APPENDIX 6.2-C

Atmospheric Environment - Emission Sources and Air Quality Modelling
List of Figures

Figure 1.3-1: MM5 Data Wind Rose for the Project Site ..................................................... 16
Figure 1.3-2: MM5 Data Wind Statistics ........................................................................... 17
Figure 1.3-3: Approximate Locations of Emission Sources .............................................. 20
Figure 1.3-4: Simplified Flow-Path Diagram Showing Potential Sources of Dust Emission .... 21
Figure 1.3-5: Dispersion Modelling of SO₂ 1 Hour Average ........................................... 25
Figure 1.3-6: Dispersion Modelling of NO₂ 1 Hour Average ............................................ 26
Figure 1.3-7: Dispersion Modelling of NO₂ 1 Hour Average 99.95th Percentiles ............... 27
Figure 1.3-8: Dispersion Modelling of NO₂ 24 Hour Average .......................................... 28
Figure 1.3-9: Dispersion Modelling of NO₂ Annual Average ............................................ 29
Figure 1.3-10: Dispersion Modelling of TSP 24 Hour Average .......................................... 30
Figure 1.3-11: Dispersion Modelling of PM₁₀ 24 Hour Average ....................................... 31
Figure 1.3-12: Dispersion Modelling of PM₂.₅ 24 Hour Average ....................................... 32
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAQO</td>
<td>Ambient Air Quality Objectives</td>
</tr>
<tr>
<td>AAQOS</td>
<td>Ambient Air Quality Objectives and Standards</td>
</tr>
<tr>
<td>Ag</td>
<td>silver</td>
</tr>
<tr>
<td>AMEC</td>
<td>AMEC Earth and Environmental</td>
</tr>
<tr>
<td>ANFO</td>
<td>ammonium nitrate - fuel oil</td>
</tr>
<tr>
<td>AQ</td>
<td>air quality</td>
</tr>
<tr>
<td>AWMA</td>
<td>Air and Waste Management Association</td>
</tr>
<tr>
<td>BC</td>
<td>British Columbia</td>
</tr>
<tr>
<td>BC MOE</td>
<td>British Columbia Ministry of Environment</td>
</tr>
<tr>
<td>CACs</td>
<td>criteria air contaminants</td>
</tr>
<tr>
<td>CH4</td>
<td>methane</td>
</tr>
<tr>
<td>CO</td>
<td>carbon monoxide</td>
</tr>
<tr>
<td>CO2</td>
<td>carbon dioxide</td>
</tr>
<tr>
<td>CSA</td>
<td>Canadian Safety Associate??</td>
</tr>
<tr>
<td>EA</td>
<td>Environmental Assessment</td>
</tr>
<tr>
<td>EC</td>
<td>Environment Canada</td>
</tr>
<tr>
<td>GHG</td>
<td>greenhouse gases</td>
</tr>
<tr>
<td>GLC</td>
<td>ground level concentrations</td>
</tr>
<tr>
<td>GWP</td>
<td>global warming potential</td>
</tr>
<tr>
<td>HC</td>
<td>hydrocarbons</td>
</tr>
<tr>
<td>hp</td>
<td>horsepower</td>
</tr>
<tr>
<td>HV</td>
<td>high volume</td>
</tr>
<tr>
<td>IC</td>
<td>internal combustion</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>Knight Piésold</td>
<td>Knight Piésold Consulting Ltd.</td>
</tr>
<tr>
<td>m.w.</td>
<td>molecular weight</td>
</tr>
<tr>
<td>MM5</td>
<td>5th generation mesoscale meteorological model</td>
</tr>
<tr>
<td>N2O</td>
<td>nitrous oxide</td>
</tr>
<tr>
<td>NO</td>
<td>nitric oxide</td>
</tr>
<tr>
<td>NO2</td>
<td>nitrogen dioxide</td>
</tr>
<tr>
<td>NOx</td>
<td>nitrogen oxide</td>
</tr>
<tr>
<td>NPRI</td>
<td>National Pollutant Release Inventory</td>
</tr>
<tr>
<td>O3</td>
<td>ozone</td>
</tr>
<tr>
<td>Pb</td>
<td>lead</td>
</tr>
<tr>
<td>PM</td>
<td>particulate matter</td>
</tr>
<tr>
<td>PM10</td>
<td>particulate matter with an aerodynamic diameter no greater than 10 µm</td>
</tr>
</tbody>
</table>
### Abbreviation
### Definition

- **PM2.5**: particulate matter with an aerodynamic diameter no greater than 2.5 µm
- **PM30**: particulate matter with an aerodynamic diameter no greater than 30 µm
- **proposed Project (the)**: Kitsault Mine site
- **SAG**: Semi-Autogenous Grinding
- **SO2**: sulphur dioxide
- **SP**: suspended particulates
- **TSP**: total suspended particulate
- **US EPA**: United States Environmental Protection Agency
- **VOCs**: volatile organic compounds

### UNITS OF MEASUREMENT

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>degrees Celcius</td>
</tr>
<tr>
<td>µg/m³</td>
<td>micrograms per cubic metre</td>
</tr>
<tr>
<td>µm</td>
<td>micrometres</td>
</tr>
<tr>
<td>d/a</td>
<td>days per annum</td>
</tr>
<tr>
<td>d/wk</td>
<td>days per week</td>
</tr>
<tr>
<td>g/m²</td>
<td>grams per metre squared</td>
</tr>
<tr>
<td>g/s</td>
<td>grams per second</td>
</tr>
<tr>
<td>h/d</td>
<td>hours per day</td>
</tr>
<tr>
<td>kg</td>
<td>kilogram</td>
</tr>
<tr>
<td>kg/d</td>
<td>kilograms per day</td>
</tr>
<tr>
<td>km/h</td>
<td>kilometres per hour</td>
</tr>
<tr>
<td>kt</td>
<td>kilotonnes</td>
</tr>
<tr>
<td>m</td>
<td>metres</td>
</tr>
<tr>
<td>m/s</td>
<td>metres per second</td>
</tr>
<tr>
<td>m²</td>
<td>metres squared</td>
</tr>
<tr>
<td>Mg</td>
<td>megagrams</td>
</tr>
<tr>
<td>mm</td>
<td>millimetres</td>
</tr>
<tr>
<td>Mt</td>
<td>megatonnes</td>
</tr>
<tr>
<td>ppbv</td>
<td>parts per billion by volume</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>t/d</td>
<td>tonnes per day</td>
</tr>
<tr>
<td>t/y</td>
<td>tonnes per year</td>
</tr>
</tbody>
</table>
1.0 IDENTIFICATION AND ANALYSIS OF POTENTIAL PROJECT EFFECTS

1.1 Introduction

The assessment presented in this section of the Environmental Assessment (EA) predicts the emissions into the atmosphere from construction and operation activities of the Kitsault Mine Site (proposed Project), estimates the resultant ambient concentrations and then compares these estimates to relevant guidelines or objectives.

Several emission sources will be present at the site. Numerous diesel engines of various kinds of both stationary and mobile equipment will emit a range of contaminants typical of diesel engines. Mining activities will generate dust composed of inert soil and molybdenum materials. The main potential sources of dust will include blasting, materials hauling, crushing and sizing, stockpiling, waste rock disposal, stripping and overburden storage. No plant emissions are expected because treatment of the molybdenite-bearing ore will be wet which prevents dust release and the processing units will be completely enclosed.

The analysis of the proposed Project effects on the atmosphere takes into consideration two categories of contaminants: criteria air contaminants (CACs) and greenhouse gases (GHG). Criteria air contaminants relevant to this proposed Project include particulate matter (PM), nitrogen dioxide (NO\textsubscript{2}), carbon monoxide (CO), and sulphur dioxide (SO\textsubscript{2}). These are primary indicators of air quality and are associated with human health impacts (primarily through inhalation) and environmental impacts, including aesthetic, visibility, and toxic effects.

GHG such as carbon dioxide, methane and nitrous oxide potentially contribute to climate change. GHG are any gases in the atmosphere that absorb radiation, particularly outgoing terrestrial infrared radiation, contributing to global warming. In this project carbon dioxide will be the only GHG emitted to the atmosphere as a product of natural gas and diesel combustion. Emissions of CO\textsubscript{2} were quantified and assessed in the context of provincial and national GHG emission totals.

Dispersion modelling was undertaken to assess the impact of atmospheric emissions associated with kimberlite open pit mining and processing on air quality. Ground level concentrations of CACs were predicted across local and regional study areas centered on the northeast corner of the Open Pit mine. The area within the proposed Project boundary was excluded for assessment purposes as this area is restricted to the general public because of safety and security concerns and subject to work-place safety standards rather than ambient air quality thresholds.

1.2 Emission Sources

The primary emission sources will consist of the following:

- Mobile and stationary equipment exhaust emissions resulting from internal combustion of diesel fuel;
• Fugitive dust emissions from blasting, ore mining, materials handling, overburden removal, and waste disposal; and
• Fugitive dust generated by vehicles in the Open Pit and along haul roads.

The secondary sources emitting infrequently will include:

• Shop vents relating to welding hoods and general shop and plant ventilation outlets;
• Natural gas fired heaters installed at some buildings operating during winter months;
• Waste incinerator running daily during an 8-hour shift; and
• Construction equipment operating at frequently changing locations depending on the construction schedule over a 2-year period.

Anticipated pollutants generated by the primary and secondary sources will likely include:

• Total suspended particulate (TSP);
• Dustfall;
• Particulates with diameter 10 µm or less (PM\textsubscript{10});
• Particulates with diameter 2.5 µm or less (PM\textsubscript{2.5});
• SO\textsuperscript{2};
• NO\textsuperscript{2};
• CO;
• CO\textsuperscript{2};
• Hydrocarbons (HC) / volatile organic compounds (VOCs); and
• Metal elements in dust including cadmium, arsenic, chromium, cobalt, lead (Pb), nickel, and molybdenum (Mo).

Not all of the above substances are considered to have the potential to pose a risk to human health or to the environment. Therefore, air pollutants of concern have been selected for detailed impact assessment involving dispersion modelling using the following criteria:

• The level of concern with reference to health effects (relates to ambient air quality objectives);
• Probability of occurrence of the substance at higher concentrations;
• Emission periods;
• Expected ground level concentrations with reference to the monitor detection limit; and
• Availability of suitable monitors for contaminants in terms of cost, accuracy, detection limits and suitability for unsupervised continuous operation in an open remote terrain.

Considering the above factors the following substances have been selected for the detailed EA which includes dispersion modelling:
Particulate matter (TSP, PM\textsubscript{10} and PM\textsubscript{2.5});
SO\textsubscript{2};
NO\textsubscript{2}; and
CO.

In addition, CO\textsubscript{2} emissions are quantified in order to address GHG emissions.

Particulate matter, sulphur dioxide, nitrogen oxides and carbon monoxide are classified by Environment Canada (EC) as CACs. They are tracked by EC to measure the effectiveness of emission reduction programs and to support scientific research (EC website: www.ec.gc.ca/air/default.asp?lang=En\&n=7C43740B-1).

General characteristics of potential emission sources mentioned above are discussed in the following paragraphs.

Crushing and milling of the molybdenite ore is associated with generation of particulate emissions which could produce nuisance problems and could have an effect upon attainment of ambient particulate standards. However, the design of the proposed facility provides a total enclosure of all crushing and milling facilities, such as the main gyratory crusher, the pebble crusher, SAG mill and ball mill. Dust generated in these facilities will be removed by dust filters of over 95% efficiency and returned to the production line. In general, dust and fume control systems will include hoods and enclosures designed to contain the contaminants at source. A dust collection system shall be employed as first choice for control of dust. Hoods and enclosures will be connected via ductwork to the dust collection equipment. Cartridge-based dust collectors, baghouses and wet scrubbers may be used depending on the application. As per design requirements, all filters will be CSA approved.

Haul truck exhaust will be the dominant gaseous air contaminant at the site. The main components of diesel engine exhaust include carbon dioxide, nitrogen oxides, sulphur dioxide, and small particulates (PM\textsubscript{10} and PM\textsubscript{2.5}). Trucks loading / unloading will be a source of fugitive dust emissions. There also will be emissions of gases from internal combustion engines (gasoline and diesel) of the on-site light vehicles, but these are considered insignificant compared to the large equipment emissions.

Winter time heating of buildings will result in the emission of carbon dioxide and water vapour due to the use of natural gas or diesel as fuel. However, numerous heaters will be distributed over the plant area resulting in a large area - low concentration dispersion of gas combustion products. This will prevent the occurrence of a high concentration of contaminants.

Dust may be generated on un-reclaimed areas of the overburden storage and other areas of exposed mineral material during prolonged dry weather. Dust can be also mobilised in the storage cycle, including material loading onto the pile, disturbances by strong wind currents, and potentially from removing loads from the pile. The potential drift distance of particles
caused by wind is determined by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence.

Blasting produces similar emissions to vehicle exhaust plus dust, and small quantities of SO\textsubscript{2} and other substances. Blasting gases readily dissipate in the atmosphere following detonation. Much of the dusty material in the initial plume is larger than the aerodynamic diameter of particles that can remain suspended in the air and is deposited within the pit area.

No emissions will be present from the processing plant sources. All processes located in the production building will be enclosed. The mineral material (ore and concentrate) subjected to milling, screening, regrinding, flotation, thickening, leaching and filtration will be wet (slurry or cake). As a result, no dust will be emitted.

The proposed Project emission sources that can be quantitatively assessed are shown in Table 1.2-1.

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Units</th>
<th>Source Type</th>
<th>Contaminant Type</th>
<th>Emission Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haul trucks Cat 793D</td>
<td>10</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Front-end loader Komatsu WA1200</td>
<td>1</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Rotary drills Sandvik 1190E</td>
<td>2</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Rotary drill Sandvik QXR920</td>
<td>1</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Wheel dozer Cat 834H</td>
<td>1</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Track dozer Cat D6</td>
<td>1</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Water truck Cat 777D</td>
<td>1</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Track dozers D10T</td>
<td>2</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Grades Cat 16M</td>
<td>2</td>
<td>Volume</td>
<td>NO\textsubscript{x}, SO\textsubscript{2}, CO, PM\textsubscript{2.5}, PM\textsubscript{10}</td>
<td>NONROAD</td>
</tr>
<tr>
<td>Blasting</td>
<td>-</td>
<td>Volume</td>
<td>PM</td>
<td>AP-42</td>
</tr>
<tr>
<td>In-pit material handling</td>
<td>-</td>
<td>Area</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>AP-42</td>
</tr>
<tr>
<td>Low grade stockpile</td>
<td>1</td>
<td>Area</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>DUSTCON</td>
</tr>
<tr>
<td>North waste rock management facility</td>
<td>-</td>
<td>Area</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>AP-42</td>
</tr>
<tr>
<td>East waste rock management facility</td>
<td>-</td>
<td>Area</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>AP-42</td>
</tr>
<tr>
<td>Wheel entrainment emissions</td>
<td>-</td>
<td>Volume</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>AP-42</td>
</tr>
<tr>
<td>Coarse ore stockpile</td>
<td>1</td>
<td>Volume</td>
<td>PM\textsubscript{2.5}, PM\textsubscript{10}, TSP</td>
<td>DUSTCON</td>
</tr>
</tbody>
</table>

Note: CO - carbon monoxide; NO\textsubscript{x} - nitrogen oxide; PM\textsubscript{2.5} - ; PM\textsubscript{10} - ; SO\textsubscript{2} - sulphur dioxide; TSP - total suspended particulate
1.3 Emission Rates

Emission rates of some of the Project sources have been calculated using AP-42 emission factors published by the United States Environmental Protection Agency (US EPA) in the document Compilation of Air Pollutant Emission Factors, Volume I – Stationary Point and Area Sources – 5th Edition (US EPA 1995). Sequential annual supplements have been published since 1995 as new information becomes available. The current supplement of July 2010 was incorporated into this proposed Project as needed. An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. In most cases, emission factors are simply averages of all available data of acceptable quality, and are generally assumed to be representative of long-term averages for all facilities in the source category. Their accuracy is rated in a letter scale from A to E where A denotes excellent quality data and E represents poor agreement between the published factor and actually measured emissions.

Emission factors for nonroad mobile equipment and haul trucks have been computed using the NONROAD inventory model (US EPA 2008). In addition to emission factors, the estimates included the power rating (horsepower (hp)) and utilisation factors for each piece of equipment.

1.3.1 Construction Phase

During the early site preparation and construction phases of the project, fugitive emissions resulting from earthwork and vehicle movement on temporary dirt roads would increase particulate concentrations. In addition, fugitive dust would be created by construction activities, exposed topsoil, moved overburden, and stored dusty construction material. The fugitive dust emissions will increase when the initially wet material dries. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, each with its own duration and potential for dust generation, and the prevailing meteorological conditions.

Emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This is in contrast to operational fugitive dust sources, where emissions are either relatively steady or follow a discernable temporal cycle.

As a detailed construction schedule is unavailable at this time of report writing, a general approach to estimate area-wide construction fugitive dust emissions is most appropriate. For these reasons, the following methods have been used by which either wide-spread or site-specific emissions are estimated.

Heavy-duty diesel vehicles and stationary construction equipment would generate diesel exhaust. Chemical analysis of exhaust has shown that it contains HC, CO, nitrogen oxides (NOx), and particulates. These pollutants disperse into the surrounding air along the
travelled route while the vehicle is in motion or at fixed location during stationary operation. Usually, humans object to smoke and odorous exhausts from the diesel engines. Because this phenomenon occurs near individual operating units, the nuisances could be severe at a construction site but normally would not extend beyond the activity area.

The quantity of fugitive dust emissions (dust picked up by wind or moving vehicles from the ground) at the construction site is proportional to the area of land being worked and to the level of construction activity. By analogy to the parameter dependence observed for other similar fugitive dust sources (Cowherd 1974), emissions from heavy construction operations are expected to be positively correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [$\mu$m] in diameter), as well as with the speed and weight of the average vehicle, and to be negatively correlated with the soil moisture content.

Based on field measurements of TSP concentrations at construction sites (Cowherd 1974; Jutze 1974), the approximate emission factors for construction activity operations are:

\[
E = 2.69 \text{ megagrams (Mg)/hectare/month of activity} \\
E = 1.2 \text{ tonnes/acre/month of activity}
\]

Therefore, dust emissions over the area of 10 acres in a one year period will be 144 tonnes. This is a very conservative estimate because precipitation (rain and snow) will greatly reduce the emissions and confine them to the activity area.

Fugitive dust may appear at higher concentrations during dry summers and windy weather. Some land will be cleared, grubbed, and regraded, according to construction requirements. Also, exposed topsoil and some stored dusty construction materials may generate fugitive dust. The AP-42 emission factor documentation (US EPA 2004) gives the following empirical equation for fugitive TSP emissions from active storage piles, as a result of wind erosion and pile maintenance:

\[
TSP = 1.8 u \text{ (kilograms (kg) / hectare / hour)}
\]

where $u$ is the average wind speed in metres per second (m/s).

The calculation of annual TSP must include mitigation efficiency due to precipitation. A calculation of TSP for 1 hectare area and 1 hour average with wind speed of 1.5 m/s will (site average for 2009 – 2010 period) result in an estimate of 2.7 kg TSP/hour.

1.3.2 6.2.2.6.3.2 Operation Phase

An air quality assessment has been carried out for the worst case scenario which occurs in Year 2 when the peak mining rate of 41,666 kilo tonnes (kt) is reached. This is shown in Table 1.3-1.
Table 1.3-1: Summarised Annual Production in Year 2

<table>
<thead>
<tr>
<th>Mine Production (kt)</th>
<th>LGS (kt)</th>
<th>Waste Rock (kt)</th>
<th>Total Mined (kt)</th>
<th>Snow (kt)</th>
<th>Mill Production (kt)</th>
<th>Grade (%Mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14,600</td>
<td>4,126</td>
<td>22,940</td>
<td>41,666</td>
<td>112</td>
<td>14,600</td>
<td>0.100</td>
</tr>
</tbody>
</table>

Note: kt - kilo tonnes; LGS - Low Grade (ore) Stockpile; Mo - Molybdenum; % - percent

The work schedule assumes that the mine will operate 24 hours per day (h/d), 7 days per week (d/wk), 365 days per annum (d/a). This will result in the ore mining rate of 40,000 tonnes per day (t/d). However, the mine plan allows for 240 hours of lost production per year due to adverse driving conditions and poor visibility resulting from snow or fog. Operational phase emissions are estimated for stationary and mobile sources using NONROAD and AP-42 emission factors, equipment manufacturer specifications, material properties and throughput rates. Frequently used supporting data needed for emission estimates is shown in Appendix 6.2-B.

The fugitive dust generation process is caused by two basic physical phenomena:

- Pulverisation and abrasion of surface materials by application of mechanical force through implements (wheels, blades, etc.; e.g., primary crusher/sizer); and
- Entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface (e.g., coarse ore stockpile, haul truck wheel entrainment).

The potential drift distance of particles is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Dispersion models have computed theoretical drift distance, as a function of particle diameter and mean wind speed, for fugitive dust emissions. Results indicate that, for a wind speed of 16 kilometres per hour (km/h), particles larger than about 100 µm are likely to settle within 6 to 9 metres (m) from the point of emission. Particles that are 30 to 100 µm in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within tens to hundreds of metres from the point of release. Smaller particles have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence (US EPA 1995).

- For air quality impact assessments, the most important are suspended particulates (SP) consisting of fractions no greater than 30 µm in aerodynamic diameter. The following definitions apply to particulate classes in the ≤30 µm range:
  - SP, which is often used as a surrogate for TSP, is defined as PM with an aerodynamic diameter no greater than 30 µm. SP may also be denoted as PM30. An effective separation size of 30 µm aerodynamic diameter is frequently assigned to the standard high volume air sampler;
PM\textsubscript{10} (particulate matter PM\textsubscript{10} refers to particulate that is greater than 10 \(\mu\text{m}\) in aerodynamic diameter). Because PM\textsubscript{10} is the size basis for the current primary Ambient Air Quality Objectives and Standards (AAQOS) for particulate matter, it represents one of the particle size ranges of the regulatory interest in some Canadian jurisdictions, for example British Columbia, Ontario and Newfoundland, and in the US; and

PM\textsubscript{2.5} (particulate matter PM\textsubscript{2.5} refers to particulate with an aerodynamic diameter no greater than 2.5 \(\mu\text{m}\)). Some provinces, including British Columbia and the Northwest Territories have introduced AAQOS for this group of particles. There are also Canada Wide Standards for PM\textsubscript{2.5}.

Fugitive dust emission rates depend on several factors, with the most important being wind speed, moisture content and dust density. Maximum fugitive emissions will take place during windy weather with small and light particles present in dry active surface material.

The following sections describe the main fugitive emission sources expected from the proposed project activities. Detailed calculations of particulate emissions are shown in Appendix 6.2-B.

1.3.2.1 In Pit Materials Handling

A mixed fleet of front-end wheel loaders and hydraulic excavators will be employed to load the blasted ore onto off-road haulage trucks. The materials will be dumped to a mobile mining sizer / crusher hopper for conveying into the stockpile at the processing plant. Also, in pit material bulldozing will generate fugitive dust.

1.3.2.2 Crushed Ore Stockpile and Conveyor

The Project as designed will include an outdoor, uncovered 40,000 tonnes live load crushed ore stockpile to be located near the plant building (mill). This stockpile will be subject to wind erosion. Damping of crushed ore by the conveyor will add to stockpile emissions.

- Dust emission levels from an open surface of a conical storage pile will depend on the following factors:
  - Age of the pile;
  - Moisture content;
  - Proportion of aggregate fines;
  - Material specific gravity; and
  - Wind speed.

1.3.2.3 Overburden and Waste Rock Management Facility Wind Erosion

The wind erosion emissions from the active storage area depend on silt content in aggregate, the number of days with >0.25 millimetres (mm) of precipitation per year, and
percentage of time that the unobstructed wind speed exceeds 5.4 m/s at the mean pile height (AWMA 1992).

1.3.2.4 Wheel Entrainment Emissions

Dust emissions from road travel result from dust entrainment by vehicle wheels and the aerodynamic wake created by moving vehicles. The force of the wheels on the road surface causes pulverization of the surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents in turbulent shear with the surface. The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. As well, dust emission from unpaved roads is proportional to the fraction of silt (particles smaller than 75 µm in diameter) in the road surface materials. In the Project a small fleet of 136 tonnes capacity haul trucks will transport the ore and associated waste rock to mobile sizers located in the pit. The trucks will also be used for the cross-bench material transfer.

1.3.2.5 Mobile Sources

The mobile sources consist of the various vehicles used at the Project site. These include ore trucks used to transport materials in the pit from the ore shovel to the main crusher, dozers, front-end loaders, transport trucks, and pickup trucks. Some of the vehicles travel along the surface dirt roads inside the proposed Project boundaries while others remain in one general location such as the mine pit below the grade. The vehicles produce both exhaust emissions and fugitive dust emissions.

Most of the pollutants from internal combustion (IC) engines are emitted through the exhaust. Evaporative losses are insignificant in diesel engines due to the low volatility of diesel fuels. Combustion of diesel fuel involves emissions of NO₂, SO₂, CO, CO₂, water vapour and some small quantities of unburned HC, PM and other compounds. Equipment units will be powered by electric motors. They are excluded from emissions inventory.

1.3.2.6 Tailings

No emissions are anticipated from the tailings management facility. Coarse and fine processed molybdenite will be discharged as a slurry with high water content and as such is not considered to be a potential source of fugitive dust.

1.3.2.7 Blasting

The emissions from blasting are influenced by many factors such as explosive composition, product expansion, method of priming, length of charge, and confinement. These factors are difficult to measure and control in the field. The proposed Project explosive will be ammonium nitrate – fuel oil (ANFO) loaded in water-proof plastic liners. Fragmentation will generate materials, on average, less than 600 mm in size. On average, blasting will be conducted every two days at a regular time providing approximately 2,300 tonnes of broken rock per blast.
TSP emissions induced by ore and overburden blasting are estimated with the AP-42 emission factor (US EPA 1995). It is dependant on the area of the blast according to the relationship:

\[
TSP = 0.00022 A^{1.5}
\]

The scaling factor for PM\(_{10}\) is 0.52 and PM\(_{2.5}\) is 0.03.

The assumed blasting area is 60 m x 30 m which is similar to the blasting area reported for the Diavik Mine. With this area of 1,800 metres square (m\(^2\)), the TSP emission would be 16.8 kg/blasting event. Below are predicted particulate emissions for the pit during the operations phase.

<table>
<thead>
<tr>
<th>Particulate size, µm</th>
<th>&lt; 30</th>
<th>&lt; 10</th>
<th>&lt; 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission per blast, kg</td>
<td>16.8</td>
<td>8.74</td>
<td>0.50</td>
</tr>
<tr>
<td>Annual emission, t/a</td>
<td>0.861</td>
<td>0.448</td>
<td>0.025</td>
</tr>
</tbody>
</table>

The wet weather coefficient is included in the yearly estimate. Blasting dust will be airborne regardless of precipitation, but if rain or snow is present the dust will be washed out and no dispersion will take place.

In addition to dust emissions, blasting will generate various gases which are products of extremely rapid combustion of fuel oil and oxygen released by ammonium nitrate. CO is the pollutant produced in greatest quantity. Nitrogen oxides (NO\(_x\)) (both nitric oxide [NO] and NO\(_2\)) are formed, but only limited data is available on these emissions. SO\(_2\) will be also emitted but only in small quantities. Traces of hydrogen sulfide, hydrogen cyanide, and ammonia all have been reported as products of explosives use. With the ANFO usage detailed above, the emissions of gaseous contaminants will be as follows:
Contaminant | CO | NOx | SO2  
--- | --- | --- | ---  
Emission factor, kg/Mg | 34 | 8 | 1  
Emissions per blast, kg | 793 | 186 | 23  
Annual emission, tonnes | 123.708 | 28.548 | 3.588  

**Note:** CO - carbon monoxide; kg - kilogram; kg/Mg - kilogram per megagram; NOx - nitrogen oxide; SO2 - sulphur dioxide

As shown above, blasting can result in a concentrated plume of PM and gases, but the volume and time duration of such plumes are constrained. The main purpose of blasting is to fragment hard rock and molybdenum ore that would be too hard to dig through otherwise. The blast will last less than one minute and will be confined to the pit area below the grade. Even when blasts result in a visible plume, the contribution to 1 hour and 24 hour averages, as in the Ambient Air Quality Regulations, will be negligible. Much of the solid material in the initial plume is larger than the aerodynamic diameter of particles that can remain suspended in the air, and fall within a relatively short distance (e.g., 100 m) of the blast site within the pit area.

To help minimise impacts from blasting on air quality Kitsault will use a number of techniques. These include reducing the maximum instantaneous charge, drill hole spacing and orientation, initiation sequence and direction, delaying blasts in adverse weather conditions (e.g. strong wind speed or temperature inversion) limiting the size of the blast area, recording, reviewing and altering future blast designs, and using technical blasting consultants where necessary.

1.3.2.8 Diesel Fuel Storage Tanks

In order to provide the mine with adequate fuel, oil and lubricants to operate equipment and infrastructure, a tank farm will be established near the processing facility. The tank farm will have a manifold/valve and a vapour control system in order to feed the tanks for bulk products and to mitigate emissions. Storage of all bulk products will be in double wall fixed roof Envirotank. Intermittent emissions of fuel vapours associated with evaporative losses during storage (known as breathing losses or standing storage losses) and evaporative losses during filling and emptying operations (known as working losses) will be insignificant due to the very low vapour pressure of diesel (0.4 mm Hg at 20°C) and the small volume of the tank for the gasoline which has higher vapour pressure than diesel. Therefore, tank emissions are considered to be negligible and are not expected to introduce perceptible changes to ambient air quality.

1.3.2.9 Greenhouse Gases

GHG such as CO2, methane (CH4) and nitrous oxide (N2O) are produced during fuel combustion in diesel engines. Nearly all of the fuel carbon is converted to CO2 during the combustion process. This conversion is relatively independent of the firing configuration. Formation of another GHG, CO will also take place, but its amount is insignificant compared
to the amount of CO\textsubscript{2} produced. Formation of N\textsubscript{2}O during the combustion process is

governed by a complex series of reactions and is dependent upon many factors. However,

the formation of N\textsubscript{2}O is minimised when combustion temperatures are kept high (above

800°C) and excess air is kept to a minimum.

The emissions of CH\textsubscript{4} and N\textsubscript{2}O are related to vehicle miles travelled rather than fuel

consumption, and quantifying their emissions is not as easily estimated for a vehicle as for

CO\textsubscript{2}. On average, their emissions represent roughly 5 - 6% of the GHG emissions from

passenger vehicles, while CO\textsubscript{2} emissions account for 94-95%, accounting for the global

warming potential of each GHG (US EPA 2010). To simplify this estimate, it is assumed that

CH\textsubscript{4} and N\textsubscript{2}O account for 5% of diesel engine emissions (in terms of CO\textsubscript{2} equivalent), and

the CO\textsubscript{2} estimate should be multiplied by 100/95 to incorporate the contribution of the other

GHGs. This multiplier incorporates the global warming potential (GWP) for CH\textsubscript{4} which is 21

and for N\textsubscript{2}O is equal to 310 (EPA 2010).

With these assumptions, annual GHG emissions consist of CO\textsubscript{2} associated with the

combustion of natural gas and diesel fuel. CO\textsubscript{2} emissions for diesel engines are estimated

with reference to the Intergovernmental Panel on Climate Change (IPCC) guideline

available online at http://www.ipcc.ch. It requires that an oxidation factor be applied to the

carbon content to account for a small portion of the fuel that is not oxidized into CO\textsubscript{2}. For all

oil and oil products, the oxidation factor used is 0.99 (99% of the carbon in the fuel is

eventually oxidized, while 1 percent remains un-oxidized). To calculate the CO\textsubscript{2} emissions

from a gallon of fuel, the carbon emissions are multiplied by the ratio of the molecular weight

of CO\textsubscript{2} (m.w. 44) to the molecular weight of carbon (m.w. 12): 44/12. The equation for

calculating CO\textsubscript{2} emissions (E) from a gallon of diesel is defined as:

\[
E = 2,778 \text{ grams} \times 0.99 \times (44/12) = 10,084 \text{ grams} = 10.1 \text{ kg / gallon (US)}
\]

Annual diesel fuel consumption in Year 2 will be 3.380 x 10\textsuperscript{6} gallons (worst case scenario).

Therefore the annual CO\textsubscript{2} emissions will be:

\[
E = 10.1 \text{ kg/gal} \times 3.380 \times 10^6 \text{ gal/a} \times 1 \text{ t/1000 kg} = 34,138 \text{ t CO\textsubscript{2} /a.}
\]

The addition of CH\textsubscript{4} and N\textsubscript{2}O (5% extra) yields total GHG emissions of 35,845 t CO\textsubscript{2} eq /a.

In summary, the total annual GHG emissions resulting from the combustion of diesel fuel will

be 35.845 kilotonnes (kt) of CO\textsubscript{2} equivalent. Under the Greenhouse Gas Reductions Target

Act, the British Columbia government made a legally binding commitment to reduce GHG

emissions by at least 33% by 2020 and 80% by 2050 below the 2007 level (BC MOE 2010).

Total provincial GHG emissions in 2008 were 68.7 megatonnes (Mt) and in Canada they

were 263 Mt. Predicted Project annual contribution to the BC inventory will be 0.0522% and

0.0136% of Canadian GHG emissions. Kitsault will implement several initiatives to control

GHG emissions including development and implementation of energy saving plans,
purchasing energy-efficient equipment and power, and other means.
1.3.2.10 Ozone

Ozone (O₃) occurs naturally at the earth’s surface due in part to transport downward from the ozone layer in the stratosphere and in part to naturally occurring chemistry in the lower atmosphere (the troposphere). However, human activities have caused an increase in ozone at the global scale, especially in the northern hemisphere. O₃ is the primary ingredient of photochemical smog, the type of air pollution that is associated with sunlight-driven chemical reactions (Sillman 2003).

Pollution events with high ozone are associated specifically with sunshine and warm temperatures. High O₃ is very rare when temperatures are below 20°C, and are usually associated with temperatures above 30°C. High O₃ is also associated with relatively light winds and conditions that suppress vertical mixing in the atmosphere (thermal inversions or subsidence layers), but the most important conditions are sunshine and high temperatures (Sillman 2003). For these reasons high ozone events are unlikely to occur at the proposed Project airshed because of low temperatures much less than 30°C. As shown in Table 6.2.3-1, the annual 30-year average temperature is only 7.1°C and the warmest month is August with 13.5°C. Sunshine is also in short supply because of northern location with only 26% of possible daylight hours (Table 6.2.3-1).

The project emissions may potentially cause ozone formation in a series of complex cycles involving NOₓ, CO, and VOCs in the presence of sunlight. NOₓ, CO, and VOCs are called O₃ precursors. Nitric oxide (NO), which is the dominant NOₓ emission constituent, is scavenged by ambient O₃ (forming NO₂) near the emission sources. Farther downwind, the NOₓ / VOC photochemical reactions (with the aid of biogenic VOC emissions from forests and vegetation) tend to lead to more net O₃ formation and result in relatively larger increases in ground-level concentrations of O₃ (Wayne 2000).

O₃ was not measured in the proposed Project airshed and concentrations were not modeled for emission sources. It is unlikely that insignificant project emissions of NO₂ (1,293 tonnes per year (t/y)) and VOCs (approximately 0.58 t/y based on diesel engines emission factors) will contribute significantly to additional increment in ground-level ozone concentrations. In a similar pit mine Mt. Milligan Copper-Gold Project in the northern BC (EIA 2008) predicted changes in ambient ozone were estimated as less than 1 part per billion by volume (ppbv). This increase is insignificant considering typical background O₃ levels at remote locations in the Northern Hemisphere are from 20 ppbv to 40 ppbv (Sillman 2003).

1.3.2.11 Metallic Elements

Concentration of metallic elements in ambient air is associated with metals content in suspended particulates (SP). Molybdenum (Mo), silver (Ag) and lead (Pb) are of a special interest for the proposed Project due to their commercial value and potential environmental impact. The average concentrations of these metals in the mined and processed mineral materials is as follows:

- Mo - 0.044%
• Ag - 5.29 ppm; and
• Pb - 245 ppm.

Estimated emission of SP in Year 2 (worst case scenario) is 31.248 gram per second (g/s) (Table 6.2.2.6-5), which is equal to 2,700 kilograms per day (kg/d). Assuming the SP composition the same as the mineral material, daily emission will be as low as 1.188 kg of Mo, 0.014 kg of Ag and 0.662 kg of Pb.

1.3.2.12 Hydrocarbons / Volatile Organic Compounds

HC / VOC will be present in ambient air at the proposed Project site. No federal or provincial objectives or standards exist for assessment of exposes to HC, of which VOCs are subset. While HC / VOCs are not criteria pollutants, they are usually highly reactive hydrocarbons which play an important role in the formation of ground level O₃ (smog). Some of them are also toxic at higher concentrations, having both carcinogenic and non-carcinogenic hazards. Their allowable maximum concentrations at the workplace are regulated by the occupational exposure limits which are beyond the scope of environmental assessment. HC are a group of chemical compound composed of carbon and hydrogen. When in a gaseous form, HC are called VOCs. Several HC and VOC are heavy gases or volatile compounds with a strong odor. They appear mostly as the result of the incomplete combustion of fossil fuel or by-products of the petrochemical industry. In the proposed Project the source of HC / VOCs will be internal combustion engines. Diesel fuel has a very high boiling point and does not evaporate at normal temperatures. Therefore, emissions of HC / VOCs during refueling operations and storage are negligible. Diesel engine emissions of are estimated using AP-42 emission factors (US EPA 1995), diesel fuel consumption rate during Year 2 operation (the worst case scenario) and the ratio of VOCs to HC in diesel exhaust which is 1.053 (US EPA 2005). The calculation revels HC / VOCs emission equal to 0.2388 kg/d or 0.0028 g/s. Because of a very low concentrations and lack of air quality objectives, modelling of HC / VOCs has not been carried out.

1.3.2.13 Dustfall

Dustfall is associated with the potential drift of fugitive dust. The drift distance is governed by the initial injection height of the particle, the terminal settling velocity of the particle, and the degree of atmospheric turbulence. Theoretical drift distance, as a function of particle diameter and mean wind speed, has been computed for fugitive dust emissions. Results indicate that, for a typical mean wind speed of 16 km/h, particles larger than about 100 µm are likely to settle out within 6 to 9 m from the edge of the road or other point of emission. Particles that are 30 to 100 µm in diameter are likely to undergo impeded settling. These particles, depending upon the extent of atmospheric turbulence, are likely to settle within tens to a few hundred metres from the road, pit or solid waste disposal area within the Project property line (US EPA 1995). It was shown in a similar Open Pit mining project that the monthly dustfall decreased from 12 g/m² at the edge of the pit to 4 g/m² at approximately 400 m off the pit, still within the property fenceline (EIA 2011). BC monthly dustfall objective is 8.7 g/m² (BC MOE 1979). Because of larger particles transportation range is confined to
the proposed Project area within the project boundary, dustfall modelling was not carried out. Smaller particles such as PM$_{2.5}$, PM$_{10}$, and SP, have much slower gravitational settling velocities and are much more likely to have their settling rate retarded by atmospheric turbulence. Their dispersion was modelled to find their maximum concentrations beyond the fenceline where there is public access and to assess the level of compliance with relevant ambient air quality objectives.

1.3.3 Dispersion Modelling

The AERMOD model was used because this model is capable of addressing the potential air quality for the proposed mine and ore processing facility, as well as addressing all nearby terrain locations, simultaneously. The BC Ministry of Environment (BC MOE) lists the AERMOD model as a refined core model for assessments in British Columbia in their Guidelines for Air Quality Modelling in British Columbia (BC MOE 2008). The AERMOD model was discussed with BC MOE Meteorologist staff as acceptable model in this particular application. The BC modelling guideline was used as the basis for modelling procedures related to this air quality evaluation.

1.3.3.1 Model Overview

The AERMOD model features include:

- The ability to mode dispersion of primary pollutants and toxic and hazardous waste pollutants;
- The ability to handle multiple sources in an industrial complex (point, area, volume and pit types) with no buildings or single or multiple buildings with building downwash;
- Constant or time-varying emissions;
- Gas and particle depositions;
- Concentration estimates for all terrain locations, except in lee areas;
- Predictions at distances up to 50 km from the source;
- Specification of receptors locations as gridded and/or discrete receptors in Cartesian or polar coordinates; and
- Use of real-time meteorological data to account for the atmospheric conditions that affect the dispersion of air pollutants.

1.3.3.2 Meteorology for Modelling

AERMOD is intended to use hourly averaged meteorological data sequentially for at least one year if site specific or MM5 data is used and 5-year regional data. Based on a dialog with BC MOE regarding calms effect and monitoring data quality on the model predictions, as well as Section 7 – Model Inputs Meteorological Data of the Guideline for Air Quality Dispersion Modelling in BC, the 5th generation mesoscale meteorological model (MM5) output data was purchased from Lakes Environmental (www.weblakes.com) for this Project. A two-year MM5 data was processed with AERMET program resulting in two types of
output: an hourly surface met data file (in SAMSON format) and an upper air met data file (in TD-6201 format). The final output was generated by creating a pseudo met-station at the site Kitsault mine location. This is shown in wind rose plot (Figure 1.3-1) generated with WRPLOT. The wind speed statistics is shown in Figure 1.3-2.

Figure 1.3-1: MM5 Data Wind Rose for the Project Site
Detailed examination of surface met file revealed occurrence of 75 hours of calms (wind speed < 0.5 m/s) over one year period (8,760 hours). The longest continuous calm period of 11 hours is reported for 7 April 2009 starting at 22:00 and ending the next day at 09:00. A few cases of continuous 2 hour calms are also shown. No special calms treatment of the meteorological data is required by AERMET. The model will identify the calm periods (those hours where the wind speed is below the anemometer threshold sensitivity) and skip these hours. Additional information concerning application of AERMET to run the MM5 data is shown in Appendix 6.2-D.
The wind data collected by Rescan at the proposed Project site in 2009 and 2010 reported in Appendix 6.2-A Atmospheric Environment Baseline Report (Knight Piésold 2011) differs from the MM5 wind data. This is summarised in Table 1.3-2.

Table 1.3-2: Comparison of Wind Data

<table>
<thead>
<tr>
<th>Wind Class (m/s)</th>
<th>MM5 (%)</th>
<th>Weather Station (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.5</td>
<td>1.6</td>
<td>12.1</td>
</tr>
<tr>
<td>0.5 – 2.1</td>
<td>11.9</td>
<td>50.8</td>
</tr>
<tr>
<td>2.1 – 3.6</td>
<td>23.9</td>
<td>24.0</td>
</tr>
<tr>
<td>3.6 – 5.7</td>
<td>34.8</td>
<td>11.4</td>
</tr>
<tr>
<td>5.7 – 8.8</td>
<td>22.5</td>
<td>1.6</td>
</tr>
<tr>
<td>8.8 – 11.1</td>
<td>3.9</td>
<td>0.1</td>
</tr>
<tr>
<td>&gt; 11.1</td>
<td>1.4</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: m/s - metres per second; MM5 - 5th generation mesoscale meteorological model; % - percent

Lower wind speeds measured by the site weather station at a fixed location can be attributed to the dumping effect of nearby natural wind barriers such as hills and trees. The site-specific wind data is required for prediction of fugitive dust emission rate from open area and volume sources. The MM5 data is generated by the meso-scale prognostic model. It represents local and regional ground and upper atmosphere winds which facilitate dispersion modelling.

1.3.3.3 Emissions for Dispersion Modelling

Three types of emission sources were considered for modelling: area, volume and open pit:

- An area source is an emission into the atmosphere that is distributed over a stationary spatial area. Parameters normally required for area sources include the coordinates of the area perimeter, the release height, and the mass emission flux rate of the pollutants of concern (i.e., mass emission rate per unit of area, g/(s-m²));
- A volume source is an emission to the atmosphere that has an initial width and depth at a stationary release point. Parameters normally required for volume sources include the coordinates of the volume dimensions and the mass emission rates; and
- Open pit sources are used to simulate fugitive emissions from below-grade open pits, such as surface mines and stone quarries. The open pit algorithm uses an effective area for modelling pit emissions, based on meteorological conditions, and then utilises the numerical integration area source algorithm to model the impact of emissions from the effective area sources. The models accept rectangular pits with an optional rotation angle specified relative to a north-south orientation.
Proposed location of emission sources included in Year 2 modelling (worst case scenario) are presented in Figure 1.3-3. Industrial flow path-diagrams showing potential emission sources in the processing line is shown in Figure 1.3-4.

Estimated emission rates of modelled contaminants in Year 2 are shown in Tables 1.3-3 and 1.3-4.
Simplified flow-path diagram showing potential sources of dust emission.

- **Roughers Scavengers**
- **1st Cleaners**
- **Scavenger Regrind Mill**
- **2nd Cleaners**
- **1st Cleaner Scavengers**
- **De-Pyritizing**
- **Scavenger Rerind Thickener**
- **3rd Cleaners**
- **Scavenger Rerind Mill**
- **4th Cleaners**
- **Concentrate Thickener**
- **5th Cleaners**
- **Concentrate Filter**
- **Tailings Pond**
- **De-Pyritizing**
- **DUST FREE WET PROCESS**
- **Concentrate Dryer**
- **Concentrate Storage Bin**
- **DUST COLLECTION**

**FUGITIVE DUST EMISSIONS**
- **STOCKPILE WIND EROSION**
- **CONVEYOR DUMPINGS**

**CLIENT**
- Kitsault Mine Project

**ANALYST**
- AMEC Earth & Environmental

**DATUM**
- Undefined

**PROJECTION**
- Undefined

**SCALE**
- Not to Scale

**DATE**
- March 2011

**PROJECT TITLE**
- Simplified flow-path diagram showing potential sources of dust emission
<table>
<thead>
<tr>
<th>Area</th>
<th>Equipment Name</th>
<th>Model</th>
<th>Location</th>
<th>Power (HP)</th>
<th>Emission Factor (g/HP-h)</th>
<th>Emission Rate (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>UTM (mE)</td>
<td>UTM (mN)</td>
<td>PM10 PM2.5 NOx SO2 CO2</td>
<td>CO2 PM10 PM2.5 NOx SO2 CO2</td>
</tr>
<tr>
<td>Pit</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Pit</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Pit</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Pit</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Pit</td>
<td>Hammer drill</td>
<td>Sandvik QXR 920</td>
<td>540</td>
<td>0.6345</td>
<td>0.6028 6.3053 0.0049 0.0024 0.1461</td>
<td>0.0962 0.0904 0.9458 0.0007 0.0004 0.0219</td>
</tr>
<tr>
<td>Pit</td>
<td>Hydraulic shovel</td>
<td>Komatsu PC5500</td>
<td>2520</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1607 0.1527 3.6176 0.0034 0.0017 0.1023</td>
</tr>
<tr>
<td>Total in pit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0011 0.9510 21.3379 0.0201 0.0098 0.5984</td>
<td></td>
</tr>
<tr>
<td>Surface</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Surface</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Surface</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Surface</td>
<td>Haul truck</td>
<td>Cat 793D</td>
<td>2337</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.1490 0.1416 3.3549 0.0032 0.0016 0.0948</td>
</tr>
<tr>
<td>Surface</td>
<td>Track dozer</td>
<td>Cat D10T</td>
<td>433</td>
<td>0.2330</td>
<td>0.2214 4.1758 0.0049 0.0024 0.1461</td>
<td>0.0280 0.0266 0.5023 0.0006 0.0003 0.0176</td>
</tr>
<tr>
<td>Surface</td>
<td>Track dozer</td>
<td>Cat D10T</td>
<td>433</td>
<td>0.2330</td>
<td>0.2214 4.1758 0.0049 0.0024 0.1461</td>
<td>0.0280 0.0266 0.5023 0.0006 0.0003 0.0176</td>
</tr>
<tr>
<td>Surface</td>
<td>Grader</td>
<td>Cat 16M</td>
<td>297</td>
<td>0.2523</td>
<td>0.2397 3.8239 0.0049 0.0024 0.1461</td>
<td>0.0208 0.0198 0.3159 0.0004 0.0002 0.0121</td>
</tr>
<tr>
<td>Surface</td>
<td>Grader</td>
<td>Cat 16M</td>
<td>297</td>
<td>0.2523</td>
<td>0.2397 3.8239 0.0049 0.0024 0.1461</td>
<td>0.0208 0.0198 0.3159 0.0004 0.0002 0.0121</td>
</tr>
<tr>
<td>Surface</td>
<td>Wheel dozer</td>
<td>Cat RTD 834G</td>
<td>525</td>
<td>0.2330</td>
<td>0.2214 4.1758 0.0049 0.0024 0.1461</td>
<td>0.0340 0.0323 0.6090 0.0007 0.0004 0.0213</td>
</tr>
<tr>
<td>Surface</td>
<td>Front-end loader</td>
<td>Komatsu WA1200</td>
<td>1565</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.0988 0.0948 2.2466 0.0021 0.0010 0.0635</td>
</tr>
<tr>
<td>Surface</td>
<td>Hydraulic excavator</td>
<td>Cat 345CL</td>
<td>345</td>
<td>0.2330</td>
<td>0.2214 4.1758 0.0049 0.0024 0.1461</td>
<td>0.0223 0.0212 0.4002 0.0005 0.0002 0.0140</td>
</tr>
<tr>
<td>Surface</td>
<td>Water truck</td>
<td>Cat 777</td>
<td>950</td>
<td>0.2296</td>
<td>0.2181 5.168 0.0049 0.0024 0.1461</td>
<td>0.0806 0.0757 1.3638 0.0013 0.0006 0.0386</td>
</tr>
<tr>
<td>Grand total pit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.9117 1.8160 41.0134 0.0394 0.0193 1.1744</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** CO - carbon monoxide; CO₂ - carbon dioxide; g/s - grams per second; HP - horsepower; mE - minutes east; mN - minutes north; NOₓ - nitrogen oxide; PM₁₀ - particulate matter with an aerodynamic diameter no greater than 2.5 µm; PM₁₀ - particulate matter with an aerodynamic diameter no greater than 10 µm; SO₂ - sulphur dioxide; UTM – Universal Transverse Mercator
Table 1.3-4: Emission Rate of Suspended Particulates From Area and Volume Sources

<table>
<thead>
<tr>
<th>Area and Volume Sources</th>
<th>Emission Rate (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SP</td>
</tr>
<tr>
<td>Overburden / waste rock areas</td>
<td>0.359</td>
</tr>
<tr>
<td>Haul truck wheel entrainment</td>
<td>21.712</td>
</tr>
<tr>
<td>Waste bulldozing</td>
<td>0.615</td>
</tr>
<tr>
<td>Ore dumping and hauling</td>
<td>0.396</td>
</tr>
<tr>
<td>Diesel exhaust in pit</td>
<td>-</td>
</tr>
<tr>
<td>Diesel exhaust surface sources</td>
<td>-</td>
</tr>
<tr>
<td>Coarse ore stockpile</td>
<td>0.481</td>
</tr>
<tr>
<td>Conveyor drop on stockpile</td>
<td>7.685</td>
</tr>
<tr>
<td>Total (g/s)</td>
<td>31.248</td>
</tr>
<tr>
<td>Total annual (tonnes/year)</td>
<td>985</td>
</tr>
</tbody>
</table>

Note: g/s - grams per second; PM\(_{2.5}\) - particulate matter with an aerodynamic diameter no greater than 2.5 µm; PM\(_{10}\) - particulate matter with an aerodynamic diameter no greater than 10 µm; SP - suspended particulates

1.3.3.4 Modelling Outline

The AERMOD dispersion modelling options selected for this project included:

- Regulatory default;
- Concentration output for gases, PM\(_{10}\) and PM\(_{2.5}\);
- Rural area;
- Elevated terrain calculation algorithms with uploaded GridASCII terrain data;
- No exponential decay;
- The 1 h, 8 h, 24 h, monthly, and annual averaging time, depending on AAQO for a particular contaminant;
- No building downwash effect;
- Exclusion of the project area within the fence line;
- All wind speed and stability classes (worst case scenario); and
- First highest concentration values and 99.95th percentile for NO\(_2\).

In the receptor pathway of the model the Cartesian grid network with uniform grid spacing was used. After defining the plant boundaries the model was run for the first time with the coarse grid of 1000 m. After determining the areas of maximum impact it was run the second time with the finer receptor grid defined as plant boundary (fence line) receptors and area receptors determined as multi-tier Cartesian grid.

The modelled study areas were adjusted accordingly with reference to concentrations obtained in the first run. Extended modelled domain allows not only to assess compliance
with AAQO but also to assess impact on other components of the environment such as soil, plants and surface water.

The spatial applicability of the AAQO usually applied to areas where there is public access (i.e., beyond the plant boundary). Within the plant boundary, meeting occupational health and safety criteria is of primary importance. The plant boundary is determined by the facility fence line or the perimeter of disturbed area that defines where public access is restricted. For that reason, the modelling results don’t show concentrations within the proposed Project area.

Temporal boundaries for dispersion modelling have been developed in consideration of those time periods during which the proposed Project air emissions have the highest potential to degrade ambient air quality which will be in Year 2. In general, emissions that could affect air quality will be relatively short-term from such operations as blasting, fuelling, welding, tire service, etc. Therefore, they were not included in the model. However, emissions from such sources as haul trucks, waste disposal, grading, and backfilling will be fairly regular so they were modelled.

1.3.3.5 Modelling Results and Assessment

Modelling results consist of graphical and tabular maximum ground level concentrations (in μg/m³) for SO₂, NO₂, TSP, PM₁₀ and PM₂·₅. The model predictions in a graphical form are shown in Figures 1.3-5 to 1.3-12. Because of low concentrations of SO₂, NO₂ (annual) and PM₂·₅ (annual), the respective graphs are not shown. However, the modelling results have been saved in the model-generated tables.
Comments
Maximum ground level concentration isopleths of SO₂.
Average time: 1 hour.
In-pit and surface SO₂ emission Sources

Reference:
Aermod View - Lakes Environmental Software

---

Dispersion Modelling of SO₂ (Sulfur Dioxide) 1-hour Average

Figure 1.3-5

CLIENT: Avanti Kitsault Mine Ltd.

PROJECT: Kitsault Mine Project

DATE: April 2011

SOURCES: 13

RECEPTORS: 564

ANALYST: MY

JOB No: VE51988

SOURCES: 2.154 ug/m³

CONCENTRATION: 2.154 ug/m³
The highest ground level concentration in ug/m³ beyond the fence line.

AAOQ for NO₂ 1-hour average is 400 ug/m³.
AAQO for NO2 1-hour average is 400 ug/m³.

The highest ground level concentration in ug/m³ 99.95th percentiles beyond the fence line AAQO for NO2 1-hour average is 400 ug/m³.

Dispersion Modelling of NO₂ (Nitrogen Dioxide) 1-hour Average 99.95th Percentiles

Reference: Aermod View - Lakes Environmental Software
The highest ground level concentration in ug/m³ beyond the fence line.

AAQO for NO₂ 1-hour average is 200 ug/m³.

Reference:
Aermod View - Lakes Environmental Software
Comments
The highest ground level concentration in ug/m³ beyond the fence line.
AAQO for NO₂ annual average is 60 ug/m³.

Reference:
Aermod View - Lakes Environmental Software

Dispersion Modelling of NO₂ (Nitrogen Dioxide) Annual Average

Avanti Kitsault Mine Ltd.

Kitsault Mine Project

Figure 1.3-9

CLIENT:

PROJECT:

DATE: April 2011

ANALYST: MY

JOB No: VES1988

CARGO: RP

PDF FILE: 04-50-007_N02_Annual.pdf

SOURCES: 13

RECEPTORS: 1491

OUTPUT TYPE: Max.

CONCENTRATION: 3.7029 ug/m³
The highest ground level concentration in ug/m³ beyond the fence line.

AAQO for TSP 24-h average is 120 ug/m³.

**Reference:**
Aermod View - Lakes Environmental Software
Comments

The highest ground level concentration in ug/m$^3$ beyond the fence line.

AAQO for PM$_{10}$ 24-h average is 50 ug/m$^3$

Reference:
Aermod View - Lakes Environmental Software

Figure 1.3-11

Dispersion Modelling of PM$_{10}$ (Particle Matter) 24-hour Average

CLIENT: Avanti Kitsault Mine Ltd.
PROJECT: Kitsault Mine Project

DATE: April 2011
JOB No: VE51988
PDF FILE: 04-50-009_PM10_24hour.pdf

ANALYST: MY
SOURCES: 17

QA/QC: RP
CONCENTRATION: 45.8818 ug/m$^3$

OUTPUT TYPE: MAX: 1769
The highest ground level concentration in ug/m³ beyond the fence line. AAQO for PM$_{2.5}$ 24-h average is 25 ug/m³.

Reference:
Aermod View - Lakes Environmental Software
The predicted hourly, daily and annual maximum ground level concentrations (GLC) for each of the modelled contaminants (model prediction plus baseline) and the percentage of compliance with AAQO are summarised in Table 1.3-5. The baseline concentrations measured at the proposed Project site are discussed in details in Section 6.2.2.3.

Table 1.3-5: Summary of Dispersion Modelling Results

<table>
<thead>
<tr>
<th>Air Contaminant</th>
<th>Averaging Period</th>
<th>AAQO (µg/m³)</th>
<th>Maximum GLC (µg/m³)</th>
<th>% AAQO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model</td>
<td>Background</td>
<td>Total</td>
</tr>
<tr>
<td>Total suspended particulate (TSP)</td>
<td>24 hour</td>
<td>120</td>
<td>4</td>
<td>126</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>70</td>
<td>N/A</td>
<td>23</td>
</tr>
<tr>
<td>Inhalable Particulate (PM₁₀)</td>
<td>24 hour</td>
<td>50</td>
<td>3</td>
<td>49</td>
</tr>
<tr>
<td>Fine particulate (PM₂.₅)</td>
<td>24 hour</td>
<td>25</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Nitrogen dioxide NO₂</td>
<td>1 hour</td>
<td>400</td>
<td>11</td>
<td>534</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>400</td>
<td>11</td>
<td>373 (1)</td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>200</td>
<td>11</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>100</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Sulphur dioxide SO₂</td>
<td>1 hour</td>
<td>450</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>150</td>
<td>4</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>30</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>1 hour</td>
<td>15000</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>8 hour</td>
<td>6000</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: AAQO - Ambient Air Quality Objectives; CO - carbon monoxide; PM₂.₅ - particulate matter with an aerodynamic diameter no greater than 2.5 µm; PM₁₀ - particulate matter with an aerodynamic diameter no greater than 10 µm; NO₂ - nitrogen dioxide; SO₂ - sulphur dioxide; µg/m³ - micrograms per cubic metre; % - percent

(1) Max GLC 99.95th percentile

The dispersion model predictions indicate that in general the Project will comply with relevant ambient air quality objectives. However, the 1 hour maximum NO₂ concentrations presented in Figure 6.2.2.6-6 shows exceedances of AAQO by approximately 33% in the immediate vicinity of the fence line. However, this concentration is only 53% of the maximum tolerable national objective which is 1,000 µg/m³. Dispersion modelling of NO₂ 1-h average 99.95th percentile, the fifth highest prediction, revealed maximum GLC equal to 362 µg/m³ which is 7% less than the maximum GLC (Figure 6.2.2.6-7). As shown in Figures 6.2.2.6-8 and 6.2.2.6-9, the 24-hour and annual maximum GLC of NO₂ are well below the respective AAQO.

Concentrations of SO₂ are predicted to be very low for all average times due to new low-sulphur diesel regulations have been enforced recently in Canada. Carbon monoxide will be at the background concentration levels due to atmospheric dispersion and low concentrations at diesel exhaust. Concentrations of particulate matter (TSP, PM₁₀ and
PM$_{2.5}$) is predicted around the maximum permissible values at 24 hour average time. This can be expected considering large amount of aggregate material being mined, handled and processed.

1.4 Monitoring
The objective of the air quality (AQ) monitoring is to provide data to determine the environmental effect of Project activities upon air quality. The AQ monitoring plan will address one of the most prominent issues for mining projects – the concentration of suspended particle matter in the air surrounding the major areas of activity (dynamic monitoring) and the deposition rate of particles (static monitoring).

Dynamic monitoring will be based on high volume (HV) air sampling for PM$_{10}$ and PM$_{2.5}$. There are several dust samplers available on the market. A commonly used one in the mining industry is the Partisol™ Model 2000 monitor or the Met One Instruments E-Sampler. The monitor will be deployed at the plant boundary in the direction of the prevailing wind, away from any taller structures or trees. It operates automatically and the results are extracted on a monthly basis and are compared to the relevant ambient air quality standards in order to determine status of the Project compliance and guide in implementation of the most appropriate mitigation method if necessary.

Static monitoring of dust deposition will follow D1739-98 Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter). It involves installation of a dust canister to measure the amount of dust that settles out of the atmosphere by the effect of gravity deposited on a unit area over a certain length of time. It is proposed to deploy three static samples: near the dynamic sampler, by the pit near the main crusher, and in the area of the processing plant near the ore stockpile. The samplers will be replaced every month and gravitational analyses performed at the accredited laboratory. The ambient air “trigger levels” for dust fallout is a mining-standard of 4 g/(m$^2$ month).

The purpose of ambient air quality monitoring is not only to check degree of compliance but also to:

- Commit to reporting emissions in support of Canada’s Voluntary Challenge Registry (see http://www.ghgregistries.ca/assets/pdf/Challenge_Guide_E.pdf);
- Refine environmental management systems, reporting and stewardship;
- Support research and data-gathering efforts to encourage a better understanding of the issue and its integration into the public policy debate;
- Promote cleaner technology to improve performance; and
- Report PM emissions to National Pollutant Release Inventory (NPRI).

The PM monitoring program will be implemented for the operations phase only as emissions during the construction phase will continuously change spatially and temporally. After the first year of monitoring during the operation phase, the results will be reviewed and, if
necessary, the sampling program will either be maintained, expanded or discontinued. The monitoring program will adhere, where applicable, to British Columbia Field Sampling Manual (Government of BC 2003).
REFERENCES


