+00	0.00E+00	0.00E+00
Crusher	0.00E+00	0.00E+00	0.00E+00	1.73E+00	6.94E-01	1.24E-01
Access Road	9.56E-01	2.38E-01	2.38E-02	0.00E+00	0.00E+00	0.00E+00
Total	**3.09E+01**	**1.11E+01**	**1.25E+00**	**5.89E+00**	**3.22E+00**	**4.51E-01**

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APPENDIX F
BASE CASE EMISSION INVENTORY

Appendix F – Base Case Emission Inventory

Stantec

August 21, 2015

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Appendix F BASE CASE EMISSION INVENTORY

F.1 INTRODUCTION

Background emissions include non-industrial emission sources such as heating, on-road mobile, rail, and paved road dust, and industrial emissions from local facilities.

F.2 NON-INDUSTRIAL SOURCES

F.2.1 AREA SOURCE TYPES

The regional study area contains non-industrial emission sources that are treated collectively as area sources. The associated emissions for the model domain were extracted from 10 km by 10 km emission database that were provided by Environment Canada (EC) for 2008 (the most recently available version). The emission data include:

- **Heating:** Commercial and residential fuel use
- **On-road Mobile:** Light duty gasoline vehicles and trucks, light duty diesel vehicles and trucks, heavy duty gasoline and diesel vehicles, motorcycles, brake lining, and tire wear
- **Rail:** Rail transportation
- **Paved Road Dust:** Dust from paved roads

The gridded 2008 emissions were updated for year 2011 using adjusted emission factors (Table F-2) based on BC provincial level 2008 and 2011 emission inventories.

F.2.2 EMISSION TOTAL IN THE DOMAIN

The extracted emission species include SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, total PM (TPM), diesel $PM_{2.5}$ ($DPM_{2.5}$), diesel PM_{10} (DPM_{10}), and diesel TPM (DTPM). Emissions from 10 km x 10 km grids located in the 30 km x 30 km domain (CALPUFF assessment area) were merged together. The total emissions in the domain for year 2011 are summarized in Table F-1. Table F-2 shows emission adjusted factors from 2008 to 2011. Seen from Table F-1, SO_2 emissions are largely from heating sources, NO_x and CO from onroad, $PM_{2.5}$ from both heating and paved road dust, PM_{10} and TPM are largely from paved road dust, $DPM_{2.5}$, DPM_{10}, and DTPM from both onroad and rail sources.

Table F-1 Non-industrial Emissions in the Domain for Year 2011 (t/y)

Sources	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TPM	$DPM_{2.5}$	DPM_{10}	DTPM
Onroad	2.80	667	7549	10.5	17.1	17.2	5.15	5.59	5.59
Rail	0.74	148	25.4	5.54	6.02	6.02	5.54	6.02	6.02
Heating	34.6	110	1043	165	167	176	-	-	-
Paved road dust [a]	-	-	-	157	619	3201	-	-	-
Total	**38.1**	**925**	**8617**	**338**	**809**	**3400**	**10.7**	**11.6**	**11.6**

NOTE:

[a] Paved road dust emissions here are one fourth of original road dust emissions provided by EC.

Table F-2 Emission Adjusted Factors from 2008 to 2011 [a]

	Sectors	SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TPM
Heating	Commercial fuel combustion	1.048	0.945	0.907	0.910	0.930	0.945
	Residential fuel combustion	0.965	0.986	0.993	0.992	0.992	0.991
	Residential fuel wood combustion	0.967	0.967	0.967	0.967	0.967	0.967
On-road	Heavy-duty diesel vehicles	1.036	0.744	0.761	0.711	0.711	0.711
	Heavy-duty gasoline vehicles	1.005	0.805	0.540	0.724	0.697	0.696
	Light-duty diesel trucks	0.632	0.902	0.963	0.861	0.860	0.860
	Light-duty diesel vehicles	0.900	0.815	0.973	0.730	0.726	0.726
	Light-duty gasoline trucks	1.046	0.896	0.912	0.915	0.896	0.897
	Light-duty gasoline vehicles	1.046	0.868	0.947	1.020	1.022	1.022
	Motorcycles	0.821	0.897	1.047	1.059	1.048	1.043
	Tire wear	-	-	-	1.035	1.045	1.045
	Brake lining	-	-	-	1.035	1.045	1.045
Rail	Rail transportation	0.209	0.911	1.005	0.975	0.975	0.975
Paved road dust	Dust from paved roads	-	-	-	1.046	1.046	1.046

NOTES:

[a] Emission adjusted factors were ratios of provincial level 2011 emission data to provincial level 2008 emission data.

For diesel vehicle and rail sources, emission adjusted factors of $DPM_{2.5}$, DPM_{10}, and DTPM are same as emission adjusted factors of $PM_{2.5}$, PM_{10}, and TPM, respectively.

F.2.3 SPATIAL VARIATION

The total emissions in the 30 km x 30 km domain were spatially allocated into 1 km by 1 km grids across the domain based on the following methodology:

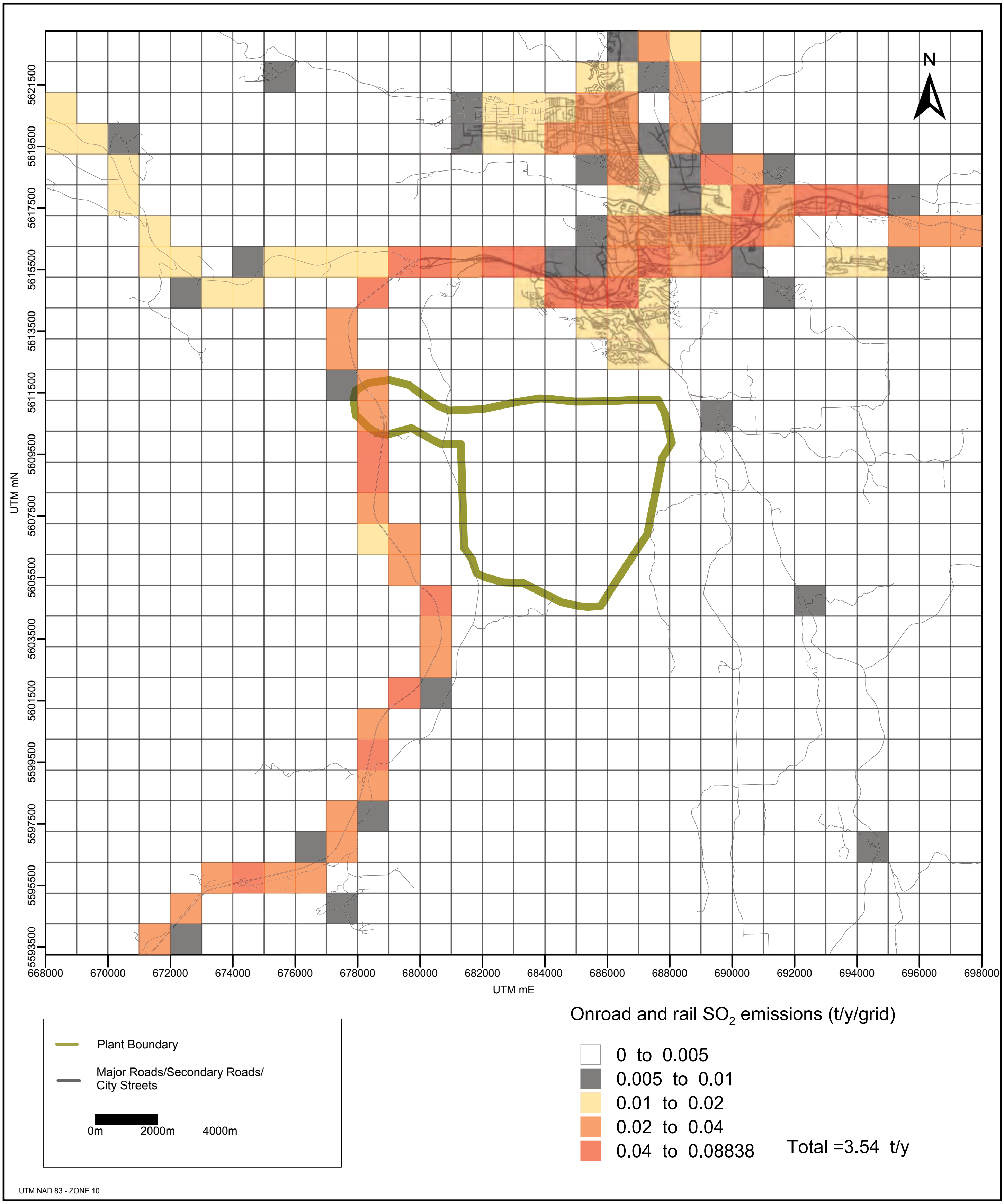
- Determine road lengths of both primary highways and other roads (non-primary highways) in each 1 km by 1 km grid.
- Assign each 1 km grid to either a rural or urban category based on satellite imagery and road network.
- Heating emission allocations were based on the ratio of the non-primary highway length in each urban grid to the non-primary highway total length in all urban grids.
- Onroad emission allocations were based on 50% emissions being attributable to primary highways, and the other 50% emissions attributable to total non-primary highways. Emissions in each 1 km by 1 km grid were determined by the ratio of road length in each grid to total road length in the domain.
- Since rail lines tend to be parallel to the primary highways, rail emission allocations were based on 100% emissions being attributable to primary highways. Emissions in each 1 km by 1 km grid were determined by the ratio of primary highway length in each grid to primary highway total length in the domain.
- Paved road dust emission allocation method is same as onroad emissions.

The onroad and rail emission spatial distributions of SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, TPM, $DTPM_{2.5}$, $DTPM_{10}$, and DTPM are shown in Figures F-1 to F-9, respectively. The heating emission spatial distributions of SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, TPM are shown in Figures F-10 to F-15, respectively. The paved road dust emission spatial distributions of $PM_{2.5}$, PM_{10}, TPM are shown in Figures F-16 to F-18, respectively. The high emission rates occur in the urban area and along major highways for onroad and rail sources and paved road dust sources. The high emission rates for heating sources occur in the urban area.

F.2.4 TEMPORAL VARIATION

The emission rates for these source types vary with time as follows:

- Residential and commercial fuel use varies with time with higher fuel use occurring during the winter. Specifically, 15% of the fuel use was assumed to be constant (i.e., associated with heating water and cooking) and the remaining 85% was assumed to be distributed on a monthly basis according to heating degree days (i.e., for space heating). The Kamloops area experiences 3452 heating-degree-days (temperature below 18°C). The monthly heating degree days were obtained from Environment Canada (Canadian Climate Normals 1981-2010). The monthly emission fraction is depicted in Figure F-19.
- Traffic flow varies primarily with time of day. Traffic volume data monitored by BC Ministry of Transportation and Infrastructure at major Kamloops highways were applied to create average temporal diurnal variation profiles (Figure F-20). This profile is assumed to use for both weekday and weekend traffic flows.



KGHM Ajax Air Quality Assessment

Onroad and Rail SO_2 Emission for Year 2011 (t/y/grid)

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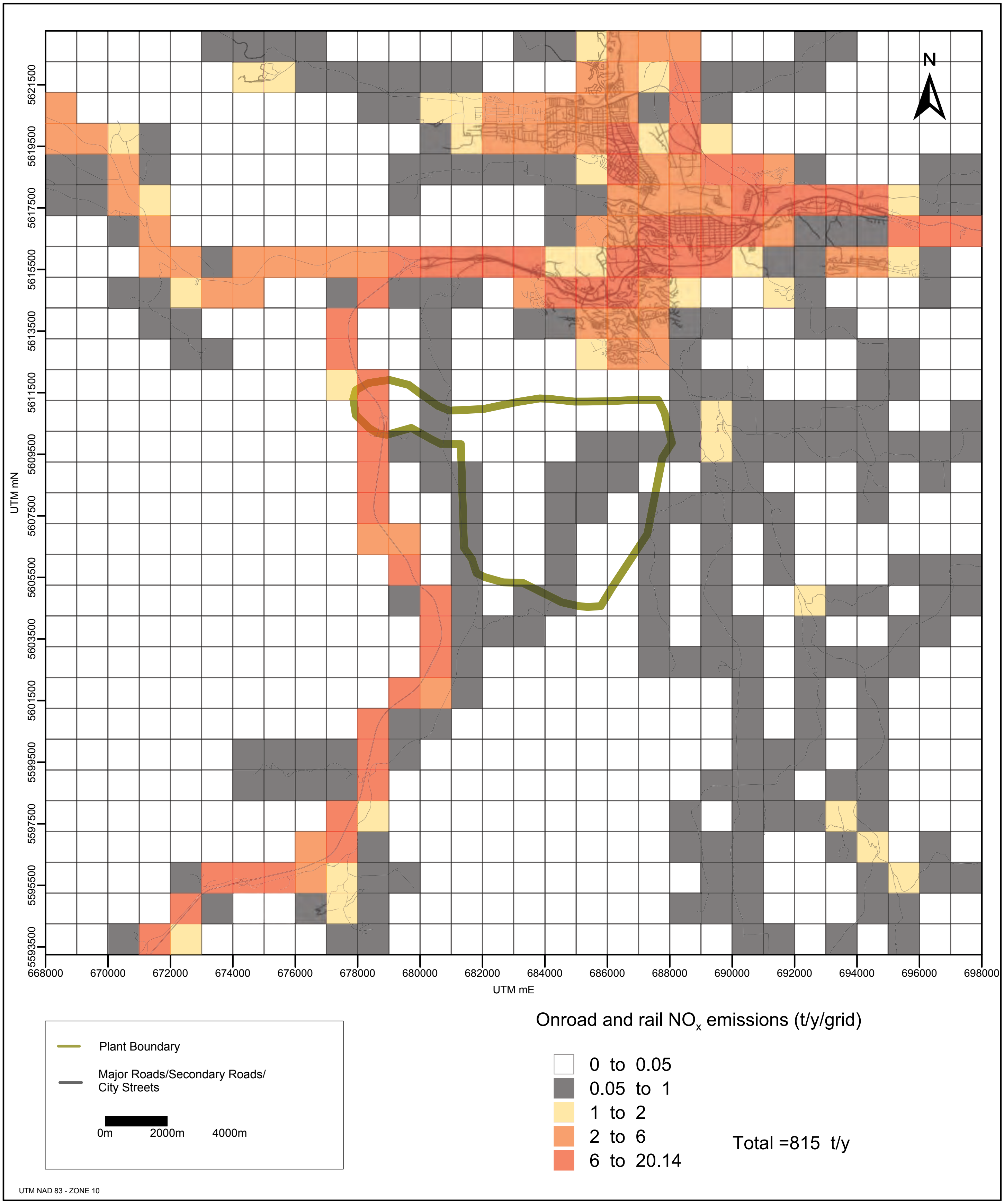
KGHM

FIGURE NO.

F-1



KGHM Ajax Air Quality Assessment

Onroad and Rail NO_x Emission for Year 2011 (t/y/grid)

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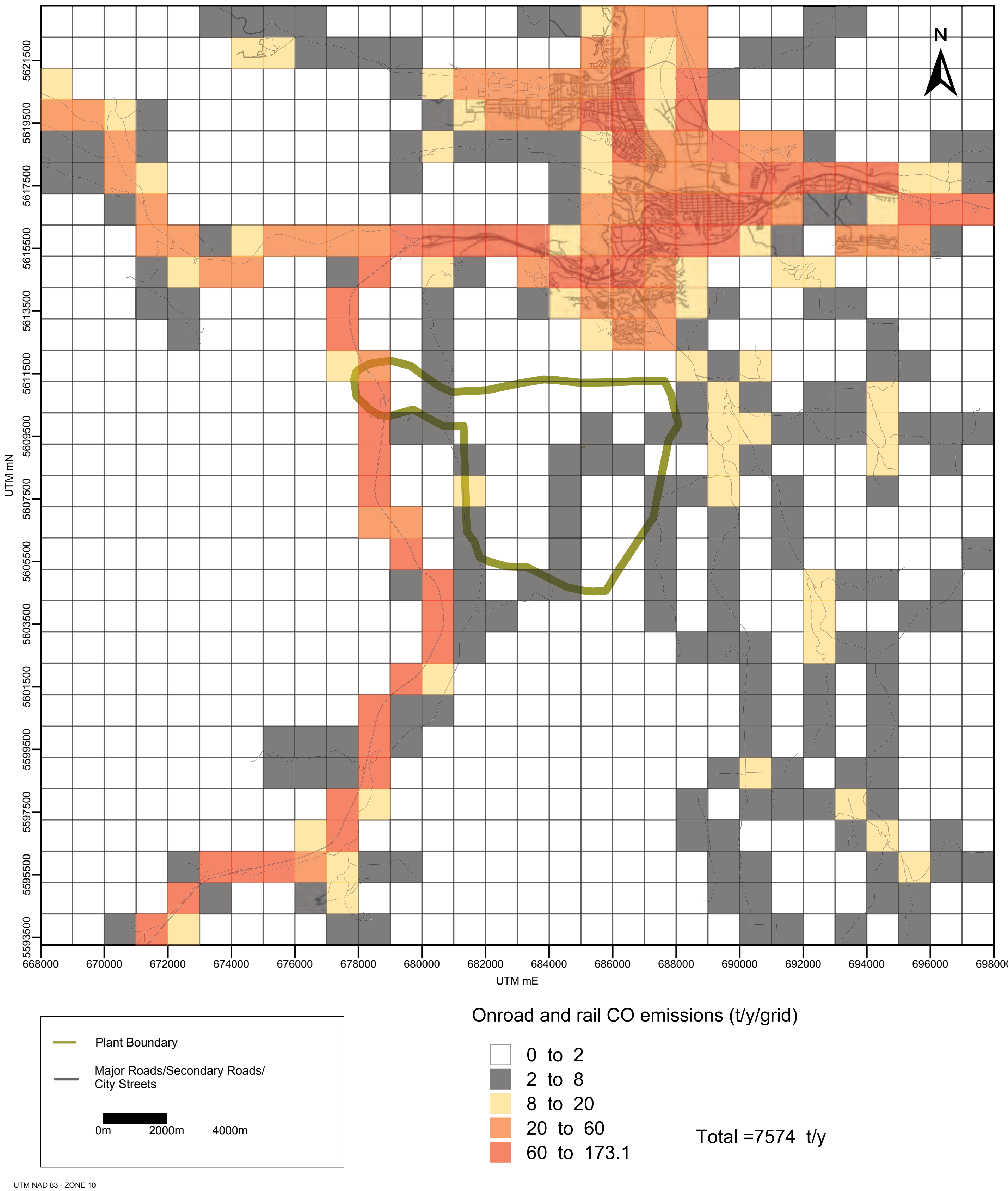
PREPARED FOR KGHM

FIGURE NO. **F-2**



KGHM Ajax Air Quality Assessment

Onroad and Rail CO Emission for Year 2011 (t/y/grid)

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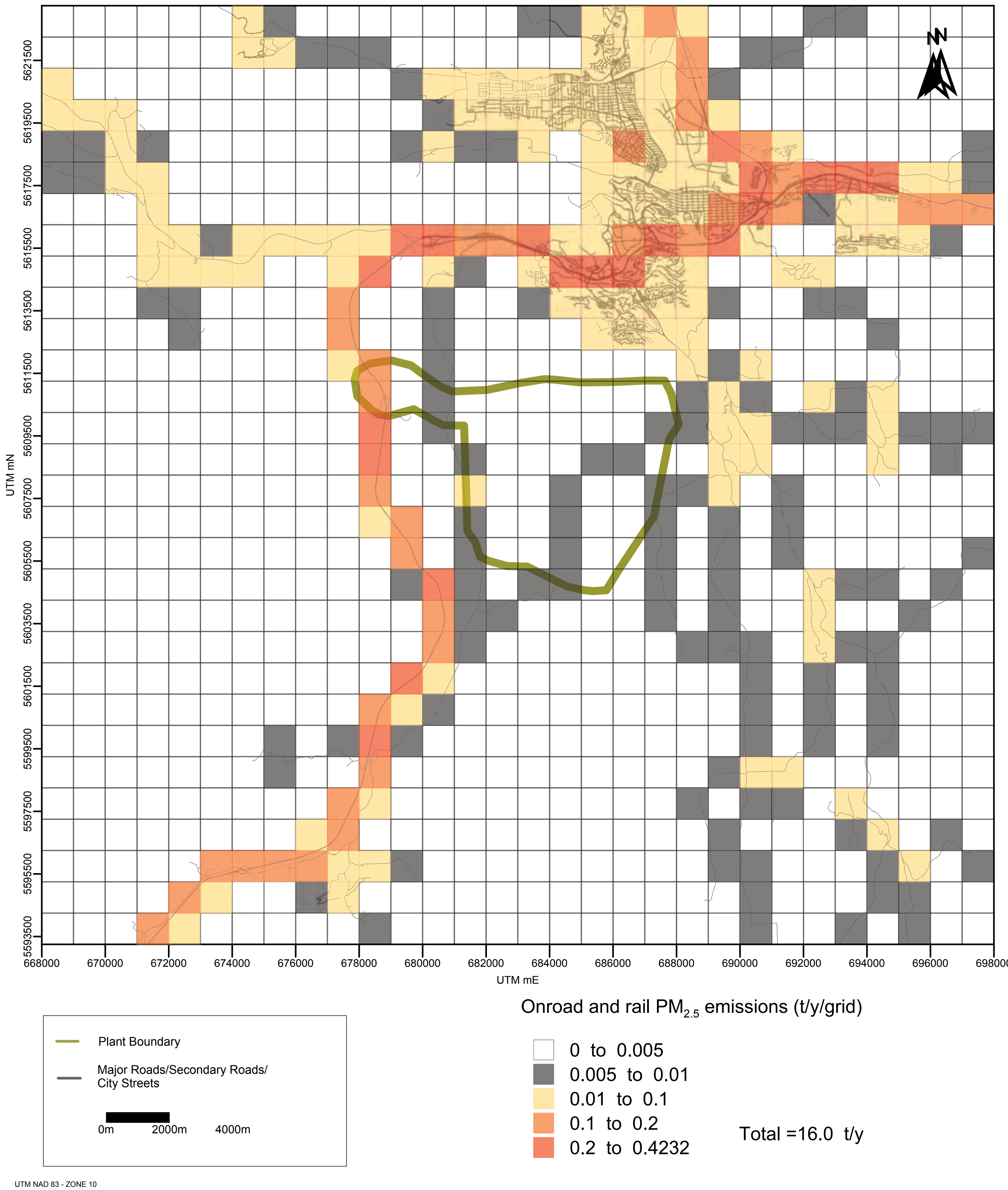
FIGURE NO.

F-3



KGHM Ajax Air Quality Assessment

Onroad and Rail $PM_{2.5}$ Emission for Year 2011 (t/y/grid)

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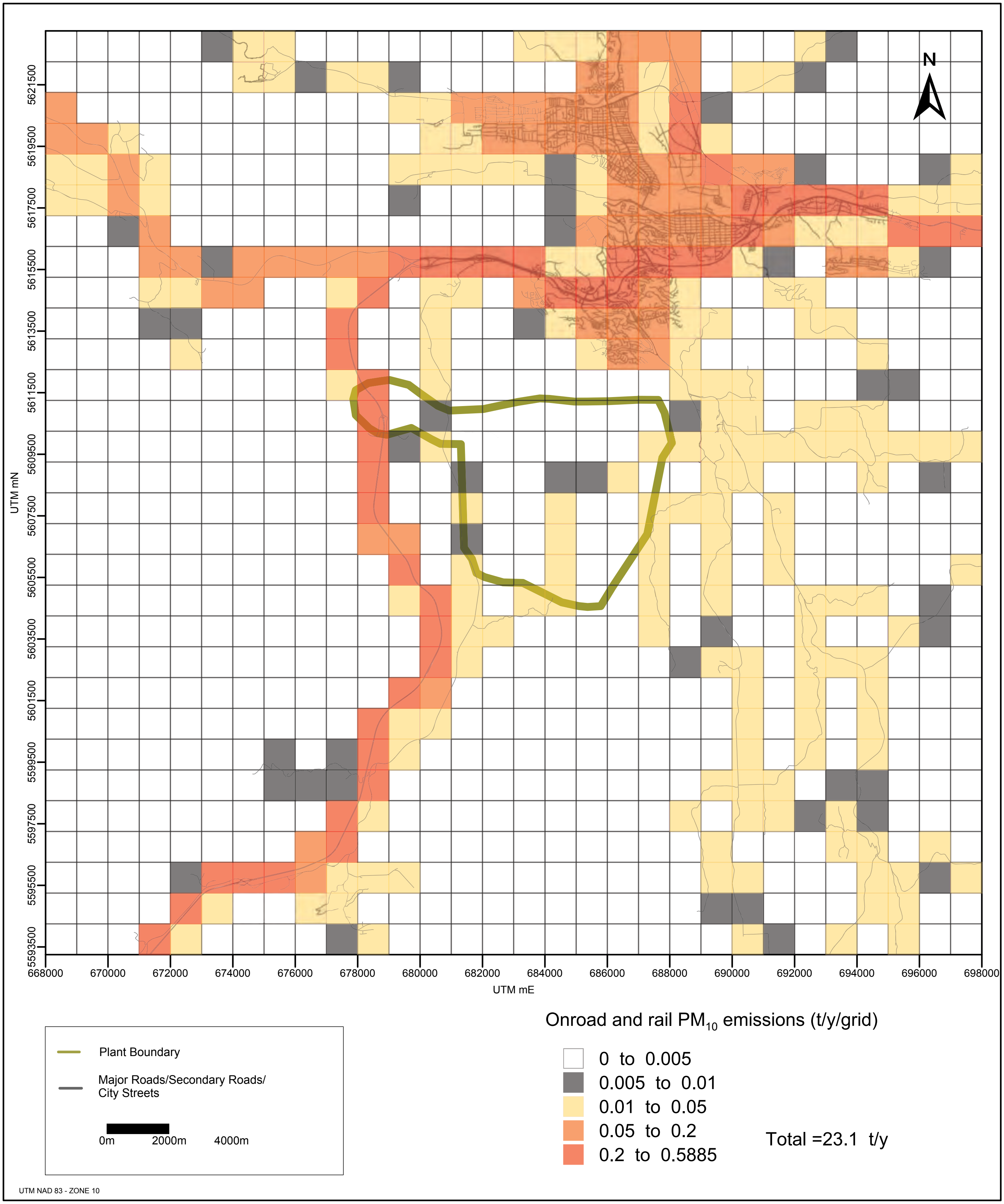
KGHM
FIGURE NO.
F-4



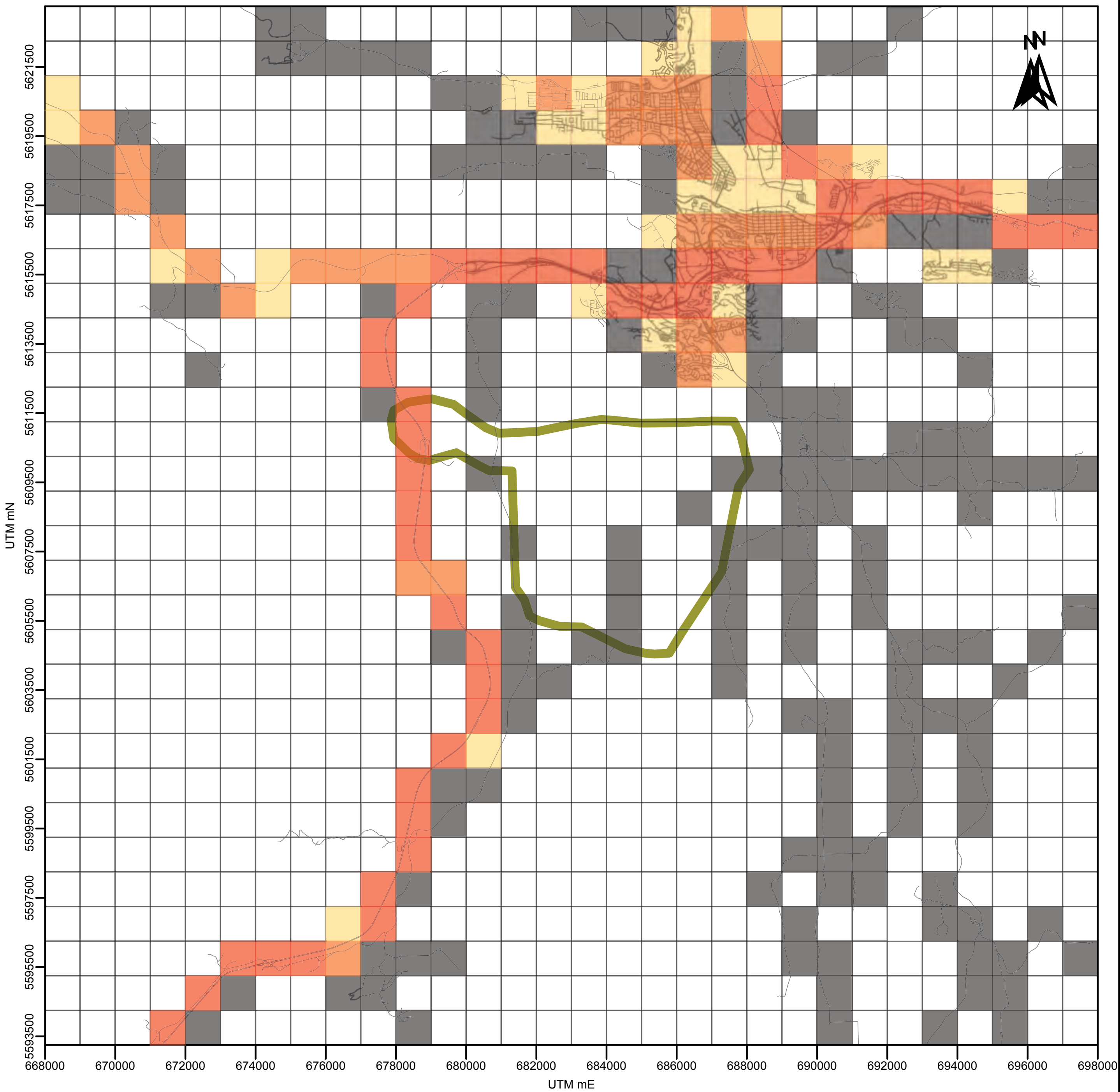
KGHM Ajax Air Quality Assessment

Onroad and Rail PM_{10} Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **F-5**



Onroad and rail TPM emissions (t/y/grid)

- 0 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5926

Total =23.2 t/y

- Plant Boundary
- Major Roads/Secondary Roads/ City Streets

0m 2000m 4000m

UTM NAD 83 - ZONE 10

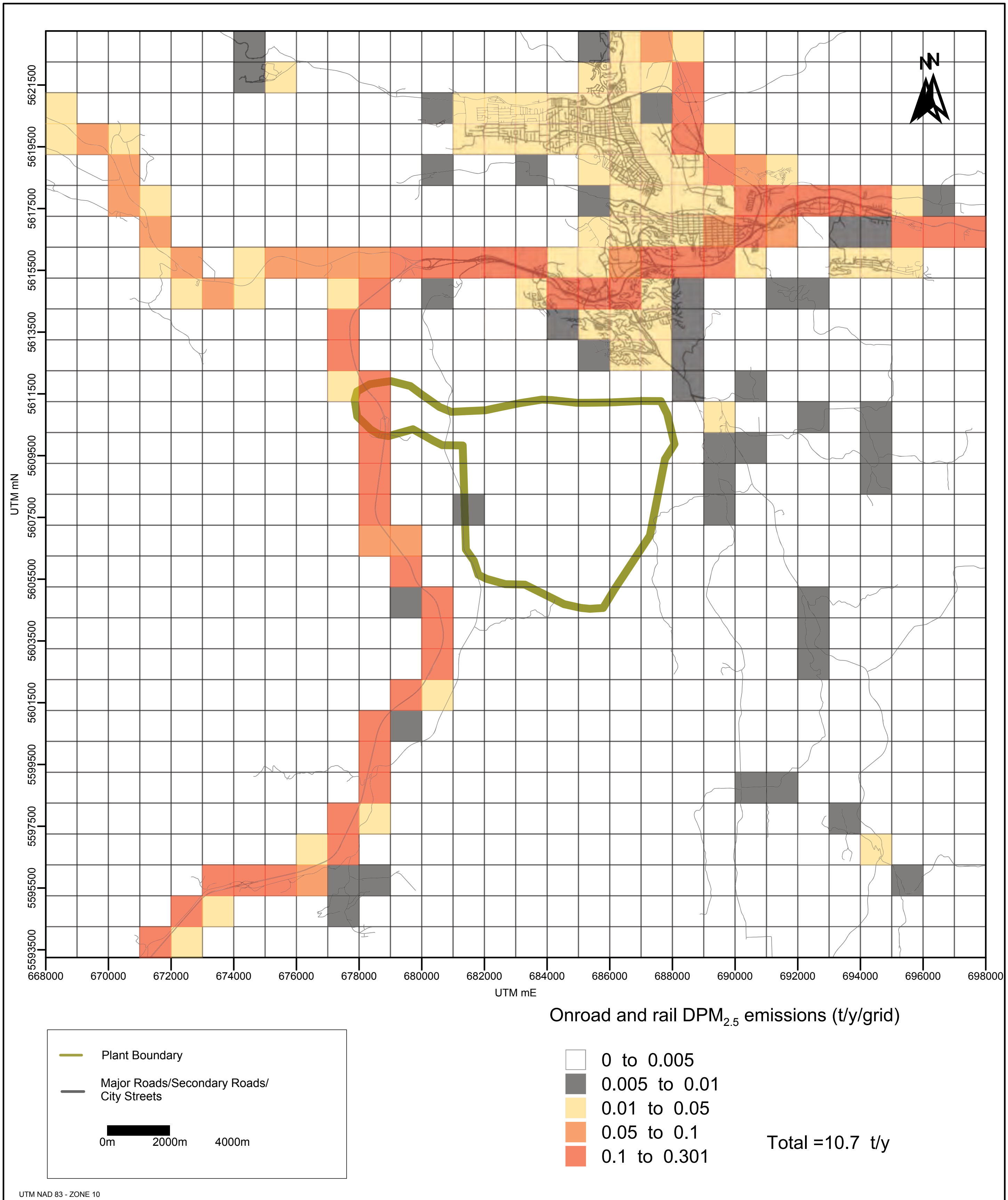
KGHM Ajax Air Quality Assessment

Onroad and Rail TPM Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **F-6**



KGHM Ajax Air Quality Assessment

Onroad and Rail $DPM_{2.5}$ Emission for Year 2011 (t/y/grid)

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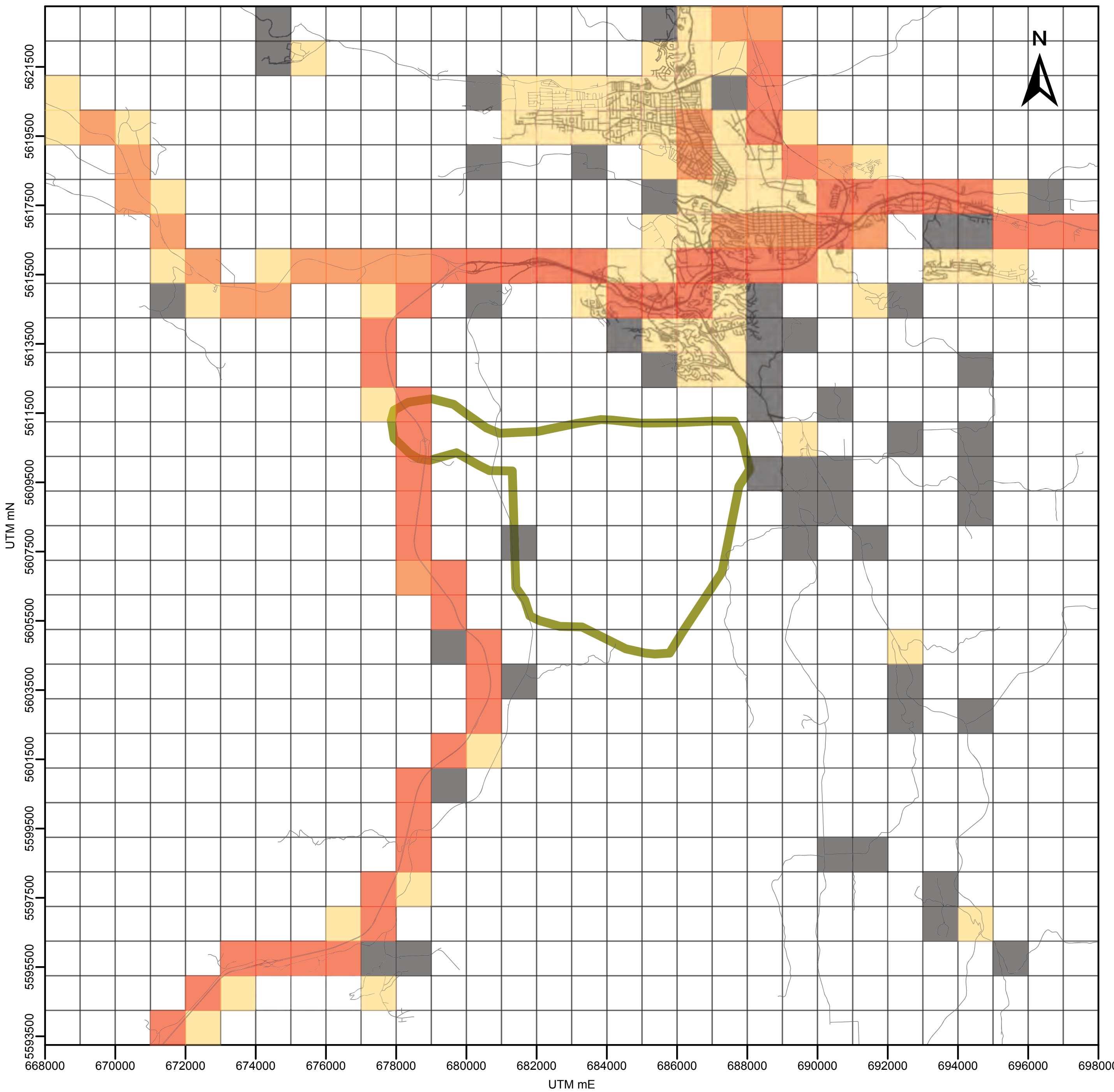
FIGURE NO.
F-7



Onroad and rail DPM10 emissions (t/y/grid)

- 0 to 0.005
- 0.005 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.3269

Total =11.6 t/y

Plant Boundary

Major Roads/Secondary Roads/
City Streets

0m 2000m 4000m

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Onroad and Rail DPM_{10} Emission for Year 2011 (t/y/grid)

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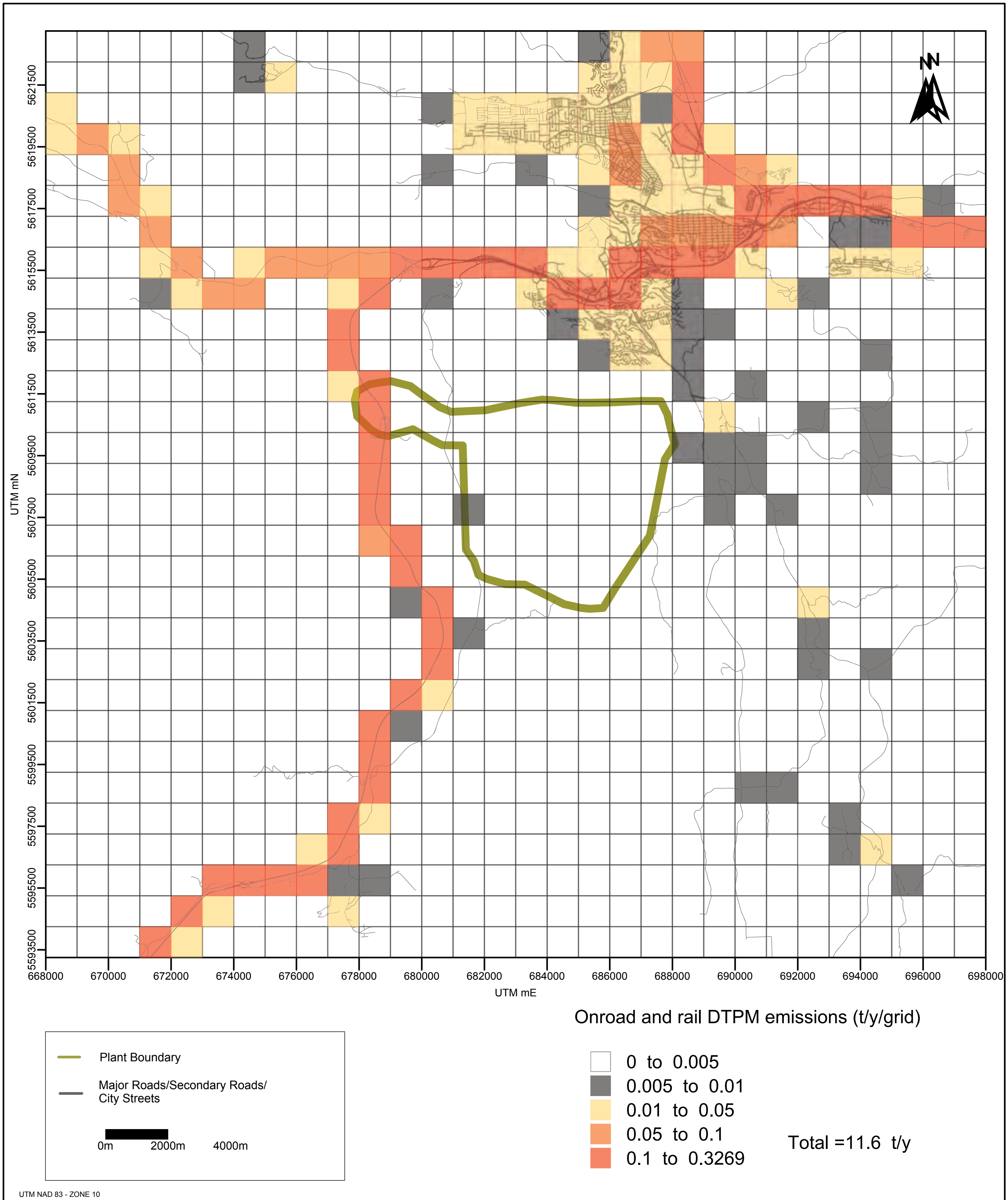
FIGURE NO.
F-8



KGHM Ajax Air Quality Assessment

Onroad and Rail DTPM Emission for Year 2011 (t/y/grid)

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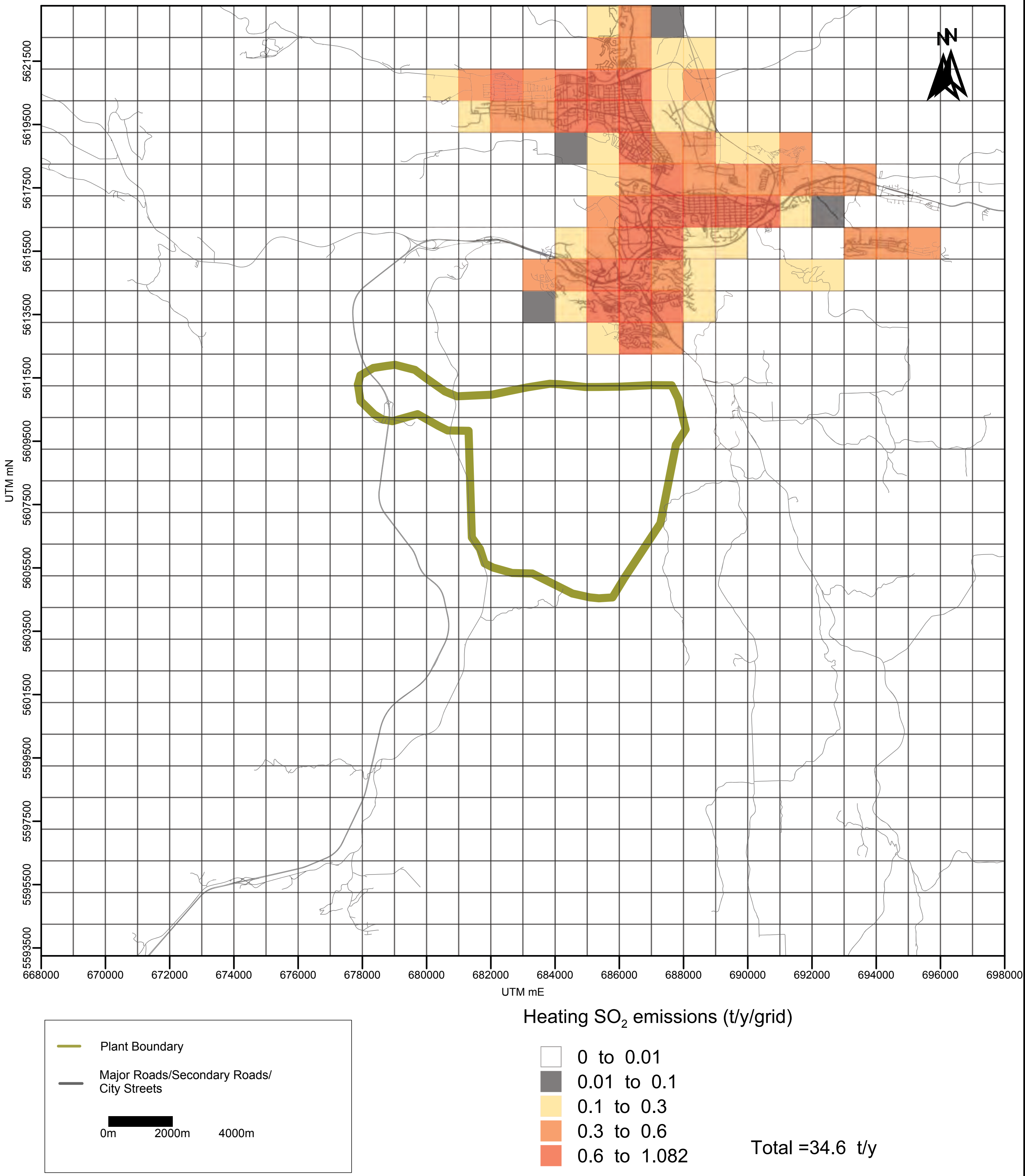
FIGURE NO.

F-9



KGHM Ajax Air Quality Assessment

Heating SO_2 Emission for Year 2011 (t/y/grid)

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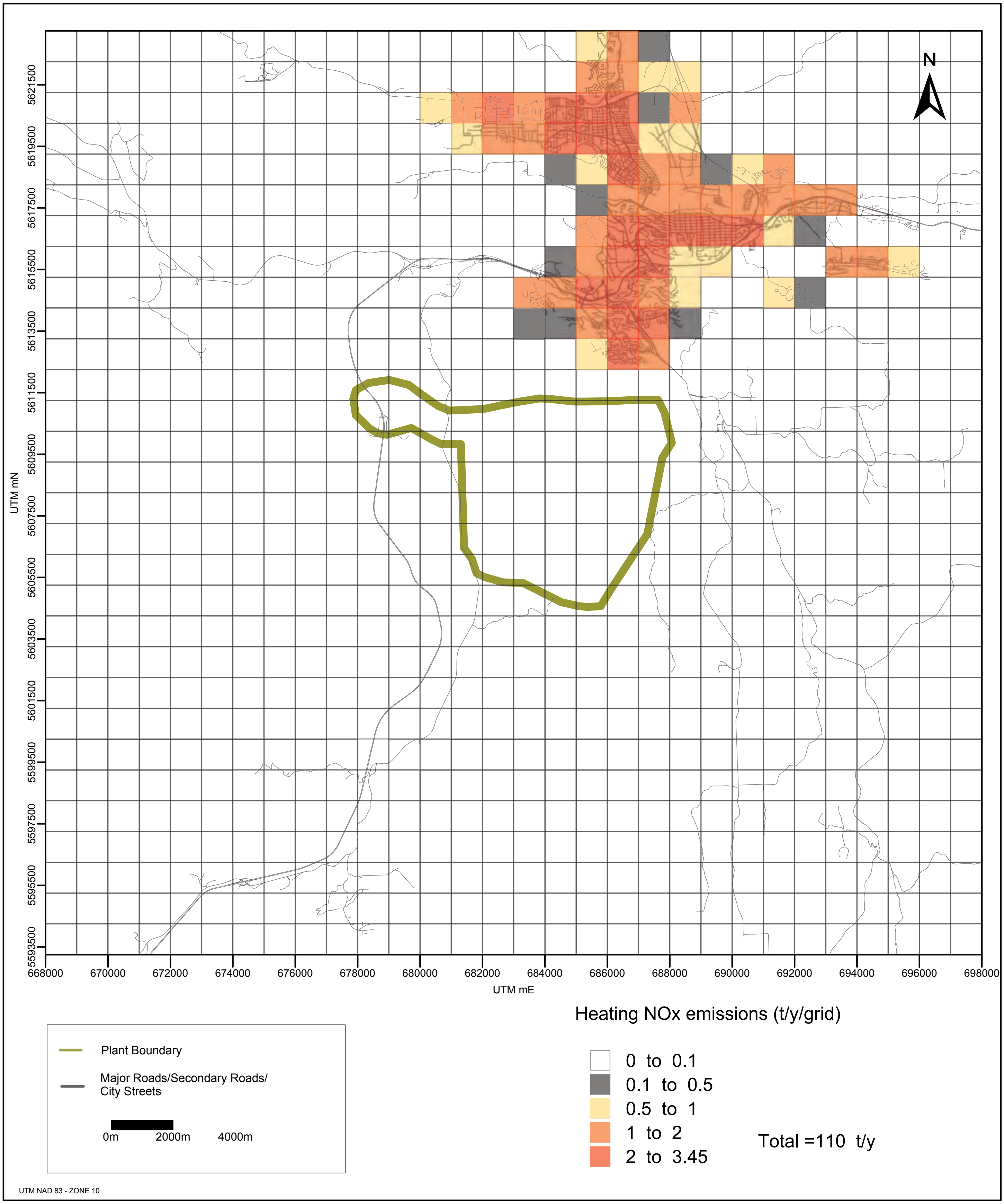
FIGURE NO. **F-10**



KGHM Ajax Air Quality Assessment

Heating NOx Emission for Year 2011 (t/y/grid)

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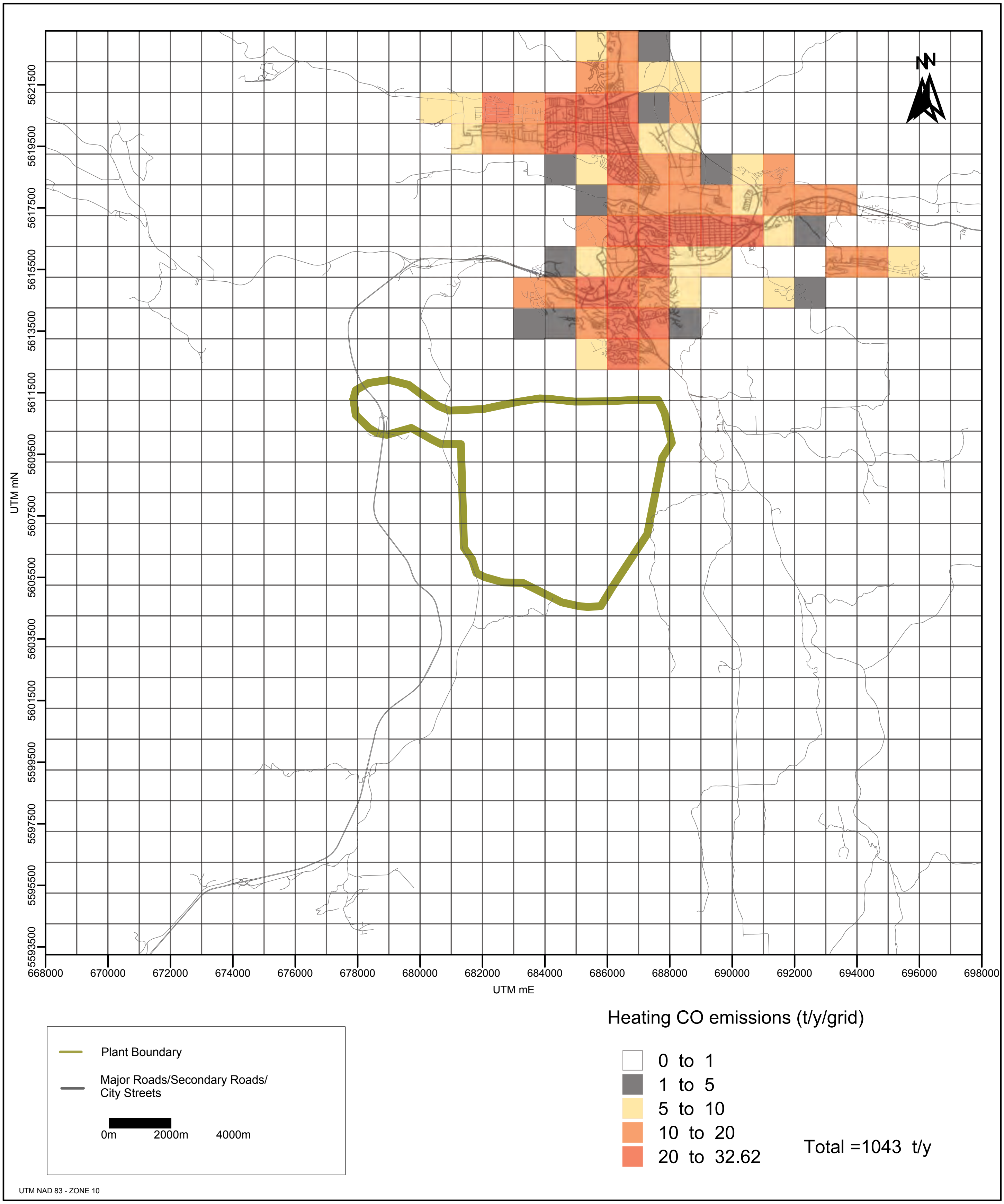
FIGURE NO.

F-11



KGHM Ajax Air Quality Assessment

Heating CO Emission for Year 2011 (t/y/grid)

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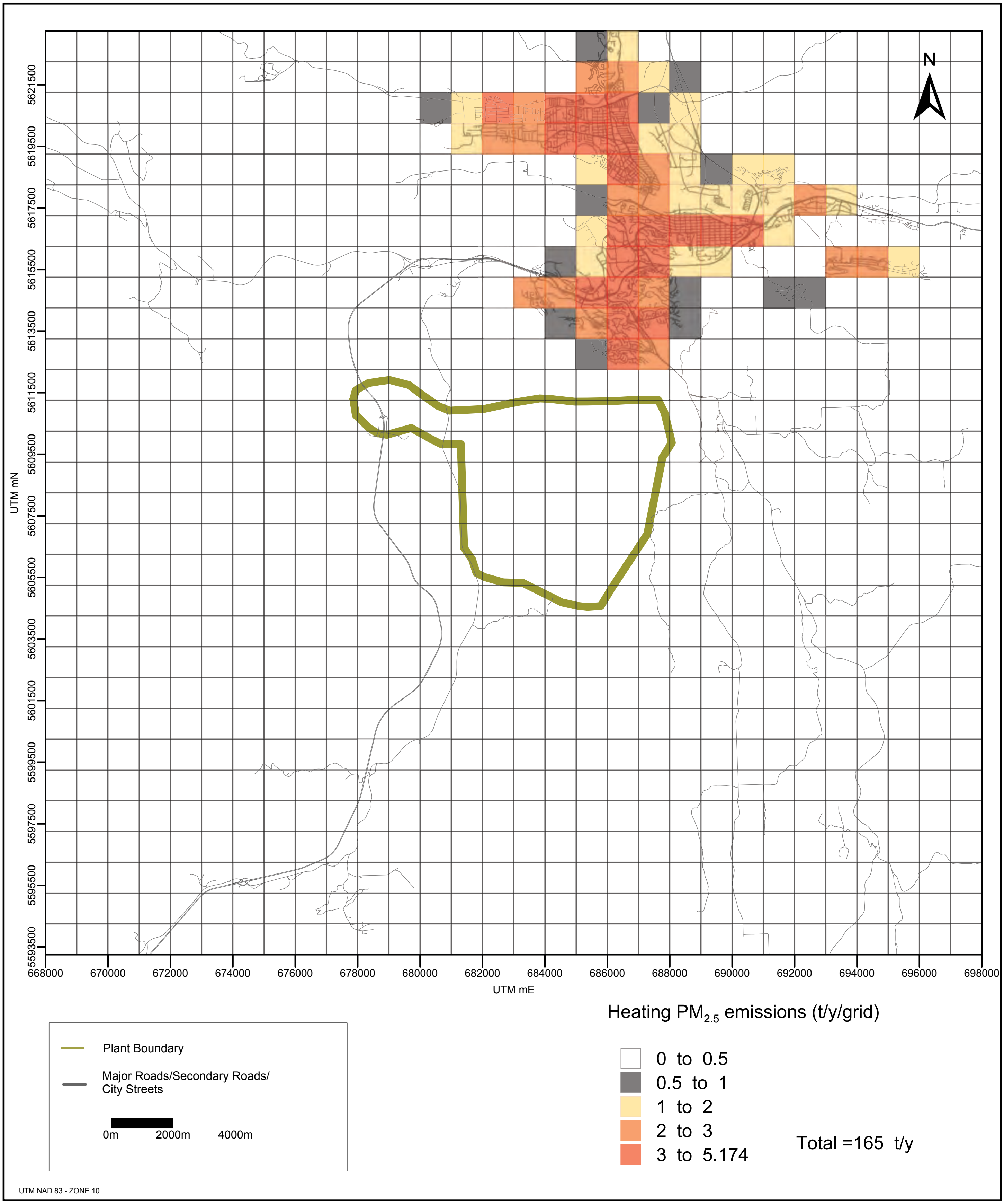
FIGURE NO.

F-12



KGHM Ajax Air Quality Assessment

Heating $PM_{2.5}$ Emission for Year 2011 (t/y/grid)

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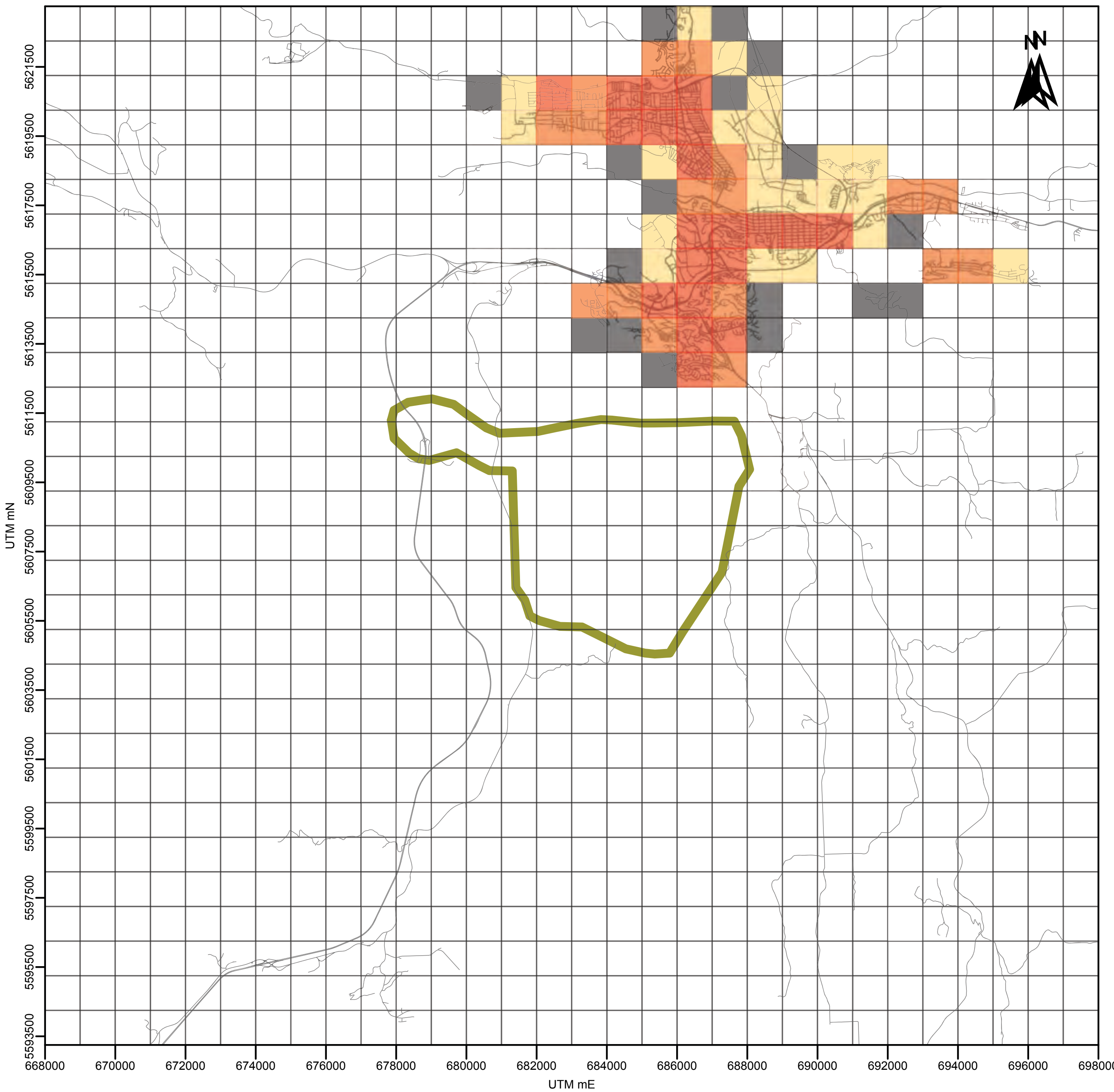
FIGURE NO.
F-13



Heating PM_{10} emissions (t/y/grid)

- 0 to 0.1
- 0.1 to 1
- 1 to 2
- 2 to 3
- 3 to 5.21

Total =167 t/y

Plant Boundary

Major Roads/Secondary Roads/ City Streets

0m 2000m 4000m

UTM NAD 83 - ZONE 10

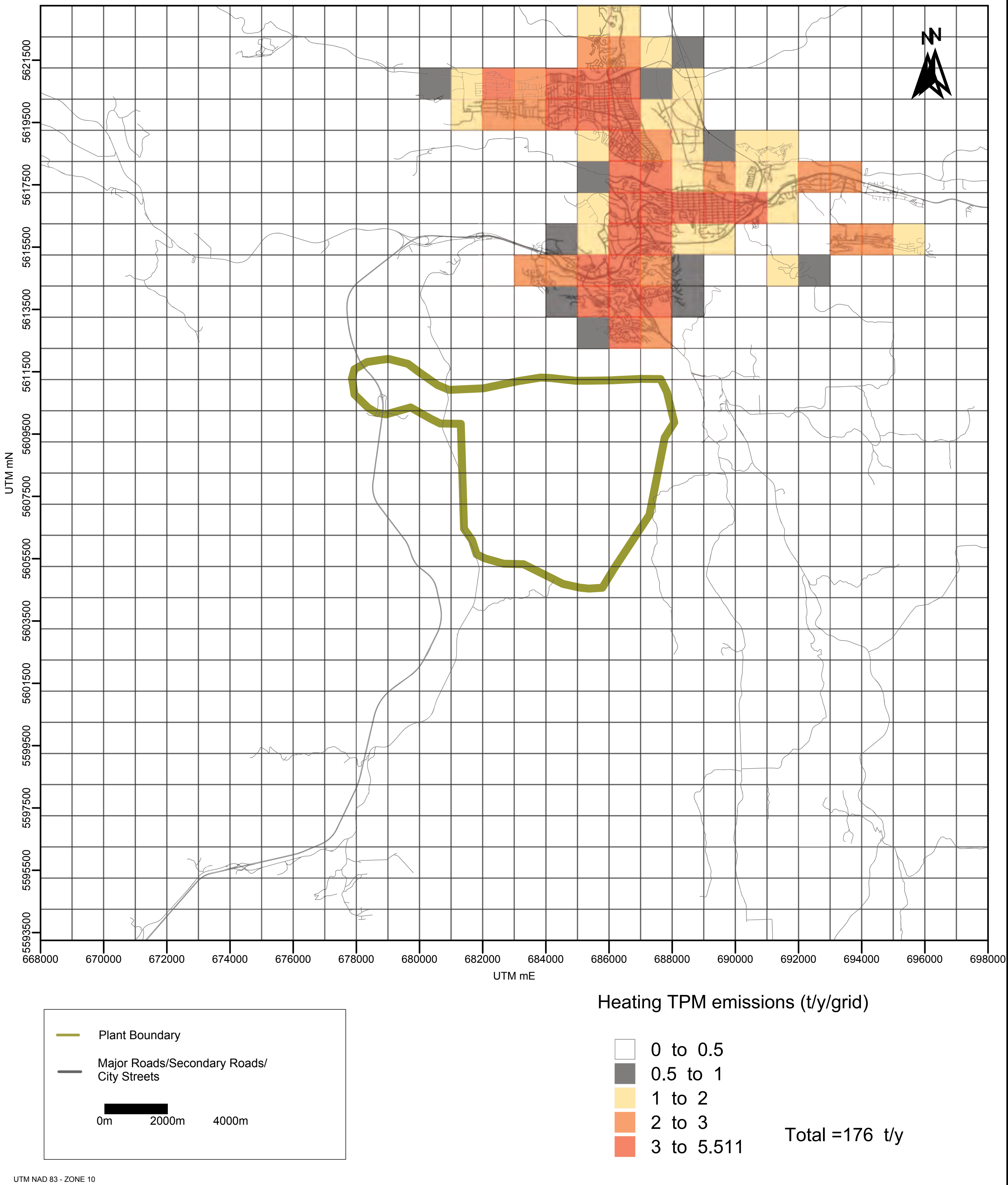
KGHM Ajax Air Quality Assessment

Heating PM_{10} Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **F-14**



KGHM Ajax Air Quality Assessment

Heating TPM Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

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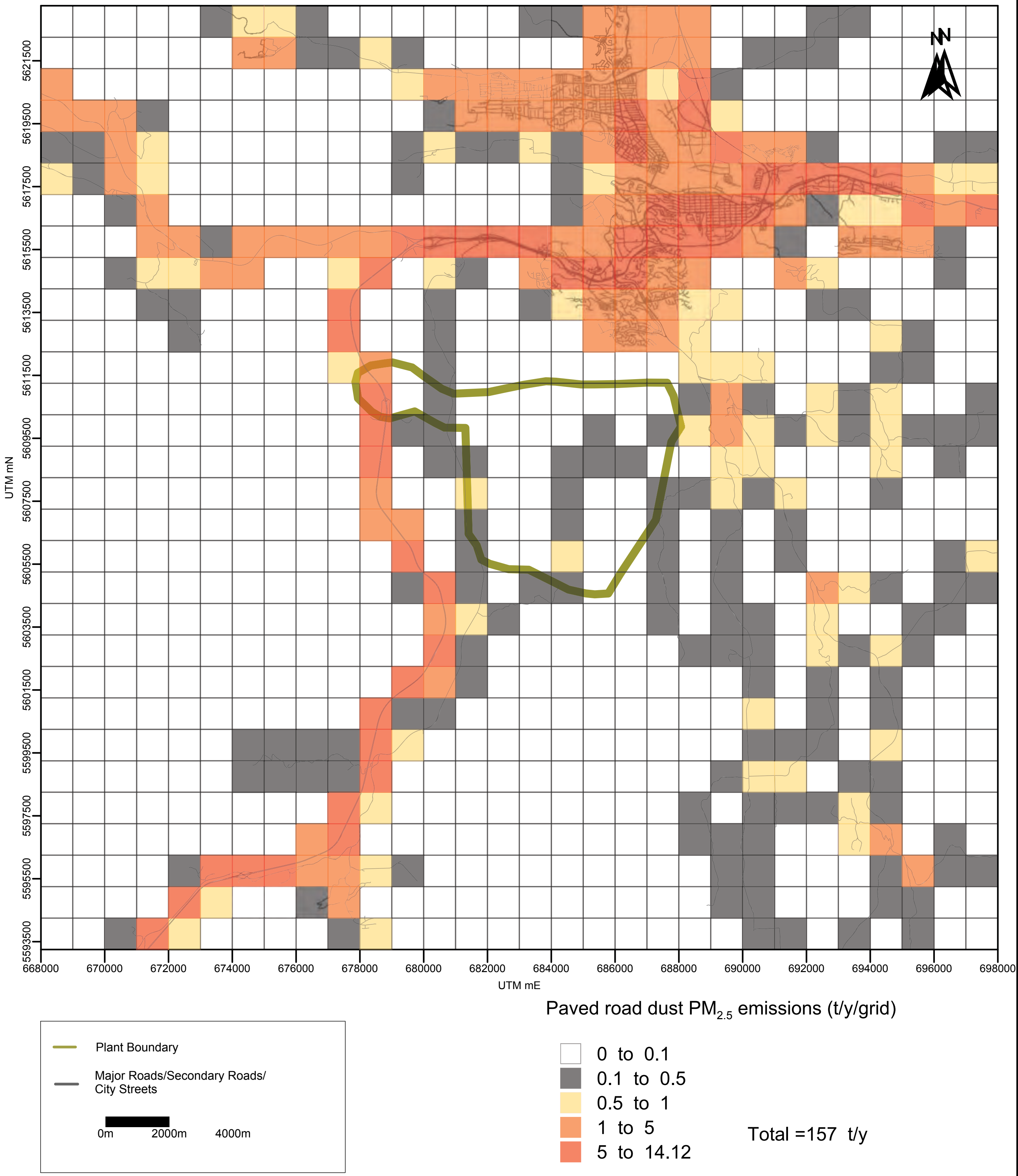
FIGURE NO. **F-15**



UTM NAD 83 - ZONE 10

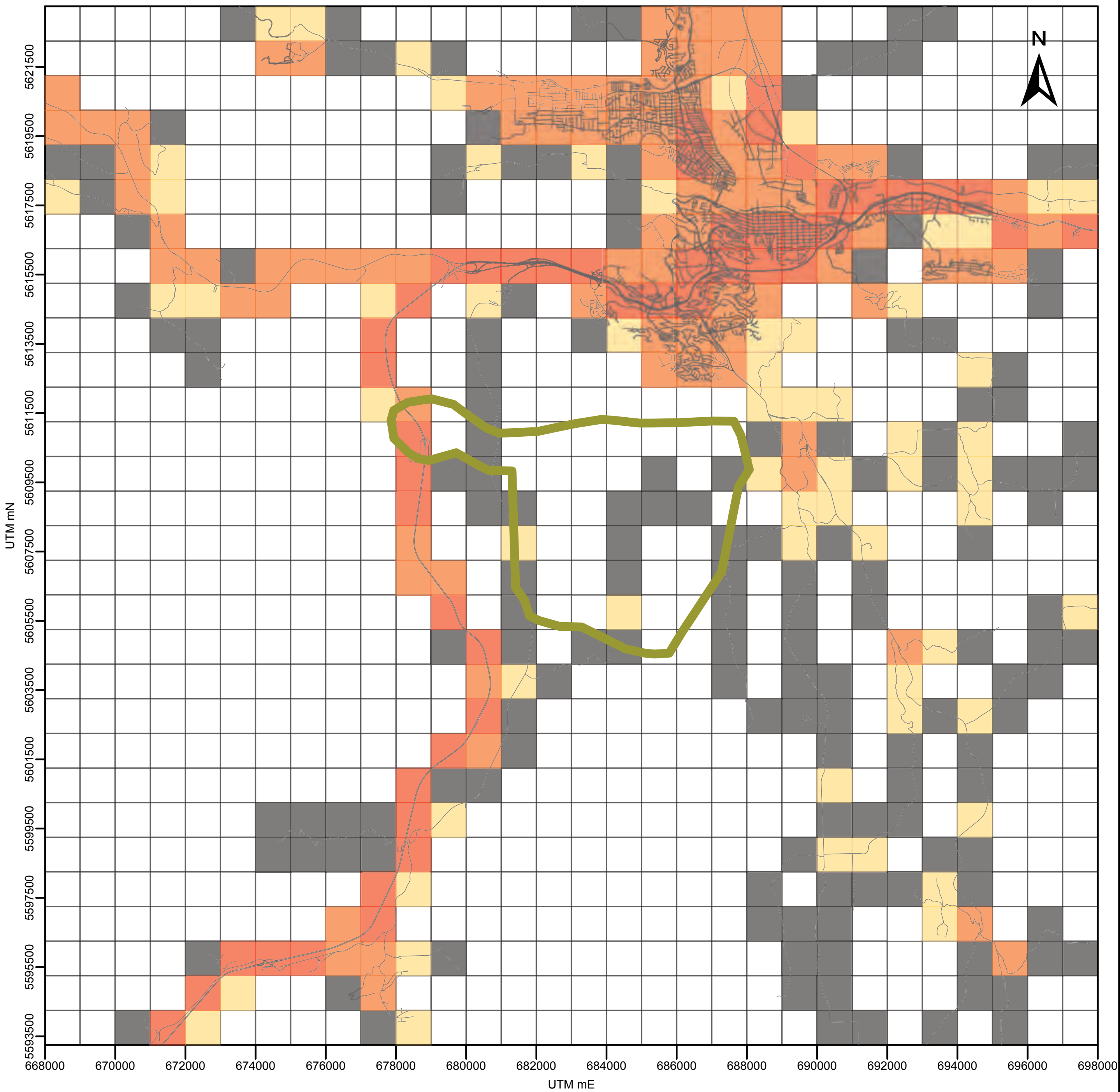
KGHM Ajax Air Quality Assessment

Paved Road Dust $PM_{2.5}$ Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **F-16**



Paved road dust PM_{10} emissions (t/y/grid)

- Plant Boundary
- Major Roads/Secondary Roads/ City Streets

0m 2000m 4000m

white	0 to 0.1
dark grey	0.1 to 0.5
light yellow	0.5 to 1
light orange	1 to 5
orange-red	5 to 14.12

Total = 619 t/y

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Paved Road Dust PM_{10} Emission for Year 2011 (t/y/grid)

PREPARED BY Stantec

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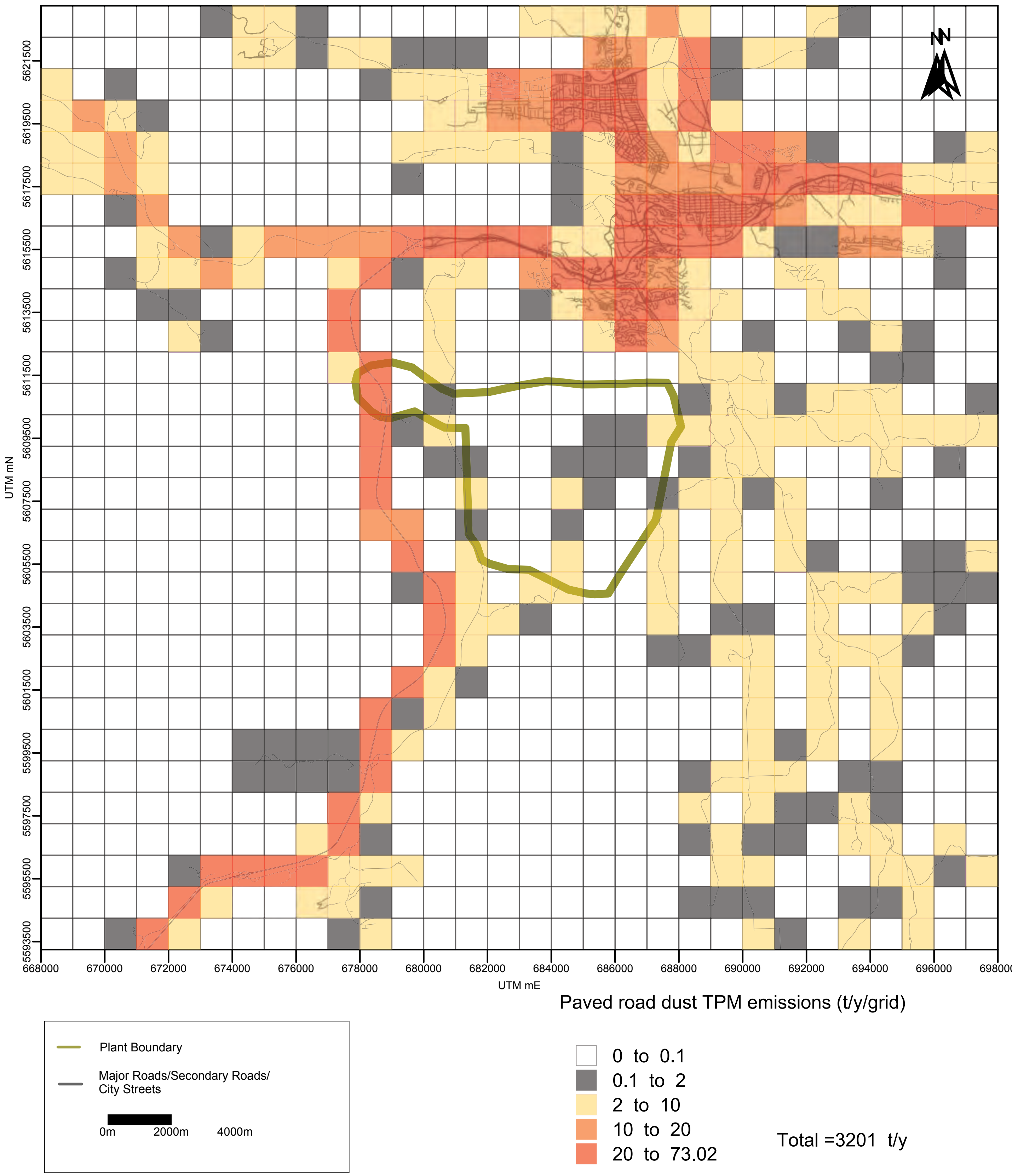
FIGURE NO. **F-17**



KGHM Ajax Air Quality Assessment

Paved Road Dust TPM Emission for Year 2011 (t/y/grid)

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FIGURE NO.

F-18

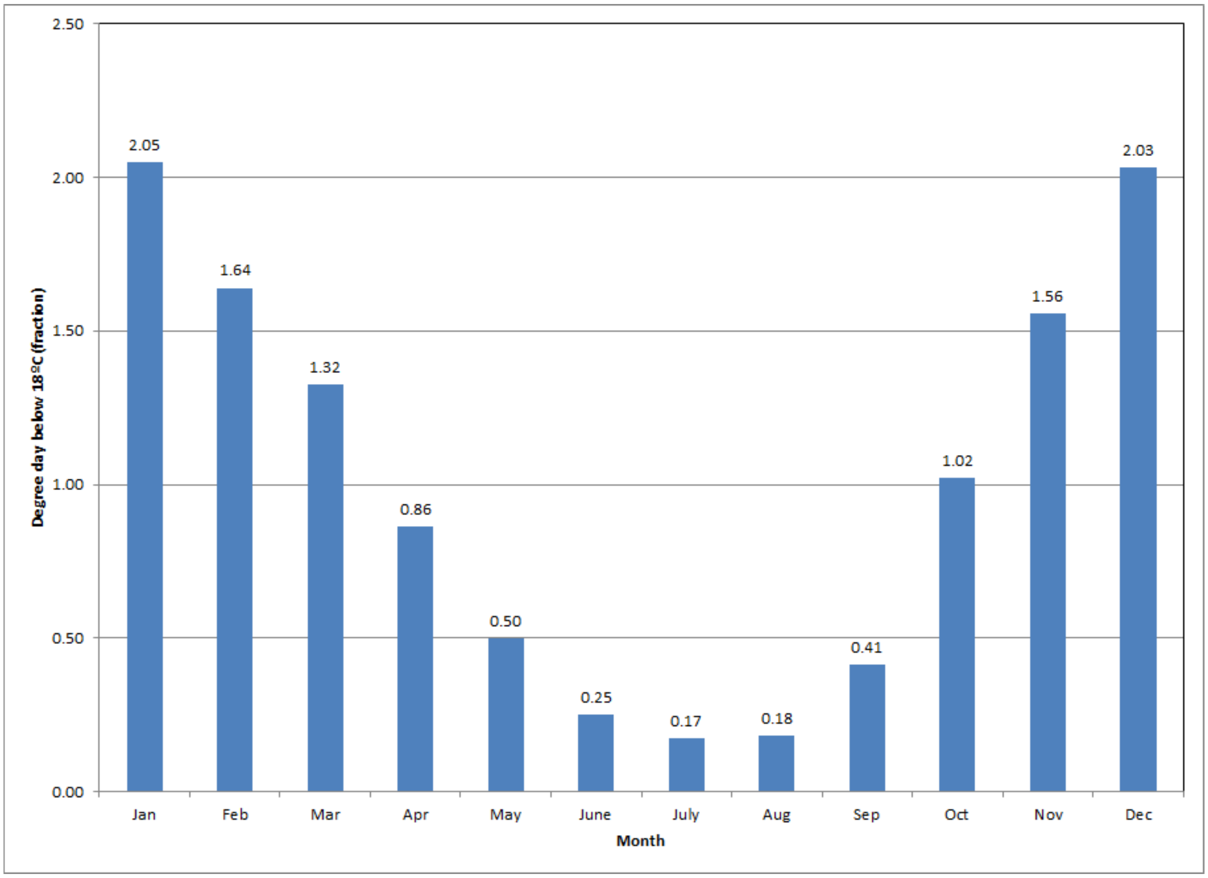


Figure F-19 Monthly Distribution of Heating Emissions (Fraction)

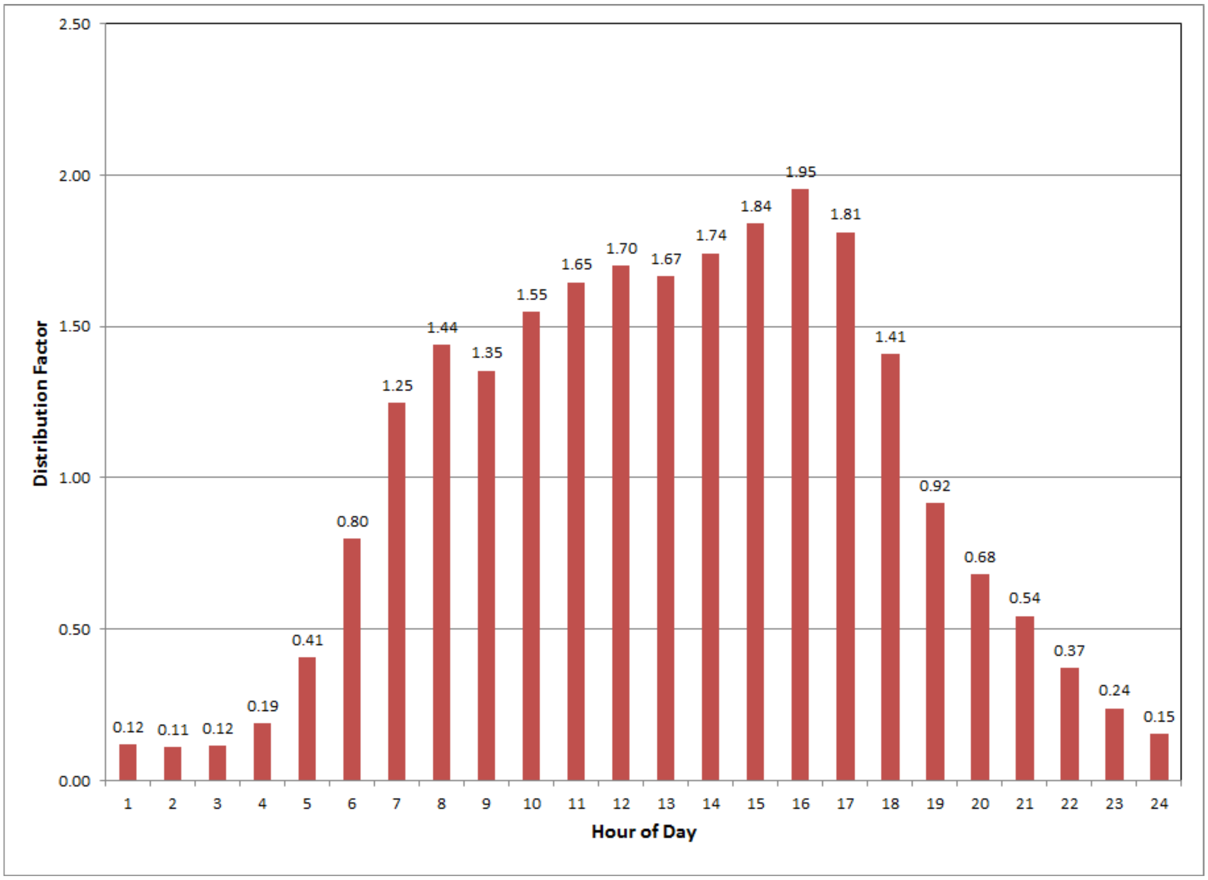


Figure F-20 Hourly Distribution of Roadway Mobile Emissions (Fraction)

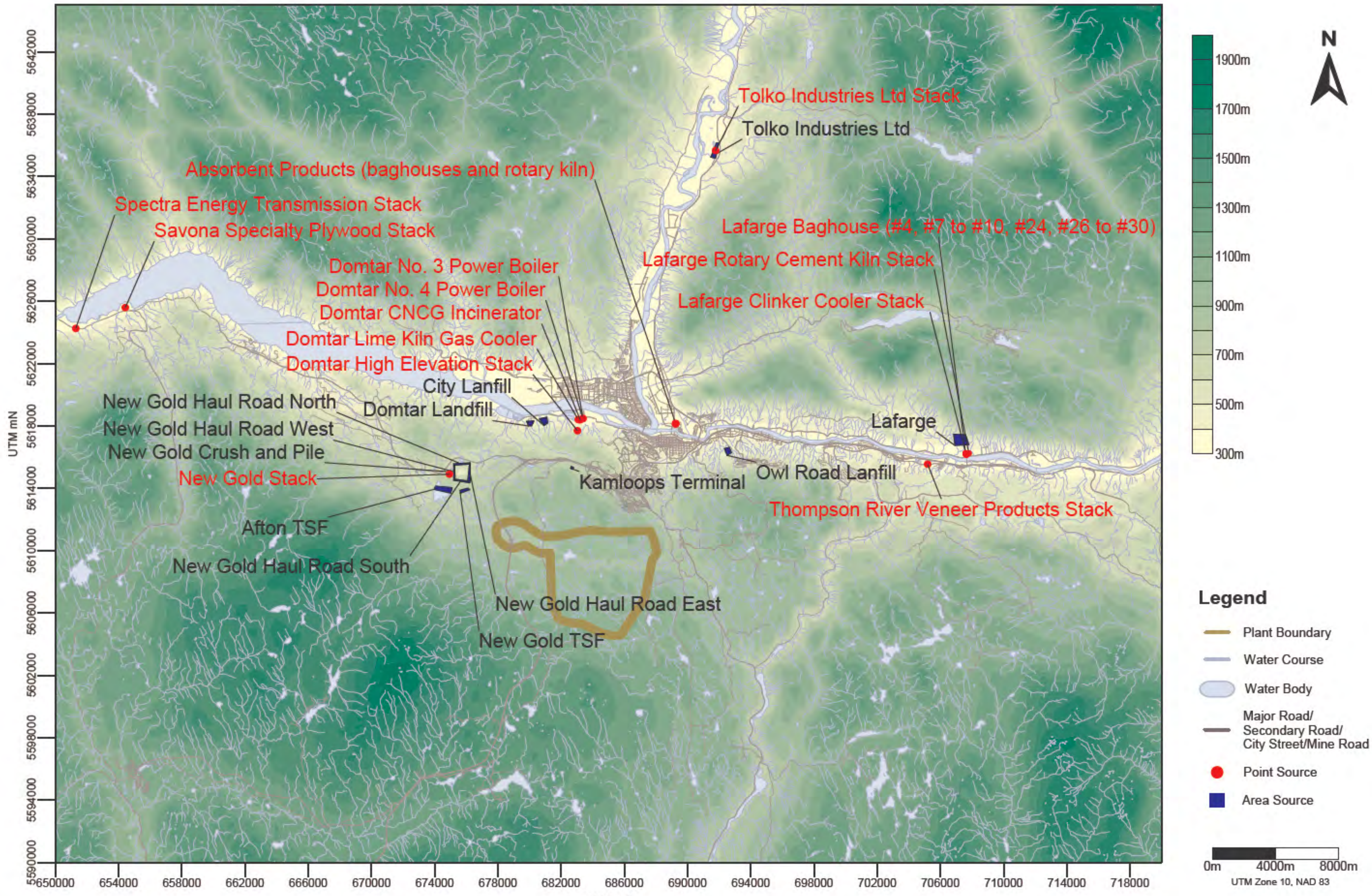
F.3 BASE CASE INDUSTRIAL SOURCES

Facilities in the CALPUFF domain 55 km x 70 km include Tolko Industries Ltd, Savona Specialty Plywood, Spectra Energy Transmission, Thompson River Veneer Products, Absorbent Products, Domtar Pulp Mill, Lafarge Cement Plant, New Gold, and Kamloops Terminal. Figure F-21 shows locations for those point and area sources. Tables F-3 to F-9 show point and area sources from those facilities. Table F-10 also shows emissions from Afton TSF, City Landfill, Domtar Landfill, and Owl Road Landfill.

Emissions from Tolko Industries Ltd, Savona Specialty Plywood, Spectra Energy Transmission, Thompson River Veneer Products, Absorbent Products, and Kamloops Terminal were from the National Pollutant Release Inventory (NPRI) annual reported emission data for year 2013/2012. Emissions from Domtar Pulp Mill and New Gold were provided by the facility owners. Emissions from Lafarge Cement Plant were estimated based on NPRI 2013 reporting, permitted limit (BC MOE, 2012), and survey data. Emission from Afton TSF, City Landfill, Domtar Landfill, and Owl Road Landfill were estimated based on AP 42 emission factors (US EPA, 1998). Please see Tables F-3 to F-9 for detail.

In the absence of detailed actual emission parameters, general boiler/heater stack parameters were applied for major emission sources for Tolko Industries Ltd, Savona Specialty Plywood, and Thompson River Veneer Products, and general reciprocating generator stack parameters were applied for major sources for Spectra Energy Transmission. The boiler/heater and generator stack information including stack height, diameter, exit velocity, and exit temperature were shown in Table F-3. Stack information for other facilities were from NPRI reporting, permit limit, facility owners, and technical reports (Stantec, 2010 and 2012). Please see Tables F-4 to F-7 for detail.

Facility total emissions are summarized in Table F-11. SO_2, NO_x, CO, $PM_{2.5}$, PM_{10}, TPM, ore $PM_{2.5}$ ($OPM_{2.5}$), ore PM_{10} (OPM_{10}), ore PM (OPM) emissions from those industrial facilities as well as from landfills in the domain are 69.4, 2248, 1792, 342, 593, 1060, 25.6, 27.7, and 68.3 t/y, respectively.



KGHM Ajax Air Quality Assessment

Locations of Industrial Point and Area Sources
(70 km x 55 km domain)

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FIGURE NO.
F-21

Table F-3 Point Source Parameters for Tolko Industries Ltd, Savona Specialty Plywood, Spectra Energy Transmission, and Thompson River Veneer Products

		Tolko Industries Ltd	Savona Specialty Plywood	Spectra Energy Transmission	Thompson River Veneer Products
Stack Location					
UTM NAD 83	mE	691773	654422	651288	705189
	mN	5635668	5625589	5624252	5615549
Elevation	m ASL	367	356	369	351
Stack Dimensions					
Height [a]	m	10	10	10	10
Inside Tip Diameter [a]	m	0.5	0.5	0.5	0.5
Exhaust Parameters					
Exit Velocity [a]	m/s	15	15	25	15
Exit Temperature [a]	°C	250	250	500	250
	K	523	523	773	523
Emission Rate [b]					
SO_2	t/y	0.0	0.0	0.0	0.0
NO_x	t/y	22.0	0.0	57.0	0.37
CO	t/y	36.0	25.0	45.0	20.0
$PM_{2.5}$	t/y	2.10	0.66	1.10	0.18
PM_{10}	t/y	12.0	1.90	1.10	2.57
TPM	t/y	38.0	6.28	1.10	8.50

NOTES:

[a] Representative values were selected by Stantec in the absence of detailed facility information.

[b] NPRI reporting data for year 2013.

Table F-4 Absorbent Products Ltd Point Source Parameters

		Plant Baghouse	Rotary Kiln	Silo Baghouse	ABF Baghouse	Total
Stack Location						
UTM NAD 83	mE	689244	689244	689244	689244	-
	mN	5618143	5618143	5618143	5618143	-
Elevation	m ASL	354	354	354	354	
Stack Dimensions						
Height [a]	m	12.19	12.19	24.38	15.24	-
Inside Tip Diameter [a]	m	1.52	1.37	0.51	0.33	-
Exhaust Parameters						
Exit Velocity [a]	m/s	9.62	9.10	11.5	15.2	-
Exit Temperature [a]	°C	16.6	80.7	33.6	21.7	-
	K	289.6	353.7	306.6	294.7	-
Emission Rate [b]						
SO_2	t/y	0.0	0.0	0.0	0.0	0
NO_x	t/y	0.0	0.0	0.0	0.0	0
CO	t/y	0.0	0.0	0.0	0.0	0
$PM_{2.5}$	t/y	1.21	1.02	0.24	0.01	2.48
PM_{10}	t/y	1.51	1.28	0.30	0.02	3.10
TPM	t/y	1.51	1.28	0.30	0.02	3.10

NOTES:

[a] Stack height, diameter, exit velocity, and exit temperature are from 2012 NPRI reporting.

[b] Facility total PM_{10} and TPM emissions are from 2012 NPRI reporting. Facility total $PM_{2.5}$ emission was calculated based on $PM_{2.5}$/TPM = 0.8 according to the Lafarge facility baghouse emissions (Stantec, 2012).

$PM_{2.5}$, PM_{10}, and TPM emissions for four specific stacks were based on facility total emissions and permit limit (BC MOE, 2013).

Table F-5 Domtar Pulp Mill Point Source Parameters

		High Elevation Stack	No. 3 Power Boiler	No. 4 Power Boiler	Lime Kiln Gas Cooler	CNCG Incinerator
Stack Location						
UTM NAD 83	mE	683034	683379	683378	683084	683204
	mN	5617693	5618482	5618466	5618408	5618390
Elevation	m ASL	553	347	347	348	348
Stack Dimensions						
Height	m	263.65 [a]	61.0 [a]	61.0 [a]	30.5 [b]	26.8 [b]
Inside Tip Diameter	m	4.88 [a]	3.2 [a]	3.2 [a]	1.8 [b]	0.8 [b]
Exhaust Parameters						
Exit Velocity	m/s	11.8 [c]	13.7 [c]	13.2 [c]	27.4 [b]	14.7 [b]
Exit Temperature	°C	71.7 [c]	178.3 [c]	180.6 [c]	66.1 [b]	71.7 [b]
	K	344.7	451.3	453.6	339.1	344.7
Emission Rate [d]						
SO_2	t/y	5.90	0	0	1.66	0.22
NO_x	t/y	501	296	308	25.8	46.5
CO	t/y	0	814	846	2.06	3.94
$PM_{2.5}$	t/y	194	6.20	4.00	23.0	1.20
PM_{10}	t/y	263	7.10	4.60	25.7	2.04
TPM	t/y	387	9.60	6.20	29.9	2.04

NOTES:
[a] NPRI 2013 reporting.
[b] Stantec (2010) and related database.
[c] Provided by Domtar Pulp Mill.
[d] Provided by Domtar Pulp Mill.

Table F-6 Lafarge Cement Plant Point Source Parameters [a]

		Rotary Cement Kiln Stack	Clinker Cooler Stack	#4 Baghouse Raw Mix Circuit	#7 Baghouse Raw Mix Silo	#8 Baghouse Raw Mix Silo	#9 Baghouse Raw Mix Circuit	#10 Baghouse Raw Mix Circuit	Total
Stack Location									
UTM NAD 83	mE	707790	707605	707595	707666	707657	707615	707628	-
	mN	5616248	5616249	5616234	5616229	5616230	5616232	5616238	-
Elevation	m ASL	362	358	357	358	358	357	358	-
Stack Dimensions									
Height	m	24.38	22.86	14.33	37.79	37.79	29.57	29.57	-
Inside Tip Diameter	m	1.83	1.83	2.0	2.0	2.0	2.0	2.0	-
Exhaust Parameters									
Exit Velocity	m/s	13.25 [b]	10.26 [b]	0.1	0.1	0.1	0.1	0.1	-
Exit Temperature	°C	284	147	100	100	100	100	100	-
	K	557	420	373	373	373	373	373	-
Emission Rate									
SO_2	t/y	61.6 [c]	0	0	0	0	0	0	91.6
NO_x	t/y	992 [d]	0	0	0	0	0	0	992
CO	t/y	0	0	0	0	0	0	0	0
$PM_{2.5}$	t/y	4.47 [e]	2.49 [e]	1.52	0.13	0.73	0.34	0.54	10.2
PM_{10}	t/y	11.7 [e]	6.46 [e]	1.62	0.13	0.77	0.37	0.58	21.6
TPM	t/y	36.0 [e]	15.5 [e]	3.46	0.29	1.66	0.78	1.24	58.0

Table F-7 Lafarge Cement Plant Point Source Parameters [a]

		#24 Baghouse Finish Mill	#26 Baghouse Cement Silo 1	#27 Baghouse Cement Silo 2	#28 Baghouse Cement Silo 3	#29 Baghouse Cement Silo 4	#30 Baghouse Cement Silo 5	Total
Stack Location								
UTM NAD 83	mE	707603	707634	707629	707642	707642	707642	-
	mN	5616199	5616175	5616160	5616161	5616175	5616175	-
Elevation	m ASL	356	356	355	355	356	356	-
Stack Dimensions								
Height	m	14.33	26.6	26.6	26.6	26.6	26.6	-
Inside Tip Diameter	m	2.0	2.0	2.0	2.0	2.0	2.0	-
Exhaust Parameters								
Exit Velocity	m/s	0.1	0.1	0.1	0.1	0.1	0.1	-
Exit Temperature	°C	100	100	100	100	100	100	-
	K	373	373	373	373	373	373	-
Emission Rate								
SO_2	t/y	0	0	0	0	0	0	0
NO_x	t/y	0	0	0	0	0	0	0
CO	t/y	0	0	0	0	0	0	0
$PM_{2.5}$	t/y	3.89	0.65	1.15	1.15	1.15	0.81	8.80

Table F-7 Lafarge Cement Plant Point Source Parameters [a]

		#24 Baghouse Finish Mill	#26 Baghouse Cement Silo 1	#27 Baghouse Cement Silo 2	#28 Baghouse Cement Silo 3	#29 Baghouse Cement Silo 4	#30 Baghouse Cement Silo 5	Total
PM_{10}	t/y	4.14	0.69	1.22	1.22	1.22	0.87	9.36
TPM	t/y	8.86	1.48	2.61	2.61	2.61	1.85	20.0

NOTES:

[a] Stack location and dimensions are from Stantec (2012). TPM emissions were estimated based on NPRI 2013 reporting and permitted limit (BC MOE, 2012). $PM_{2.5}$ and PM_{10} emissions were estimated using ratios PM_{10}/TPM = 0.85 and $PM_{2.5}$/TPM = 0.8 based on US EPA webFIRE for SCC 30500613 Cement Manufacturing - Raw Material Grinding and Drying, uncontrolled.

[b] Based on permitted flow rates (BC MOE, 2012).

[c] Updated by BC MOE. [d] NPRI 2013 reporting. [e] Based on the maximum survey data.

Table F-8 New Gold Point Source Parameters [a]

		Venting Stack
Stack Location		
UTM NAD 83	mE	674930
	mN	5614908
Elevation	m ASL	719
Stack Dimensions		
Height	m	4.0
Inside Tip Diameter	m	4.0
Exhaust Parameters		
Exit Velocity	m/s	13.9
Exit Temperature	°C	20
	K	293
Emission Rate		
SO_2	t/y	0
NO_x	t/y	0
CO	t/y	0
$PM_{2.5}$	t/y	25.4 [b]
PM_{10}	t/y	27.4 [b]
TPM	t/y	64.1 [b]
$OPM_{2.5}$	t/y	25.4
OPM_{10}	t/y	27.4
OPM	t/y	64.1

NOTE:

[a] Stack information was provided by New Gold. There are three stacks in horizontal direction. Three stacks were treated as one source. Stack exit velocity was estimated based on exhaust flow rate dividing by 3.

[b] Provided by New Gold.

Table F-9 New Gold Area Source Parameters

		Crush and Pile	New Gold TSF	West Road	North Road	East Road	South Road	Total
Area Location								
UTM NAD 83	NW mE	674939	675600	675191	675195	676196	675290	-
	NW mN	5615136	5613879	5615480	5615583	5615546	5614589	-
	NE mE	675010	676104	675266	676248	676248	676250	-
	NE mN	5615144	5614018	5615484	5615640	5615640	5614460	-
	SE mE	675027	676230	675290	676196	676250	676223	-
	SE mN	5615068	5613916	5614589	5615546	5614460	5614352	-
	SW mE	674947	675615	675199	675191	676086	675199	-
	SW mN	5615063	5613685	5614519	5615480	5614488	5614519	-
Area	km^2	0.0057	0.096	0.078	0.099	0.119	0.097	-
Elevation	m ASL	679	724	686	672	697	712	-
Area Source Details								
Effective Height	m	5.0	3.0	3.0	3.0	3.0	3.0	-
Initial Sigma Z	m	4.65	5.0	5.0	5.0	5.0	5.0	-
Emission Rate								
SO_2	t/y	0	0	0	0	0	0	0
NO_x	t/y	0	0	0	0	0	0	0
CO	t/y	0	0	0	0	0	0	0
$PM_{2.5}$	t/y	0.216 [a]	0.085 [a]	0.197 [b]	0.253 [b]	0.302 [b]	0.247 [b]	1.30
PM_{10}	t/y	0.287 [c]	0.113 [c]	3.73 [b]	4.78 [b]	5.72 [b]	4.66 [b]	19.3
TPM	t/y	4.17 [d]	1.63 [e]	13.0 [b]	16.7 [b]	20.0 [b]	16.3 [b]	71.8
$OPM_{2.5}$	t/y	0.216	-	-	-	-	-	0.216
OPM_{10}	t/y	0.287	-	-	-	-	-	0.287
OPM	t/y	4.17	-	-	-	-	-	4.17

NOTES:

[a] Based on New Gold provided fugitive emission ratio of $PM_{2.5}$/TPM and estimated crush and pile TPM emission.

[b] New Gold provided road dust emission was distributed to the west road, north road, east road, and south road based on road length.

[c] Based on New Gold provided fugitive emission ratio of PM_{10}/TPM and estimated crush and pile TPM emission.

[d] Difference between New Gold provided fugitive emission and New Gold TSF emission.

[e] Use emission factor in US EPA AP 42 Table 11.9-4 (wind erosion of exposed areas) (US EPA, 1998) to estimate TPM emission, with assumption of natural mitigation factor 0.8.

Table F-10 Area Source Parameters for Tolko Industries Ltd, Kamloops Terminal, and Lafarge Cement Plant

		Tolko Industries Ltd	Kamloops Terminal	Lafarge Cement Plant
Area Location				
UTM NAD 83	NW mE	691834	682637	706830
	NW mN	5636172	5615407	5617470
	NE mE	691973	682798	707596
	NE mN	5636137	5615334	5617440
	SE mE	691761	682749	707796
	SE mN	5635164	5615224	5616793
	SW mE	691471	682596	706917
	SW mN	5635246	5615285	5616745
Area	km^2	0.221	0.021	0.566
Elevation	m ASL	367	756	485
Area Source Details				
Effective Height	m	3.0	3.0	3.0
Initial Sigma Z	m	5.0	5.0	5.0
Emission Rate				
SO_2	t/y	0	0	0
NO_x	t/y	0	0	0
CO	t/y	0	0	0
$PM_{2.5}$ [a]	t/y	1.60	1.10	57.0
PM_{10} [a]	t/y	23.0	11.0	142
TPM [a]	t/y	76.0	42.0	201

NOTE:
[a] NPRI 2013 reporting.

Table F-11 Area Source Parameters for Afton TSF, City landfill, Domtar landfill, and Owl Road landfill

		Afton TSF	Kamloops City Landfill	Domtar Landfill	Owl Road Landfill
Area Location					
UTM NAD 83	NW mE	674060	680623	679806	692333
	NW mN	5614150	5618453	5618298	5616553
	NE mE	675108	681086	680286	692638
	NE mN	5614049	5618567	5618327	5616634
	SE mE	675018	681156	680136	692785
	SE mN	5613691	5618196	5618002	5616289
	SW mE	673949	680918	679937	692499
	SW mN	5613935	5618023	5617996	5616113
Area	km^2	0.321	0.167	0.106	0.136
Elevation	m ASL	705	427	426	449
Area Source Details					
Effective Height	m	5.0	5.0	5.0	5.0
Initial Sigma Z	m	4.651	4.651	4.651	4.651
Emission Rate					
SO_2	t/y	0	0	0	0
NO_x	t/y	0	0	0	0
CO	t/y	0	0	0	0
$PM_{2.5}$ [a]	t/y	1.08	0.582	0.369	0.440
PM_{10} [b]	t/y	7.09	3.82	2.43	2.89
TPM [c]	t/y	14.9	8.09	5.13	6.11

NOTES:

a Based on ratio of $PM_{2.5}$/TPM 0.072 and TPM emission rate.

b Based on ratio of PM_{10}/TPM 0.473 and TPM emission.

c Use emission factor in US EPA AP 42 Table 11.9-4 (wind erosion of exposed areas) (US EPA, 1998) to estimate TPM emission, with assumption of natural mitigation factor 0.42.

Base Case Industrial Sources
August 21, 2015

Table F-12 Facility and Landfill Source Emission Summary (t/y)

Facility		SO_2	NO_x	CO	$PM_{2.5}$	PM_{10}	TPM	$OPM_{2.5}$	OPM_{10}	OPM
Tolko Industries Ltd	Point source	0	22.0	36.0	2.10	12.0	38.0	-	-	-
	Area source	0	0	0	1.60	23.0	76.0	-	-	-
Savona Specialty Plywood	Point source	0	0	25.0	0.660	1.90	6.28	-	-	-
Spectra Energy Transmission	Point source	0	57.0	45.0	1.10	1.10	1.10	-	-	-
Thompson River Veneer Products	Point source	0	0.370	20.0	0.180	2.57	8.50	-	-	-
Absorbent Products Ltd	Point source	0	0	0	2.48	3.10	3.10	-	-	-
Domtar Pulp Mill	Point source	7.78	1177	1666	228	302	435	-	-	-
Lafarge Cement Plant	Point source	61.6	992	0	19.0	31.0	79.0	-	-	-
	Area source	0	0	0	57.0	142	201	-	-	-
New Gold	Point source	0	0	0	25.4	27.4	64.1	25.4	27.4	64.1
	Area source	0	0	0	1.30	19.3	71.8	0.216	0.287	4.17
Kamloops Terminal	Area source	0	0	0	1.10	11.0	42.0	-	-	-
Afton TSF	Area source	0	0	0	1.08	7.09	14.9	-	-	-
Kamloops City Landfill	Area source	0	0	0	0.582	3.82	8.09	-	-	-
Domtar Landfill	Area source	0	0	0	0.369	2.43	5.13	-	-	-
Owl Road Landfill	Area source	0	0	0	0.44	2.89	6.11	-	-	-
Total in the Domain		**69.4**	**2248**	**1792**	**342**	**593**	**1060**	**25.6**	**27.7**	**68.3**

F.4 REFERENCES

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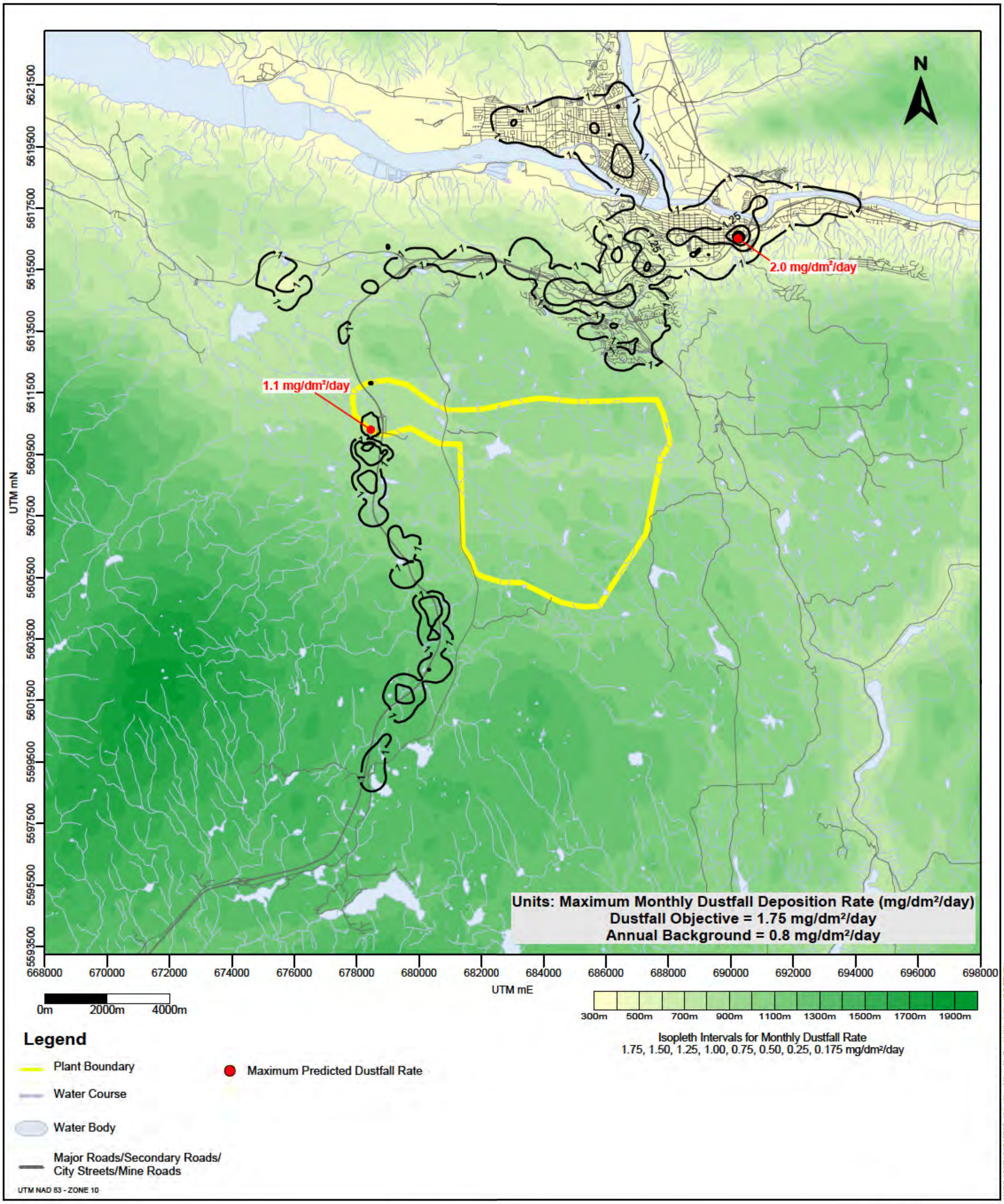
US EPA, 1998. AP 42, Fifth Edition, Volume I, Chapter 11: Mineral Products Industry. Section 11.9 Western Surface Coal Mining. October 1998. Available at http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s09.pdf

APPENDIX G
BASE CASE MODELLING ISOPLETH MAPS

Appendix G BASE CASE MODELLING ISOPLETH MAPS

List of Figures



U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted Monthly Average Dustfall Rate (mg/dm²/day)
With Global/Regional Background Added

PREPARED BY
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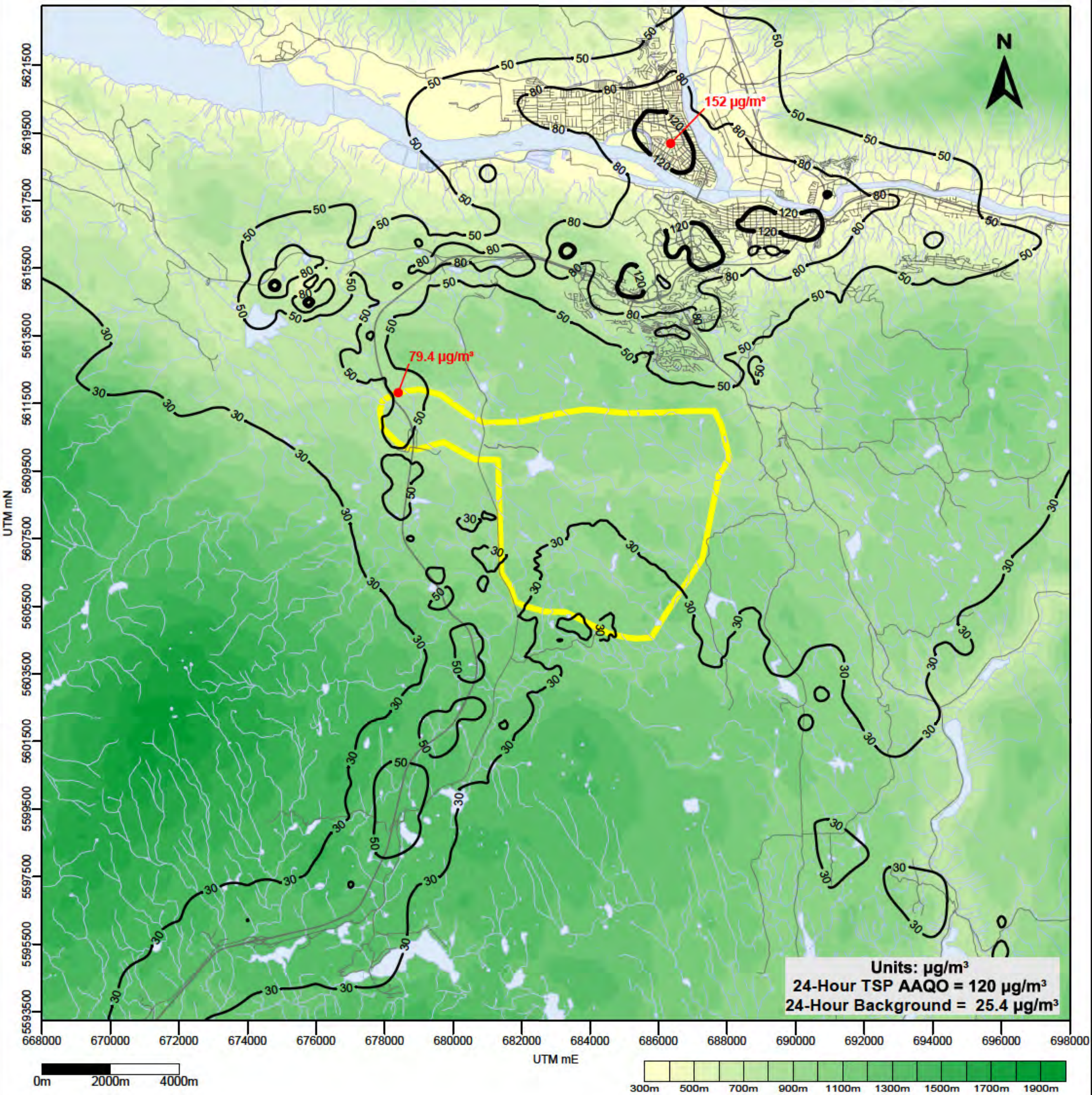
KGHM

FIGURE NO.
G-1

Last Modified: 04/27/2015 By: KW



Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted 24-Hour Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

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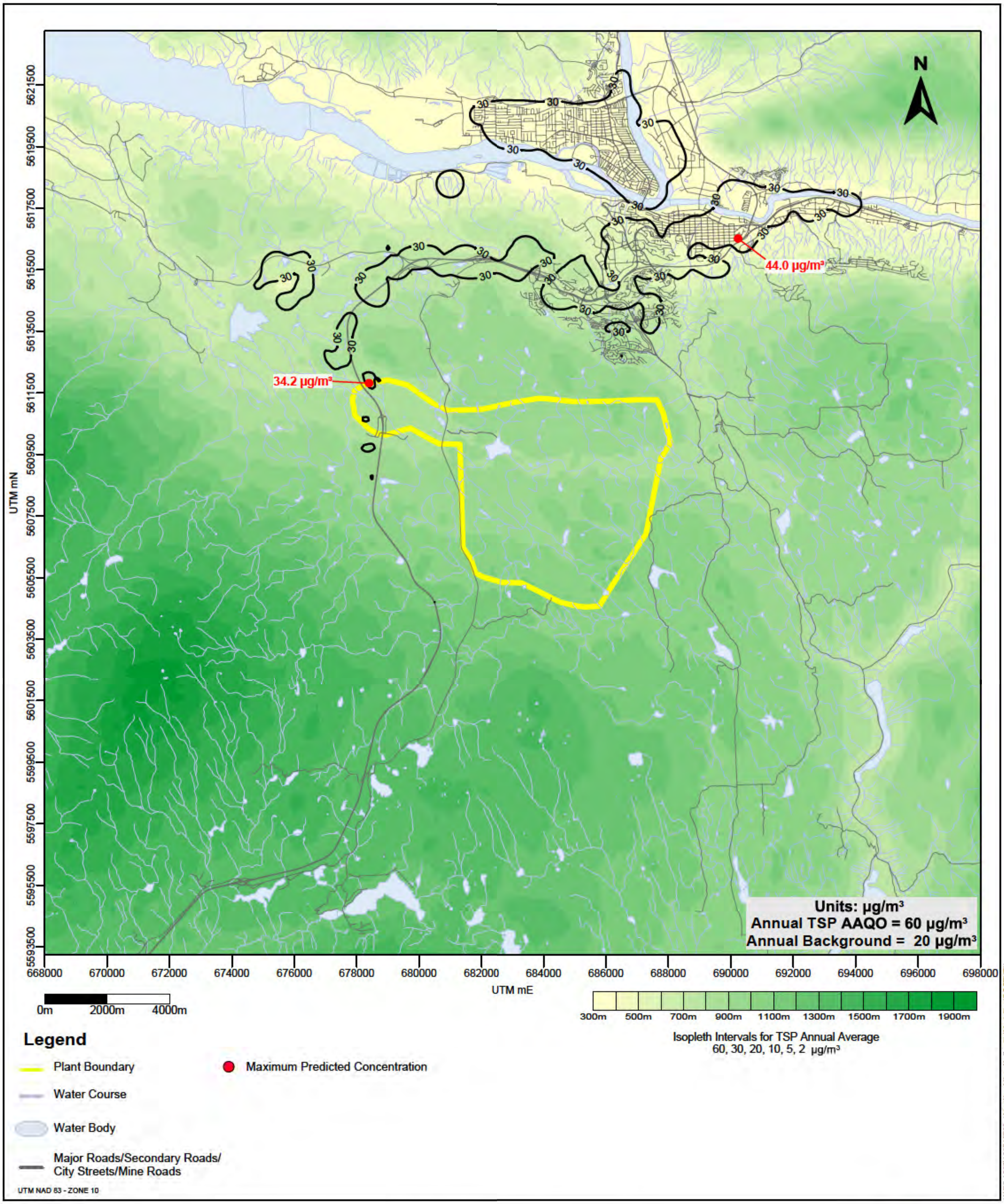
FIGURE NO. **G-2**

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted Annual Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

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FIGURE NO. **G-3**

U:\PC 1235\12351076\2_New Ajax Mine Air Quality\Modeling\POSTUTIL

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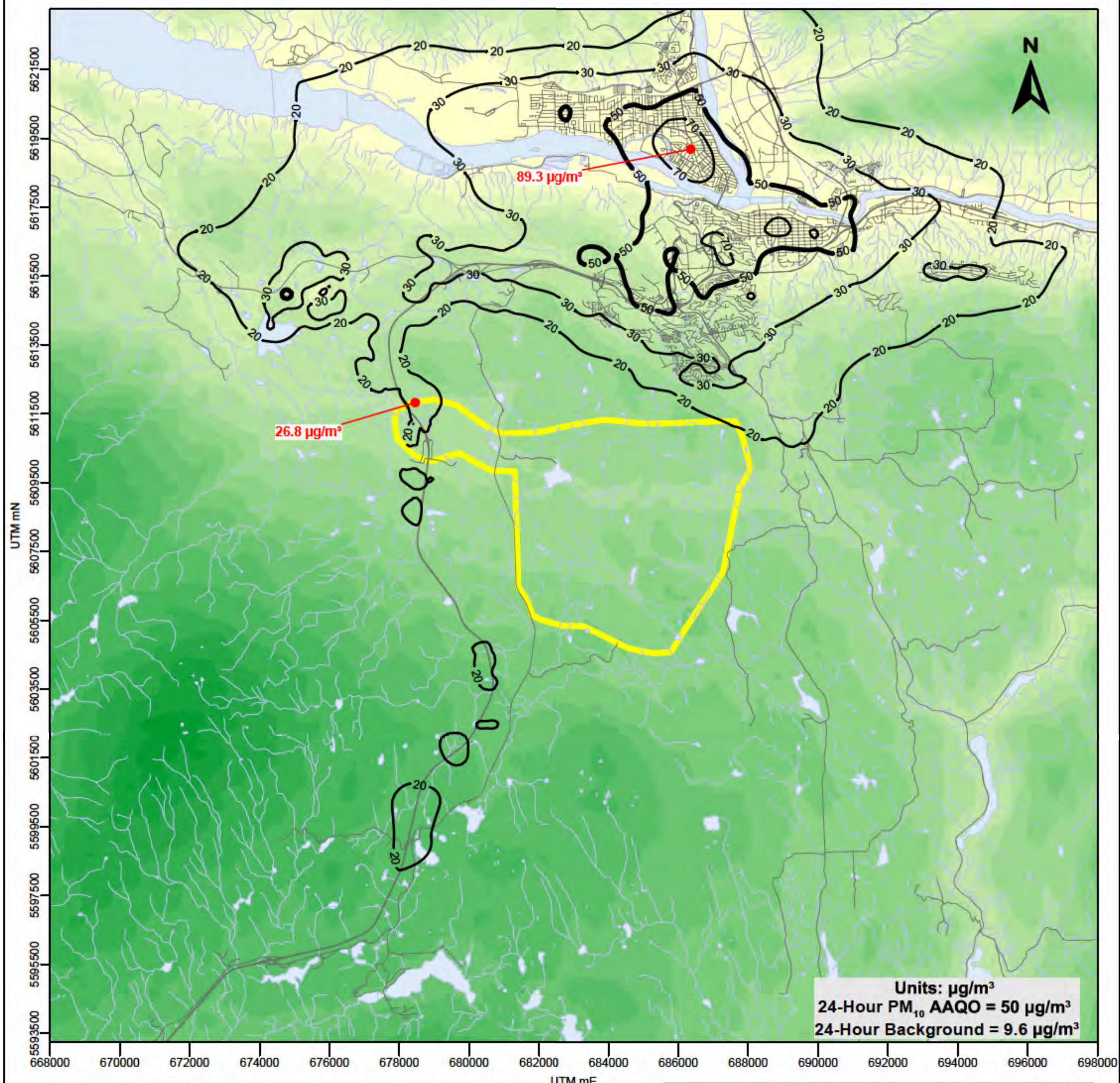

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted 24-Hour Average Ground-level PM_{10} Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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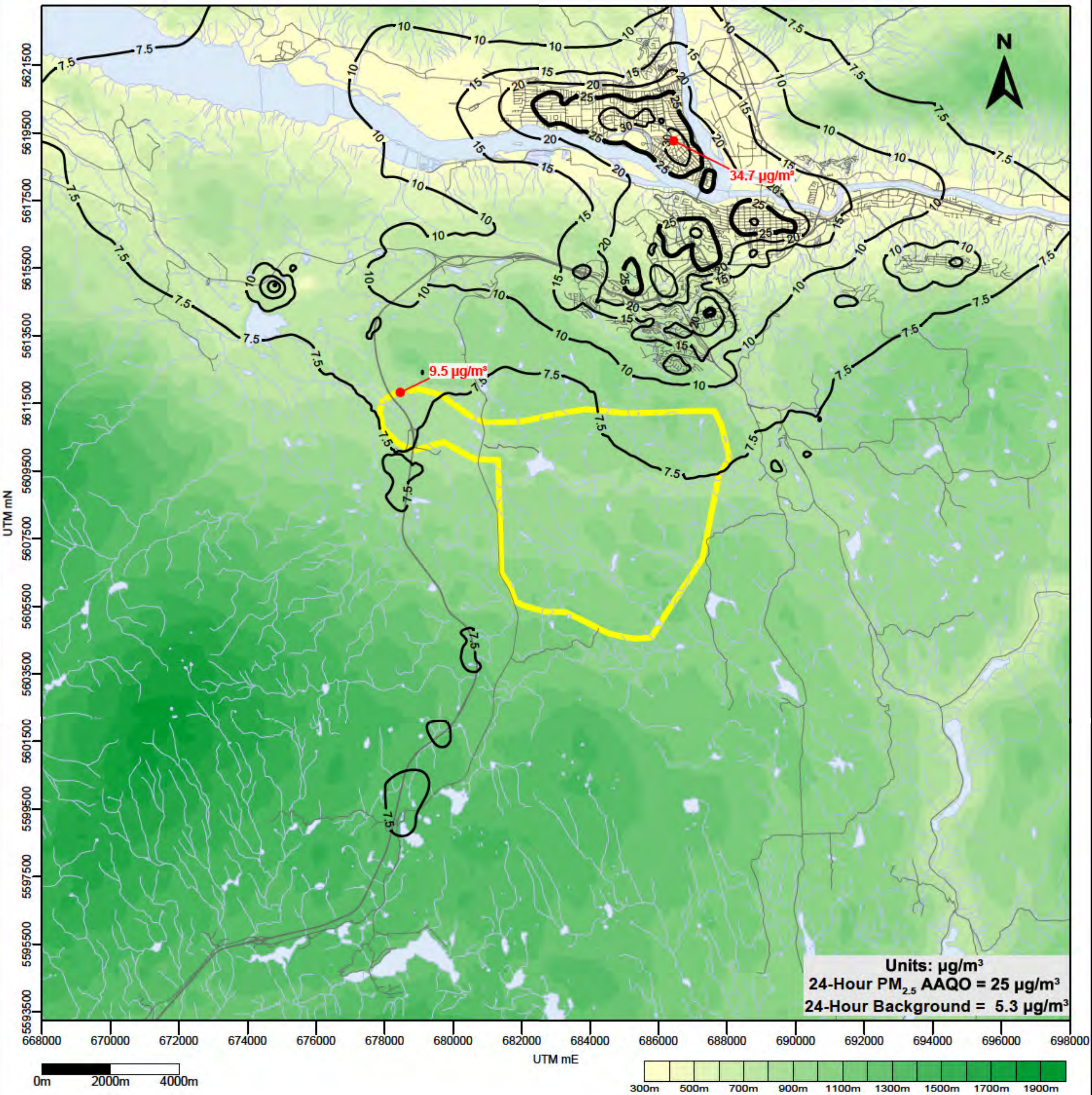
FIGURE NO. **G-4**

Last Modified: 04/27/2015 By: KW



Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads

UTM NAD 83 - ZONE 10

V:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Base Case Predicted 98th Percentile 24-Hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

YT NWT BC AB Ajax USA

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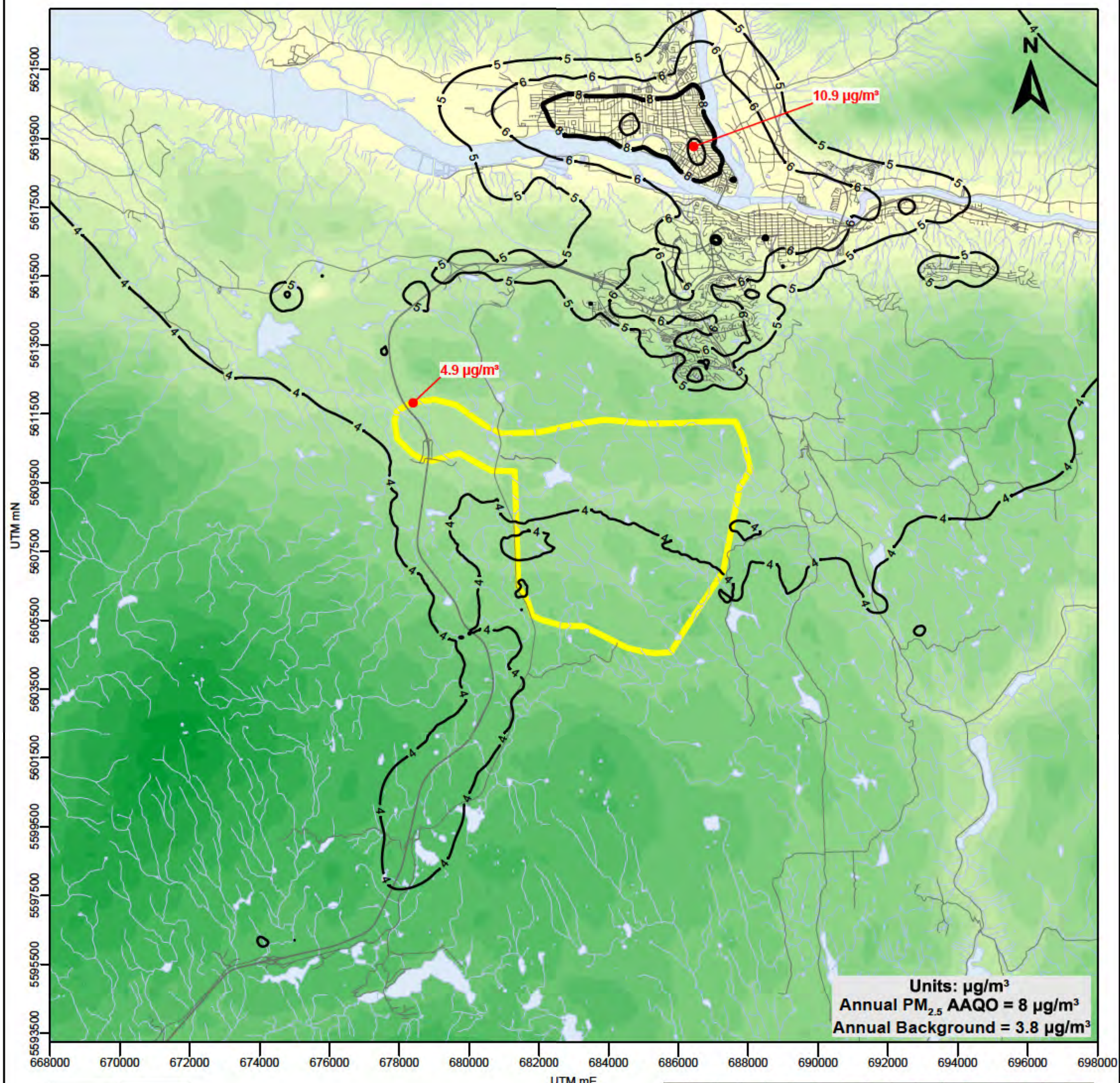
PREPARED FOR KGHM

FIGURE NO. **G-5**

Last Modified: 04/27/2015 By: KW



0m 2000m 4000m

300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for $PM_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

YT NWT BC AB Ajax USA

KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

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FIGURE NO. **G-6**

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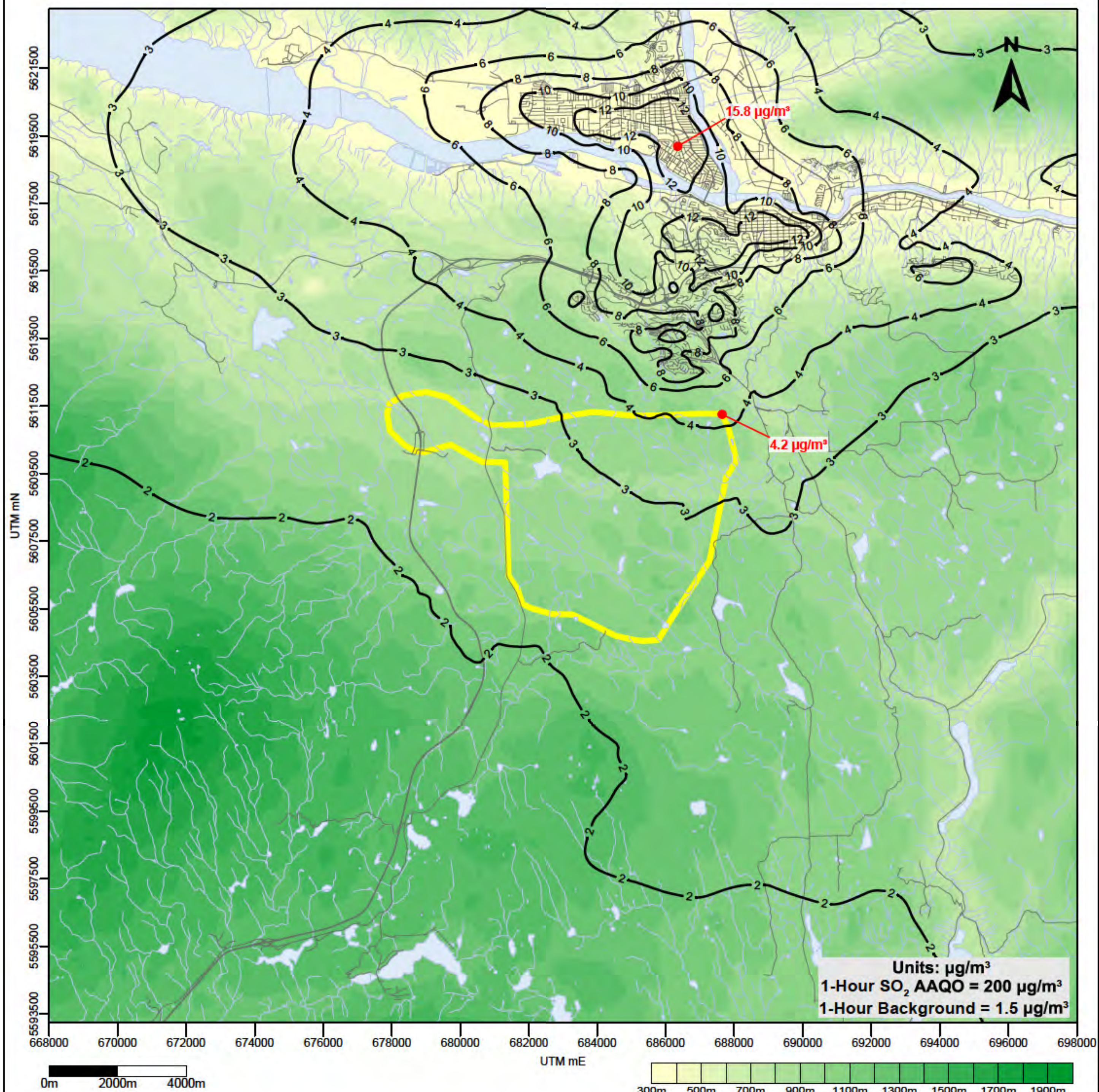

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Base Case Predicted 99th Percentile Daily 1-Hour Maximum Ground-level SO_2 Concentrations (µg/m³) With Global/Regional Background Added

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FIGURE NO. **G-7**

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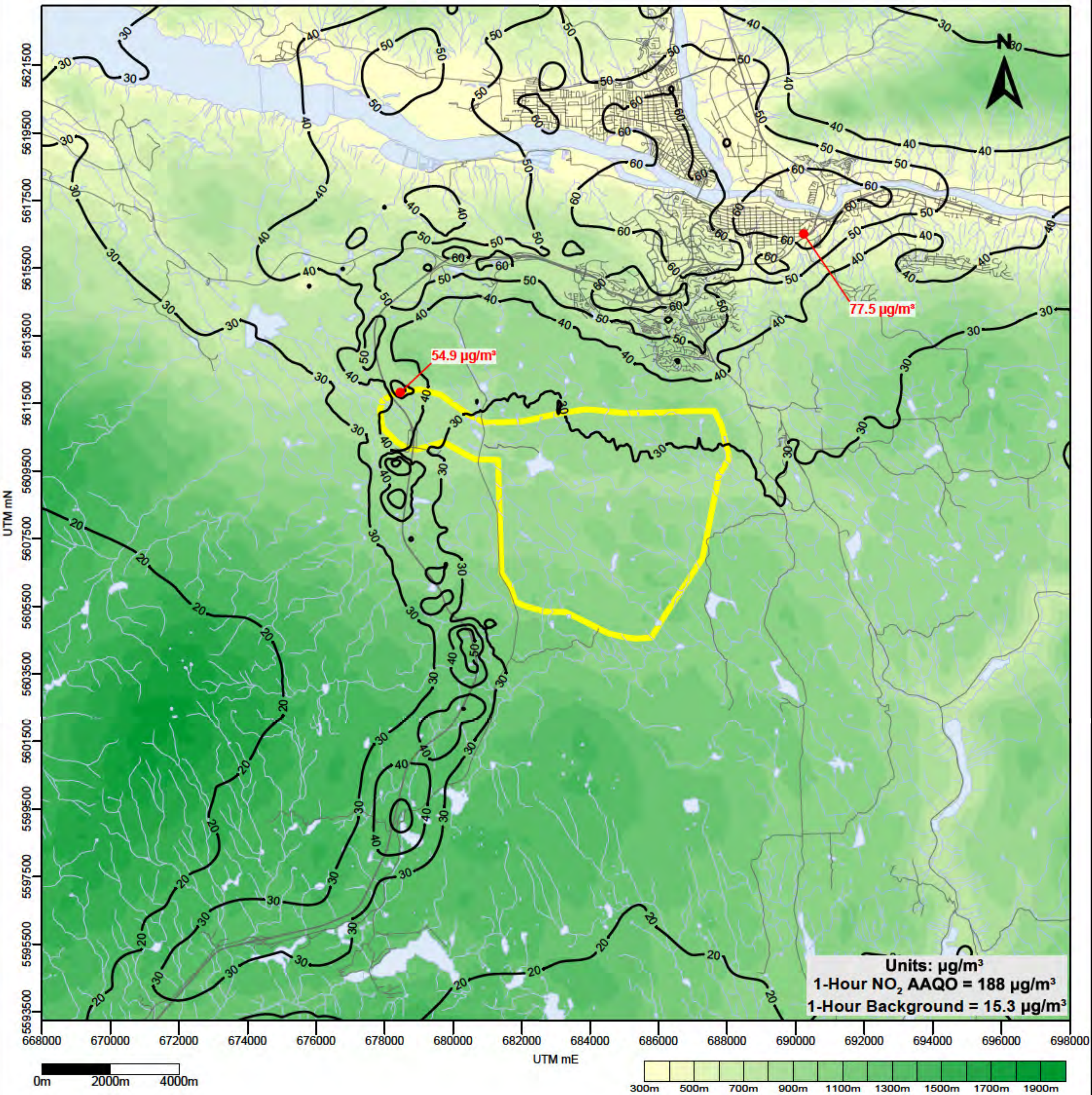

Isopleth Intervals for NO_2 1-Hour Average
90, 60, 50, 40, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

V:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Base Case Predicted 98th Percentile Daily 1-Hour Maximum Ground-level NO_2 Concentrations (µg/m³) With Global/Regional Background Added

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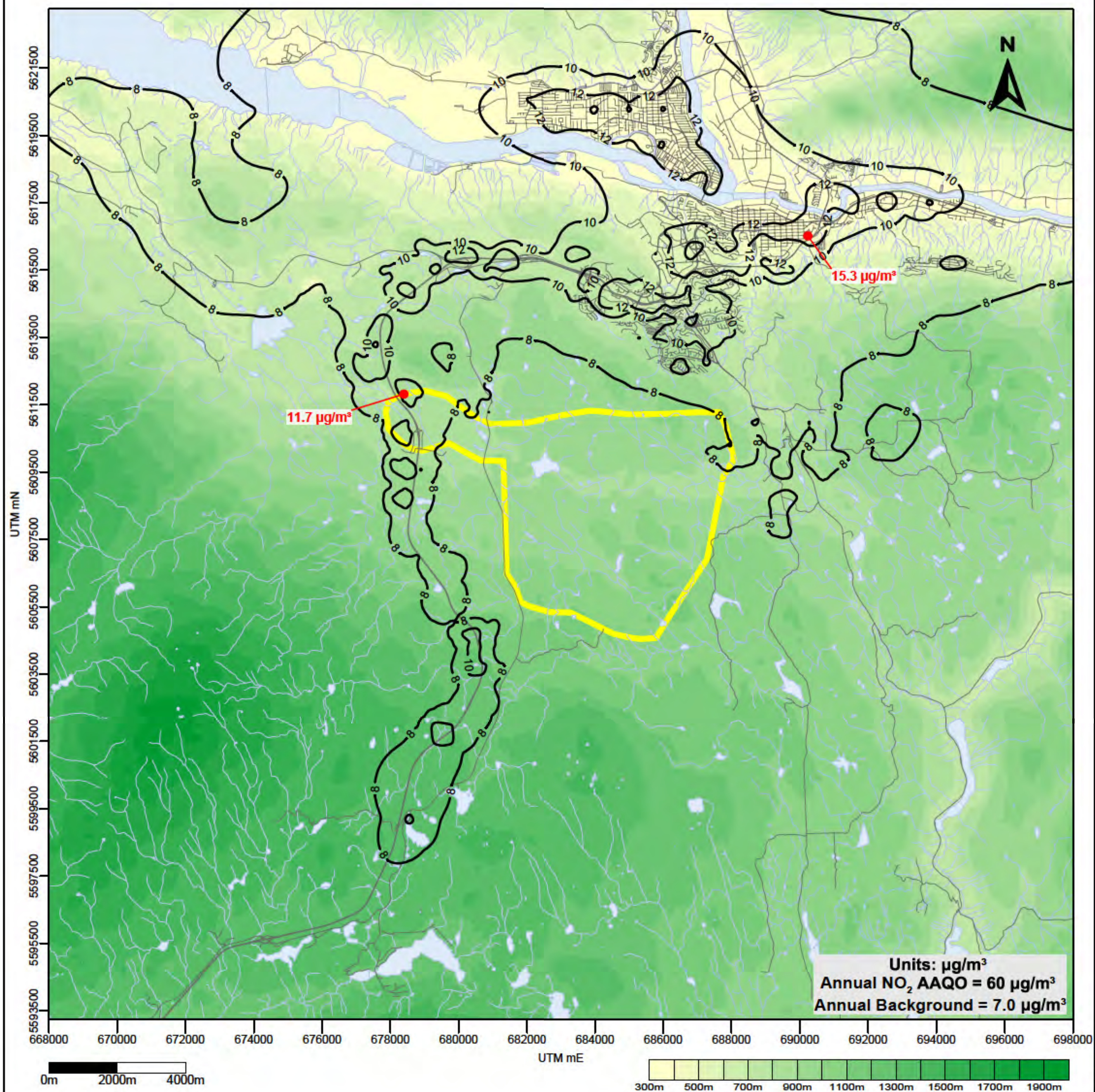
FIGURE NO. **G-8**

Last Modified: 04/27/2015 By: KW



Isopleth Intervals for NO_2 Annual Average
12, 10, 8, 6, 4, 3, 2, 1 µg/m³

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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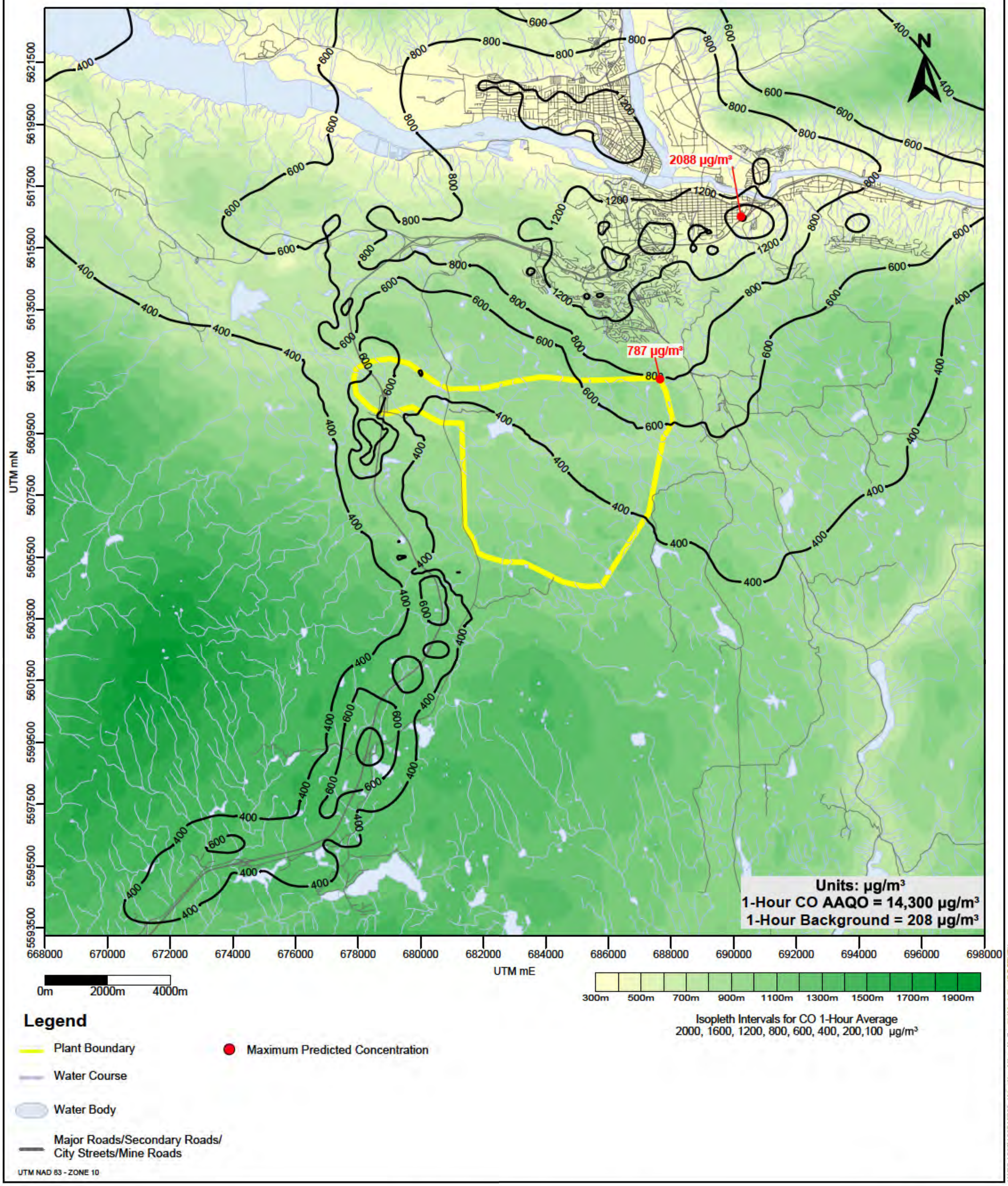
FIGURE NO. G-9

V:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted 1-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

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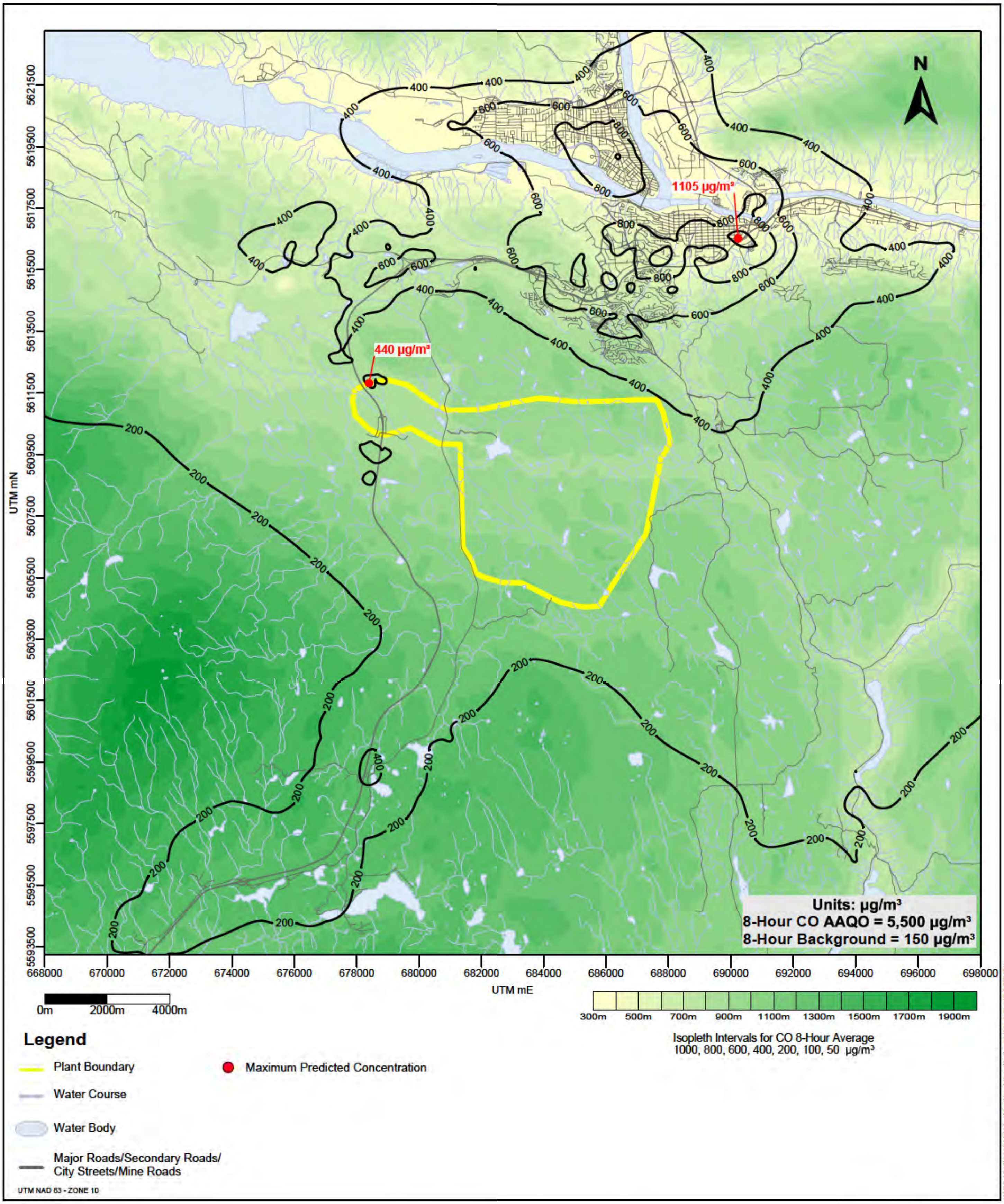
FIGURE NO. **G-10**

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Base Case Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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FIGURE NO. **G-11**

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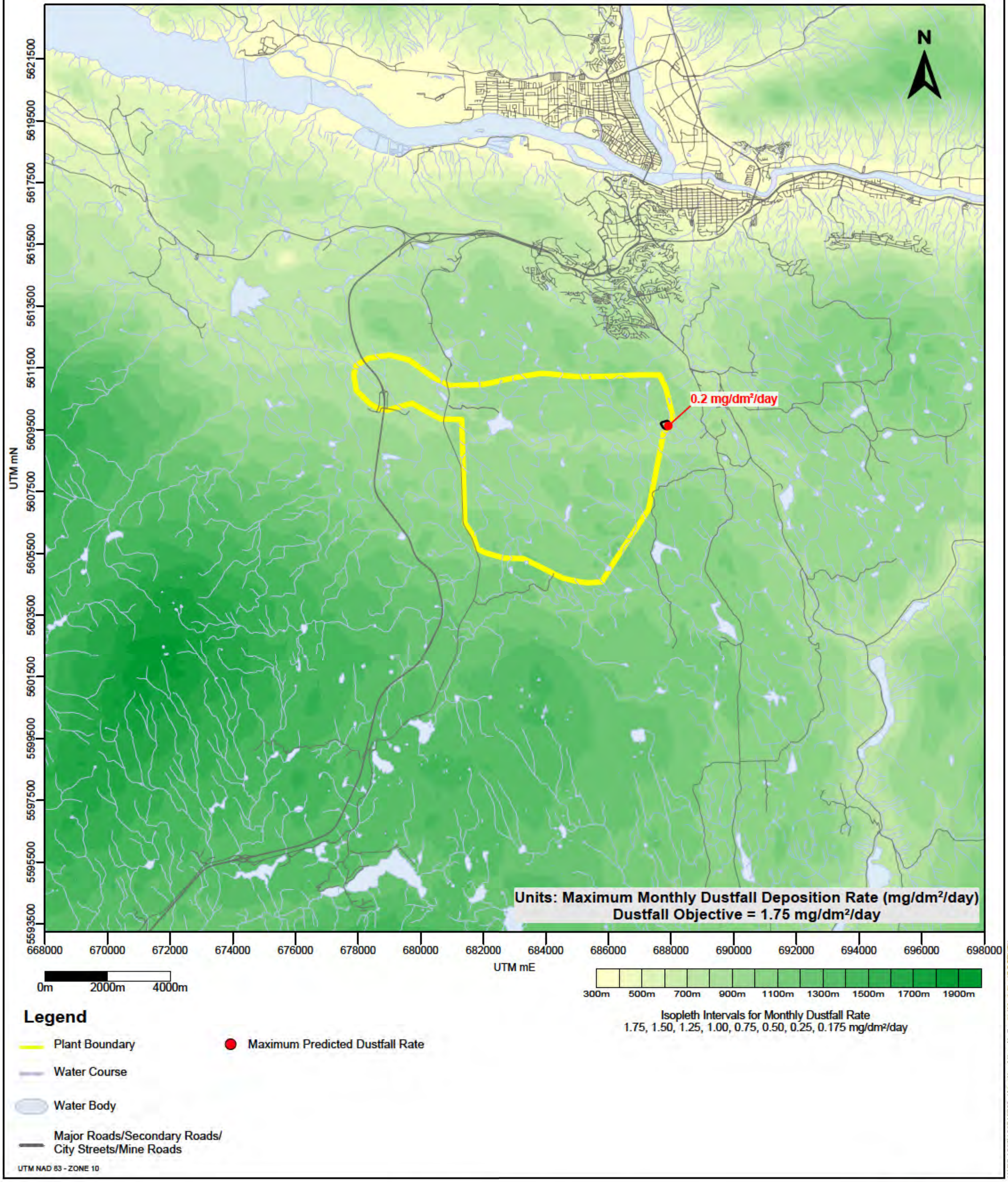
APPENDIX H
PROJECT CASE AND APPLICATION CASE CONSTRUCTION MODELLING ISOPLETH MAPS

Appendix H PROJECT CASE AND APPLICATION CASE CONSTRUCTION MODELLING ISOPLETH MAPS

List of Figures



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted Monthly Average Dustfall Rate (mg/dm²/day)
Without Global/Regional Background Added

PREPARED BY Stantec

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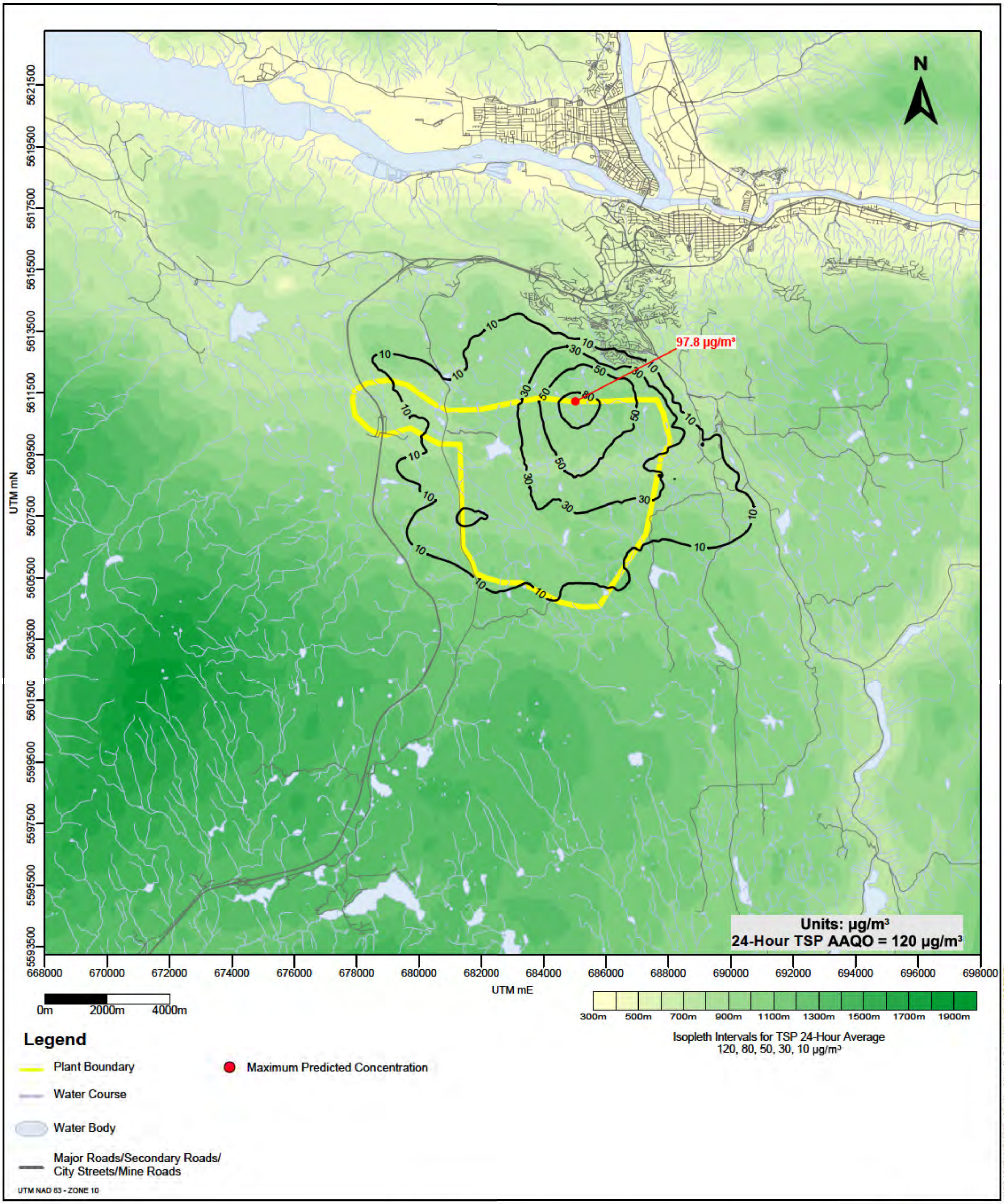
FIGURE NO. **H-1**



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted 24-Hour Average Ground-level TSP Concentrations (µg/m³) Without Global/Regional Background Added

PREPARED BY Stantec

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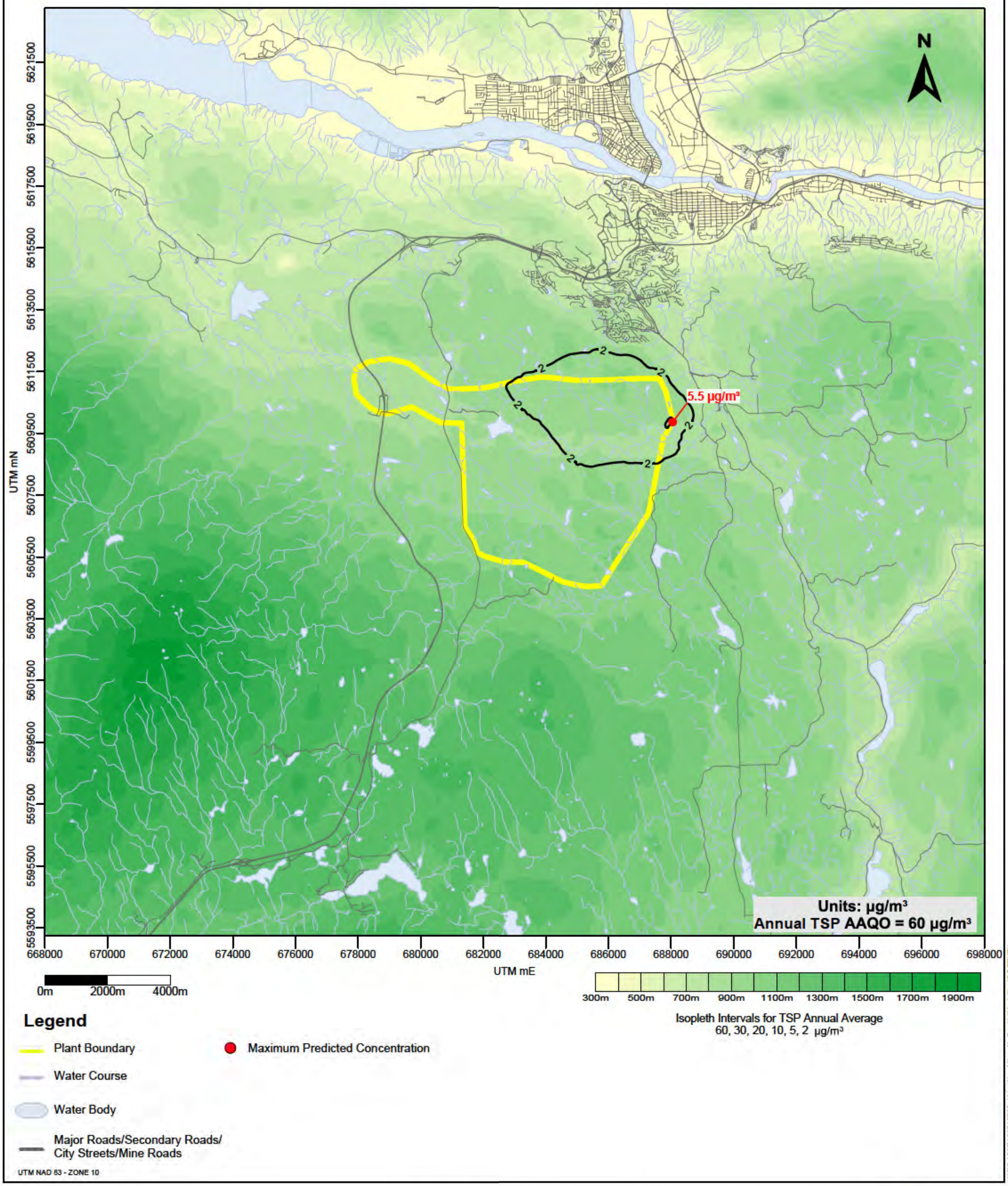
FIGURE NO. **H-2**

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted Annual Average Ground-level TSP Concentrations (µg/m³) Without Global/Regional Background Added

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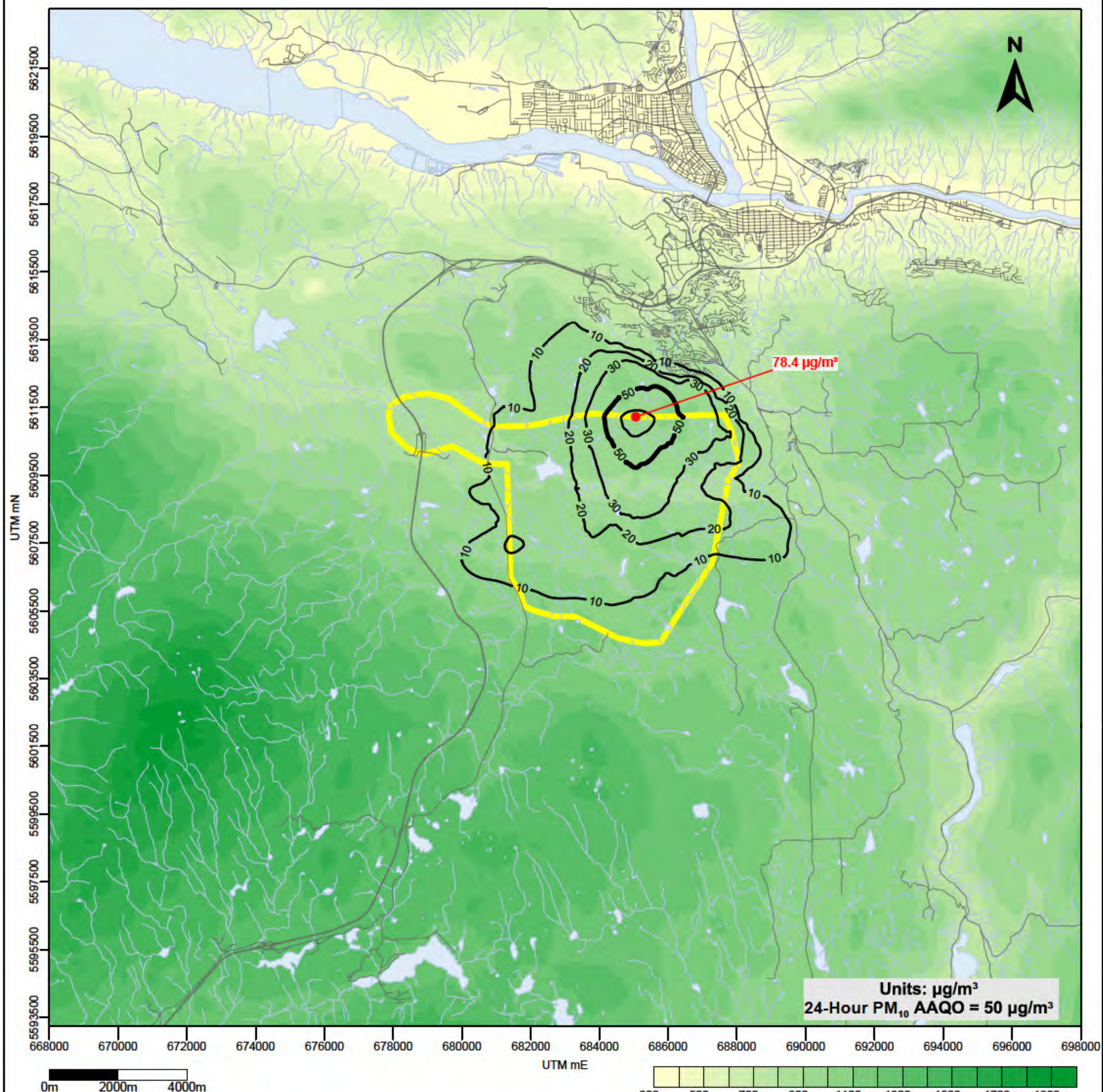
KGHM

FIGURE NO.
H-3



Isopleth Intervals for PM_{10} 24-Hour Average
70, 50, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/27/2015 By: KW

KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted 24-Hour Average Ground-level PM_{10} Concentrations (µg/m³) Without Global/Regional Background Added

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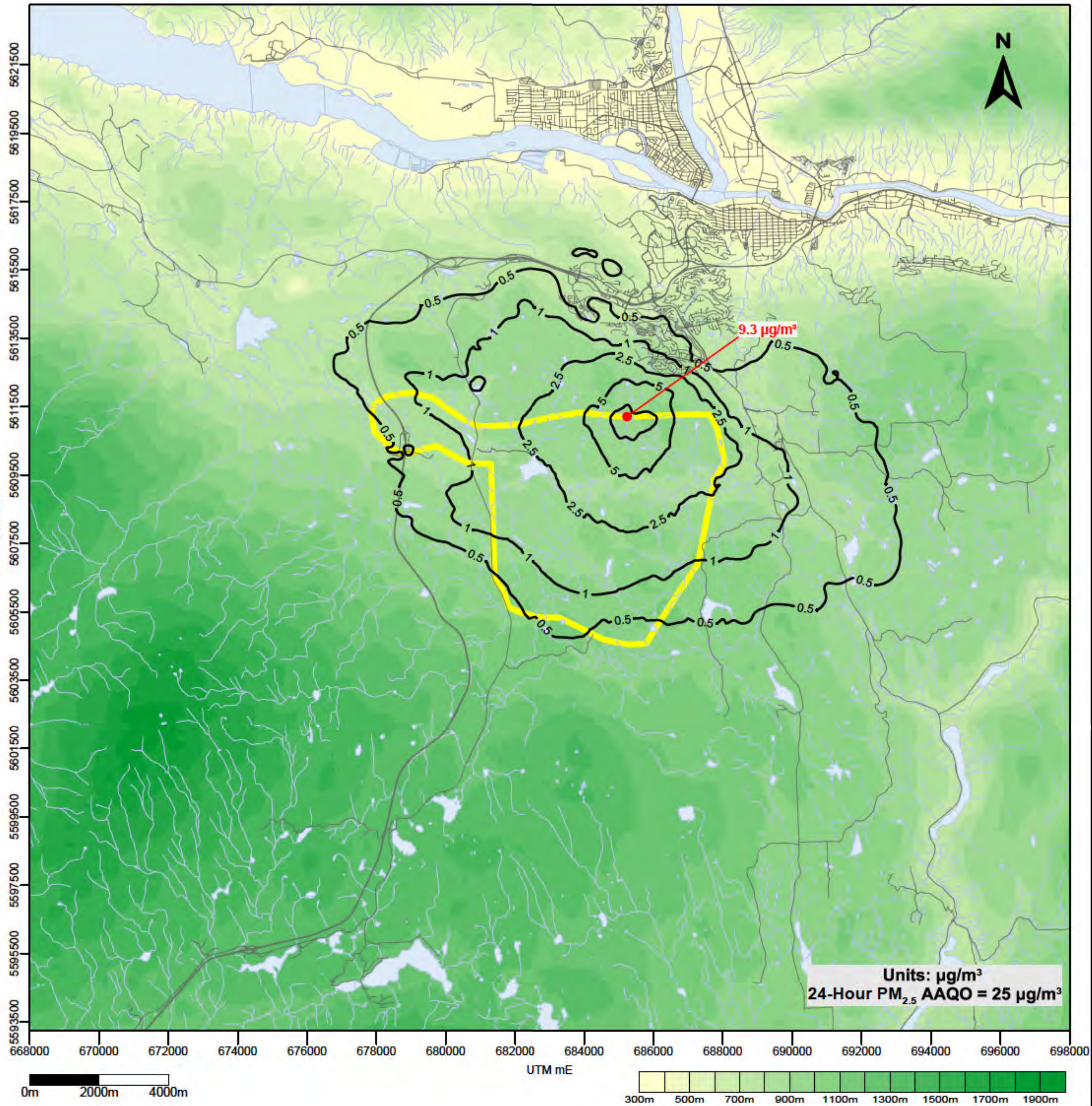
PREPARED FOR KGHM

FIGURE NO. **H-4**



Isopleth Intervals for $PM_{2.5}$ 24-Hour Average
30, 25, 20, 15, 10, 7.5, 5, 2.5, 1, 0.5 µg/m³

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Project Case Construction Predicted 98th Percentile 24-Hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Without Global/Regional Background Added

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FIGURE NO. **H-5**

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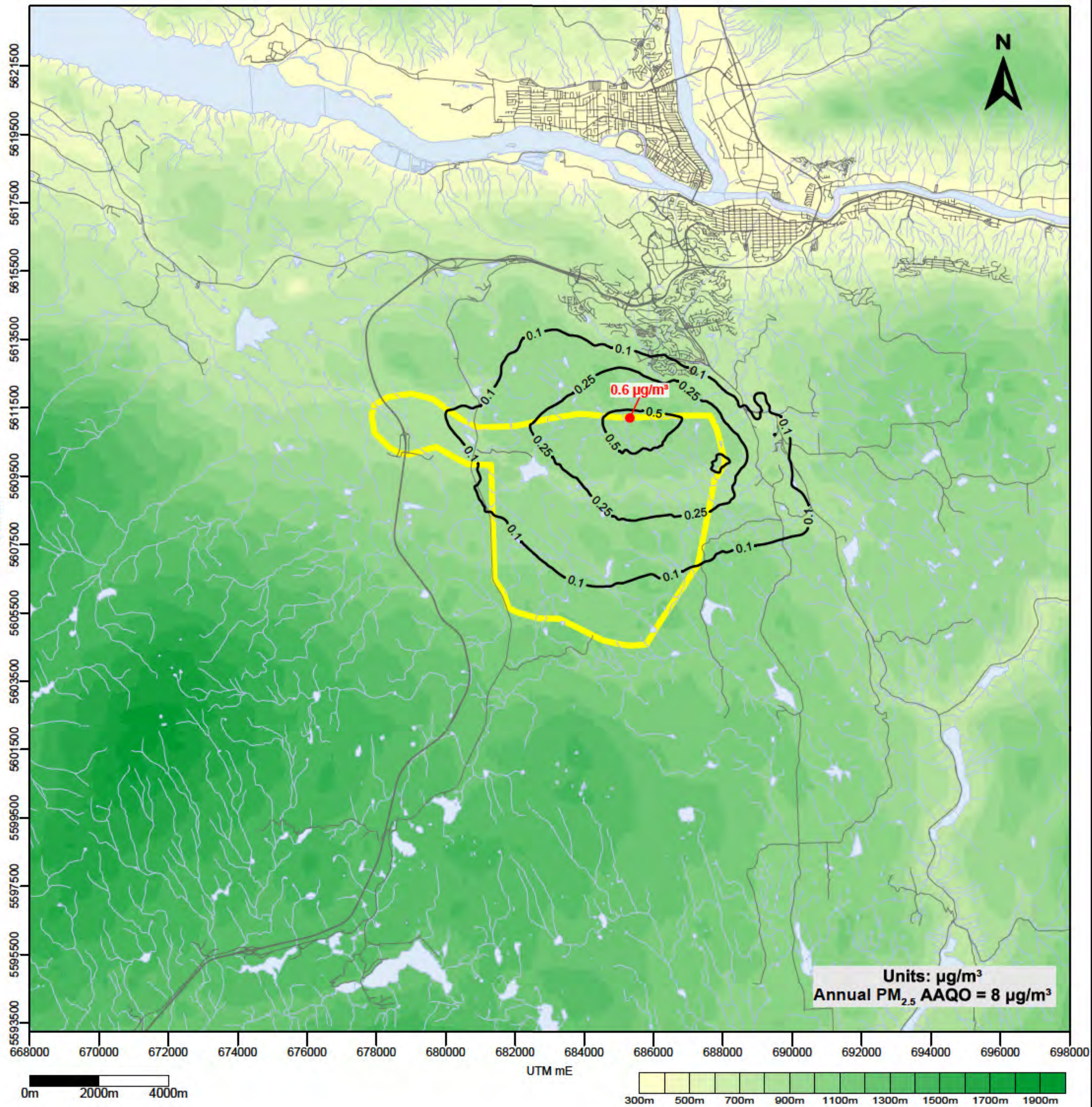

Isopleth Intervals for $PM_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 μg/m³

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads

UTM NAD 83 - ZONE 10

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (μg/m³) Without Global/Regional Background Added

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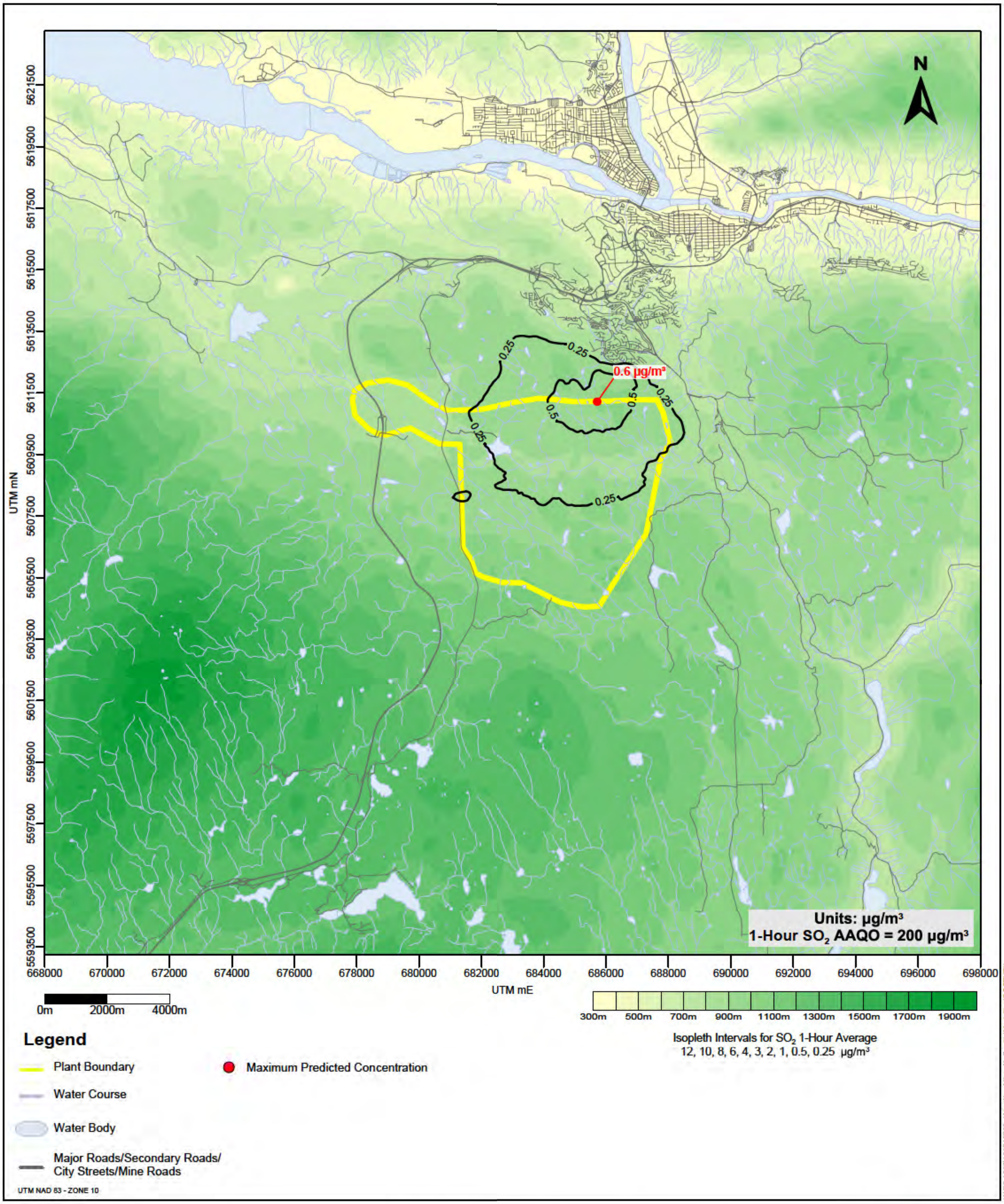
FIGURE NO.
H-6

Last Modified: 04/27/2015 By: KW



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KGHM Ajax Air Quality Assessment

Project Case Construction Predicted 99th Percentile Daily 1-Hour Maximum Ground-level SO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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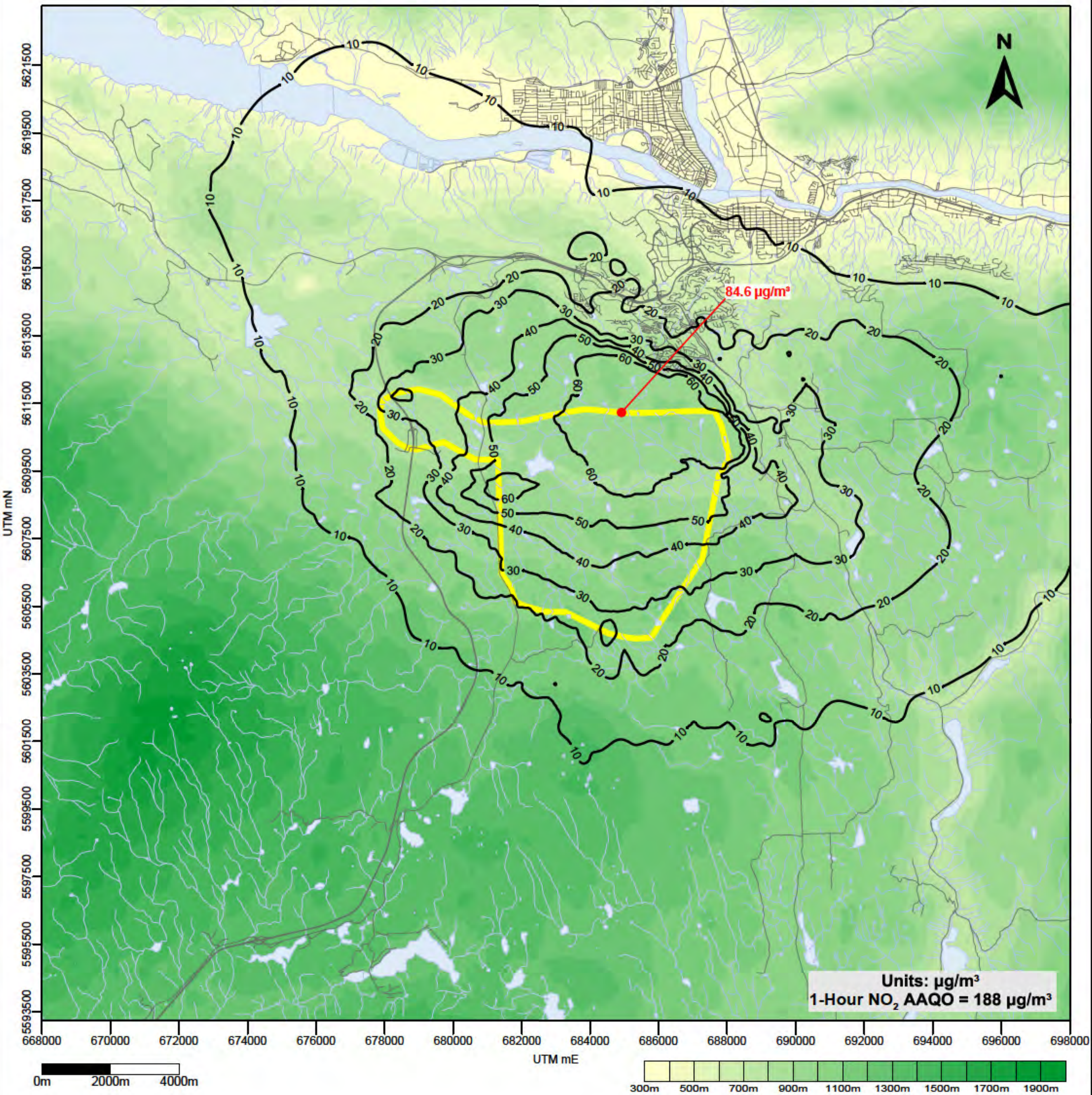
FIGURE NO.
H-7

Last Modified: 04/27/2015 By: KW



Isopleth Intervals for NO_2 1-Hour Average
90, 60, 50, 40, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Maximum Predicted Concentration
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Project Case Construction Predicted 98th Percentile Daily 1-Hour Maximum Ground-level NO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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FIGURE NO.
H-8

U:\PC 1235\1235\10762_New Ajax Mine Air Quality\Modelling\POSTUTIL

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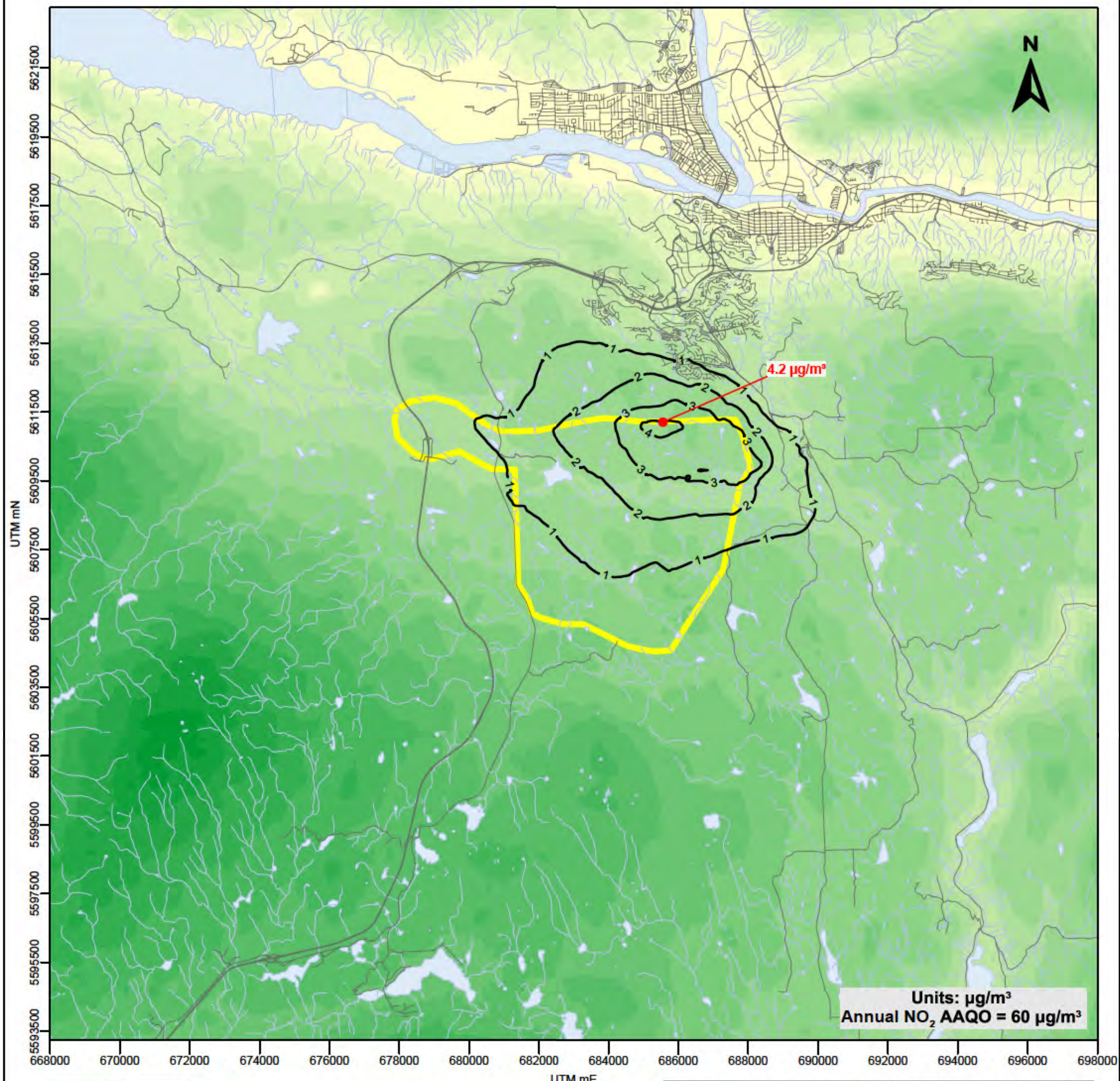

Isopleth Intervals for NO_2 Annual Average
12, 10, 8, 6, 4, 3, 2, 1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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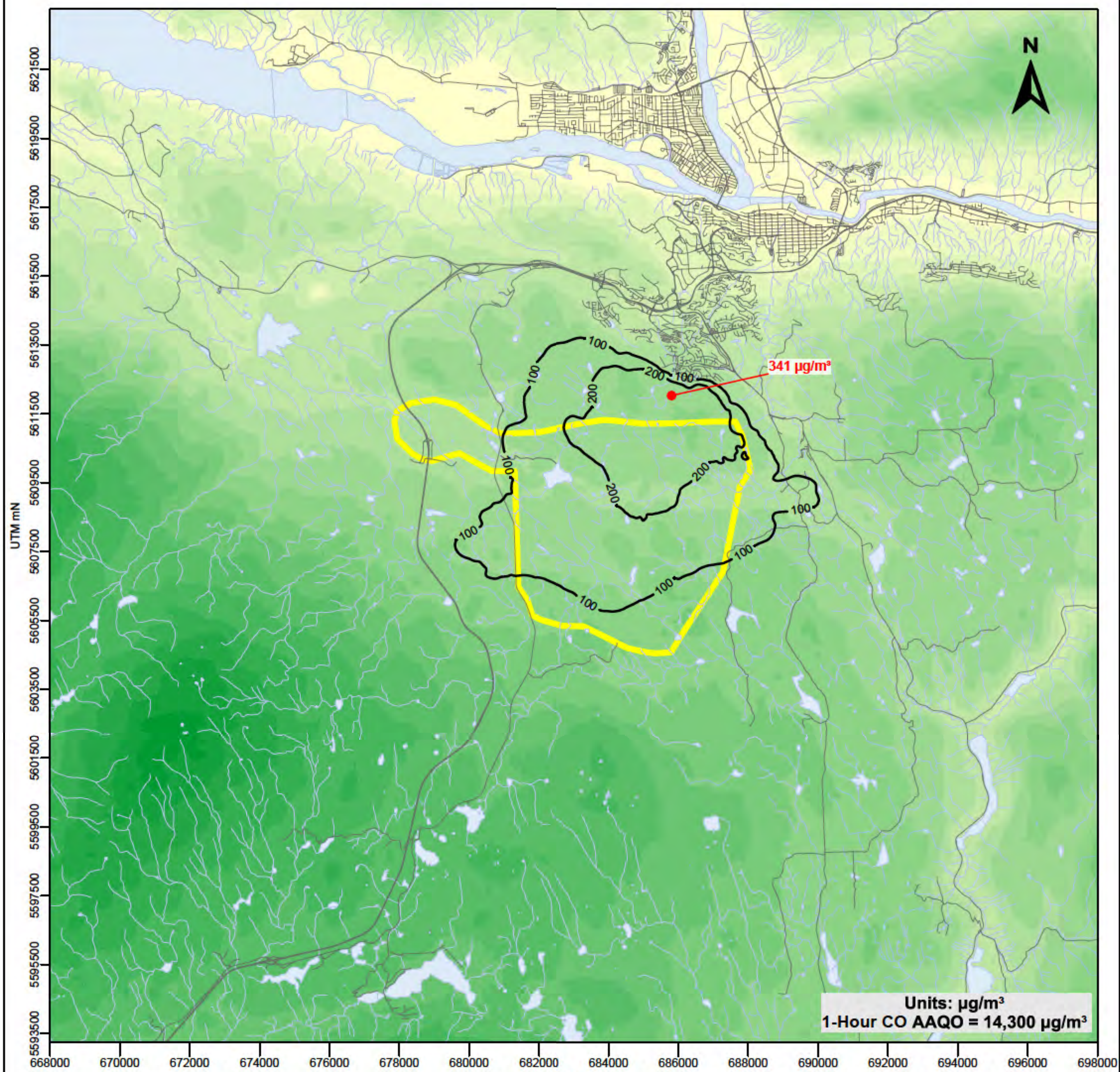
FIGURE NO.
H-9

Last Modified: 04/27/2015 By: KW



0m 2000m 4000m

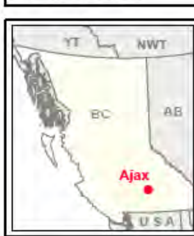
300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for CO 1-Hour Average
2000, 1600, 1200, 800, 600, 400, 200,100 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted 1-Hour Average Ground-level CO Concentrations (µg/m³) Without Global/Regional Background Added

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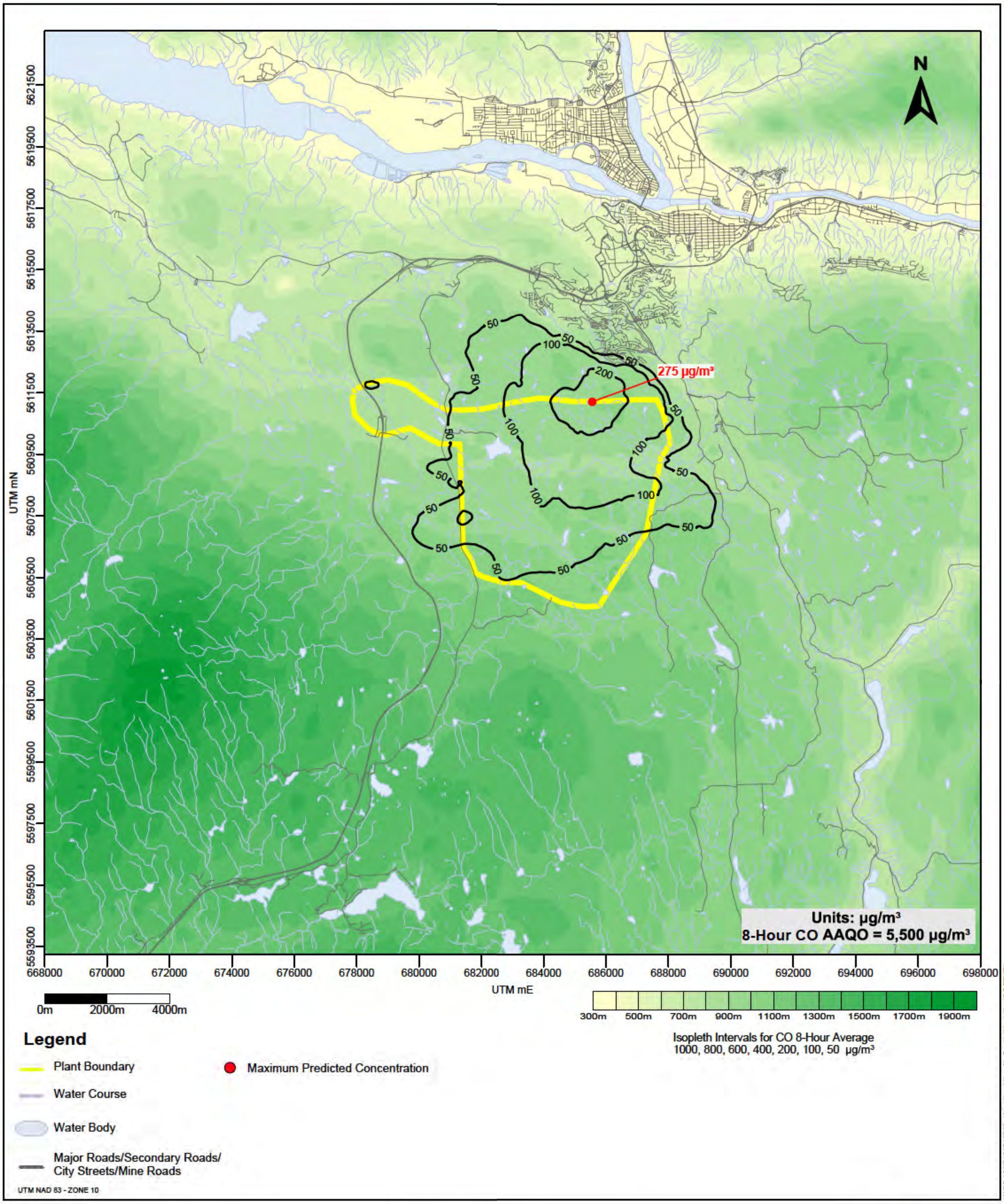
PREPARED FOR KGHM

FIGURE NO. **H-10**

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Project Case Construction Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) Without Global/Regional Background Added

PREPARED BY Stantec

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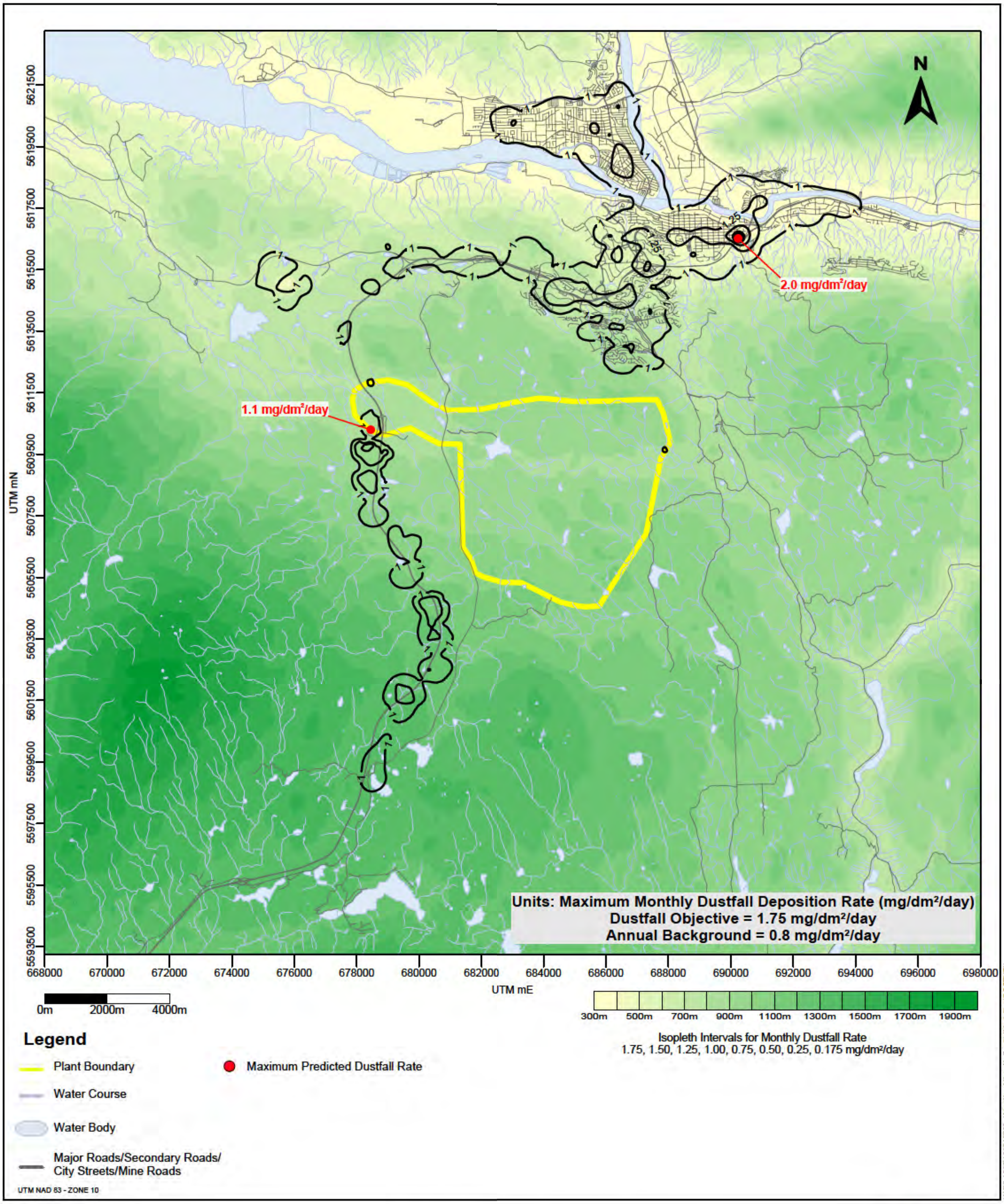
FIGURE NO. **H-11**

Last Modified: 04/27/2015 By: KW



KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted Monthly Average Dustfall Rate (mg/dm²/day)
With Global/Regional Background Added

PREPARED BY
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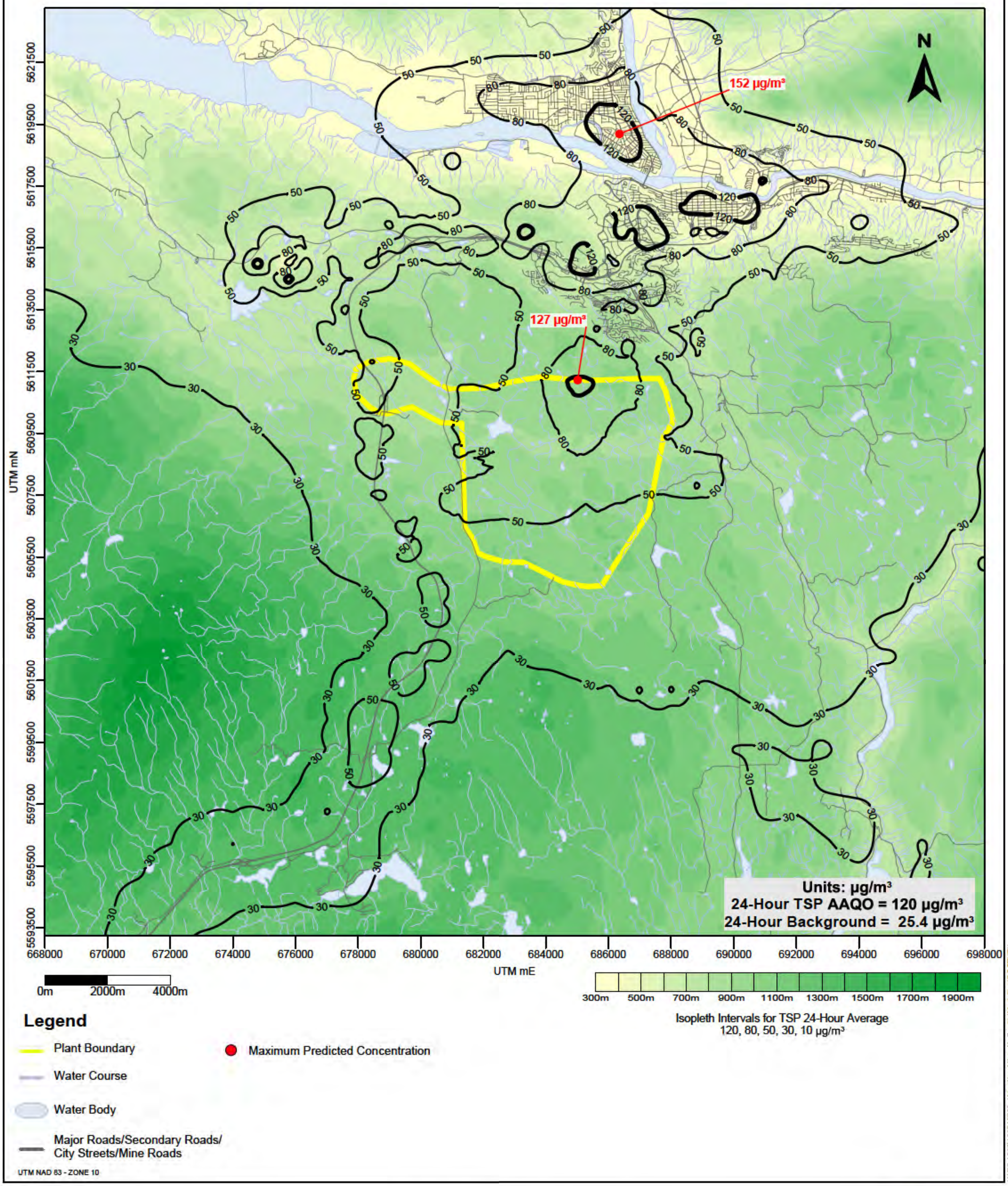
KGHM

FIGURE NO.
H-12

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modelling\POSTUTIL
Last Modified: 04/27/2015 By: KW



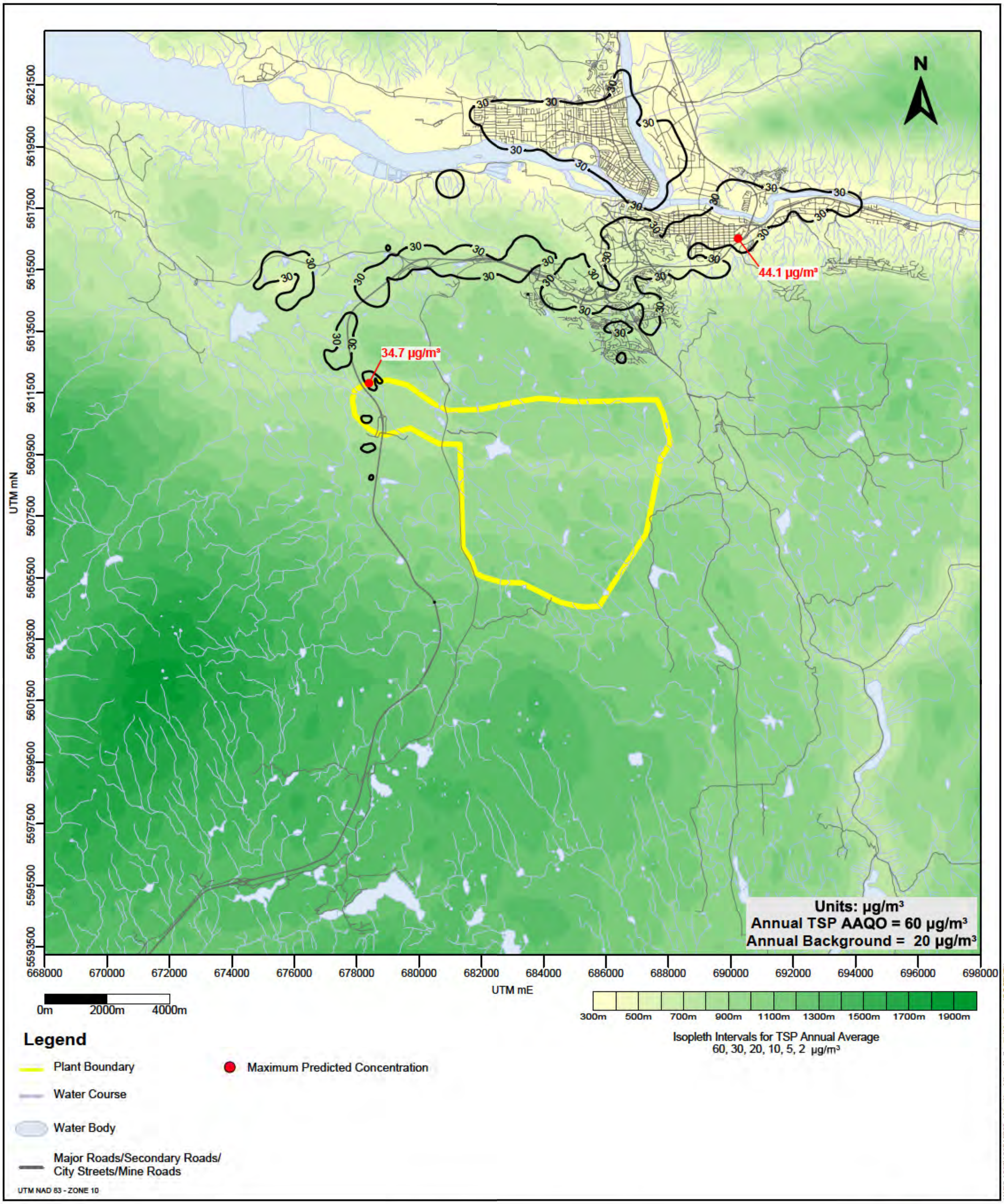
KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted 24-Hour Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **H-13**



KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted Annual Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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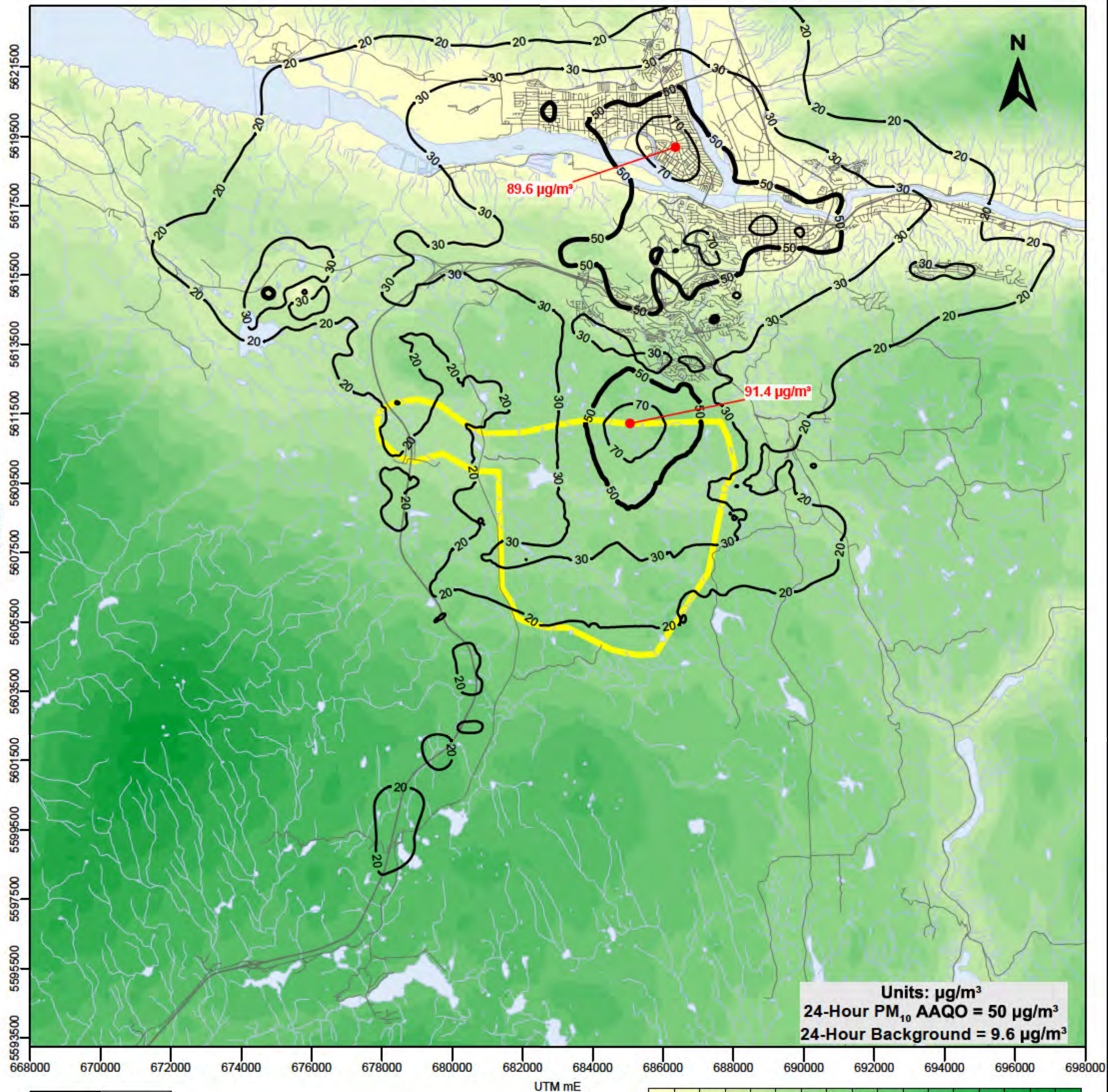
FIGURE NO. **H-14**



Isopleth Intervals for PM_{10} 24-Hour Average
70, 50, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted 24-Hour Average Ground-level PM_{10} Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY
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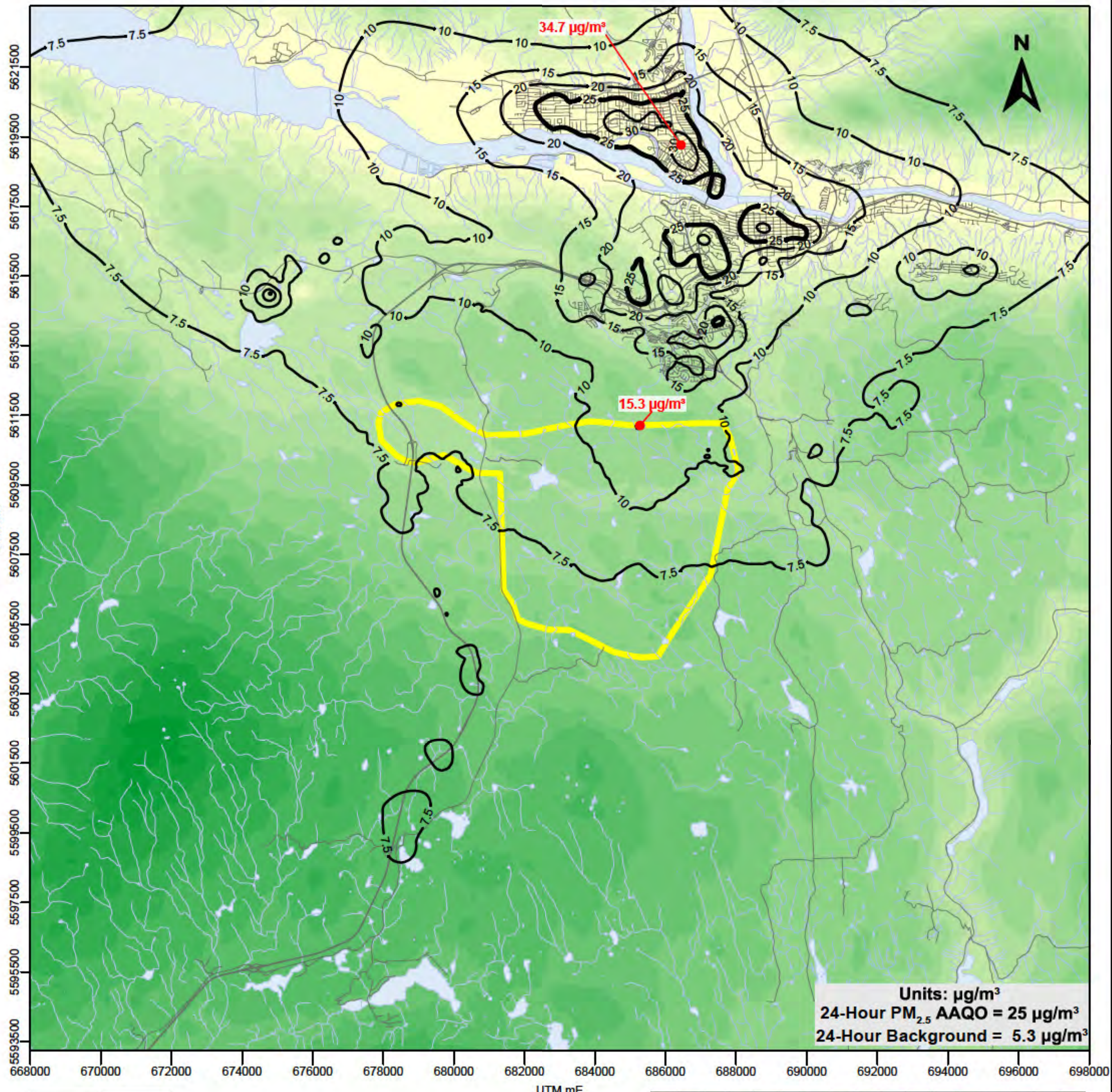
FIGURE NO.
H-15

Last Modified: 04/27/2015 By: KW



Isopleth Intervals for $PM_{2.5}$ 24-Hour Average
30, 25, 20, 15, 10, 7.5, 5, 2.5, 1, 0.5 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Application Case Construction Predicted 98th Percentile 24-Hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

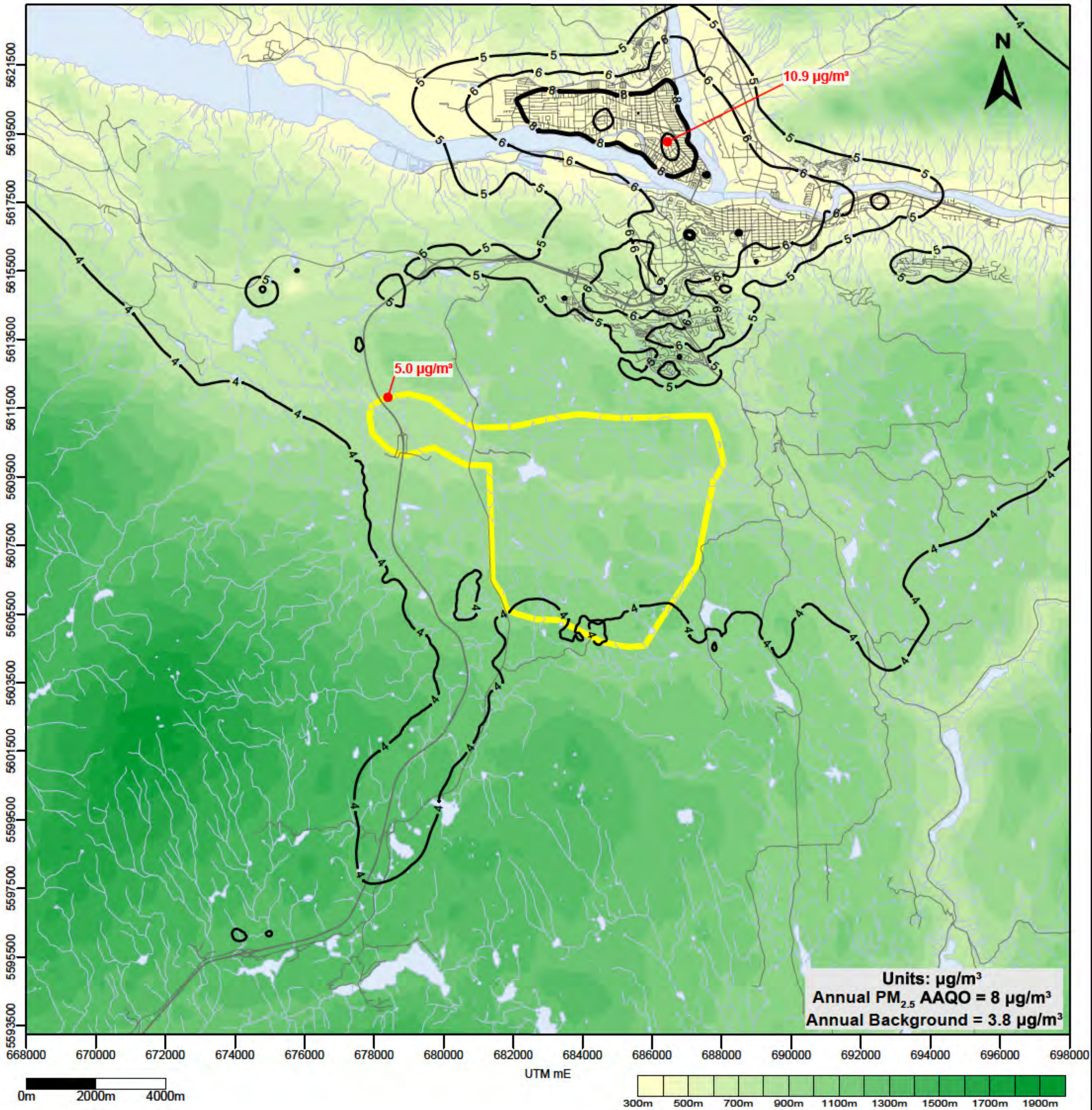
PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **H-16**

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/27/2015 By: KW



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/27/2015 By: KW

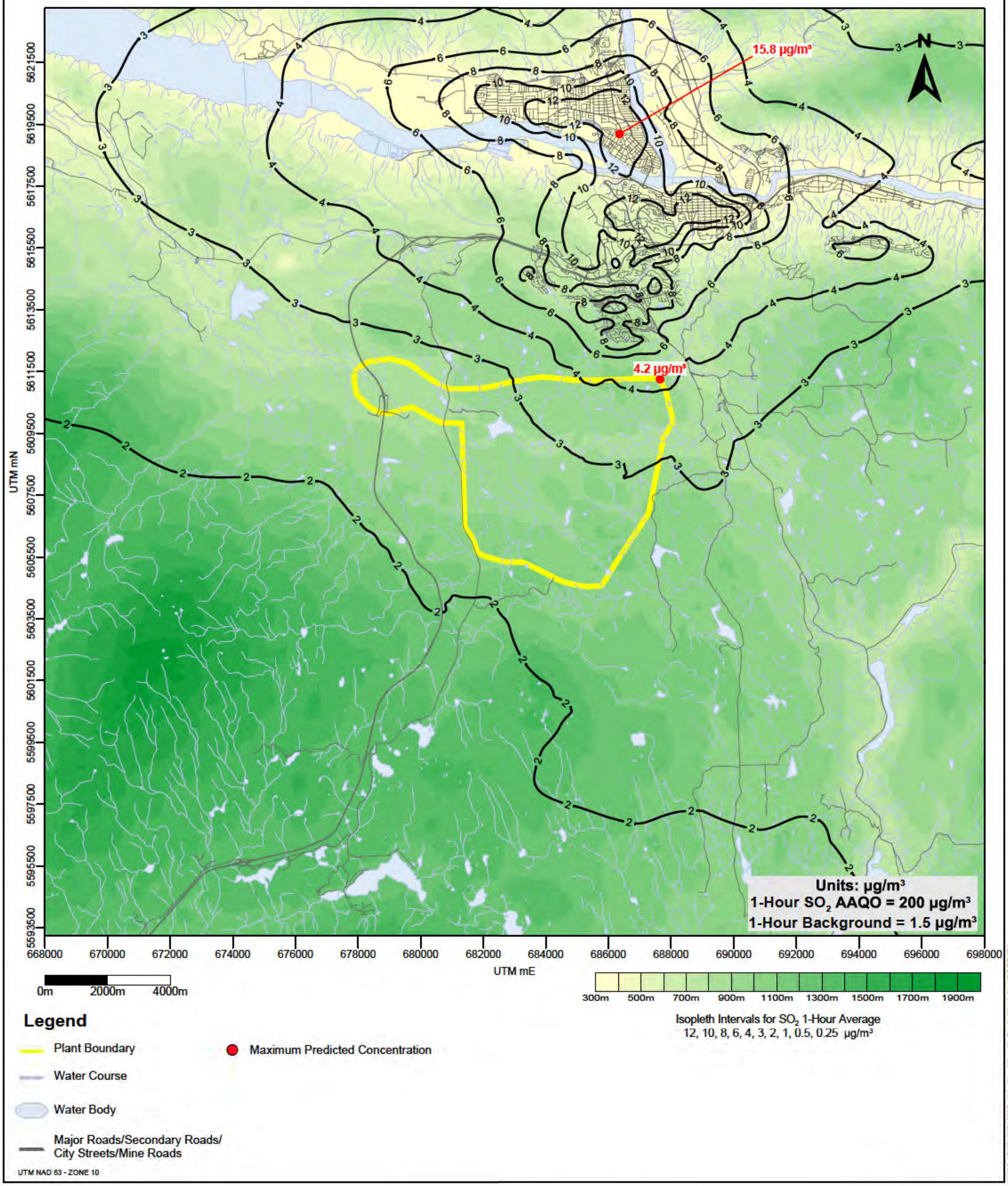
KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **H-17**



KGHM Ajax Air Quality Assessment

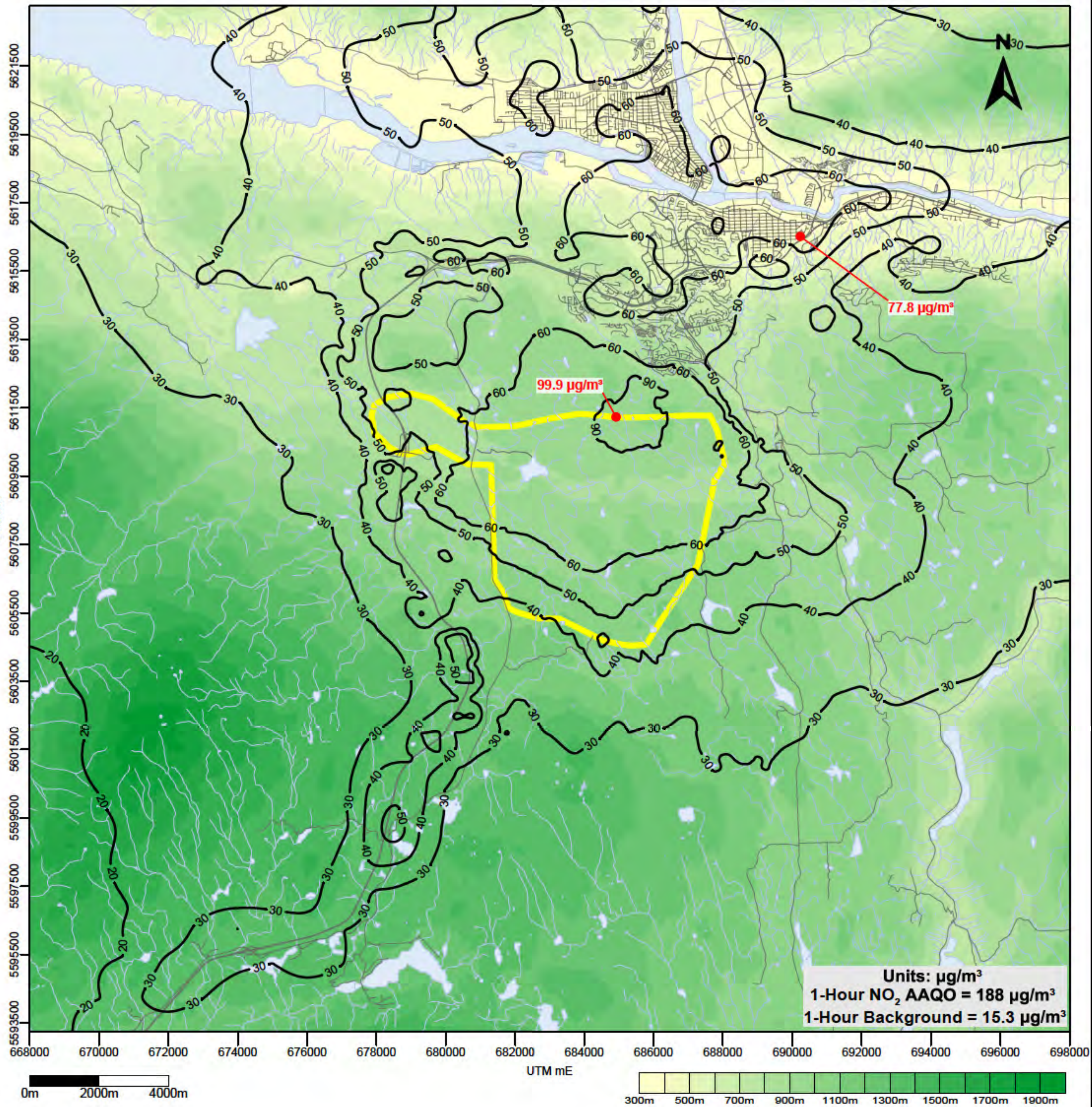
Application Case Construction Predicted 99th Percentile Daily 1-Hour Maximum Ground-level SO_2 Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **H-18**

Last Modified: 04/27/2015 By: KW



Isopleth Intervals for NO_2 1-Hour Average
90, 60, 50, 40, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Application Case Construction Predicted 98th Percentile Daily 1-Hour Maximum Ground-level NO_2 Concentrations (µg/m³) With Global/Regional Background Added

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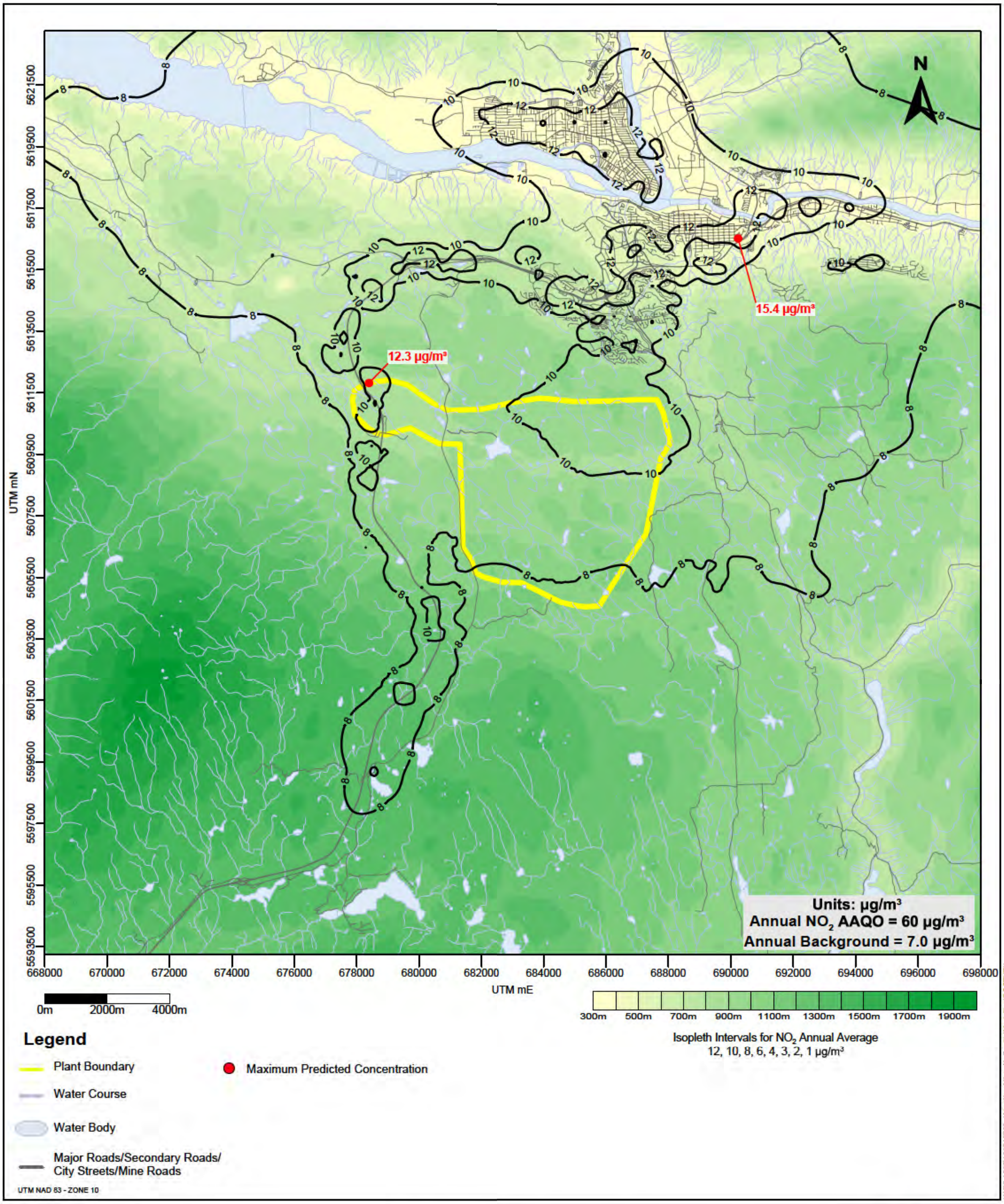
FIGURE NO. **H-19**



KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted Annual Average Ground-level NO_2 Concentrations (μg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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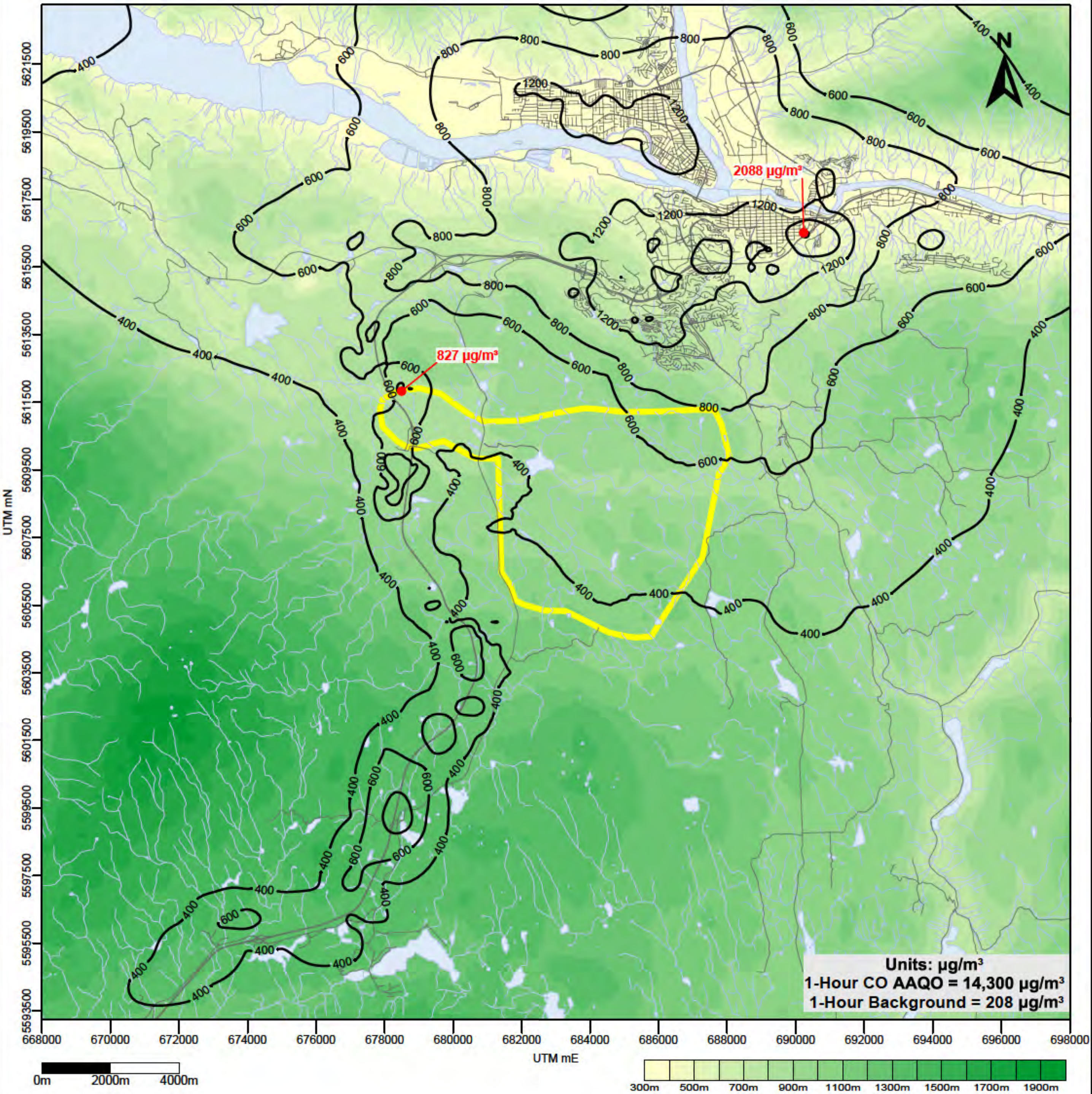
FIGURE NO. **H-20**

Last Modified: 04/27/2015 By: KW



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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Last Modified: 04/27/2015 By: KW

KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted 1-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

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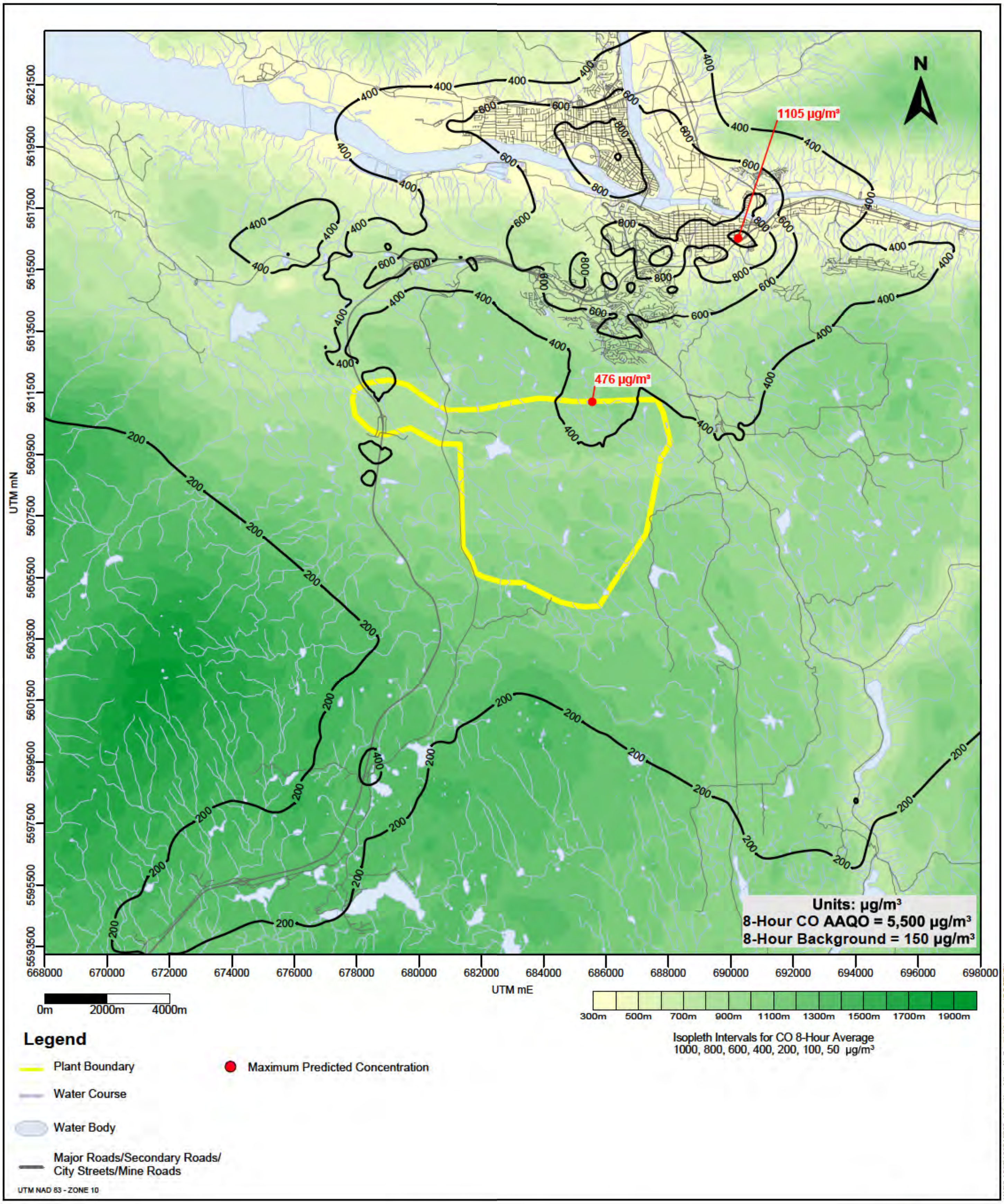
FIGURE NO. **H-21**



KGHM Ajax Air Quality Assessment

Application Case Construction Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

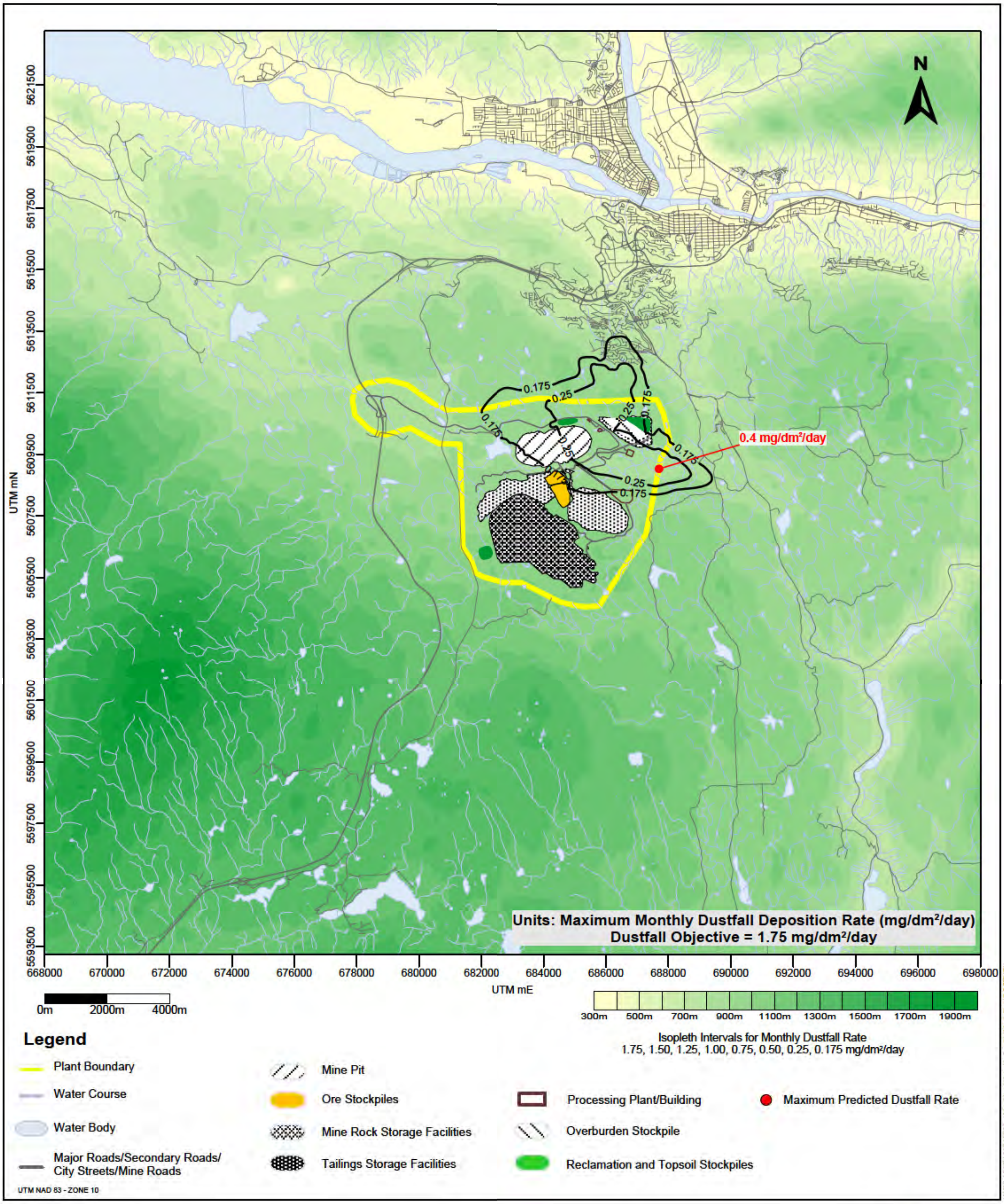
FIGURE NO. **H-22**

Last Modified: 04/27/2015 By: KW

APPENDIX I
PROJECT CASE AND APPLICATION CASE OPERATIONS MODELLING ISOPLETH MAPS

Appendix I PROJECT CASE AND APPLICATION CASE OPERATIONS MODELLING ISOPLETH MAPS

List of Figures



KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted Monthly Average Dustfall Rate (mg/dm²/day) Without Global/Regional Background Added

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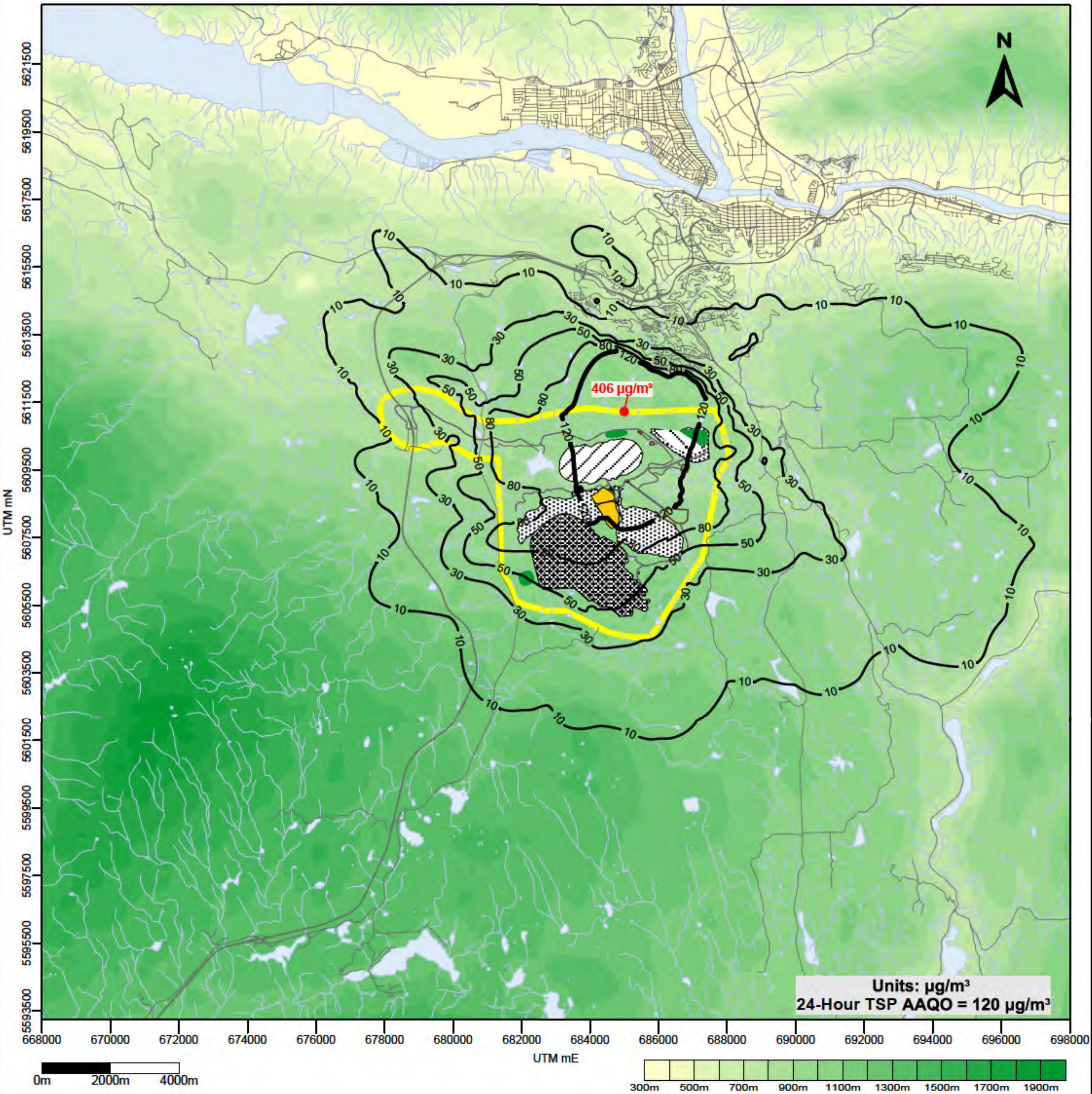
FIGURE NO. I-1

Last Modified: 04/27/2015 By: KW



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted 24-Hour Average Ground-level TSP Concentrations (µg/m³) Without Global/Regional Background Added

PREPARED BY Stantec

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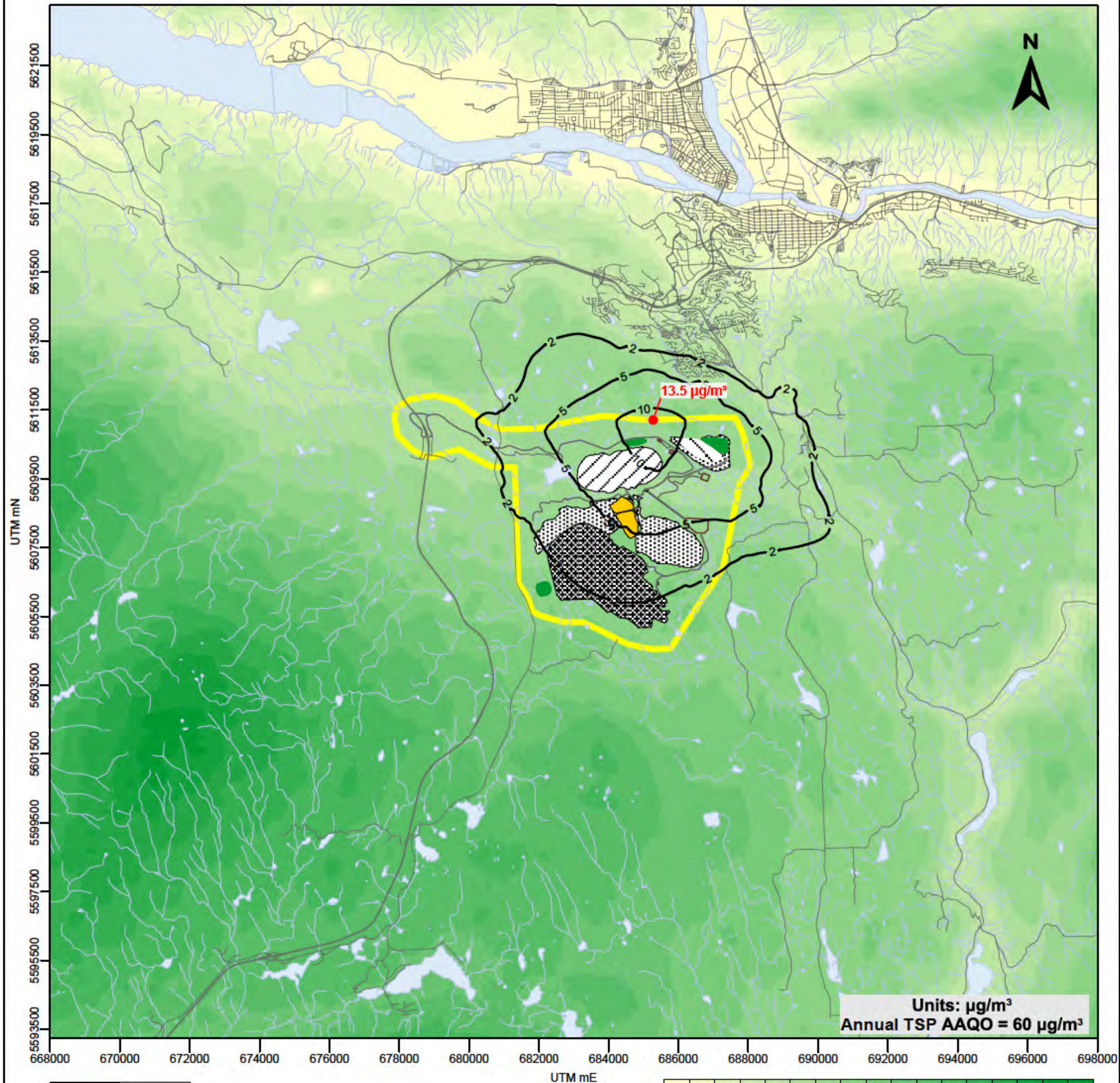
FIGURE NO. I-2



0m 2000m 4000m

300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for TSP Annual Average
60, 30, 20, 10, 5, 2 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted Annual Average Ground-level TSP Concentrations (µg/m³) Without Global/Regional Background Added

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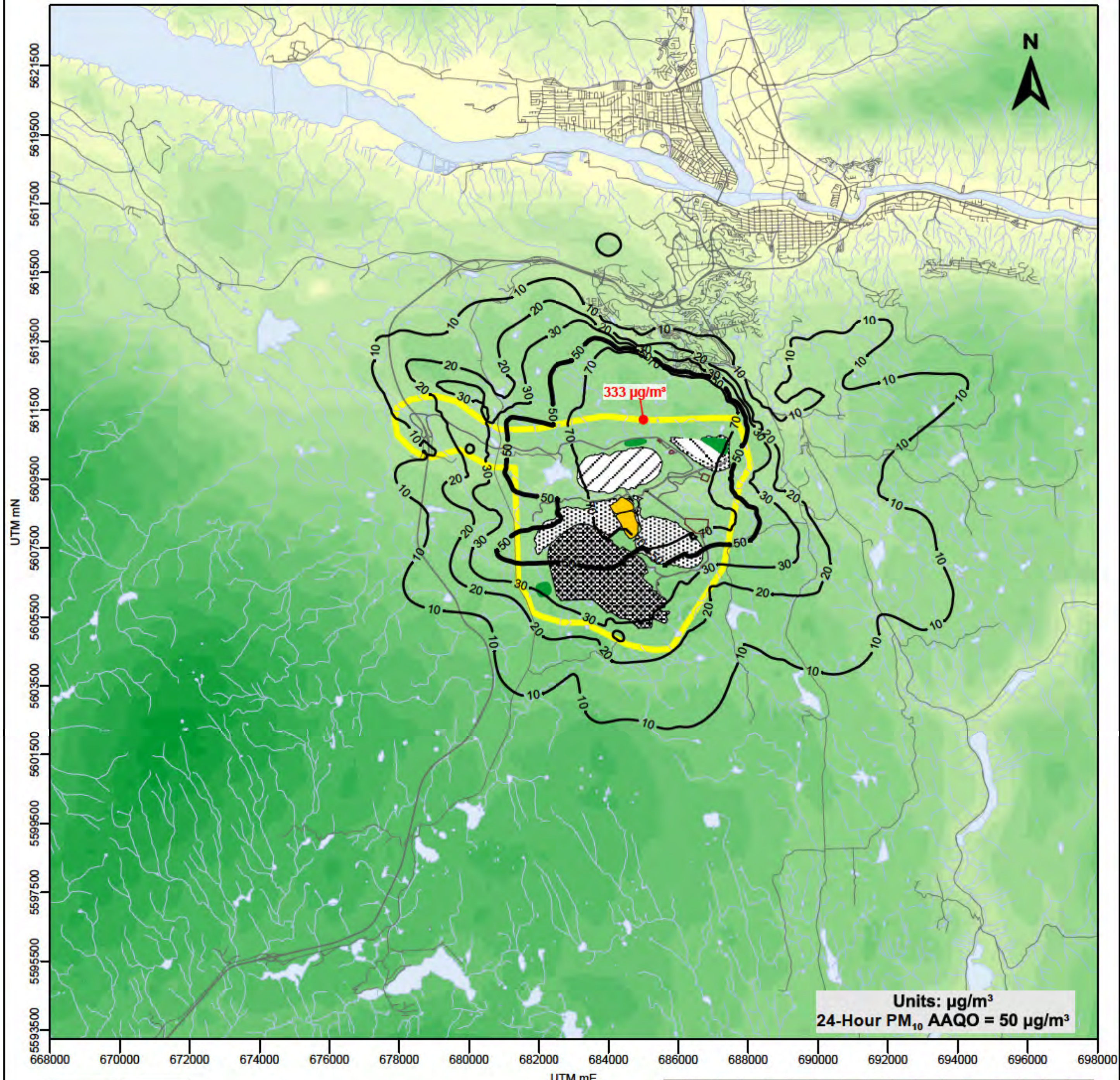
FIGURE NO. I-3



300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for PM_{10} 24-Hour Average
70, 50, 30, 20, 10 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted 24-Hour Average Ground-level PM_{10} Concentrations (µg/m³) Without Global/Regional Background Added

PREPARED BY Stantec

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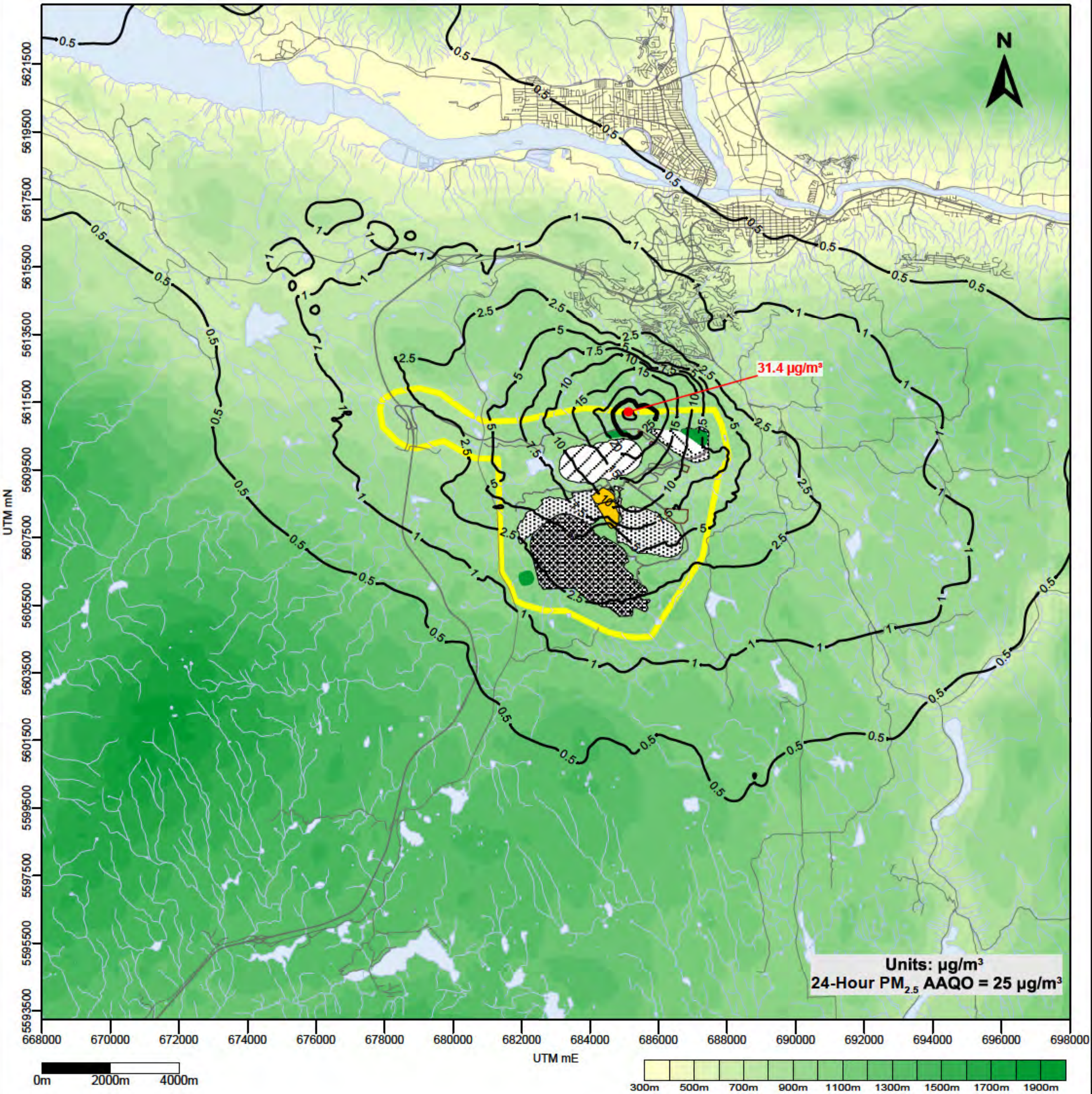
FIGURE NO. I-4



Isopleth Intervals for $PM_{2.5}$ 24-Hour Average
30, 25, 20, 15, 10, 7.5, 5, 2.5, 1, 0.5 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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YT NWT BC AB Ajax USA

KGHM Ajax Air Quality Assessment

Project Case Operations Predicted 98th Percentile 24-Hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) Without Global/Regional Background Added

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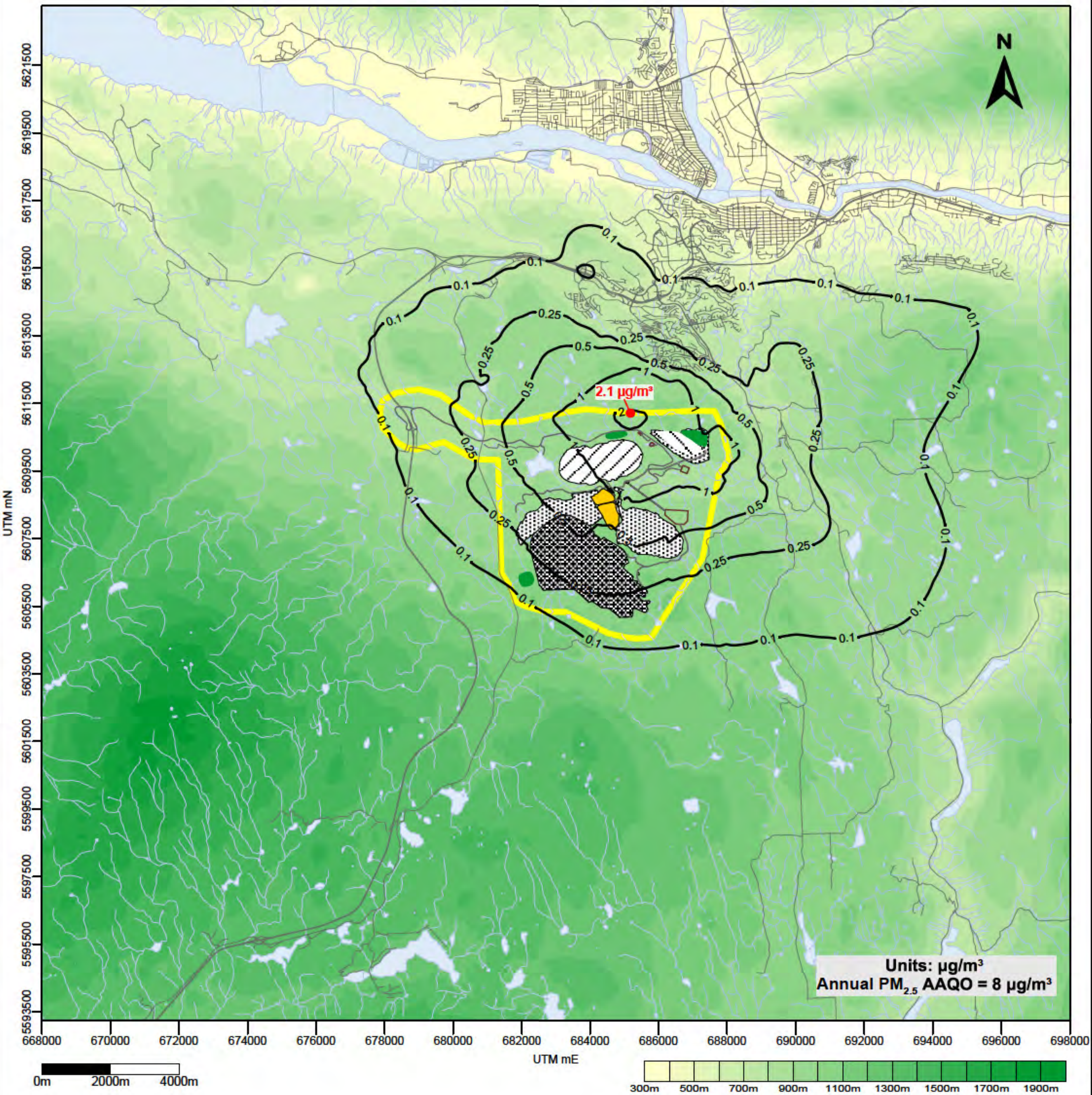
FIGURE NO. I-5

Last Modified: 04/28/2015 By: KW



Isopleth Intervals for PM$_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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Last Modified: 04/28/2015 By: KW

KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted Annual Average Ground-level PM$_{2.5}$ Concentrations (µg/m³) Without Global/Regional Background Added

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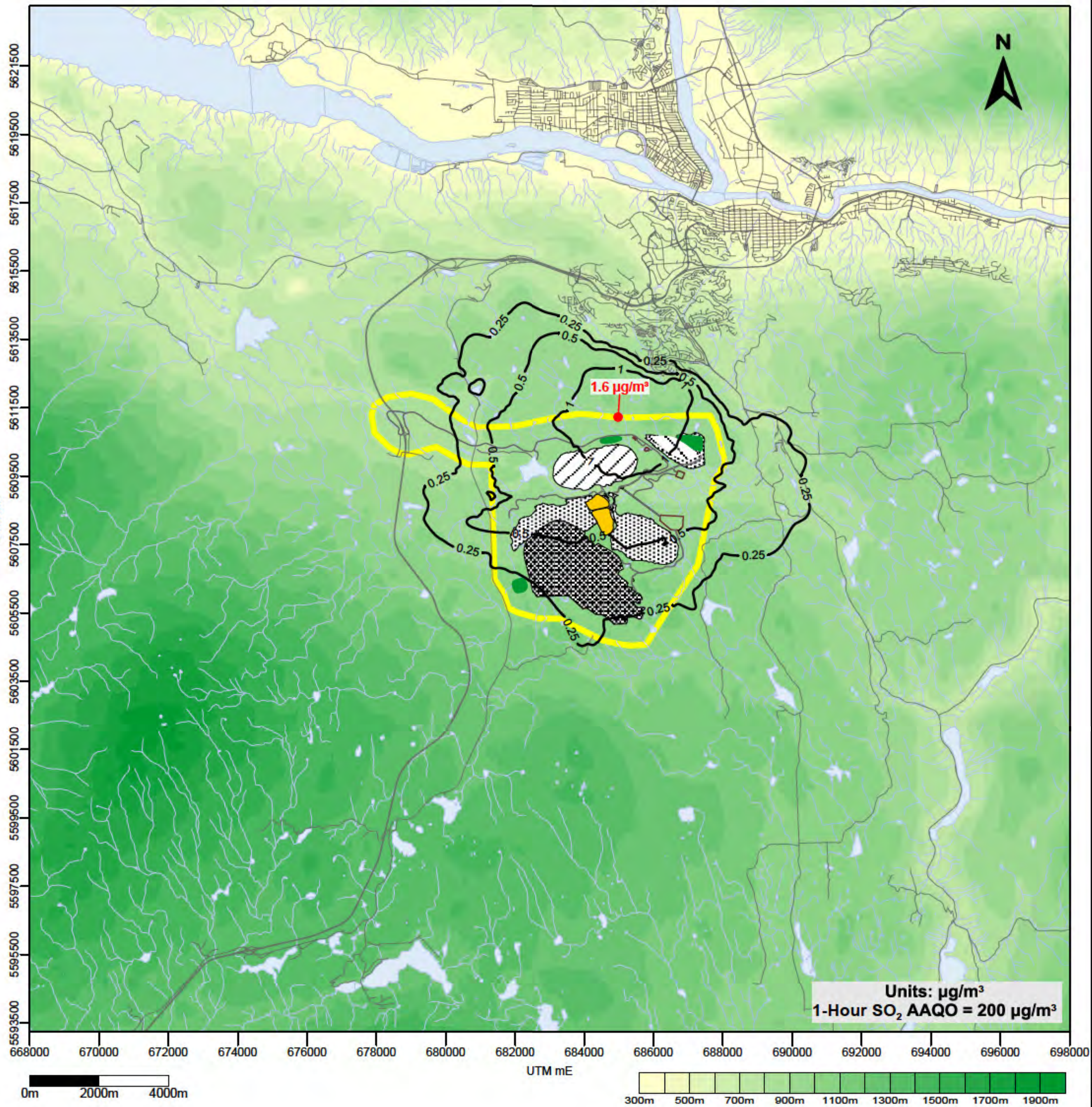
FIGURE NO. I-6



Isopleth Intervals for SO_2 1-Hour Average
12, 10, 8, 6, 4, 3, 2, 1, 0.5, 0.25 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

YT NWT BC AB Ajax USA

KGHM Ajax Air Quality Assessment

Project Case Operations Predicted 99th Percentile Daily 1-Hour Maximum Ground-level SO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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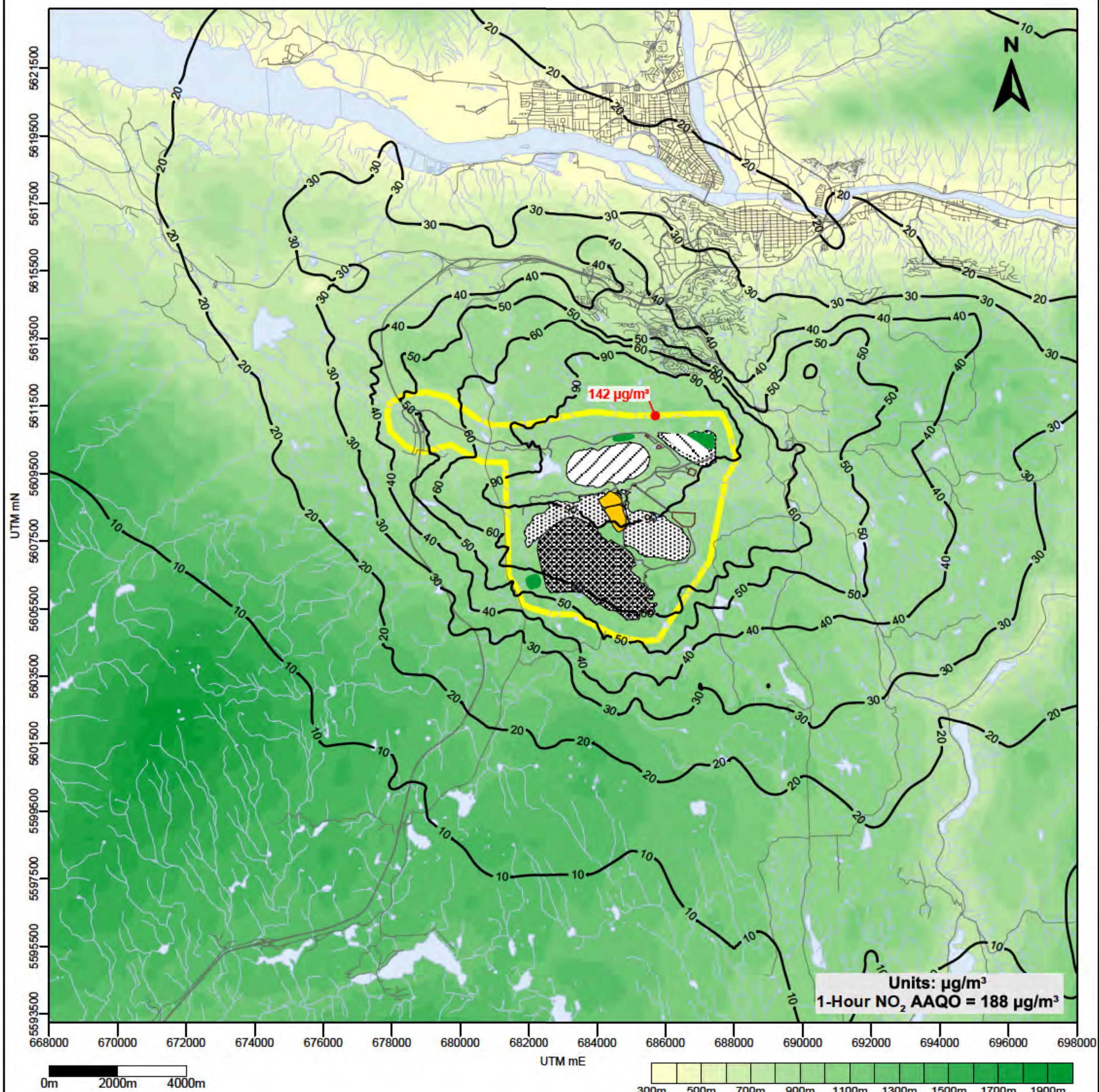
FIGURE NO. **I-7**

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/28/2015 By: KW



KGHM Ajax Air Quality Assessment

Project Case Operations Predicted 98th Percentile Daily 1-Hour Maximum Ground-level NO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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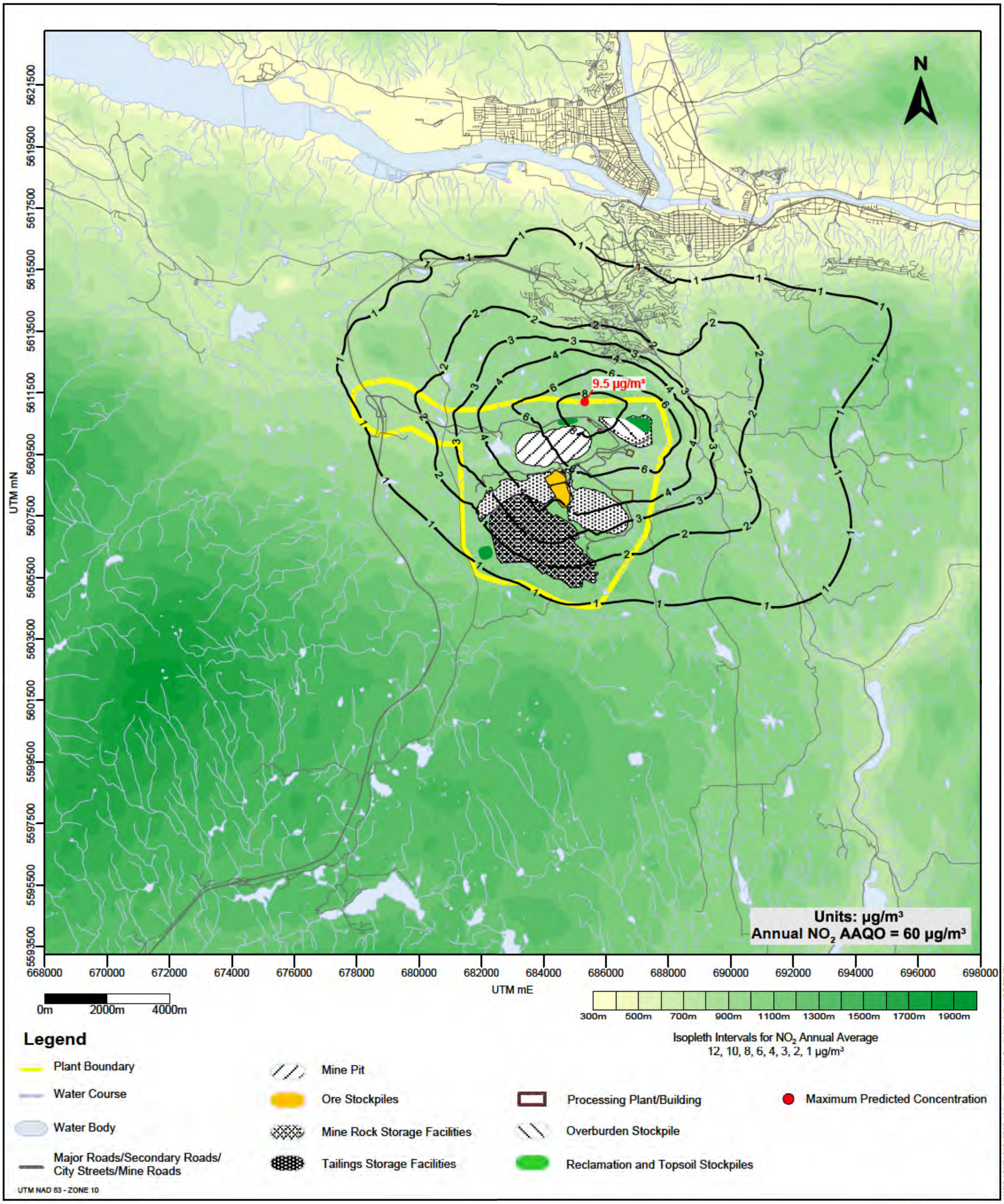
FIGURE NO. I-8

V:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/28/2015 By: KW



KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) Without Global/Regional Background Added

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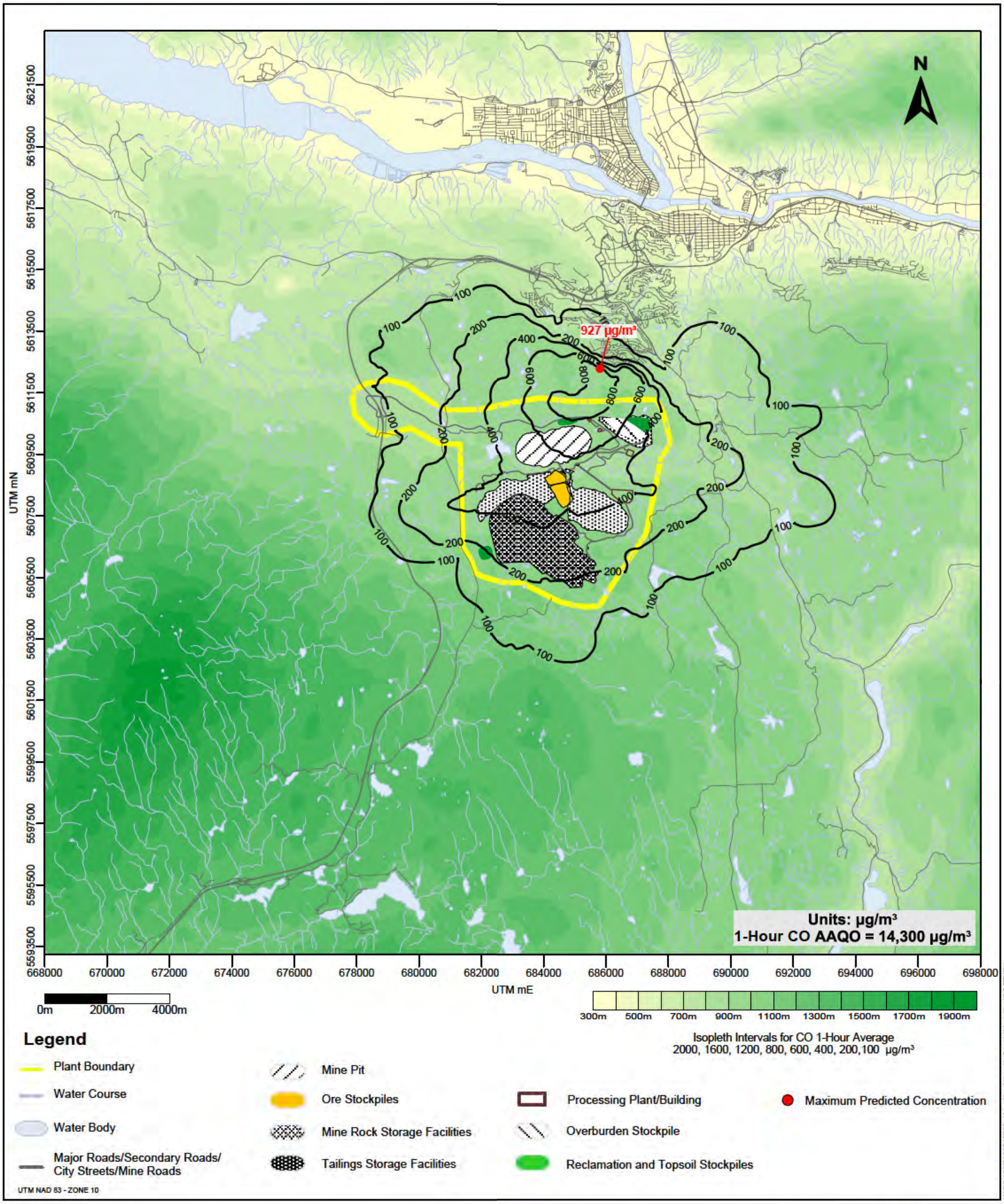
FIGURE NO. **I-9**

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/28/2015 By: KW



KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted 1-Hour Average Ground-level CO Concentrations (µg/m³) Without Global/Regional Background Added

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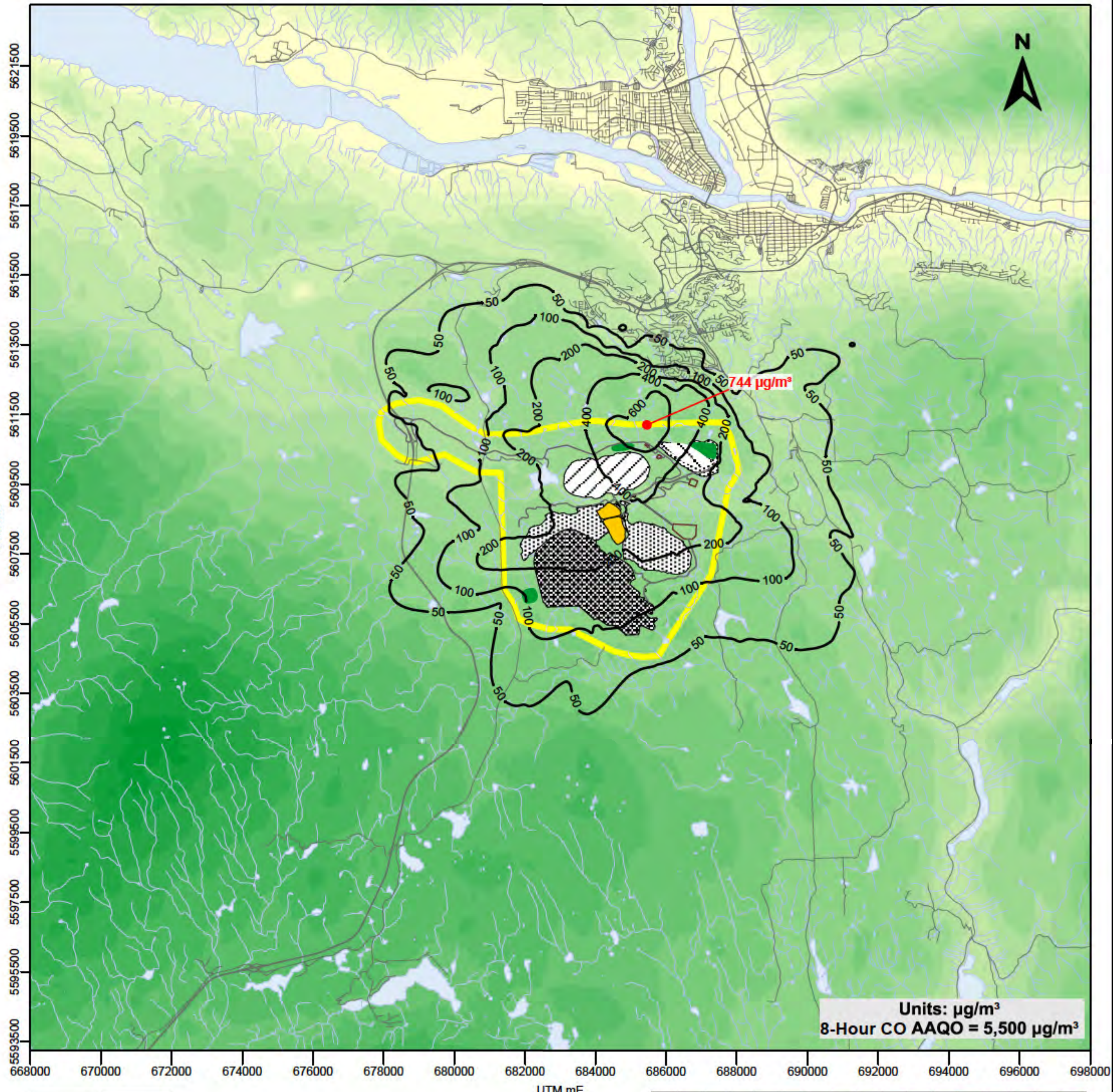
FIGURE NO. I-10



Isopleth Intervals for CO 8-Hour Average
1000, 800, 600, 400, 200, 100, 50 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Project Case Operations Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) Without Global/Regional Background Added

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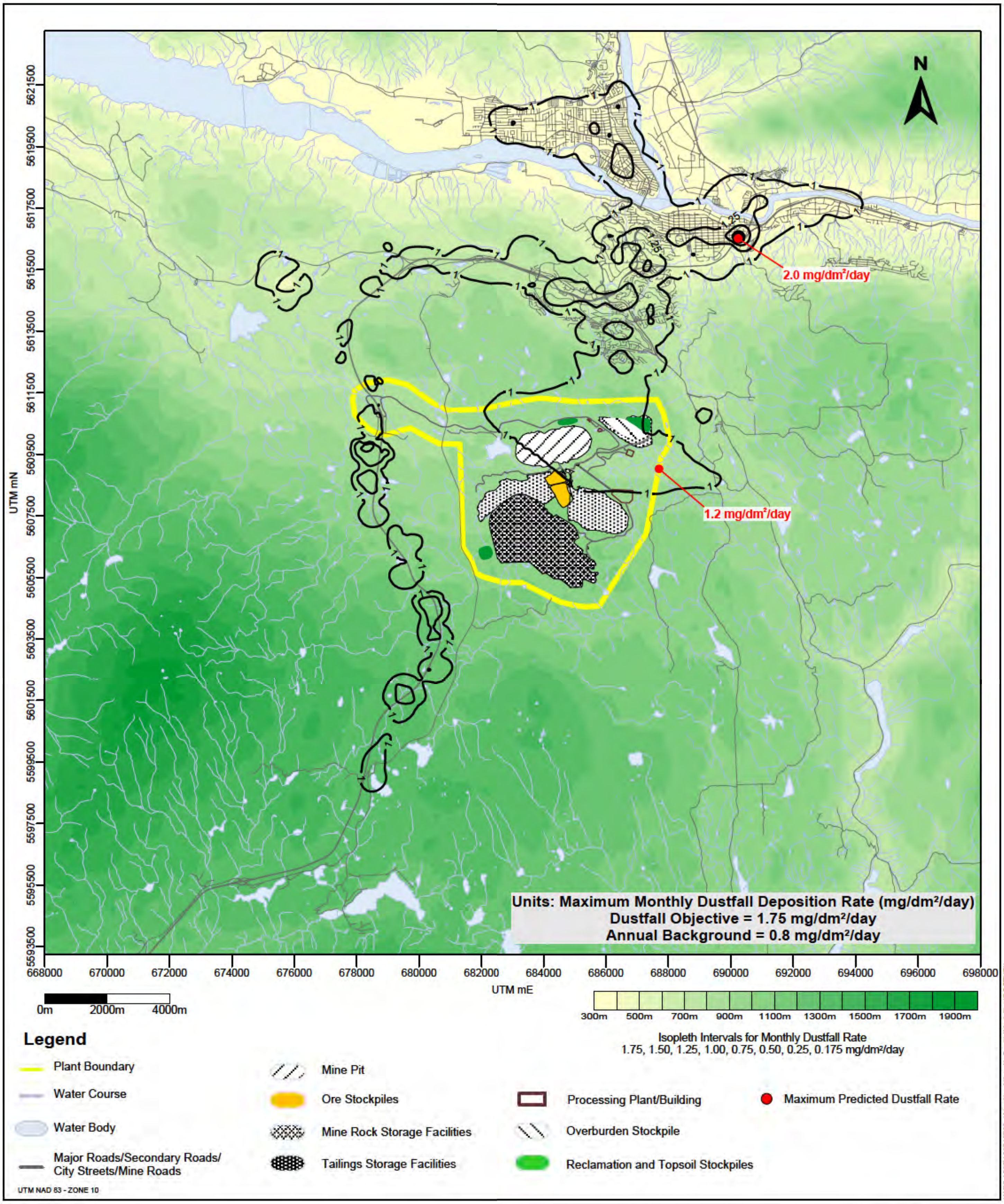
FIGURE NO. **I-11**

Last Modified: 04/28/2015 By: KW



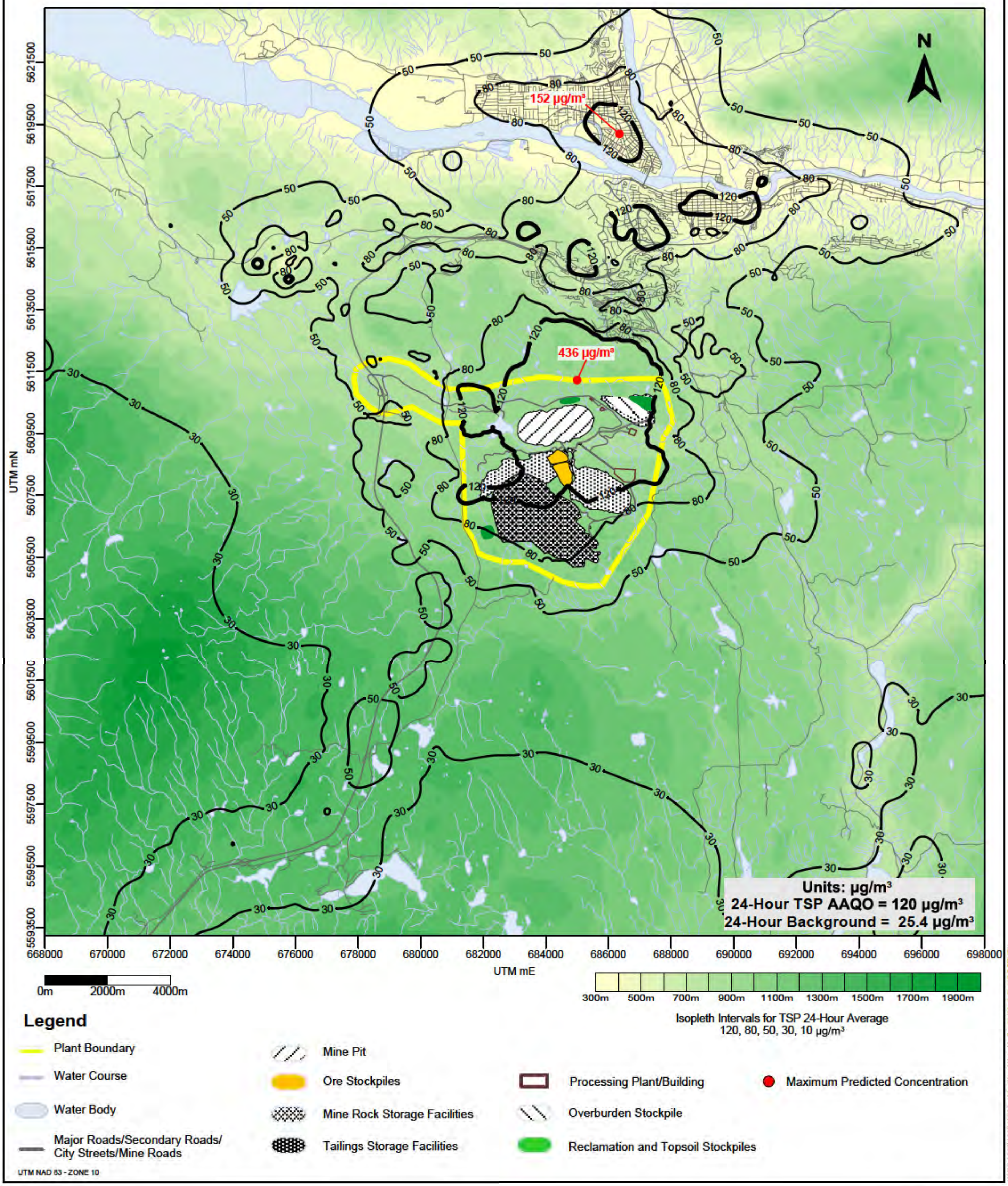
KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted Monthly Average Dustfall Rate (mg/dm²/day) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. **I-12**



KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted 24-Hour Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

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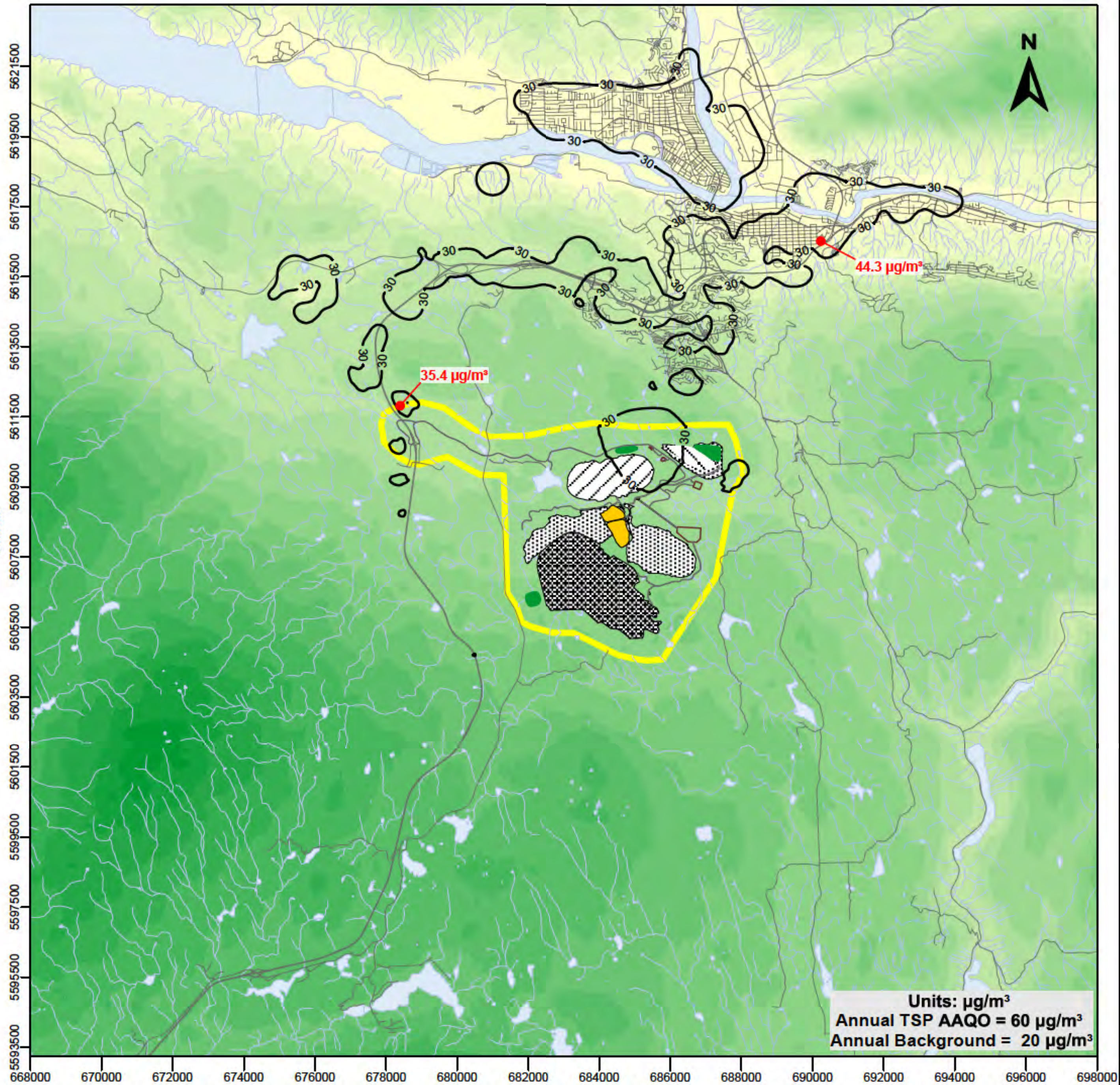
FIGURE NO. I-13

U:\PC 1235\123510762_New Ajax Mine Air Quality\Modeling\POSTUTIL

Last Modified: 04/28/2015 By: KW



Isopleth Intervals for TSP Annual Average
60, 30, 20, 10, 5, 2 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted Annual Average Ground-level TSP Concentrations (µg/m³) With Global/Regional Background Added

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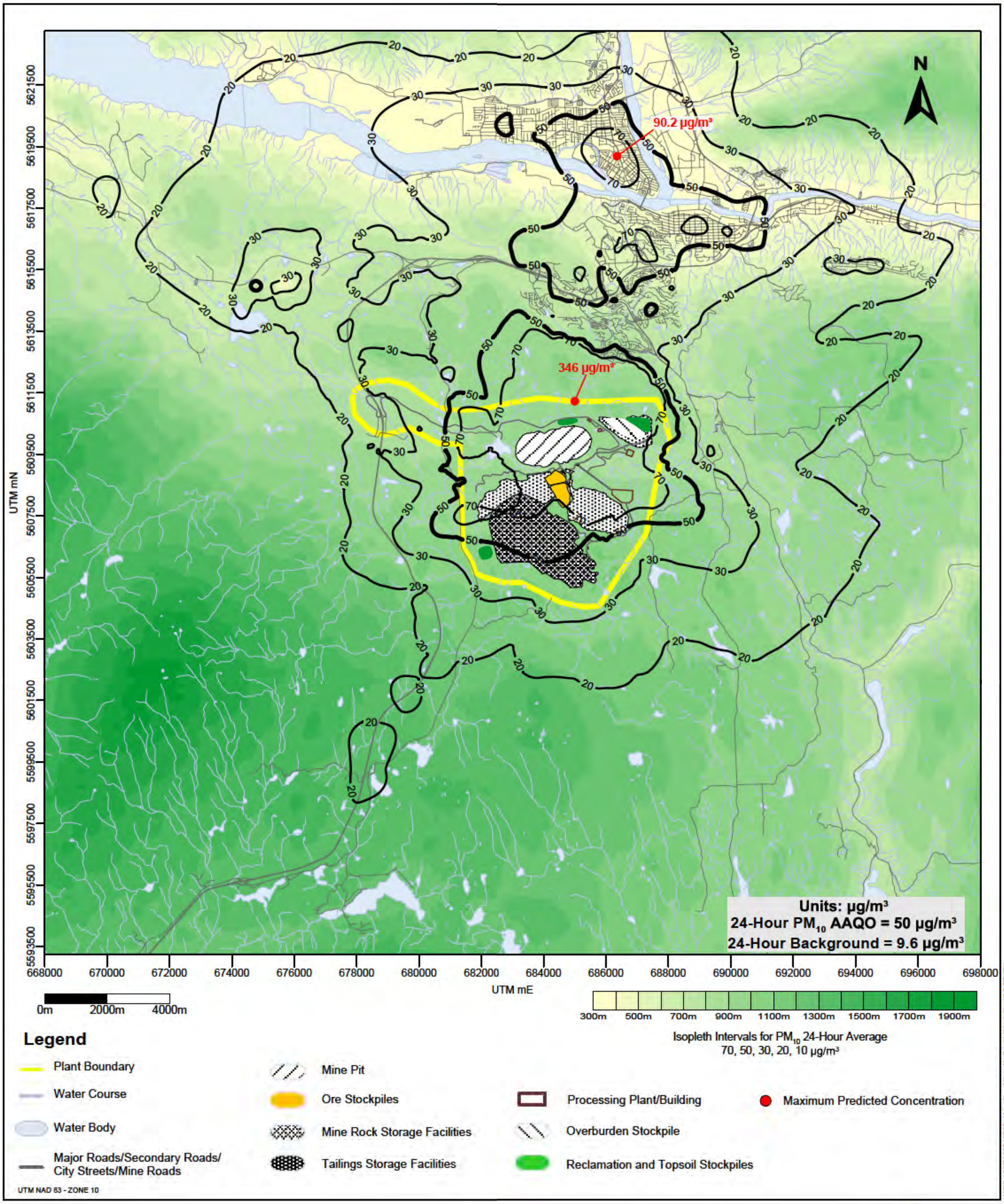
FIGURE NO. I-14

Last Modified: 04/28/2015 By: KW



KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted 24-Hour Average Ground-level PM_{10} Concentrations (µg/m³) With Global/Regional Background Added

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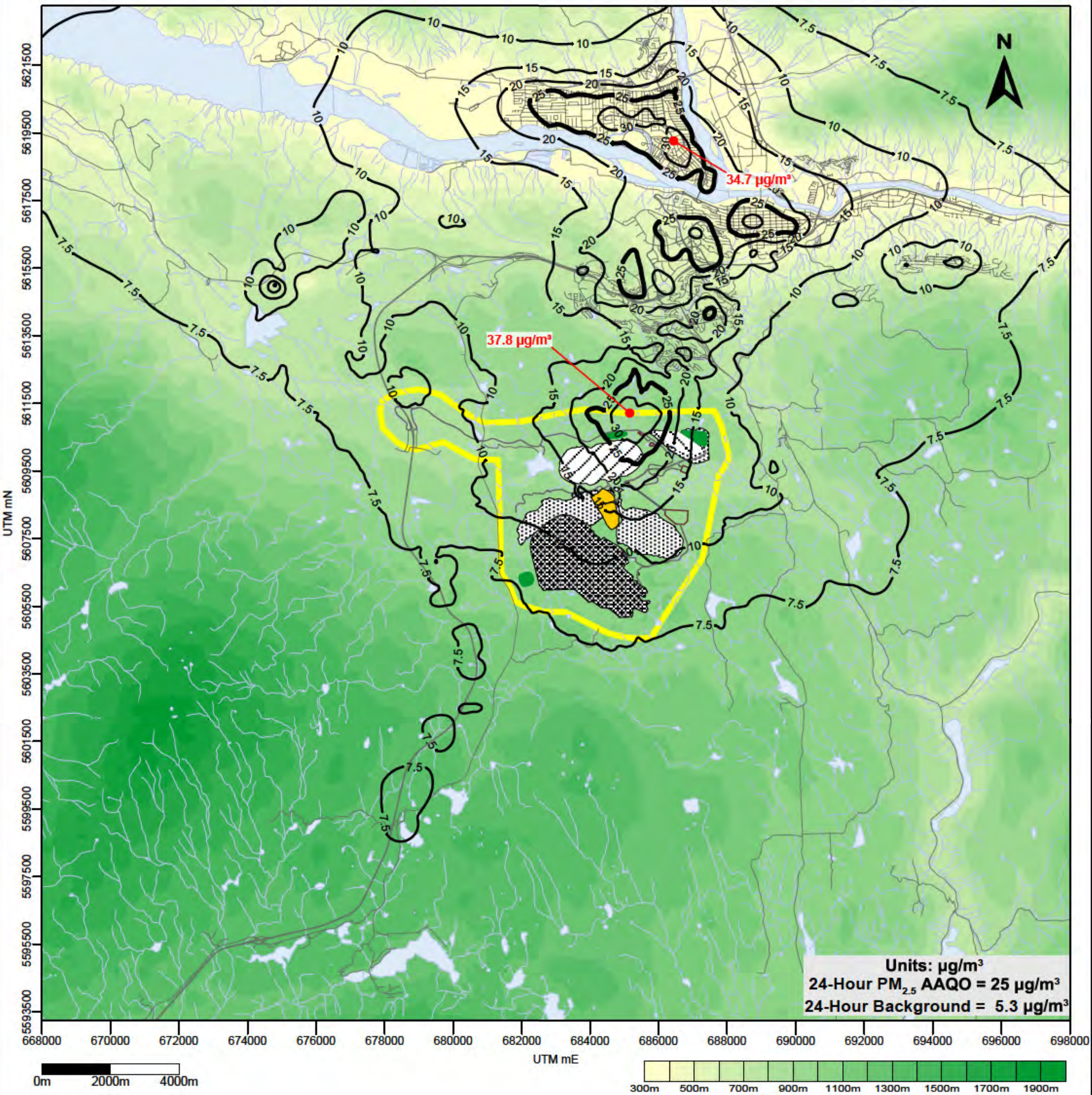
FIGURE NO. I-15



Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

KGHM Ajax Air Quality Assessment

Application Case Operations Predicted 98th Percentile 24-Hour Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

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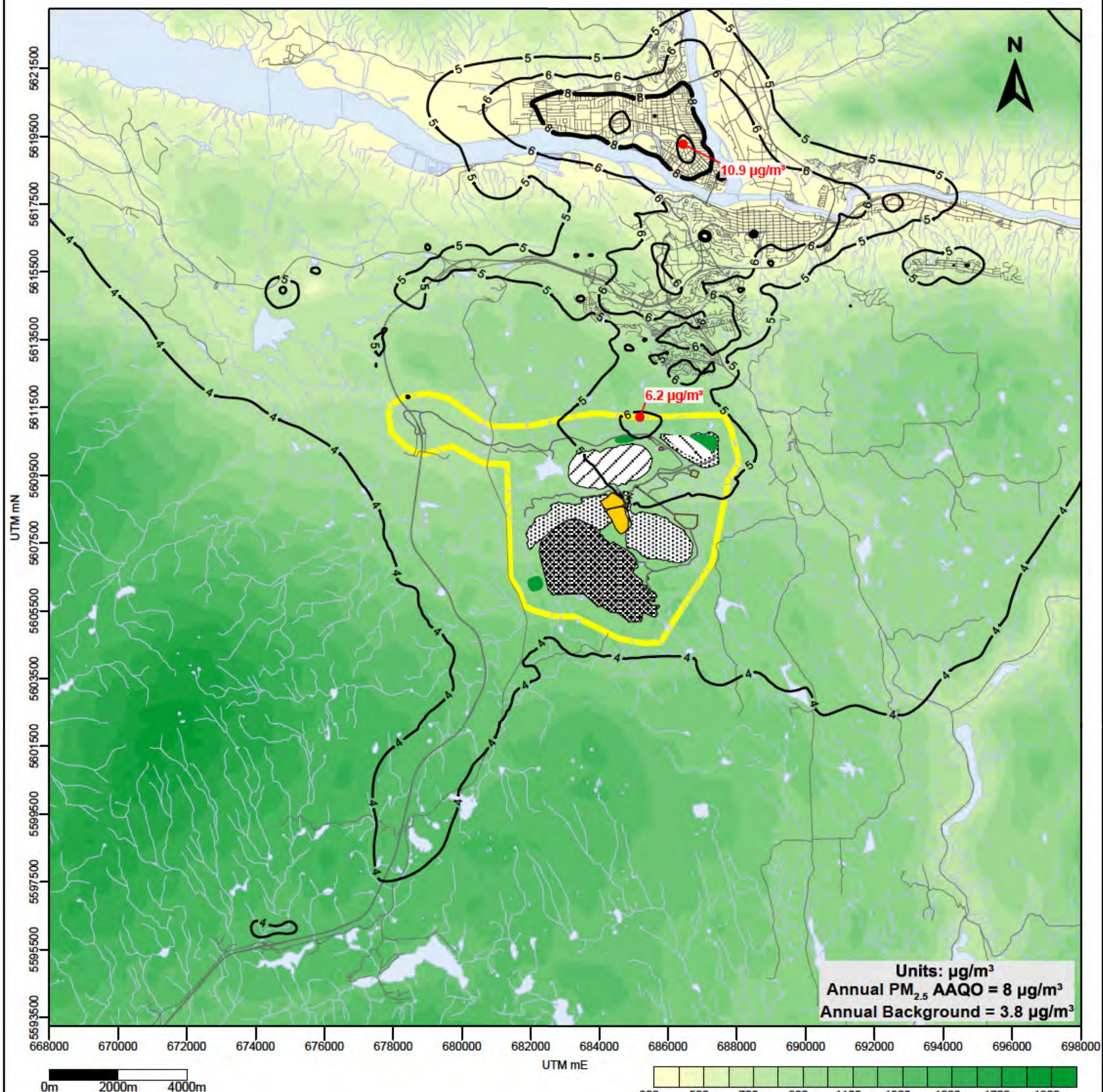
FIGURE NO. I-16



Isopleth Intervals for $PM_{2.5}$ Annual Average
10, 8, 6, 5, 4, 3, 2, 1, 0.5, 0.25, 0.1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted Annual Average Ground-level $PM_{2.5}$ Concentrations (µg/m³) With Global/Regional Background Added

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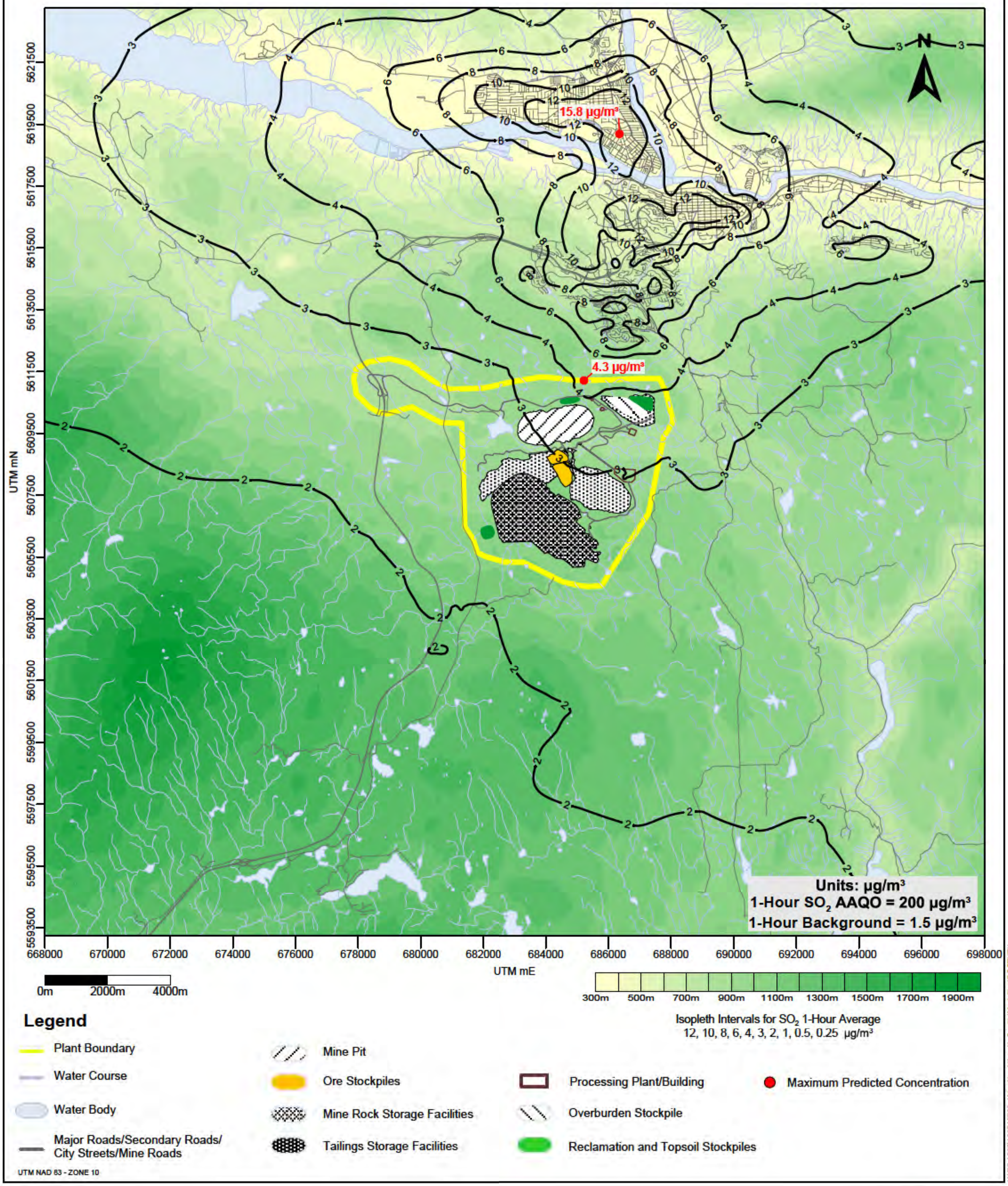
KGHM

FIGURE NO.
I-17

Last Modified: 04/30/2015 By: KW



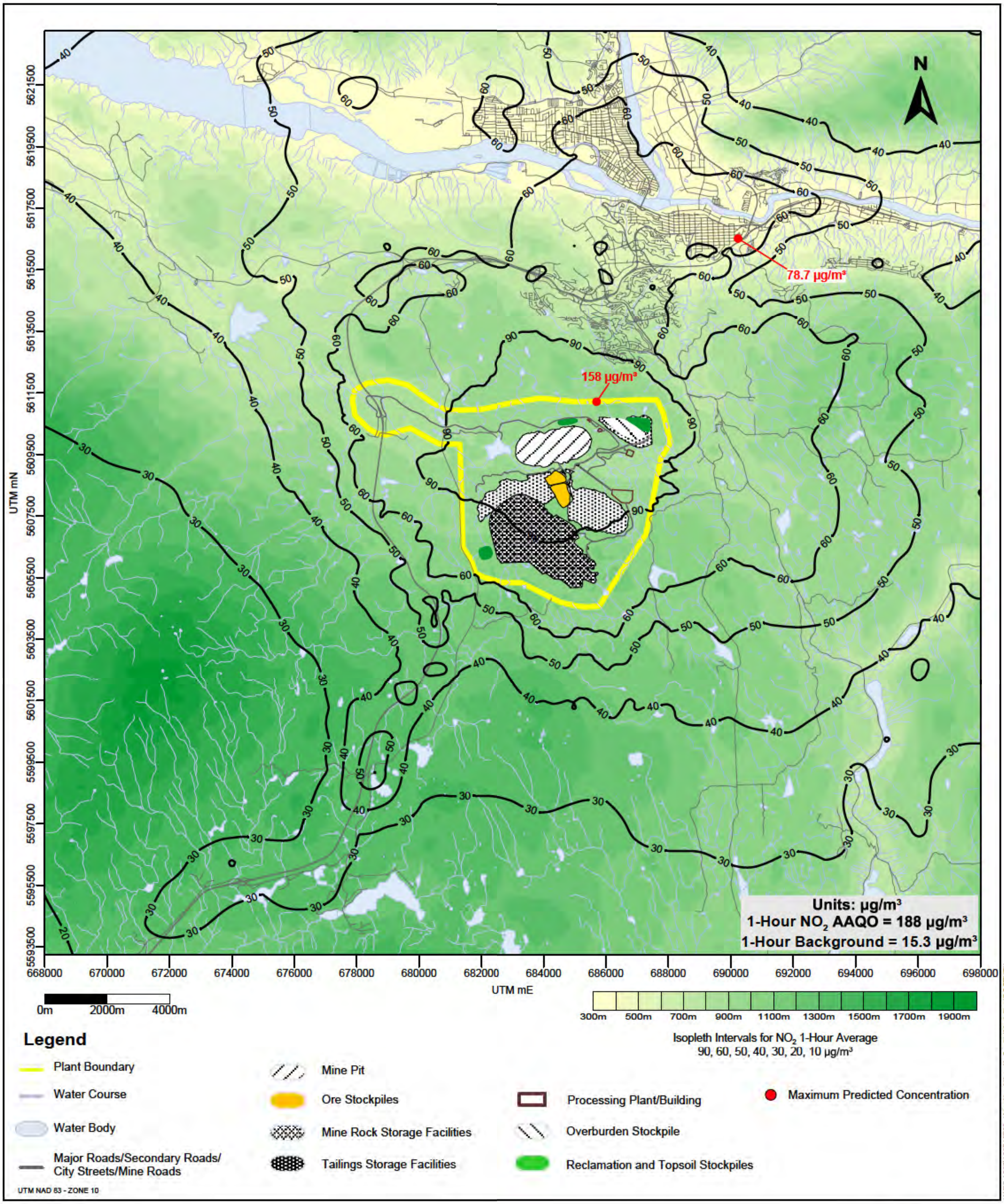
KGHM Ajax Air Quality Assessment

Application Case Operations Predicted 99th Percentile Daily 1-Hour Maximum Ground-level SO_2 Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. I-18



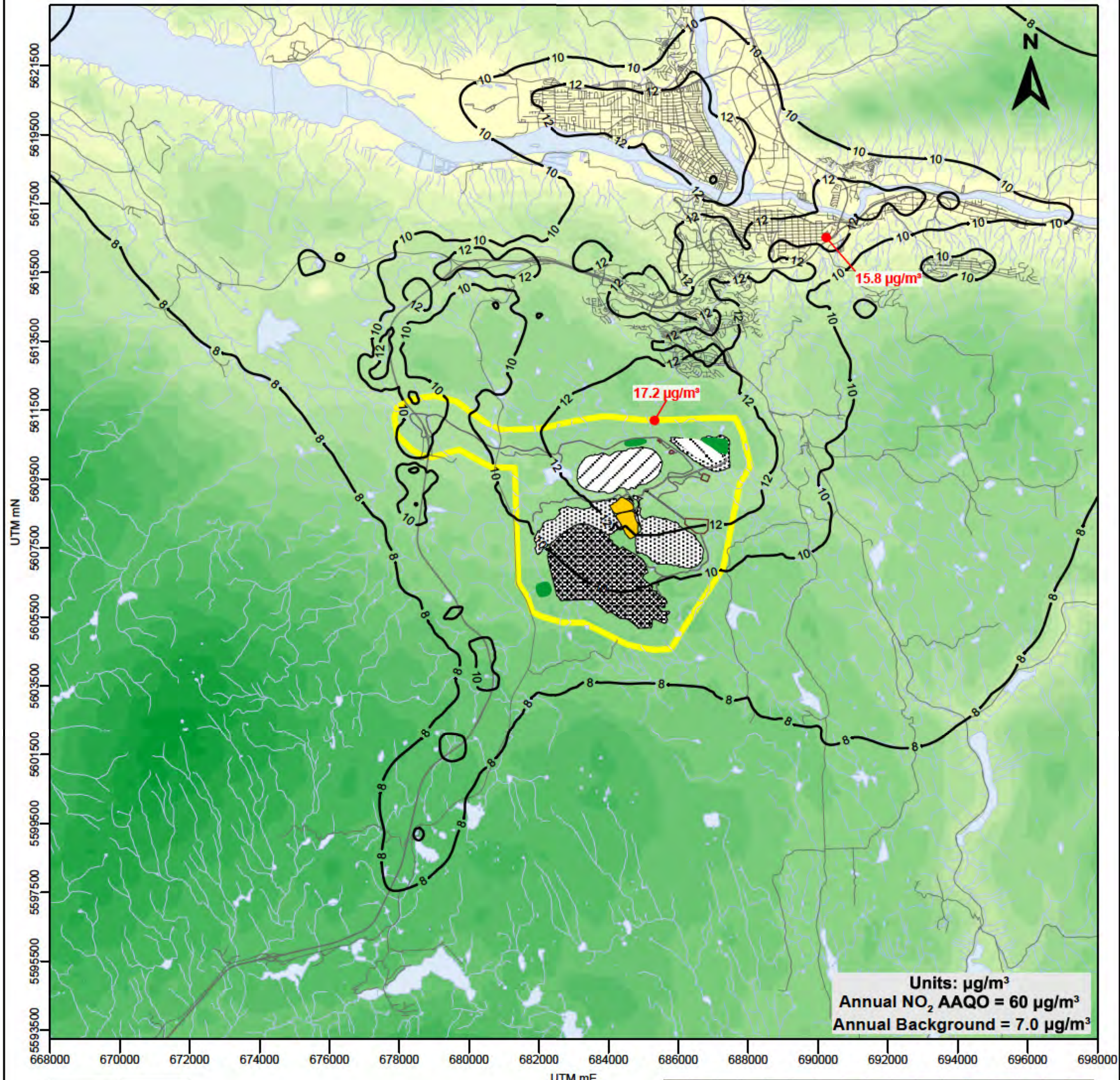
KGHM Ajax Air Quality Assessment

Application Case Operations Predicted 98th Percentile Daily 1-Hour Maximum Ground-level NO_2 Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. I-19



0m 2000m 4000m

300m 500m 700m 900m 1100m 1300m 1500m 1700m 1900m

Isopleth Intervals for NO_2 Annual Average
12, 10, 8, 6, 4, 3, 2, 1 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

Application Case Operations Maximum Predicted Annual Average Ground-level NO_2 Concentrations (µg/m³) With Global/Regional Background Added

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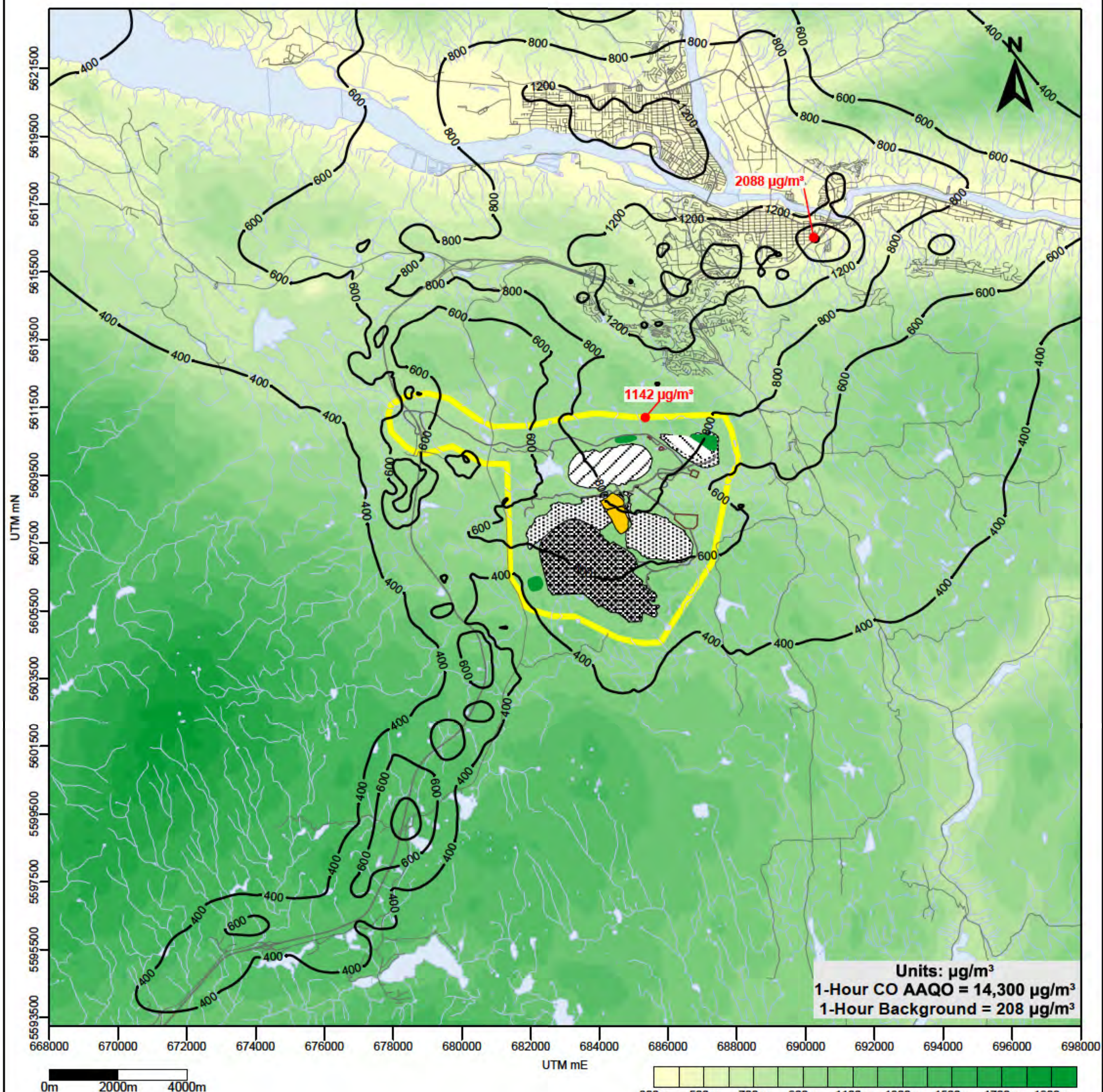
FIGURE NO. **I-20**

Last Modified: 04/28/2015 By: KW



Isopleth Intervals for CO 1-Hour Average
2000, 1600, 1200, 800, 600, 400, 200,100 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

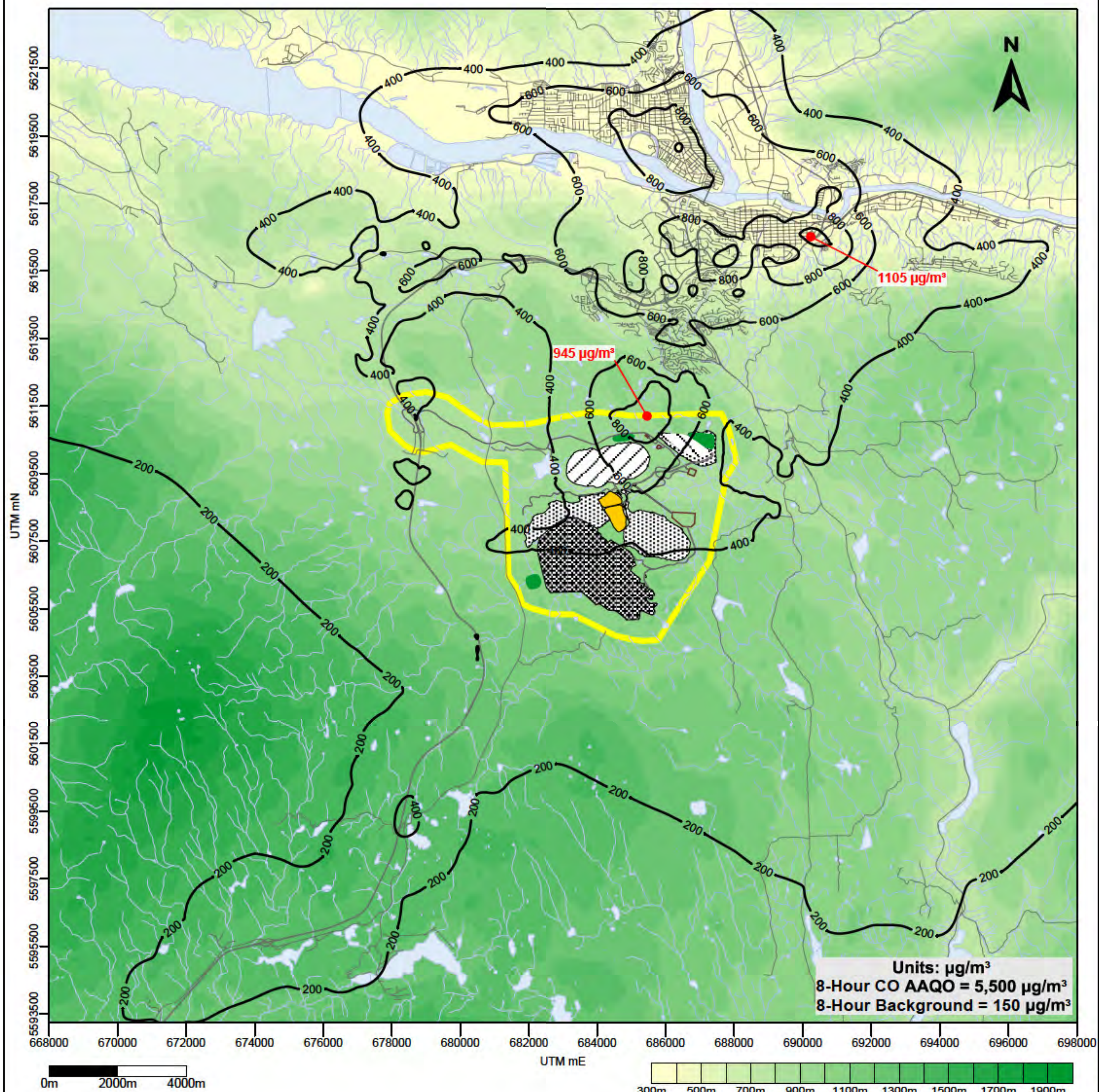
Application Case Operations Maximum Predicted 1-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

PREPARED BY Stantec

PREPARED FOR KGHM

FIGURE NO. I-21

Last Modified: 04/28/2015 By: KW



Isopleth Intervals for CO 8-Hour Average
1000, 800, 600, 400, 200, 100, 50 µg/m³

Legend

- Plant Boundary
- Water Course
- Water Body
- Major Roads/Secondary Roads/ City Streets/Mine Roads
- Mine Pit
- Ore Stockpiles
- Mine Rock Storage Facilities
- Tailings Storage Facilities
- Processing Plant/Building
- Overburden Stockpile
- Reclamation and Topsoil Stockpiles
- Maximum Predicted Concentration

UTM NAD 83 - ZONE 10

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KGHM Ajax Air Quality Assessment

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Application Case Operations Maximum Predicted 8-Hour Average Ground-level CO Concentrations (µg/m³) With Global/Regional Background Added

FIGURE NO.
I-22

Last Modified: 04/28/2015 By: KW