VOLUME INDEX

FOR THE DIRECT TRANSFER COAL FACILITY ENVIRONMENTAL IMPACT ASSESSMENT

VOLUME 1: MAIN DOCUMENT

VOLUME 2: APPENDICES I TO VII

Appendix I: Project Application to Port Metro Vancouver (PMV)
Appendix II: Binding and Suppression Agents
Appendix III: Dust Control and Anti-Idling
Appendix IV: Procedures for Small and Large-Scale Coal Spills
Appendix V: Standard Operating Procedures for Barge Transport
Appendix VI: Environmental Management Plans
Appendix VII: Community Engagement

VOLUME 3: APPENDICES VIII TO IX

Appendix VIII: Draft Air Quality Assessment and Draft Air Quality Management Plan
Appendix IX: Health Effects Associated with Exposure to PM
Appendix X: Metro Vancouver Wildlife List (HectaresBC 2013)
Appendix XI: Plants with Special Status
Appendix XII: Wildlife with Special Status
Appendix XIII: Expert Letters
Appendix XIV: VanHook Statement (Fall 2012)

VOLUME 4: ATTACHMENTS

Engineering Drawings

SNC·LAVALIN

APPENDIX VIII

DRAFT AIR QUALITY ASSESSMENT AND DRAFT AIR QUALITY MANAGEMENT PLAN

SNC·LAVALIN

Fraser Surrey Docks Direct Coal Transfer Facility: Air Quality Assessment

DRAFT

Prepared for:

Fraser Surrey Docks LP

11060 Elevator Road
Surrey, BC V3V 2R7

Prepared by:

Levelton Consultants Ltd.

150 - 12791 Clarke Place
Richmond, BC V6V 2H9

Date: November 15th, 2013
Levelton File #: EE12-1611-00

Table of Contents

page

LIST OF FIGURES III

LIST OF TABLES VI

1. INTRODUCTION 1

2. PROJECT DESCRIPTION 1

2.1 Coal Operations 1

2.1.1 Coal Delivery 1

2.1.2 Land-based Operations Traffic 1

2.1.3 Coal Conveyance 2

2.1.4 Dust control 2

2.1.4.1 Wetting 2

2.1.4.2 Dust Suppressing Agents 2

2.1.4.3 Dust Limiting Design 3

2.1.5 Barge Loading 3

2.1.6 Water-Based Traffic Operations 4

2.2 Agricultural Operations 4

2.3 Scope of Air Quality Assessment 5

3. AMBIENT AIR QUALITY OBJECTIVES (AAQOS) 6

4. BACKGROUND AMBIENT AIR QUALITY 7

5. SOURCE EMISSIONS ESTIMATION 13

5.1 Air Emission Contaminants 13

5.2 Project Emission Sources 13

5.3 General Quantification Approach 15

5.4 Coal Handling Operations 15

5.4.1 Railcar Unloading 17

5.4.2 Material Transfer Points 18

5.4.3 Coal Loading onto Barges 19

DRAFT

5.4.4 Coal Stockpiles on Railcars and Barges 20
5.4.5 Tugboats 21
5.4.6 Rail 25
5.5 Agricultural Goods Handling Operation 30
5.5.1 Baghouse Emissions 32
5.5.2 Material Transfer Points 34
5.5.1 Loading onto Ships 35
6. CALMET AND CALPUFF MODELLING METHODOLOGY 37
6.1 Domain and Receptors 37
6.2 CALPUFF Modelling Options 38
6.3 Deposition (Wet Removal and Dry Deposition) 39
6.3.1 Deposition Methodology 39
6.4 Source Parameters 40
6.5 Conversion from NO_x to NO_2 53
7. AIR DISPERSION MODELLING RESULTS 54
7.1 Project Emission Sources (FSD) 54
7.2 Agricultural Emission Sources 64
7.3 Project (FSD) + Agricultural Emission Sources 73
7.4 Rail and Barge (In Transit) 82
8. CONCLUSION 88
APPENDIX A: CALMET QA/QC 89
A-1. Local Climate and Meteorology 90
A-1.1 Temperature 90
A-1.2 Wind 93
A-1.3 Conclusion from Comparison of Meteorological Data to Climate Normals 98
A-2. Modelling Methodology 99
A-2.1 Model Selection 99
A-2.2 CALMET 99

DRAFT

List of Figures

Figure 4-1 Lower Fraser Valley Air Quality Monitoring Network 8

Figure 5-1 Current Fraser Surrey Docks Site Plan 14

Figure 5-2 Coal Handling Operation Process 16

Figure 5-3 Agricultural Goods Handling Operation Process 31

Figure 6-1 CALMET and CALPUFF Modelling Domain with Receptor Locations 38

Figure 6-2 Sources Modelled - FSD Large Area Sources 42

Figure 6-3 Sources Modelled - FSD Area and Volume Sources (Zoomed View) 43

Figure 6-4 Sources Modelled – FSD Cumulative Sources 44

Figure 6-5 NO_2/NO_x Ratio versus 1-hour Average NO_x Observations from Metro Vancouver Station T18 (Burnaby South) 53

Figure 7-1 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background 56

Figure 7-2 Contour Plot of NO_2 Annual Predicted Concentrations with Background 57

Figure 7-3 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background 58

Figure 7-4 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background 59

Figure 7-5 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background 60

Figure 7-6 Contour Plot of PM_{10} Annual Predicted Concentrations with Background 61

Figure 7-7 Location of Sensitive Receptors near FSD 62

Figure 7-8 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background 66

Figure 7-9 Contour Plot of NO_2 Annual Predicted Concentrations with Background 67

Figure 7-10 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background 68

Figure 7-11 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background 69

Figure 7-12 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background 70

Figure 7-13 Contour Plot of PM_{10} Annual Predicted Concentrations with Background 71

Figure 7-14 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background 75

Figure 7-15 Contour Plot of NO_2 Annual Predicted Concentrations with Background 76

DRAFT

Figure 7-16 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background 77

Figure 7-17 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background 78

Figure 7-18 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background 79

Figure 7-19 Contour Plot of PM_{10} Annual Predicted Concentrations with Background 80

Figure 7-20 BNSF Lower Mainland Operating Area 83

Figure 7-21 Individual CALPUFF Domains used for the Screening-Level Analysis 84

Figure 7-22 Receptor Layout for the Barge 1 Screening Analysis 85

Figure 7-23 Maximum Predicted Concentrations of 24-hour TPM, $PM_{2.5,}$ and PM_{10} versus Distance from Barge 1 87

Figure A-1 Temperature Normals for T13 North Delta (1992-2011)....91

Figure A-2 2000-2001 Temperature Observations for T13 North Delta 92

Figure A-3 2000-2001 Temperatures Near the FSD Site (Extracted from CALMET Output) 93

Figure A-4 1987- 2011 Wind Rose for T13 North Delta 94

Figure A-5 2002 - 2011 Wind Rose for T38 Annacis Island 95

Figure A-6 2000-2001 Wind Rose Near the T13 North Delta Station (Extracted from CALMET Output) 96

Figure A-7 2000-2001 Wind Rose Near the T38 Annacis Island Station (Extracted from CALMET Output) 97

Figure A-8 2000-2001 Wind Rose Near FSD Site (Extracted from CALMET Output)....98

Figure A-9 Map Displaying the CALMET and CALPUFF Modelling Domain.... 100

Figure A-10 Example wind field generated by CALMET for the 10 m level for the hour ending at 11:00 on November 10, 2000. (The wind speed is denoted by the length of the arrows). 104

Figure A-11 Frequency distribution of surface (10 m level) winds for surface stations and the near the FSD site (CALMET).... 105

Figure A-12 Average monthly wind speeds at surface (10 m level) for surface stations and the FSD site (CALMET). 106

Figure A-13 Diurnal wind speed distribution of surface (10 m level) winds for surface stations and the FSD site (CALMET). 107

Figure A-14 Monthly temperatures at surface stations and FSD site (CALMET). 108

Figure A-15 Hourly temperatures at surface stations and the FSD site (CALMET). 109

Figure A-16 Frequency distribution of stability classes calculated for Vancouver Airport (YVR) and the FSD site (CALMET) for the modelling period.... 110

Figure A-17 Hourly predicted mixing heights for the FSD site (CALMET). 111

DRAFT

Figure A-18 Monthly predicted precipitation totals for the FSD site (CALMET) versus observational data. 112

DRAFT

List of Tables

Table 2-1 Estimated Annual Train Movement Resulting from the Direct Coal Transfer Project 2

Table 2-2 Estimated Annual Barge Movement Along The Transfer Route 4

Table 3-1 Metro Vancouver's Ambient Air Quality Objectives 6

Table 3-2 British Columbia Air Quality Objectives for Total Suspended Particulate Matter and Dustfall 7

Table 4-1 Summary of CO Ambient Air Quality Data 9

Table 4-2 Summary of NO_2 Ambient Air Quality Data 9

Table 4-3 Summary of SO_2 Ambient Air Quality Data 10

Table 4-4 Summary of PM_{10} Ambient Air Quality Data 10

Table 4-5 Summary of $PM_{2.5}$ Ambient Air Quality Data 11

Table 4-6 Summary of the Background Ambient Air Quality Concentrations 12

Table 5-1 Railcar Unloading – Modelling Parameters and Emission Rates 17

Table 5-2 Material Transfer Points - Modeling Parameters and Emission Rates 18

Table 5-3 Coal Loading Onto Barges - Modelling Parameters and Emission Rates 19

Table 5-4 Coal Stockpiles on Railcars and Barges – Modelling Parameters and Emission Rates 21

Table 5-5 Tugboat Diesel Engine Data 22

Table 5-6 SO_x and PM Emission Factors for Harbour Tugboats 22

Table 5-7 Emission Factors for Tugboats 23

Table 5-8 Tugboats - Modeling Parameters and Emission Rates 24

Table 5-9 Available SW900 Yard Locomotive HP and Fuel Consumption Data 25

Table 5-10 HP Distribution for the SW900, MP15DC and EMD GP9 Yard Locomotives 26

Table 5-11 Yard Switching Locomotive Diesel Engine Data 27

Table 5-12 Locomotive Emission Factors 28

Table 5-13 Rail - Modeling Parameters and Emission Rates 29

Table 5-14 Baghouse #1 - Modelling Parameters and Emission Rates 32

Table 5-15 Baghouse #2 - Modelling Parameters and Emission Rates 33

Table 5-16 Front End Loader Emission Rates 34

Table 5-17 Modeling Parameters and Fugitive Emissions from the Transfer Points 35

Table 5-18 Emissions Associated with Agricultural Good Unloading 36

DRAFT

Table 6-1 Selected Dispersion Options used in CALPUFF Modelling 39
Table 6-2 Summary of Modelling Parameters and Emission Rates (Project) 45
Table 6-3 Summary of Modelling Parameters and Emission Rates (Agricultural Scenario #2 for 1-hour and 24-hour, Scenario #1+2 for Annual) 47
Table 6-4 Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates for Each Averaging Period (Project) 49
Table 6-5 Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates for Each Averaging Period (Agricultural) 51
Table 7-1 Predicted Air Contaminant Concentrations from All Sources without and with Background Concentrations 55
Table 7-2 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Project) 63
Table 7-3 Predicted Air Contaminant Concentrations from Agricultural Sources without and with Background Concentrations 65
Table 7-4 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Agricultural Goods Operation) 72
Table 7-5 Predicted Air Contaminant Concentrations from All Sources without and with Background Concentrations 74
Table 7-6 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Project + Agricultural) 81
Table 7-7 Predicted Air Contaminant Concentrations from the Rail / Barge Screening Analysis without and with Background Concentrations 86
Table A-1 Heights of CALMET Model Layers 101
Table A-2 Surface Meteorological Stations Used for CALMET Input 102
Table A-3 Selected CALMET Wind Field Model Options 103

DRAFT

1. Introduction

Fraser Surrey Docks LP (FSD) retained Levelton Consultants Ltd. (Levelton) to conduct an air quality assessment for FSD's proposed Direct Transfer Coal Facility (the Project) in Surrey, BC. The assessment considers the proposed emission sources related to the facility's operations, in addition to the current emission sources from FSD's agricultural operations, both which will operate on industrial lands leased from the Port of Metro Vancouver (PMV). A detailed air dispersion modelling plan was developed by Levelton through consultation with PMV and Metro Vancouver which forms the basis for the air quality assessment conducted and presented herein.

2. Project Description

FSD is seeking PMV approval for the construction of the Project and is currently applying for an Air Quality Management Permit from Metro Vancouver. The proposed Project is to accommodate the receipt and unloading of full unit trains of coal at FSD for transfer onto barges. A third party partner will transport the barges to the west coast of Texada Island where the coal will be stored for further conveyance onto deep-sea vessels.

2.1 Coal Operations

The duration of Project operations are expected to last over five years. FSD operations will include:

- Receiving rail cars loaded with sub-bituminous coal;
- Transfer of coal along a conveyance system to waiting barges;
- Collection of coal drainage wastewater and discharge following appropriate treatment; and,
- Transportation of coal-loaded barges from FSD to Texada Island for long-term stockpiling.

The application of binding and suppressing agents to control fugitive dust will occur at the mine site, mid-way between the mine site and at FSD at the Surge Bin on the conveyance system before barge loading. The Project will have an onsite wastewater collection and treatment facilities.

2.1.1 Coal Delivery

The coal will be transported from the mine site to the terminal via 125 to 135 bottom-dump car unit BNSF (Burlington Northern Santa Fe Corp.) trains operated by four 4,500 horsepower diesel engines (two at the front and two at the rear of the unit train). Loaded rail cars will be received in the covered receiving shed, where unloading pits are designed to accommodate the unloading (dumping) of two railcars simultaneously. FSD estimates that the Project will handle 2.0 million MT tons in the first year of operations, with the volume increasing to 4.0 million MT in years two through five.

2.1.2 Land-based Operations Traffic

FSD estimates that in the first year of operations, there will be a total of 160 unit train deliveries to FSD, with the number doubling to 320 in years two through five. This would be approximately one train arriving/leaving from FSD every two days in the first year, and one train arriving/leaving per day in years two through five, summarized in Table 2-1 below. Trains carrying cargo are scheduled to arrive at FSD between 0400h to 0800h and empty trains are scheduled to depart between 1700h and

DRAFT

2100h. When trains will not adhere to this schedule, FSD will post the amended schedule on their website 48 hours prior to the specific operations.

Table 2-1 Estimated Annual Train Movement Resulting from the Direct Coal Transfer Project

Year	Coal Trains Arriving at FSD (trains/year)	Empty Trains Departing FSD (trains/year)	Total Train Movement (trains/year)
1	160	160	320
2-5	320	320	640

2.1.3 Coal Conveyance

Coal will be deposited into the receiving pits and moved along a series of conveyor segments and transfer points, with final deposition on the waiting barge(s). It is estimated that a full 135-car unit train will be unloaded onto two 8,000 DWT (deadweight tonnage) barges in less than 8 hrs (i.e. one shift).

Once the coal transfer process has commenced (i.e. a coal-loaded train has been received at FSD), the conveyance system will be manned and monitored at all times.

2.1.4 Dust control

There will be a number of dust control methods utilized during operations including water, dust suppressing agents, and/or incorporating physical barriers into the Project design (i.e. fencing, enclosures, walls, etc.). One or more of the following dust control methods will be used at various stages of the coal transport process, from pre-departure at the mine site through to the final storage site at Texada Island. Dust control methods are listed below.

2.1.4.1 Wetting

Wetting keeps coal moist and prevents dust generation, while fogging/misting removes airborne dust particles. Water will be delivered to the coal handling area through a combination of misting sprays, large nozzle sprays, large volume sprays, and/or agricultural sprinkler piping. FSD will use recycled coal drainage wastewater or clean freshwater (supplied by the City of Surrey) for dust suppression on site to wet down as required the barges, coal conveyor transfer points, the receiving building pits, and for railcar, equipment, and pavement cleaning. A wastewater management system will be implemented to manage all waste water. This process is outlined in detail in the Water Management Plan[1].

2.1.4.2 Dust Suppressing Agents

As part of the dust control strategies, dust suppressing agents will be utilized at several stages of the coal transfer process. A primary "body agent" that helps bind coal particles will be applied at the mine site. A secondary "body agent" will be applied to assist in preventing oxidation. BNSF will load coal in accordance with their coal loading template, including profiling the coal into a bread loaf shape

[1] *Omni Engineering Inc. (Omni). 2013. Direct Transfer Coal Facility Water Management Plan. August 9, 2013.*

DRAFT

to reduce the potential for wind erosion. A "topping agent" will be applied once the coal is loaded into the railcar at the mine site, pre-departure. This topping agent will act as a cover and sealant, and prevent coal dust from leaving the railcar. Additionally, in accordance with the coal industry 'best practice,' re-spray of the topping agent on BNSF rail cars will occur approximately halfway between the mine and FSD (location to be determined).

For the water-based barge transport from FSD to Texada Island, FSD has committed to using a combination of two products to minimize potential dust emissions during the barge journey with a minimum effectiveness of 90%[2].

A dust suppression product is injected at the rate or 250 parts per million (ppm) into the water stream, which is equal to 0.00045 kgs/M. This product is used to improve the wettability of the solution and enhance the coverage of the main dust suppression component of the program. The main dust suppression component is applied at a dosage or 0.025 kgs/MT and is injected into the water stream. The combined solution is then directed to the spray headers at the application point.

The two products will be applied on site at FSD at the conveyor transfer point in the surge bin with spray nozzles located 360 degrees around the product flow. This technique will allow all to the coal surface to be treated rather than just the top layer of coal on the barge, providing greater effectiveness. The products are expected to maintain dust control effectiveness for the entire barge movement, in a range of climatic environments; e.g., during a rainfall event.

2.1.4.3 Dust Limiting Design

All coal when loaded into the rail cars will be profiled to reduce the possibility for wind erosion and dispersion. The coal will be profiled into a rounded 'bread loaf' shape eliminating sharp angles that could catch wind.

All conveyors (eight segments) will be covered on three sides and conveyor transfer points (three main transfer points) will be completely enclosed. Points of transfer will incorporate chutes, baffles, belts skirting, shrouds and/or drop height limiting designs (i.e. lufting) to limit dust.

The barge loader and snorkel arrangement will be used to profile the coal that has been loaded onto the barge in a slightly rounded (not peaked) shape, to reduce the chance of wind catching the coal and creating airborne fugitive dust particulate while en route to Texada Island.

Wind fencing can be installed in areas that are subject to regular high winds or to protect adjoining property from fugitive dust.

To provide real-time air quality readings, several air quality monitoring stations will be positioned on and around the Project.

2.1.5 Barge Loading

Barge loading operations will be conducted at existing FSD berth Nos. 2 and 3. As described by Det Norske Veritas (Canada) Limited[3], transport from FSD to Texada Island will be via single hulled coastal barges, with approximately 9 compartments, transversely framed. Barges are 8,000 DWT in capacity,

---

[2] *GE. 2013. GE Letter on Dust Control from Peter Macois to Fraser Surrey Docks, November 14, 2013.*

[3] *Det Norske Veritas (Canada) Limited (DNV). 2012. Risk Assessment Study for Coal Barge Operation Fraser Surrey Docks. Rev 2A. September 26, 2012.*

DRAFT

with the dimensions of 284 feet (86 m) long x 72 feet (22 m) wide x 16 foot (5 m) draft and a 20 foot (6 m) load height on average. Deck to top of side walls will be a minimum of 10 feet (3 m). It was noted that barges will be loaded, to a maximum of 85% capacity for transit to the mouth of the river. During loading, coal barges are expected to be at berth for between 5 and 24 hours (with an average of 15 hours).

2.1.6 Water-Based Traffic Operations

The route is an already established barge route to/from Texada Island. While on the river, barges will be towed in a single barge configuration. Transit speeds will be approximately 6.3 knots (over ground).

FSD estimates that in the first year of operations there will be 320 fully-loaded barges traveling to Texada Island, with the number doubling to 640 barges in years two through five. It is expected that in the first year, on average there will be two barges every second day; in years two to five, there will be an average of two barges every day. It should be noted that water traffic/activity resulting from the empty barges returning from Texada Island to the FSD could double these estimated numbers; however, most of the barges used for the Project operations are currently being operated by Lafarge, FSD's barge operator on the Fraser River and in the Strait of Georgia. These barges are currently being transported empty between the Fraser River Lafarge cement plant and Texada Island. By utilizing these currently empty barges to transport coal to Texada Island, FSD will be able to significantly reduce the net increase in barge traffic from the figures stated below. Table 2-2 summarizes the estimated annual barge movements between FSD and Texada Island (if empty barges are not utilized).

Table 2-2 Estimated Annual Barge Movement Along The Transfer Route

Year	Coal Loaded barges to Texada Island (barges/year)	Empty barges to FSD (barges/year)	Total Barges between FSD and Texada Island (barges/year)
1	320	320	640
2-5	640	640	1280

Note: Whenever possible (i.e. weather permitting), towing two barges in tandem will occur in the section between Texada Island and the mouth of the Fraser River (or the reverse), potentially reducing the estimated tug movements in the Strait of Georgia.

2.2 Agricultural Operations

Currently, FSD operates a agricultural bulk facility which completed construction in April 2011, in collaboration with Parrish & Heimbecker. The facility has enabled FSD to meet the domestic and global needs of its customers as the facility is designed to handle a variety of agricultural products in bulk including Canola Meal, DDGs, Malt, Lentils, etc. The facility has a railcar belly dump system with conveyor belts and a weighing system. The agricultural industry has shown a growing demand for additional loading terminals on the West Coast that are equipped to handle bulk agricultural products loading to deep-sea vessels. FSD's intermodal rail solution and the seven deep-sea berths provide congestion-free vessel loading/discharging both for ships carrying the bulk cargo and for container and break-bulk carriers.

DRAFT

2.3 Scope of Air Quality Assessment

The primary objectives of the air quality assessment from the Project Terms of Reference (TOR) are:

- To identify the expected air emissions from proposed project, specifically on the Fraser River at km 34, FSD's direct to barge coal facility, and Port Authority Rail Yard (PARY), as outlined in the proposed project phases.
- To characterize the baseline air quality at the project location.
- To conduct an air dispersion modelling assessment.
- To identify specific reduction mitigation processes and procedures that could be implemented to reduce air emissions and improve or maintain air quality.

The study considers air emission associated with:

- Handling coal on barges in the Fraser River at FSD.
- Handling coal on rail to FSD
- The FSD proposed direct to barge coal facility
- The FSD current agricultural goods facility
- The PARY

The study has been designed to address the activity expected at the facility. The following dispersion modelling scenario was assessed:

- Normal Operations (4 Million Metric Tonnes per annum).

The emission sources considered include the following:

Coal Operations (Proposed):

- Rail locomotives - exhaust emissions
- Tugboats - exhaust emissions
- Material Transfer Points – fugitive dust
- Coal unloading (rail) and loading (barge) – fugitive dust
- Rail (in PARY and nearby the facility) and barges (at berth and nearby the facility) – fugitive dust

Agricultural Operations (Current):

- Baghouses – fugitive dust and exhaust emissions
- Material Transfer Points – fugitive dust
- Ship Loading (barge) – fugitive dust

DRAFT

The study also provides screening-level assessment of potential impacts from:

- Combustion and fugitive dust emissions from the transportation of coal to and from FSD from rail and barge sources.

3. Ambient Air Quality Objectives (AAQOs)

The federal and provincial governments, as well as Metro Vancouver, have developed ambient air quality objectives (AAQOs) to promote long-term protection of public health and the environment. Federally, up to three objective values have been recommended using the categories "maximum desirable", "maximum acceptable", and "maximum tolerable". The "maximum desirable" objective is the most stringent standard. British Columbia has established similar sets of objective values, designated as levels A, B and C, with level A being the most stringent. Level A is typically applied to new and proposed discharges to the environment, and is usually the same as the federal "maximum desirable" objective. As with the federal and provincial AAQOs, Metro Vancouver establishes AAQOs are based on the current knowledge regarding air quality and health science. Objectives from other jurisdictions around the world, as well as the ability to achieve the objectives within Metro Vancouver, are also considered.

Table 3-1 summarizes Metro Vancouver's AAQOs. British Columbia's AAQOs for Total Suspended Particulate Matter (TSP) and dustfall have been summarized in Table 3-2 as Metro Vancouver does not have objectives for these air contaminants.

Table 3-1 Metro Vancouver's Ambient Air Quality Objectives[4]

Air Contaminant	Averaging Time	Ambient Air Quality Objectives ($\mu g/m^3$)
Carbon Monoxide (CO)	1-hour	30,000
	8-hour	10,000
Nitrogen Dioxide (NO_2)	1-hour	200
	Annual	40
Sulphur Dioxide (SO_2)	1-hour	450
	24-hour	125
	Annual	30

[4] Metro Vancouver *Integrated Air Quality and Greenhouse Gas Management Plan (October, 2011)* (http://www.metrovancouver.org/about/publications/Publications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf)

DRAFT

Ozone (O_3)*	1-hour	160
	8-hour	126
Inhalable Particulate Matter (PM_{10})	24-hour	50
	Annual	20
Fine Particulate Matter ($PM_{2.5}$)	24-hour	25
	Annual	8 (6)**

* Ozone impacts were not considered in the assessment.
** Annual $PM_{2.5}$ objective of 8 µg/m^3 and a planning goal of 6 µg/m^3 which is a longer term aspiration target to support continuous improvement.

Table 3-2 British Columbia Air Quality Objectives for Total Suspended Particulate Matter and Dustfall[5]

Air Contaminant	Averaging Time	Level*	Ambient Air Quality Objectives
Total Suspended Particulate Matter (TSP)	24-hour	Maximum Desirable Level	120 (µg/m^3)
	Annual	Provincial Level A	60 (µg/m^3)
Dustfall	1 month	Lower Level	1.7 (mg/dm^2/day)

* The most stringent level is presented and has been applied in the assessment.

4. Background Ambient Air Quality

Metro Vancouver operates an extensive network of ambient air quality monitoring stations (Figure 4-1). Data from two monitoring stations (T13 North Delta and T18 Burnaby South) were used for characterizing the background air quality in the area surrounding FSD's location. The yellow circles identify the stations and the yellow star identifies the approximate location of FSD's facility. The monitoring stations were chosen based on their proximity to the FSD's facility and the air quality parameters monitored.

[5] British Columbia Ministry of Environment *BC Ambient Air Quality Objectives - Updated August 12, 2013* (http://www.bcairquality.ca/reports/pdfs/aqotable.pdf)

DRAFT



Figure 4-1 Lower Fraser Valley Air Quality Monitoring Network[6]

Five years of data from 2008 through 2012 from North Delta (T13) and Burnaby South (T18) were analysed. Of the air contaminants of interest for this study, the following were included in the background ambient air quality data analysis:

North Delta (T13): NO_2; and

Burnaby South (T18): CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$.

The data is summarized in Table 4-1 through Table 4-5 for each averaging time corresponding to the averaging times for the AAQOs. In additional, the 98th percentile concentrations were determined for the 1-hour, 8-hour and 24-hour averaging periods. The 98th percentile is defined as the value at or below which 98 percent of the values in the data fall. For the five year data record the 98th percentile values were determined based on the entire data record and over all stations (NO_2 was the only air contaminant with both stations being analysed).

[6] Metro Vancouver *2011 Lower Fraser Valley Air Quality Monitoring Report* (April, 2013)

DRAFT

Table 4-1 Summary of CO Ambient Air Quality Data

Year	Ambient Monitoring Station	Summary of CO Ambient Air Quality Data ($\mu g/m^3$)				Data Recovery (%)	
		1-hour		8-hour			
		Maximum	98th Percentile	Maximum	98th Percentile	1-hour	8-hour
2008	Burnaby South (T18)	1,480	734	1,021	642	98	98
2009	Burnaby South (T18)	2,097	897	1,557	827	98	98
2010	Burnaby South (T18)	1,549	606	801	564	97	98
2011	Burnaby South (T18)	1,258	571	1,120	532	95	96
2012	Burnaby South (T18)	1,107	524	832	469	97	98
Average 2008-2012		1,498	**687***	1,066	**615***		

* The 98th percentile is calculated based on the full data set across all years.

Table 4-2 Summary of NO_2 Ambient Air Quality Data

Year	Ambient Monitoring Station	Summary of NO_2 Ambient Air Quality Data ($\mu g/m^3$)			Data Recovery (%)
		1-hour		Annual Average	
		Maximum	98th Percentile		1-hour
2008	North Delta (T13)	94	70	28	98
2008	Burnaby South (T18)	107	65	29	97
2009	North Delta (T13)	121	73	28	98
2009	Burnaby South (T18)	96	69	30	95
2010	North Delta (T13)	94	63	24	97
2010	Burnaby South (T18)	86	63	26	96
2011	North Delta (T13)	89	64	26	98
2011	Burnaby South (T18)	88	62	27	94
2012	North Delta (T13)	95	66	26	98
2012	Burnaby South (T18)	101	63	27	97
Average 2008-2012		97	**67***	**27**	

* The 98th percentile is calculated based on the full data set across all years and stations.

DRAFT

Table 4-3 Summary of SO_2 Ambient Air Quality Data

Year	Ambient Monitoring Station	Summary of SO_2 Ambient Air Quality Data ($\mu g/m^3$)					Data Recovery (%)	
		1-hour		24-hour		Annual Average		
		Maximum	98th Percentile	Maximum	98th Percentile		1-hour	24-hour
2008	Burnaby South (T18)	26.6	8.0	10.5	5.8	1.3	98	100
2009	Burnaby South (T18)	29.3	8.0	10.2	6.5	1.6	98	100
2010	Burnaby South (T18)	28.2	8.0	8.2	5.0	1.5	98	100
2011	Burnaby South (T18)	31.7	8.8	10.6	6.3	1.8	98	100
2012	Burnaby South (T18)	50.6	8.8	12.6	5.5	1.8	97	99
Average 2008-2012		33.3	**8.3***	10.4	**5.9***	**1.6**		

* The 98th percentile is calculated based on the full data set across all years.

Table 4-4 Summary of PM_{10} Ambient Air Quality Data

Year	Ambient Monitoring Station	Summary of PM_{10} Ambient Air Quality Data ($\mu g/m^3$)			Data Recovery (%)
		24-hour		Annual Average	
		Maximum	98th Percentile		24-hour
2008	Burnaby South (T18)	40.2	27.6	12.5	99
2009	Burnaby South (T18)	42.4	28.6	13.3	99
2010	Burnaby South (T18)	47.6	24.8	11.5	99
2011	Burnaby South (T18)	32.4	22.0	11.2	99
2012	Burnaby South (T18)	37.5	28.4	11.6	96
Average 2008-2012		40.0	**26.8***	**12.0**	

* The 98th percentile is calculated based on the full data set across all years.

DRAFT

Table 4-5 Summary of $PM_{2.5}$ Ambient Air Quality Data

Year	Ambient Monitoring Station	Summary of $PM_{2.5}$ Ambient Air Quality Data ($\mu g/m^3$)			Data Recovery (%)
		24-hour		Annual Average	
		Maximum	98th Percentile		24-hour
2008	Burnaby South (T18)	17.4	11.6	4.2	99
2009	Burnaby South (T18)	22.4	12.5	4.7	99
2010	Burnaby South (T18)	29.7	11.1	3.8	92
2011	Burnaby South (T18)	12.6	8.8	3.8	99
2012	Burnaby South (T18)	17.0	11.2	3.9	98
Average 2008-2012		19.8	**11.3***	**4.1**	

* The 98th percentile is calculated based on the full data set across all years.

The background ambient air quality data collected at the Metro Vancouver stations (T13 and T18) provides an indication of the air contaminant levels given the current transportation, residential, commercial and industrial sources in the area near FSD's facility.

The background ambient air quality concentrations used in the air quality assessment are summarized in Table 4-6 below. The 98th percentile concentrations are presented for the 1-hour, 8-hour and 24-hour averaging periods and the average concentration for the annual averaging period. Maximum values have been presented in Table 4-1 through Table 4-5 for the 1-hour, 8-hour and 24-hour averaging periods as applicable for the various air contaminants. However, the 98th percentile values are used to characterise the background ambient air quality as these values are less extreme than the maximum observed concentrations, and are considered to be more representative of the expected background air quality, while being more conservative than using the arithmetic mean average. The methodology used to estimate the background ambient air quality concentrations is consistent with the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (AQMG)[7] and has been accepted by regulatory agencies in other air quality assessments.

[7] *British Columbia Ministry of Environment (MOE), 2008. Guidelines for Air Quality Dispersion Modelling in British Columbia. British Columbia Ministry of Environment, Environmental Protection Division, Environmental Quality Branch, Air Protection Section, Victoria, British Columbia. March 2008.*

DRAFT

Table 4-6 Summary of the Background Ambient Air Quality Concentrations

Air Contaminant	Averaging Time	Background ($\mu g/m^3$)
CO	1-hour	687
	8-hour	615
NO_2	1-hour	67
	Annual	27
SO_2	1-hour	8.3
	24-hour	5.9
	Annual	1.6
PM_{10}	24-hour	26.8
	Annual	12.0
$PM_{2.5}$	24-hour	11.3
	Annual	4.1
TSP	24-hour	N/A*
	Annual	N/A*
Dustfall	1 month	N/A*

* TSP and dustfall background data is not available.

DRAFT

5. Source Emissions Estimation

5.1 Air Emission Contaminants

For this study, the following Criteria Air Contaminants (CACs) were included for air quality assessment:

- Carbon Monoxide (CO);
- Nitrogen Oxides (NO_x);
- Sulphur Oxides (SO_x); and
- Particulate Matter:
    - Particulate matter less than 10 microns in equivalent diameter (PM_{10});
    - Particulate matter less than 2.5 microns in equivalent diameter ($PM_{2.5}$); and,
    - Total particulate matter (TPM).

5.2 Project Emission Sources

Project emission estimates were based on the data provided by FSD and emission estimate methods detailed in Sections 5.3 through 5.4. The following sources were included in air dispersion modelling and assessment for the Project:

Coal Handling Operations:

- Section 5.4.1: Railcar Unloading (fugitive dust);
- Section 5.4.2: Material Transfer Points (fugitive dust);
- Section 5.4.3: Coal Loading onto Barges (fugitive dust);
- Section 5.4.4: Coal Stockpiles on Railcars and Barges Fugitive (fugitive dust);
- Section 5.4.5: Tugboats (combustion emissions); and,
- Section 5.4.6: Rail (combustion emissions - yard switcher exhausts and unit train exhaust).

Agricultural Goods Handling Operation:

- Section 5.5.1: Baghouse Emissions (fugitive dust and combustion emissions);
- Section 5.5.2: Material Transfer Points (fugitive dust); and,
- Section 5.5.3: Ship Loading (fugitive dust);

Figure 5-1 presents an overall site plan of FSD. Detailed figures indicating the emission source locations and major buildings are available in Section 6.4. An air emissions inventory for the above sources was prepared based on design parameters for the proposed Project.

DRAFT

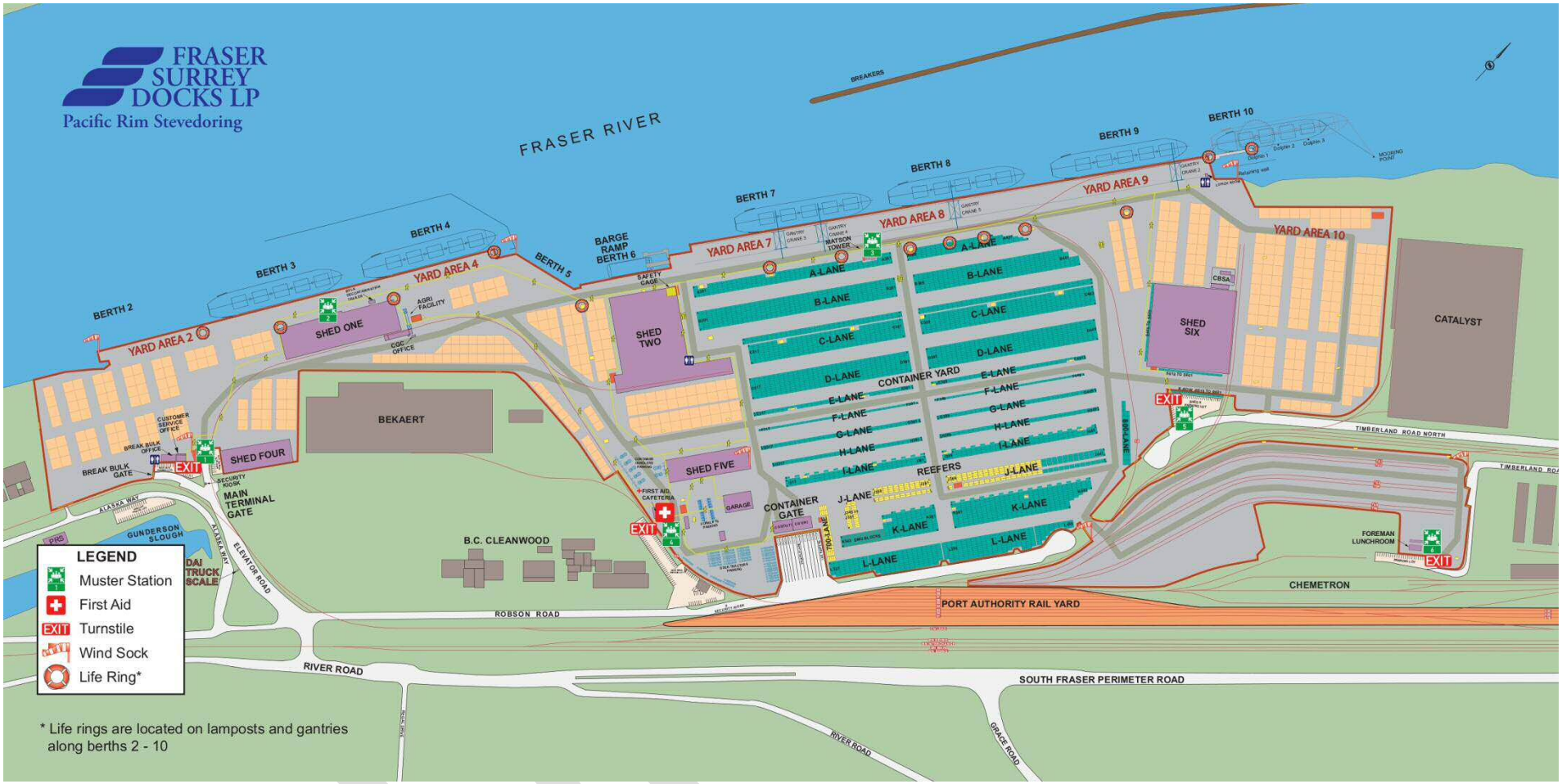


Figure 5-1 Current Fraser Surrey Docks Site Plan

5.3 General Quantification Approach

The general approach for estimating emissions from a source was determined using the following equation:

Emission Rate = (Emission Factor) x (Activity) x (1-Control Efficiency)

ER = EF x Activity x (1-CE)

where:

EF = Emission factor

Activity = Activity data, e.g. raw material processed/handled, horsepower of on-site non-road engines

CE = Emission control efficiency

For sources where more than one emission control measure is applied, the CE was calculated as follows:

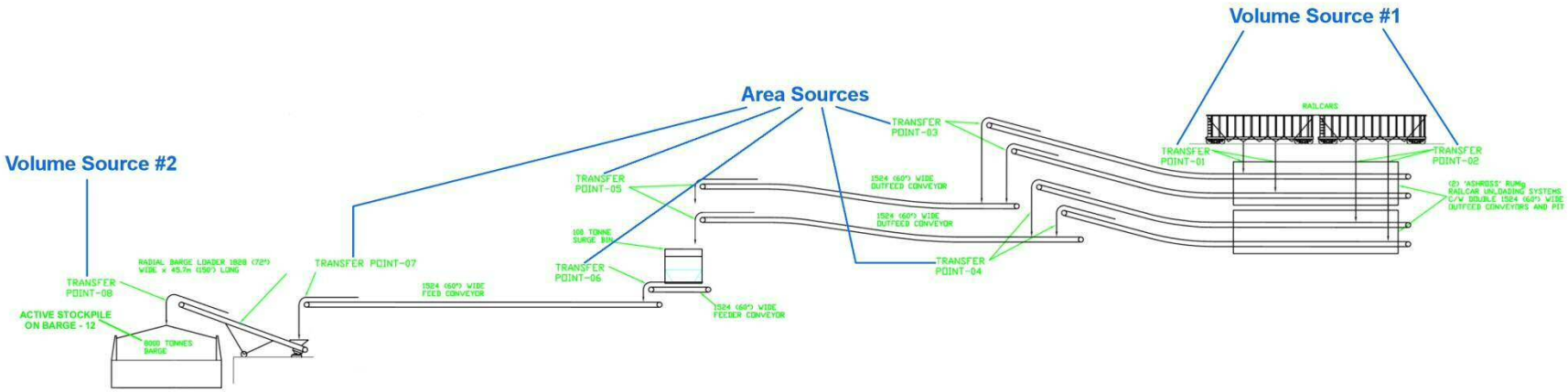
CE_{FINAL} = 100% - (100% - CE_1) x (100% - CE_2) x ... x (100% - CE_N)

In order to address separately the short-term and long-term air quality impacts from the Project, emission rates for: hourly, daily, and annual operations were developed for each source. The following sections below detail the source activity parameters, calculation methodologies, and resulting emission rates used in the air quality assessment.

5.4 Coal Handling Operations

Figure 5-2 shows a detailed overview of the coal handling process. Coal is unloaded from railcars (volume source #1), passing through a number of material transfer points #3 - #7, before ultimately being loaded onto the barge (volume source #2). Sections 5.4.1 through 5.4.6 detail each emission source in greater detail, including fugitive dust and combustion emissions from the trains and barges. Further details on the dispersion modelling parameters used including the amount of material transferred can be seen in section 6.4.

DRAFT



Coal Handling Operation Process

Figure 5-2 Coal Handling Operation Process

5.4.1 Railcar Unloading

The method selected for determining emissions from railcar unloading was from the USEPA AP-42, Chapter 13.2.4 – Aggregate handling and storage piles[8]. The emission factor equation is shown below:

$$EF = k\ (0.0016)\ (U/2.2)^{1.3} / (M/2)^{1.4}$$

where:

EF = Particulate emission factors (kg/Mg)

U = Mean wind speed (m/s)

M = Material moisture content (%)

k = Particle size multiplier (dimensionless)

The wind speed was obtained by extracting meteorological data from CALMET at the project site. The 1-hour maximum wind speed was 12.89 m/s, the 24-hour maximum wind speed was 7.27 m/s, and the annual maximum wind speed was 2.44 m/s. Unbound moisture content data of the coal was not available. Therefore, the USEPA AP-42 (Table 13.2.4-1)[8] mean moisture content of western surface mining coal was used for this assessment. The railcar unloading is located in a building with two sidewalls and a covered roof. During the unloading of rail cars, water (with a chemical suppressant) is sprayed to reduce fugitive dust. Railcar unloading emissions were parameterized as a volume source in the dispersion modeling. Model parameters along with emissions associated with railcar unloading activity are presented in Table 5-1, based on an overall emission control efficiency of 94% from both chemical suppression (80%)[9] and an enclosure (70%)9.

Table 5-1 Railcar Unloading – Modelling Parameters and Emission Rates

Source Description		Railcars Coal Unloading
Source Location		
UTM NAD 83	mE	506,058.7
	mN	5,447,537
Base Elevation	m ASL	8.8
Release Dimensions		
Effective Height	m	4
Initial Lateral Dimensions (sigma y)	m	5.14
Initial Vertical Dimensions (sigma z)	m	6.98
Hourly Emission Rates		
TPM	g/s	8.33E-02
PM_{10}	g/s	3.94E-02
$PM_{2.5}$	g/s	5.97E-03
Daily Emission Rates		
TPM	g/s	8.67E-03

[8] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 13: Miscellaneous Sources. Aggregate Handling and Storage Piles*

[9] *Air Pollution Engineering Manual, Second Edition, 2000, Air & Waste Management Association, Edited by Wayne. T. Davis, page 694, Table 4.*

DRAFT

PM_{10}	g/s	4.10E-03
$PM_{2.5}$	g/s	6.21E-04
Annual Emission Rates		
TPM	g/s	1.96E-03
PM_{10}	g/s	9.27E-04
$PM_{2.5}$	g/s	1.40E-04

5.4.2 Material Transfer Points

Once coal is received from railcars, it will be transferred using conveyors for direct shipment onto barges. All transfer points are covered and sprayed with water (with a chemical suppressant) to reduce fugitive dust. Emission factors for conveyor material transfer points were taken from the USEPA AP-42, Chapter 11.19.2 – crushed stone processing and pulverized mineral processing[10]. An overall emission control efficiency of 97% was applied for each transfer points from both chemical suppression (90%)[10] and an enclosure (70%)[10]. Table 5-2 summarizes the emission and modeling parameters for the material transfer points.

Table 5-2 Material Transfer Points - Modeling Parameters and Emission Rates

Source Description		Coal Transfer Point #3	Coal Transfer Point #4	Coal Transfer Points #5+#6	Coal Transfer Point #7
Source Location (NAD83 UTM)					
Northwest	mE	506,070	506,082	505,995	505,933
	mN	5,447,526	5,447,539	5,447,410	5,447,382
Northeast	mE	506,072	506,084	506,001	505,935
	mN	5,447,525	5,447,538	5,447,405	5,447,378
Southeast	mE	506,070	506,081	505,997	505,933
	mN	5,447,521	5,447,534	5,447,400	5,447,377
Southwest	mE	506,067	506,079	505,990	505,931
	mN	5,447,523	5,447,535	5,447,406	5,447,381
Base Elevation	m ASL	9.2	9	9	9
Release Dimensions					
Effective Height	m	2	2	9.5	9.5
Initial sigma z	m	0.93	0.93	4.42	4.42
Hourly Emission Rates					
TPM	g/s	1.50E-02	1.50E-02	6.00E-02	3.00E-02

[10] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 11: Mineral Products Industry*

DRAFT

PM_{10}	g/s	5.50E-03	5.50E-03	2.20E-02	1.10E-02
$PM_{2.5}$	g/s	1.39E-03	1.39E-03	5.57E-03	2.79E-03
Daily Emission Rates					
TPM	g/s	3.26E-03	3.26E-03	1.30E-02	6.51E-03
PM_{10}	g/s	1.19E-03	1.19E-03	4.77E-03	2.39E-03
$PM_{2.5}$	g/s	3.02E-04	3.02E-04	1.21E-03	6.05E-04
Annual Rates					
TPM	g/s	2.85E-03	2.85E-03	1.14E-02	5.71E-03
PM_{10}	g/s	1.05E-03	1.05E-03	4.19E-03	2.09E-03
$PM_{2.5}$	g/s	2.65E-04	2.65E-04	1.06E-03	5.30E-04

5.4.3 Coal Loading onto Barges

At the Project site, coal received from railcars will be transferred onto barges for shipment to oversea markets. The method for quantifying emissions for coal loading is the same as railcar unloading as described in Section 5.4.1. An overall of 95% of emission control efficiency was applied to this process due to the use of telescopic chutes (75%)[11] and chemical suppression (80%)[11] during the loading process to reduce fugitive dust. Emissions and modeling parameters associated with coal loading are presented in Table 5-3.

Table 5-3 Coal Loading Onto Barges - Modelling Parameters and Emission Rates

Source Description		Coal Load to Barge
Volume Source Locations		
UTM NAD 83	mE	505,903
	mN	5,447,392
Base Elevation	m ASL	9
Release Dimensions		
Effective Height	m	5.25
Initial Lateral Dimensions (sigma y)	m	0.25
Initial Vertical Dimensions (sigma z)	m	1.22
Hourly Emission Rate		
TPM	g/s	6.94E-02
PM_{10}	g/s	3.28E-02
$PM_{2.5}$	g/s	4.97E-03
Daily Emission Rate		
TPM	g/s	7.23E-03

[11] *Air and Waste Management Association (AWMA), 2000. Air Pollution Engineering Manual, Second Edition, Wiley-Interscience Publication, edited by Wayne T. Davis., page 694, Table 4*

DRAFT

PM_{10}	g/s	3.42E-03
$PM_{2.5}$	g/s	5.18E-04
Annual Emission Rate		
TPM	g/s	1.52E-03
PM_{10}	g/s	7.17E-04
$PM_{2.5}$	g/s	1.09E-04

5.4.4 Coal Stockpiles on Railcars and Barges

Fugitive dust from the railcar and barge coal stockpiles will be generated by the surface erosion of material exposed to the wind. The method selected for determining fugitive emissions from wind erosion was from the US EPA AP-42 Chapter 13.2.5 – Industrial Wind Erosion[12]. The emission factor equation is shown below:

$$EF = 58(U^*-U_t^*)^2 + 25(U^*-U_t^*)$$

$$EF = 0 \text{ for } U^* <= U_t^*$$

where:

EF = Erosion potential corresponding to the observed fastest mile of wind for the i^{th} period between disturbances (g/m^2)

U^* = Friction velocity (m/s)

U_t = Threshold friction velocity (m/s)

The friction velocity was calculated using the following equation:

$$U^* = 0.053\ U_{10}^+$$

where:

U_{10}^+ = Fastest mile of reference anemometer for period between disturbance (m/s)

The threshold friction velocity was taken from Table 13.2-5-2 of the US EPA AP42 for fine coal dust on concrete pad (0.54 m/s). The U_{10}^+ was extracted from the CALMET data at the project site and exposed surface area was estimate based on drawings provided by FSD. A control efficiency of 75% was applied to railcars stockpiles due to wet suppression with chemical treatment on the railcar coal before arriving onsite.

A control efficiency of 75% was assumed for the fugitive dust originating from the coal stockpiles on the railcars and barges. The AWMA Air Pollution Engineering Manual[13] provides a control efficiency of 99% for wet suppression with chemicals from wind erosion, and the Western Regional Air Partnership

[12] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 13.2.5: Industrial Wind Erosion*

[13] *Air and Waste Management Association (AWMA), 2000. Air Pollution Engineering Manual, Second Edition, Wiley-Interscience Publication, edited by Wayne T. Davis., page 694, Table 4*

DRAFT

Fugitive Dust Handbook[14] provides a control efficiency of 90% for watering of the storage pile by hand or applying cover when wind events are declared. However, these values were considered too high considering the chemical topping agent would be applied off-site from the facility, therefore a value of 75% was chosen.

Table 5-4 summarizes the emission and modeling parameters for the coal stockpiles on the barges and railcars.

For the railcar and barge stockpiles a variable emission file was created which contained the actual hourly emission rates pertaining to the meteorological conditions for that hour. Therefore, Table 5-4 does not show hourly, daily and annual emission rates as with the other emission sources as the rate will vary.

Table 5-4 Coal Stockpiles on Railcars and Barges – Modelling Parameters and Emission Rates

Source Description		Stockpile on Barge A	Stockpile on Barge B	Railcar Fugitive Dust
Source Locations (NAD 83 UTM)				
Northwest	mE	505,911	505,871	506,914
	mN	5,447,355	5,447,342	5,448,189
Northeast	mE	505,878	505,890	506,928
	mN	5,447,367	5,447,332	5,448,180
Southeast	mE	505,907	505,860	506,698
	mN	5,447,448	5,447,249	5,447,841
Southwest	mE	505,941	505,835	506,686
	mN	5,447,436	5,447,262	5,447,852
Base Elevation	m ASL	9	9	8
Source Release Dimensions				
Effective Height	m	4.5	4.5	4.5
Initial sigma z	m	2.09	2.09	2.09

5.4.5 Tugboats

Tugboats will be used to position empty barges into the winching system at the FSD berth and to transport loaded barges from the facility once the barges are filled. Marine CAC emissions were estimated based on the following equation for diesel fuel-fired engines for harbour tugboats.

$$E_m = EC * LF * EF_m / T$$

where:

E_m = Emission rate of a given pollutant from a tugboat engine (g/s)

EC = Engine capacity (kW)

[14] *WRAP Fugitive Dust Handbook, 2006, Table 9-4*

DRAFT

LF = Engine load factor (fraction)

EF_m = Activity-based emission factors for a given pollutant (g/kWh)

T = Operating time (seconds/hour)

The following Table 5-5 summarizes the engine information for tugboats, supplied by the tug operator.

Table 5-5 Tugboat Diesel Engine Data

Parameters	
Tier Level	Tier 1
Power Rating	1,400 HP (1,044 KW)
Load Factor	0.55[15]
No. of Single-Tow Tug	1

Tugboat combustion emission factors from the recent Environment Canada (EC) *Canadian 2010 National Marine Emissions Inventory*[16] were adopted for this study. For SO_x and PM emission factors, the emission factor calculations incorporating fuel sulphur content from the 2010 EC Inventory were applied. The SO_x and PM emission factor calculations, along with the particulate size distribution, are shown in Table 5-6. For this study, a fuel sulphur content of 15 ppmw (mg/kg) was used in the corresponding emission factor calculations according to the level stipulated in the *Regulations Amending the Sulphur in Diesel Fuel Regulations*[17] (2012) for diesel fuel produced, imported or sold for use in vessel engines after May 31, 2014.

Table 5-6 SO_x and PM Emission Factors for Harbour Tugboats

Source	Emission Factor (g/kWh)		Particulate Fractions	
	SO_X	PM	PM_{10}/PM Ratio	$PM_{2.5}$/PM_{10} Ratio
Auxiliary Engine	4.2*S	0.4653*S + 0.25	0.96	0.92

S = sulphur content of fuel (%)

Based on the above calculation methodology, SO_x, PM, PM_{10} and $PM_{2.5}$ emission factors were calculated and presented with other CAC factors in Table 5-7. Environment Canada was consulted to ensure the factors used in this study were consistent with those used in the 2010 National Marine Emissions Inventory for West Coast tug operations[18]. Modelling parameters and emission rates for the single-tow tugs operating at the FSD facility are shown in Table 5-8.

[15] *Metro Vancouver, 2010, "2005 LFV Air Emissions Inventory & Forecast and Backcast" for General Towing & Barging.*

[16] *SNC-Lavalin, 2012, "Canadian 2010 National Marine Emissions Inventory", Draft Final, April 17.*

[17] *Canada Gazette, 2012. Regulations Amending the Sulphur in Diesel Fuel Regulations, June 20, 2012.* www.gazette.gc.ca/rp-pr/p2/2012/2012-07-04/html/sor-dors135-eng.html

[18] *Private Communications with Mr. Richard Holt of Environment Canada, July 2012.*

DRAFT

Table 5-7 Emission Factors for Tugboats

Contaminant	Emission Factor (g/kWh)
CO	1.10
NO_x	13.90
SO_2	0.006
TPM	0.25
PM_{10}	0.24
$PM_{2.5}$	0.22

DRAFT

Table 5-8 Tugboats - Modeling Parameters and Emission Rates

Source Description		Tugboat exhaust
Source Location (UTM NAD83)		
Northwest	mE	505,866
	mN	5,447,234
Northeast	mE	505,820
	mN	5,447,250
Southeast	mE	505,900
	mN	5,447,466
Southwest	mE	505,946
	mN	5,447,450
Base Elevation	m ASL	9.0
Release Dimensions		
Effective Height	m	4.5
Initial sigma z	m	2.09
Hourly Emission Rates		
TPM	g/s	4.00E-02
PM_{10}	g/s	3.84E-02
$PM_{2.5}$	g/s	3.53E-02
CO	g/s	1.76E-01
NO_x	g/s	2.22E+00
SO_x	g/s	1.01E-03
Daily Emission Rates		
TPM	g/s	3.33E-03
PM_{10}	g/s	3.20E-03
$PM_{2.5}$	g/s	2.94E-03
CO	g/s	1.46E-02
NO_x	g/s	1.85E-01
SO_x	g/s	8.38E-05
Annual Emission Rates		
TPM	g/s	2.92E-03
PM_{10}	g/s	2.81E-03
$PM_{2.5}$	g/s	2.58E-03
CO	g/s	1.28E-02
NO_x	g/s	1.62E-01
SO_x	g/s	7.34E-05

5.4.6 Rail

For the proposed facility, CACs are emitted from the combustion of diesel fuel from incoming unit trains as well as by on-site yard locomotives used to assemble and disassemble rail cars. The general equation below is used to calculate rail engine emissions.

$$Er = FC * EF_r / T$$

where:

Er = Emissions of a given pollutant from a locomotive engine (g/s)

FC = Fuel consumption rate (L/h)

EF_r = Fuel-based locomotive emission factors for a given pollutant (g/L fuel)

T = Operating time (seconds/hour)

In order to apply the above emission factor method, fuel consumption data for the unit and yard engines was obtained from FSD. The unit train engine and associated fuel consumption rate of 3 US gallons per hour during idling was subsequently provided for this study by BNSF through FSD[19]. The unit train has 4 diesel engines at 4,500 horsepower (HP) each.

For the single SW900 yard switching engine, HP output and corresponding fuel consumption data at each notch setting (N1 to N8) was provided by Southern Railway through FSD[20], except for idling and dynamic brake (DB) modes. The yard engine data is shown in Table 5-9.

Table 5-9 Available SW900 Yard Locomotive HP and Fuel Consumption Data

Engine Mode	HP	Fuel Use at Each Notch Setting (US gal/h)
N1	25	1.71
N2	120	8.22
N3	220	15.07
N4	375	25.68
N5	500	34.25
N6	750	51.37
N7	900	61.64
N8	1000	68.49

[19] *Jurgen Franke, FSD (personal communication, September 5, 2012)*

DRAFT

To estimate the missing HP output and fuel consumption for the idling and DB settings, the engine profiles from a MP15DC and an EMD GP9 facility locomotive engine commonly used in rail yards in the Lower Fraser Valley[20], were reviewed for potential adoption for use in this study. Table 5-10 shows the relative similarity in notch-specific engine HP profiles of the MP15DC, EMD GP9 and the SW900, which are proposed for this project. By averaging the percent of maximum HP values (4.4% for the MP15DC and 3.9% for the EMD GP90), the resulting average value of 4.1% was applied to the SW900 to arrive at an approximate HP output of 41 HP at the DB setting (1000 HP * 0.041). The idling HP output of the SW900 was similarly estimated, as a first approximation, and a value of 8 HP was obtained.

Table 5-10 HP Distribution for the SW900, MP15DC and EMD GP9 Yard Locomotives

Engine Mode	SW900		MP15DC		EMD GP9	
	HP	% of max HP	HP*	% of max HP	HP*	% of max HP
DB	N/A	N/A	52.2	4.4	61.2	3.9
Idle	N/A	N/A	11.2	0.9	11.2	0.7
N1	25	2.5	53.7	4.5	73.1	4.6
N2	120	12.0	173.8	14.7	248.3	15.7
N3	220	22.0	328.1	27.7	439.2	27.7
N4	375	37.5	498.9	42.2	649.5	41.0
N5	500	50.0	659.9	55.8	865.8	54.7
N6	750	75.0	827	69.9	1092.5	69.0
N7	900	90.0	1023.1	86.5	1349.7	85.2
N8	1000	100.0	1182.7	100.0	1583.9	100.0

* Data from Table C-1 of PMV 2010 Landside Emissions Inventory

In order to estimate the fuel consumption rates at the DB and Idle settings, an estimated engine brake-specific fuel consumption (BSFC) was applied to the calculated HP outputs of 41 HP and 8 HP. The BSFC was estimated based on the notch-specific HP and fuel data provided by Southern Railway [e.g. BSFC at notch N3 = 15.07 gal/h / 220 HP (from Table 5-10) = 0.0685 gal/HP-h, which is identical for each of the 8 notch settings from N1 to N8]. The overall weighted average fuel consumption for the yard locomotive was subsequently derived by accounting for the engine duty cycle, which is a generic yard switching locomotive duty cycle profile available from the latest Railway Association of Canada (RAC) 2009 Locomotive Emissions Monitoring (LEM) report (RAC 2011)[21], as well as Transport Canada[22].

[20] *SNC-Lavalin, 2012, "Port of Metro Vancouver 2010 Landside Emission Inventory", March 26.*

[21] *Railway Association of Canada, "Locomotive Emissions Monitoring Program 2009".*

[22] http://www.tc.gc.ca/eng/programs/environment-ecofreight-rail-report2009-2730.htm#5.2

DRAFT

As an example, the N3 duty cycle weighted fuel rate of 0.33 gal/h was obtained as the product of the notch specific fuel use of 15.07 gal/h and the 2.2% of total time that the engine spends at this setting (Table 5-11).

Table 5-11 Yard Switching Locomotive Diesel Engine Data

Engine Mode	HP	BSFC (US gal/hp-h)	Fuel Use at Each Notch Setting (US gal/h)	RAC Duty Cycle (%)	Weighted Average Fuel Use (US gal/h)
DB*	41	0.0685	2.84	0.2	0.01
Idle*	8	0.0685	0.57	84.9	0.48
N1	25	0.0684	1.71	5.4	0.09
N2	120	0.0685	8.22	4.2	0.35
N3	220	0.0685	15.07	2.2	0.33
N4	375	0.0685	25.68	1.4	0.36
N5	500	0.0685	34.25	0.6	0.21
N6	750	0.0685	51.37	0.3	0.15
N7	900	0.0685	61.64	0.2	0.12
N8	1,000	0.0685	68.49	0.6	0.41
				Total	2.51

* The HP output for the DB and idle modes were calculated, as a first approximation, by averaging the corresponding HP levels of a MP15DC and an EMD GP9 facility locomotive that are commonly used in local rail yards.

Published fuel-based CAC emission factors from the RAC 2009 Locomotive Emissions Monitoring (LEM) program were used to estimate emissions from the incoming BNSF coal trains arriving from the US. These factors were deemed reasonable as a first approximation since they were based on emissions data from freight locomotives operating in Canada.

An ultra-low sulphur diesel (ULSD) of 15 parts per million (ppm) was used for estimating SO_2 emissions from yard switcher and from rail engines according to the requirement under the *Regulations Amending the Sulphur in Diesel Fuel Regulations*[23] (2012) for the production or import of diesel fuel for locomotives effective June 1, 2012. The CAC emission factors for the unit train and switcher engines are shown in Table 5-12. The modelling parameters and emission rates used are presented in Table 5-13.

[23] *Canadian Gazette, 2012. Regulations Amending the Sulphur in Diesel Fuel Regulations. June 20, 2012.* www.gazette.gc.ca/rp-pr/p2/2012/2012-07-04/html/sor-dors135-eng.html

DRAFT

Table 5-12 Locomotive Emission Factors

Pollutants	Emission Factor (g/L fuel)	
	Unit Train	Yard Locomotive
CO	7.07	7.35
NO_x	50.41	69.42
SO_2	0.025	0.003
PM_{10}	1.31	1.53
$PM_{2.5}$	1.27	1.48

DRAFT

Table 5-13 Rail - Modeling Parameters and Emission Rates

Source Description		Unit Train Exhaust	Yard Switcher				
Area Source Locations (UTM NAD83)			Polygon				
Northwest	mE	506,914	506,108	506,407	506,516	506,586	506,465
	mN	5,448,189	5,447,274	5,447,436	5,447,589	5,447,702	5,447,724
Northeast	mE	506,928	506,295	506,425	506,534	506,622	506,622
	mN	5,448,180	5,447,266	5,447,424	5,447,577	5,447,724	5,447,724
Southeast	mE	506,698	506,304	506,304	506,425	506,534	506,586
	mN	5,447,841	5,447,244	5,447,244	5,447,424	5,447,577	5,447,702
Southwest	mE	506,686	506,103	506,295	506,407	506,516	506,465
	mN	5,447,852	5,447,256	5,447,266	5,447,436	5,447,589	5,447,708
Base Elevation	m ASL	8	11				
Release Dimensions							
Effective Height	m	4.5	4.5				
Initial sigma z	m	2.09	2.09				
Hourly Emission Rates							
TPM	g/s	1.65E-02	4.04E-03				
PM_{10}	g/s	1.65E-02	4.04E-03				
$PM_{2.5}$	g/s	1.60E-02	3.92E-03				
CO	g/s	8.92E-02	1.94E-02				
NOx	g/s	6.36E-01	1.83E-01				
SOx	g/s	3.10E-04	8.45E-06				
Daily Emission Rates							
TPM	g/s	1.65E-02	3.03E-03				
PM_{10}	g/s	1.65E-02	3.03E-03				
$PM_{2.5}$	g/s	1.60E-02	2.94E-03				
CO	g/s	8.92E-02	1.45E-02				
NO_x	g/s	6.36E-01	1.37E-01				
SO_x	g/s	3.10E-04	6.33E-06				
Annual Emission Rates							
TPM	g/s	4.46E-03	2.65E-03				
PM_{10}	g/s	4.46E-03	2.65E-03				
$PM_{2.5}$	g/s	4.32E-03	2.57E-03				
CO	g/s	2.40E-02	1.27E-02				
NO_x	g/s	1.71E-01	1.20E-01				
SO_x	g/s	8.35E-05	5.55E-06				

5.5 Agricultural Goods Handling Operation

Figure 5-3 below shows a detailed overview of the agricultural goods handling process. Agricultural goods that are directly loaded onto the ships follow this sequence: goods are unloaded from rail cars, pass through the headhouse, and then pass through material transfer point #1 (where all 3 fugitive dust sources are controlled by baghouse #1); the agricultural goods are then passed through material transfer points #2 - 6, and then loaded onto the ship.

Agricultural goods that require shed storage go through a similar process: goods are unloaded from rail cars, pass through the headhouse, pass through material transfer point #1 (where all 3 fugitive dust sources are controlled by baghouse #1), pass through material transfer point #2, and then are loaded into the shed. Once shipment is required, Front End Loaders (controlled by baghouse #2) transfer the material through material transfer points #2 - 6, ultimately to be loaded onto the ship.

In total, there were 3 different scenarios evaluated for the agricultural goods operations:

1) Rail Loading to Shed

2) Shed Loading to Ship

3) Direct Load to Ship (from Rail)

For the annual averaging period, scenarios 1 and 2 were combined together as there is a potential for all the agricultural goods to require shed storage before being loaded on ships.

Sections 5.5.1 through 5.5.3 detail each emission source in greater detail. Further details on the dispersion modelling parameters used including the amount of material transferred can be seen in section 6.4.

DRAFT

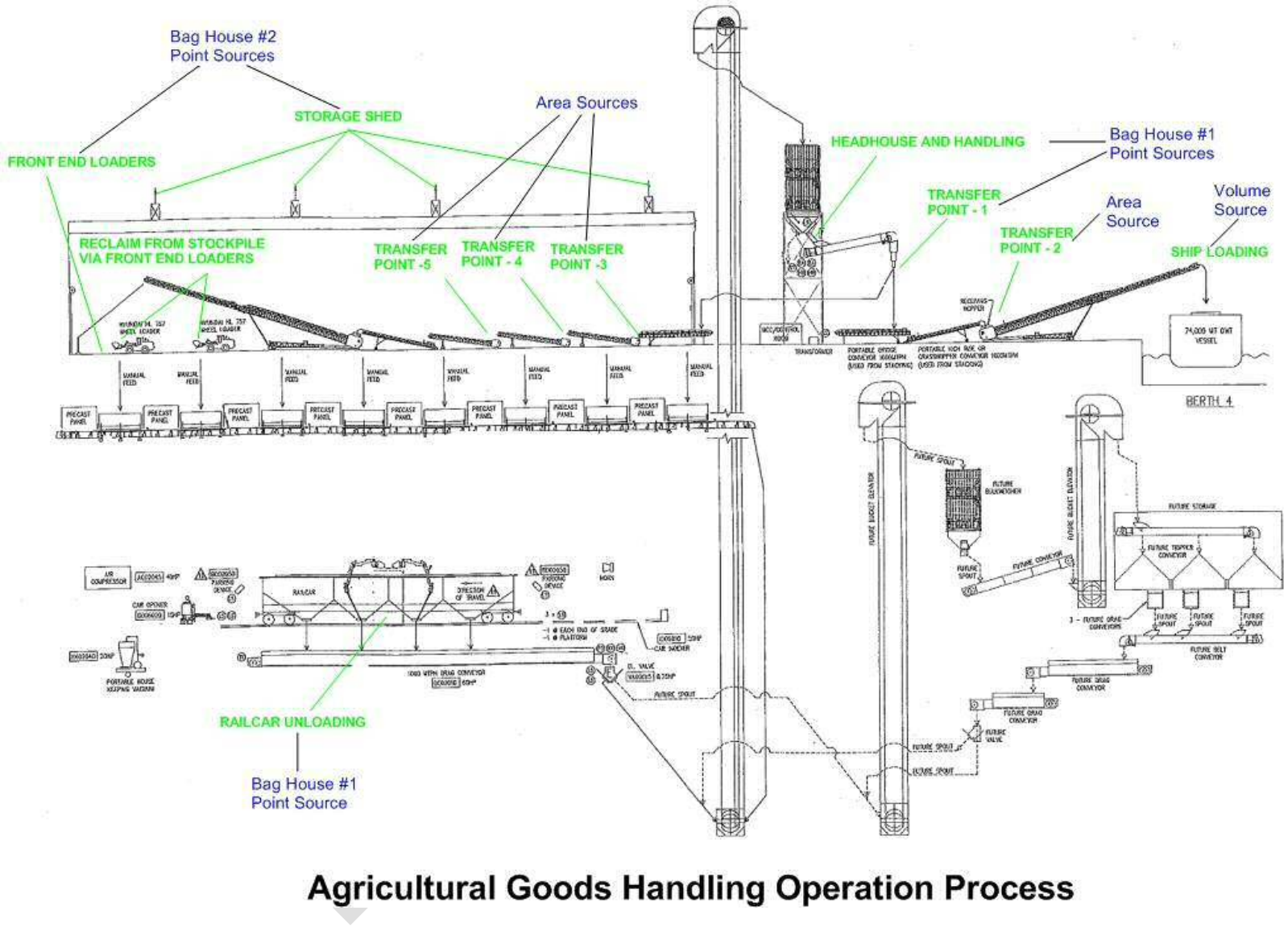


Figure 5-3 Agricultural Goods Handling Operation Process

5.5.1 Baghouse Emissions

At the project site, there will be two baghouses installed at the agricultural goods handling operations in order to mitigate fugitive dust emissions.

Baghouse #1 will handle emissions from the following three sources: railcar unloading, the headhouse, and transfer point #1. At the project site, agricultural goods are received from bottom-dump railcars. The methodology selected for determining emissions from railcar unloading is from the USEPA AP-42, Chapter 9.9.1 – Grain Elevators and Processes[24]. Once agricultural goods are received from the railcars, they are sent to the headhouse for further processing. Emission factors for the headhouse and handling were obtained from the USEPA AP-42, Chapter 9.9.1 – Grain Elevators and Processes[23]. The first transfer point, directly connected to the headhouse, conveys the material to the next series of material transfer points.

All three of these sources (railcar unloading, headhouse, and transfer point #1) are vented through Baghouse #1. An emission control efficiency of 99%[25] was applied for these sources. The modelling parameters associated with Baghouse #1 is presented in Table 5-14 below.

Table 5-14 Baghouse #1 - Modelling Parameters and Emission Rates

Source Description		Railcar Unloading	Headhouse	Transfer Point #1
Source Location				
UTM NAD 83	mE	506,067		
	mN	5,447,609		
Base Elevation	m ASL	9.2		
Stack Dimensions				
Stack Height	m	5.43		
Stack Diameter	m	1.46		
Exit Velocity	m/s	16.93		
Exit Temperature	K	293.15		
Hourly Emission Rates				
TPM	g/s	4.44E-02	8.47E-02	1.25E-01
PM_{10}	g/s	1.08E-02	4.72E-02	4.58E-02
$PM_{2.5}$	g/s	1.81E-03	8.06E-03	1.16E-02
Daily Emission Rates				
TPM	g/s	6.67E-03	1.27E-02	1.88E-02
PM_{10}	g/s	1.63E-03	7.08E-03	6.88E-03
$PM_{2.5}$	g/s	2.71E-04	1.21E-03	1.74E-03
Annual Emission Rates				
TPM	g/s	5.07E-03	9.67E-03	1.43E-02
PM_{10}	g/s	1.24E-03	5.39E-03	5.23E-03
$PM_{2.5}$	g/s	2.06E-04	9.20E-04	1.33E-03

[24] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 9: Food and Agricultural Industries*

[25] *Air Pollution Engineering Manual, Second Edition, 2000, Air & Waste Management Association, Edited by Wayne. T. Davis, page 694, Table 4.*

DRAFT

Baghouse #2 deals with the storage shed emissions and the front-end loaders operating within.

During situations when direct shipment is not possible, the received agricultural goods are transferred to a storage shed for temporary storage. The method for determining emissions from the storage shed was taken from the USEPA AP-42, Chapter 9.9.1 – Grain Elevators and Processes[26]. When direct shipment of agricultural goods is not possible, two front end loaders will be simultaneously operating in the storage shed for transferring of the goods in and out. Emissions are discharged from the storage shed through Baghouse #2 with an emissions control efficiency of 99%[27]. The emission rates and modeling parameters are seen below in Table 5-15.

Table 5-15 Baghouse #2 - Modelling Parameters and Emission Rates

Source Description		Storage Shed	Front End Loader Exhaust
Source Location			
UTM NAD 83	mE	505,996	
	mN	5,447,454	
Base Elevation	m ASL	9.8	
Stack Dimensions			
Stack Height	m	5.43	
Stack Diameter	m	1.46	
Exit Velocity	m/s	16.93	
Exit Temperature	K	293.15	
Hourly Emission Rates			
TPM	g/s	3.47E-02	2.88E-04
PM_{10}	g/s	8.75E-03	2.88E-04
$PM_{2.5}$	g/s	1.53E-03	2.88E-04
CO	g/s		8.28E-02
NO_x	g/s		3.12E-01
SO_x	g/s		2.82E-04
Daily Emission Rates			
TPM	g/s	5.21E-03	2.16E-04
PM_{10}	g/s	1.31E-03	2.16E-04
$PM_{2.5}$	g/s	2.29E-04	2.16E-04
CO	g/s		6.21E-02
NO_x	g/s		2.34E-01
SO_x	g/s		2.11E-04
Annual Emission Rates			
TPM	g/s	3.96E-03	3.28E-05
PM_{10}	g/s	9.99E-04	3.28E-05
$PM_{2.5}$	g/s	1.74E-04	3.28E-05
CO	g/s		9.45E-03
NO_x	g/s		3.56E-02
SO_x	g/s		3.22E-05

[26] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 9: Food and Agricultural Industries*

[27] *Air Pollution Engineering Manual, Second Edition, 2000, Air & Waste Management Association, Edited by Wayne. T. Davis, page 694, Table 4.*

FSD indicated that the front end loaders would be Hyundai HL 757 with US EPA Tier 1 compliant emissions. Horsepower ratings were taken directly from manufacturer specifications. A fuel sulphur content of 15 ppmw (mg/kg) was used in the corresponding correlations according to the level stipulated in the Regulations Amending the Sulphur in Diesel Fuel Regulations.

Maximum deterioration factors as given by the USEPA model NONROAD 2008a were used for emissions due to the older Tier 1 compliant vehicles. Emission factors were based on the methodology discussed in the US EPA document *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression-Ignition*[28]. Emission factors are expressed in grams per operating hour. A load factor (0.59) was applied for the exhaust emissions. The resulting emission rate estimates are presented in Table 5-16.

Table 5-16 Front End Loader Emission Rates

CAC	HP	Emission Factor (g/HP-hr)	Load Factor	Deterioration Factor	Units	Tran. Adj Factor	Hourly Rate (g/s)	Daily Rate (g/s)	Annual Rate (g/s)
TPM	173	0.2799	0.59	1.473	2	1.23	2.88E-02	2.16E-02	3.28E-03
PM_{10}	173	0.2799	0.59	1.473	2	1.23	2.88E-02	2.16E-02	3.28E-03
$PM_{2.5}$	173	0.2715	0.59	1.473	2	1.23	2.79E-02	2.09E-02	3.18E-03
NO_x	173	5.6523	0.59	1.024	2	0.95	3.12E-01	2.34E-01	3.56E-02
SO_2	173	0.0050	0.59	1.000	2	1.00	2.82E-04	2.11E-04	3.22E-05
CO	173	0.8667	0.59	1.101	2	1.53	8.28E-02	6.21E-02	9.45E-03

5.5.2 Material Transfer Points

Downstream of the headhouse, agricultural goods are transferred through conveyors for direct shipment. All of the conveyors and transfer points are covered in order to minimize fugitive dust emissions from the transfer points. The approach for quantifying emissions from material transfer points is identical to the methodology presented previously in Section 5.4.2. A total of five transfer points were included for this assessment as a conservative approach. A control efficiency of 70% was applied for material transfer points #2 - #5 due to covered conveyors and transfer points[29]. The first transfer point was treated as a point source and is already accounted for in the baghouse #1, while the remaining four transfer points were treated as area sources during normal operating conditions. The modeling parameters and emissions for the remaining 4 transfer points are presented in Table 5.17.

[28] *US EPA (2010). Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling - Compression-Ignition. Assessment and Standards Division, Office of Transportation and Air Quality, USEPA. July 2010.*

[29] *Air Pollution Engineering Manual, Second Edition, 2000, Air & Waste Management Association, Edited by Wayne. T. Davis, page 694, Table 4.*

DRAFT

Table 5-17 Modeling Parameters and Fugitive Emissions from the Material Transfer Points #2-5

Source Description		Transfer Point #2	Transfer Point #3	Transfer Point #4	Transfer Point #5
Area Source Locations (UTM NAD83)					
Northwest	mE	506,023	506,009	505,996	505,984
	mN	5,447,628	5,447,592	5,447,555	5,447,521
Northeast	mE	506,025	506,011	505,998	505,985
	mN	5,447,628	5,447,591	5,447,554	5,447,520
Southeast	mE	506,024	506,010	505,997	505,985
	mN	5,447,626	5,447,589	5,447,553	5,447,518
Southwest	mE	506,023	506,009	505,995	505,983
	mN	5,447,627	5,447,590	5,447,553	5,447,519
Base Elevation	m ASL	7	7.2	8	8.7
Release Dimensions					
Effective height	m	1	2	4	6
Initial sigma z	m	0.47	0.93	1.86	2.79
Hourly Emission Rate					
TPM	g/s	1.25E-01	1.25E-01	1.25E-01	1.25E-01
PM_{10}	g/s	4.58E-02	4.58E-02	4.58E-02	4.58E-02
$PM_{2.5}$	g/s	1.16E-02	1.16E-02	1.16E-02	1.16E-02
Daily Emission Rate					
TPM	g/s	1.88E-02	1.88E-02	1.88E-02	1.88E-02
PM_{10}	g/s	6.88E-03	6.88E-03	6.88E-03	6.88E-03
$PM_{2.5}$	g/s	1.74E-03	1.74E-03	1.74E-03	1.74E-03
Annual Emission Rate					
TPM	g/s	1.43E-02	1.43E-02	1.43E-02	1.43E-02
PM_{10}	g/s	5.23E-03	5.23E-03	5.23E-03	5.23E-03
$PM_{2.5}$	g/s	1.33E-03	1.33E-03	1.33E-03	1.33E-03

5.5.1 Loading onto Ships

Emissions for ship loading was quantified using emission factors from the USEPA AP-42, Chapter 9.9.1 – Grain Elevators and Processes[30] for grain shipping via ship. Fugitive dust emissions from loading are treated as a volume source in the dispersion modeling. Modeling parameters and fugitive emissions associated with ship loading are presented in the following table based on an emission control efficiency of 75%[31] with the use of telescopic chutes.

[30] *USEPA (2006) AP42, Fifth Edition, Volume I. Chapter 9: Food and Agricultural Industries*

[31] *Air Pollution Engineering Manual, Second Edition, 2000, Air & Waste Management Association, Edited by Wayne. T. Davis, page 694, Table 4.*

Table 5-18 Emissions Associated with Agricultural Good Unloading

Source Description		Agricultural Goods Ship Loading
Source Location		
UTM NAD 83	mE	505,934
	mN	5,447,486
Base Elevation	m ASL	9
Release Dimensions		
Effective Height	m	10
Initial Lateral Dimensions (sigma y)	m	0.25
Initial Vertical Dimensions (sigma z)	m	0.70
Hourly Emission Rate		
TPM	g/s	1.67E+00
PM_{10}	g/s	4.17E-01
$PM_{2.5}$	g/s	7.64E-02
Daily Emission Rate		
TPM	g/s	2.50E-01
PM_{10}	g/s	6.25E-02
$PM_{2.5}$	g/s	1.15E-02
Annual Emission Rate		
TPM	g/s	1.90E-01
PM_{10}	g/s	4.76E-02
$PM_{2.5}$	g/s	8.72E-03

DRAFT

6. CALMET and CALPUFF Modelling Methodology

Air dispersion modelling was conducted following the methods recommended in the AQMG in addition to guidance from PMV and Metro Vancouver. This section presents a summary of the modelling methodology.

The CALPUFF modelling suite was used for this analysis. CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) that are used in series to determine the impact of emissions in the vicinity of a source or group of sources. Detailed three-dimensional meteorological fields were produced by the diagnostic computer model CALMET (version 5.8, BC Ministry of Environment (MOE) and US EPA approved version), based on surface and upper air weather data, digital land use data, terrain data, and prognostic meteorological data. The three-dimensional meteorological fields produced by CALMET were used by CALPUFF (version 5.8, MOE and US EPA approved version), a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport. Finally CALPOST, a statistical processing program, was used to summarize and tabulate the pollutant concentrations calculated by CALPUFF.

The three-dimensional CALMET meteorological fields were generated using meteorological data from numerous surface stations and upper air stations, prognostic meteorological data from the Mesoscale Compressible Community (MC2) model, and digital terrain and land use data.

6.1 Domain and Receptors

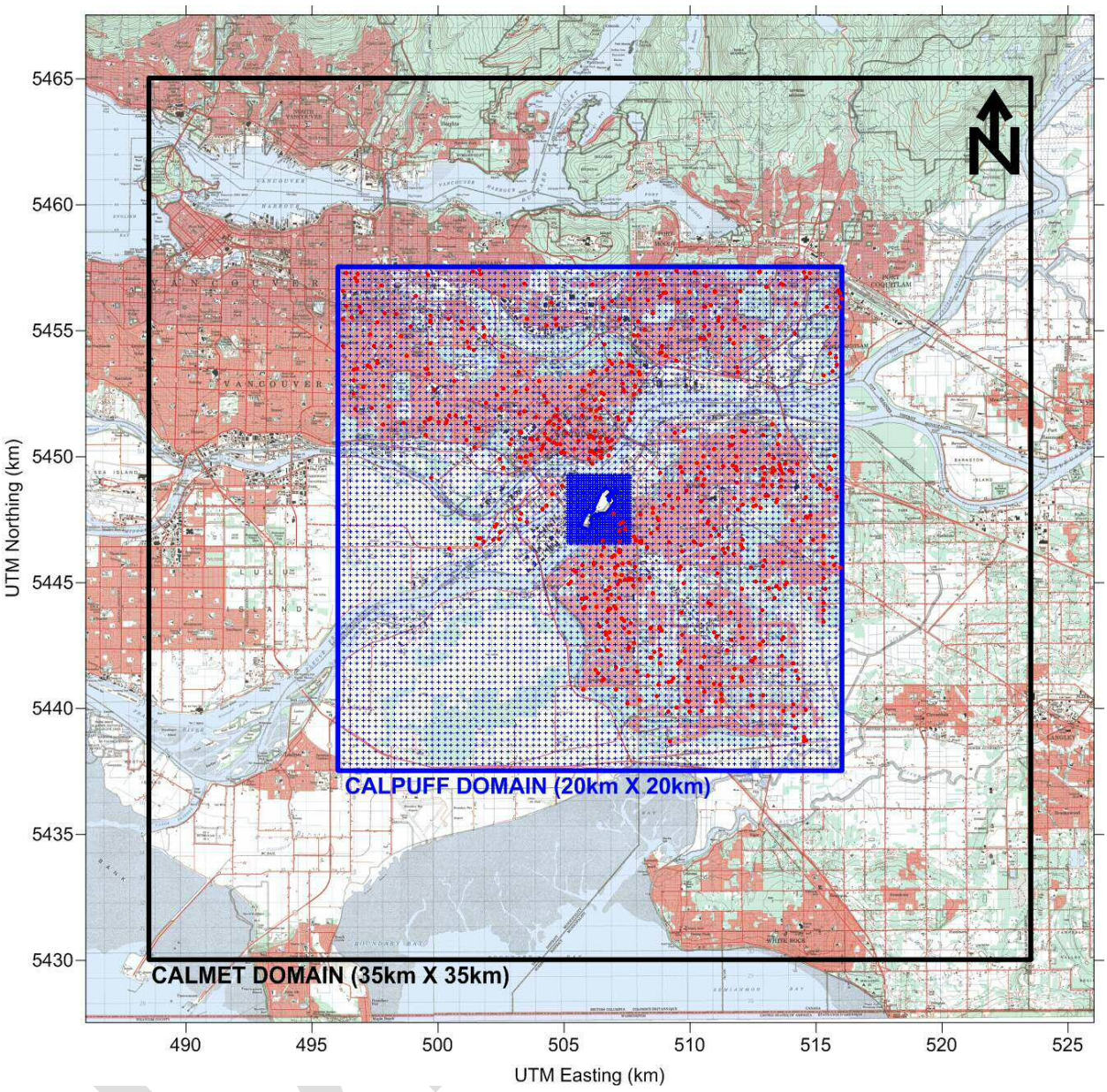
The CALMET modelling domain is a 35 km by 35 km area centered on FSD's facility. The CALMET domain was characterized using 250 m grid resolution and nine vertical layers. Details of the CALMET modelling methodology are provided in the Appendix A.

The CALPUFF modelling domain is a 20 km by 20 km area centered on the facility. Within the domain, a nested sampling grid of receptors was created with the following spatial distribution:

- 20 m spacing along the facility fenceline;
- 50 m spacing within 500 metres of the facility fenceline; and,
- 250 m spacing beyond 2 km of the facility fenceline.

Receptors were not included within the FSD facility fenceline, where the AAQOs are not applicable. The fenceline was extended into the Fraser River to the main navigational channel to encompass the marine operations at the facility and includes the PARY. Both of these areas have either limited or no public access. A 1.5 m receptor height was used to simulate the average height of human air intake. Sensitive receptors (hospitals, schools, senior care residences, and day care centres) were also added to the receptors grid. Figure 6-1 shows the CALPUFF domain including the receptors. The blue crosses indicate the gridded receptors, while the red crosses indicate the sensitive receptors.

DRAFT



Notes: *Gridded receptors are indicated as blue crosses while sensitive receptors are indicated as red crosses.*

Figure 6-1 CALMET and CALPUFF Modelling Domain with Receptor Locations

6.2 CALPUFF Modelling Options

The CALPUFF air dispersion model was used to model air emissions and predict ambient concentrations of air contaminants from the sources described in Section 5. The model used 9,336 hours of CALMET data which is equivalent to 389 days. The total number of modelled hours was used to determine the maximum hourly and daily concentrations. The annual concentrations were determined from the entire dataset.

CALPUFF model options chosen were consistent with those outlined for CALMET/CALPUFF in the AQMG.

Table 6-1 Selected Dispersion Options used in CALPUFF Modelling

Parameter	Option Selected	AQMG Default
Terrain Adjustment Method	Partial Plume Adjustment	✓
Transitional Plume Rise	Modelled	✓
Stack Tip Downwash	Modelled	✓
Vertical Wind Shear above Stack Top	Not modelled	✓
Chemical Mechanism	Not modelled	Not applicable
Wet Removal	Not modelled	Not applicable
Dry Deposition	Not modelled	Not applicable
Method Used to Compute Dispersion Coefficients	Computed from internally calculated micrometeorology	✓
Partial Plume Penetration of Elevated Inversion	Modelled	✓
Minimum Wind Speed Allowed for Non-Calm Conditions	0.5 m/s	✓

6.3 Deposition (Wet Removal and Dry Deposition)

Deposition is the process by which theair contaminants mass is depleted from the transporting plume onto the surface, decreasing the concentration of the contaminants in the air. It can be divided into two sub-processes: dry and wet deposition. Dry deposition refers to the process that air contaminants fall down onto the earth's surfaces due to gravitation. Wet deposition refers to a mechanism by which air contaminants are deposited on the ground due to precipitation scavenging. Total deposition is the sum of wet plus dry deposition at a particular point.

The deposition is a combination of different removal process depending on, for example: the characteristics of emission sources, geophysical distribution of particulate size, and the affinity to be scavenged by precipitation. For this study, wet removal and dry deposition were considered for particulate matter to provide a more refined assessment and to provide the basis for future health risk assessment studies.

6.3.1 Deposition Methodology

The assumptions and method applied for prediction deposition were similar to other modeling projects Levelton has conducted for organizations such as Health Canada, described below:

DRAFT

Since only a limited number of deposition parameters exist in CALPUFF's species library, the US EPA's Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion[32], and Volume II of the ISC User's Guide[33] were used as guidance documents to supplement the deposition parameters required for modeling;

For dry deposition, the CALPUFF model was used to calculate dry deposition rates as a function of geophysical parameters, surface roughness of vegetation, meteorological conditions, and pollutant species;

For wet deposition, a wet scavenging rate coefficient approach was used in CALPUFF to compute the wet deposition due to precipitation scavenging. Figure 1-11 in Volume II of the ISC User's Guide[39] was used to determine a wet scavenging rate coefficient depending on particle size of different COPCs. The following size parameters assumptions were made and used for wet deposition.

- The size classes for particulate matter were divided into the following groups for the purpose of the dispersion modeling:
  - A mean particulate size of 1.25 microns was assumed for $PM_{2.5}$;
  - A mean particulate size of 5 microns was assumed for PM_{10}; and,
  - A mean particle size of 20 microns was assumed for TPM.
- A standard deviation of 1.24 microns was assumed for all particle sizes.

The maximum predicted concentrations for deposition were then calculated by summing the modelled particle size classes together.

6.4 Source Parameters

Emissions as described in Section 5 were used to calculate source emission rates (i.e. g/s). Given the nature of the sources for the proposed Project and agricultural goods operations, most emission sources were modelled as area sources by applying the approximate "area" from which the source would be emitting from to establish an area emission rate (i.e. $g/m^2/s$). The railcar unloading and loading to barge were modelled as volume sources. The modelled area and volume sources for the Project are detailed in Figures 6-1, 6-2 and 6-3.

Each area source requires an effective release height, base elevation and an initial vertical dispersion parameter (initial sigma Z) to be defined. The material transfer volume sources require an initial horizontal dispersion parameter (initial sigma Y) to be defined. The modelling parameters and emission rates used in the assessment are provided in Table 6-2. The initial dispersion vertical and horizontal dispersion parameters were determined based on SCREEN 3 guidance[34] for these types of sources. Table 6-2 and Table 6-3 also provide the modelled emission rates for each area and volume source, for the Project and agricultural goods operations, respectively. For the agricultural goods 1-hour and 24-hour averaging periods, only the emission factors from scenario #2 are presented as they

[32] *US EPA 2005, Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facility, Chapter 3, Air Dispersion and Deposition Modeling.*

[33] *US EPA, 1995 User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volume II - Description of Model Algorithms, EPA-454/B-95-003b*

[34] *USEPA (1995). SCREEN3 Model User's Guide. United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Emissions Monitoring and Analysis Division. Research Triangle Park, North Carolina. September 1995.* http://www.epa.gov/scram001/userg/screen/screen3d.pdf

DRAFT

are the worst-case emissions. Similarly, only the emission factors from scenario #1+2 in conjunction are presented as the worst-case emissions occur when all material is assumed to transfer through the shed.

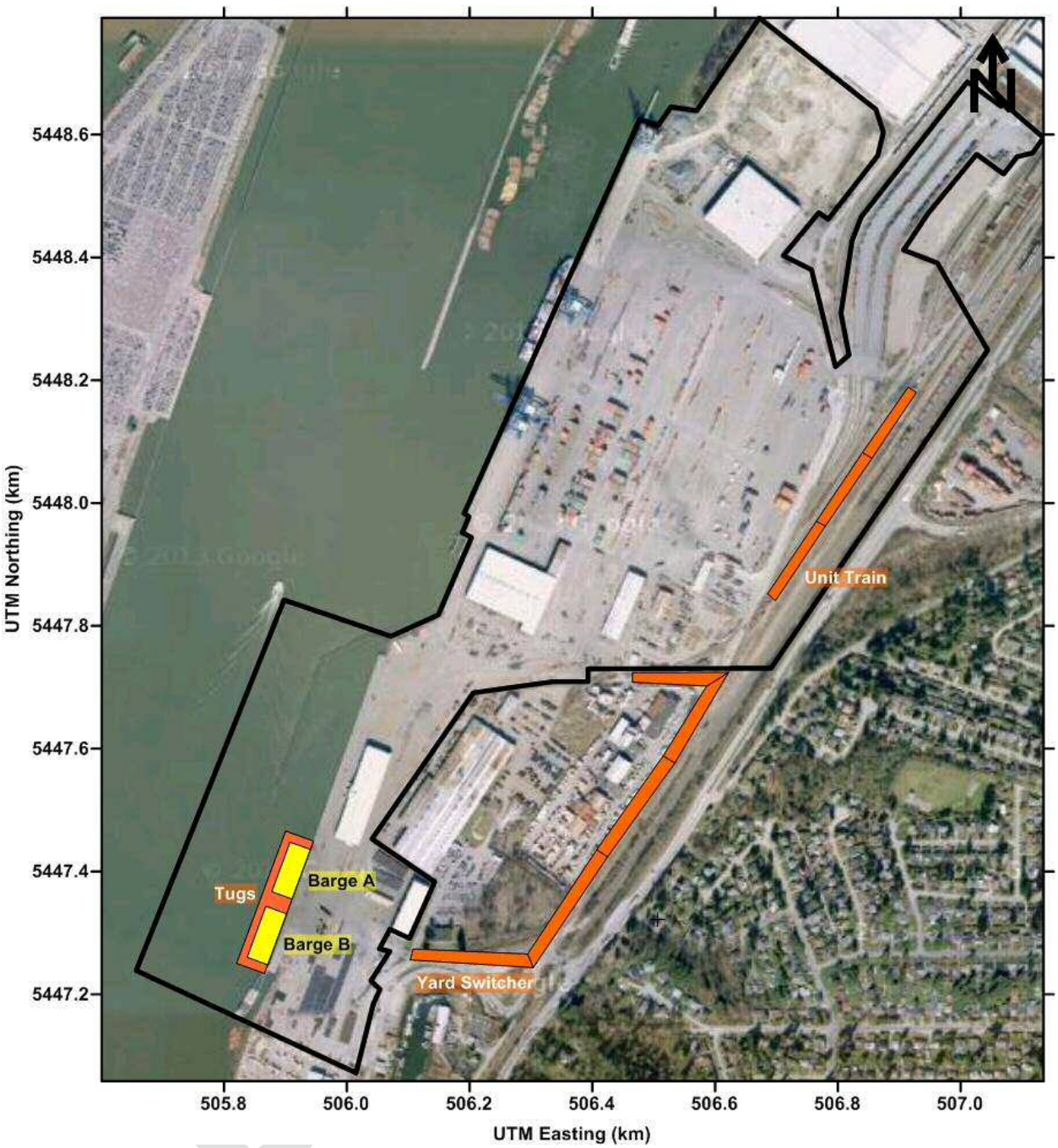
The 1-hour emission rates estimate the peak emissions from the sources. The 1-hour emissions were modelled to predict the 1-hour average air contaminant concentrations for comparison against the 1-hour AAQOs.

The 24-hour emission rates estimate daily emissions from sources taking into account daily operating hours for combustion sources, and daily throughput for material transfers and exposure to wind for railcar and barge stockpiles. The 24-hour emissions were modelled to predict the 24-hour average air contaminant concentrations for comparison against the 24-hour AAQOs.

Annual emission rates were determined in a similar manner as the 24-hour emissions based on the annual operating hours (combustion sources), annual throughput (material transfer points) and exposure to the wind (railcar and barge stockpiles). Annual emission rates were modelled to determine the annual average air contaminant concentrations for comparison against the annual average AAQOs.

Table 6-4 and Table 6-5 provides the assumptions used to establish realistic worst-case scenario emission rates for each averaging period, for the Project and agricultural goods operations, respectively.

DRAFT

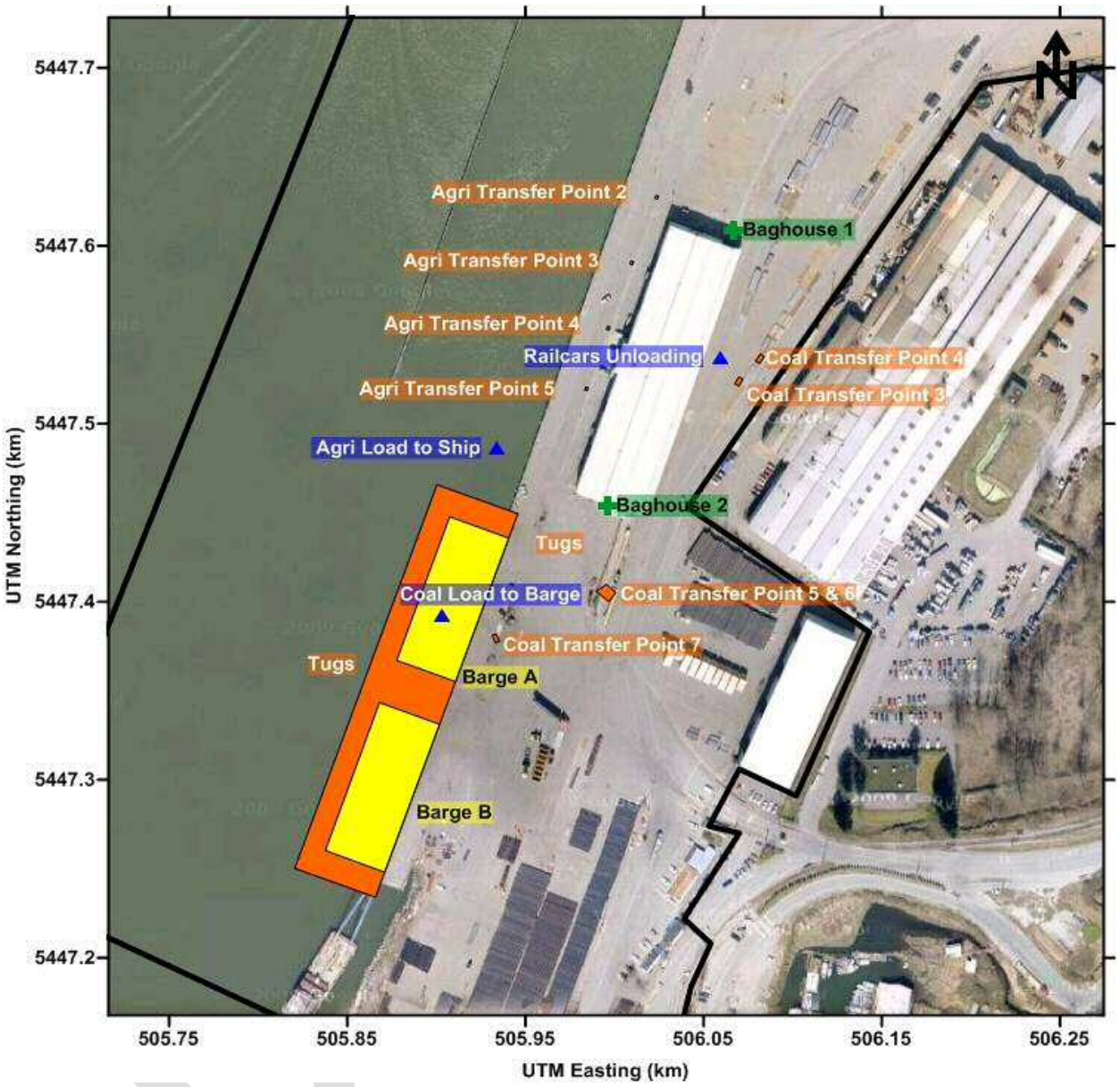


Notes: *Unit train area sources consider combustion and fugitive dust emissions. Tugboat and the yard switcher area sources consider combustion emissions.*

Location of the FSD fenceline is indicated by the black outline.

Cumulative sources modelled are shown in Figure 6-4.

Figure 6-2 Sources Modelled - FSD Large Area Sources



Notes: *Location of the FSD fenceline is indicated by the black outline.*

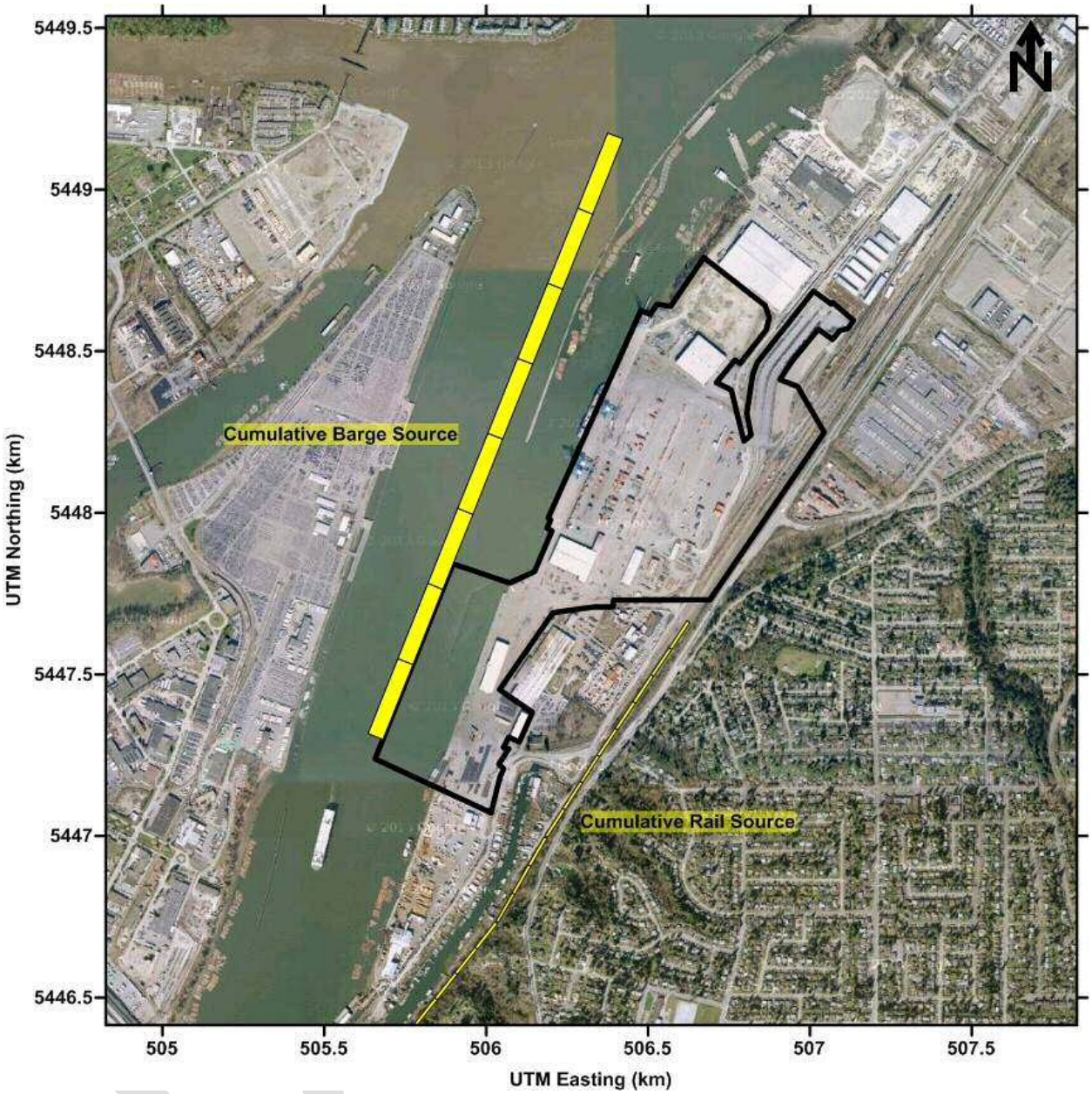
Point Sources Shown: Agri baghouse 1 and 2.

Volume Sources Shown: Railcar unloading and coal loading to barge.

Area Sources Shown: Project material transfer points (3-7), Agri material transfer points (2-5), barges (noted as A and B) and tugboats.

Cumulative sources modelled are shown in Figure 6-4.

Figure 6-3 Sources Modelled - FSD Area and Volume Sources (Zoomed View)



Note: *Location of the FSD fenceline is indicated by the black outline.*

Cumulative Barge and Rail Sources modelled considered combustion and fugitive dust emissions.

Figure 6-4 Sources Modelled – FSD Cumulative Sources

Table 6-2 Summary of Modelling Parameters and Emission Rates (Project)

Emission Source	Averaging Period	Source Parameters				Emission Rates (g/m^2/s - area, g/s - volume)					
		Effective Height (m)	Initial sigma z (m)	Initial sigma y (m)	Equivalent Surface Area (m^2)	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	TPM
Coal Load to Barge (Volume Source)	1-hour	5.25	1.22	0.25	n/a	-	-	-	4.972E-03	3.283E-02	6.942E-02
	24-hour					-	-	-	5.175E-04	3.418E-03	7.226E-03
	Annual					-	-	-	1.085E-04	7.166E-04	1.515E-03
Tugboats (Area Source)	1-hour	4.5	2.09	n/a	1.11E+04	1.585E-05	2.002E-04	9.076E-08	3.190E-06	3.467E-06	3.612E-06
	24-hour					1.321E-06	1.669E-05	7.563E-09	2.658E-07	2.889E-07	3.010E-07
	Annual					1.158E-06	1.463E-05	6.631E-09	2.330E-07	2.533E-07	2.639E-07
Yard Switch (Area Source)	1-hour	4.5	2.1	n/a	1.21E+04	1.076E-06	1.016E-05	4.686E-10	2.172E-07	2.239E-07	2.239E-07
	24-hour					4.034E-07	3.810E-06	1.757E-10	8.146E-08	8.398E-08	8.398E-08
	Annual					3.537E-07	3.341E-06	1.541E-10	7.142E-08	7.363E-08	7.363E-08
Unit Train (Area Source)	1-hour	4.5	2.09	n/a	6.64E+03	1.286E-05	9.170E-05	4.465E-08	2.312E-06	2.383E-06	2.383E-06
	24-hour					1.286E-05	9.170E-05	4.465E-08	2.312E-06	2.383E-06	2.383E-06
	Annual					3.468E-06	2.473E-05	1.204E-08	6.233E-07	6.425E-07	6.425E-07
Coal Transfer Point #1 (Area Source)	1-hour	2	0.93	n/a	1.20E+01	-	-	-	1.164E-04	4.595E-04	1.253E-03
	24-hour					-	-	-	2.525E-05	9.972E-05	2.720E-04

DRAFT

Emission Source	Averaging Period	Source Parameters				Emission Rates (g/m²/s - area, g/s - volume)					
		Effective Height (m)	Initial sigma z (m)	Initial sigma y (m)	Equivalent Surface Area (m^2)	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	TPM
	Annual					-	-	-	2.214E-05	8.743E-05	2.384E-04
Coal Transfer Point #2 (Area Source)	1-hour	2	0.93	n/a	1.24E+01	-	-	-	1.124E-04	4.438E-04	1.210E-03
	24-hour					-	-	-	2.439E-05	9.630E-05	2.626E-04
	Annual					-	-	-	2.138E-05	8.443E-05	2.303E-04
Coal Transfer Point #3 + #4 (Area Source)	1-hour	9.5	4.42	n/a	5.28E+01	-	-	-	1.054E-04	4.163E-04	1.135E-03
	24-hour					-	-	-	2.288E-05	9.035E-05	2.464E-04
	Annual					-	-	-	2.006E-05	7.921E-05	2.160E-04
Coal Transfer Point #5 (Area Source)	1-hour	9.5	4.42	n/a	1.10E+01	-	-	-	2.541E-04	1.003E-03	2.737E-03
	24-hour					-	-	-	5.515E-05	2.178E-04	5.939E-04
	Annual					-	-	-	4.835E-05	1.909E-04	5.207E-04
Railcars Unloading (Volume Source)	1-hour	4	6.98	5.1	n/a	-	-	-	5.966E-03	3.940E-02	8.330E-02
	24-hour					-	-	-	6.210E-04	4.101E-03	8.671E-03
	Annual					-	-	-	1.404E-04	9.272E-04	1.960E-03

DRAFT

Table 6-3 Summary of Modelling Parameters and Emission Rates (Agricultural Scenario #2 for 1-hour and 24-hour, Scenario #1+2 for Annual)

Emission Source	Averaging Period	Source Parameters				Emission Rates ($g/m^2/s$ - area, g/s - volume)					
		Effective Height (m)	Initial sigma z (m)	Initial sigma y (m)	Equivalent Surface Area (m^2)	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	TPM
Baghouse 1 (Point Source)	1-hour	5.43	n/a	n/a	n/a	-	-	-	1.966E-02	9.306E-02	2.097E-01
	24-hour					-	-	-	2.949E-03	1.396E-02	3.146E-02
	Annual					-	-	-	4.695E-03	2.248E-02	5.296E-02
Baghouse 2 (Point Source)	1-hour	5.43	n/a	n/a	n/a	8.279E-02	3.118E-01	2.820E-04	1.815E-03	9.038E-03	3.501E-02
	24-hour					6.209E-02	2.338E-01	2.115E-04	4.448E-04	1.528E-03	5.424E-03
	Annual					9.451E-03	3.559E-02	3.219E-05	3.816E-04	2.031E-03	7.960E-03
Agricultural Transfer Point #2	1-hour	1	0.47	n/a	2.7	-	-	-	4.310E-03	1.702E-02	4.641E-02
	24-hour					-	-	-	6.465E-04	2.553E-03	6.962E-03
	Annual					-	-	-	9.840E-04	3.886E-03	1.060E-02
Agricultural Transfer Point #3	1-hour	2	0.93	n/a	2.7	-	-	-	4.363E-03	1.723E-02	4.699E-02
	24-hour					-	-	-	6.545E-04	2.584E-03	7.048E-03
	Annual					-	-	-	4.981E-04	1.967E-03	5.364E-03
Agricultural Transfer Point #4	1-hour	4	1.86	n/a	2.7	-	-	-	4.233E-03	1.671E-02	4.558E-02
	24-hour					-	-	-	6.349E-04	2.507E-03	6.838E-03

DRAFT

Emission Source	Averaging Period	Source Parameters				Emission Rates (g/m²/s - area, g/s - volume)					
		Effective Height (m)	Initial sigma z (m)	Initial sigma y (m)	Equivalent Surface Area (m^2)	CO	NO_x	SO_2	$PM_{2.5}$	PM_{10}	TPM
	Annual					-	-	-	4.832E-04	1.908E-03	5.204E-03
Agricultural Transfer Point #5	1-hour	6	2.79	n/a	2.7	-	-	-	4.292E-03	1.695E-02	4.623E-02
	24-hour					-	-	-	6.439E-04	2.542E-03	6.934E-03
	Annual					-	-	-	4.900E-04	1.935E-03	5.277E-03
Agricultural Load to Ship (Volume Source)	1-hour	10	0.70	0.25	n/a	-	-	-	7.639E-02	4.167E-01	1.667E+00
	24-hour					-	-	-	1.146E-02	6.250E-02	2.500E-01
	Annual					-	-	-	8.720E-03	4.756E-02	1.903E-01

DRAFT

Table 6-4 Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates for Each Averaging Period (Project)

Emission Source	Averaging Period	Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates
Material Transfer Points	1-hour	The peak emission rate for the material transfer point was determined from the amount of material transferred per unit train (12,500 MT) with an hourly handling rate of 2400 tonnes/hr, based on FSD's coal train unloading methodology.
	24-hour	The 24-hour emission rate considered the maximum mass of pollutants released during a worst-case operations day defined as: • One unit train with 125 cars bottom-dumping at a rate of 100 tonnes/car, for a total of 12,500 tonnes/day being handled. The total mass emissions were assumed to occur during one 24-hour period and an average emission rate (g/s) was calculated for the 24-hour period.
	Annual	To calculate the annual emissions, the mass of pollutants released during the unloading of one unit train was multiplied by 320 unit trains expected under this scenario. The average emission rate (g/s) over the year was then calculated.
Tugboats	1-hour	The peak emission rate modelled includes emissions from 2 tugboats operating simultaneously for a half an hour to position barges into place (or tow away loaded barges).
	24-hour	The 24-hour emission rate considers the maximum mass of pollutants released during a worst-case operations day defined as: • A tugboat operates for a half an hour to position each empty barge at the berth (two barges per day). • A tugboat operates for a half an hour to tow away each loaded barge from the berth (two barges per day). The total mass emissions from these events assumed to occur during one 24-hour period was determined and an average emission rate (g/s) was calculated for the 24-hour period.
	Annual	For each unit train unloaded at the facility, tugboat operations were defined as: • A tugboat operates for a half an hour to position each empty barge at the berth (two barges per day). • A tugboat operates for a half an hour to tow away each loaded barge from the berth (two barges per day). To calculate the annual emissions, the mass of pollutants released during one of these events was multiplied by the 320

DRAFT

Emission Source	Averaging Period	Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates
		unit trains expected under this scenario. The average emission rate (g/s) over the year was then calculated.
Yard Switcher	1-hour	The peak emission rate modelled reflected the emissions from the operational duty cycle of the yard switch engine.
	24-hour	The 24-hour emission rate considers the maximum mass of pollutants released during a worst-case operations day as: • The yard switch engine operational for the entire time the unit train is at FSD (estimated at 9 hours). The total mass emissions from these events conservatively assumed to occur during one 24-hour period was determined and an average emission rate (g/s) was calculated for the 24-hour period.
	Annual	For each unit train unloaded at the facility, yard switch operations of 9 hours were considered. To calculate the annual emissions, the mass of pollutants released during one of these events was multiplied by the 320 unit trains expected under this scenario. The average emission rate (g/s) over the year was then calculated.
Unit Train	1-hour	The peak emission rate modelled assumes all four locomotives are idling continuously for the hour.
	24-hour	The peak emission rate modelled assumes all four locomotives are idling continuously for the entire day.
	Annual	For each unit train unloaded at the facility, the four locomotives were conservatively considered to idle for 4 hours on "warm days" (above 40 degrees Fahrenheit = 250 days/yr) and the entire 12 hours period the units are at the facility on "cold days" (below 40 degrees Fahrenheit = 115 days/yr). To calculate the annual emissions, the mass of pollutants released during each of these events was multiplied by the appropriate "warm" and "cold" percentages of the 160 unit trains expected under this scenario. The average emission rate (g/s) over the year was then calculated.

DRAFT

Table 6-5 Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates for Each Averaging Period (Agricultural)

Emission Source	Averaging Period	Assumptions Used to Establish Realistic Worst-Case Scenario Emission Rates
Baghouse #1	1-hour	The 1-hour emission rate for the unloading operation, material transfer point, and headhouse was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the unloading operation, material transfer point, and headhouse was determined from a daily handling rate of 3,600 tonnes/day.
	Annual	The annual emission rate for the unloading operation was determined from an annual handling rate of 1,000,000 tonnes/year. For the material transfer point and headhouse, the worst-case scenario was represented from all 1,000,000 tonnes/year passes through twice for a total of 2,000,000 tonnes/year.
Baghouse #2	1-hour	The 1-hour emission rate for the shed operations was determined from an hourly handling rate of 1,000 tonnes/hr. The peak emission rate modelled for the Front End Loaders reflected the emissions from continuous operation of Tier 1 Front End Loaders.
	24-hour	The 24-hour emission rate for the shed operations was determined from an hourly handling rate of 3,600 tonnes/day. The daily emission rate modelled for the Front End Loaders reflected the emissions from an 18-hour operation period of Tier 1 Front End Loaders.
	Annual	The annual emission rate for the shed operations was determined from an annual handling rate of 1,000,000 tonnes/year. The annual emission rate modelled for the Front End Loaders reflected the emissions from 1000 hours of operation of Tier 1 Front End Loaders.
Agri Material Transfer Point #2	1-hour	The 1-hour emission rate for the material transfer point was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the material transfer point was determined from a daily handling rate of 3,600 tonnes/day.
	Annual	The annual emission rate for the material transfer point was determined from the worst-case scenario where the entire 1,000,000 tonnes/year passes through the material transfer point twice for a total of 2,000,000 tonnes/year.
Agri Material Transfer Point #3	1-hour	The 1-hour emission rate for the material transfer point was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the material transfer point was determined from a daily handling rate of 3,600 tonnes/day.

DRAFT

	Annual	The annual emission rate for the material transfer point was determined from an annual handling rate of 1,000,000 tonnes/year
Agri Material Transfer Point #4	1-hour	The 1-hour emission rate for the material transfer point was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the material transfer point was determined from a daily handling rate of 3,600 tonnes/day.
	Annual	The annual emission rate for the material transfer point was determined from an annual handling rate of 1,000,000 tonnes/year
Agri Material Transfer Point #5	1-hour	The 1-hour emission rate for the material transfer point was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the material transfer point was determined from a daily handling rate of 3,600 tonnes/day.
	Annual	The annual emission rate for the material transfer point was determined from an annual handling rate of 1,000,000 tonnes/year
Agri Ship Loading	1-hour	The 1-hour emission rate for the ship loading was determined from an hourly handling rate of 1,000 tonnes/hr.
	24-hour	The 24-hour emission rate for the ship loading was determined from a daily handling rate of 3,600 tonnes/day.
	Annual	The annual emission rate for the ship loading was determined from an annual handling rate of 1,000,000 tonnes/year

DRAFT

6.5 Conversion from NO_x to NO_2

AAQOs refer to NO_2 (not NO_x), and the CALPUFF model as applied does not account for NO to NO_2 conversion. In accordance with the AQMG, if 100% NO_x conversion leads to exceedances of the AAQO, the Ambient Ratio (AR) method should be implemented to convert predicted NO_x concentrations into NO_2 concentrations. The AR method utilizes representative hourly NO_x and NO_2 monitoring data to characterize the NO_2/NO_x ratio given the ambient NO_x concentration. The method then applies this ratio to the model predicted NO_x emissions from the Project.

Ambient air quality data from Metro Vancouver station T18 (Burnaby South) was used to calculate the ratio of NO_2/NO_x. The resulting ratio was validated against NO_2/NO_x ratios and ambient air quality from Metro Vancouver stations T13 (North Delta) and T17 (Richmond South). For the 1-hour averaging period, an exponential equation of the form $y = ax^b$ was fit to the upper envelope of observed NO_2/NO_x versus NO_x, where *a* and *b* are empirically determined constants. The resulting equation was used to determine the ratio of NO_2/NO_x subject to the constraints that the equation is only valid for NO_x values where the corresponding NO_2/NO_x ratio is less than 1. Figure 6-5 illustrates the dependence of NO_2/NO_x ratio on ambient NO_x air quality.

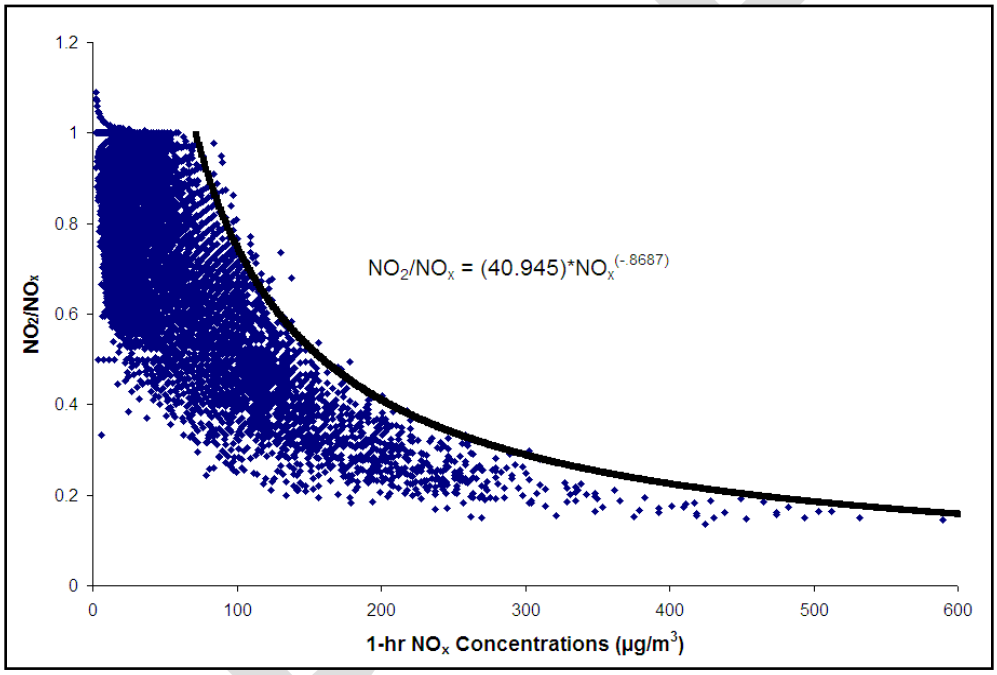


Figure 6-5 NO_2/NO_x Ratio versus 1-hour Average NO_x Observations from Metro Vancouver Station T18 (Burnaby South)

7. Air Dispersion Modelling Results

7.1 Project Emission Sources (FSD)

A summary of model results for the emission sources from the proposed Project is presented in Table 7-1. Detailed information regarding the emission sources can be found in the preceeding sections (Sections 5 and 6). Table 7-1 shows the maximum predicted modelled concentrations from all sources for each averaging periods without and with ambient background added. This table also provides the maximum predicted concentrations at the nearest resident receptor identified in Figure 7-1 and the appropriate AAQOs for comparison with predicted model results.

All predicted air contaminant concentrations were below AAQOs with ambient background added, with the exception being annual NO_2 which was predicted to be in line with the AAQO with ambient background added. At the nearest residential receptor, predicted concentrations are much lower than the maximum predicted concentrations.

Predicted annual NO_2 concentrations (with background) at the fenceline to the south of the barging operations at the berth were at the AAQO (40 µg/m^3) at one receptor. Elevated annual NO_2 concentrations (with background) were localized in this area around the berth and increase in closer proximity to the tug area source modelled at the berth.

Contour plots of predicted NO_2, PM_{10} and $PM_{2.5}$ concentrations are provided in Figure 7-1 through Figure 7-6. The PM_{10} and $PM_{2.5}$ contour plots are provided to display the predicted impacts near the facility. For all air contaminants, the highest concentrations are predicted to occur along the facility fenceline. The predicted air contaminant concentrations quickly diminish as emissions disperse further away from FSD's facility fenceline.

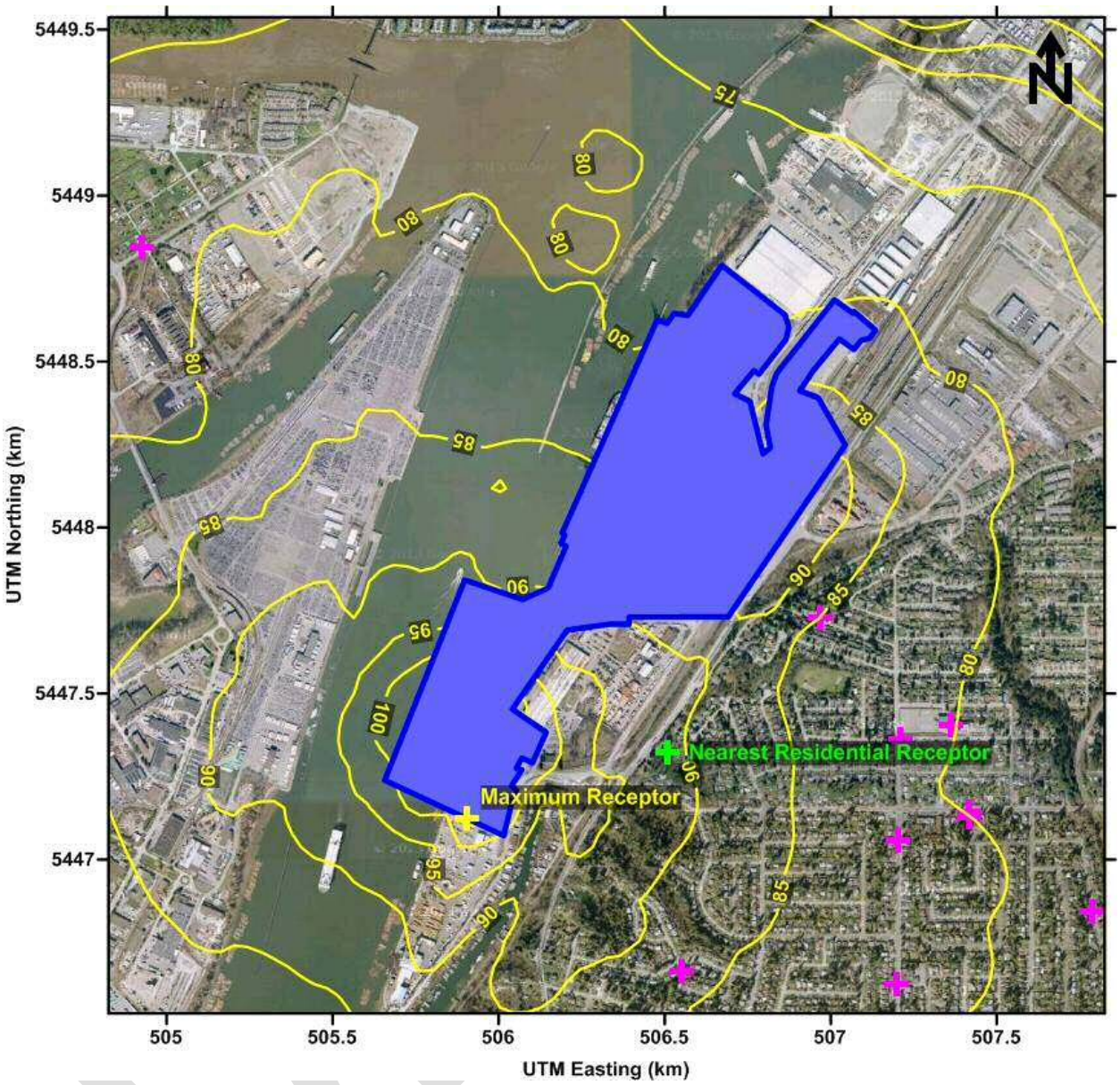
DRAFT

Table 7-1 Predicted Air Contaminant Concentrations from All Sources without and with Background Concentrations

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Receptor	Nearest Residential Receptor	Maximum Receptor	Nearest Residential Receptor
CO	1-hour	30,000	687	121	38	808	725
	8-hour	10,000	615	76	22	691	637
NO_2	1-hour	200	67	108**	93**	108	93
	Annual	40	27	13.04	2.08	40	29
SO_2	1-hour	450	8.3	0.68	0.19	8.98	8.49
	24-hour	125	5.9	0.08	0.01	5.98	5.91
	Annual	30	1.6	0.01	0.00	1.61	1.60
PM_{10}	24-hour	50	26.8	10.5	1.4	37.3	28.2
	Annual	20	12.0	1.4	0.1	13.4	12.1
$PM_{2.5}$	24-hour	25	11.3	4.1	0.8	15.4	12.1
	Annual	8 (6)*	4.1	0.4	0.1	4.5	4.2
TSP	24-hour	120	N/A***	24.7	2.2		
	Annual	60	N/A***	3.6	0.2		
Dustfall	1-month	1.7(mg/dm^2/day)	N/A	0.089	0.001		

* Annual $PM_{2.5}$ objective of 8 $\mu g/m^3$ and a planning goal of 6 $\mu g/m^3$ which is a longer term aspiration target to support continuous improvement.
** The Ambient Ratio Method (ARM) has been applied to the 1-hour NOx results which includes background in the calculation as per the BC AQMG.
*** Background data is not available for Total Suspended Particulate (TSP).

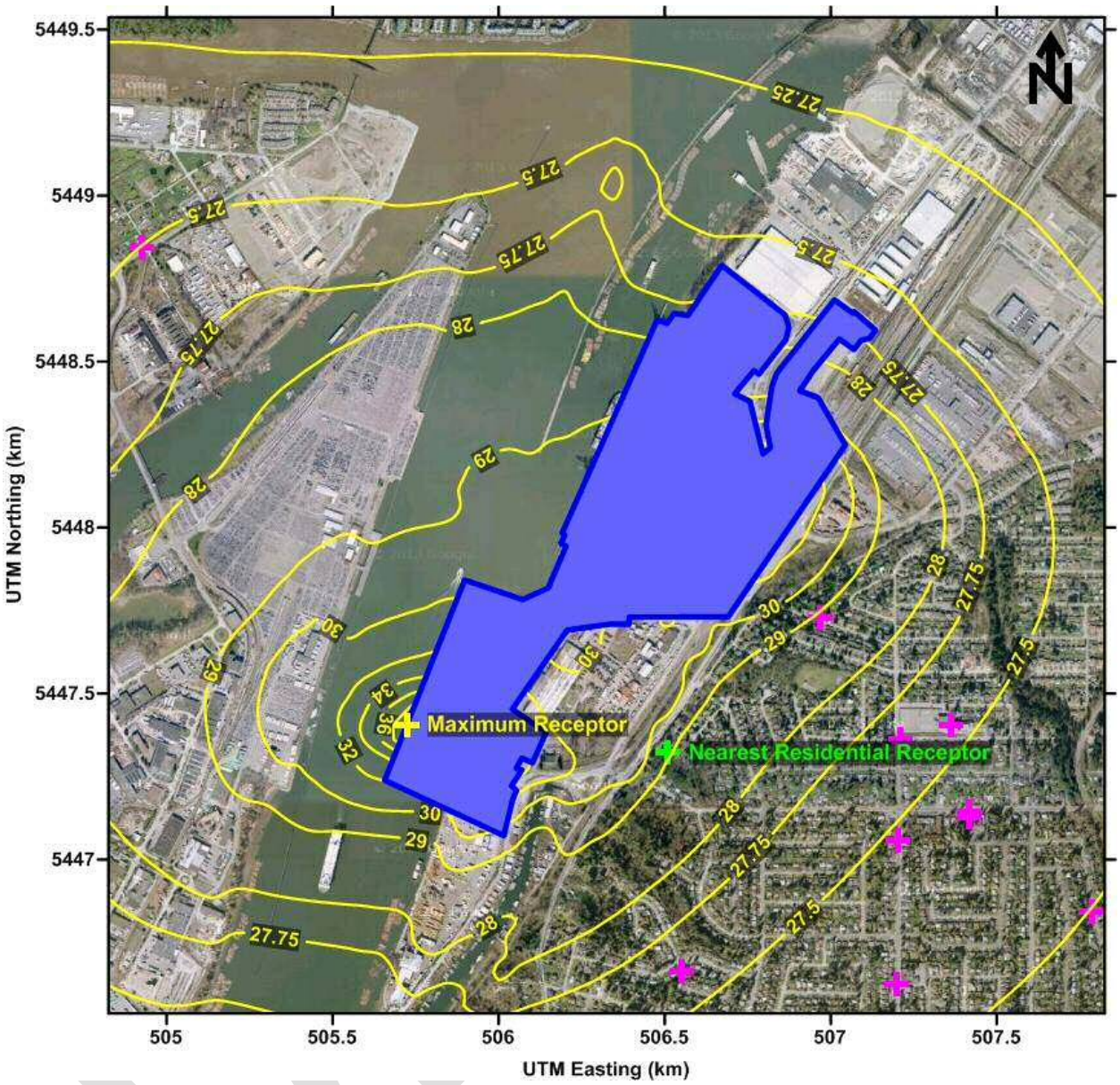
DRAFT



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 80, 85, 90, 95, and 100 µg/m^3.

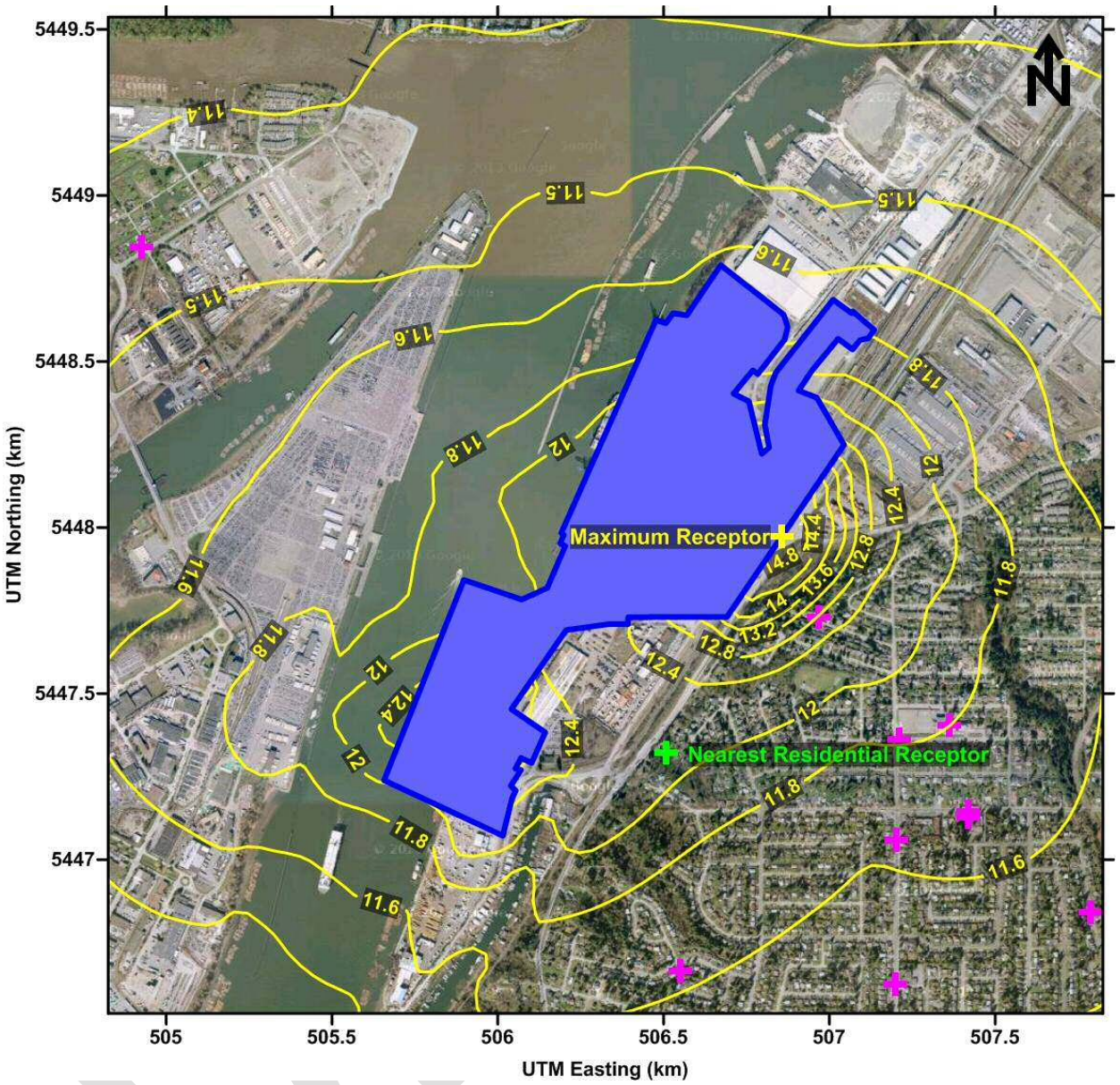
Figure 7-1 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 27.25, 27.5, 27.75, 28, 29, 30, 32, 34, and 36 µg/m^3.

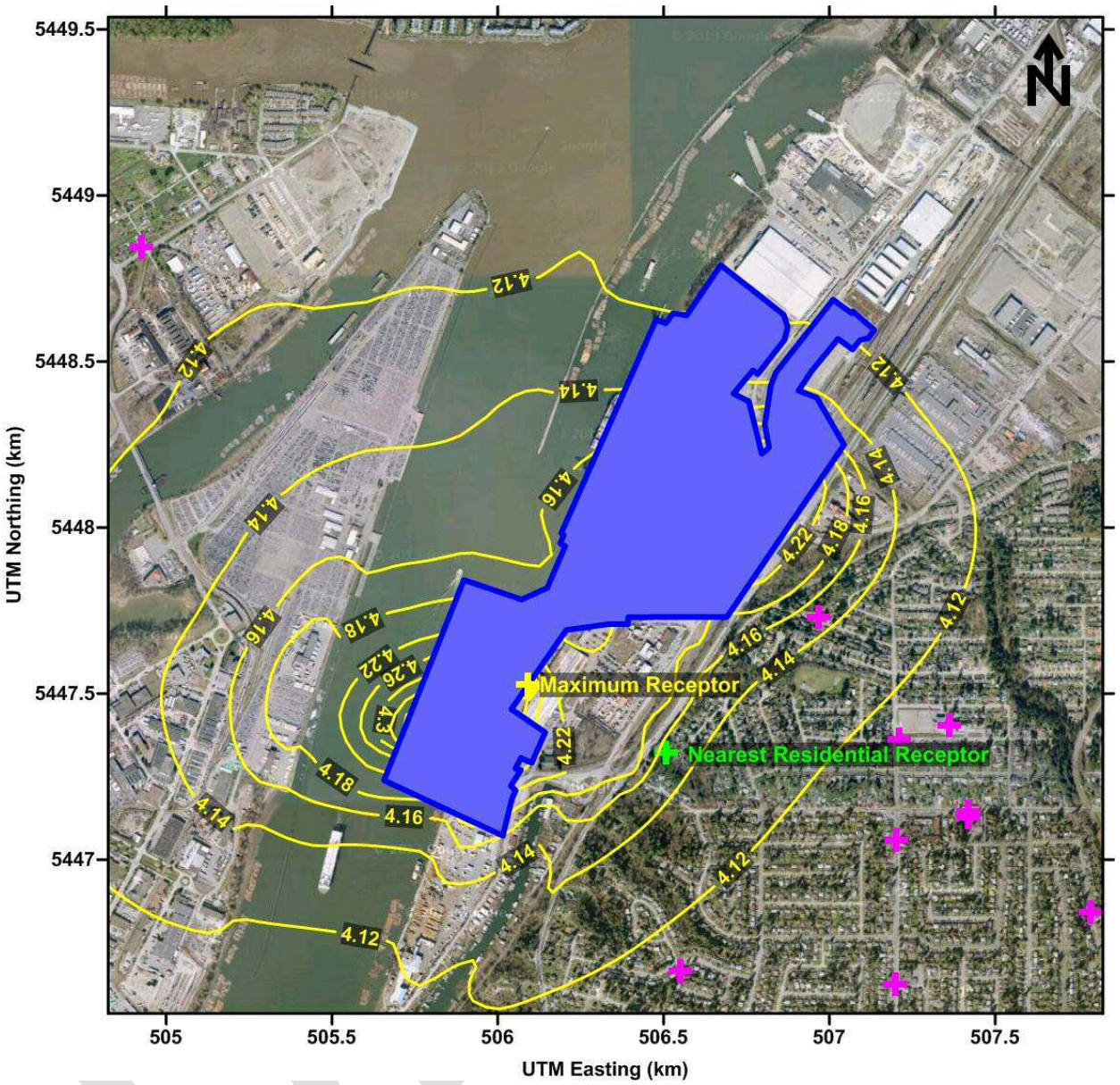
Figure 7-2 Contour Plot of NO_2 Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 11.4, 11.5, 11.6, 11.8, 12, 12.4, 12.8, 13.2, 14, 14.4, and 14.8 µg/m^3.

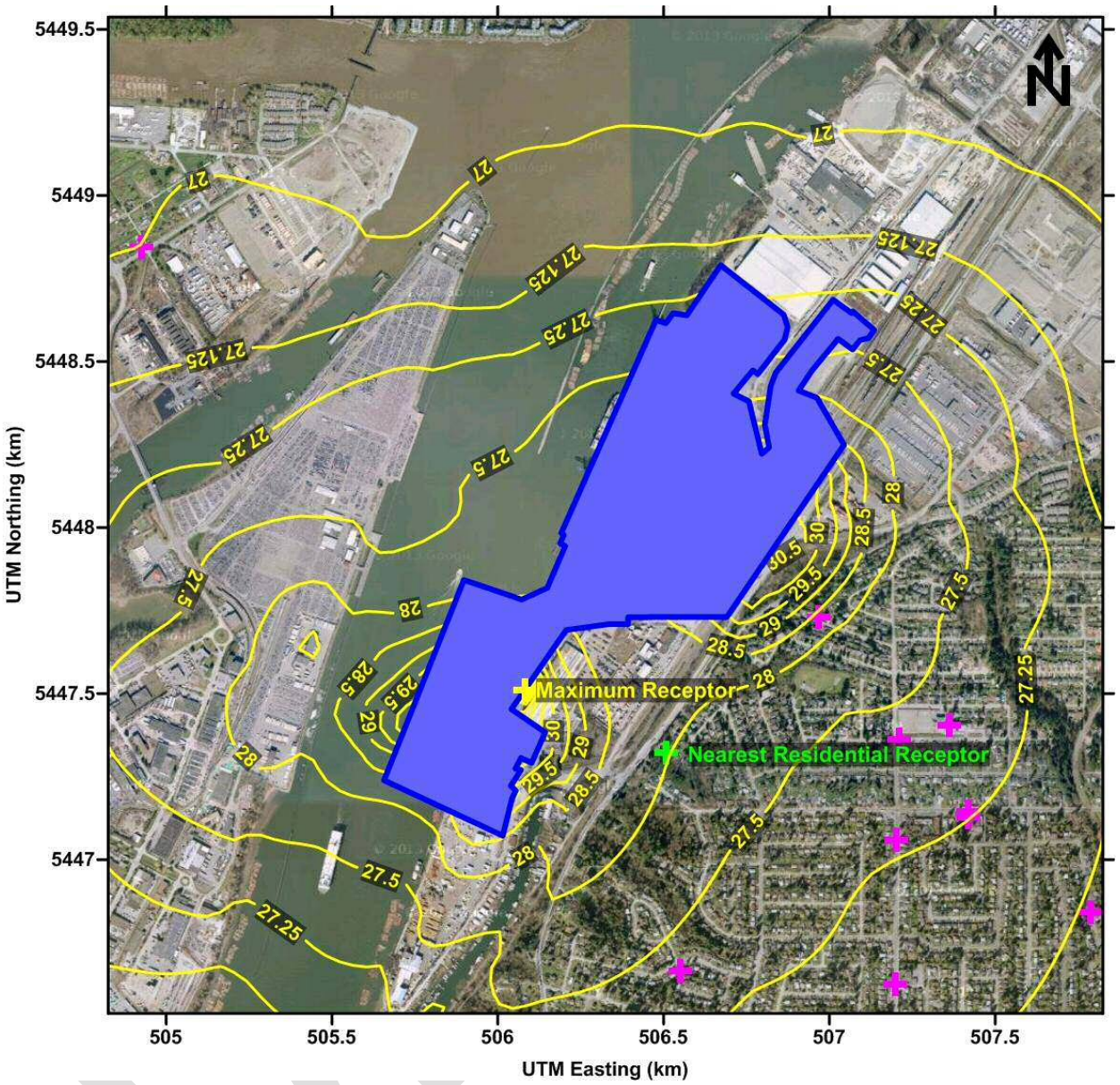
Figure 7-3 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 4.12, 4.14, 4.16, 4.18, 4.22, 4.26, and 4.3 µg/m^3.

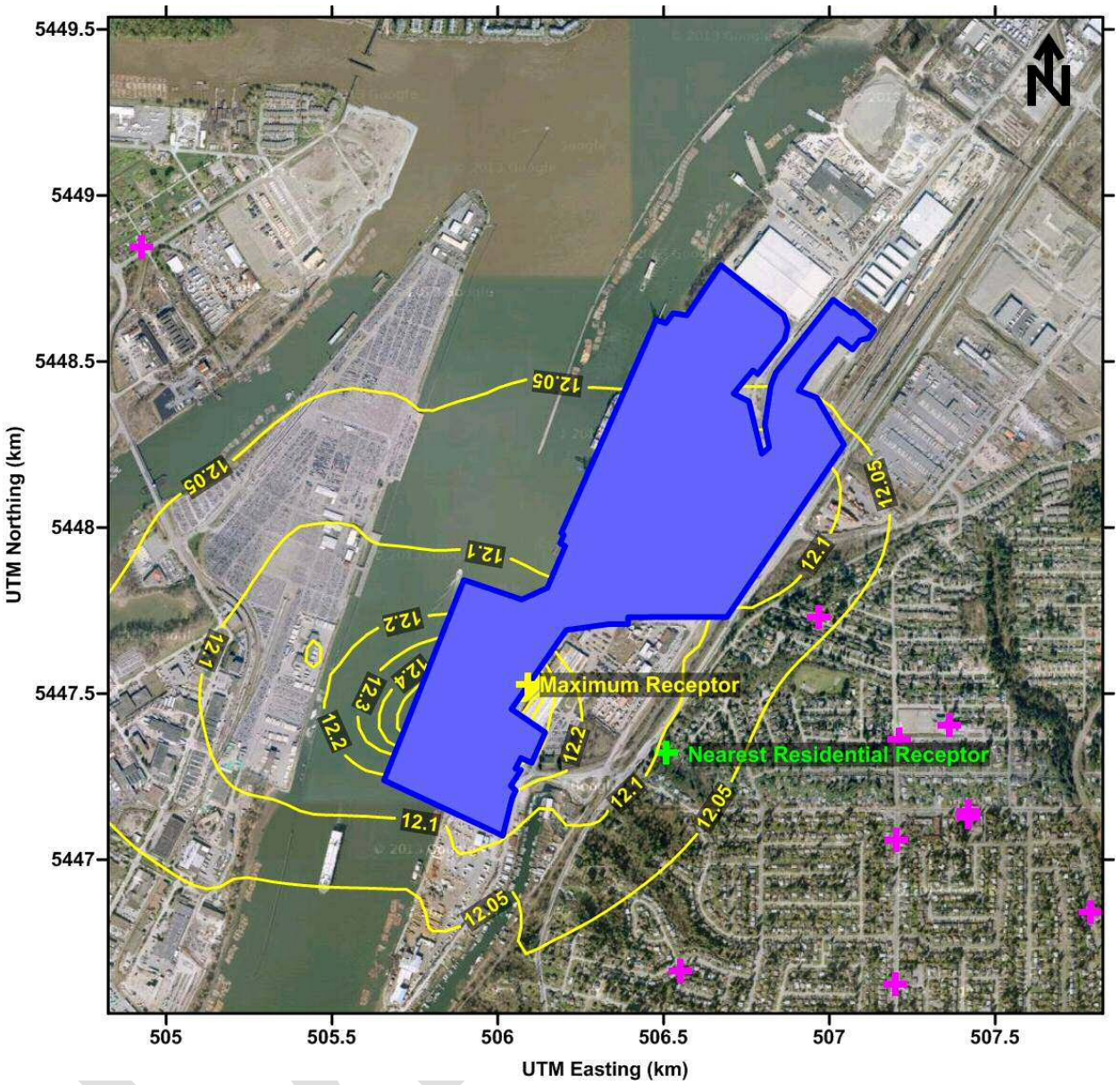
Figure 7-4 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 27, 27.125, 27.25, 27.5, 28, 28.5, 29, 29.5, 30, and 30.5 µg/m^3.

Figure 7-5 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 12.05, 12.1, 12.2, 12.3, and 12.4µg/m^3.

Figure 7-6 Contour Plot of PM_{10} Annual Predicted Concentrations with Background

Sensitive receptors (hospitals, schools, child care facilities, senior care residences, and parks) in the CALPUFF domain were identified through the City of Surrey's COSMOS system, the DataBC Catalogue, and through a search of Google Maps and Google Earth. Figure 7-7 shows the location of sensitive receptors closest to FSD. Table 7-2 shows the maximum predicted concentration for each averaging period at the identified sensitive receptors.

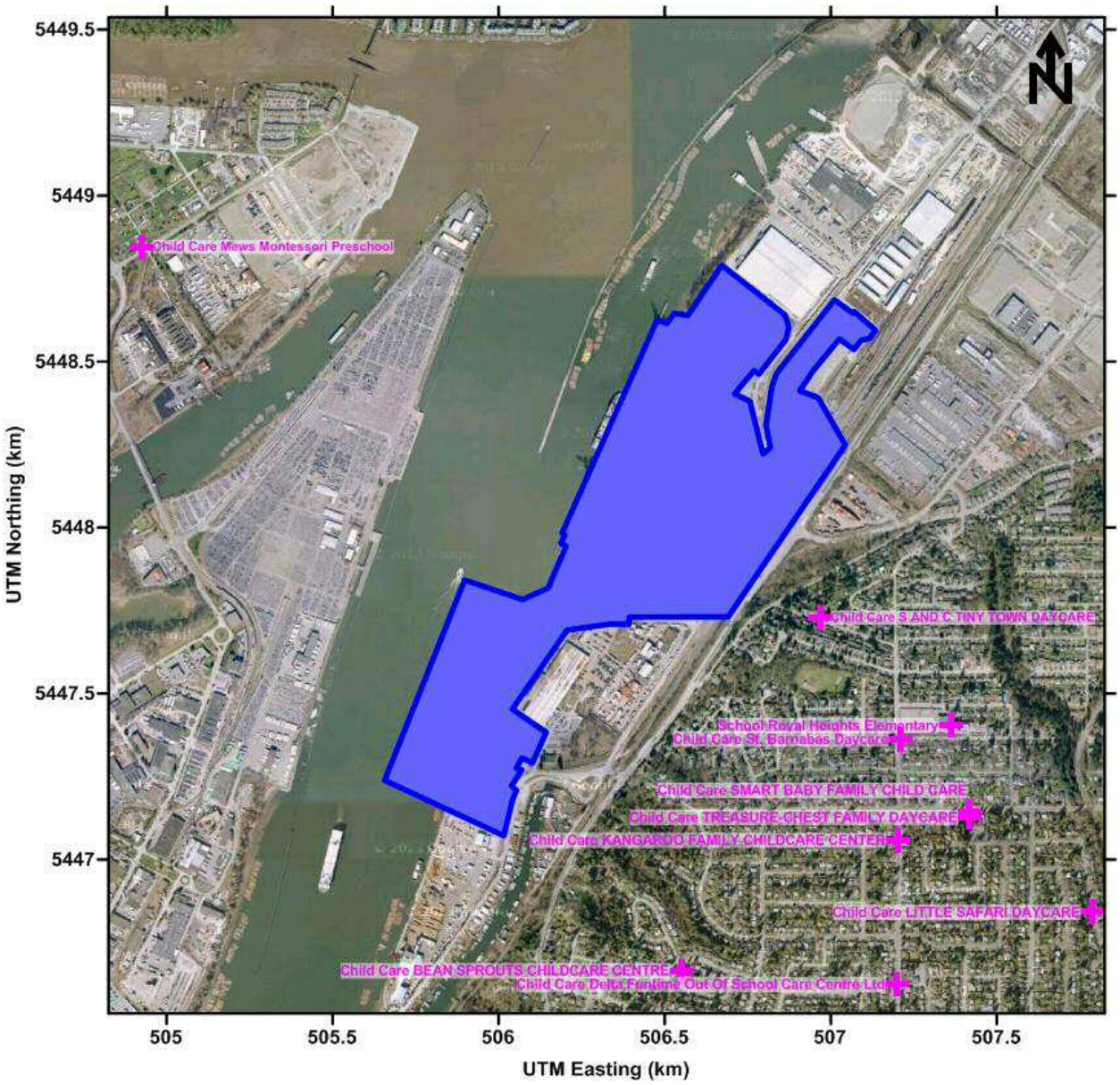


Figure 7-7 Location of Sensitive Receptors near FSD

Table 7-2 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Project)

Pollutant	Averaging Period	AAQO	Background	Bean Sprouts Child Care Centre	Delta Funtime Out of School Care Centre Ltd.	Kangaroo Family Childcare Center	Little Safari Daycare	Mews Montessori Preschool	Royal Heights Daycare	S and C Tiny Town Daycare	Smart Baby Family Child Care	St. Barnabas Daycare	Treasure-Chest Family Daycare
CO	1-hour	30,000	687	711.51	703.57	703.23	699.12	697.97	693.61	720.13	700.82	704.00	700.88
	8-hour	10,000	615	627.21	622.09	622.93	619.42	621.36	618.89	635.29	621.47	623.57	621.45
NO_2	1-hour	200	67	88.85	84.70	85.11	82.21	82.20	78.72	87.58	83.58	84.69	83.71
	Annual	40	27	27.61	27.32	27.47	27.25	27.50	27.10	28.88	27.41	27.64	27.41
SO_2	1-hour	450	8.3	8.43	8.38	8.38	8.36	8.36	8.33	8.42	8.37	8.38	8.37
	24-hour	125	5.9	5.90	5.90	5.91	5.90	5.90	5.90	5.93	5.91	5.91	5.91
	Annual	30	1.6	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
PM_{10}	24-hour	50	26.8	27.40	27.19	27.31	27.12	27.02	26.95	28.38	27.26	27.42	27.26
	Annual	20	12	12.03	12.01	12.02	12.01	12.02	12.01	12.06	12.02	12.03	12.02
$PM_{2.5}$	24-hour	25	11.3	11.63	11.52	11.63	11.54	11.47	11.38	12.77	11.67	11.82	11.66
	Annual	8 (6)*	4.1	4.12	4.11	4.11	4.11	4.11	4.10	4.15	4.11	4.12	4.11
TPM	24-hour	120	N/A	1.08	0.69	0.81	0.45	0.39	0.27	1.67	0.69	0.83	0.69
	Annual	60	N/A	0.06	0.03	0.04	0.02	0.04	0.01	0.08	0.03	0.04	0.03
Dustfall	1-month (mg/dm^2-d)	1.7	N/A	0.0002	0.0001	0.0002	0.0001	0.0002	0.0000	0.0003	0.0002	0.0003	0.0002

DRAFT

7.2 Agricultural Emission Sources

A summary of model results for the emission sources from the proposed Project is presented in Table 7-3. Detailed information regarding the emission sources can be found in the preceding sections (Sections 5 and 6). Table 7-3 shows the maximum predicted modelled concentrations from the agricultural sources for each averaging periods without and with ambient background added. This table also provides the maximum predicted concentrations at the nearest resident receptor identified in Figures 7-8 to 7-13 and the appropriate AAQOs for comparison with predicted model results.

Three separate scenarios were considered for the agricultural emissions analysis, as follows:

1) Load to Shed
2) Load out from Shed
3) Direct Load to Ship

For the 1-hour, 8-hour, and 24-hour averaging periods, only the results from scenario 2), the load out from shed are presented as they had the worst-case emissions in comparison to the other two scenarios. For the annual averaging periods, the combination of scenarios 1) and 2) were added together as this created the highest emissions, resulting from the assumption that all agricultural products would be loaded to the shed and then loaded out to the ship.

All predicted air contaminant concentrations were below AAQOs with ambient background added. At the nearest residential receptor, predicted concentrations are much lower than the maximum predicted concentrations.

Predicted annual NO_2 concentrations (with background) are concentrated to the east of the facility near the 2nd baghouse that FSD plans on installing. Elevated annual NO_2 concentrations (with background) were localized in this area but are well below AAQO even with background concentrations added.

Contour plots of predicted NO_2, PM_{10} and $PM_{2.5}$ concentrations are provided in Figure 7-10 through Figure 7-13. The PM_{10} and $PM_{2.5}$ contour plots are provided to display the predicted impacts near the facility. For all air contaminants, the highest daily concentrations are predicted to occur along the east side of the facility fenceline close to the 2nd baghouse. The annual PM_{10} and $PM_{2.5}$ concentrations are predicted to have the greatest impacts on the western side of the facility nearest the agricultural transfer points.

Table 7-4 shows the maximum predicted concentrations from agricultural related processes for each averaging period at the identified sensitive receptors.

DRAFT

Table 7-3 Predicted Air Contaminant Concentrations from Agricultural Sources without and with Background Concentrations

Scenario 2: Load Out from Shed

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Receptor	Nearest Residential Receptor	Maximum Receptor	Nearest Residential Receptor
CO	1-hour	30,000	687	14	4	701	691
	8-hour	10,000	615	7	2	622	617
NO_2	1-hour	200	67	51*	16*	118	83
SO_2	1-hour	450	8.3	0.05	0.01	8.3	8.3
	24-hour	125	5.9	0.01	0.00	5.9	5.9
PM_{10}	24-hour	50	26.8	21.2	4.2	48.0	31.0
$PM_{2.5}$	24-hour	25	11.3	4.7	0.9	16.0	12.2
TSP	24-hour	120	N/A**	24.7	2.2		
Dustfall	1-month	1.7(mg/dm^2/day)	N/A	0.087	0.013		

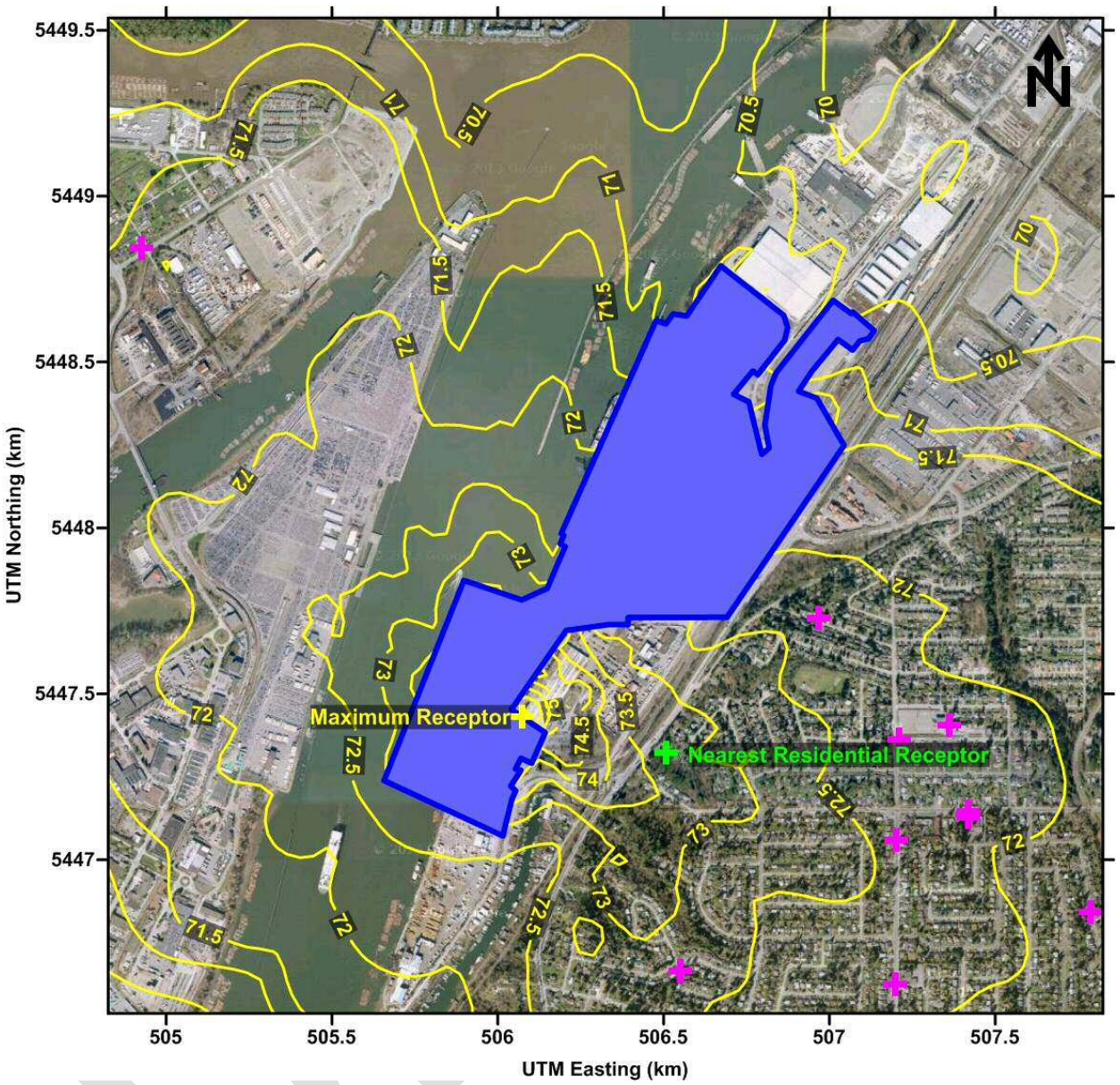
* The Ambient Ratio Method (ARM) has been applied to the 1-hour NOx results which includes background in the calculation as per the BC AQMG.
** Background data is not available for Total Suspended Particulate (TSP).

Scenario 1+2: Load to Shed, Load Out from Shed

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Receptor	Nearest Residential Receptor	Maximum Receptor	Nearest Residential Receptor
NO_2	Annual	40	27	0.2	0.0	27.2	27.0
SO_2	Annual	30	1.6	0.0	0.0	1.6	1.6
PM_{10}	Annual	20	12	3.8	0.3	15.8	12.3
$PM_{2.5}$	Annual	8 (6)*	4.1	0.9	0.1	5.0	4.2
TSP	Annual	60	N/A**	11.5	1.1		

* Annual $PM_{2.5}$ objective of 8 $\mu g/m^3$ and a planning goal of 6 $\mu g/m^3$ which is a longer term aspiration target to support continuous improvement.
** Background data is not available for Total Suspended Particulate (TSP).

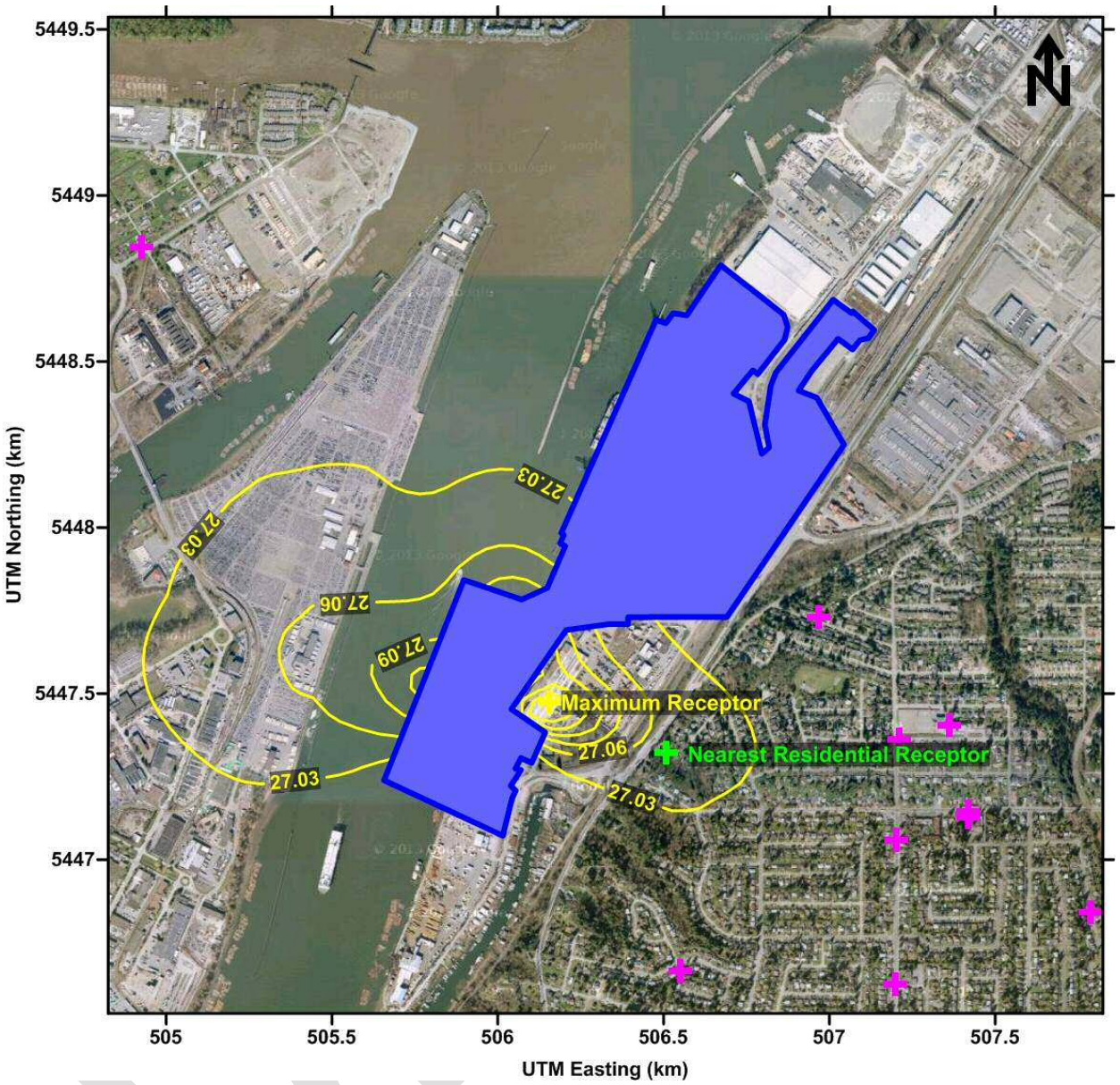
DRAFT



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 70, 70.5, 71, 71.5, 72, 72.5, 73, 75, 75.6, and 75 µg/m^3.

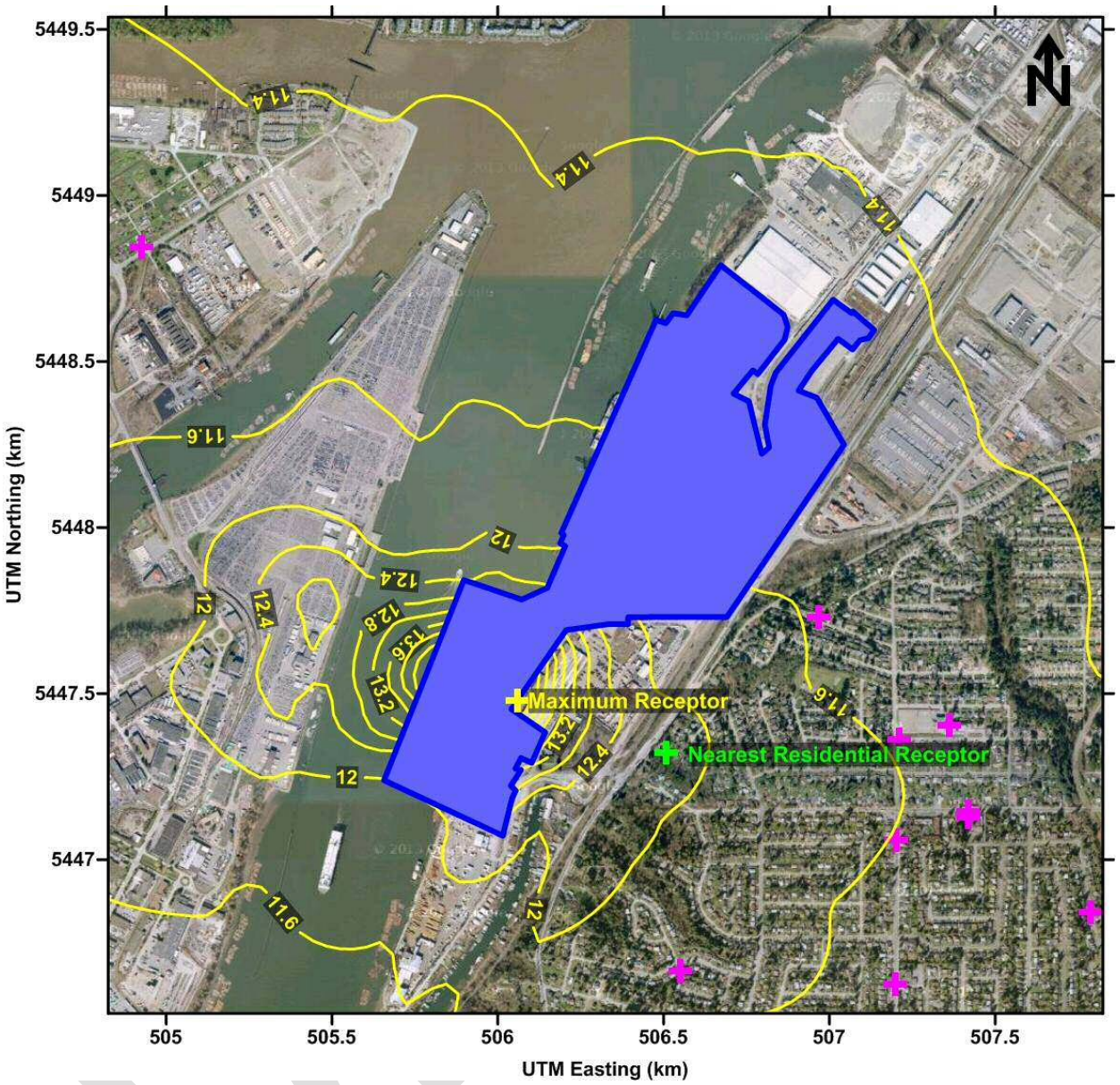
Figure 7-8 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 27.03, 27.06, 27.09, 27.12, 27.15, 27.18, and 27.21 µg/m³.

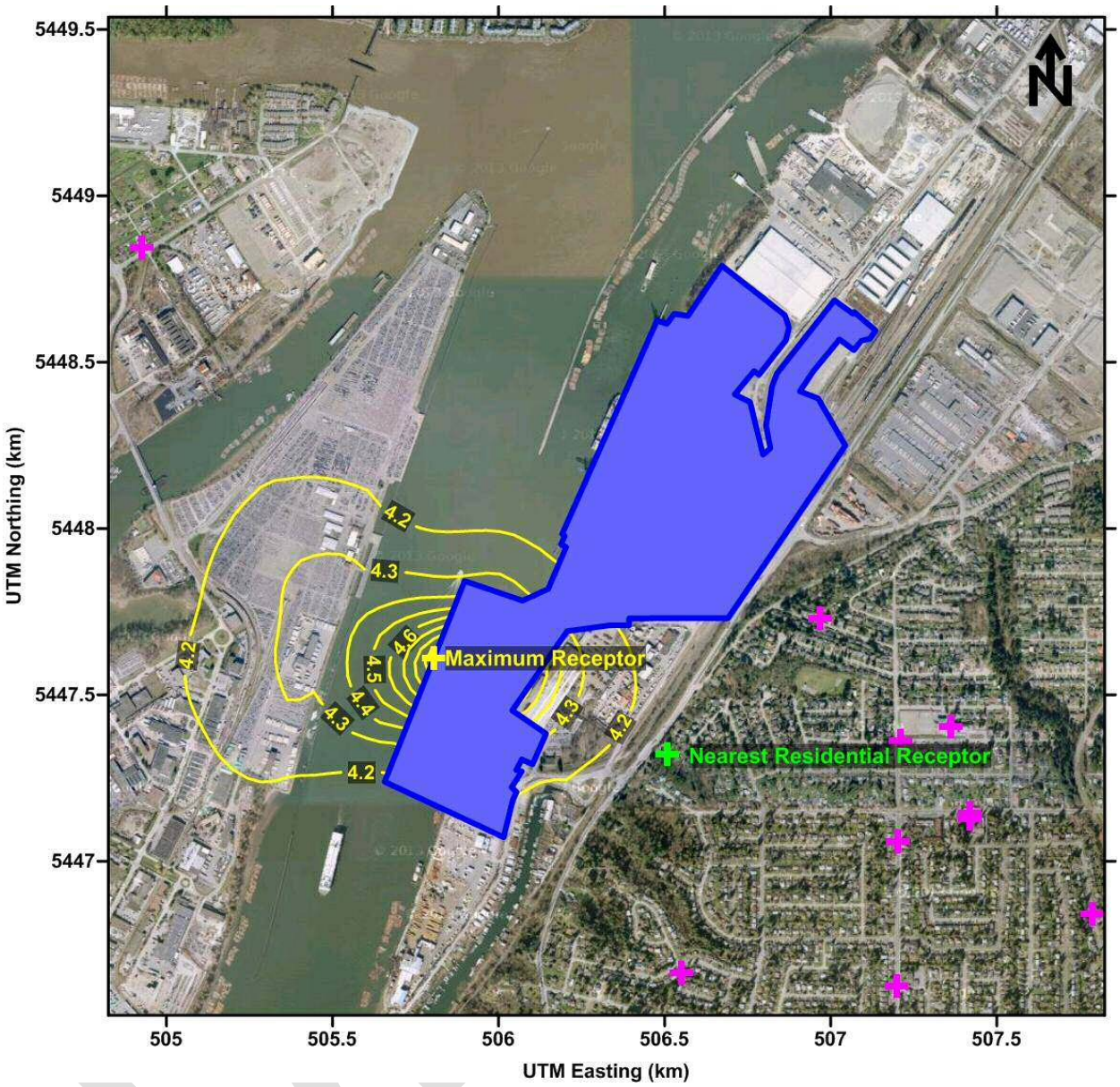
Figure 7-9 Contour Plot of NO_2 Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 11.6, 12, 12.4, 12.8, 13.2, 3.6, 14, and 14.4 µg/m³.

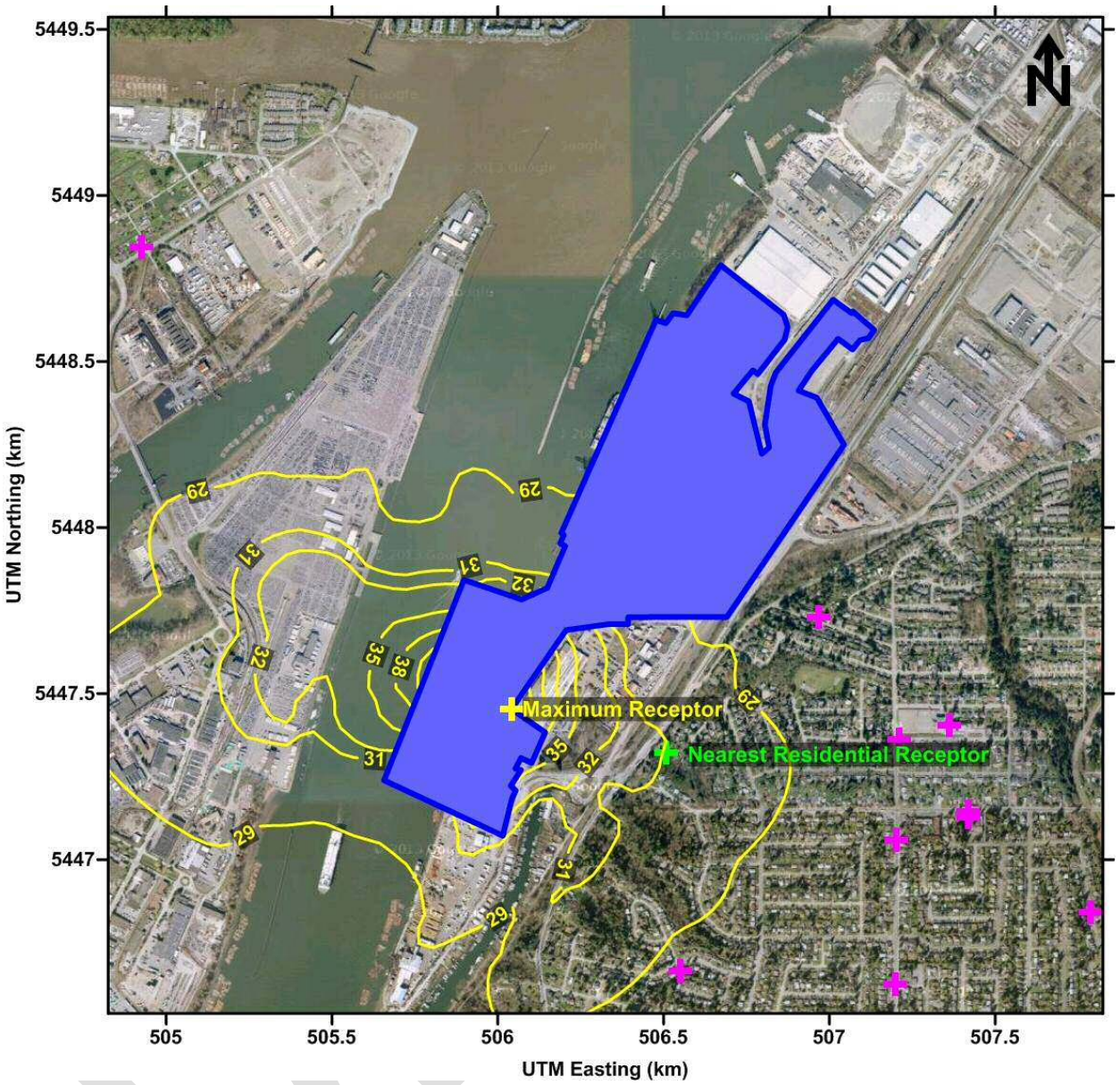
Figure 7-10 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, and 4.8 µg/m^3.

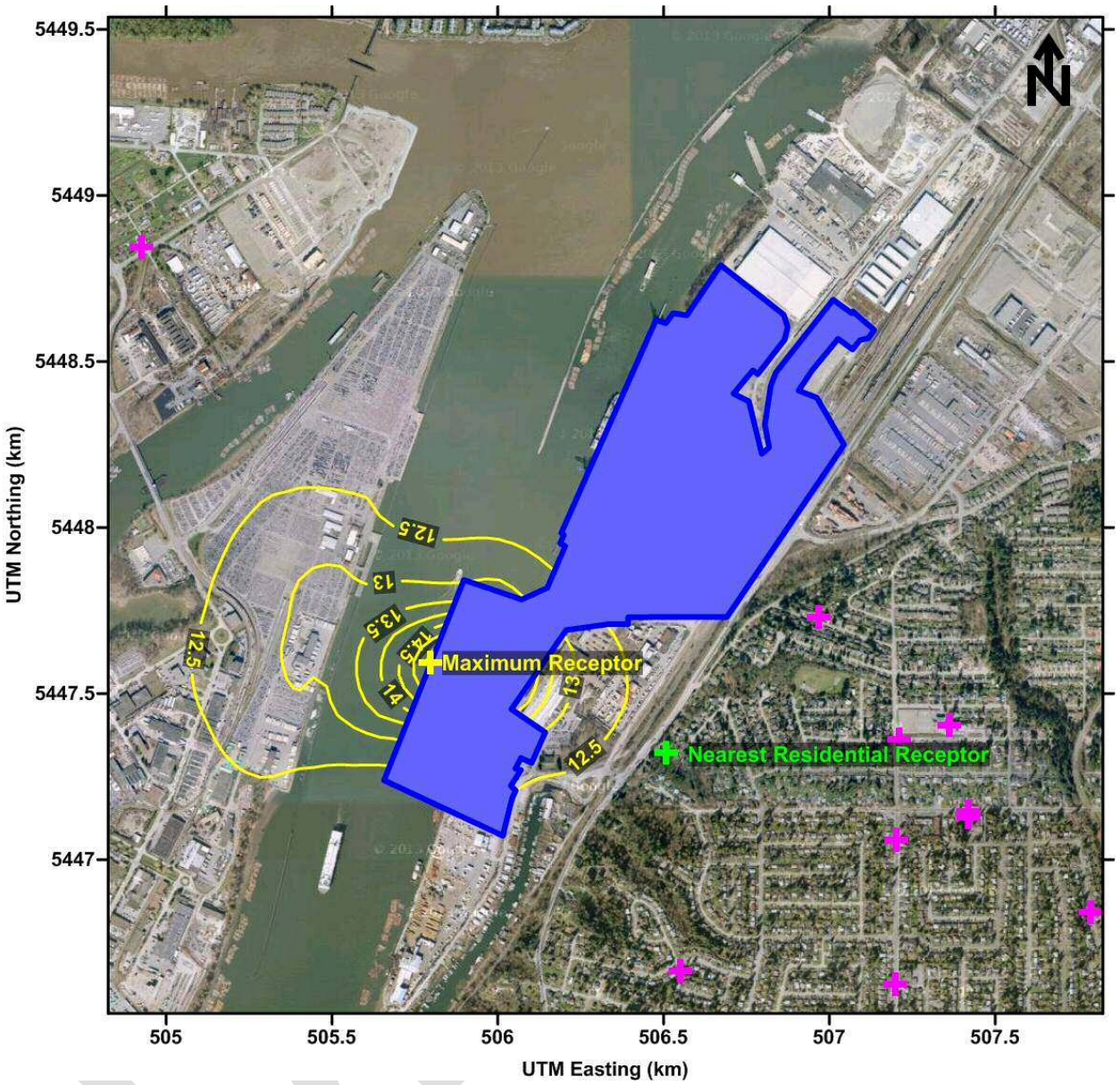
Figure 7-11 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 29, 31, 32, 35, 38, and 41 µg/m³.

Figure 7-12 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 12.5, 13, 13.5, 14, 14.5, and 15 µg/m^3.

Figure 7-13 Contour Plot of PM_{10} Annual Predicted Concentrations with Background

Table 7-4 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Agricultural Goods Operation)

Pollutant	Averaging Period	AAQO	Background	Bean Sprouts Child Care Centre	Delta Funtime Out of School Care Centre Ltd.	Kangaroo Family Childcare Center	Little Safari Daycare	Mews Montessori Preschool	Royal Heights Daycare	S and C Tiny Town Daycare	Smart Baby Family Child Care	St. Barnabas Daycare	Treasure-Chest Family Daycare
CO	1-hour	30,000	687	690.34	689.01	689.50	688.48	688.21	688.20	689.40	688.95	689.39	688.91
	8-hour	10,000	615	627.21	622.09	622.93	619.42	621.36	618.89	635.29	621.47	623.57	621.45
NO_2	1-hour	200	67	88.85	84.70	85.11	82.21	82.20	78.72	87.58	83.58	84.69	83.71
	Annual	40	27	27.01	27.01	27.02	27.01	27.01	27.00	27.02	27.01	27.02	27.01
SO_2	1-hour	450	8.3	8.31	8.31	8.31	8.31	8.30	8.30	8.31	8.31	8.31	8.31
	24-hour	125	5.9	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90	5.90
	Annual	30	1.6	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
PM_{10}	24-hour	50	26.8	28.85	28.08	28.25	27.58	27.59	27.30	28.48	27.99	28.11	27.98
	Annual	20	12	12.13	12.07	12.09	12.05	12.10	12.03	12.12	12.07	12.09	12.07
$PM_{2.5}$	24-hour	25	11.3	11.71	11.56	11.60	11.46	11.47	11.40	11.64	11.55	11.58	11.55
	Annual	8 (6)*	4.1	4.13	4.11	4.12	4.11	4.12	4.11	4.13	4.11	4.12	4.11
TPM	24-hour	120	N/A	1.08	0.69	0.81	0.45	0.39	0.27	1.67	0.69	0.83	0.69
	Annual	60	N/A	0.06	0.03	0.04	0.02	0.04	0.01	0.08	0.03	0.04	0.03
Dustfall	1-month (mg/dm^2-d)	1.7	N/A	0.0002	0.0001	0.0002	0.0001	0.0002	0.0000	0.0003	0.0002	0.0003	0.0002

DRAFT

7.3 Project (FSD) + Agricultural Emission Sources

A summary of model results for the agricultural together with the proposed Project emission sources is presented in Table 7-5. Detailed information regarding the emission sources can be found in the preceding sections (Sections 5 and 6). Table 7-5 shows the maximum predicted modelled concentrations from all sources for each averaging periods without and with ambient background added. This table also provides the maximum predicted concentrations at the nearest resident receptor identified in Figures 7-14 to 7-19 and the appropriate AAQOs for comparison with predicted model results.

Three separate scenarios were considered for the agricultural emissions analysis, as follows:

1) Load to Shed
2) Load out from Shed
3) Direct Load to Ship

For the 1-hour and 24-hour averaging periods, only the results from scenario 2), the load out from shed are presented as they had the worst-case emissions in comparison to the other two scenarios. For the annual averaging periods, the combination of scenarios 1) and 2) were added together as this created the highest emissions, resulting from the assumption that all agricultural products would be loaded to the shed and then loaded out to the ship.

Most predicted air contaminant concentrations were below AAQOs, with the exception being annual NO_2 which was predicted to be 0.1 µg/m^3 over the AAQO with ambient background added and 24-hour PM_{10} concentrations which was predicted to exceed the AAQO by 4.8 µg/m^3 with ambient background added. At the nearest residential receptor, predicted concentrations are much lower than the maximum predicted concentrations.

Predicted annual NO_2 concentrations (with background) at the fenceline to the west of the barging operations at the berth were at the AAQO (40.1 µg/m^3) at one receptor. Elevated annual NO_2 concentrations (with background) were localized in this area around the berth and increase in closer proximity to the tug area source modelled at the berth.

Contour plots of predicted NO_2, PM_{10} and $PM_{2.5}$ concentrations are provided in Figure 7-16 through Figure 7-19. The PM_{10} and $PM_{2.5}$ contour plots are provided to display the predicted impacts near the facility. For all air contaminants, the highest daily concentrations are predicted to occur along the east side of the facility fenceline close to the 2nd baghouse. The annual PM_{10} and $PM_{2.5}$ concentrations are predicted to have the greatest impacts on the western side of the facility nearest the agricultural transfer points.

Table 7-6 shows the maximum predicted concentrations from agricultural related processes for each averaging period at the identified sensitive receptors.

DRAFT

Table 7-5 Predicted Air Contaminant Concentrations from All Sources without and with Background Concentrations

Agricultural Scenario 2: Load Out from Shed

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Receptor	Nearest Residential Receptor	Maximum Receptor	Nearest Residential Receptor
CO	1-hour	30,000	687	121	38	808	725
	8-hour	10,000	615	76	21.7	691	636.7
NO_2	1-hour	200	67	108.8	95.8	175.8	162.8
SO_2	1-hour	450	8.3	0.7	0.2	9.0	8.5
	24-hour	125	5.9	0.1	0.0	6.0	5.9
PM_{10}	24-hour	50	26.8	28.0	5.5	54.8	32.3
$PM_{2.5}$	24-hour	25	11.3	6.8	1.6	18.1	12.9
TSP	24-hour	120	N/A**	77	16.8		
Dustfall	1-month	1.7(mg/dm^2/day)	N/A	0.149	0.014		

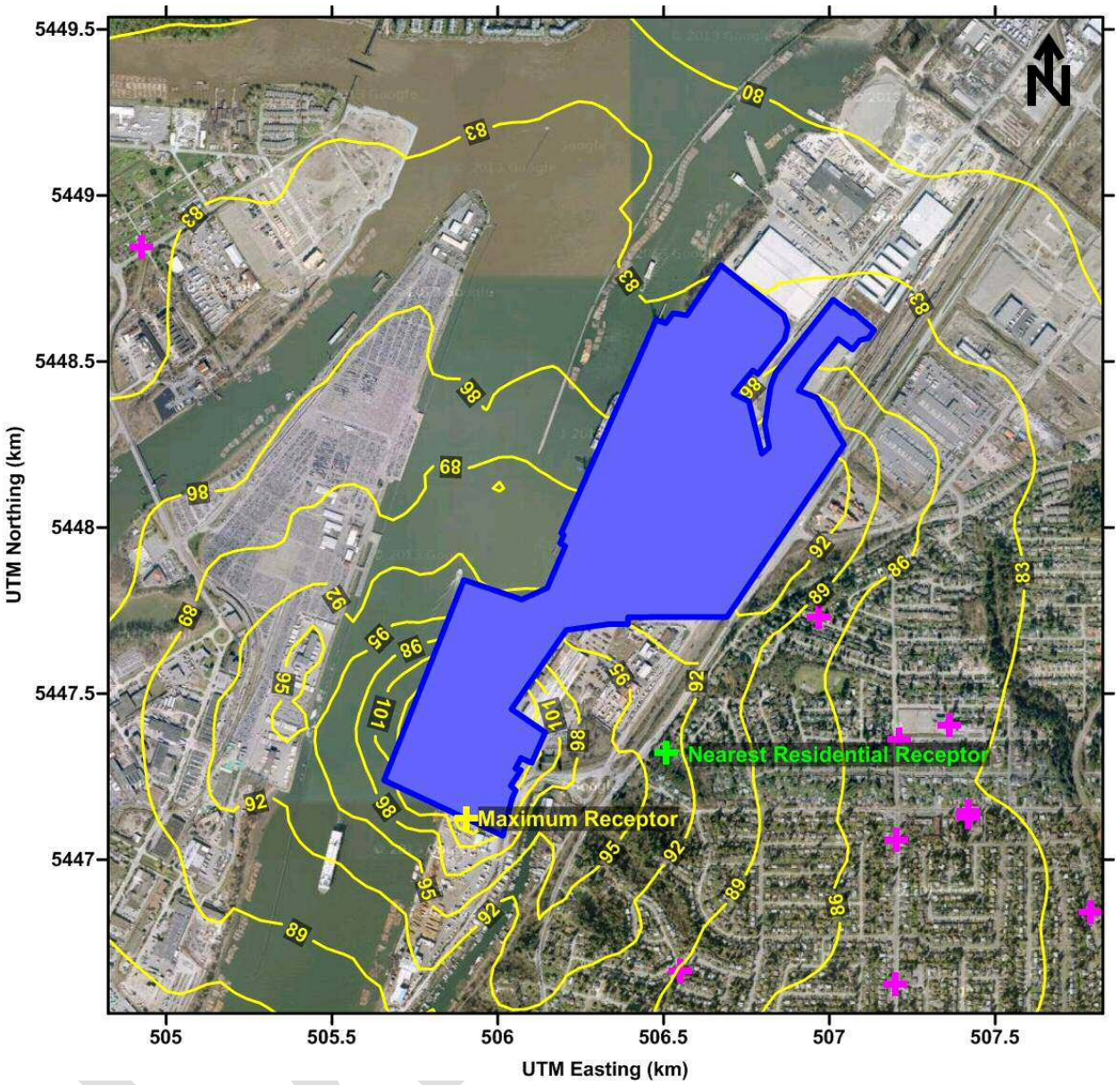
* The Ambient Ratio Method (ARM) has been applied to the 1-hour NOx results which includes background in the calculation as per the BC AQMG.
** Background data is not available for Total Suspended Particulate (TSP).

Agricultural Scenario 1+2: Load to Shed, Load Out from Shed

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Receptor	Nearest Residential Receptor	Maximum Receptor	Nearest Residential Receptor
NO_2	Annual	40	27	13.1	2.1	40.1	29.1
SO_2	Annual	30	1.6	0.0	0.0	1.6	1.6
PM_{10}	Annual	20	12	4.2	0.4	16.2	12.4
$PM_{2.5}$	Annual	8 (6)*	4.1	1.1	0.1	5.2	4.2
TSP	Annual	60	N/A**	12.5	1.3		

* Annual $PM_{2.5}$ objective of 8 $\mu g/m^3$ and a planning goal of 6 $\mu g/m^3$ which is a longer term aspiration target to support continuous improvement.
** Background data is not available for Total Suspended Particulate (TSP).

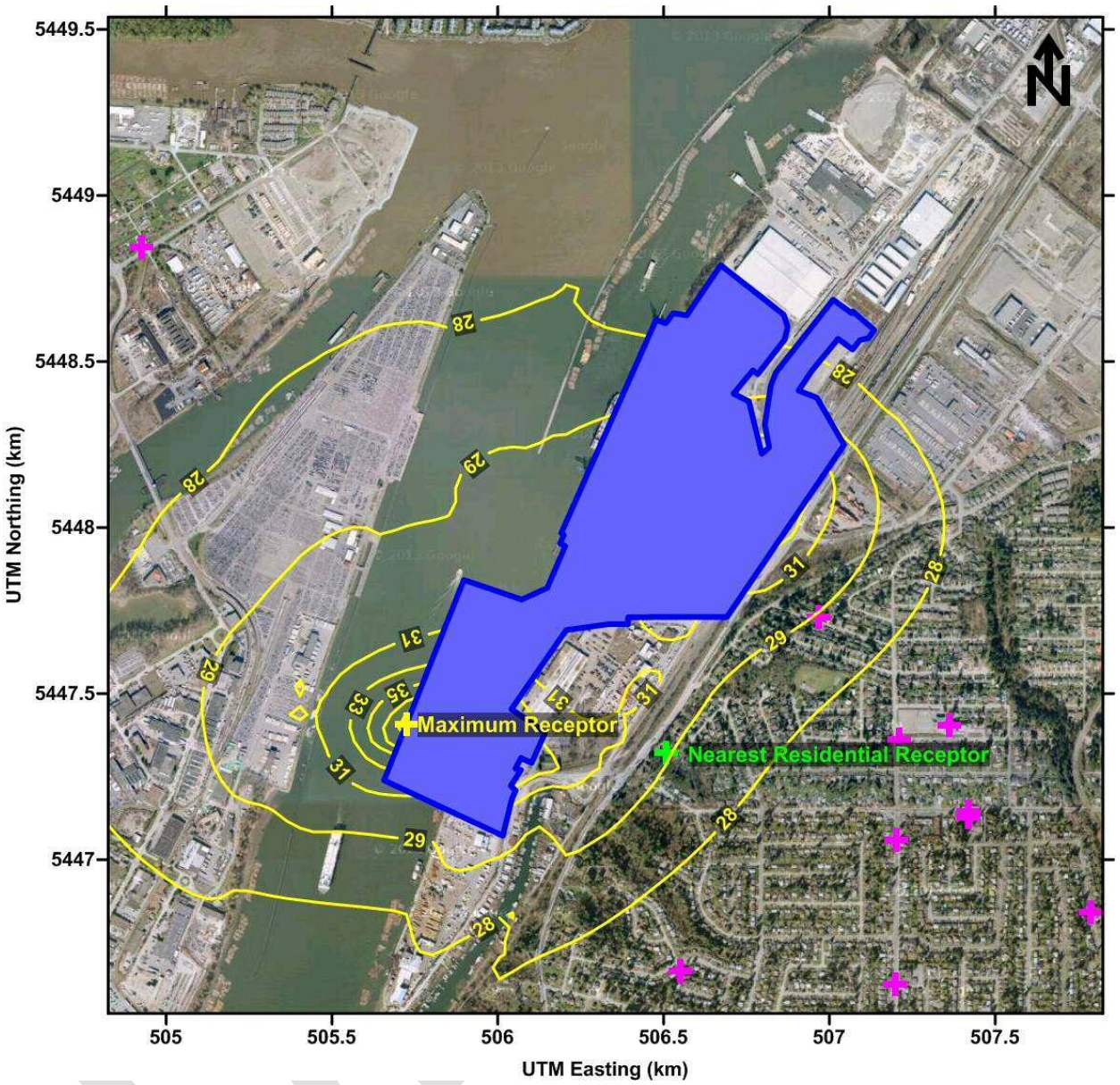
DRAFT



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 80, 89, 92, 95, 98, 101 and 104 µg/m^3.

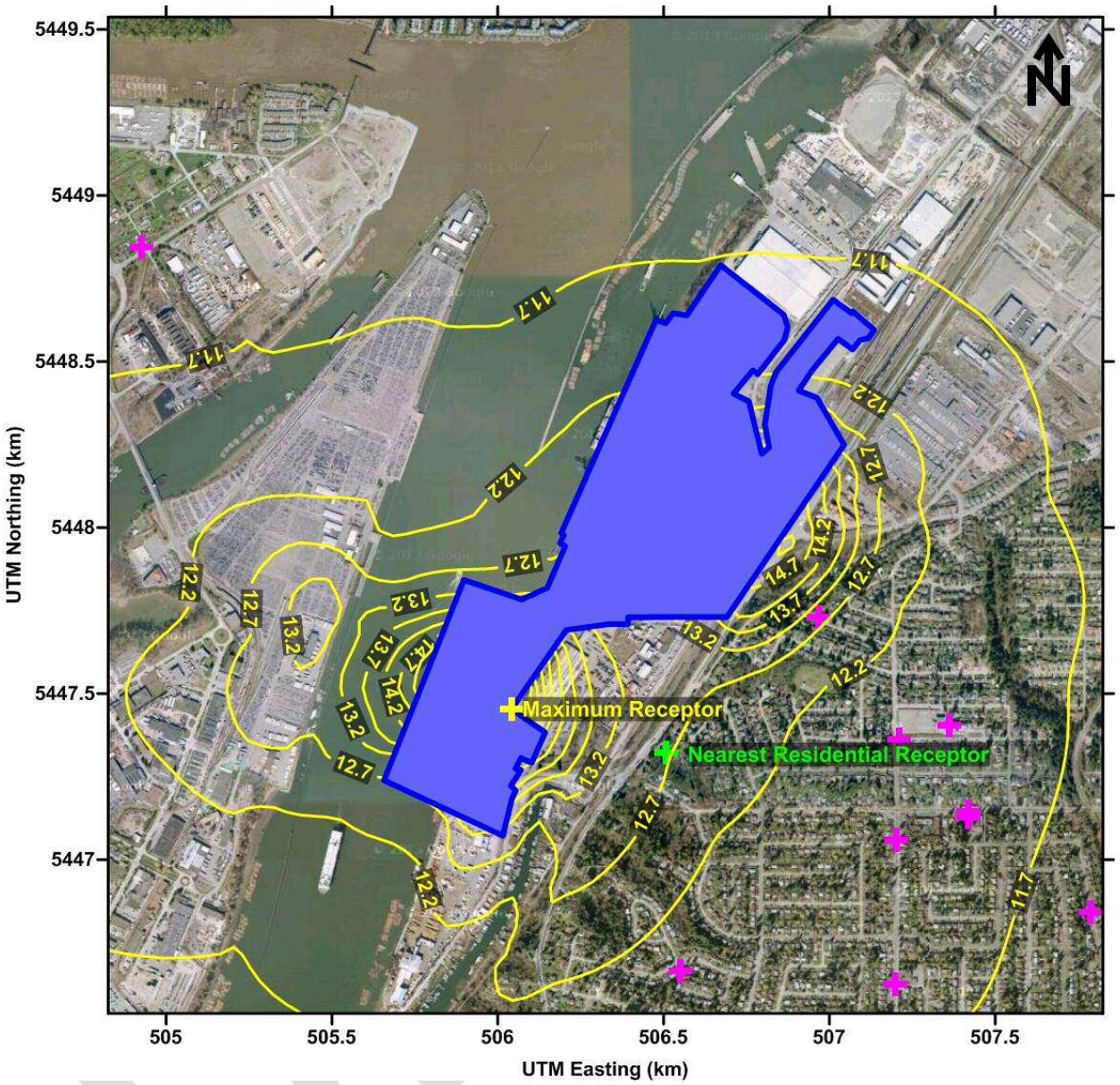
Figure 7-14 Contour Plot of NO_2 Maximum 1-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 27, 28, 29, 31, 33, 35, and 37 µg/m^3.

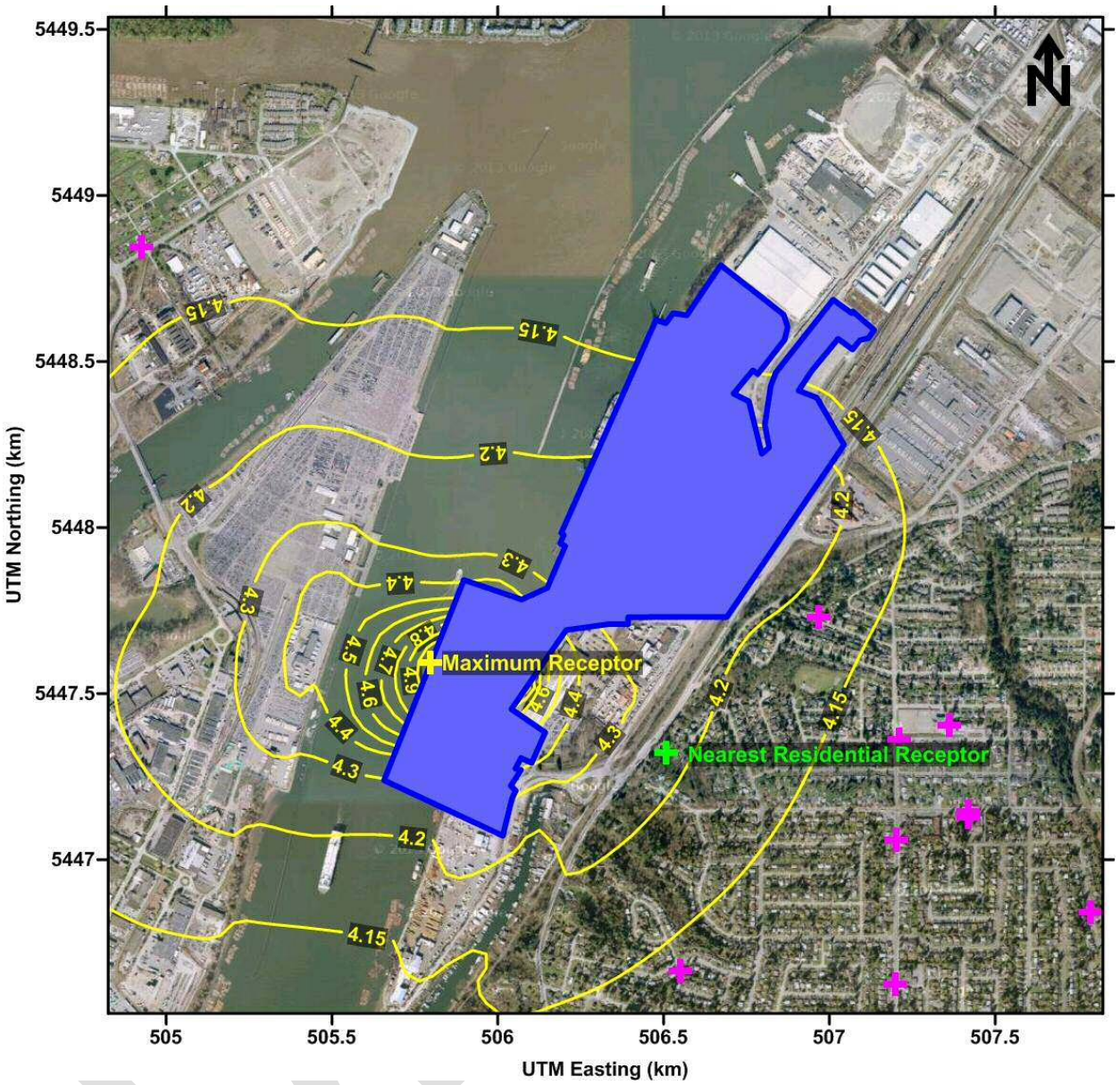
Figure 7-15 Contour Plot of NO_2 Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 11.7, 12.2, 12.7, 13.2, 13.7, 14.2, 14.7, 15.2, and 16.2 µg/m^3.

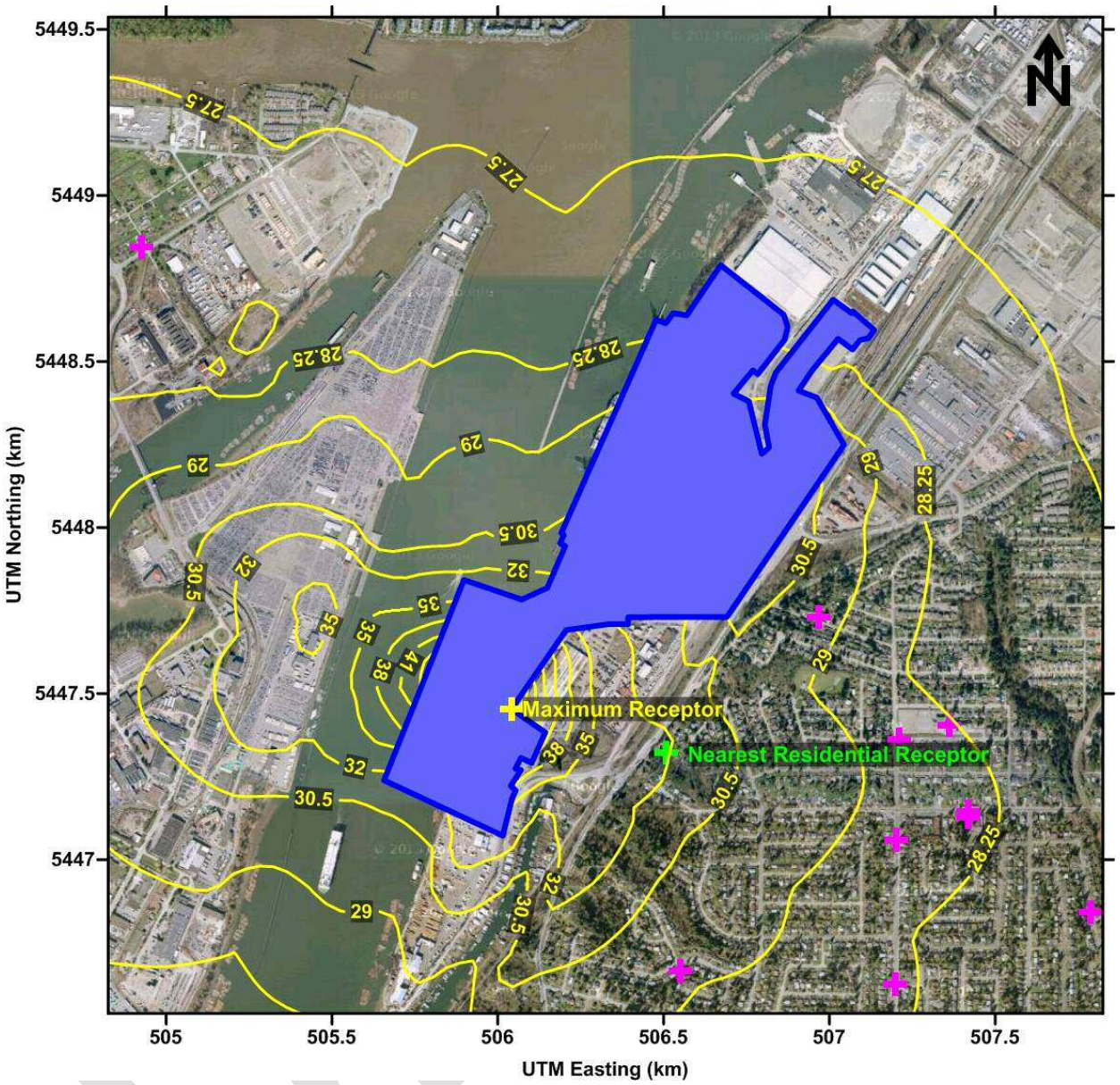
Figure 7-16 Contour Plot of $PM_{2.5}$ Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 4.15, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, and 5 µg/m^3.

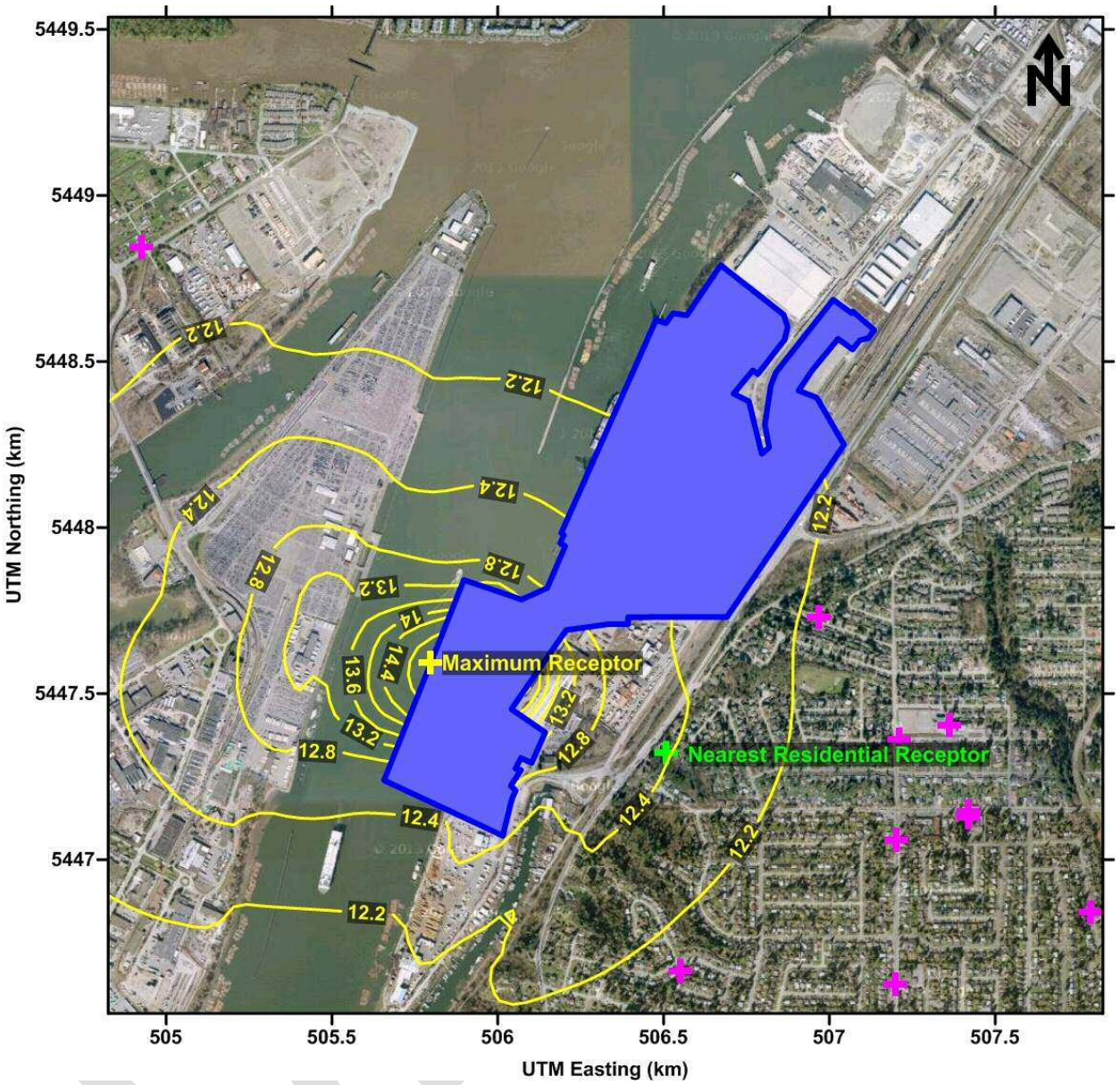
Figure 7-17 Contour Plot of $PM_{2.5}$ Annual Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 27.5, 28.25, 29.5, 30.5, 32, 35, 38, 41, 44, and 47 µg/m³.

Figure 7-18 Contour Plot of PM_{10} Maximum 24-hour Predicted Concentrations with Background



Note: *Location of the FSD fenceline is indicated by the blue coloured polygon.*

Contour intervals are: 12.2, 12.4, 12.8, 13.2, 13.6, 14.0, 14.4, and 14.8 µg/m^3.

Figure 7-19 Contour Plot of PM_{10} Annual Predicted Concentrations with Background

Table 7-6 Predicted Air Contaminant Concentrations at Sensitive Receptors near FSD with Background (Project + Agricultural)

Pollutant	Averaging Period	AAQO	Background	Bean Sprouts Child Care Centre	Delta Funtime Out of School Care Centre Ltd.	Kangaroo Family Childcare Center	Little Safari Daycare	Mews Montessori Preschool	Royal Heights Daycare	S and C Tiny Town Daycare	Smart Baby Family Child Care	St. Barnabas Daycare	Treasure-Chest Family Daycare
CO	1-hour	30,000	687	711.78	703.57	703.23	699.66	698.08	693.61	720.15	701.32	704.06	701.39
	8-hour	10,000	615	628.57	622.89	623.44	619.77	621.57	619.10	635.38	621.81	623.84	621.81
NO_2	1-hour	200	67	88.85	84.70	85.11	82.21	82.20	78.72	87.58	83.58	84.69	83.71
	Annual	40	27	27.62	27.33	27.49	27.26	27.52	27.10	28.89	27.43	27.65	27.42
SO_2	1-hour	450	8.3	8.43	8.38	8.38	8.36	8.36	8.33	8.42	8.37	8.38	8.37
	24-hour	125	5.9	5.91	5.90	5.91	5.90	5.90	5.90	5.93	5.91	5.91	5.91
	Annual	30	1.6	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
PM_{10}	24-hour	50	26.8	29.44	28.44	28.74	27.85	27.78	27.45	29.64	28.41	28.69	28.40
	Annual	20	12	12.16	12.08	12.11	12.06	12.13	12.03	12.18	12.09	12.12	12.09
$PM_{2.5}$	24-hour	25	11.3	12.01	11.76	11.90	11.64	11.57	11.48	12.89	11.81	11.99	11.81
	Annual	8 (6)*	4.1	4.14	4.12	4.13	4.12	4.13	4.11	4.17	4.13	4.14	4.13
TPM	24-hour	120	N/A	1.08	0.69	0.81	0.45	0.39	0.27	1.67	0.69	0.83	0.69
	Annual	60	N/A	0.06	0.03	0.04	0.02	0.04	0.01	0.08	0.03	0.04	0.03
Dustfall	1-month (mg/dm^2-d)	1.7	N/A	0.0002	0.0001	0.0002	0.0001	0.0002	0.0000	0.0003	0.0002	0.0003	0.0002

DRAFT

7.4 Rail and Barge (In Transit)

As screening-level analysis of combustion and fugitive dust emissions from in transit trains and barges was conducted in order to assess the potential air quality impacts. In order to provide a screening analysis of these potential air quality impacts, a series of area sources representing either a passing train or barge were modelled at different locations along the transit route within Metro Vancouver; four (4) study areas for the rail analysis, and two (2) study areas for the barge analysis.

The CALPUFF modelling domains for the screening-level analysis can be seen in Figure 7-21, based off the BNSF Lower Mainland operating area as seen in Figure 7-20. A zoomed-in plot for the Barge 1 scenario is shown in Figure 7-22, with the receptors indicated by blue crosses and the area sources modelled indicated by red rectangles. The emission rates as defined in Section 5.4 were used to model potential emissions from this area source, after appropriate proration of the emission factors to account for the time train or barge would be within the area sources defined in the CALPUFF model.

The meteorological data set is identical to the meteorology used in the other portion of this assessment. Table 7-7 tabulates the predicted maximum concentrations from all of the screening-level scenarios, with and without background. There are no exceedences of AAQOs for any of the averaging periods for all air contaminants. Figure 7-23 illustrates the concentrations of TPM, $PM_{2.5,}$ and PM_{10} at a cross-sectional area through the middle of the modelled barges for scenario Barge 1, illustrating how quickly air contaminants are dispersed with increasing distance from the emission source. Overall, the air quality impacts predicted from the barges traveling along the Fraser River and trains travelling along the rail corridor are predicted to be negligible based on emissions estimated from the Project.

DRAFT

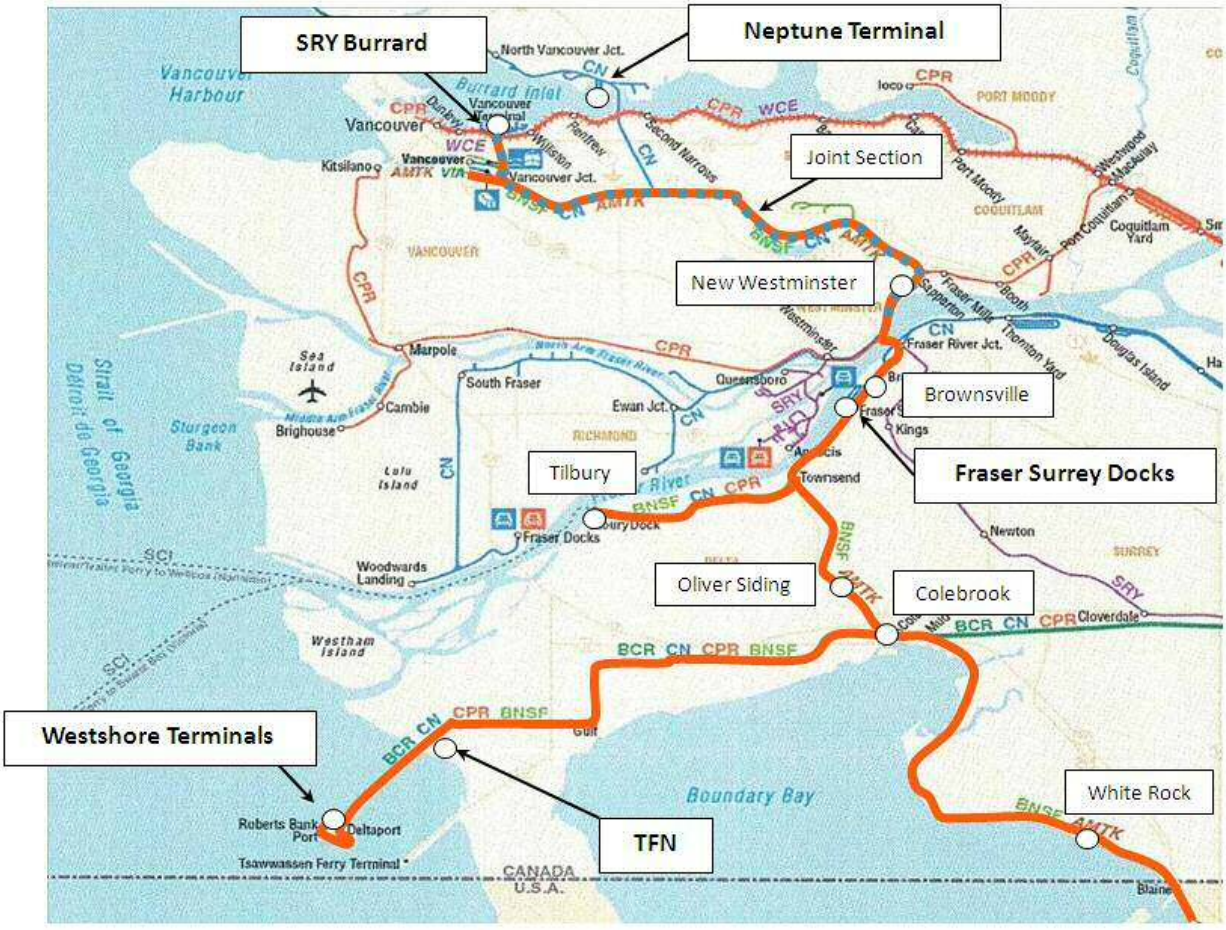


Figure 7-20 BNSF Lower Mainland Operating Area

DRAFT

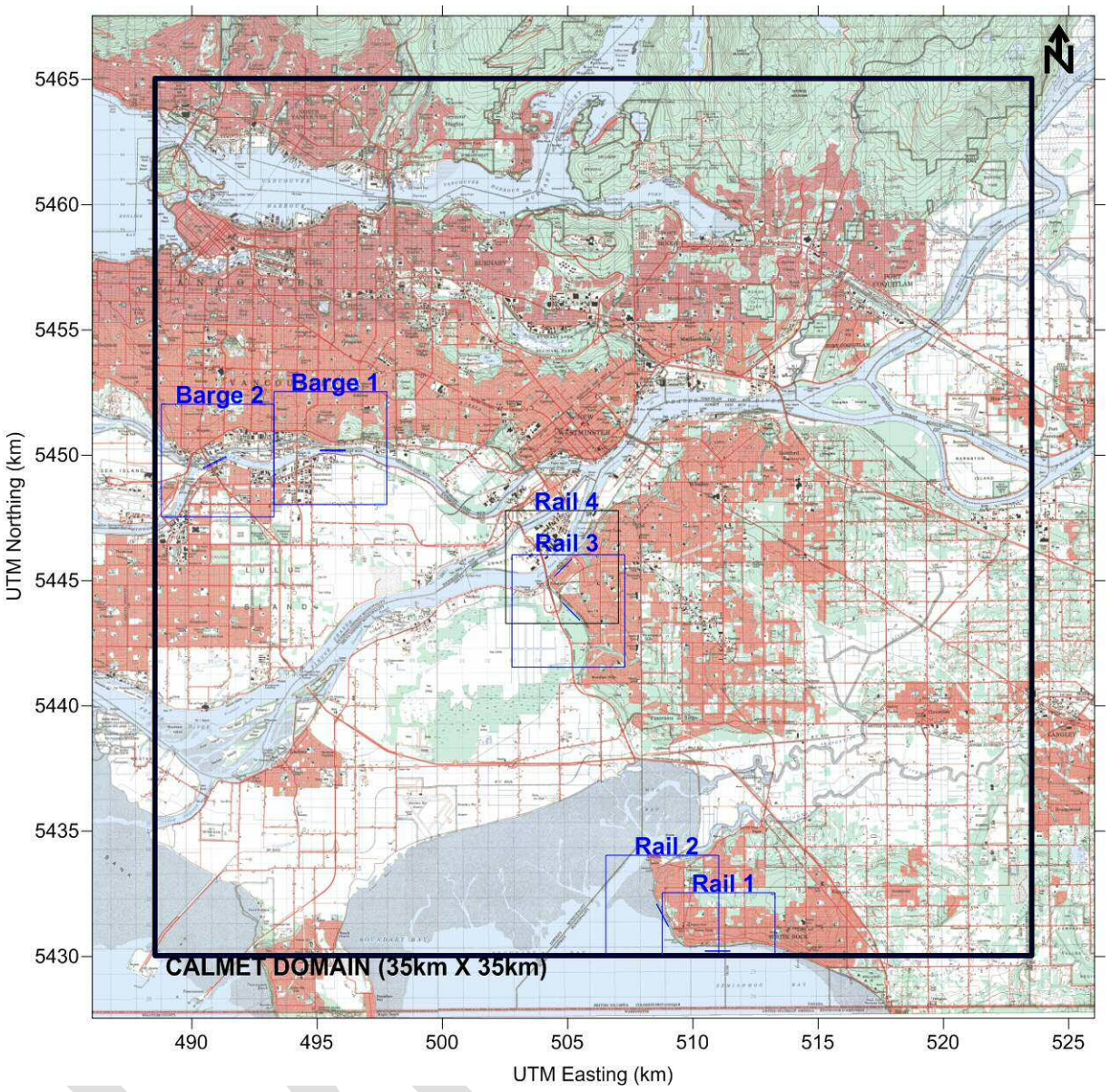


Figure 7-21 Individual CALPUFF Domains used for the Screening-Level Analysis

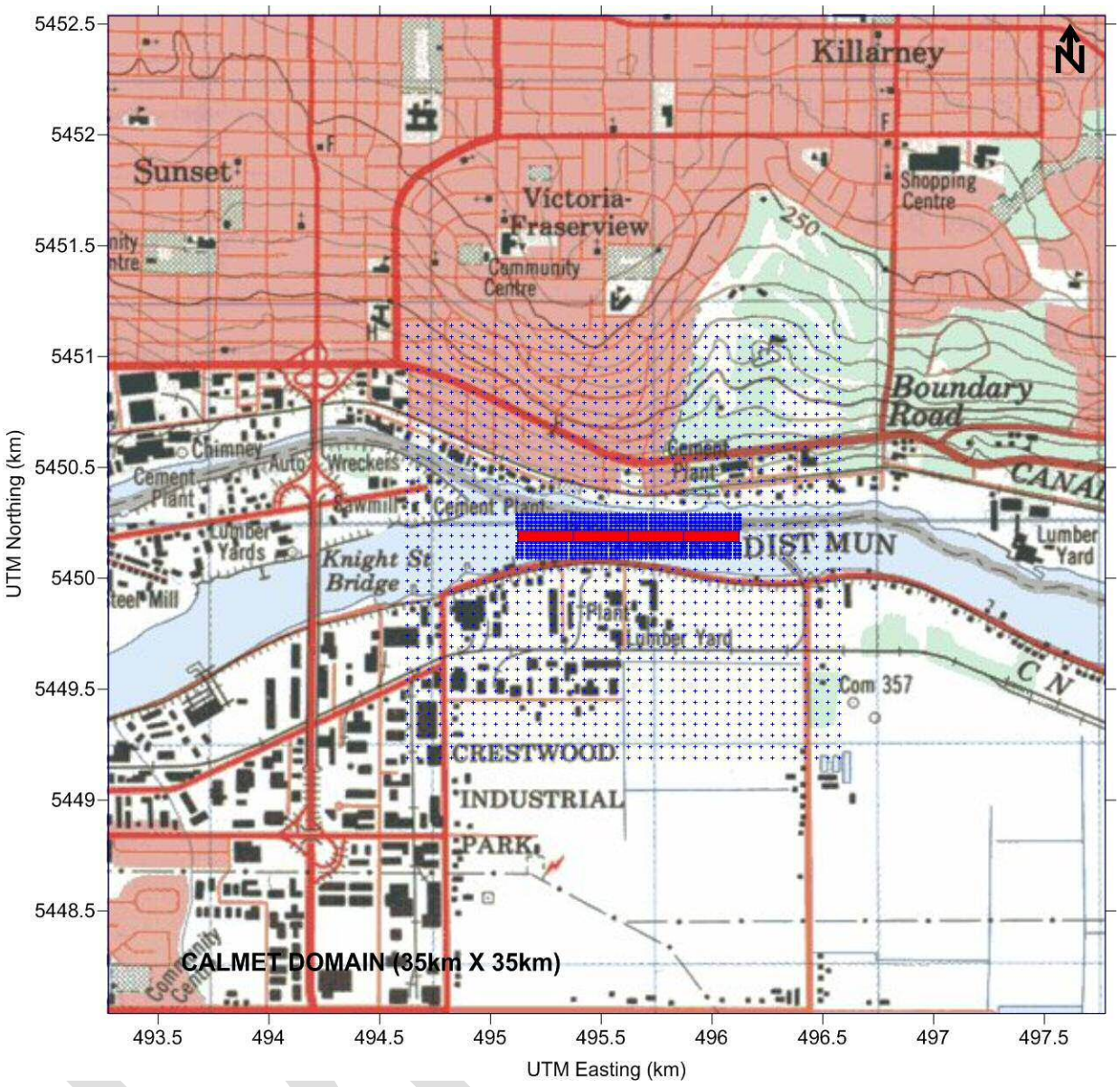


Figure 7-22 Receptor Layout for the Barge 1 Screening Analysis

Table 7-7 Predicted Air Contaminant Concentrations from the Rail / Barge Screening Analysis without and with Background Concentrations

Air Contaminant	Averaging Time	AAQO ($\mu g/m^3$)	Background ($\mu g/m^3$)	Maximum		Maximum + Background	
				Maximum Rail Receptor	Maximum Barge Receptor	Maximum Rail Receptor	Maximum Barge Receptor
CO	1-hour	30,000	687	7.50	9.83	694.50	696.83
	8-hour	10,000	615	3.34	5.88	618.34	620.88
NO_2	1-hour	200	67	53.50	124.24	120.50	191.24
	Annual	40	27	0.34	0.63	27.34	27.63
SO_2	1-hour	450	8.3	0.03	0.06	8.33	8.36
	24-hour	125	5.9	0.00	0.00	5.90	5.90
	Annual	30	1.6	0.00	0.00	1.60	1.60
PM_{10}	24-hour	50	26.8	0.53	0.06	27.33	26.86
	Annual	20	12.0	0.01	0.01	12.01	12.01
$PM_{2.5}$	24-hour	25	11.3	0.11	0.04	11.41	11.34
	Annual	8 (6)*	4.1	0.01	0.01	4.11	4.11
TSP	24-hour	120	N/A**	0.86	0.09		
	Annual	60	N/A**	0.02	0.01		

* Annual $PM_{2.5}$ objective of 8 $\mu g/m^3$ and a planning goal of 6 $\mu g/m^3$ which is a longer term aspiration target to support continuous improvement.
** Background data is not available for Total Suspended Particulate (TSP).

DRAFT

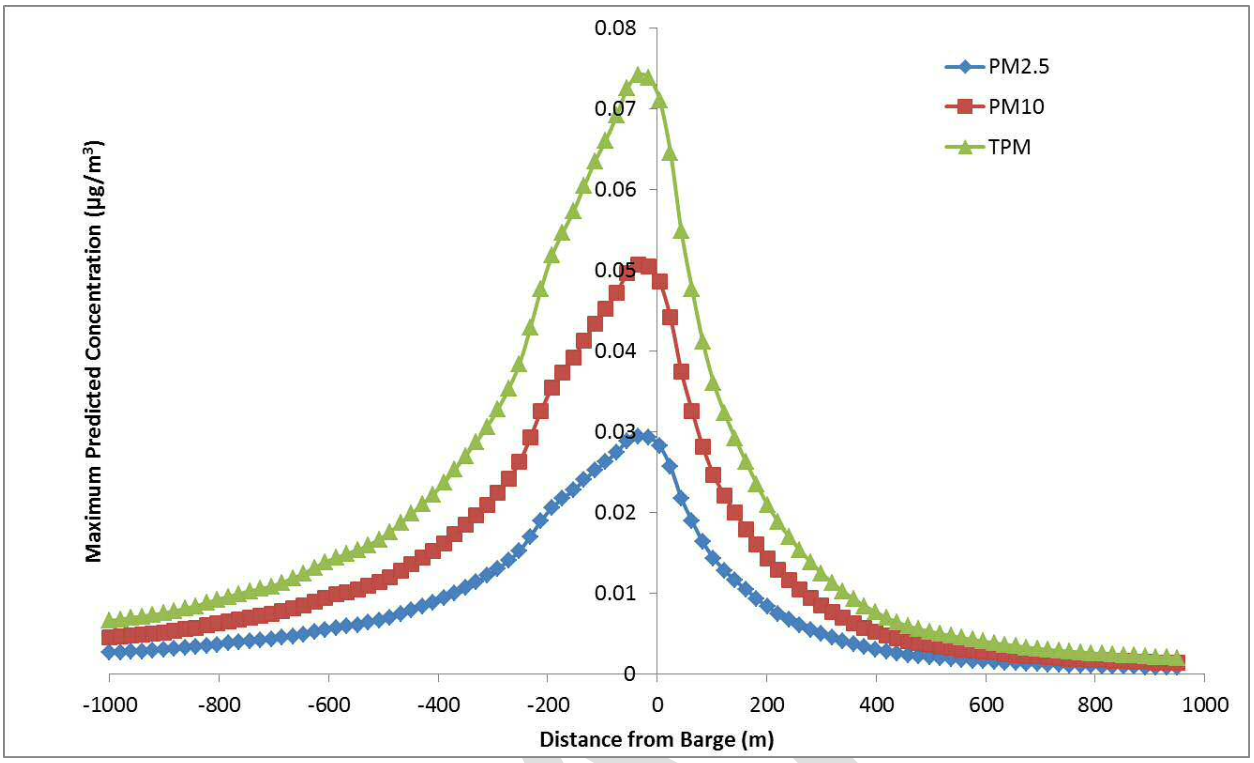


Figure 7-23 Maximum Predicted Concentrations of 24-hour TPM, $PM_{2.5,}$ and PM_{10} versus Distance from Barge 1

DRAFT

8. Conclusion

Based on the air quality modelling assessment for the proposed Project at FSD, the following conclusions have been drawn regarding potential impact from the proposed Project:

- Particulate matter emissions from fugitive dust sources are localized around the facility and predicted air quality impacts are low. With the mitigation planned for the facility the fugitive dust sources are predicted to have low impact on air quality in the area.
- There are predicted exceedences noted for 24-hour averaged PM_{10} and annual NO_2 when combining the impacts of the proposed Project, current agricultural goods operations, and ambient background concentrations. The predicted 24-hour averaged PM_{10} exceedences are located on the facility fenceline inland, while the predicted annual NO_2 exceedences are receptors located over the Fraser River. While the modelling results are likely to be conservative by nature, monitoring after facility commission is recommended to validate that air quality exceedences will not occur.
- For all air contaminants, the maximum concentrations were predicted to occur along the facility fenceline. The predicted air contaminant concentrations quickly diminish as emissions disperse further away from FSD's facility.
- Predicted air quality impacts at sensitive receptors and within residential neighbourhoods in the vicinity of FSD with the ambient background added are low and remain below all AAQOs.
- The planned project mitigation measures will assist in the management and mitigation of combustion and fugitive dust emissions from the Project.
- Further details regarding the air quality: management, mitigation, monitoring and reporting can be found in the Air Quality Management Plan (AQMP)[35].

[35] *Levelton Consultants Ltd. 2013. Fraser Surrey Docks Direct Coal Transfer Facility DRAFT Air Quality Management Plan. November 15, 2013.*

DRAFT

APPENDIX A:
CALMET QA/QC

DRAFT

A-1. Local Climate and Meteorology

To assess the local climate in the area of the FSD site, 30-year climate normals were obtained from the Meteorological Service of Canada (MSC) for Vancouver International Airport (YVR). The meteorological fields generated by the CALMET model were compared to these climate normals and to observed YVR meteorological data for the June 13, 2000 – July 7, 2001 modelling period, in order to determine the suitability of the CALMET data for the dispersion modelling.

A-1.1 Temperature

Ambient temperatures recorded at T13 North Delta from 1992 - 2011, and for the 2000-2001 modelling period are shown in Figure A-1 and Figure A-2. The temperatures extracted from the CALMET output near the FSD site are shown in Figure A-3. The mean daily temperatures listed in the figures were calculated by averaging the daily mean temperature over the entire monitoring period for each month. The mean daily maximum and minimum temperatures were calculated by averaging daily maximum and minimum temperatures for the month. The extreme maximum and minimum temperatures are the maximum and minimum temperatures for the monthly period.

The mean, maximum and minimum extracted CALMET temperatures are within the climate normals for the area as outlined by the data from T13 North Delta, and are in good agreement with the observed temperatures for the 2000-2001 modelling period. Thus, the temperature data set employed in this analysis is a good representation of statistically normal conditions for the air shed.

DRAFT

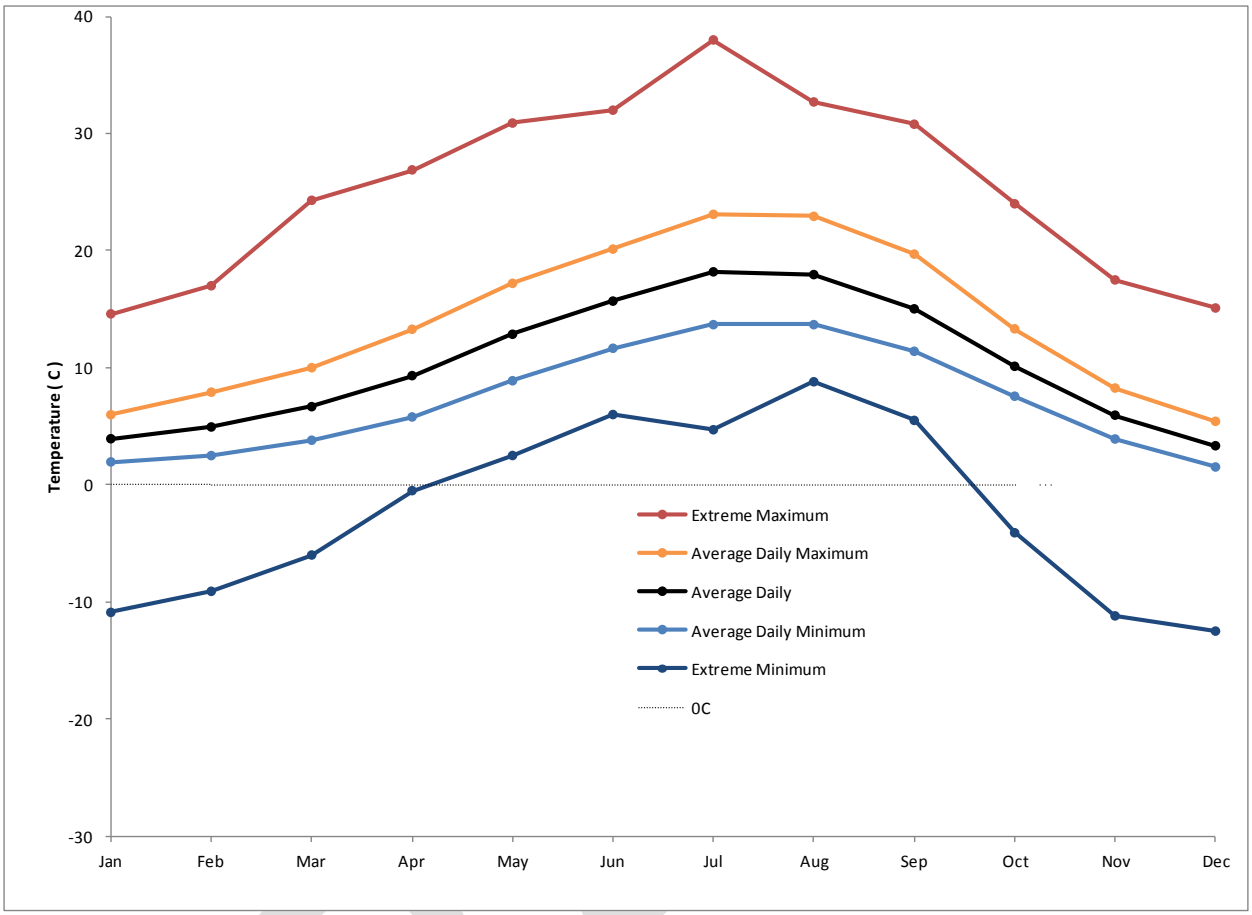


Figure A-1 Temperature Normals for T13 North Delta (1992-2011)

DRAFT

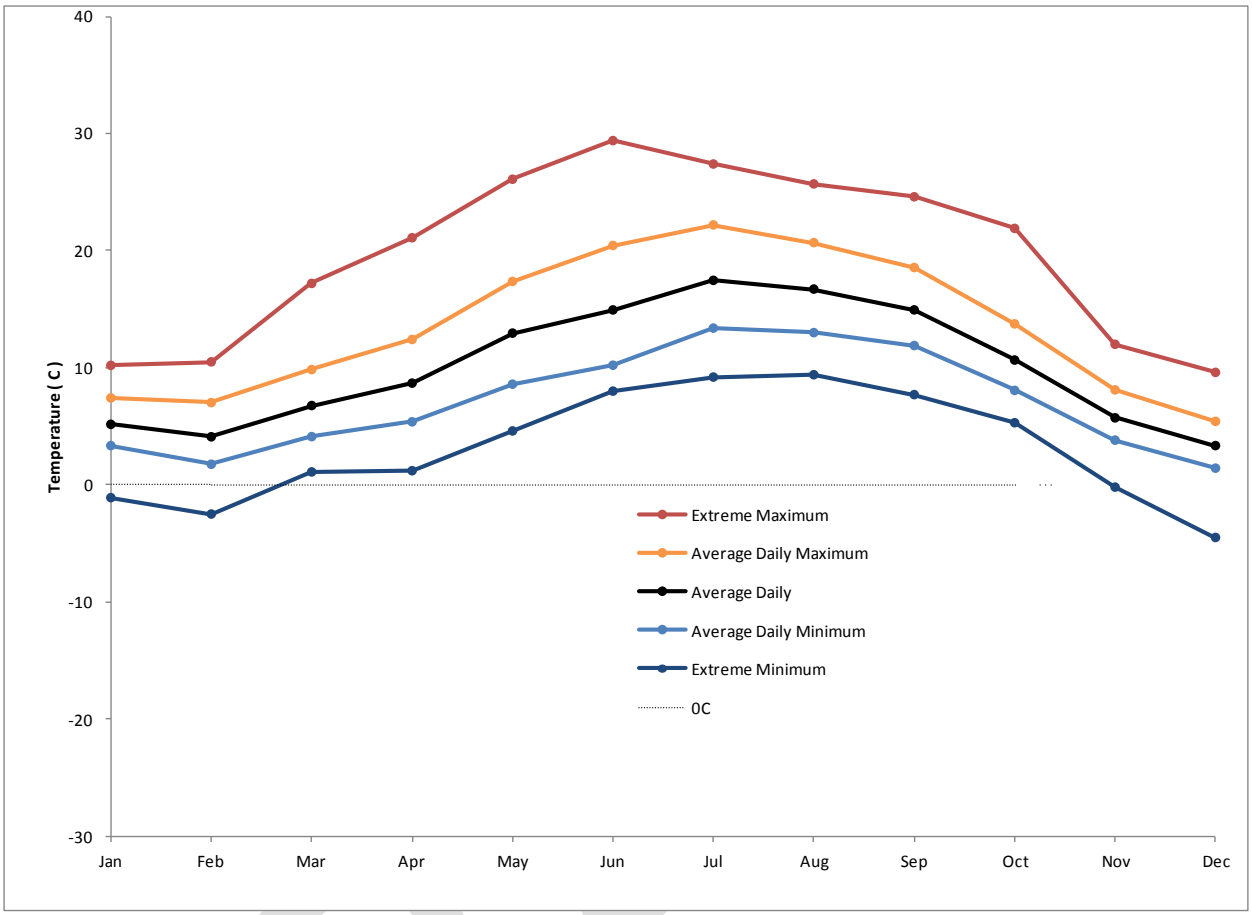


Figure A-2 2000-2001 Temperature Observations for T13 North Delta

DRAFT

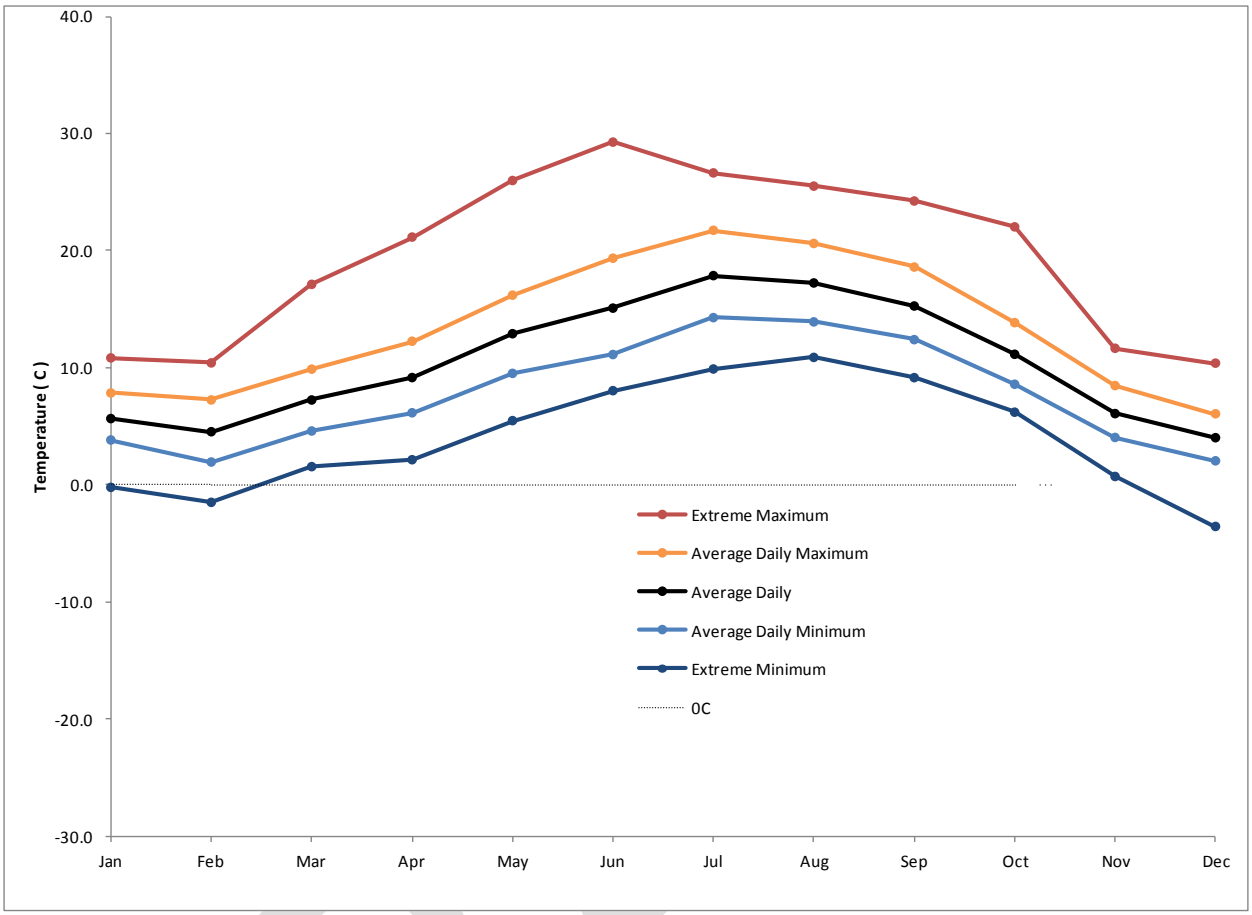


Figure A-3 2000-2001 Temperatures Near the FSD Site (Extracted from CALMET Output)

A-1.2 Wind

Representative wind data are required for dispersion modelling, as model predictions will be significantly affected if appropriate data are not utilised. As a general rule, dispersion model predictions of ground level concentration at a given point are determined by wind direction and are inversely proportional to mean wind speed.

Figure A-4 shows wind rose data from 1987-2011, which demonstrates the observed wind conditions at the T13 North Delta station over that period. Figure A-5 shows wind rose data from 2002-2011, which demonstrates the observed wind conditions at the T38 Annacis Island station over that period. Figure A-6 and A-7 show wind roses for the 2000-2001 modelling period, from CALMET output extracted near the T13 North Delta and T38 Annacis Island, respectively. The predominant winds for the area are from the east, however, the Annacis Island station shows a different wind pattern, presumably influenced by the river. CALMET data at the FSD site shows slight variation from each of the surrounding stations (Figure A-8). Predominant winds at the FSD site are from the east, and more closely resemble winds from the T13 North Delta station. However, based on Figure A-7 at the Annacis Island station, winds in this portion of the domain more closely resemble the T38 Annacis Island station.

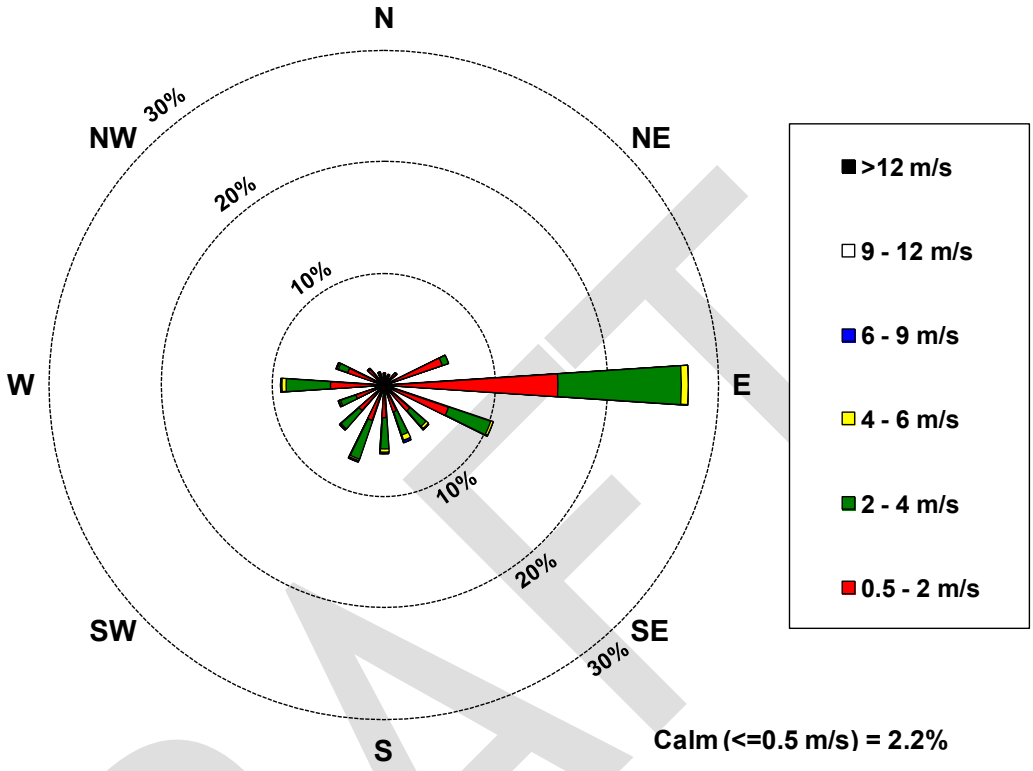


Figure A-4 1987- 2011 Wind Rose for T13 North Delta

DRAFT

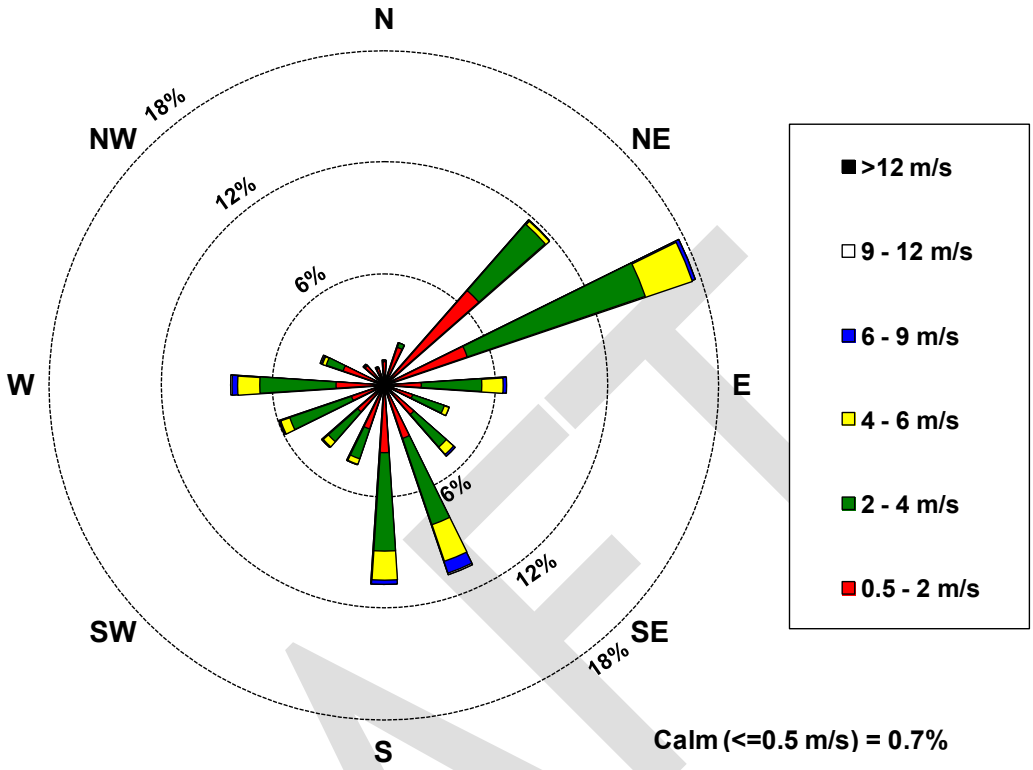


Figure A-5 2002 - 2011 Wind Rose for T38 Annacis Island

DRAFT

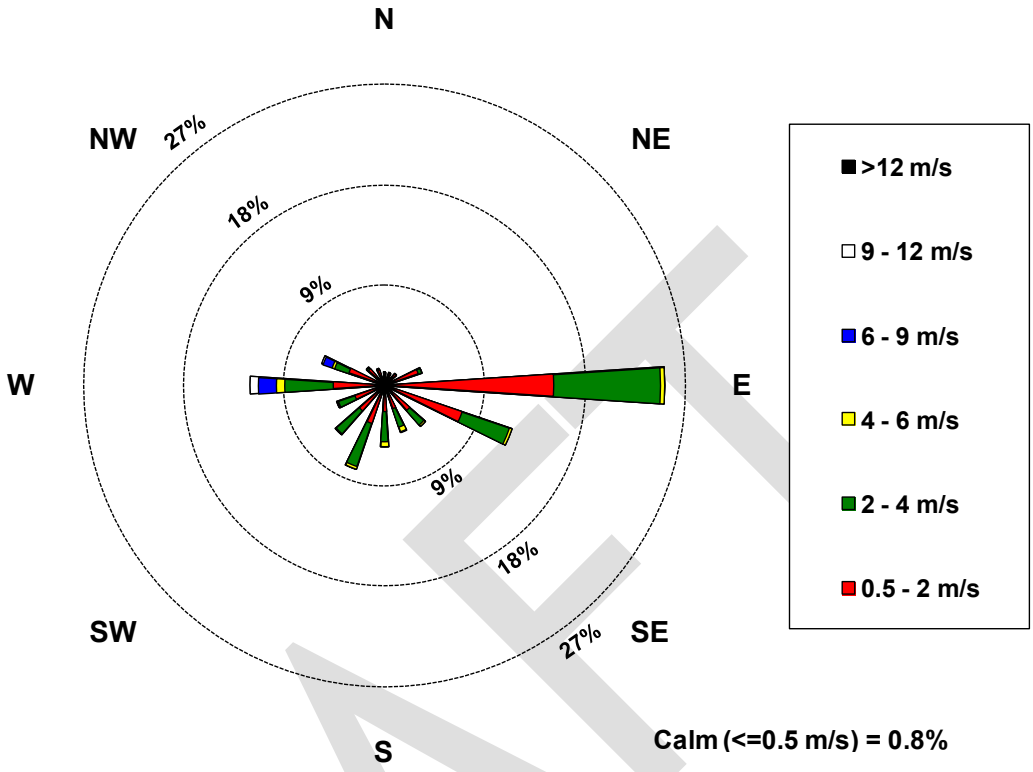


Figure A-6 2000-2001 Wind Rose Near the T13 North Delta Station (Extracted from CALMET Output)

DRAFT

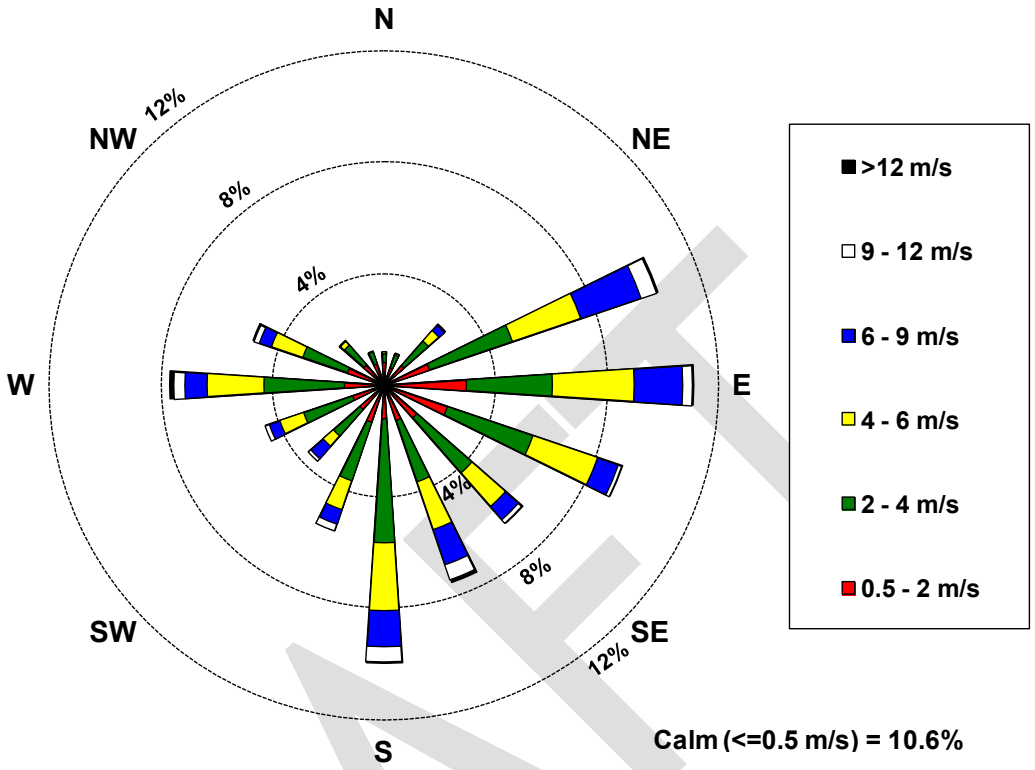


Figure A-7 2000-2001 Wind Rose Near the T38 Annacis Island Station (Extracted from CALMET Output)

DRAFT

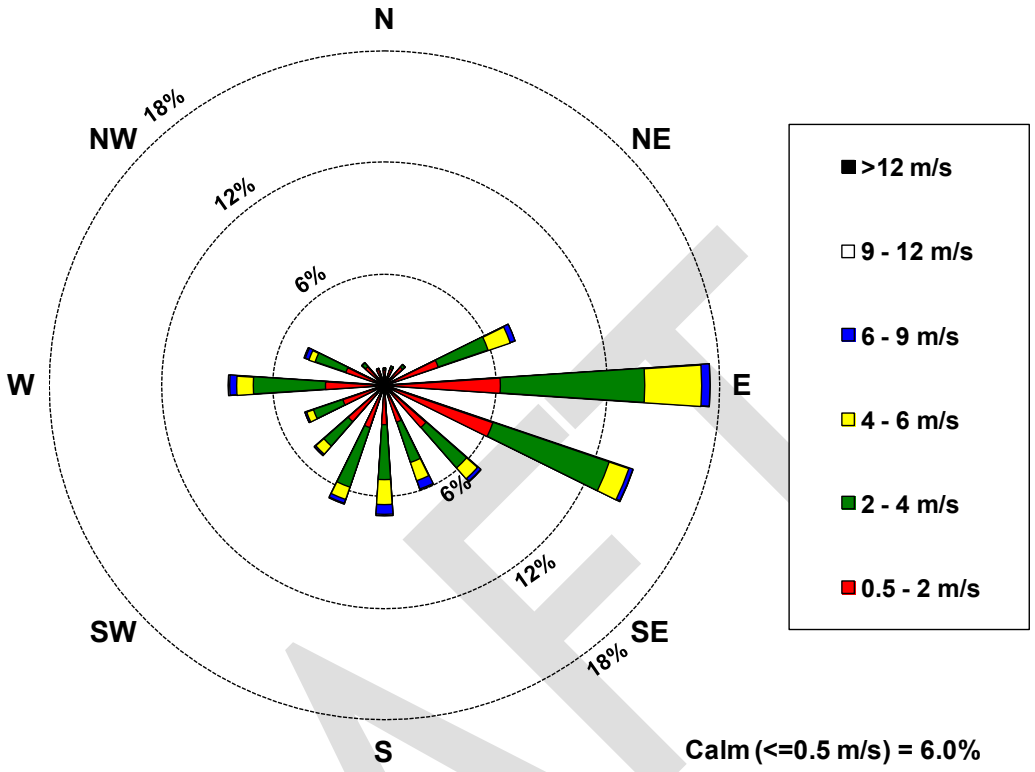


Figure A-8 2000-2001 Wind Rose Near FSD Site (Extracted from CALMET Output)

A-1.3 Conclusion from Comparison of Meteorological Data to Climate Normals

A comparison of the CALMET extracted wind rose for the FSD site shows agreement with the wind patterns typically observed at the T13 North Delta station. The discrepancy in wind speeds between the FSD extracted point and the T38 Annacis Island station is due to the mid river siting of the T38 stations, which leads to stronger winds influenced by the river channel. The other meteorological parameters are in good agreement with the observed data. Hence modelling using 2000-2001 observations is sufficient to assess the potential impacts of the FSD emissions on ground level pollutant concentrations in the area. Utilising more meteorological data or subsequent years of meteorology would likely not provide greater insight into the maximum predicted pollutant concentrations and their frequency of occurrence.

DRAFT

A-2. Modelling Methodology

A-2.1 Model Selection

CALPUFF is a suite of numerical models (CALMET, CALPUFF, and CALPOST) that are used in series to determine the impact of emissions in the vicinity of a source or group of sources. Detailed three-dimensional meteorological fields are produced by the diagnostic computer model CALMET, based on surface, marine (optional) and upper air weather data, digital land use data, terrain data, and prognostic meteorological data (optional). The three-dimensional fields produced by CALMET are used by CALPUFF, a three-dimensional, multi-species, non-steady-state Gaussian puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport. Finally CALPOST, a statistical processing program, is used to summarize and tabulate the pollutant concentrations calculated by CALPUFF.

A-2.2 CALMET

The CALMET (version 5.8, EPA approved) model was executed to calculate meteorological fields for the period from June 13, 2000 to July 7, 2001. This modelling period was chosen in order to utilize available three-dimensional prognostic meteorological data from the Mesoscale Compressible Community (MC2) model, provided by the University of British Columbia, to improve the performance of the CALMET model. Meteorological input data was used from 17 surface stations and two upper air stations. The meteorological data and CALMET output for this modelling period were analysed and compared with climate normals to ensure that this modelling period is climatologically representative, as discussed in Section B-1. A description of the CALMET methods and data sets follows. This methodology presented in this section applies to the original modelling domain. Identical methodology applies to the larger domain used for NO_2 modelling.

A-2.2.1 CALMET Modelling Domain

The Universal Transverse Mercator (UTM, NAD 83) co-ordinate system was used for this model application. The CALMET domain was a 35 km by 35 km area, as shown in Figure A-9. The extracted MC2 domain encompassed a slightly larger area around the CALMET domain. Within the CALMET modelling domain a 250 m grid resolution was used. The CALMET modelling domain and grid resolution were chosen to encompass the main topographical features for generating the CALMET three-dimensional diagnostic meteorological fields. On the vertical axis, nine atmospheric layers were included in order to capture the expected paths of the plumes from the modelled source. The heights of these layers are given in Table A-1.

DRAFT

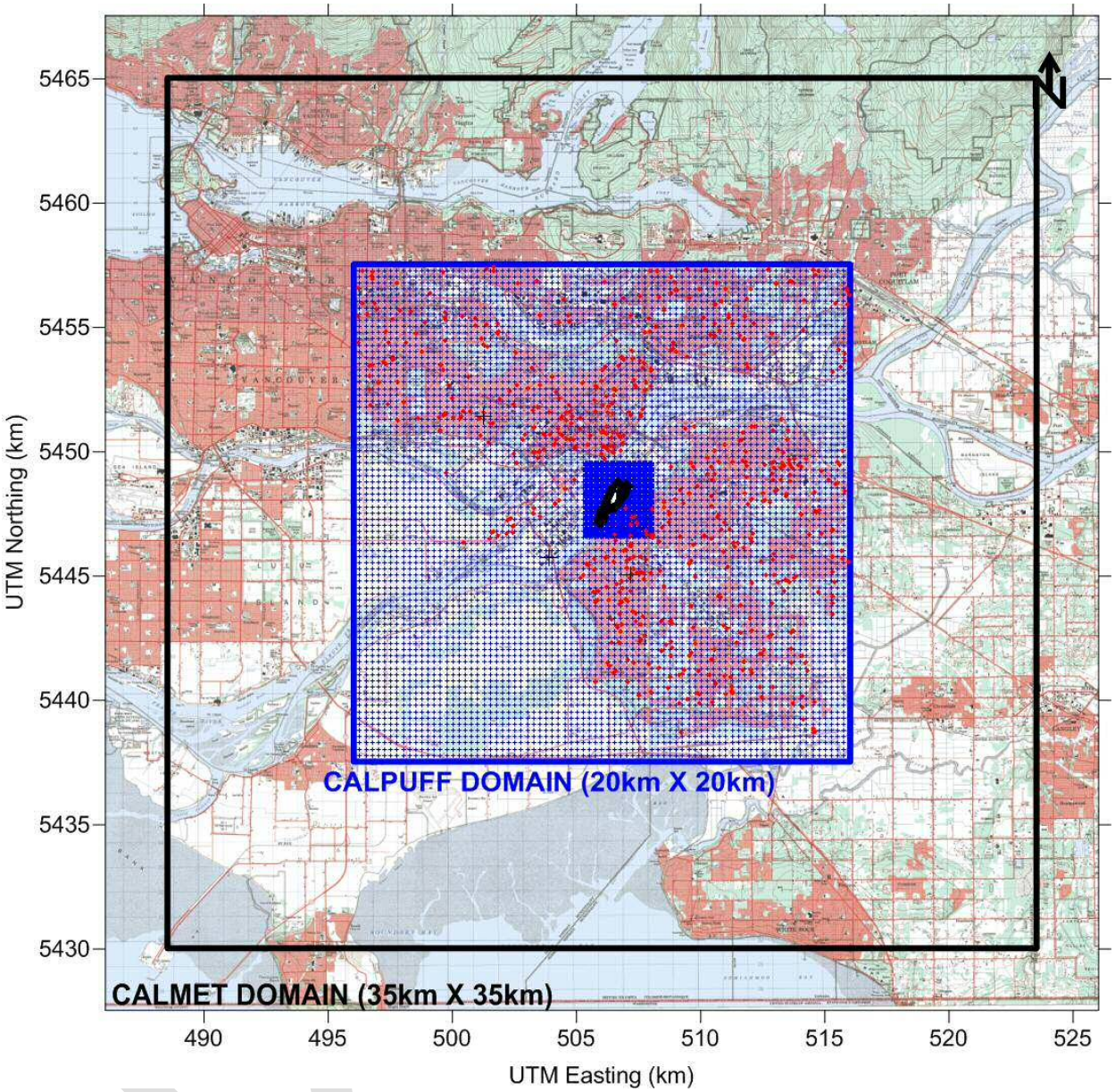


Figure A-9 Map Displaying the CALMET and CALPUFF Modelling Domain.

Table A-1 Heights of CALMET Model Layers

Vertical Layer Number	Height at Top of Layer (m)
1	20
2	40
3	80
4	140
5	200
6	500
7	1000
8	2000
9	4000

A-2.2.2 Terrain Elevation and Land Use Data

Digital terrain and land use data covering the model domain was included in the CALMET input data set. Digital terrain files with a 1:50000 scale were used to generate the CALMET grid cells. Land use characteristics for each grid cell based on LandData BC data sets were used. The BC land use class codes were translated into the land use class codes used by CALMET according to the procedures in the BC Air Quality Modelling Guidelines (AQMG).

A-2.2.3 Meteorological Data

Surface meteorological stations that record hourly data include those operated by the Meteorological Service of Canada (MSC), the BC MOE and Metro Vancouver. Data from seventeen surface stations, listed in Table A-2, were used as input to the CALMET model. Upper air data from the vicinity of the area was used from the Port Hardy station, operated by Environment Canada, and the Quillayute, Washington station, operated by the US National Weather Service.

In its normal mode, CALMET requires a measured data value for every hour from at least one meteorological station in order to simulate the three-dimensional fields. Missing data procedures were implemented, when required, as per the AQMG.

As a supplement to the observational data, three-dimensional meteorological fields from the MC2 prognostic model were used (provided by the University of British Columbia). The MC2 prognostic data was used as input into CALMET as the “initial estimate” field. The "initial estimate" wind field is calculated by interpolating the winds to the fine CALMET scale and then adjusting them for terrain and land-use effects. Utilising the MC2 data in this fashion allows for maximum use of actual surface data, while allowing the MC2 data to replace the surface extrapolated data described in the upper air

DRAFT

section, and thus overall, an improved wind field is generated, both at the surface and aloft.

Table A-2 Surface Meteorological Stations Used for CALMET Input

Surface Meteorological Station	Operated By:
T02 Kitsilano - Vancouver	Metro Vancouver
T04 Kensington Park - Burnaby	Metro Vancouver
T06 Second Narrows - North Vancouver	Metro Vancouver
T09 Rocky Point Park - Port Moody	Metro Vancouver
T13 North Delta	Metro Vancouver
T14 Burnaby Mountain	Metro Vancouver
T15 Surrey East	Metro Vancouver
T17 Richmond South	Metro Vancouver
T18 Burnaby South	Metro Vancouver
T20 Pitt Meadows	Metro Vancouver
T23 Capitol Hill - Burnaby	Metro Vancouver
T24 Burnaby North	Metro Vancouver
T26 Mahon Park - North Vancouver	Metro Vancouver
T30 Maple Ridge	Metro Vancouver
T32 Coquitlam	Metro Vancouver
Vancouver Airport	MSC
Annacis Island	BC MOE

DRAFT

A-2.2.4 CALMET Model Options

The CALMET model has a number of user-specified input switches and options that determine how the model handles terrain effects, interpolation of observational input data, etc. The differences in the modelled and measured meteorological fields were examined for a short time frame, and this analysis was used to determine which model options were appropriate for modelling of impacts over the whole year.

Table A-3 outlines the options that were used that have not been previously described. The current recommended AQMG default parameters were used whenever applicable.

Table A-3 Selected CALMET Wind Field Model Options

Parameter	Option Selected	AQMG Default
Froude Number Adjustment Effects Calculated?	Yes	✓
Kinematic Effects Computed?	No	✓
Slope Effects Computed?	Yes	✓
Surface Wind Observations Extrapolated to Upper Layers?	Yes	✓
Surface Winds Extrapolated even if Calm?	No	✓
Maximum Radius of Influence over Land in the Surface Layer (RMAX1)	5 km	No default
Maximum Radius of Influence over Land Aloft (RMAX2)	20 km	No default
Radius of Influence of Terrain Features	10 km	No default
Relative Weighting of the First Guess Field and Observations in the Surface Layer (R1)	3 km	No default
Relative Weighting of the First Guess Field and Observations in the Layers Aloft (R2)	5 km	No default

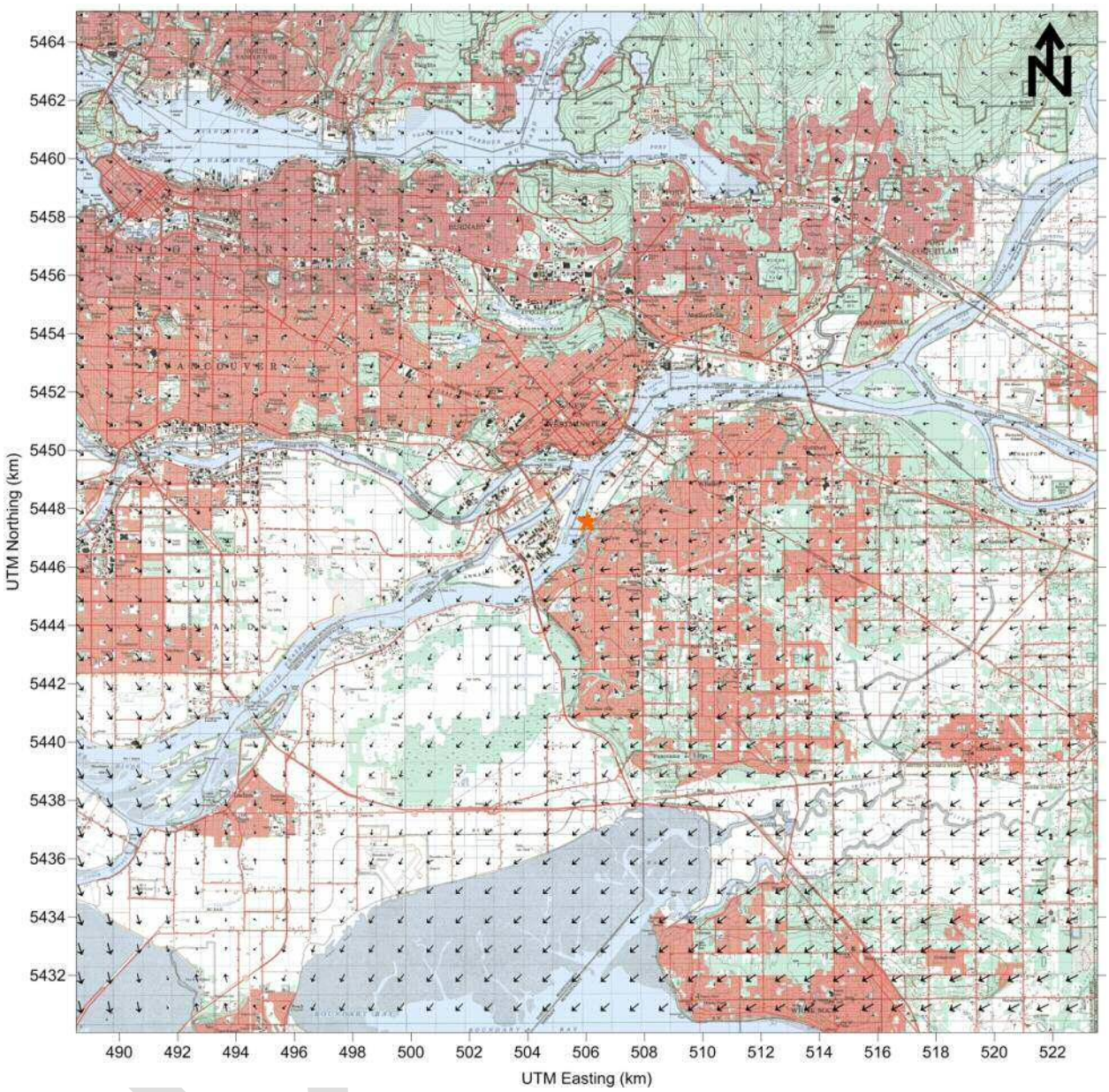
A-2.2.5 CALMET Quality Assurance and Control

When generating model results it is essential to determine if the output is appropriate and reasonable when compared with observational data. This section outlines the quality assurance and control (QA/QC) procedures implemented upon the CALMET modelling results to determine the suitability of the modelling output.

Wind

An example output wind field from CALMET is shown in Figure A-10 for the 10 m level on November 10, 2000 at 11AM. This hour was shown as it was a relatively clear calm autumn morning, and therefore terrain effects should predominantly dominate the wind field, which is seen in the figure.

DRAFT



Note: Location of the FSD site is indicated by the ★.

Figure A-10 Example wind field generated by CALMET for the 10 m level for the hour ending at 11:00 on November 10, 2000. (The wind speed is denoted by the length of the arrows).

Data was extracted from the Level 1 (10 m level) CALMET output for a grid cell located at the facility site. This data was then compared with the closest surface stations used in the modelling (T38 Annacis Island, T13 North Delta and T17 - Richmond South), as well as MSC Vancouver International Airport. The frequency distribution of measured surface winds for the surface stations and the predicted values from the extracted CALMET point are shown below in Figure A-11. The CALMET output follows a similar

trend to that of the nearest surface stations, with wind speed frequencies generally falling in between those observed at the surface stations.

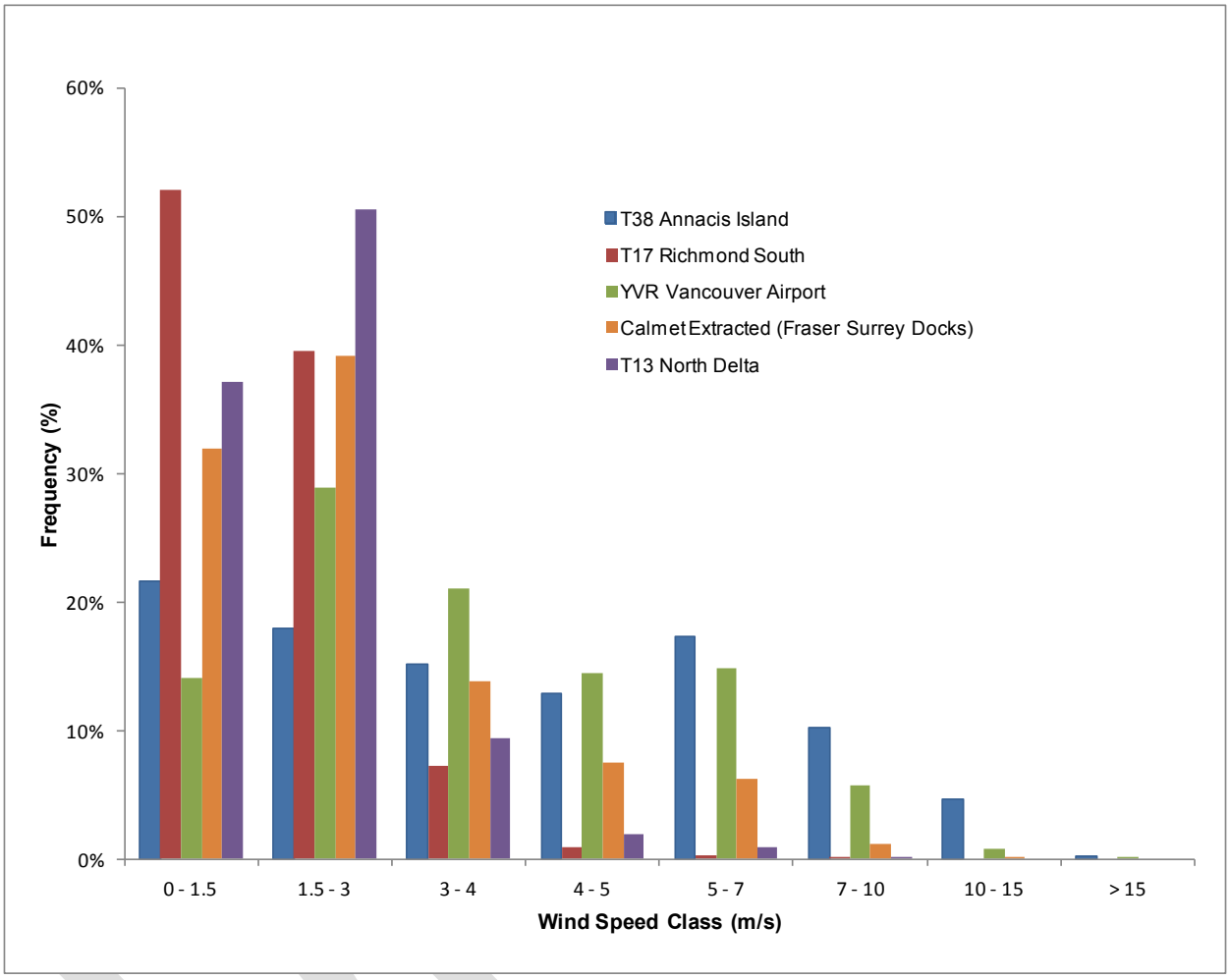


Figure A-11 Frequency distribution of surface (10 m level) winds for surface stations and the near the FSD site (CALMET).

Figure A-12 and Figure A-13 below show monthly and diurnal variations respectively for the surface stations and the extracted CALMET point. The extracted point falls between the values measured at the surface stations, and follows similar trends to the nearby Richmond South station.

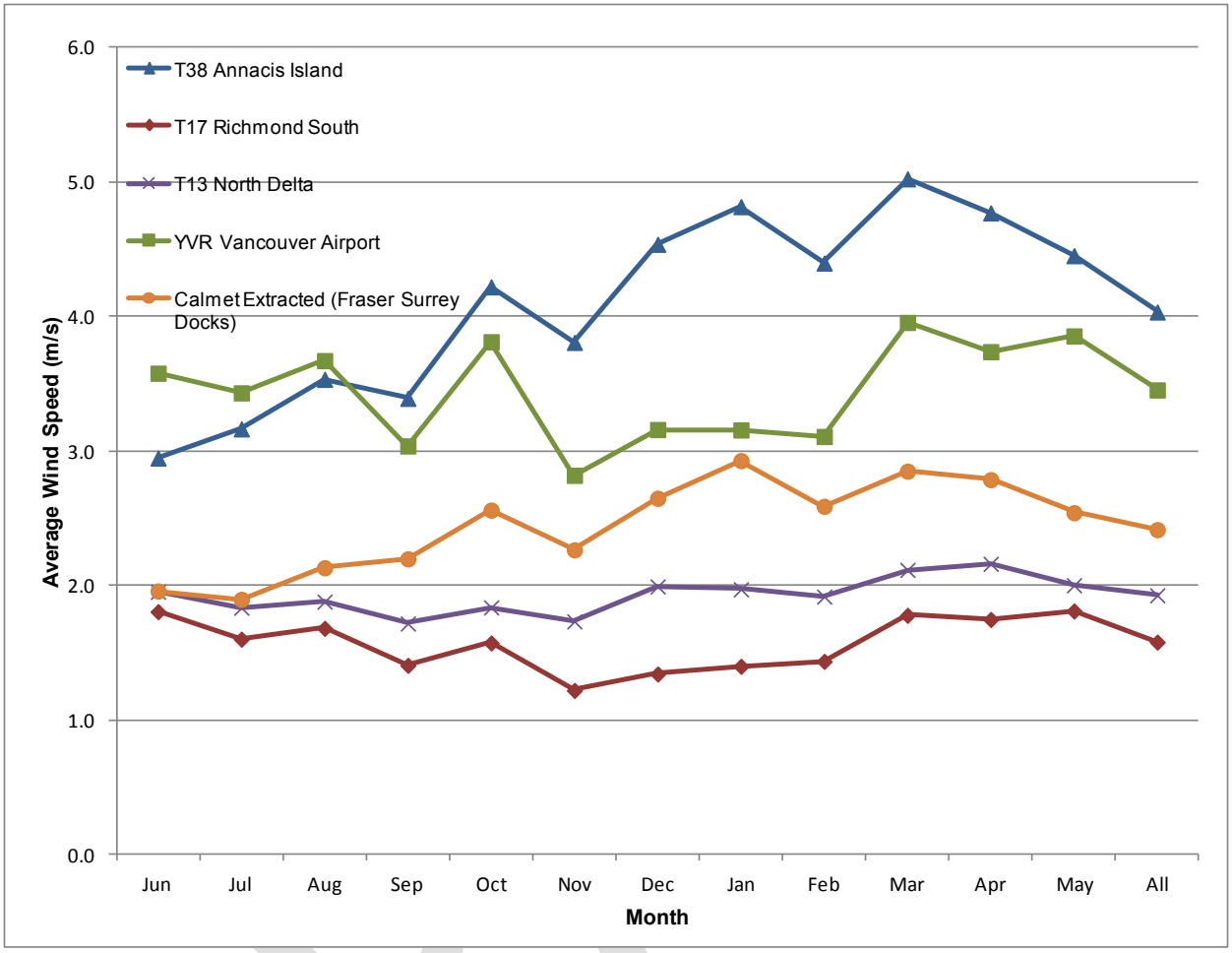


Figure A-12 Average monthly wind speeds at surface (10 m level) for surface stations and the FSD site (CALMET).

DRAFT

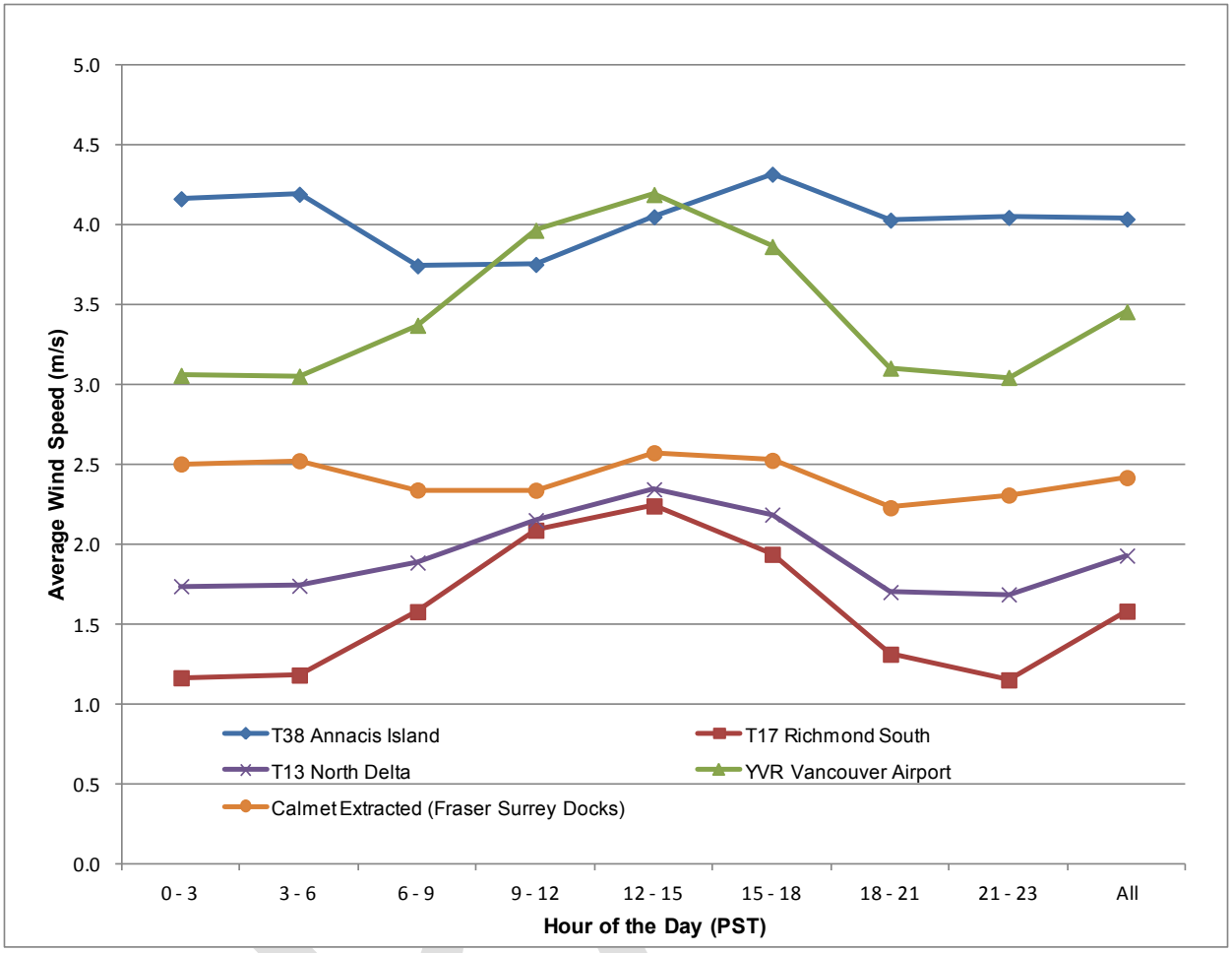


Figure A-13 Diurnal wind speed distribution of surface (10 m level) winds for surface stations and the FSD site (CALMET).

DRAFT

Temperature

Figure A-14 shows the average monthly surface temperature and Figure A-15 shows the average hourly temperature (binned into 3 hour intervals) for the available surface data and the extracted CALMET output for the FSD site. Both plots show an excellent agreement between the predicted and observed values.

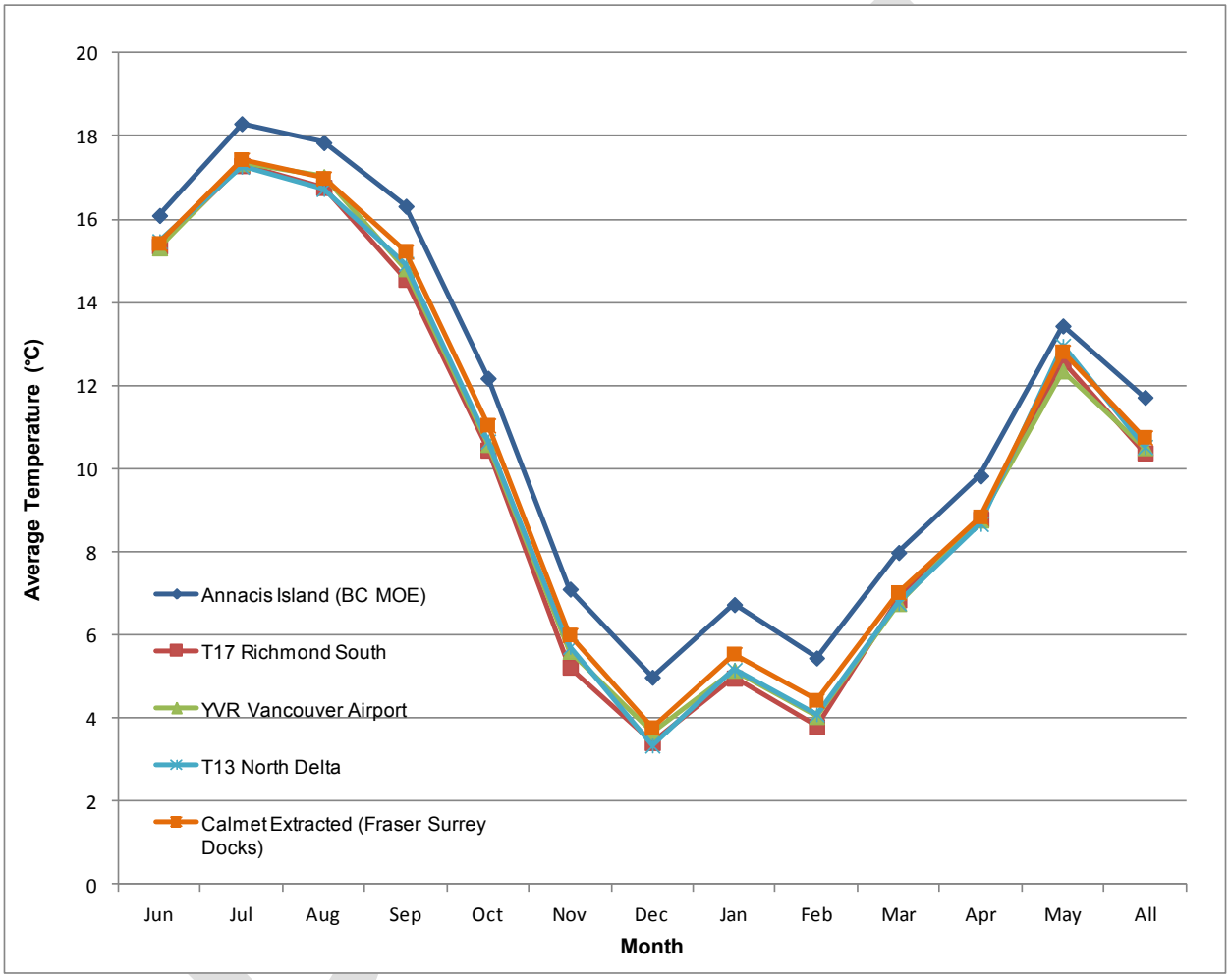


Figure A-14 Monthly temperatures at surface stations and FSD site (CALMET).

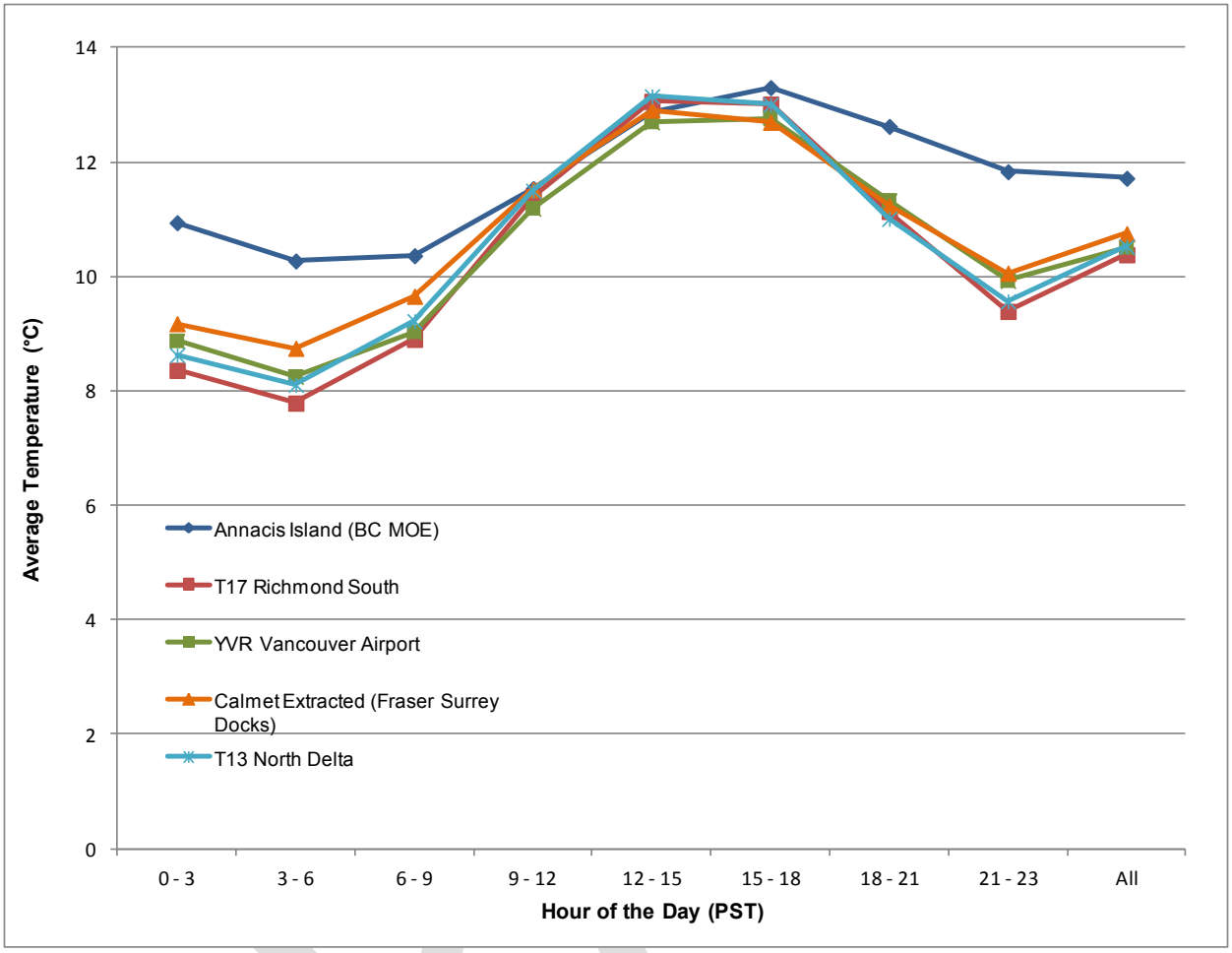


Figure A-15 Hourly temperatures at surface stations and the FSD site (CALMET).

DRAFT

Stability Class

The frequency distribution of predicted stability for the FSD site was compared with the calculated stability for Vancouver Airport (YVR). YVR was used as the other surface stations used in the modelling did not have the required parameters to determine stability. As seen in Figure A-16, the extracted CALMET data is in good agreement with the calculated stability from YVR.

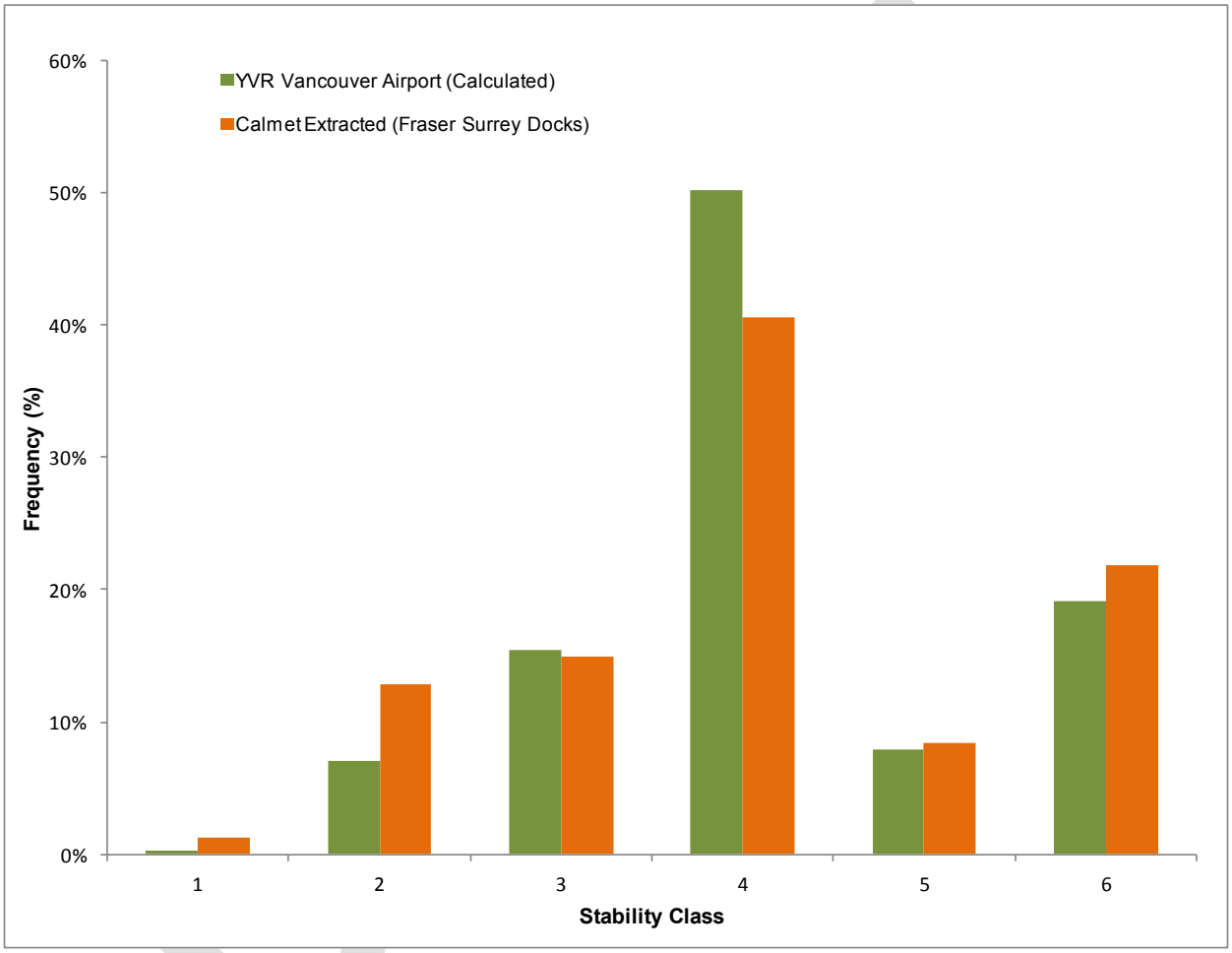


Figure A-16 Frequency distribution of stability classes calculated for Vancouver Airport (YVR) and the FSD site (CALMET) for the modelling period.

Mixing Height

Predicted mixing heights from CALMET are shown in Figure A-17. Mixing heights are not available from the input data, but the predicted values appear representative of typical mixing heights of a similar location[36]



Figure A-17 Hourly predicted mixing heights for the FSD site (CALMET).

[36] *Senes et al, 1996, "A Mixing Height Study for North America (1987 - 1991)"*

Precipitation

Predicted monthly precipitation totals from CALMET at the project site are shown versus observed precipitation values from Metro Vancouver meteorological stations (Figure A-18). The predicted values appear representative of precipitation in the Metro Vancouver area.

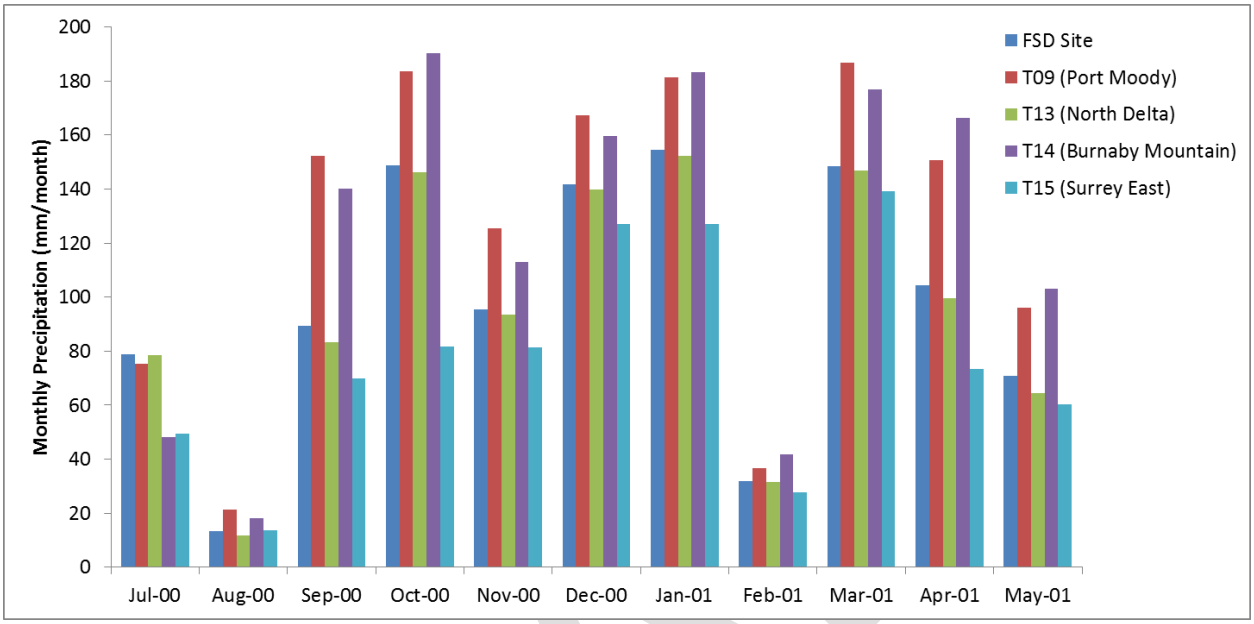


Figure A-18 Monthly predicted precipitation totals for the FSD site (CALMET) versus observational data.

DRAFT

FRASER SURREY DOCKS
DIRECT COAL TRANSFER FACILITY:
DRAFT AIR QUALITY MANAGEMENT PLAN

Prepared for:

FRASER SURREY DOCKS
Pacific Rim Stevedoring

11060 Elevator Road
Surrey, BC
V6P 3Y7

Prepared by:

Levelton Consultants Ltd.
150-12791 Clarke Place
Richmond, BC
Canada, V6V 2H9

DRAFT

Disclaimer

This report has been prepared in a working draft form and has not been finalised or formally reviewed. As such it should be taken as an indication only of the material and conclusions that will form the final report and management plan. Any calculation, findings, conclusions or opinions presented here are not necessarily those of Port Metro Vancouver and may be changed or altered. This draft report and associated management plan are intended for public review and comment.

Date: November 15th, 2013 **File:** EE12-1611-00

TABLE OF CONTENTS

1. PURPOSE AND SCOPE 1
   1.1 GUIDANCE DOCUMENTATION 1
2. REGULATORY CONSIDERATIONS 1
   2.1 PORT METRO VANCOUVER 1
   2.2 METRO VANCOUVER 2
   2.3 APPLICABLE LEGISLATION, REGULATION, GUIDELINES, OBJECTIVES AND STANDARDS 2
3. SOURCES OF AIR EMISSIONS 2
4. SENSITIVE RECEPTORS 3
5. CONSTRUCTION AIR QUALITY MANAGEMENT 4
   5.1 BEST MANAGEMENT PRACTICES (BMPS) 4
   5.2 FUGITIVE DUST 5
   5.3 COMBUSTION EMISSIONS 6
6. OPERATIONAL AIR QUALITY MANAGEMENT 6
   6.1 BEST MANAGEMENT PRACTICES (BMPS) 6
   6.2 FUGITIVE DUST 6
   6.3 COMBUSTION EMISSIONS 18
7. AIR QUALITY ASSESSMENT, MONITORING AND REPORTING 18
   7.1 VISUAL SITE INSPECTION 19
   7.2 AIR QUALITY MONITORING 20
   7.3 TRACKING / COMPLAINT MANAGEMENT SYSTEM 27
   7.4 QUARTERLY REPORTING 28
   7.5 PUBLIC WEBSITE FOR DATA ACCESS 29
   7.6 AIR QUALITY MANAGEMENT PLAN EFFECTIVENESS 29
8. CONTACTS 29
9. REFERENCES 30

APPENDIX A – ANTI-IDLING POLICIES ..... A

APPENDIX B – OVERVIEW OF PROPOSED DUST SUPPRESSION AND WASTEWATER MANAGEMENT SYSTEMS ..... B

APPENDIX C – ENVIRONMENTAL POLICY C

APPENDIX D – VISUAL SITE INSPECTION REPORT (EXAMPLE) ..... D

APPENDIX E – MONITORING EQUIPMENT INFORMATION ..... E

APPENDIX F – DUST FALL MONITORING GUIDANCE ..... F

APPENDIX G – DUST COMPLAINT MANAGEMENT FORM ..... G

DRAFT

LIST OF FIGURES

Figure 4-1 Location of sensitive receptors near FSD 4
Figure 7-1 Air Quality Monitoring Locations 26

LIST OF TABLES

Table 6-1 Terminal Operation Process Mitigation Strategy – Air Quality 7

DRAFT

1. PURPOSE AND SCOPE

The purpose of the Air Quality Management Plan (AQMP) is to address the air quality management requirements relating to construction and operation of Fraser Surrey Docks (FSD) Direct Coal Transfer Facility (the Project).

Specifically, this AQMP describes the Best Management Practices (BMPs) that will be followed, where practical, during construction and operation of the Facility. Air quality monitoring and reporting commitments are also outlined in order to:

- Assess the effectiveness of the mitigation measures in place at the Facility, and take corrective actions to mitigate air quality concerns caused by FSD's operations; and,
- Confirm the results of the air quality assessment prepared for the Environmental Impact Assessment of the Facility which predicted air quality impacts localized around the Facility.

1.1 GUIDANCE DOCUMENTATION

The primary guidance documentation used in the development of the AQMP and the BMPs outlined in the AQMP are:

- *Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities,* (Cheminfo, 2005);
- *BC Ministry of Energy and Mines, 2002. Aggregate Operators Best Management Practices Handbook for British Columbia. Volume II – Best Management Practices. April 2002*; and
- *Fraser Surrey Docks Direct Coal Transfer Facility: Air Quality Assessment (DRAFT). Prepared for Fraser Surrey Docks, by Levelton Consultants Ltd. November 15th, 2013.*

2. REGULATORY CONSIDERATIONS

2.1 PORT METRO VANCOUVER

Port Metro Vancouver (PMV) requires a permit be obtained by FSD for the construction of the Facility. As part of the environmental review process to obtain the permit, FSD was required to conduct an air quality assessment of the Facility. The air quality assessment was based upon a number of mitigation measures being in place at the Facility. FSD has a commitment to meet those mitigation measures, which have been summarized in Section 6.

In addition to the mitigation measures planned for the Facility, FSD has committed to the following in discussions with PMV:

- Meteorological station near the barge loader (including an anemometer, rain gauge and temperature / relative humidity sensor);
- Particulate matter monitoring near the barge loader;
- Particulate matter monitoring station near the facility;
- Dust fall monitoring near the barge loader and facility; and,
- Nitrogen dioxide monitoring at and near the facility fenceline.

DRAFT

Specific details regarding the monitoring program are provided in Section 7. The AQMP that follows outlines how each of these commitments will be met.

2.2 METRO VANCOUVER

The Facility will require an air permit from Metro Vancouver prior to the commencement of operations. Metro Vancouver may require further monitoring or mitigation activities that are not outlined in this AQMP, at which time the AQMP would need to be revised to incorporate Metro Vancouver's additional requirements.

2.3 APPLICABLE LEGISLATION, REGULATION, GUIDELINES, OBJECTIVES AND STANDARDS

Legislation, regulations, guidelines, objectives and standards that are relevant to the AQMP are the following (see also Section 9 for full references):

- *British Columbia Environmental Management Act* (BC EMA, 2004) (forms the basis for provincial ambient air quality objectives)*;*
- *Canadian Environmental Protection Act* (CEPA, 2012) (forms the basis for federal ambient air quality objectives);
- Applicable Metro Vancouver (Greater Vancouver Regional District (GVRD)) Air Quality Bylaws (GVRD, 2008) (forms the basis of Metro Vancouver's regional ambient air quality objectives);
- Provincial Air Quality Objectives and Standards – *British Columbia Ambient Air Quality Objectives* (BC MOE, 2013);
- Metro Vancouver Air Quality Objectives – *Integrated Air Quality and Greenhouse Gas Management Plan* (Metro Vancouver, 2011); and,
- Relevant Occupational Health and Safety Requirements as outlined in British Columbia's Occupational Health and Safety Regulation (Worksafe, 2013).

3. SOURCES OF AIR EMISSIONS

Construction and operational activities for the Project could result in localized air quality impacts. Construction related impacts are generally of short-term duration but may still cause adverse air quality impacts. Potential air quality impacts relating to construction and operation include, but are not limited to: fugitive dust (particulate matter) and combustion emission from vehicles and equipment (e.g. from mobile and stationary diesel and gas powered equipment).

Common construction activities that result in fugitive dust emissions include, but are not limited to: excavation, pile driving, sandblasting, clearing, grubbing, aggregate handling, stockpiling, crushing, grading, compacting, paving, demolition of existing structures, the use of construction vehicles and equipment, etc.

Common construction activities that result is combustion emissions include, but are not limited to, mobile and stationary diesel and gas power equipment such as: drills, excavators, crawler tractors, loaders, graders, cranes, concrete trucks, dump trucks, generators, welding equipment, marine vessels, etc.

These sources form the general basis by which potential air quality impacts can be examined during the construction of the Project.

Operational fugitive dust emission sources for the Project will be designed and constructed to incorporate mitigation measures. Fugitive dust sources include: rail transit, loaded and empty rail cars in rail yard, coal receiving pits and conveyors, loading coal on barges, loaded barges at berth, and coal barge transit down Fraser River to Texada Island.

Operational combustion emission sources for the Project include: yard-switch engines, locomotives within the rail yard and in transit, and tugboats at the berth and in transit.

4. SENSITIVE RECEPTORS

Sensitive receptors (hospitals, schools, senior care residences, and day care centres) surrounding FSD were identified in the air quality assessment (Levelton, 2013). Figure 4-1 shows the location of sensitive receptors closest to FSD.

The air quality monitoring program outlined in Section 7 for the Facility includes a particulate matter monitor and dust fall canister at the nearest residential location to the east from the Project coal handling operations. Given the relative distances of the sensitive receptors in the area from the Facility, and the predictions from the air quality assessment, it is reasonable to assume that monitoring at this location would be represent the potential worst-case impacts from the Facility on the local community when considering annual PM concentrations. The dust fall canister monitoring results at this location will also be used, as necessary, to determine potential impacts to nearby ecologically sensitive sites, such as Shadow Brook.

Additional monitoring will also be conducted as outline in Section 7.

DRAFT

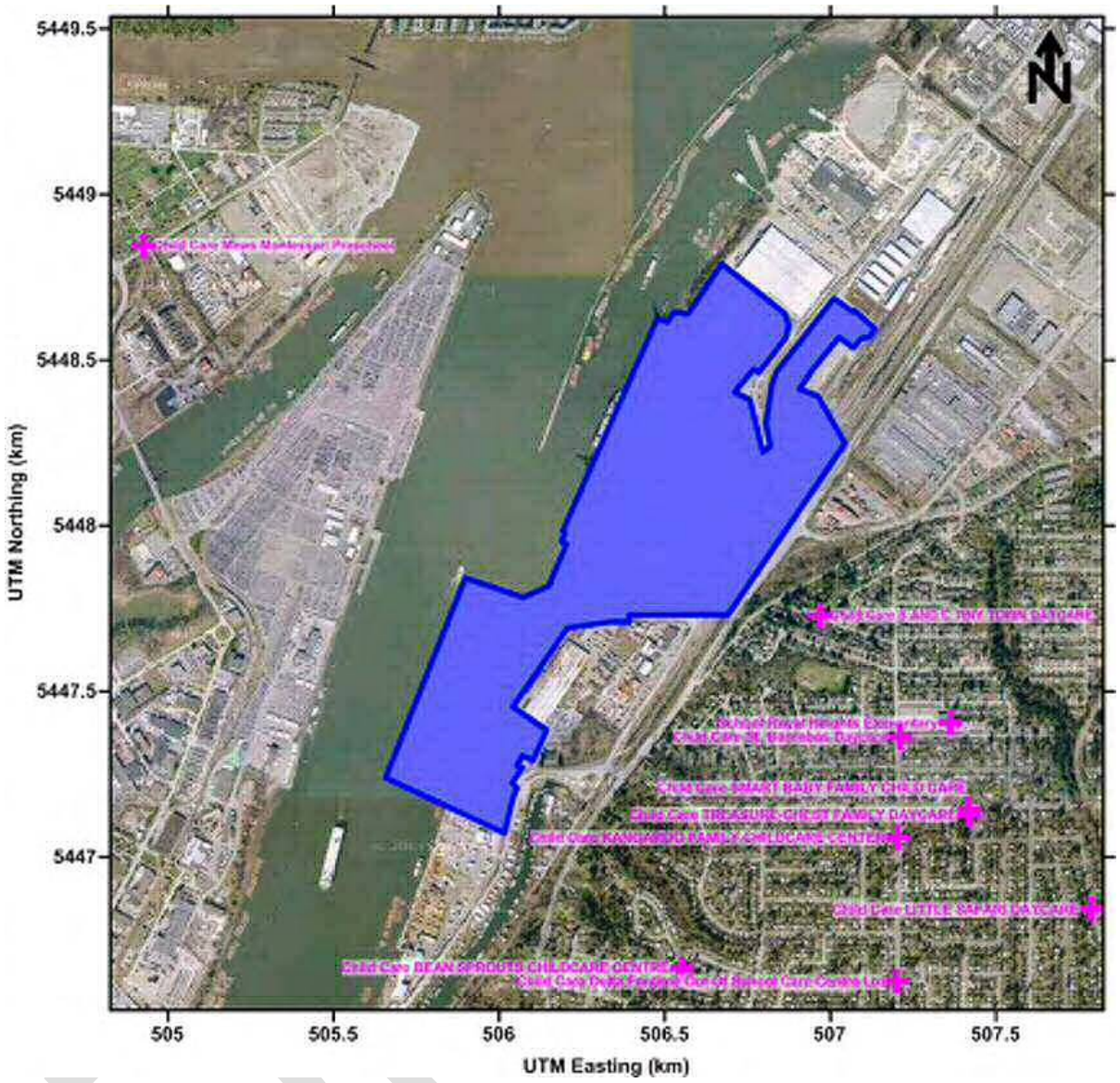


Figure 4-1 Location of sensitive receptors near FSD

5. CONSTRUCTION AIR QUALITY MANAGEMENT

5.1 BEST MANAGEMENT PRACTICES (BMPS)

This section provides a summary of BMPs that will be implemented to reduce fugitive dust and combustion related air emissions from construction and demolition activities related to the Project. For additional information please refer to *Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities* (Cheminfo, 2005).

Required mitigation strategies contained within this plan will be incorporated into all contracts with all contractors. Contractors will be required to review, acknowledge and agree to the mitigation strategies and commit to compliance controls. Contractor performance will be

monitored by management on an ongoing basis. Further details regarding construction monitoring is provided in Section 7.

5.2 FUGITIVE DUST

Fugitive dust and airborne particulate matter will be minimized and mitigated by implementing BMPs that include, but are not limited to, the following:

- Grade the construction site in phases, timed to coincide with the actual construction in that area;
- Start linear construction at the location that is upwind from the prevailing wind direction;
- Minimize the amount of clearing required to conduct the works;
- Minimize generation of road dust (e.g. minimize the time that unpaved surfaces are exposed and use watering and / or sweeping);
- Use wind fencing in construction areas that are frequently subjected to high winds;
- During dry conditions and when necessary, control dust sources (e.g. minimize the time that unpaved surfaces are exposed, water or cover potential dust sources, sweep paved surfaces);
- As necessary, use environmentally acceptable dust suppressants or water to control dust on access roads, lay-down areas, work areas, and disposal areas;
- Prefer the use of water for dust control, with consideration for water conservation, drainage and sediment control where appropriate;
- Do not use oils for dust control;
- Stabilize surfaces of completed earthworks and / or base areas with vegetation, stones, geotextile, mulch or other erosion resistant cover;
- Compact distributed soils;
- Reduce activities that create fugitive dust during windy conditions;
- Manage storage piles (e.g. by shaping them, installing enclosures or coverings around piles, conducting storage pile activities downwind of sensitive receptors);
- Control mud and dirt track-out from construction sites;
- Minimize drop height at material transfer locations (e.g. when loading soil onto haul trucks);
- Prohibit burning as a means of disposal of any organic or construction materials; and,
- Implement on-site vehicle restrictions (e.g. limit the speed of vehicles travelling on unpaved access / haul roads).

Based on experiences with similar construction projects, the Project Air Quality Specialists (Levelton Consultants Ltd.) also recommends limiting traffic speeds to 15 km/hr on unpaved roads, where practicable.

It is planned that these considerations will be reviewed by Levelton as part of visual site inspections that will occur during the air quality monitoring portions of the Project.

DRAFT

Air quality and dust fall monitoring will be conducted during the construction period as described in Section 7.

5.3 COMBUSTION EMISSIONS

Combustion emissions will be minimized and mitigated by implementing BMPs that include, but are not limited to, the following:

- Implement an anti-idling protocol (see Appendix A) for construction equipment and vehicles that requires equipment to be turned off, if practical and when not in use, unless continuous idling is required by the equipment operation specifications. Make use of best available technologies and practices to reduce emissions;
- Operate equipment at and within load tolerances and ratings;
- Ensure that all motorized equipment is in good working order and maintained to manufacturer's specifications;
- Comply with applicable regulation regarding heavy-duty diesel non-road equipment and other construction equipment (including Metro Vancouver's Non-Road Diesel Emission Regulation); and,
- Use grid power rather than locally generated power whenever practical to reduce emissions.

6. OPERATIONAL AIR QUALITY MANAGEMENT

6.1 BEST MANAGEMENT PRACTICES (BMPS)

This section provides a summary of BMPs to reduce fugitive dust and combustion related air emissions from operations at the Facility. The BMPs are those already included in the Permit Application submitted to PMV.

6.2 FUGITIVE DUST

Table 6-1 summarizes the source specific mitigation measures that will be in place during operations. The recommended BMPs focus on:

- Rail transit;
- Coal receiving pits and conveyors;
- Loading coal on barges; and,
- Barge transit down the Fraser River to Texada Island; and,

Appendix B provides an overview of the proposed dust suppression and wastewater management systems.

DRAFT

Table 6-1 Terminal Operation Process Mitigation Strategy – Air Quality

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
	Pre- Normal Operations – BASELINE	Fugitive Dust CACs	Baseline creation	Dust Fall PM NO_2	Prior to the start of Operations, a "baseline level" particulate matter, dust fall and nitrogen dioxide monitoring program will be implemented to quantify the pre-project levels. This will provide a comparative reference for future monitoring. Two monitoring stations with Met One E- Samplers and dust fall canisters would be installed at least six months prior to Operations and take continual samples over that period. Air Quality Monitoring Station #1, or terminal monitoring station, will be located on the southwestern fence line of the facility within 10 m of the barge loader. The station would be fitted with a Met One E- Sampler and dust fall canister and will take continual samples of PM_{10} and dust fall. The station will also be fitted with a meteorological monitoring station that would measure wind speed, wind direction, rainfall, temperature and relative humidity. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2, the nearest resident monitoring station, will be fitted with a Met One E- Sampler and dust fall canister and will take continual samples of $PM_{2.5}$ and dust fall. The monitoring station would be installed less than 100 m from the western rail entrance to the rail yard adjacent to Shadowbrook Creek. Data would be monitored from the Met One E-Sampler in real time via cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Nitrogen dioxide would be tested using a hand held monitor on a monthly basis. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources.	Once in operation, a written *Quarterly Air Quality Report* (by Levelton) summarizing the quarterly findings from both monitoring stations will be provided on a quarterly basis to PMV four to six weeks following the end of the quarter. The baseline data will be summarized and used for comparison to the ongoing air quality monitoring data in these reports. FSD will also post the report on their website. The *Quarterly Air Quality Report* will include the following: 1. Overview 2. Meteorological, Air Quality and Dust Fall Monitoring Data 2.1 Meteorological Monitoring Data This section will include average and maximum wind speed, wind roses, wind speed excursion above 19 km/h, total precipitation, maximum and minimum temperature for the previous quarter. 2.2 Air Quality Monitoring Data Summary of PM_{10}/$PM_{2.5}$ (1-hour maximum, 24-hour average results and annual average results (when sufficient data become available) and nitrogen dioxide monitoring results (short-term average results collected by the handheld monitor). Ongoing air quality monitoring data will be compared to the baseline data collected. 2.3 Dust Fall Monitoring Data Monthly dust fall monitoring results reported based on compositional analysis (total and fixed residue and coal content) based on laboratory analysis. 3. Summary of Visual Site Inspection 3.1 FSD's Visual Site Inspections Summary of visual site inspections for the previous quarter which would include details of identified issues, recommendations, follow-up and resolution. 3.2 Levelton's Visual Site Inspections Summary of visual site inspections for the previous quarter which would include details of identified issues, recommendations, follow-up and resolution. 4. Summary of Complaints Summary from complaints logging system which would include details of any mitigation or follow-up actions required. 5. Corrective Action 6. Conclusion	N/A

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
						7. Closure 8. References Appendices (Dust Fall Laboratory Analysis, Visual Site Inspection Records, Water Application, Rail Anti-Idling Records, and Visual Opacity Training Records)	
1	***Normal Operations - Rail***						
	(a) Fully loaded unit train of approximately 125 cars enters Port Authority Rail Yard (PARY), split into 90 and 35 car blocks and placed into separate tracks 91 and 92 respectively. Process performed by four AC SD40 road power locomotives. After split, all four road power locomotives are placed into short holding track for storage.	CACs	All rail traffic entering and exiting the PARY will be governed to operate at less than 5 mph. FSD has mandated the rail carrier only utilize AC locomotives equipped with Variable Frequency Drives (VFD's). The newer technology provides the locomotive with the same amount of torque at lower speeds and reduced emissions. FSD has implemented an anti-idling policy within the PARY. Requires the rail carries to shut down the road power locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer.	Dust Fall PM NO_2	Although entry and exit speeds will not be verified, experienced FSD yard crews, if present upon train arrival, will be able to identify excessive speeds if present. Further to this, all road power locomotives brought into the yard will be confirmed to be AC with VFD's type by FSD yard crew. Issues with either case would be noted by the Rail Yard Foreman Daily Activity Log. Compliance of FSD's anti-idling policy in accordance with FSD's standard operating procedures will be monitored by FSD's yard crews and noted in the Rail Yard Foreman Daily Activity Log. Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources.	General reporting of monitored over speeding, improperly fitted road power locomotives, and/or anti-idling infractions records of all operational checks will be logged and filed, and made available if requested. Noncompliance in any of these cases will trigger a Notice of Safety and Environmental Standards Letter to be sent by FSD's Environmental Sustainability Committee to the rail carrier. Nitrogen dioxide monitoring results (short-term average results collected by the handheld monitor) will be summarized quarterly by Levelton and issued as part of the *Quarterly Air Quality Report*. Ongoing air quality monitoring data will be compared to the baseline data collected.	Noise, Spills
		Fugitive Dust	To be compliant with the BNSF loading requirements, all customers will be required to contractually commit to: - Applying a veneer suppressant at mines pre departure and re-application between the mine and port (binds the surface particles together to provide a membrane that is resistant to dust lift off) - Applying an anti-dusting body agent at mines pre departure (binds the majority of fines to larger particulates to the entire body of coal entering rail car) - Profiling coal loads in accordance with the BNSF loading template - Removing excess coal on wagon sills by using a car sill brush	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
	b) A 900 HP yard locomotive splits the 90 and 35 loaded rail car into six blocks of 24 cars or five blocks of 24 cars (depending on yard availability) onto yard holding tracks.	Fugitive Dust	To be compliant with the BNSF loading requirements, all customers will be required to contractually commit to: - Applying a veneer suppressant at mines pre departure and re-application between the mine and port (binds the surface particles together to provide a membrane that is resistant to dust lift off) - Applying an anti-dusting body agent at mines pre departure (binds the majority of fines to larger particulates to the entire body of coal entering rail car) - Profiling coal loads in accordance with the BNSF loading template - Removing excess coal on wagon sills by using a car sill brush.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
		CACs	All rail traffic working the PARY or Terminal will be governed to operate at less than 3 mph. FSD has implemented an anti-idling policy. Requires the shutdown of the yard locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer and the temperature is greater than -3 degrees Celsius.	NO_2 PM Dust Fall	Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
					Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.		
	(b) A 900 HP yard locomotive shuttles a single block of 24 cars from PARY clockwise onto coal rail loop on the terminal for unloading.	Fugitive Dust	To be compliant with the BNSF loading requirements, all customers will be required to contractually commit to: - Applying a veneer suppressant at mines pre departure and re-application between the mine and port (binds the surface particles together to provide a membrane that is resistant to dust lift off) - Applying an anti-dusting body agent at mines pre departure (binds the majority of fines to larger particulates to the entire body of coal entering rail car) - Profiling coal loads in accordance with the BNSF loading template - Removing excess coal on wagon sills by using a car sill brush.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
		CACs	All rail traffic working the Port Authority Rail Yard or Terminal will be governed to operate at less than 3 mph. FSD has implemented an anti-idling policy. Requires the shutdown of the yard locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer and the temperature is greater than -3 degrees Celsius.	NO_2 PM Dust Fall	Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
	(c) The block of 24 loaded rail cars are indexed via electric positioner and bottom dumped	Fugitive Dust	Cars will be shunted through the two bottom dump receiving pits via an electric positioner (an indexer), which does not release any emissions. A water and chemical mist/fog system will be projected directly at both sides and tops of both bottom dump rail car unloading pits. There are three spray bars, one on each side and one on top, equipped with several nozzles at appropriate distances to ensure complete coverage. The system is automatically triggered by the railcar movement and will apply a steady mist to all areas receiving coal during the entire unloading process. Receiving pits will be within a covered structure, except for the opening at either end for the train to enter/exit.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
	(d) A 900 HP yard locomotive shuttles a single block of 24 empty cars clockwise from receiving pits on coal rail loop in the terminal back to the PARY	Fugitive Dust	The exterior sides and top of the empty cars will be automatically sprayed to remove any remaining coal after leaving dumper pit shed enclosure at a defined wash car station. The spray device is configured in a “U” shape up either side and across the top with nozzles at specific intervals to ensure full coverage. The spray device is automatically triggered from a sensor that recognizes movement of the railcar.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular	*Quarterly Air Quality Report* as summarized above.	Noise

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
					modem. Data would be collected from the dust fall canister manually on a monthly basis.		
		CACs	All rail traffic working the Port Authority Rail Yard or Terminal will be governed to operate at less than 3 mph. FSD has implemented an anti-idling policy. Requires the shutdown of the yard locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer and the temperature is greater than -3 degrees Celsius.	NO_2 PM Dust Fall	Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
	(e) A 900 HP yard locomotive builds the 90 and 35 empty rail car from the six blocks of 24 cars onto two splits of 90 and 35 cars onto yard holding tracks 91 and 92 respectively.	Fugitive Dust	Empty rail cars will have been washed.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise
		CACs	All rail traffic working the PARY or Terminal will be governed to operate at less than 3 mph. FSD has implemented an anti-idling policy. Requires the shutdown of the yard locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer and the temperature is greater than -3 degrees Celsius.	NO_2 PM Dust Fall	Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Spills
	(f) Rail carrier rebuilds full unit train of empties from two splits. Process performed by four AC SD40 road power locomotives that parked. Full unit train departs PARY with two road power locomotives on the front and tail end	CACs	All rail traffic entering and exiting the PARY will be governed to operate at less than 5 mph. FSD has mandated the rail carrier only utilize AC locomotives equipped with VFD's. The newer technology provides the locomotive with the same amount of torque at lower speeds and reduced emissions. FSD has implemented an anti-idling policy within the PARY. Requires the rail carries to shut down the road power locomotives when it is known that the locomotive is not required for a period of 3 hours in duration or longer.	NO_2 PM Dust Fall	Although entry and exit speeds will not be verified, experienced FSD yard crews, if present upon train arrival, will be able to identify excessive speeds if present. Further to this, all road power locomotives brought into the yard will be confirmed to be AC with VFD's type by FSD yard crew. Issues with either case would be noted by the Rail Yard Foreman Daily Activity Log. Compliance of FSD's anti-idling policy in accordance with F SD's standard operating procedures will be monitored by FSD's yard crews and noted in the Rail Yard Foreman Daily Activity Log.	General reporting of monitored over speeding, improperly fitted road power locomotives, and/or anti-idling infractions records of all operational checks will be logged and filed, and made available if requested. Noncompliance in any of these cases will trigger a Notice of Safety and Environmental Standards Letter to be sent by FSD's Environmental Sustainability Committee to the rail carrier. Nitrogen dioxide monitoring results (short-term average results collected by the handheld monitor) will be summarized quarterly by Levelton and issued as part of the *Quarterly Air*	Noise, Spills

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
	respectively.				Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources.	*Quality Report*. Ongoing air quality monitoring data will be compared to the baseline data collected.	
		Fugitive Dust	Empty rail cars will have been washed.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise
2	***Normal Operations – Transfer Process to Barge Loading***						
	(a) Coal dump from rail.	Fugitive Dust	A water and chemical mist/fog system will be projected directly at both sides and tops of both bottom dump rail car unloading pits. There are three spray bars, one on each side and one on top, equipped with several nozzles at appropriate distances to ensure complete coverage. The system is automatically triggered by the railcar movement and will apply a steady mist to all areas receiving coal during the entire unloading process. Receiving pits will be within a covered structure, except for the opening at either end for the train to enter/exit. Drop height will be less than 1 m. FSD's Environmental Coordinator will conduct visual opacity readings, a "visual determination of fugitive emissions from material processing sources" during every barge loading operation. The Environmental Coordinator can authorize the shutdown of the barge loading operation, or any other operation, should visual observations of emissions indicate an opacity of > 20%.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. FSD's Environmental Coordinator will conduct visual opacity readings, a "visual determination of fugitive emissions from material processing sources" during every barge loading operation. They will advise the Director of Maintenance and Engineering of any issues and will make recommendations to remedy potential air quality issues. Levelton will conduct visual site inspections during each monthly air quality monitoring site visit.	*Quarterly Air Quality Report* as summarized above. FSD's Environmental Coordinator will prepare a monthly report to the Director of Engineering. The report will include: 1. Any issues noted 2. Recommendations to remedy potential air quality issues 3. Further mitigation measures aimed at preventing potential fugitive dust issues 4. Feedback on the results of past mitigation strategies implemented This report can be made available upon request.	Grey Water Management, Leachate
	(b) Transfer of Coal along Conveyors Eight conveyor segments: - Quad receiving conveyors (4) exiting the dual receiving pits - Dual out feed conveyors (2) from the quad conveyors - Single feed conveyor - Single barge loading conveyor	Fugitive Dust	All conveyors will be covered on the top and sides with steel sheeting to prevent coal or dust from exiting. All transfer points from one conveyor to the other will be fully enclosed on all four sides, top and bottom. In addition, all transfer points will be equipped with water and chemical/misting spray that is automatically applied on a continual basis while system is in operation. A spray bar is located above the conveyor and has several nozzles at appropriate distances to ensure complete coverage. Transfer points are also equipped with washdown equipment used for cleaning out the system. Coal on conveyors will be mechanically profiled to not exceed belt edge height to limit exposure to air flow. Profiling is accomplished through the use of a steel plate at the designated height to shape the coal as it passes by.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Leachate

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
	Three transfer points: - Quad receiving conveyors to dual out feed conveyors - 100 mt Surge hopper - Dual out conveyors to single feed conveyor - Single feed conveyor to barge loader		Water/chemical spray will automatically be applied at each transfer point between conveyors on a continual basis while system is in operation. The spray bar is located above the conveyor and has several nozzles at appropriate distances to ensure complete coverage. Dust suppression technology will be incorporated into the design of the transfer point chutes. Use of dust limiting shapes such as curved chutes or drop limiting devices such as baffles, belt skirting and shrouds to reduce the amount of turbulence and wind which increases exposure to air and can create dust.				
	(c) Coal loaded onto barge	Fugitive Dust	Coal drop heights will be limited through the use of a variable height (lufting) loader to reduce the ability for the product to catch wind and create dust. The loader will be covered to contain the product and reduce emissions. A short directional snorkel off the end of barge loader will be used to reduce turbulence of the product and drop height which eliminates the ability for the product to separate or catch wind and create dust. The snorkel will be enclosed to contain the product and reduce emissions. The adjustable barge loader will be used to shape the coal pile on the barge such that it is slightly rounded and not peaked to reduce the ability of the coal to catch wind and create dust. The barge loader will be manually controlled and the operator will move the unit side to side, forward and back to flatten out the coal. In response to dust generation, and when weather conditions are expected to lead to dust generation (days with no precipitation, sunny conditions, winds greater than 19 km/hr), water with chemicals will be applied to wet the coal as it is loaded onto the barge and when the barge is sitting at the berth awaiting departure. The trigger value for spraying the barges has been adapted from other bulk terminals, and will be evaluated on a continual basis. Application will be via a manually operated spray halo installed on the tip of the barge loader and a series of manually operated rain birds along the berth face. Operations will shut down the barge loading operation in periods of winds in excess of 40 km/hr on a sustained basis of more than 5 minutes. This operational cut-off value has been adapted from other bulk terminals, and will be evaluated on a continual basis. FSD's Environmental Coordinator will conduct visual opacity readings, a "visual determination of fugitive emissions from material processing sources" during every barge loading operation. The Environmental Coordinator can authorize the shutdown of the barge loading operation, or any other operation, should visual observations of emissions indicate an opacity of > 20%.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #1, or terminal monitoring station, will be located on the southwestern fence line of the facility within 10 m of the barge loader. Meteorological data will be monitored continuously and will be available in real time to the terminal operator and on the terminal's website to the general public. The monitoring will include air quality, temperature, relative humidity and rain. Data from the anemometer will be used to control the watering of the barges (i.e. 19 km/hr) and the shutdown of the barge loading operation (i.e. 40 km/hr). FSD's Environmental Coordinator will conduct visual opacity readings, a "visual determination of fugitive emissions from material processing sources" during every barge loading operation. They will advise the Director of Maintenance and Engineering of any issues and will make recommendations to remedy potential air quality issues. Levelton will conduct visual site inspections during each monthly air quality monitoring site visit.	*Quarterly Air Quality Report* as summarized above. FSD's Environmental Coordinator will prepare a monthly report to the Director of Engineering. The report will include: 1. Any issues noted 2. Recommendations to remedy potential air quality issues 3. Further mitigation measures aimed at preventing potential fugitive dust issues 4. Feedback on the results of past mitigation strategies implemented This report can be made available upon request.	Leachate

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
3	***Normal Operations – 8k DWT Barge Loading***						
	(a) Single tug arrives with single empty barge. Barge is positioned into place by tug and tied up at Berth 3 upstream of the Barge Loader in reach of the warping system. Awaits loading.	CACs	All tug traffic accessing FSD berths will be required to operate under the safe guidelines of the Navigable Waters Act. Tugs are also required to position the barges at the berths using experience and minimal amounts of propulsion as possible. FSD requests that the marine carrier also consider maximizing the use of tugs fitted with the newer technology of Z drives, which provide the same amount of torque at lower speeds and reduced emissions. All tug crews will be experienced operators.	NO_2 PM Dust Fall	Although berthing speeds will not be verified, experienced FSD line crews will be able to identify excessive speeds if present. Issues would be noted by the Operations Foreman and reported to the Superintendent. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources.	General reporting of monitored over speeding, improperly operating tugs, or any other infractions will not be available to the public. Noncompliance in any of these cases will trigger a Notice of Safety and Environmental Standards Letter to be sent by FSD's Environmental Sustainability Committee to the Tug Operator. *Quarterly Air Quality Report* as summarized above.	Noise, Marine
	(b) Barges are warped downstream in response to barge loading operations	Fugitive Dust	Barges will be warped along the berths during loading operations via an electric motor and winching arrangement (warping system), which does not release any emissions. A veneer suppressant will be applied to top of the coal on the barge once it is loaded (binds the surface particles together to provide a membrane that is resistant to dust lift off). While the barges are at the berths, the coal surface on loaded barges will be wetted with river water/chemicals as required (i.e. on days with no precipitation, sunny conditions, winds greater than 19 km/hr, rain birds operated from the berth could be used for five minutes every 30 minutes or as required). The coal on the barges is expected to absorb all of the water/chemicals that will be sprayed on it during normal operations.	Dust Fall PM	Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	*Quarterly Air Quality Report* as summarized above.	Noise, Marine
	(c) Single tug arrives and removes single loaded barge downriver of Barge Loader	CACs	All tug traffic accessing FSD berths will be required to operate under the safe guidelines of the Navigable Waters Act. Tugs are also required to position the barges at the berths using experience and minimal amounts of propulsion as possible. FSD requests that the marine carrier also consider maximizing the use of tugs fitted with the newer technology of Z drives, which provide the same amount of torque at lower speeds and reduced emissions. All tug crews will be experienced operators.	NO_2 PM Dust Fall	Although berthing speeds will not be verified, experienced FSD line crews will be able to identify excessive speeds if present. Issues would be noted by the Operations Foreman and reported to the Superintendent. Air Quality Monitoring Station #1 will take continual samples of PM_{10} and dust fall. Data would be monitored from the Met One E-Sampler and meteorological monitoring station in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis. Air Quality Monitoring Station #2 will take continual samples of $PM_{2.5}$ and dust fall. Data would be monitored from the Met One E-Sampler in real time via a cellular modem. Data would be collected from the dust fall canister manually on a monthly basis.	General reporting of monitored over speeding, improperly operating tugs, or any other infractions will not be available to the public. Noncompliance in any of these cases will trigger a Notice of Safety and Environmental Standards Letter to be sent by FSD's Environmental Sustainability Committee to the Tug Operator. *Quarterly Air Quality Report* as summarized above.	Noise, Marine

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
					Nitrogen dioxide would be tested using a hand held monitor on a monthly basis or more frequent as required. PM and dust fall concentrations can be analyzed by wind speed and direction to infer potential sources.		

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
		Fugitive Dust	A veneer suppressant will be applied to top of the coal on the barge once it is loaded (binds the surface particles together to provide a membrane that is resistant to dust lift off). While the barges are at the berths, the coal surface on loaded barges will be wetted with river water/chemicals as required (i.e. on days with no precipitation, sunny conditions, winds greater than 19 km/hr, rain birds operated from the berth could be used for five minutes every 30 minutes or as required). The coal on the barges is expected to absorb all of the water/chemicals that will be sprayed on it during normal operations. Barge sidewalls will be used to partially protect coal from airflow and wind. The adjustable barge loader will be used to shape the coal pile on the barge such that it is slightly rounded and not peaked to reduce the ability of the coal to catch wind and create dust. The barge loader will be manually controlled and the operator will move the unit side to side, forward and back to flatten out the coal. Barge movements will only be conducted when wind conditions are appropriate. Coal barges will not operate in periods of high wind in excess of 40 km/hr (22 knots per hour) on a sustained basis of more than 5 minutes. The wind speed will be monitored on the tug by the Capitan as part of a BMP by the marine carrier.	PM	None	None	Noise, Marine

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
	(d) Single tug and loaded barge travel Texada Island	CACs	FSD requests that the marine carrier also consider maximizing the use of tugs fitted with the newer technology of Z drives, which provide the same amount of torque at lower speeds and reduced emissions. All tug crews will be experienced operators.	None	None	None	Noise, Marine
		Fugitive Dust	A veneer suppressant will be applied to top of the coal on the barge once it is loaded (binds the surface particles together to provide a membrane that is resistant to dust lift off). While the barges are at the berths, the coal surface on loaded barges will be wetted with river water/chemicals as required (i.e. on days with no precipitation, sunny conditions, winds greater than 19 km/hr, rain birds operated from the berth could be used for five minutes every 30 minutes or as required). The coal on the barges is expected to absorb all of the water/chemicals that will be sprayed on it during normal operations. Barge sidewalls will be used to partially protect coal from airflow and wind. The adjustable barge loader will be used to shape the coal pile on the barge such that it is slightly rounded and not peaked to reduce the ability of the coal to catch wind and create dust. The barge loader will be manually controlled and the operator will move the unit side to side, forward and back to flatten out the coal. Barge movements will only be conducted when wind conditions are appropriate. Coal barges will not operate in periods of high wind in excess of 40 km/hr (22 knots per hour) on a sustained basis of more than 5 minutes. The wind speed will be monitored on the tug by the Capitan as part of a BMP by the marine carrier.	PM	None	None	Noise, Marine
4	***Emergency Operations – Regular 8k DWT Coal barges unavailable for loading or transit – Stockpile Avoidance***						
	(a) Option 1 - Delay of rail unloading	CACs Fugitive Dust	In the event that an 8k DWT barge is unavailable for loading or that weather conditions disallow barges transiting the river, a loaded coal train will remain unloaded and staged in the PARY for a maximum of 48 hours. Mitigation strategies same as listed under 1a.	Dust Fall PM NO_2	Monitoring strategies same as listed under Section 1a.	Reporting strategies same as listed under Section 1a.	Noise, Spills
	(b) Option 2 - Alternate barges loaded	CACs Fugitive Dust	In the event that an 8k DWT barge is unavailable for loading or that weather conditions disallow barges transiting the river, alternate barges will be loaded. These barges will most likely be smaller, (i.e. 6k DWT or less). Alternate barges can be utilized for storage of coal for a maximum of two coal trains. Depending on annual coal throughput, this could postpone the	Dust Fall PM NO_2	Loading of alternate coal barges will maintain the same monitoring strategies as listed under Section 2c and 3.	Loading of alternate coal barges will maintain the same reporting strategies as listed under Section 2c and 3.	Leachate, Noise, Marine

DRAFT

Item #	Activity Source	Type of Emission	Mitigation Strategy Description	Emission Monitored	Monitoring	Reporting	Non AQ Environmental Impacts
			transit of coal for up to four days. Loading of alternate coal barges will maintain the same mitigation strategies as listed under 2c and 3.				
	(c) Option 3 - Delay of Rail Carrier unit train on US siding	N/A	In the event that an 8k DWT barge is unavailable for loading or that weather conditions disallow barges transiting the river, FSD has the option of requesting the rail carrier to hold a loaded coal train on the nearest siding (in the US) for a maximum of 24 hours. Mitigation strategies same as listed under 1a.	N/A	N/A	N/A.	N/A

* Fugitive Dust from coal: Particulate Matter (PM) (PM_{10} and $PM_{2.5}$)
** Criteria Air Contaminants (CACs) from combustion sources: SO_x, NO_x, PM, VOCs, CO, NH_3)

DRAFT

6.3 COMBUSTION EMISSIONS

As discussed above, operational combustion emission sources for the Project include yard-switch engines and locomotives within the rail yard, and tugboats. Combustion emissions during operations will be minimized and mitigated by implementing similar BMPs to those during construction that include, but are not limited to, the following:

- Implement an anti-idling protocol (see Appendix A) for equipment and vehicles that requires equipment and vehicles to be turned off, if practical and when not in use, unless continuous idling is required by the equipment operation specifications. Make use of legislated best available technologies and practices to reduce emissions;
- Operate equipment at and within load tolerances and ratings;
- Ensure that all motorized equipment is in good working order and maintained to manufacturer's specifications;
- Comply with applicable regulation regarding heavy-duty diesel non-road equipment and other construction equipment (including Metro Vancouver's Non-Road Diesel Emission Regulation); and,
- Use grid power rather than locally generated power whenever practical to reduce emissions.
- All mainline rail engines delivering coal to the FSD will be equipped with anti-idling technology. FSD will perform operational checks to ensure anti-idling is occurring in accordance with FSD's standard operating procedures (see Appendix A). This will be conducted through visual checks with rail operators and records will be included as part of the quarterly air quality reports discussed in Section 7.4.

7. AIR QUALITY ASSESSMENT, MONITORING AND REPORTING

Levelton will manage and maintain the air quality assessment and monitoring program, including all of the monitoring equipment, on behalf of FSD. Analytical testing services will be provided by CARO Analytical Services who provide a full service environmental laboratory and are a Canadian Association for Laboratory Accreditation (CALA) laboratory.

The section above outlined a number of BMPs to be implemented at the Facility to control potential fugitive dust and combustion emissions. This section outlines procedures to be implemented to:

- Assess the effectiveness of the mitigation measures in place at the Facility, and take corrective actions to mitigate air quality concerns caused by FSD's operations; and,
- Confirm the results of the air quality assessment prepared for the Environmental Impact Assessment of the Facility which predicted air quality impacts localized around the facility.

Continuous air quality and meteorological monitoring will be undertaken by Levelton and Levelton will conduct air quality site visits on a monthly basis to conduct visual site inspections and to perform necessary maintenance, calibration and operational activities for the monitoring program. Reporting will be conducted on a quarterly basis, and a public website will be created to share the monitoring and reporting data.

DRAFT

FSD has contracted Levelton to conduct analysis and assessment to provide corrective action strategies. Levelton will also be responsible for assessing corrective action and mitigation strategies to ensure they are effective. In conjunction with FSD's Environmental Coordinator, Levelton will jointly review the results and agree on the status of mitigation measures. FSD's Environmental Coordinator will produce a quarterly performance report which will compare actual results to key performance targets. Key performance targets will be set for ambient air quality (total particulate matter) and dust fall recorded at the FSD monitoring locations, visual observations of emissions with an opacity >20%, and complaints received. A copy of the "scorecard" will be given to PMV and reviewed on a quarterly basis.

The Environmental Coordinator will report to the Director of Maintenance and Engineering who is responsible for environmental sustainability. Sustainability targets will be set on an annual basis and will be a key performance indicator corporately. FSD's Environmental Coordinator will produce a quarterly performance report which will compare actual results to key performance targets. Key performance targets will be set for ambient air quality (total particulate matter) and dust fall recorded at the FSD monitoring locations, visual observations of emissions with an opacity >20%, and complaints received. A copy of the "scorecard" will be given to FSD's Executive along with corrective action on a quarterly basis.

A copy of FSD's Environmental Policy can be found in Appendix C.

7.1 VISUAL SITE INSPECTION

A visual inspection procedure will implemented to identify areas of potential compliance / non-compliance with dust mitigation goals and BMPs. Appendix D contains an example Visual Site Inspection Form which is to be completed during site inspections. Potential fugitive dust sources (eg. stockpiles, material transfer points, road dust, etc.) would be visually identified. It would be recommended that a visual site inspection be completed by the Environmental Coordinator (to be hired by FSD once construction commences) daily while the site construction is active and conditions are dry. During operations visual site inspections will occur during each barge load and during each monthly air quality monitoring site visit conducted by Levelton.

It is recommended that visual observations of emissions with an opacity >20% characterize an air quality issue not in line with the air quality goals for the Facility. The Environmental Coordinator will be responsible for carrying out visual opacity readings. Training to perform visual opacity measurements would require the Environmental Coordinator to take a Visible Emissions Training Course (VETC) according to EPA Method 9: "The Evaluation of Visible Emissions" and EPA Method 22: "Visible Determination of Fugitive Emissions from Material Processing Sources". Training records will be included in the first quarterly report and subsequent reports (See Section 7.4) if re-certifications or new certifications have been completed.

For identified air quality issues:

- The on-site inspector and/or Environmental Coordinator will advise the Director of Maintenance and Engineering of any issues and will make recommendations to remedy potential air quality issues;
- The on-site inspector and/or Environmental Coordinator will advise the Director of Maintenance and Engineering on further mitigation measures aimed at preventing potential fugitive dust issues; and,
- The Director of Maintenance and Engineering will respond to these recommendations and mitigation measures which the on-site inspector and/or Environmental Coordinator will include in interim reports.

DRAFT

In the event of observed air quality events/issues, recommendations for mitigation will be made based on those provided in this AQMP. The Director of Maintenance and Engineering will be responsible for implementing mitigation measures recommended by the on-site inspector and/or Environmental Coordinator to reduce opacity readings below 20%. The Environmental Coordinator would determine that the mitigation measures were effective in reducing the opacity by performing visual opacity measurements following the implementation of the measures.

7.2 AIR QUALITY MONITORING

Ambient air concentrations of pollutants can be influenced by meteorology, precipitation, and other sources, in addition to construction and operation activities. Since variations in all of these factors is expected when monitoring ambient air quality, the monitoring data may not necessarily reflect the contribution of Facility activities to the ambient air quality; thus the ambient monitoring data does not constitute a definitive quantitative measure to track air quality impacts from the Facility. Nonetheless, the concentrations can act as a guide, and if ambient concentrations exceed the air quality objectives, or baseline levels, then:

- The origin / source of the emissions will be investigated and documented; and,
- If it is determined that the emissions are a result of FSD's operations, then;
    - The causes and potential reasons will be investigated; and,
    - Appropriate corrective action(s) will be taken to mitigate air quality impacts.

Permanent Monitoring Locations

Two permanent monitoring locations have been identified where monitoring equipment will be installed and operated for the duration of the Project. Air Quality Monitoring Station #1 will be located on the southwestern fenceline of the facility as shown in Figure 7-1 within 10 metres of the barge loader. This location was chosen as it's located on the fenceline downwind of the predominant winds, and is directly exposed to potential emissions from the facility. Air Quality Monitoring Station #2 will be located to the east of the facility which is considered to be the most appropriate monitoring location to represent maximum exposure to the community based on the air quality assessment (Levelton, 2013) annual $PM_{2.5}$ and PM_{10} results. This location, shown in Figure 7-1, is referred to as the "nearest resident" location. Both of these stations would be equipped with a Met One E-Sampler particulate monitor (PM_{10} at Station #1 and $PM_{2.5}$ at Station #2) and dust fall canister.

Near or collocated with Air Quality Monitoring Station #1 will be a meteorological station which will include an anemometer, rain gauge and temperature / relative humidity sensor. The station will be powered using main power.

Overview of Air Quality Monitoring Station #1:

Location:	On FSD's property located on the fenceline within 10 metres of the barge loader.
Security:	Fencing and locks.
Power:	Main power with a battery backup.
Mounting:	Instrumentation will be mounted onto a 10 metre lattice tower (see Appendix E for tower details) with exception being the precipitation gauge and dust fall canisters, which will be mounted separately on pole mounts nearby the tower.

DRAFT

Communications:	Communications with the station will be via a direct connect and cellular modem. Appendix E provides modem details.
Instruments:	PM_{10} (Met One E-Sampler), wind speed and direction (RM Young 05305 Wind Monitor-AQ), rain gauge (Campbell Scientific TE525M), and temperature and relative humidity (Rotronic Instrument Corporation HC2-S3-L). Canister for dust fall. See Appendix E for details.
Datalogger:	Datalogger (Campbell Scientific CR1000) and weather proof enclosure (Campbell Scientific). See Appendix E for details.

Meteorological and particulate matter data will be monitored continuously and will be available in real time to govern operations at the Facility.

As Air Quality Monitoring Station #2 is located off FSD's property, FSD's Environmental Coordinator will coordinate a land lease agreement with the appropriate land owner. The Environmental Coordinator will also ensure main power is provided to the monitoring station either directly from BC Hydro or through an arrangement with a neighbouring property to the monitoring station. The station will be secured using fencing and locks by Levelton and access will be on foot from River Road.

Overview of Air Quality Monitoring Station #2:

Location:	See Figure 7-1 "nearest residential receptor".
Security:	Fencing and locks.
Power:	Main power with a battery backup.
Mounting:	E-Sampler and dust fall will be mounted on separate a pole mounts.
Communications:	Communications with the station will be via a direct connect and cellular modem. Appendix E provides modem details.
Instruments:	$PM_{2.5}$ (Met One E-Sampler). Canister for dust fall. See Appendix E for details.
Datalogger:	Not required. Direct connection to the E-Sampler is made via the modem.

Establishing a Pre-Project Baseline

Prior to the start of construction on the Project, a baseline particulate matter, dust fall and nitrogen dioxide (NO_2) monitoring program will be implemented to characterize pre-project particulate matter, dust fall and NO_2 concentrations. The monitoring will continue through the construction period and operations. The objective of the monitoring program is to:

- Characterize the typical range of particulate matter concentrations and dust fall experienced at the facility fenceline and in the neighbourhood to the east of FSD;
- Conduct a chemical analysis of the coal to assist in determining the percentage of the particulate matter / dust fall containing coal once the Project has commenced;
- Characterize the typical range of nitrogen dioxide (NO_2) concentrations experienced at and near facility fenceline; and,
- Provide a comparative reference for future monitoring required by FSD.

Two monitoring stations with E-Samplers and dust fall canisters, as highlighted in the previous section, would be installed at least six months period prior to project construction. Ideally, this period would capture particulate matter concentrations during approximately 3 months of the "dry" season (April – September) and 3 months of the "wet" season (October – March).

Monthly site visits would be conducted to collect the dust fall canisters for analysis and to perform calibrations and maintenance of the monitoring equipment. During this time a visual site inspection will also be conducted which will include monitoring of NO_2 concentrations using a handheld monitor. Sampling will be conducted at locations along and near the facility's fenceline. Sampling locations will be based on the results from the Project's air quality assessment (Levelton, 2013).

In addition to installing the particulate matter / dust fall monitoring stations, a meteorological monitoring station would also be installed at this time to begin measuring wind speed, wind direction, rainfall, temperature and relative humidity. The anemometer would be installed at a height and in a location to be free of the influence of structures and buildings surrounding. By deploying the anemometer, particulate matter concentrations measured by the continuous monitors can be analyzed by wind direction and wind speed to infer potential existing sources of particulate matter in the area. Figure 7-1 indicates the locations where the monitor stations will be located.

Baseline air quality monitoring data will be summarized and assessed prior to operations.

Operational Air Quality Monitoring

As discussed previously, the air quality impacts from the coal transfer facility at FSD are predicted to be low. Therefore, the AQMP for the Project relies primarily on the implementation of the proposed mitigation measures and BMPs. Baseline air quality monitoring is recommended to allow for future comparison should air quality events or issues be identified despite the implementation of the proposed mitigation measures and BMPs.

The monitoring methodology and monitoring equipment used for the baseline monitoring will continue for the duration of the Project. The E-Sampler, dust fall and NO_2 measurements will be used to assess the effectiveness of the BMPs implemented for the Facility by comparing to baseline levels. E-sampler data will not be directly compared to air quality objectives for compliance purposes, but the concentrations can act as a guide, and if ambient concentrations exceed the air quality objectives, or baseline levels, then causes and potential reasons will be investigated to improve operations.

Air quality monitoring data can also be used:

- In combination with the wind data collected, to infer whether elevated particulate matter concentrations were potentially caused by FSD activities; and,
- To address community complaints or concerns regarding dust from FSD.

The sections below provide more specific details regarding monitoring of meteorological data nitrogen dioxide, particulate matter and dust fall from the facility.

DRAFT

Facility Monitoring – Nitrogen Dioxide (NO_2)

The air quality assessment for the Project (Levelton, 2013) predicted elevated NO_2 concentrations along or near the facility's fenceline based on conservative assumptions of combustion emissions from tugboat operations at berth. Short-term average data will be collected using a handheld NO_2 monitor during monthly air quality monitoring site visits at locations along or near the facility fenceline - locations based on the results from the Project's air quality assessment. The data will be compared to the modelling results; extrapolated and compared to ambient air quality objectives; and, operational data will be compared to background data collected.

Monitoring will be conducted with a VRAE (or similar) hand held monitor. Additional information on the VRAE can be found in Appendix E.

If the NO_2 monitoring results indicate potential health or air quality impacts from FSD's emissions, then mitigation measures will be recommended and implemented (where practical) and follow-up monitoring will be conducted to evaluate the effectiveness of the measures. Based on the finding additional monitoring measures may be recommended, such as passive monitoring or continuous monitoring.



VRAE Hand Held Monitor

DRAFT

Facility Monitoring – Meteorological, Particulate Matter and Dust fall

An example meteorological, particulate matter and dust fall monitoring station which was used for the South Fraser Perimeter Road Project can be seen in the image on the right. The stations to be deployed for FSD's project contain the same key elements.



Meteorological, Particulate Matter and Dust fall Monitoring Station

Project: ***South Fraser Perimeter Road***

Meteorological data will be monitored continuously and will be available in real time to govern operations at the Facility and will also be made available in real-time on the Project's website to the public, see Section 7.5.

The meteorological station for the project will include the following key elements:

- A standard height meteorological tower;
- A datalogger;
- Anemometer (Air quality specific model);
- Temperature / Relative Humidity sensor;
- Rain Gauge;
- A wireless modem; and
- Enclosure (for datalogger and modem)

Additional information regarding the meteorological equipment can be found in Appendix E.

Particulate matter monitoring will be conducted using Met One E-Samplers (PM_{10} at Station #1 and $PM_{2.5}$ at Station #2), shown in the image to the right. Data from the E-Samplers (PM_{10} at Station #1 and $PM_{2.5}$ at Station #2) at both fixed monitoring locations will monitor particulate matter continuously and results will be provided in real-time to FSD operators to govern operations and to the public via the project website.



E-Sampler Particulate Matter Monitor

Additional information regarding the E-Sampler can be found in Appendix E.

If particulate monitoring data exceeds air quality objectives or baseline levels the origin or source of the emissions will be investigated and documented. If based on the investigation it's determined the elevated particulate matter concentrations were the result of FSD operations, then the cause and potential reasons will be determined and corrective action will be taken to mitigate the air quality impacts.

Dust fall monitoring will be conducted based on guidance provided in the *British Columbia Environmental Laboratory Manual: 2009* (see Appendix F, analysis will include: Particulate – Insoluble, Particulate – Ashed Insoluble, Particulate – Soluble and Particulate – Ashed Soluble). Based on the above analysis Particulate – Total can be calculated. Dust fall canisters are deployed for approximately 30 days each calendar month. The samples will be sent to CARO Analytical for analysis which will include a compositional analysis (total and fixed residue and

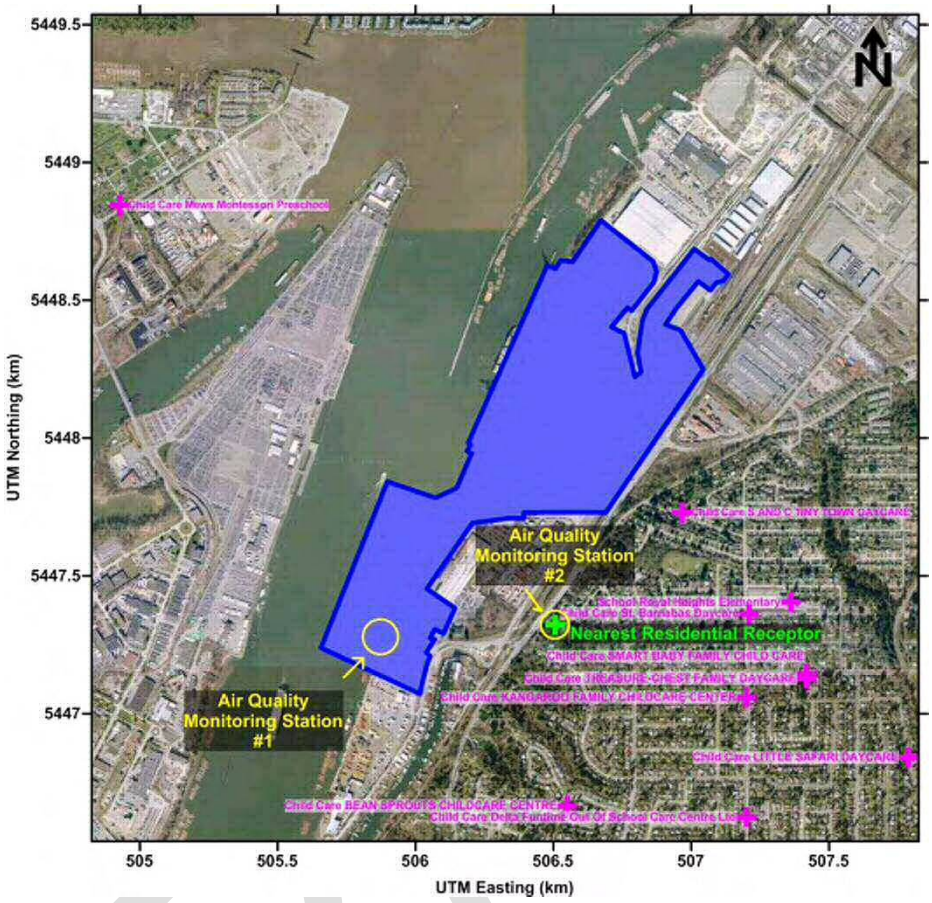
DRAFT

coal content). If results are found to be above the monthly dust fall standard in BC, then the cause will be investigate. If it's found that FSD's operations have caused the exceedance, corrective actions will be taken.

Additional dust fall monitoring will be considered within the adjacent community from FSD's facility based on complaints or requests from the community.

DRAFT

Overview Map of Monitoring Locations



Zoomed View of Nearest Residential Receptor Monitoring Location



Figure 7-1 Air Quality Monitoring Locations

7.3 TRACKING / COMPLAINT MANAGEMENT SYSTEM

The AQMP will implement a BMP effectiveness monitoring tracking sheet, an example of which is shown in Appendix D. Tracking allows the Environmental Coordinator and Air Quality Specialists to monitor if the mitigation measures are appropriately mitigating the emission sources as intended. If BMPs and mitigation measures are observed to be ineffective, the Director of Maintenance and Engineering would be responsible for ensuring modifications or new mitigation measures are implemented.

In parallel with the BMP effectiveness monitoring tracking sheet, a dust complaint management system would be implemented under the AQMP. The logging system would include:

- **FSD personnel completing the form:**
  - Name, Title and Date;
- **Complaint Information:**
  - Resident location, name, phone number, email address, date / time complaint was received, and the reason for the complaint (visual / cosmetic or health related);
- **Source and timing of dust:**
  - Date and time of dust occurrence;
  - Specific nature of complaint / source of dust;
  - Onsite / rail traffic activities at the time of the complaint;
  - Wind conditions (anemometer data) at the time of the complaint;
  - General weather conditions during the time of the complaint;
  - Opacity reading when the complaint was received;
  - Particulate matter monitoring readings when the complaint was received;
- **Investigative actions:**
  - Investigations of dust source;
  - Anemometer / weather data / particulate matter data at the time of the investigation (as this may differ from when the complaint was received);
- **Resolution**
  - Actions taken (where feasible) to eliminate future occurrences;
  - Follow-up with resident;
  - Status post follow-up (resolved to resident satisfaction Y/N); and
  - Date file closed.

The logging system will help to gauge the effectiveness of the mitigation measures and BMPs implemented at the facility and will help in validating complaints and determining patterns of

DRAFT

complaints and corresponding activities on-site. An example of a *Dust Complaint Management Form* is included in Appendix G.

The metric for tracking air quality will be both qualitative and quantitative. For example, the visual site inspection reports and efficiency of feedback / actions taken will provide an indication of progress in a qualitative manner while the number of compliance and non-compliance items observed and complaints received, along with the air quality monitoring data will provide a quantitative measure.

7.4 QUARTERLY REPORTING

Reports written by Levelton summarizing the quarterly findings of the air quality monitoring program will be provided on a quarterly basis to PMV four to six weeks following the end of the quarter. The reports and any corrective action will be reviewed with PMV on a quarterly basis. FSD will also post the reports on their website.

An example quarterly report outline and content is as follows:

1. Overview

2. Meteorological, Air Quality and Dust Fall Monitoring Data

2.1 Meteorological Monitoring Data
This section will include average and maximum wind speed, wind roses, wind speed excursion above 19 km/h, total precipitation, maximum and minimum temperature for the previous quarter.

2.2 Air Quality Monitoring Data
Summary of $PM_{2.5}$/PM_{10} (1-hour maximum, 24-hour average results and annual average results (when sufficient data become available) and nitrogen dioxide monitoring results (short-term average results collected by the handheld monitor). Ongoing air quality monitoring data will be compared to the baseline data collected.

2.3 Dust Fall Monitoring Data
Monthly dust fall monitoring results reported based on compositional analysis (total and fixed residue and coal content) based on laboratory analysis.

3. Summary of Visual Site Inspections

3.1 FSD's Visual Site Inspections
Summary of visual site inspections for the previous quarter which would include details of identified issues, recommendations, follow-up and resolution.

3.2 Levelton Visual Site Inspections
Summary of visual site inspections for the previous quarter which would include details of identified issues, recommendations, follow-up and resolution.

4. Summary of Complaints
Summary from complaints logging system which would include details of any mitigation or follow-up actions required.

5. Corrective Action

DRAFT

6. Conclusion

7. Closure

8. References

Appendix A– Dust Fall Laboratory Analysis
Analytical laboratory results will be included in this appendix.

Appendix B– Visual Site Inspection Records
Visual site inspection records will be included in this appendix if an issue has been identified.

Appendix C– Water Application
Identification of volume of water applied for mitigation for each operation day.

Appendix D– Rail Anti-Idling Records
FSD will perform operational checks to ensure anti-idling is occurring in accordance with FSD's standard operating procedures (Appendix A). Records of the operational checks will be included in this appendix.

Appendix E– Visual Opacity Training Records
Visual opacity training records will be included in the first quarterly report and subsequent reports if re-certifications or new certifications have been complete.

7.5 PUBLIC WEBSITE FOR DATA ACCESS

In addition to quarterly reporting a publically available website linked from FSD's website (http://www.fsd.bc.ca/) will provide access to real-time data from the particulate matter / meteorological monitoring station at FSD and the particulate matter monitoring station representing the nearest residential receptor. The website will also include an archive of the quarterly air quality monitoring reports.

7.6 AIR QUALITY MANAGEMENT PLAN EFFECTIVENESS

The AQMP has been developed based on BMPs and Levelton's experience with similar projects. It is Levelton's professional opinion that the AQMP will be effective in mitigating fugitive dust emissions from operations. However, the effectiveness of the program will be tracked and necessary corrective action will be taken to improve any and all aspects of the AQMP including mitigation measures, operating procedures, and air quality monitoring.

8. CONTACTS

Contacts concerning air quality issues at the Project site and implementation of the AQMP are as follows:

Environmental Coordinator (Fraser Surrey Docks)

TBD (an Environmental Co-ordinator will be hired once construction of the Project commences)

Director of Engineering and Maintenance (Fraser Surrey Docks)

Jurgen Franke 604-495-1184

DRAFT

Air Quality Specialists (Levelton Consultants Ltd.)

Chris Koscher / Tyler Abel 604-278-1411

9. REFERENCES

BC EMA, 2004. *British Columbia Environmental Management Act* (BC EMA). Government of British Columbia. Brought into force July 8th, 2004.

http://www.env.gov.bc.ca/epd/main/ema.htm

BC MOE, 2013. *British Columbia Ambient Air Quality Objectives.* British Columbia Ministry of Environment. 2013.

http://www.bcairquality.ca/reports/pdfs/aqotable.pdf

BC Ministry of Energy and Mines, 2002. *Aggregate Operators Best Management Practices Handbook for British Columbia. Volume II – Best Management Practices*. April 2002. http://www.empr.gov.bc.ca/Mining/Aggregate/BMP/Pages/default.aspx

CEPA, 2012. *Canadian Environmental Protection Act*. Government of Canada. CEPA 2012 brought into force July 6th, 2012.

http://www.ec.gc.ca/CEPARegistry/the_act/

Cheminfo 2005. *Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities*. Report prepared for Environment Canada, Transboundary Issues Branch by Cheminfo Services Inc. March, 2005.

http://www.bieapfremp.org/Toolbox%20pdfs/EC%20-%20Final%20Code%20of%20Practice%20-%20Construction%20%20Demolition.pdf

Levelton, 2013. *Fraser Surrey Docks Direct Coal Transfer Facility: Air Quality Assessment (DRAFT).* Report prepared for Fraser Surrey Docks, by Levelton Consultants Ltd. November 15th, 2013.

Metro Vancouver, 2011. *Integrated Air Quality and Greenhouse Gas Management Plan*. Report prepared by Metro Vancouver). October, 2011.

http://www.metrovancouver.org/about/publications/Publications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf

Metro Vancouver, 2008. *Air Quality Management Bylaws*.

http://www.metrovancouver.org/services/permits/Pages/airquality.aspx

Worksafe, 2013. *Occupational Health and Safety (OH&S) Regulation*. 2013.

http://www2.worksafebc.com/Publications/OHSRegulation/Home.asp

DRAFT

APPENDIX A – ANTI-IDLING POLICIES

DRAFT

Date: May 1 2013
Policy Number: 200-10

Anti-Idling Policy

Purpose:

To educate our employees on the environment & health benefits of an anti-idling policy. To limit diesel and gas exhaust particulate matter by limiting unnecessary idling of vehicles and equipment.

Facts:

Clean air is important to everyone. Today, in the Fraser Valley, air pollution causes health problems for residents, threatens the region's natural beauty and damages the agriculture and tourism industries. Solving the problem of air pollution and climate change is our collective responsibility. Every day, the choices we make as individuals are as important to improving air quality as are those made by governments and communities.

Transportation is responsible for nearly a third of Canada's total greenhouse gas emissions. Unless we reverse some of the following trends in vehicle use, transportation emissions will continue to rise.

Quick Facts

- Health Canada estimates that more than 5000 Canadians die prematurely each year because of air pollution, and thousands more become unnecessarily ill.
- An idling engine releases twice as many exhaust fumes than a vehicle in motion

Procedure:

- Turn off your engine if you're going to be stopped for more than 10 seconds
- Minimize warm-up idling
- Avoid high speeds and rapid acceleration

This effort will contribute to reducing air pollution and greenhouse gas emissions for the entire region. Emissions from idling vehicles are needless and can be easily prevented – all it takes is the turn of a key. When it comes to idling, one person can make a difference.

FRASER SURREY DOCKS LP
Pacific Rim Stevedoring

STANDARD OPERATING PROCEDURES
SWP-03-Rail

TITLE		EFFECTIVE DATE
Locomotive Shut Down		Marc h 31 2013
SECTION	Page 1 of 1	REVISION DATE
Operating Procedures		

Locomotive Shut down procedures;

- Locomotives are to shut down on completion of shift and hand brake applied.
- When temperatures are expected to drop to - 3 degrees, the locomotive is not to be shut down.
- If during the working shift, if it is know that the locomotive is not required for a period 3 hours in duration or longer, the locomotive is to be shut down.

FRASER SURREY DOCKS LP
Pacific Rim Stevedoring

FSTB13 SAFETY RECORD FORM
RAIL SWITCHING OPERATIONS

Date & Shift:	**Rail Switching:**
Foreman Name & Man #:	**Switch Crew Names:**

General Safety Items	
Mandatory PPE: • Hi-Viz Vest is mandatory at all times. • Steel-toed CSA-approved safety boots at all times. • Gloves (should you require gloves, please ask)	☐
Common Injuries: • Legs, ankles; jumping from railcars; tripping on tracks and uneven ground	☐
Surroundings: • Be aware of other dock equipment working in same area. • Always protect the point. • Apply proper 3-point protection before going between equipment. • Ensure workmen are not on or near railcars before tying on or moving of same. • Never cross between moving equipment. • Never jump from equipment. • Never step or walk on the rail tracks. • Always ride the side of a car, not the front of it. • Always have the ability to stop movement within half your range of vision. • Never step on a coupler. • Air must be cut in on all railcars being handled at all times. • Crew to carry out intra-crew radio test prior to commencing duty. • Always be aware of who is giving movement instruction. • Receiver must repeat instruction given by sender. • Ensure proper use of engine bell and whistle. • Always expect movement of other trains, engines, cars or track movements. • Always keep a distance of 25ft when walking around standing equipment. • Open angle cocks slowly to avoid kick back from hose. • Apply sufficient hand brakes on railcars being spotted for loading and unloading. • Do not get on or off moving equipment. • Be familiar with areas of restricted clearance. • See separate Safe Work Procedures for the AGRI Facility.	☐
• Report all injuries immediately to your Foreman and First Aid. • Report all accidents and near misses immediately to your Foreman. • Cell phones and other personal electronic devices NOT to be used when working. • No idling of dock trucks and machinery when not is use	☐
Environmental Concerns and/or Other Items Addressed: • Entering rail carrier approached yard in a safe, managed and controlled manner • Exiting rail carrier departed yard in a safe, managed and controlled manner • Rail carrier locomotives were fitted with operational and effective Anti-Idling devices and exhibited anti-idling as per FSD SWP • Rail carrier locomotives were fitted with efficient AC VFD drives	☐
Safety Concerns and/or Other Items Addressed:	☐

Complete and return with payroll

APPENDIX B – OVERVIEW OF PROPOSED DUST SUPPRESSION AND WASTEWATER MANAGEMENT SYSTEMS

DRAFT

Omni ENGINEERING INC.	**TECHNICAL MEMORANDUM 2113-1 Rev 2**	
	Project Title:	FRASER SURREY DOCKS PROPOSED COAL LOADOUT FACILITY
	Subject:	Overview Of Proposed Dust Suppression And Wastewater Management Systems
	Omni File: 2096	Date of Memorandum: May 3, 2013

To: Fraser Surrey Docks – Jurgen Franke P.Eng.

Purpose of Memorandum:

To provide an overview including design criteria of the proposed dust suppression systems ie water sprays, including the treatment and disposal of coal laden runoff water.

Dust Suppression by Water Sprays:

(See Appendix A for details on the proposed spray types and design criteria)

Dust Suppression by Water Sprays will be installed at:

1. Railcar Dumper – misting sprays which produce very small droplets to knock any fugitive dust out of the air plus larger nozzle sprays to wet coal as it is being dumped. The misting sprays will use fresh water (necessary to avoid nozzle clogging). The large nozzle sprays will use *recycled water* (see following section).

2. Railcar Wash – after dumping the railcars will pass under a spray arch to wash off any residual coal which otherwise could generate dust on their return journey. The spray arch will use recycled water.

3. Spraybars on conveyor- the surface of the coal on the conveyor belts will be wetted with recycled water.

4. Transfers will have misting sprays, similar to dumpers, using fresh water.

5. Shiploader will have medium size nozzles and fine misting nozzles to mitigate dust generated by falling coal. These will be supplied with fresh water.

6. Emergency coal stockpile – Large volume industrial sprays ("Big Guns") using fresh water will be used to keep the stockpile moist. This is expected to be an intermittent requirement as emergency stockpile will be an infrequent occurrence. Also this is a seasonal requirement in that during the rainy winter months, there is often no need to wet the piles. The sprays will be supplied through agricultural sprinkler piping which can be relocated or removed as necessary.

7. Coal Barges – After loading, the coal barges will be wetted down by Big Guns on the dock. Similar to the emergency coal pile, the Big Guns will be supplied with fresh water

in agricultural piping. The requirement to wet down the barges will likely not be necessary during the wet winter months. Spraying frequency and duration will be controlled by a PLC program to minimize risk of excessive water application



Portable Water Spray in Operation

The sprays can be relocated to suit the configuration of a coal pile the prevailing wind direction



Railcar wash in operation.

Wastewater Management System
(See Schematic Sketch)

Wastewater on a coal terminal will fall into three categories:

1. Wastewater Slurry

Coal terminals generate a surprising amount of coal laden wastewater (slurry) from:

- washdowns of transfers and equipment
- rainfall on coal handling areas
- flushing of dumper and transfer spillage
- railcar wash
- stockpile runoff

The suspended solids content of the slurry varies widely depending upon the source and the flow rate but it is typically in the range of 800 ppm to 5000 ppm or higher.

2. Recycled Water

After settling in primary and secondary settlement ponds, the suspended solids content will be reduced so that it can be recycled on site for:

- reuse in the railcar wash
- reuse in the dumper for flushing and moisture addition to coal
- application to coal on belt to increase moisture content

The suspended solids content in the recycled water will vary depending upon the fineness of the suspended solids content in the wastewater and the overflow rate of the settlement ponds. It is desirable to keep the suspended solids content below 500 ppm for the above uses. Recycled water is unsuitable for fine misting sprays as it will clog the nozzles. In the Fraser Surrey Docks proposed system it is also considered unsuitable for wetting down the barges and the emergency coal pile due to the possibility of overspray into the Fraser River.

Although much of the recycled water is consumed in application to the coal, there is an inevitable excess of water due to rainfall and equipment washdowns. This is particularly so in the wet winter months.

3. Treated Wastewater for disposal

Excess recycled water can be discharged to the Metro Vancouver Sanitary sewer (under permit) if the suspended solids content is less than 600 ppm.

Components of Fraser Surrey Docks Wastewater Management System:

1) Secondary Settling Pond with Transfer Pump A secondary settling pond with a slurry handling pump will be installed in the vicinity of the shiploader to pump all the slurry wastewater generated in this portion of the site to the settlement ponds. The paving in the vicinity of the shiploader will be graded to direct local drainage to the pond.

2) Emergency Coal Stockpile Drainage Collection System: Drainage from the emergency coal stockpile will be collected in asphalt swales surrounding the area which will drain into sump with two outgoing pipes each a valve. One pipe will be connected to the Slurry Sump and the other connected to the storm drain. When there is actually coal in the stockpile area the valve on the pipe connected to the sump will be opened while the other valve remains closed. When the coal pile is removed and after the stockpile area is thoroughly washed down, the valve on the pipe to the storm drain will be opened and the valve on the pipe to the sump will be closed. This arrangement prevents large amounts of relatively clean storm runoff from being sent to the primary/secondary settling pond.

3) Primary/Secondary Settlement Pond: The primary settling pond will be located in the general vicinity of the dumper. (See Appendix B for a general description and approximate size) This pond will receive slurry wastewater from:

   a) Pump in Secondary Settling Pond at shiploader area
   b) Local drainage and washdowns of transfers
   c) Flushing water from Dumper
   d) Run off from Railcar wash

   The purpose of the primary/secondary settlement pond is to reduce the suspended solids in the slurry wastewater so that it can be recycled as described preceding.

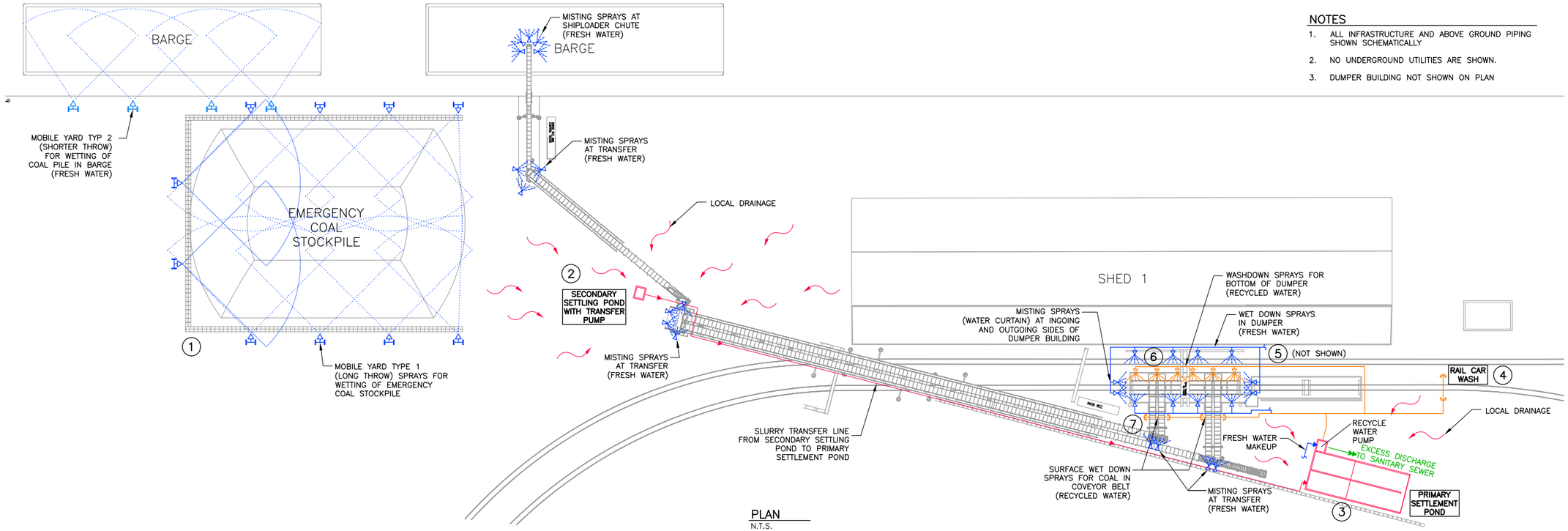
4) Recycle Pump: This will be a submersible high volume pump located in a sump at the end of the secondary pond. There will be a freshwater supply pipe to the sump to provide makeup water to augment the recycle water when necessary, typically in the dry summer months.

5) Overflow to Sanitary Sewer: During the wet winter months there will be an excess of water in the primary and secondary ponds due to stormwater runoff and equipment washdowns. The excess water will flow over a weir in the recycle pump sump to discharge to the sanitary sewer.

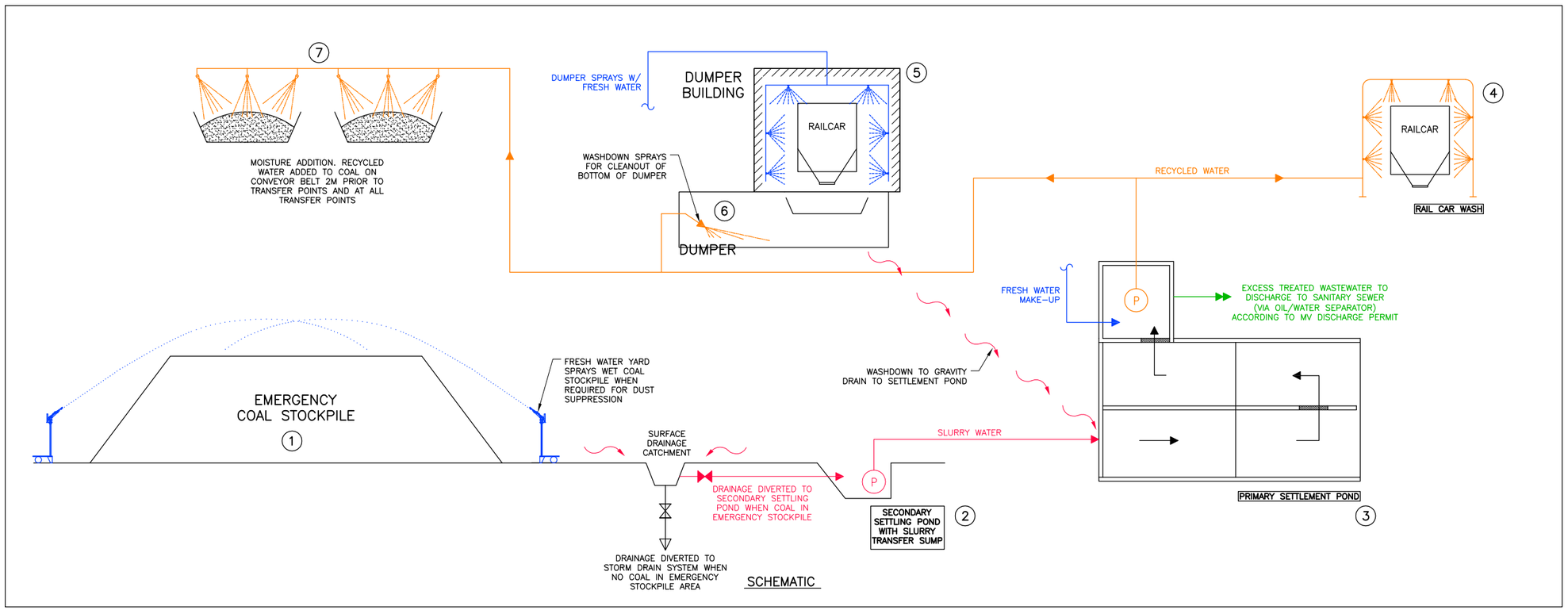
6) Flushing Sprays in Dumper: To avoid the buildup of spilled coal on the floor of the dumper, high volume flushing sprays will run continuously using recycled water. The wastewater slurry generated by this flushing out will be directed back to the primary settling pond.

7) Railcar Wash: As the railcars are positioned for dumping, they will pass under a spray arch which will be supplied with recycle water also. The runoff from the railcar wash will be directed back to the primary settling pond.

8) Wetting down of Coal on Belt: Recycled water will be sprayed on the surface of the coal on the conveyor belt at the dumper and transfer (to be confirmed). This surface wetting will mitigate the problem of wind generated dust.



PLAN
N.T.S.



SCHEMATIC

NOTES

1. ALL INFRASTRUCTURE AND ABOVE GROUND PIPING SHOWN SCHEMATICALLY
2. NO UNDERGROUND UTILITIES ARE SHOWN.
3. DUMPER BUILDING NOT SHOWN ON PLAN

REFERENCE DRAWINGS	
DRAWING NUMBER	REV.

NO.	BY	DATE	DESCRIPTION
P2	CV	MAY07/13	ISSUED FOR MEMORANDUM 2113-1
P1	CV	MAY06/13	ISSUED FOR REVIEW

REVISION

SEAL:

DATE:

CONSULTANT:

Omni ENGINEERING INC.
#206 E. HASTINGS STREET
VANCOUVER, BC V5K 2A9
PH: 604 - 298 - 0508
FAX: 604 - 298 - 0536

CLIENT:

FRASER SURREY DOCKS LP
Pacific Rim Stevedoring Ltd.

PROJECT:

FRASER SURREY DOCKS LP
PROPOSED COAL LOADOUT FACILITY

DRAWING TITLE:

WATER SPRAYS AND WASTEWATER MANAGEMENT SCHEMATIC

ENGINEER:	DS	DATE:	MAY03/13
DESIGN BY:	DS	SCALE:	AS SHOWN
DRAWN BY:	CV	ACAD FILE NO:	2113
DRAWING NUMBER:	2113-SK001	REVISION NUMBER:	P2

Filename: Z:\Omni Projects\2113 Fraser Surrey Docks Dust Suppression\Omni Drawings\2113-SK001 (P2).dwg - Layout1
Last Saved: May. 06/13 9:18pm Plotted: May. 07/13

APPENDIX A – DESIGN OF THE WATER SPRAYS

Water is used for dust suppression in two different ways:

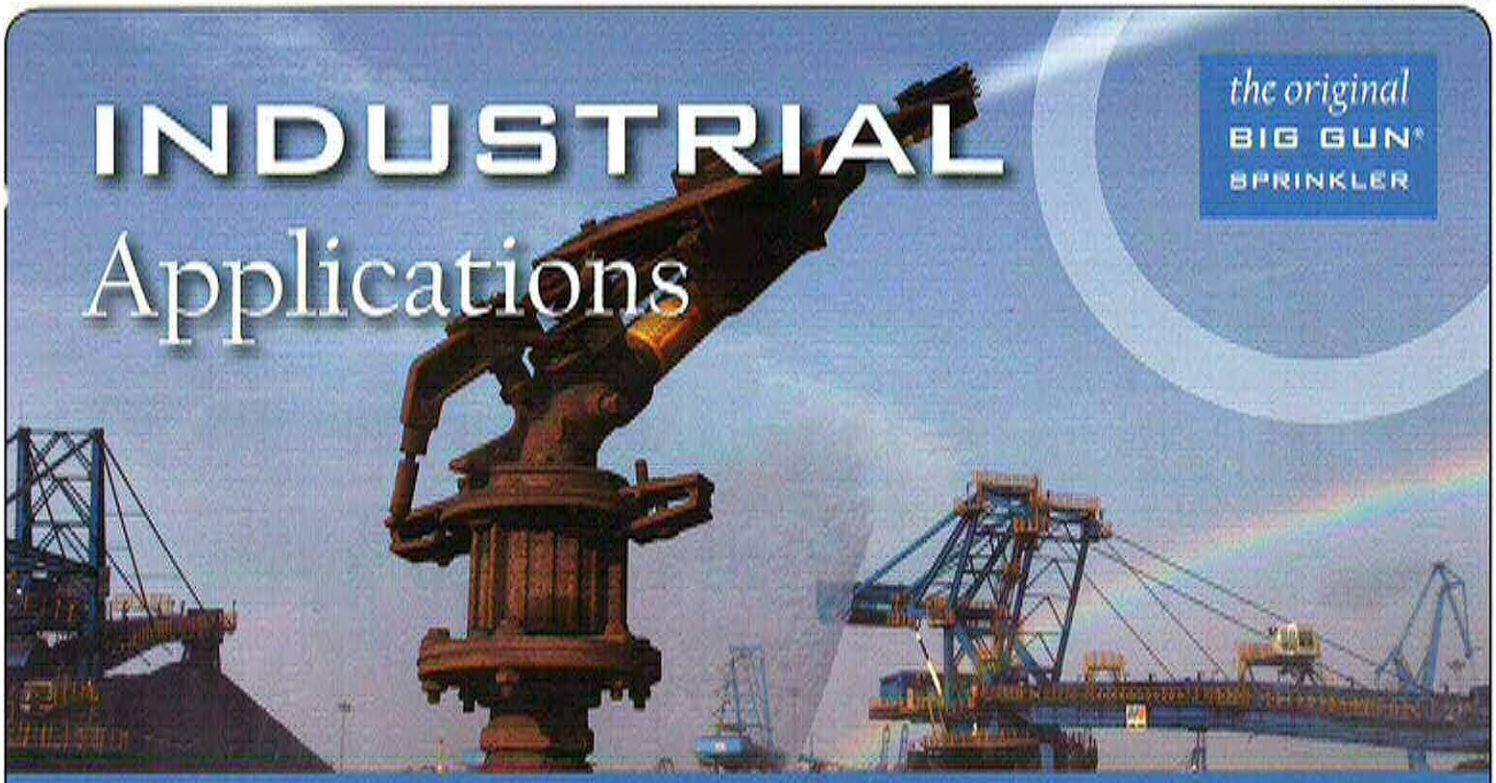
1. WETDOWN COAL STOCKPILE AND LOADED BARGES: To keep coal piles wet and prevent the generation of dust by wind. This is done with large nozzle sprinklers such as the Nelson Big Gun which have specifically been designed for this purpose. They are similar to agricultural sprinklers but have a higher trajectory (43 degrees) which is approximately the angle of repose of a coal pile. The nozzles have a very large orifice, up to 1.2", to provide a high volume of water and long throw. Droplet size is not critical. Coal is to some degree hydrophobic and care has to be taken to limit the duration of the sprays to avoid a pile washout and/or excessive runoff.

   Design of the wet down system will include the selection of appropriate sized Big Gun sprays, layout to provide full coverage and a PLC control system to sequence them and to avoid overspraying.

   The following pages contain some general information on the Big Gun spray nozzles proposed for this purpose.

INDUSTRIAL Applications

the original BIG GUN® SPRINKLER



Why choose a Nelson Big Gun®

- The **Nelson name** is synonymous with the best quality available.
- **Heavy-duty construction** ensures long wear life & reliability.
- **Greatest range of options.** Full & part-circle sprinklers available in a variety of trajectory, nozzle & coating options.
- **Valve combinations available** for maximum system efficiency.
- **Easy to operate, maintain and repair** with readily available parts and documentation.

Advantages for Industrial Applications

- Efficient dust suppression.
- High volume in short time.
- Rugged durability in dirty & corrosive conditions.
- Large nozzles less likely to plug, filtration requirements minimal.
- All ball bearings are sealed.

NELSON
WWW.NELSONIRRIGATION.COM

IT'S THE ONE FOR THE JOB



Nelson Big Gun® sprinklers are ideal for a wide range of industrial applications. With a full range of models available (see *The Original Big Gun®* brochure), flow rates of 30-1200 GPM (6.8-275 m^3/hr) can be achieved with maximum uniformity to match a variety of needs.

MINING DUST SUPPRESSION

The rugged durability of Nelson Big Gun® sprinklers make them a favorite for dust suppression. Big Guns are preferred because of the ability to move a large amount of water in a short time. The large nozzle is less likely to plug and the filtration requirements are minimal. All bearings on the gun are sealed ball bearings. Some sprinklers are mounted on high towers in order to throw over the piles. Alternatively, a high trajectory Big Gun sprinkler (fixed 43° and adjustable 15-45° models available) can achieve the necessary stream height to reduce tower height and clear the top of the piles.

SPECIAL OPTIONS:

ANODIZED, POWDER COATED AND STAINLESS STEEL BIG GUNS® for sprinkling with corrosive waters.

COUNTER BALANCE KIT for operation of the Big Gun® with a tilted riser.

WEDGE INSERT for modified trajectory.

HEAVY DUTY BRONZE BRAKE for operation in environments with airborne, abrasive, dust particles (100 Series only).



BIG GUN® PERFORMANCE FOR 43° MODELS

R = Radius of Throw; H = Maximum Stream Height; rH = Distance from Big Gun to Maximum Stream Height
(See *The Original Big Gun®* brochure or www.nelsonirrigation.com for performance information of 24° models.)

SR75DS TAPER RING NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.4"				0.45"				0.5"				.55"				.6"				.65"				.7"				.75"				.8"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
30	—	—	—	—	—	—	—	—	37	68	28	49	46	66	30	50	55	69	30	51	64	72	31	55	75	76	32	56	87	78	33	58	99	80	34	60
40	27	62	30	49	36	67	31	50	43	71	31	52	52	75	33	53	63	79	33	56	74	82	36	61	87	86	36	63	98	89	37	64	112	92	39	66
50	30	67	31	50	39	72	32	52	46	76	32	54	59	81	34	56	70	85	36	60	83	88	39	64	95	92	42	67	109	96	43	68	123	99	45	71
60	33	70	32	52	42	77	33	55	50	82	33	59	64	87	36	62	77	92	38	63	91	95	43	67	104	99	46	70	120	102	47	71	136	106	48	73
70	36	73	33	54	45	81	33	58	57	87	34	62	69	92	37	66	83	97	43	69	98	101	46	72	113	106	49	75	129	108	50	76	147	113	52	78
80	39	76	34	58	49	86	36	62	61	93	37	66	74	97	41	70	89	102	45	73	105	107	48	77	121	111	52	80	138	114	53	81	156	118	55	83

SR75DS TAPER RING NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	10.2 mm				11.4 mm				12.7 mm				14.0 mm				15.2 mm				16.5 mm				17.8 mm				19.1 mm				20.3 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
2.00	—	—	—	—	7.6	23	9.2	14	9.4	24	9.5	15	11.4	26	9.7	15	13.0	27	9.9	16	16.0	28	10.2	17	18.5	30	10.3	18	21.1	31	10.7	19	24.0	32	11.5	20
3.00	6.6	23	9.2	16	8.3	26	9.5	15	10.3	26	9.7	16	12.4	28	10.1	16	14.9	29	10.4	17	17.6	30	11.0	19	20.3	31	11.0	19	23.1	33	11.6	20	26.3	34	12.2	21
3.50	7.1	24	9.5	15	9.0	26	9.6	16	11.1	28	9.8	16	13.4	29	10.4	17	16.1	31	11.0	18	19.0	31	11.9	20	21.9	33	12.0	20	25.0	34	13.1	21	28.4	36	13.7	22
4.00	7.6	25	9.6	15	9.6	28	9.8	16	11.9	29	9.9	17	14.4	30	10.6	18	17.2	32	11.3	19	20.3	33	12.2	20	23.4	35	13.2	21	26.7	36	13.4	21	30.4	37	14.1	22
4.50	8.1	26	9.7	16	10.2	28	9.9	16	12.6	30	10.0	17	15.2	32	10.7	18	18.3	33	11.7	19	21.5	35	12.6	20	24.8	37	13.6	21	28.4	38	13.8	22	32.3	39	14.4	22
5.00	8.5	26	10.1	16	10.8	29	10.1	18	13.3	32	10.4	19	16.1	33	11.3	20	19.3	35	13.1	21	22.7	36	14.0	22	26.1	38	14.0	23	29.9	39	15.2	23	34.0	41	15.8	24
5.50	8.9	27	10.4	18	11.3	31	11.0	19	13.9	33	11.3	20	16.9	35	12.5	21	20.2	36	13.7	22	23.8	38	14.6	24	27.4	40	15.9	24	31.3	41	16.1	25	35.7	42	16.8	25
6.00	9.3	28	10.7	19	11.8	31	11.9	20	14.6	34	12.2	21	17.6	36	13.7	23	21.1	37	14.3	24	24.8	39	15.3	25	28.6	41	16.6	26	32.7	42	17.0	26	37.2	43	17.7	27

SR100DS TAPER BORE NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.6"				0.65"				0.7"				.75"				.8"				.85"				.9"				1.0"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
50	74	98	36	59	87	108	40	65	100	117	44	71	115	120	44	72	130	123	46	75	150	126	46	76	165	129	47	78	204	136	46	82
60	81	102	39	63	96	109	44	68	110	121	47	74	126	124	48	75	143	127	49	77	164	131	49	79	182	133	50	81	224	140	51	85
70	88	105	43	66	103	114	47	73	120	125	50	79	136	128	51	81	155	131	53	83	177	133	54	85	197	138	55	87	243	144	56	91
80	94	111	46	74	110	119	49	79	128	129	53	84	146	132	54	86	165	135	56	88	189	138	56	90	210	142	59	92	258	148	60	97
90	100	118	49	79	117	123	52	83	135	133	56	87	155	136	57	90	175	139	59	93	201	143	60	94	223	146	62	95	274	153	64	99
100	106	120	51	82	123	126	54	87	143	137	58	92	163	140	59	93	185	143	61	95	212	148	62	96	235	150	65	101	289	157	67	105
110	111	122	52	84	129	132	56	89	150	141	60	94	171	144	62	96	195	147	64	98	222	151	65	100	247	154	67	103	304	162	69	108
120	115	124	53	85	135	135	58	90	157	145	61	96	179	148	63	99	204	151	65	103	232	155	67	105	258	159	69	107	320	166	71	111

SR100DS TAPER BORE NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	15.2 mm				16.5 mm				17.8 mm				19.1 mm				20.3 mm				21.6 mm				22.9 mm				25.4 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
3.5	15.6	30	11	18	18.3	33	12	20	21.0	36	13	22	24.1	37	14	22	27.5	38	14	23	31.5	38	14	23	34.0	39	14	24	42.8	42	15	25
4	16.0	31	12	19	21.1	33	13	21	24.6	37	14	22	27.8	38	14	23	31.2	38	15	23	36.2	40	15	24	40.4	40	15	25	49.5	42	16	26
5	20.1	32	13	21	23.6	36	14	23	27.5	38	15	24	31.2	39	16	25	34.9	40	16	26	40.5	41	17	26	46.2	42	17	27	55.6	44	17	28
6	22.1	36	15	24	25.9	37	16	25	30.1	40	17	26	34.3	41	17	27	38.2	42	18	28	44.5	43	18	28	49.5	44	19	29	60.5	46	19	30
7	23.8	37	16	25	27.9	39	17	27	32.5	42	18	28	37.0	43	18	28	41.3	44	19	29	48.0	45	19	30	53.5	46	20	31	65.5	48	21	32
8	25.5	38	16	26	29.7	41	17	27	34.8	44	18	29	39.4	46	19	30	44.1	46	20	31	51.2	47	20	31	57.2	48	21	32	70.2	50	21	33

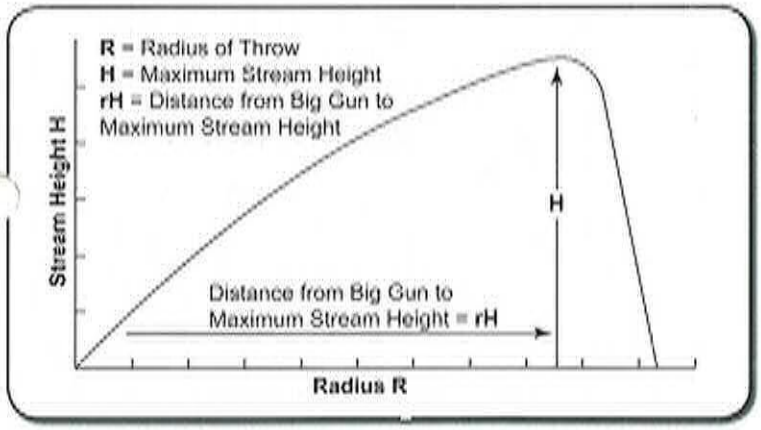
SR150DS TAPER BORE NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.7"				0.8"				0.9"				1.0"				1.1"				1.2"				1.3"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
50	100	117	44	71	130	123	46	75	165	129	47	78	205	136	48	82	255	140	49	85	300	149	50	90	350	153	51	93
60	110	121	47	74	143	127	49	77	182	133	50	81	225	140	51	85	275	145	52	88	330	154	53	94	385	157	54	96
70	120	125	50	79	155	131	53	83	197	138	55	87	245	144	56	91	295	151	57	95	355	158	59	100	415	161	60	101
80	128	129	53	84	165	135	56	88	210	142	59	92	260	149	60	97	315	162	61	105	380	163	64	106	445	167	65	112
90	135	133	56	87	175	139	59	93	223	146	62	95	275	153	64	99	335	165	65	107	405	168	68	109	475	171	70	114
100	143	137	58	92	185	143	61	96	235	150	65	101	290	157	67	105	355	167	68	110	425	172	71	113	500	176	73	116
110	150	141	60	94	195	147	64	98	247	154	67	103	305	162	69	108	370	172	70	115	445	176	74	118	525	180	76	121
120	157	145	61	97	204	151	65	103	258	159	69	107	320	166	71	111	385	177	72	119	465	180	77	122	545	183	79	123

SR150DS TAPER BORE NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	17.8 mm				20.3 mm				22.9 mm				25.4 mm				27.9 mm				30.5 mm				33.0 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
3.5	23.0	36	13	22	29.8	38	14	23	37.8	39	14	24	46.9	42	15	25	57.1	43	15	26	68.3	46	15	28	80.1	47	16	28
4	24.6	37	14	22	31.9	38	15	23	40.5	40	15	25	50.1	42	15	26	61.0	44	16	27	73.0	47	16	28	85.7	48	16	29
5	27.5	38	15	25	35.7	40	16	26	45.2	42	17	27	56.0	44	17	28	68.2	47	18	30	81.7	49	18	31	95.8	50	19	32
6	30.1	40	17	26	39.1	42	18	28	49.5	44	19	29	61.3	46	19	30	74.7	50	19	32	89.5	51	20	33	105	52	21	35
7	32.5	42	18	28	42.2	44	19	29	53.5	46	20	31	66.3	48	21	32	80.7	51	21	34	96.6	53	22	35	113	54	22	36
8	34.9	44	18	29	45.1	46	20	31	57.2	48	21	32	70.8	50	21	33	86.3	53	22	36	103	54	23	37	121	55	24	37

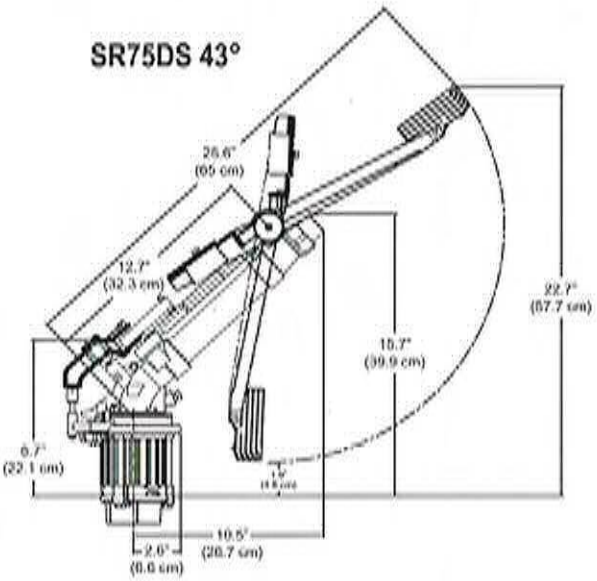
Big Gun® Performance data has been obtained under ideal test conditions and may be adversely affected by wind, poor hydraulic entrance conditions or other factors. Test riser height of 3 feet (0.91 meters) above measurement surface. No representation regarding droplet condition, uniformity, application rate, or suitability for a particular application is made herein.



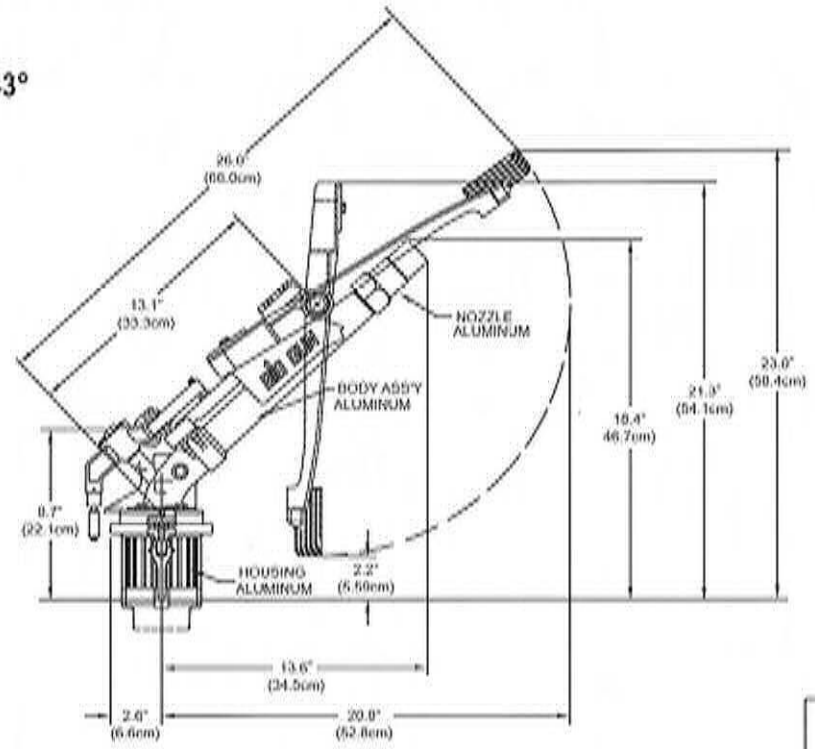
NOTE: The rotation speed of the gun is an important factor in some dust control applications. In general the rotation of the gun is 2-3 minutes when the mid-range pressure and nozzle are used. Drive arm speed adjustment can increase the rotation speed to twice as fast if more frequent wetting is wanted. A full circle Big Gun has ½ the water application rate of a half circle Big Gun with the same nozzle. The half circle Big Gun will pass over a specific location twice as often as a full circle Big Gun.

Contact the factory for information on the SRA100, SRA150 and the 12° Wedge Kit.

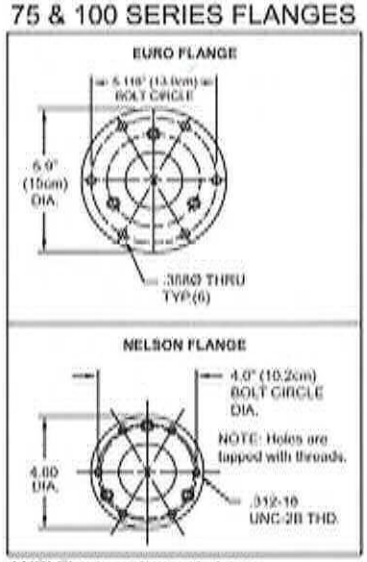
SR75DS 43°



SR100DS 43°

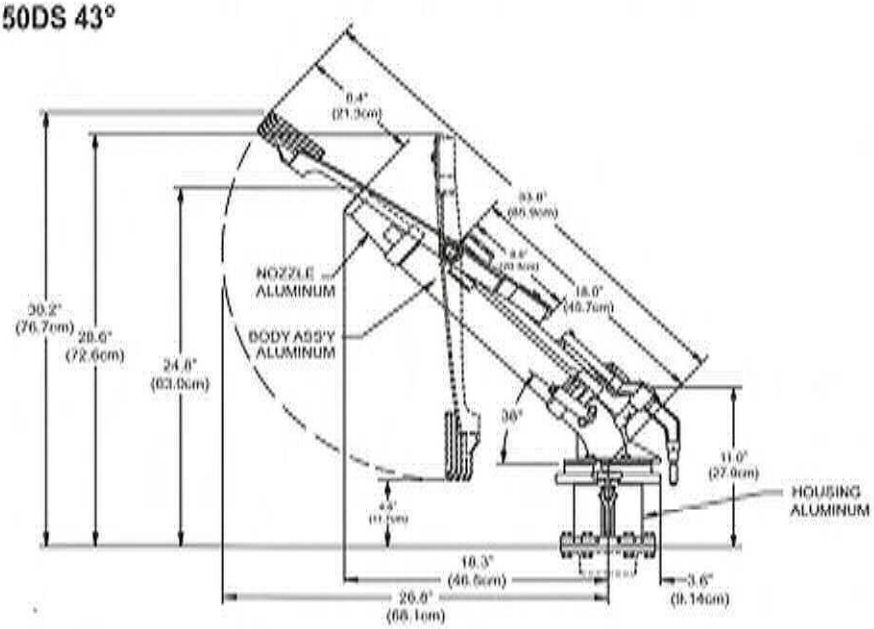


75 & 100 SERIES FLANGES

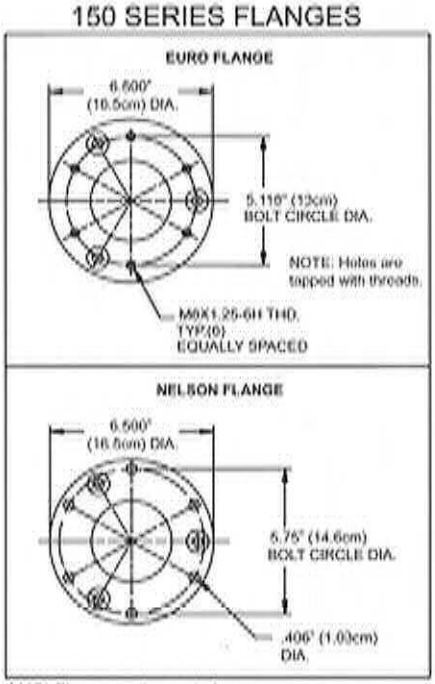


ANSI Flange option not shown.

SR150DS 43°



150 SERIES FLANGES



ANSI Flange option not shown.

BIG GUN® PERFORMANCE FOR 43° MODELS

R = Radius of Throw; **H** = Maximum Stream Height; **rH** = Distance from Big Gun to Maximum Stream Height
(See *The Original Big Gun®* brochure or www.nelsonirrigation.com for performance information of 24° models.)

SR75DS TAPER RING NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.4"				0.45"				0.5"				.55"				.6"				.65"				.7"				.75"				.8"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
30	—	—	—	—	—	—	—	—	37	66	28	49	45	66	30	50	55	69	30	51	64	72	31	55	75	78	32	56	87	78	33	58	99	80	34	60
40	27	62	30	49	35	67	31	50	43	71	31	52	52	75	33	53	63	79	33	56	74	82	35	61	87	85	35	63	98	89	37	64	112	92	39	66
50	30	67	31	50	39	72	32	52	48	76	32	54	59	81	34	56	70	85	36	60	83	88	39	64	95	92	42	67	109	96	43	69	123	99	45	71
60	33	70	32	52	42	77	33	55	53	82	33	59	64	87	35	62	77	92	38	63	91	95	43	67	104	99	46	70	120	102	47	71	136	106	49	73
70	36	73	33	54	45	81	33	56	57	87	34	62	69	92	37	66	83	97	43	69	98	101	46	72	113	106	49	75	129	108	50	76	147	113	52	78
80	39	76	34	58	49	86	35	62	61	93	37	66	74	97	41	70	89	102	45	73	106	107	48	77	121	111	52	80	138	114	53	81	156	118	55	83

SR75DS TAPER RING NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	10.2 mm				11.4 mm				12.7 mm				14.0 mm				15.2 mm				16.5 mm				17.8 mm				19.1 mm				20.3 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
2.50	—	—	—	—	7.6	23	9.2	14	9.4	24	9.6	15	11.4	26	9.7	15	13.6	27	9.9	16	16.0	28	10.2	17	18.6	30	10.3	18	21.1	31	10.7	19	24.0	32	11.6	20
3.00	6.6	23	9.2	15	8.3	25	9.6	15	10.3	26	9.7	16	12.4	28	10.1	16	14.9	29	10.4	17	17.6	30	11.0	19	20.3	31	11.0	19	23.1	33	11.6	20	26.3	34	12.2	21
3.50	7.1	24	9.6	15	9.0	26	9.8	16	11.1	28	9.8	16	13.4	29	10.4	17	16.1	31	11.0	18	19.0	31	11.9	20	21.9	33	12.8	20	25.0	34	13.1	21	28.4	36	13.7	22
4.00	7.6	25	9.6	15	9.6	26	9.8	16	11.9	29	9.9	17	14.4	30	10.5	18	17.2	32	11.3	19	20.3	33	12.2	20	23.4	35	13.2	21	26.7	36	13.4	21	30.4	37	14.1	22
4.50	8.1	26	9.7	16	10.2	28	9.9	16	12.6	30	10.0	17	15.2	32	10.7	18	18.3	33	11.7	19	21.5	35	12.6	20	24.8	37	13.6	21	28.4	38	13.8	22	32.3	39	14.4	22
5.00	8.5	26	10.1	16	10.8	29	10.1	18	13.3	32	10.4	19	16.1	33	11.3	20	19.3	35	13.1	21	22.7	36	14.0	22	26.1	38	14.9	23	29.9	39	15.2	23	34.0	41	15.6	24
5.50	8.9	27	10.4	18	11.3	31	11.0	19	13.9	33	11.3	20	16.9	35	12.5	21	20.2	36	13.7	22	23.8	38	14.6	24	27.4	40	15.9	24	31.3	41	16.1	25	35.7	42	16.6	25
6.00	9.3	28	10.7	19	11.8	31	11.9	20	14.6	34	12.2	21	17.6	36	13.7	23	21.1	37	14.3	24	24.8	39	15.3	25	28.6	41	16.8	26	32.7	42	17.0	26	37.2	43	17.7	27

SR100DS TAPER BORE NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.6"				0.65"				0.7"				.75"				.8"				.85"				.9"				1.0"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
50	74	98	38	59	87	108	40	65	100	117	44	71	116	120	44	72	130	123	46	75	150	125	46	76	165	129	47	78	204	136	48	82
60	81	102	39	63	96	109	44	68	110	121	47	74	126	124	46	75	143	127	49	77	164	131	49	79	182	133	50	81	224	140	51	85
70	88	105	43	66	103	114	47	73	120	125	50	79	136	128	51	81	155	131	53	83	177	133	54	85	197	138	55	87	243	144	56	91
80	94	111	46	74	110	119	49	79	128	129	53	84	146	132	54	86	165	135	56	88	189	138	56	90	210	142	58	92	258	148	60	97
90	100	118	49	79	117	123	52	83	135	133	56	87	155	136	57	90	175	139	59	93	201	143	60	94	223	146	62	95	274	153	64	99
100	106	120	51	82	123	128	54	87	143	137	58	92	163	140	59	93	185	143	61	96	212	146	62	98	235	150	65	101	289	157	67	105
110	111	122	52	84	129	132	56	89	150	141	60	94	171	144	62	96	195	147	64	98	222	151	65	100	247	154	67	103	304	162	69	108
120	115	124	53	85	135	135	58	90	157	145	61	95	179	148	63	99	204	151	65	103	232	155	67	106	258	159	69	107	320	166	71	111

SR100DS TAPER BORE NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	15.2 mm				16.5 mm				17.8 mm				19.1 mm				20.3 mm				21.6 mm				22.9 mm				25.4 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
3.5	15.6	30	11	18	18.3	33	12	20	21.0	36	13	22	24.1	37	14	22	27.5	38	14	23	31.5	38	14	23	34.8	39	14	24	42.8	42	15	26
4	16.0	31	12	19	21.1	33	13	21	24.6	37	14	22	27.8	38	14	23	31.2	38	15	23	36.2	40	15	24	40.4	40	15	25	49.6	42	16	26
5	20.1	32	13	21	23.6	35	14	23	27.5	38	15	24	31.2	39	16	25	34.9	40	16	26	40.6	41	17	26	46.2	42	17	27	55.6	44	17	28
6	22.1	35	16	24	25.9	37	16	25	30.1	40	17	26	34.3	41	17	27	38.2	42	18	28	44.5	43	18	28	49.5	44	19	29	60.5	46	19	30
7	23.8	37	16	25	27.9	39	17	27	32.5	42	18	28	37.0	43	18	28	41.3	44	19	29	48.0	45	19	30	53.5	46	20	31	65.5	48	21	32
8	25.5	38	16	26	29.7	41	17	27	34.8	44	18	29	39.4	45	19	30	44.1	46	20	31	51.2	47	20	31	57.2	48	21	32	70.2	50	21	33

SR150DS TAPER BORE NOZZLE — 43° TRAJECTORY (U.S. UNITS - RADIUS IN FEET)

	0.7"				0.8"				0.9"				1.0"				1.1"				1.2"				1.3"			
PSI	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH	GPM	R	H	rH
50	100	117	44	71	130	123	46	75	165	129	47	78	205	136	48	82	255	140	49	85	300	149	50	90	350	153	51	93
60	110	121	47	74	143	127	49	77	182	133	50	81	225	140	51	85	278	145	52	88	330	154	53	94	385	157	54	96
70	120	125	50	79	155	131	53	83	197	138	55	87	245	144	56	91	295	151	57	95	355	158	59	100	415	161	60	101
80	128	129	53	84	165	135	56	88	210	142	59	92	260	149	60	97	315	162	61	105	380	163	64	106	445	167	65	112
90	135	133	56	87	175	139	59	93	223	146	62	95	275	153	64	99	335	165	65	107	405	168	66	109	475	171	70	114
100	143	137	58	92	185	143	61	96	235	150	65	101	290	157	67	105	355	167	68	110	425	172	71	113	500	176	73	116
110	150	141	60	94	195	147	64	98	247	154	67	103	305	162	69	108	370	172	70	110	445	176	74	118	525	180	76	121
120	157	145	61	97	204	151	65	103	258	159	69	107	320	166	71	111	385	177	72	110	465	180	77	122	545	183	79	123

SR150DS TAPER BORE NOZZLE — 43° TRAJECTORY (METRIC UNITS - RADIUS IN METERS)

	17.8 mm				20.3 mm				22.9 mm				25.4 mm				27.9 mm				30.5 mm				33.0 mm			
kg/cm²	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH	M³/H	R	H	rH
3.5	23.0	36	13	22	29.8	38	14	23	37.8	39	14	24	46.9	42	15	25	57.1	43	15	26	68.3	46	15	26	80.1	47	16	28
4	24.6	37	14	22	31.9	38	15	23	40.6	40	16	25	50.1	42	15	25	61.0	44	16	27	73.0	47	16	28	85.7	48	16	29
5	27.5	38	15	24	35.7	40	16	25	45.2	42	17	27	56.0	44	17	28	68.2	47	18	30	81.7	49	18	31	95.8	50	19	32
6	30.1	40	17	26	39.1	42	18	28	49.5	44	19	29	61.3	46	19	30	74.7	50	19	32	89.5	51	20	33	105	52	21	35
7	32.5	42	18	28	42.2	44	19	29	53.5	46	20	31	66.3	48	21	32	80.7	51	21	34	96.6	53	22	35	113	54	22	36
8	36.9	44	18	29	46.1	46	20	31	57.2	48	21	32	70.6	50	21	33	86.3	53	22	36	103	54	23	37	121	55	24	37

Big Gun® Performance data has been obtained under ideal test conditions and may be adversely affected by wind, poor hydraulic entrance conditions or other factors. Test riser height of 3 feet (0.91 meters) above measurement surface. No representation regarding droplet condition, uniformity, application rate, or suitability for a particular application is made herein.

2. MISTING NOZZLES To capture fugitive airborne dust. This requires nozzles with very fine orifices to produce small droplets which will capture the fine dust particles. The volumes of water required are minimal. Spraying Systems company " Whirljet" nozzles will be installed in the dumper, at the transfers and at the shiploader for this purpose. The piping to the nozzles is small diameter and it is relatively easy to relocate the misting nozzles if operating experience indicates some particularly troublesome locations.

   The following pages contain some general information on the Whirljet misting nozzles proposed for the this purpose.

Understanding drop size and the role it plays in your dust suppression application

Many important factors determine the overall effectiveness of a dust suppression spray nozzle. One of these factors is drop size, and understanding drop size and its role in nozzle performance will help you select the best spray nozzle for your application.



The volume of one large drop equals the volume of eight drops with diameters one-half the size of the large drop.

What is drop size?

Drop size is a by-product of atomization. The process of atomization begins by forcing liquid through a nozzle. The potential energy of the liquid, along with the geometry of the nozzle, causes the liquid to emerge as small ligaments. These ligaments then break up further into very small "pieces," which are usually called drops, droplets, or liquid particles.

Each spray provides a range of drop sizes; this range is referred to as drop size distribution. The drop size distribution is dependent on the nozzle type and will vary significantly from one nozzle type to another.

The importance of drop size in dust suppression stems from the role it plays in Airborne (Fugitive) Dust Knockdown. Once dust particles become airborne the dust reduction application becomes one of capturing, knocking down, or scrubbing many of the particles from the air or gas.

Studies have shown that dust-capturing efficiency depends strongly on the ratio of spray drop size to dust particle size. Dust particles in the range of 2 to 3 microns were best captured with drop of about 100 times the size of the dust particles. For capturing much larger size dust particles, a drop size of approximately the same size or somewhat larger than the particle size would be adequate.

The drop size required for a specific application has an important effect on nozzle selection. Generally, air atomizing nozzles provide the finest drop size followed by hollow cone, flat fan, and full cone nozzles. The range of drop size and a relative comparison between Spraying Systems Co. nozzle drop sizes are represented in Data Sheet 13911-1. The importance of nozzle selection was also emphasized in another U.S. Bureau of Mines (NIOSH) study. In this study, it was shown that full cone and flat fan nozzles were two-thirds as effective as hollow cone nozzles in dust knockdown applications.



For more information on dust particle size and drop size, Spraying Systems Co. nozzle drop size comparison, or the U.S. Bureau of Mines (NIOSH) Study, contact your local Spraying Systems Co. sales engineer. Your sales engineer will be pleased to provide you with a copy of our "Engineer's Practical Guide to Drop Size". This handy reference tool offers an up-close look at drop size instrumentation, statistics and terminology, and more.

You'll also find the U.S. Bureau of Mines (NIOSH) Study to be a valuable source for technical information on dust knockdown performance of spray nozzles, the characteristics of particles and particle dispersions, and the relative comparison between Spraying Systems Co. nozzle drop sizes.

COMPARATIVE DROP SIZE DATA					
Drop Size Range Microns* Median Volume Diameter	Comparative Subject In Drop Size Range	Time For Drop To Fall 10 Ft. In Seconds	Drift In 3 MPH Wind 10 Ft. Fall Feet	No. of Drops Per Sq. In. If Applied At Rate of 1 Gal Per Acre	Nozzle Group No.*** Nozzle Types And Sizes Generally Falling In Given Drop Size Range
Below .001	Molecular Dimensions				
.001 To 0.1	Smoke	**			
0.1 To 1.0	Fumes	**			
2 To 5	Dry Fog	25400 4070	112000 18000	144060000 9220000	
10 To 40	Wet Fog	1020 64	4500 280	1152500 18000	I
50 To 100	Misty Rain	40 11	175 48	9200 1152	II
200 To 400	Light Rain	4.2 1.9	19 8	144 18	III
500 To 1000	Moderate Rain	1.6 1.1	7 5	9 1	IV
1000 To 2000	Intense Rain	1.1 0.9	5 4	1 21 Per Sq Ft	V
2000 To 5000	Heavy Rain	0.9 0.85	4 3.5	21 Per Sq Ft 1-1/3 Per Sq Ft	VI

Note: *One micron equals 1/25400 of an inch.

**Below 0.1 micron, drops are suspended in air due to molecular shock (Brownian Motion).

***See following pages for listing of Nozzle Group Nos., Nozzle Nos., and pressure ranges.

WhirlJet® SPRAY NOZZLES

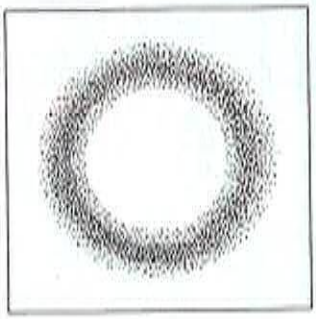
STANDARD ANGLE
SMALL CAPACITY

A

removable cap
⅛"-¾" NPT or BSPT (F)







AX

removable cap/slope-bottom design
⅛"-¾" NPT or BSPT (F)



B

removable cap
⅛"-¾" NPT or BSPT (M)



BX

removable cap/slope-bottom design
⅛"-¾" NPT or BSPT (M)



DESIGN FEATURES



Standard WhirlJet spray nozzles feature a hollow cone spray pattern with a ring-shaped impact area and spray angles of 40° to 90°.

They produce a uniform distribution of small to medium-sized droplets over a wide range of flow rates and pressures.

WhirlJet nozzles produce excellent results in applications requiring good atomization of liquids at lower pressures... especially where quick heat transfer or effective air-borne droplet impingement is required.

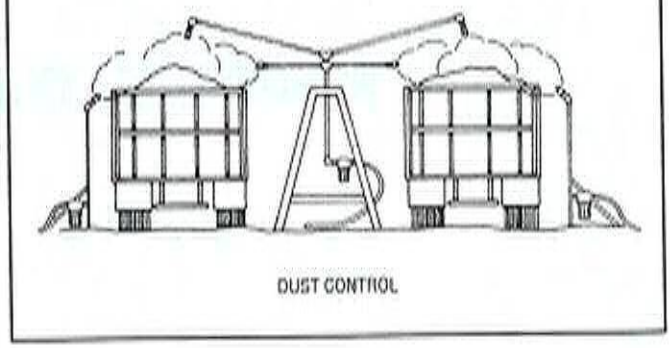
WhirlJets also provide an important benefit with their large and unobstructed flow passages, which minimize or eliminate clogging.

A and B series small capacity WhirlJet spray nozzles are precision-machined from solid bar stock to exacting internal proportions. They have removable caps and the original design WhirlJet whirlchamber.

AX and BX series small capacity slope bottom WhirlJets feature the same uniform spray distribution and precision two-piece bar stock construction as the A and B series...plus the added advantage of the longer-life slope bottom design...to reduce the "drilling effect" of the fluid vortex in the whirlchamber.

COMMON APPLICATIONS

- Washing gas and air to remove fly ash and other products of combustion
- Gas cooling
- Water cooling
- Metal treating
- Product degreasing
- Suppression and control of fugitive dust
- Brine spraying
- Water aerating



DUST CONTROL

ACCESSORIES

Split-Eyelet Connector	Pressure Gauge	Adjustable Ball Fittings	124 Strainer	Other Accessories
				• Pressure Regulators • Control Valves • Solenoid Valves • Swivel Connectors **SEE SECTION G FOR COMPLETE INFORMATION.**

PERFORMANCE DATA

Nozzle Inlet Conn. NPT or BSPT	NOZZLE TYPE STANDARD (F) Conn. A	(F) Conn. AX	(M) Conn. B	(M) Conn. BX	Capacity Size	Body Inlet Diam. Nom. Inches	Orifice Diam. Nom. Inches	CAPACITY (gallons per minute) 3 psi	5 psi	10 psi	15 psi	20 psi	30 psi	40 psi	60 psi	80 psi	100 psi	SPRAY ANGLE 7 psi	20 psi	80 psi
1/8	•	•	•	•	0.5	1/32	3/64			.05	.06	.07	.09	.10	.12	.14	.16		58°	69°
	•	•	•	•	1	1/16	1/16			.10	.12	.14	.17	.20	.24	.28	.31		64°	76°
	•	•	•	•	2	3/64	3/64		.14	.20	.25	.28	.35	.40	.48	.56	.63	52°	61°	69°
	•	•	•	•	3	3/32	3/32		.21	.30	.37	.42	.52	.60	.73	.85	.95	52°	64°	77°
	•	•	•	•	5	1/8	1/8	.27	.35	.50	.61	.70	.86	1.0	1.2	1.4	1.6	56°	67°	76°
	•	•	•	•	8	5/32	5/32	.44	.57	.80	.98	1.1	1.4	1.6	2.0	2.3	2.5	56°	65°	70°
	•	•	•	•	10	11/64	11/64	.55	.71	1.0	1.2	1.4	1.7	2.0	2.5	2.8	3.2	55°	65°	72°
1/4	•	•	•	•	1	1/16	1/16			.10	.12	.14	.17	.20	.24	.28	.31		53°	67°
	•	•	•	•	2	3/64	3/64			.20	.25	.28	.35	.40	.48	.56	.63		62°	71°
	•	•	•	•	3	3/32	3/32		.21	.30	.37	.42	.52	.60	.73	.85	.95	51°	65°	78°
	•	•	•	•	5	9/64	9/64	.27	.35	.50	.61	.70	.86	1.0	1.2	1.4	1.6	63°	73°	79°
	•	•	•	•	8	5/32	5/32	.44	.56	.80	.98	1.1	1.4	1.6	2.0	2.3	2.5	61°	69°	73°
	•	•	•	•	10	3/16	11/64	.55	.71	1.0	1.2	1.4	1.7	2.0	2.5	2.8	3.2	63°	70°	74°
	•	•	•	•	15	15/64	13/64	.82	1.1	1.5	1.8	2.1	2.6	3.0	3.7	4.2	4.7	63°	71°	72°
3/8	•	•	•	•	5	9/64	1/8	.27	.35	.50	.61	.70	.86	1.0	1.2	1.4	1.6	64°	73°	79°
	•	•	•	•	8	11/64	5/32	.44	.56	.80	.98	1.1	1.4	1.6	2.0	2.3	2.5	62°	70°	74°
	•	•	•	•	10	13/64	13/64	.55	.72	1.0	1.2	1.4	1.7	2.0	2.4	2.8	3.1	64°	72°	75°
	•	•	•	•	15	15/64	7/32	.82	1.1	1.5	1.8	2.1	2.6	3.0	3.7	4.2	4.7	64°	72°	74°
	•	•	•	•	20	9/32	1/4	1.1	1.4	2.0	2.4	2.8	3.5	4.0	4.9	5.6	6.3	63°	70°	74°
	•	•	•	•	25	25/64	13/64	1.4	1.8	2.5	3.1	3.5	4.3	5.0	6.1	7.1	7.9	63°	70°	74°
	•	•	•	•	30	21/64	5/16	1.6	2.1	3.0	3.7	4.2	5.2	6.0	7.3	8.5	9.5	63°	70°	74°
	•		•		15-30.1	15/64	5/16	1.3	1.6	2.3	2.8	3.2	4.0	4.6	5.6	6.5	7.3	40°	50°	54°
	•		•		25-30.1	25/64	5/16	1.5	2.0	2.8	3.4	4.0	4.8	5.6	6.9	8.0	8.9	40°	47°	51°
	•		•		50-50.1	1/2	3/8	2.7	3.5	5.0	6.1	7.1	8.7	10.0	12.3	14.2	15.8	40°	47°	50°
	•		•		50-50.3	1/2	3/8	2.7	3.5	5.0	6.1	7.1	8.7	10.0	12.3	14.2	15.8	72°	76°	78°
1/2	•	•	•	•	25	3/8	1/4	1.4	1.8	2.5	3.1	3.5	4.3	5.0	6.1	7.1	7.9	63°	66°	71°
	•	•	•	•	30	3/8	15/64	1.6	2.1	3.0	3.7	4.2	5.2	6.0	7.3	8.5	9.5	67°	71°	75°
	•	•	•	•	40	1/2	23/64	2.2	2.8	4.0	4.9	5.7	6.9	8.0	9.8	11.3	12.6	72°	76°	78°
	•	•	•	•	50	3/4	7/16	2.7	3.5	5.0	6.1	7.1	8.5	10.0	12.3	14.2	15.8	74°	79°	82°
	•	•	•	•	60	3/4	23/64	3.3	4.3	6.0	7.3	8.5	10.4	12.0	14.7	17.0	19.0	77°	82°	86°
3/4	•	•	•	•	40	1/2	5/16	2.2	2.8	4.0	4.9	5.7	6.9	8.0	9.8	11.3	12.6	70°	73°	74°
	•	•	•	•	50	1/2	3/8	2.7	3.5	5.0	6.1	7.1	8.5	10.0	12.3	14.2	15.8	72°	75°	77°
	•	•	•	•	60	1/2	7/16	3.3	4.3	6.0	7.3	8.5	10.4	12.0	14.7	17.0	19.0	74°	76°	79°
	•	•	•	•	70	1/2	1/2	3.8	5.0	7.0	8.5	9.9	12.1	14.0	17.1	19.8	22.0	76°	79°	83°
	•	•	•	•	80	1/2	9/16	4.4	5.7	8.0	9.8	11.3	13.8	16.0	19.6	23.0	25.0	78°	82°	84°
	•	•	•	•	90	1/2	37/64	4.9	6.4	9.0	11.0	12.7	15.6	18.0	22.0	25.0	29.0	81°	84°	84°
	•	•	•	•	100	1/2	5/8	5.5	7.1	10.0	12.2	14.1	17.3	20.0	25.0	28.0	32.0	83°	86°	86°
	•	•	•	•	110	1/2	43/64	6.0	7.8	11.0	13.5	15.5	19.0	22.0	27.0	31.0	35.0	85°	88°	88°
	•	•	•	•	120	1/2	23/32	6.6	8.5	12.0	14.7	17.0	21.0	24.0	29.0	34.0	38.0	87°	90°	90°

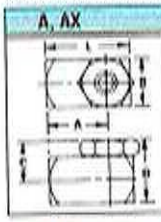
Standard Materials

Material Code
no material code = Brass
I = Mild Steel
SS = 303 Stainless Steel
316SS = 316 Stainless Steel
PVC = Polyvinyl Chloride

INTERMEDIATE CAPACITIES—Caps are interchangeable for in-between capacities within each pipe size group... write for Data Sheets 3055, 3986 and 3987.
Spray Dimension Data... write for Data Sheets 15350 and 15362.

DIMENSIONS & WEIGHTS

Based on largest/heaviest version of each type.



A, AX	A	B	C	D	L	Net Weight oz.
1/8 A, AX	11/16"	3/8"	13/32"	29/32"	1"	1⅛
1/4 A, AX	5/8"	3/4"	17/32"	29/32"	1 1/4"	2¾
3/8 A, AX	1 1/16"	7/8"	11/16"	1 1/8"	1 15/32"	4¾
1/2 A, AX	1 3/8"	1 1/8"	23/32"	1 13/32"	1 15/16"	8¾
3/4 A, AX	1 5/16"	1 1/2"	15/16"	1 9/16"	2 3/16"	11
3/8 A-30.1	2 1/32"	3/4"	3/4"	1 1/4"	1 11/32"	4
3/8 A-50.1	2 1/32"	3/4"	27/32"	1 1/32"	1 11/32"	3¾
3/8 A-50.3	2 1/32"	3/4"	11/16"	1 1/16"	1 11/32"	3¾



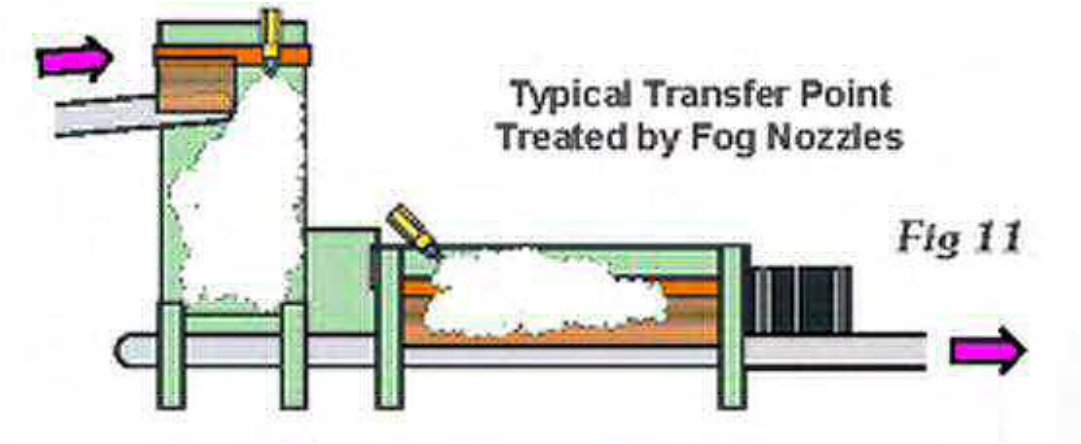
B, BX	A	B	C	D	L	Net Weight oz.
1/8 B, BX	7/8"	3/4"	13/32"	29/32"	1 3/16"	1½
1/4 B, BX	1"	3/4"	17/32"	29/32"	1 5/8"	2¼
3/8 B, BX	1 1/8"	7/8"	11/16"	1 1/8"	1 9/16"	4
1/2 B, BX	1 3/8"	1 1/8"	23/32"	1 13/32"	1 15/16"	7
3/4 B, BX	1 5/8"	1 1/4"	15/16"	1 9/16"	2 1/4"	10¼
3/8 B-30.1	1 1/8"	3/4"	3/4"	1 1/4"	1 1/2"	3¾
3/8 B-50.1	1 1/8"	3/4"	27/32"	1 1/32"	1 1/2"	3½
3/8 B-50.3	1 1/8"	3/4"	11/16"	1 1/16"	1 1/2"	3½

ORDERING INFORMATION

STANDARD SPRAY NOZZLE

1/4	A	-	SS	10
Inlet Connection Pipe Size	Nozzle Type		Material Code	Capacity Size

The location of the sprays at the transfer and surge bin will be both at the incoming point (the headbox) and outgoing end (tail end of conveyor)



The dumper building will have very fine misting sprays at the outgo and ingo end of the building to act as dust curtain (continuous operation).

There will also be plus wet down nozzles which will operate at conclusion of dumping operation for 20 seconds (to be confirmed after operating experience). They will have relatively large nozzles to provide the volume of water required for this purpose:



APPENDIX B – DESIGN OF THE SETTLING POND

The vertical velocity ie the settling rate of any particle in a liquid is determined by Stokes Law which takes into account:

- particle diameter
- particle specific gravity
- viscosity of the liquid
- specific gravity of the liquid

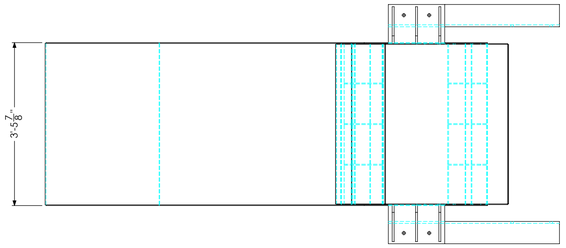
Coal has low specific gravity (typically 1.4) vs mineral aggregates (typically 2.7). The particle diameter of any coal sample is illustrated by a particle size distribution curve and available information on the Powder River Basin coal to be loaded out indicates a relatively fine particle distribution. The combination of low specific gravity and small particle diameter will result in a low settling velocity and the settlement ponds have to be sized accordingly.

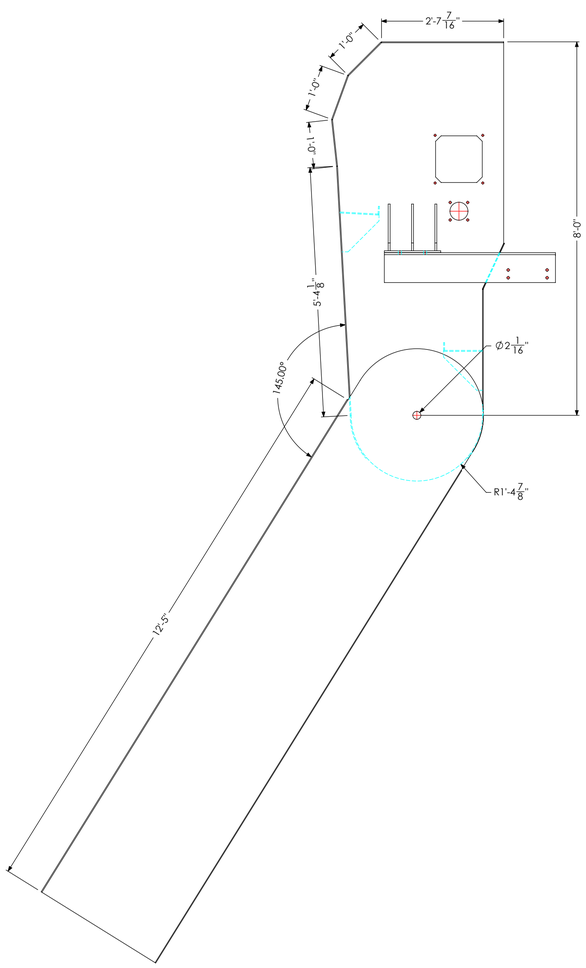
The performance of the primary and secondary settling ponds is not critical as the effluent is to be recycled with only the excess sent off site to the sanitary sewer. However a fair amount of solids will accumulate in them and they need to have enough volume to store these solids without frequent cleaning out. They also need to be wide enough to allow a front end loader access. Preliminary sizing for these ponds is 18 feet wide x 90 ft long x 6 feet deep. A ramp will be provided at one end for front end loader access. Details of construction are to be finalized.

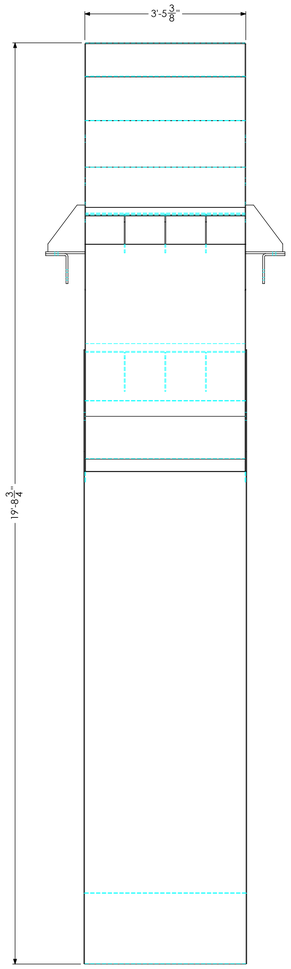


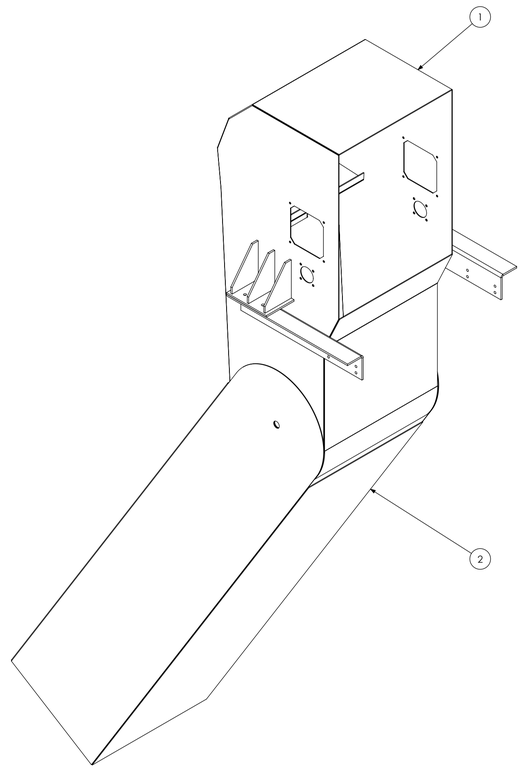
Typical Primary/Secondary Settling Basin under construction

BOM SHOWN FOR ONE ASSEMBLY ONLY(REF-1648-SNORKLE ASSY), TOTAL OF 01 REQUIRED				
ITEM NO.	DESCRIPTION	QTY.	WEIGHT	TOTAL WEIGHT
1	REF-1648-KRS-3036-125 00 00-CHUTE	1	1327.16	1327
2	REF-1648-KRS-3036-125 00 00-SNORKLE	1	1371.64	1372









(01 REQ'D) REF-1648-SNORKLE ASSY
MARK MK# ON THE PART

REV.	DESCRIPTION	DATE	REVISED BY	APPROVED BY
A	ISSUED FOR REVIEW AND APPROVAL	02-05-2013	K.G.	

REVISIONS

PAINTING PROCEDURE AND SPECIFICATIONS:

THIRD ANGLE PROJECTION

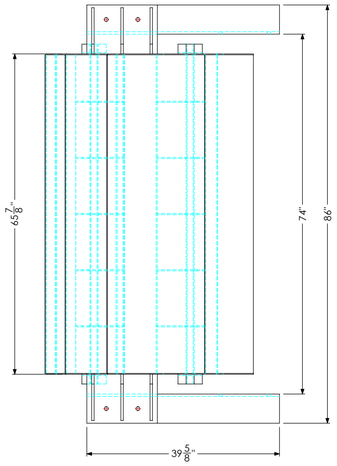
GENERAL NOTES:
1) KREATOR EQUIPMENT ENGINEERING DEPARTMENT MUST BE NOTIFIED IN WRITING OF ANY CHANGES OR DISCREPANCIES IN DIMENSIONS OR MATERIALS AS DESCRIBED IN THIS DOCUMENT
2) ALL WELDING PROCEDURES WILL CONFORM TO CWB 47.1 DIVISION 1 AND 2
3) ALL WELDS TO BE 3/16" CONTINUOUS FILLET OR BUTT WELDS U.O.S.
4) DIMENSION TOLERANCES UNLESS NOTED: ± 1/16" ON CONNECTION POINTS AND 1/8" ON FABRICATED COMPONENTS
5) DECIMAL DIMENSION TOLERANCES UNLESS NOTED:
(i) PLACE DECIMAL (.00) USE ± 0.025"
(ii) PLACE DECIMAL (.000) USE ± 0.0125"

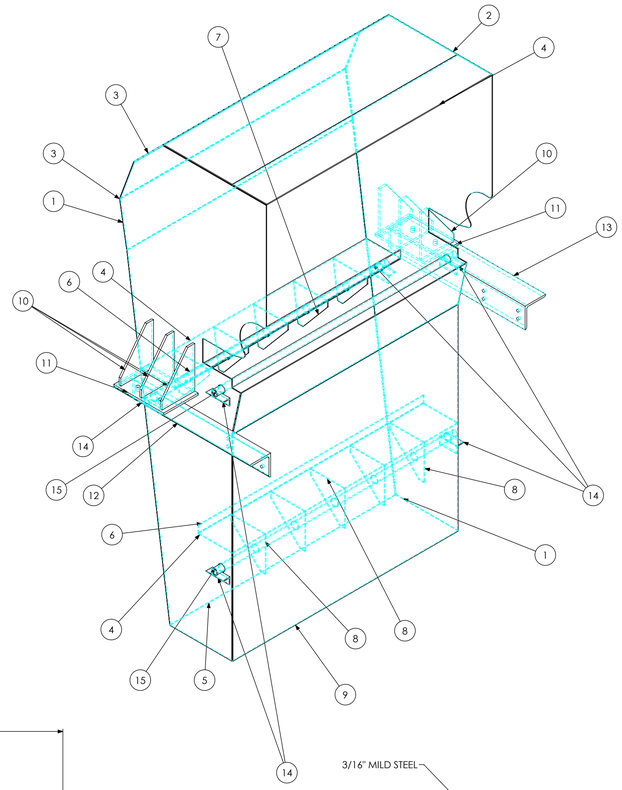
THIS DRAWING IS THE EXCLUSIVE PROPERTY OF KREATOR EQUIPMENT AND THE DESIGNED PRODUCT OR INFORMATION SHOWN HEREIN MAY NOT BE USED IN WHOLE OR PART WITHOUT EXPRESS PERMISSION OF THE OWNER. ALL RIGHTS RESERVED.

KREATOR EQUIPMENT & SERVICES INC.

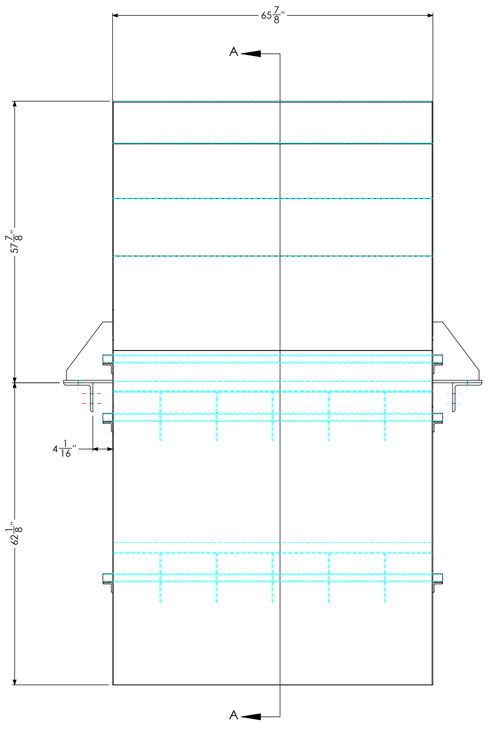
EQUIPMENT: 125 BARGE LOADER — DO NOT SCALE DRAWING
PROJECT: FSD-COAL LOADING SYSTEM
CLIENT: LAFARGE-FSD-GA
TITLE: REF-1648-SNORKLE ASSY
WO# 1648 | DWN: K.G. | CHK'D:
WEIGHT: 2698.81Lb | SCALE: 1:20 | APP'D:
DATE: 02-05-2013 | DES'D: K.G.
DRG No. REF-1648-SNORKLE ASSY | REV. A | SHEET 1 OF 1 | SIZE A1

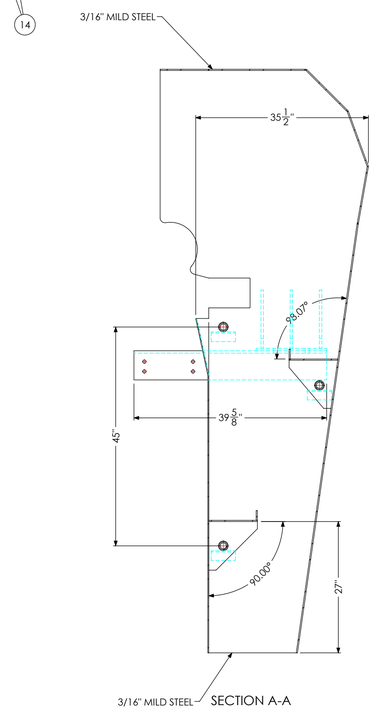
ISSUED TO:	ISSUED DATE:	COMPLETION DATE:

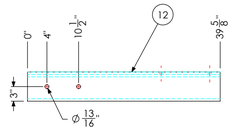




BOM SHOWN FOR ONE ASSEMBLY ONLY(1648-CC1A-CHUTE), TOTAL REQUIRED: 01						
ITEM NO.	DESCRIPTION	ANGLE1	ANGLE2	QTY.	LENGTH	WEIGHT
1	3/16" PLATE - 35 1/16" x 119 3/4"			2		177.67
2	1/4" PLATE - 20" x 65 1/2"			1		92.29
3	1/4" PLATE - 12" x 65 1/2"			3		55.37
4	1/4" PLATE - 10" x 65 1/2"			3		46.14
5	1/4" PLATE - 65 1/2" x 89 1/16"			1		410.92
6	1/4" FLAT - 2" x 65 1/2"			2		9.23
7	1/4" PLATE - 10" x 10"			5		4.16
8	1/4" PLATE - 10" x 10"			5		4.28
9	3/16" PLATE - 65 1/2" x 69"			1		238.79
10	1/2" PLATE - 9 1/2" x 12"			6		10.78
11	1/2" PLATE - 10 1/16" x 14 1/2"			2		20.41
12	L6x6x0.5	0.00	0.00	1	39 5/8"	63.25
13	L6x6x0.5	0.00	0.00	1	39 5/8"	63.25
14	L2x2x0.25	0.00	0.00	6	5"	1.31
15	1 11/16" OD x 1 1/4" ID - SCH 40 PIPE			3		18.45







L 6" x 6" x 1/2"
1 REQ'D AS SHOWN FOR (12)
1 REQ'D OPP. HAND FOR (13)

NOTE: THIS IS TYPICAL AT ALL TRANSFER POINTS
THIS IS A CONCEPTUAL DESIGN MAY CHANGE IN FINAL DESIGN

(01 REQ'D) 1648-CC1A-CHUTE
MARK MK# ON THE PART

REV.	DESCRIPTION	DATE	REVISED BY	APPROVED BY
A	ISSUED FOR REVIEW AND APPROVAL	30/04/2013	K.G.	

REVISIONS

PAINTING PROCEDURE AND SPECIFICATIONS:

THIRD ANGLE PROJECTION

GENERAL NOTES:
1) KREATOR EQUIPMENT ENGINEERING DEPARTMENT MUST BE NOTIFIED IN WRITING OF ANY CHANGES OR DISCREPANCIES IN DIMENSIONS OR MATERIALS AS DESCRIBED IN THIS DOCUMENT
2) ALL WELDING PROCEDURES WILL CONFORM TO CWB 47.1 DIVISION 1 AND 2
3) ALL WELDS TO BE 3/16" CONTINUOUS FILLET OR BUTT WELDS U.O.S.
4) DIMENSION TOLERANCES UNLESS NOTED: ± 1/16" ON CONNECTION POINTS AND 1/8" ON FABRICATED COMPONENTS
5) DECIMAL DIMENSION TOLERANCES UNLESS NOTED:
(i) PLACE DECIMAL (.00) USE ± 0.025"
(ii) PLACE DECIMAL (.000) USE ± 0.0125"

THIS DRAWING IS THE EXCLUSIVE PROPERTY OF KREATOR EQUIPMENT AND THE DESIGNED PRODUCT OR INFORMATION SHOWN HEREIN MAY NOT BE USED IN WHOLE OR PART WITHOUT EXPRESS PERMISSION OF THE OWNER. ALL RIGHTS RESERVED.

KREATOR EQUIPMENT & SERVICES INC.

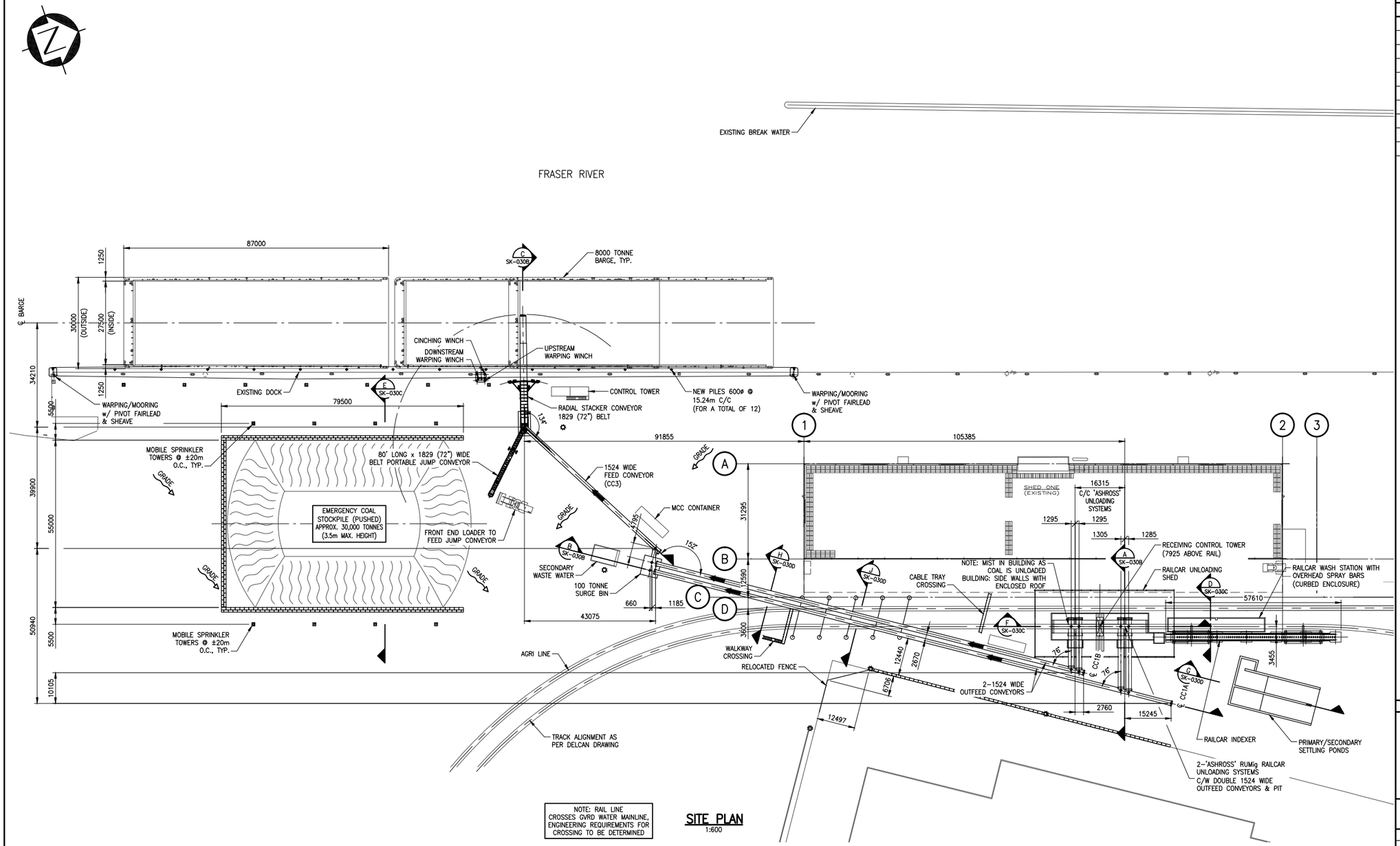
EQUIPMENT# CC1 | DO NOT SCALE DRAWING

PROJECT: FSD-COAL LOADING SYSTEM

CLIENT: LAFARGE-FSD-BC

TITLE: 1648-CC1A-CHUTE

WO# 1648	DWN: K.G.	CHK'D:	DRG No. 1648-CC1A-CHUTE	REV. A	SHEET 1 OF 2	SIZE A1
WEIGHT: 1757.78Lb	SCALE: 1:16	APP'D:				
	DATE: 30/04/2013	DES'D: K.G.				



SITE PLAN
1:600

REFERENCE DRAWINGS / DESIGN STANDARDS	
NUMBER	DESCRIPTION

PRELIMINARY
FOR PERMITTING ONLY

No.	Revision	By	D/M/Y

CWA
www.cwaengineers.com
Suite 380–2925 Virtual Way
Vancouver, B.C. Canada
V5M 4X5
Phone: (604) 637–2275
Fax: (604) 637–2276

This drawing has been prepared for the exclusive use of the intended client, and may not be used in whole or in part by any other individual or company.

Project Number:

This drawing has been prepared for the exclusive use of the intended client, and may not be used in whole or in part by any other individual or company.

	Name	Day	Month	Year
Drawn By	JRM/CPL	–	–	–
Design By				
Dwg Check By				
Design Check By				
Approved By				

Scale: 1:600 | Acad File: –

FRASER SURREY DOCKS LP
PACIFIC RIM STEVEDORING
SURREY, B.C.

TEMPORARY COAL BARGE LOADING FACILITY GENERAL ARRANGEMENT

Drawing No. 12022–SK–030A | Rev. P1

Issue	D/M/Y	By	Issued For:	Rev.
A	30/04/13	CPL	PERMIT APPLICATION	P1

APPENDIX C – ENVIRONMENTAL POLICY

DRAFT

Environmental Policy Template



Environmental Policy Statement

Fraser Surrey Docks is committed to operating in an environmentally responsible manner and for promoting environmental stewardship amongst all of our key stakeholders, including employees, customers, shareholders, suppliers, contractors and the public. We will implement practices and policies that promote Environmental Stewardship and adhere to all environmental compliances. We will strive for continuous improvements of performance through consistent and measureable goals and objectives.

Our commitments are:

- To comply with all relevant environmental regulatory requirements and support through corresponding internal policies
- To prevent air quality impacts by implementing appropriate air emission mitigation strategies and monitoring our performance against pre-established baselines and regulatory target levels
- To prevent pollution and emissions by continually working on process improvements to minimize the generation of hazardous waste and to reduce or prevent the release of regulated substances into the environment
- To foster, establish and maintain an internal environmental awareness culture for our employees and contractors that supports excellence in Environmental Stewardship
- To engage with our customers, suppliers, contractors and shareholders to promote environmental stewardship, to address and reduce the environmental impacts of our products and services along the value chain
- To reach out to the communities in which we operate and promote Environmental Stewardship and awareness
- To establish a process of continual improvements governed by the commitments of this policy and assessed against key performance indicators and corporate targets (SMART)
- To establish and maintain an environmentally conscious Purchasing Policy

Jeff Scott
CEO & President
Fraser Surrey Docks LP
January 1, 2013

APPENDIX D – VISUAL SITE INSPECTION REPORT (EXAMPLE)

DRAFT

VISUAL SITE INSPECTION REPORT (Example)

Date/ Time:
(dd/mm/yy hh:mm) _____ Report #: _____

Project Location: FSD Facility

Inspector:

Weather Conditions (incl. wind dir.):	Surface Moisture Conditions:

Operation Activities Witnessed:

IF THERE IS NOTICABLE DUST INDICATE MITIGATION MEASURES BEING APPLIED OR THOSE RECOMMENDED. PROVIDE PHOTOGRAPHIC DOCUMENTATION WHEN APPROPRIATE

POTENTIAL FUGITIVE DUST SOURCES: (Stockpiles, unpaved roads, excavation, track out, other)

Description:	**Moisture Level** (Wet/Damp/Dry)	**Noticeable Dust?** (Y/N)	**Mitigation Measure Applied?**	**Visual Opacity (%)**	**Comments/ Mitigation Measures Effectiveness/ Recommendations**
Stockpiles					
Material Transfer					
Trucks / Road Dust					
Other					

Notes/ Observations:

LEVELTON CONSULTANTS LTD.

Per: _____
Onsite Inspector

DRAFT

APPENDIX E – MONITORING EQUIPMENT INFORMATION

DRAFT

VRAE

Hand Held 5 Gas Surveyor



VRAE is a hand held 1, 2, 3, 4 or 5 gas monitor with built-in sampling pump and optional data logging.

Sensors include new RAE dual range 0-100% Volume and 0-100% LEL, oxygen and three, smart, interchangeable toxic sensors or up to four smart, interchangeable toxic sensors may be added. The dual range combustible sensor can monitor explosive gases in an oxygen-free environment at percent by volume levels.

The internal pump automatically shuts off plus an alarm is activated, if the remote probe tubing crimps or water is sucked onto the field replaceable filter.

Toxic Sensors Include

- Carbon monoxide
- Hydrogen sulfide
- Sulfur dioxide
- Nitric oxide
- Nitrogen dioxide
- Chlorine
- Ammonia
- Hydrogen cyanide
- Phosphine

Features

- Large, alarm activated back light LCD display
- Visual alarm with flashing
- Large keys usable with gloved hand
- Rigid inlet probe
- 10 hours operation
- Sample collection port
- 16,000 data points download to PC
- Rubber boot

Special Points of Interest:

- Protected from portable radios
- Internal sample draw pump for quick response and remote sampling
- Smart battery charging with status indication and LED indicator
- Snap-in rechargeable NMH or alkaline battery pack
- 48 built-in correction factors for LEL sensor
- 4 toxic sensor version

Applications

- Refineries and petrochemical plants — confined space entry, hot work permits
- Utilities — cable vaults, transformer stations
- Waste water treatment plants — confined space entry
- Marine and off shore oil wells — testing of confined spaces
- Landfill operations — monitoring wells and confined spaces
- Food processing — refrigeration, decomposition, process off gasing, poultry farms
- Fire departments
- Confined Space Entry — trenches, silos, railcars

1339 Moffett Park Drive • Sunnyvale, California 94089 USA
Tel: 408.752.0723 • Fax: 408.752.0724
Email: RaeSales@raesystems.com • www.raesystems.com

Ch010 Rev. 3-2/99

RAE SYSTEMS

Specifications

Intrinsic Safety	UL Class 1, Division I, Group A,B,C,D cUL and EEx ia liC T4 (Europe) PENDING
Size	8.3" (21 cm) L x 3.0" (7.6 cm) W x 1.9" (4.9 cm) H
Weight	20 oz (568 gm) with battery pack
Detector	Catalytic sensor for combustible gas. Thermal conductivity sensor for percentage volume combustible gas. Electrochemical sensors for oxygen and toxic gases
Battery	Rechargeable, snap-in, field replaceable 4.8V, 1.1Ah NMH battery pack, 4 AA alkaline battery adapter
Operating Hours	10 hours continuous
Battery Charging	10 hours charge through built-in charger or an external battery charger
Display	2 line by 16 digit LCD with LED back light automatically in dim light or alarm condition
Keypads	1 operation and 2 program keys
Direct Readout	Instantaneous (up to 5 values): • Oxygen as percentage by volume • Combustible gas as percentage by volume or percentage of lower explosion limit • Toxic gases as parts per million • High and low values for all gases • STEL, TWA for toxic gases • Battery and shut down voltage
Alarm	90 dB buzzer and flashing red LED to indicate exceeded preset alarms: • High — 3 beeps and flashes per second • Low — 2 beeps and flashes per second • STEL and TWA — 1 beep and flash per second Alarms latching with manual override or automatic reset Additional diagnostic alarm and display message for low battery and pump stall
Calibration	Two points field calibration of zero and span gas
Datalogging	16,000 points (53 hours, 5 channels at one minute intervals) down load to PC with serial number of unit, user ID, site ID and calibration date
Datalogging Interval	1 - 3,600 seconds, programmable
Sampling Pump	Internal pump, flow rate 400 cc/minute Automatic shut off at low flow condition
Temperature	-4°F to 113°F (-20°C to 40°C)
Humidity	0% to 95% relative humidity (non-condensing)

Gas	Nominal Range	Extended Range	Resolution	Response Time (t90)
Combustible	0 - 100% LEL		1%	15 sec
	0 - 100 VOL		1%	20 sec
Oxygen	0 - 30%		0.1%	15 sec
Carbon Monoxide	0 - 500 ppm	1500 ppm	1 ppm	40 sec
Hydrogen Sulfide	0 - 100 ppm	500 ppm	1 ppm	35 sec
Sulfur Dioxide	0 - 20 ppm	150 ppm	0.1 ppm	35 sec
Nitric Oxide	0 - 250 ppm	1000 ppm	1 ppm	30 sec
Nitrogen Dioxide	0 - 30 ppm	150 ppm	0.1 ppm	25 sec
Chlorine	0 - 10 ppm	30 ppm	0.1 ppm	60 sec
Hydrogen Cyanide	0 - 100 ppm	100 ppm	1 ppm	200 sec
Ammonia	0 - 50 ppm	200 ppm	1 ppm	150 sec
Phosphine	0 - 5 ppm	20 ppm	0.1 ppm	60 sec

Ordering Information

Models 7800 & 7840

- VRAE unit with combustible, oxygen and up to 3 toxic sensors (7800) OR combustible, and up to 4 toxic sensors (7840)
- Rechargeable NMH battery pack
- AC/DC charging adapter
- Backup Alkaline battery adapter (accept 4 AA size alkaline)
- Inlet probe and water trap filter
- Operation and maintenance manual
- 2 year warranty for LEL / O2 / CO / H2S VRAE monitor

Accessories

- Confined space entry kit
- Calibration kits with gas cylinder, flow regulator and tubing
- ProRAE Suite Software and interface cable
- Automotive charging adapter
- Collapsible remote sampling probe
- Vibration alarm
- Additional sensors — contact the factory for details

VRAE



ISO 9001 CERTIFIED

DISTRIBUTED BY:

UT20 and UT30

Instrumentation Towers

CAMPBELL SCIENTIFIC
CANADA CORP
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

The UT20 and UT30 are corrosion-resistant instrument towers that provide sturdy long-term support for Campbell Scientific's sensors, enclosures, and measurement electronics. The UT20 and UT30 have a crossarm measurement height of 20 ft and 30 ft, respectively. The towers include UV-resistant cable ties and require a mounting base (B18 or RFM18) and grounding kit (UTGND). Campbell Scientific recommends guying the towers with our UTGUY Guy Kit.

The towers can be used as an instrument mount in a variety of applications. For meteorological applications, they can be augmented with mounts (e.g., CM204 crossarm) that allow attachment of sensors such as wind sets, pyranometers, and temperature/relative humidity probes. Barometers, soil temperature and moisture probes, and rain gages can also be used with a tower-based station.



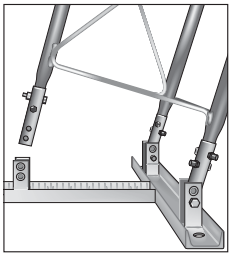
For this air quality weather station, a UT30 30-ft tower uses the B18 base and UTGUY kit to secure it to the ground. An environmental enclosure, CM206 crossarm, Wind Monitor, and two 43502 Aspirated Radiation Shields are mounted directly to the tower. A 27106T vertical anemometer is mounted to each end of the crossarm.

Ordering Information (see note 1)

Towers	
UT20	Universal 20 ft Instrument Tower & Adjustable Mast
UT30	Universal 30 ft Instrument Tower & Adjustable Mast

Accessories	
B18	Concrete Mounting Base for UT20 or UT30
RFM16	Flat Roof Mounting Base for UT20 or UT30
UTGUY	Tower Guy Kit (requires either the UTEYE or UTDUK)
UTEYE	Eyebolt Anchors for UTGUY
UTDUK	Duckbill Anchors for UTGUY
UTGND	Tower Grounding Kit

Use the RFM18 to mount the tower on a roof.

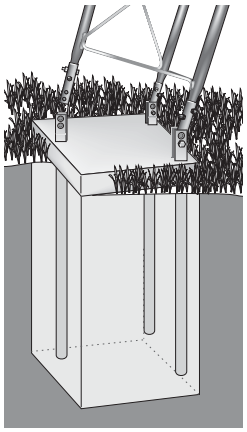


The UTDUK's drive bar is used to drive the duckbill guy anchors in the soil.





The three UTEYE guy anchors embed in concrete.



The B18's stakes embed in a concrete pad.

Specifications

	UT20	UT30
Height	20 ft (6 m)	30 ft (10 m)
Shipping Weight	50 lbs (23 kg)	65 lbs (29 kg)
Material	hardened drawn 6063-T832 aluminum	hardened drawn 6063-T832 aluminum
Vertical Pipe Outer Diameter	1 in. (2.5 cm)	1 in. (2.5 cm)
Cross Support Pipe Outer Diameter	0.375 in. (0.953 cm)	0.375 in. (0.953 cm)
Guyed Tower Area Requirements	~11.5 ft radius	~17 ft radius
Required Concrete Pad Dimensions for B18 Concrete Mounting Base (see note 2)	36 L x 36 W x 48 D in. (91 x 91 x 122 cm)	36 L x 36 W x 48 D in. (91 x 91 x 122 cm)
Maximum Wind Load Recommendations (see note 3)	110 mph (B18 base unguyed); 110 mph (RFM18 base w/UTGUY)	110 mph (B18 base unguyed); 110 mph (RFM18 base w/UTGUY)

Notes:

1. Refer to the "Instrumentation Mounts" product brochure for crossarm, solar radiation mounts, and radiation shield options.
2. The concrete pad requirements assume heavy soil; light, shifting, or sandy soils require a bigger concrete pad.
3. The recommended wind load assumes proper installation, proper anchoring, and total instrument projected area of less than two square feet. For the RFM18 base, the wind load recommendation also assumes that the UTGUY's turnbuckles are preloaded just enough to equalize tension and that the tower is guyed at 60 degree angle relative to the ground (maximum). The amount of wind load that these towers can withstand is affected by quality of anchoring and installation, guy wire tension, soil type, guy angle, and the number, type, and location of instruments fastened to the tower.
4. The UT30 is Universal Towers' model #9-30. A more detailed drawing of this tower is available at www.universaltowers.com.

11564 149 Street | Edmonton, AB T5M 1W7 | CAN | phone (780) 454-2505 | www.campbellsci.ca
Australia | Brazil | Canada | England | France | Germany | South Africa | Spain | USA [headquarters]

Copyright © 1997, 2010
Campbell Scientific, Inc.
Printed July 2010

CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER



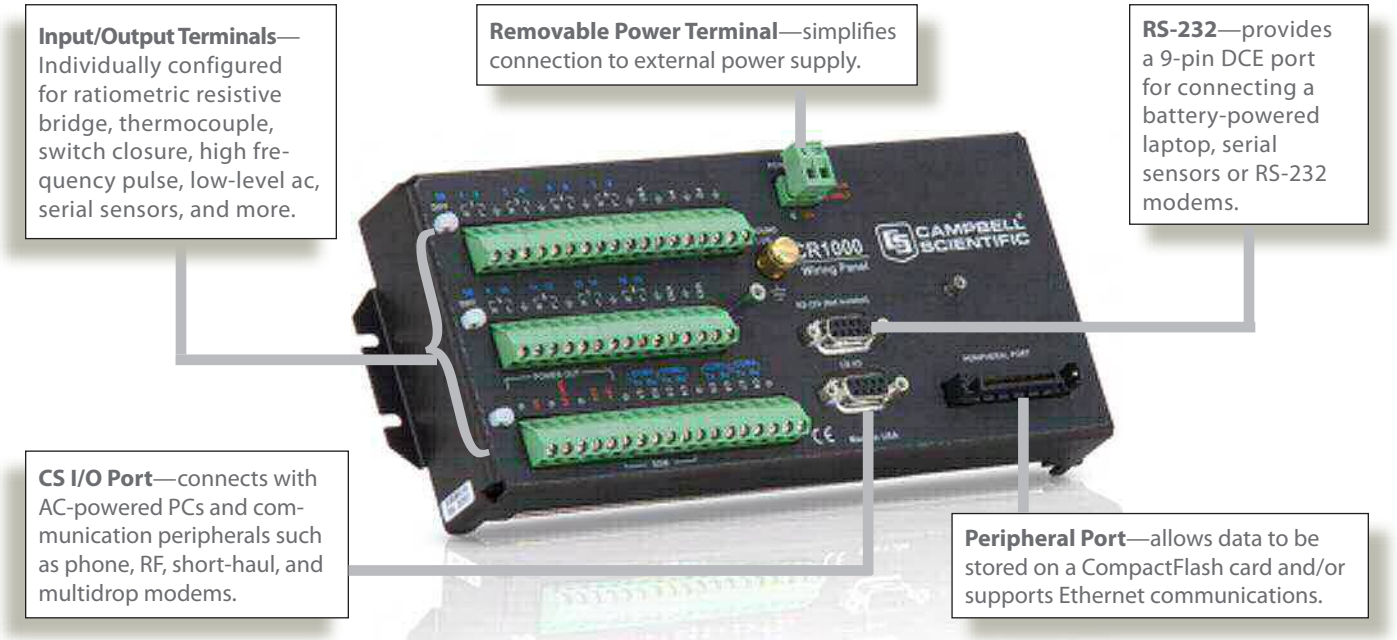
CR1000

measurement & control datalogger

A rugged instrument with research-grade performance.

CR1000 Measurement and Control System

The CR1000 provides precision measurement capabilities in a rugged, battery-operated package. It consists of a measurement and control module and a wiring panel. Standard operating range is -25° to +50°C; an optional extended range of -55° to +85°C is available.



Features

- 4 Mbyte memory*
- Program execution rate of up to 100 Hz
- CS I/O and RS-232 serial ports
- 13-bit analog to digital conversions
- 16-bit H8S Renesas Microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Single DAC used for excitation and measurements to give ratio metric measurements
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- Battery-backed SRAM memory and clock ensuring data, programs, and accurate time are maintained while the CR1000 is disconnected from its main power source
- Serial communications with serial sensors and devices supported via I/O port pairs
- PakBus®, Modbus, DNP3, TCP/IP, FTP, and SMTP protocols supported

Measurement and Control Module

The module measures sensors, drives direct communications and telecommunications, reduces data, controls external devices, and stores data and programs in on-board, non-volatile storage. The electronics are RF shielded and glitch protected by the sealed, stainless steel canister. A battery-backed clock assures accurate timekeeping. The module can simultaneously provide measurement and communication functions. The on-board, BASIC-like programming language supports data processing and analysis routines.

Wiring Panel

The CR1000WP is a black, anodized aluminum wiring panel that is compatible with all CR1000 modules. The wiring panel includes switchable 12 V, redistributed analog grounds (dispersed among analog channels rather than grouped), unpluggable terminal block for 12 V connections, gas-tube spark gaps, and 12 V supply on pin 8 to power our COM-series phone modems and other peripherals. The control module easily disconnects from the wiring panel allowing field replacement without rewiring the sensors. A description of the wiring panel's input/output channels follows.

**Originally, the standard CR1000 had 2 MB of data/program storage, and an optional version, the CR1000-4M, had 4 MB of memory. In September 2007, the standard CR1000 started having 4 MB of memory, making the CR1000-4M obsolete. Dataloggers that have a module with a serial number greater than or equal to 11832 will have a 4 MB memory. The 4 MB dataloggers will also have a sticker on the canister stating "4M Memory".*

Analog Inputs
Eight differential (16 single-ended) channels measure voltage levels. Resolution on the most sensitive range is 0.67 µV.

Pulse Counters
Two pulse channels can count pulses from high level (5 V square wave), switch closure, or low level AC signals.

Switched Voltage Excitations
Three outputs provide precision excitation voltages for resistive bridge measurements.

Digital I/O Ports
Eight ports are provided for frequency measurements, digital control, and triggering. Three of these ports can also be used to measure SDM devices. The I/O ports can be paired as transmit and receive. Each pair has 0 to 5 V UART hardware that allows serial communications with serial sensors and devices. An RS-232-to-logic level converter may be required in some cases.

CS I/O Port
AC-powered PCs and many communication peripherals connect with the CR1000 via this port. Connection to an AC-powered PC requires either an SC32B or SC-USB interface. These interfaces isolate the PC's electrical system from the datalogger, thereby protecting against ground loops, normal static discharge, and noise.

RS-232 Port
This non-isolated port is for connecting a battery-powered laptop, serial sensor, or RS-232 modem. Because of ground loop potential on some measurements (e.g., low level single-ended measurements), AC-powered PCs should use the CS I/O port instead of the RS-232 port (see above).

Peripheral Port
One 40-pin port interfaces with the NL115 Ethernet Interface & CompactFlash Module, the NL120 Ethernet Interface, or the CFM100 CompactFlash® Module.

Switched 12 Volt
This terminal provides unregulated 12 V that can be switched on and off under program control.

Storage Capacity
The CR1000 has 2 MB of flash memory for the Operating System, and 4 MB of battery-backed SRAM for CPU usage, program storage, and data storage. Data is stored in a table format. The storage capacity of the CR1000 can be increased by using a CompactFlash card.

Communication Protocols
The CR1000 supports the PakBus, Modbus, DNP3, TCP/IP, FTP, and SMTP communication protocols. With the PakBus protocol, networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in the case of delivery failure, allows automatic switch over to a configured backup route.

The Modbus RTU protocol supports both floating point and long formats. The datalogger can act as a slave and/or master.

The DNP3 protocol supports only long data formats. The dataloggers are level 2 slave compliant, with some of the operations found in a level 3 implementation.

The TCP/IP, FTP, and SMTP protocols provide TCP/IP functionality when the CR1000 is used in conjunction with an NL240, NL200, NL115, or NL120. Refer to the CR1000 manual for more information.

Power Supplies
Typically, the CR1000 is powered with a PS200, PS100, or BPALK. The PS200 and PS100 provide a 7-Ah sealed rechargeable battery that should be connected to a charging source (either a wall charger or solar panel). The BPALK consists of eight non-rechargeable D-cell alkaline batteries with a 7.5-Ah rating at 20°C.

Also available are the BP12 and BP24 battery packs, which provide nominal ratings of 12 and 24 Ah, respectively. These batteries should be connected to a regulated charging source (e.g., a CH200 or CH100 connected to a unregulated solar panel or wall charger).



The PS200 (at right) and CH200 are micro-controller-based smart chargers that have two input terminals that allow simultaneous connection of two charging sources.

Enclosure/Stack Bracket
A CR1000 housed in a weather-resistant enclosure can collect data under extremely harsh conditions. The 28960 Enclosure Stack Mounting Kit allows a small peripheral to be placed under the mounting bracket, thus conserving space.

Data Storage and Retrieval Options

To determine the best option for an application, consider the accessibility of the site, availability of services (e.g., cellular phone or satellite coverage), quantity of data to collect, and desired time between data-collection sessions. Some communication options can be combined—increasing the flexibility, convenience, and reliability of the communications.

Keyboard Display

The CR1000KD can be used to program the CR1000, manually initiate data transfer, and display data. The CR1000KD displays 8 lines x 21 characters (64 x 128 pixels) and has a 16-character keyboard. Custom menus are supported allowing customers to set up choices within the datalogger program that can be initiated by a simple toggle or pick list.



One CR1000KD can be carried from station to station in a CR1000 network.

iOS Devices, Android Devices, and PDAs

An iOS device, an Android device, our Archer-PCON Field PC, or a user-supplied PDA can be used to view and collect data, set the clock, and download programs. To use an iOS or Android device, go to the Apple Store or Google Play and purchase our LoggerLink Mobile Apps. User-supplied PDAs require either PConnect or PConnectCE software.

Direct Links

AC-powered PCs connect with the datalogger's CS I/O port via an SC32B or SC-USB interface. These interfaces provide optical isolation. A battery-powered laptop can be attached to the CR1000's RS-232 port via an RS-232 cable—no interface required.

External Data Storage Devices

A CFM100 or NL115 module can store the CR1000's data on an industrial-grade CompactFlash (CF) card. The CR1000 can also store data on an SC115 2-GB Flash Memory Drive.

Mountable Displays

The CD100 and CD295 can be mounted in an enclosure lid. The CD100 has the same functionality and operation as the CD1000KD, allowing both data entry and display without opening the enclosure. The CD295 displays real-time data only.

Short Haul Modems

The SRM-5A RAD Short Haul Modem supports communications between the CR1000 and a PC via a four-wire unconditioned line (two twisted pairs).

Multidrop Interface

The MD485 intelligent RS-485 interface permits a PC to address and communicate with one or more dataloggers over the CABLE2TP two-twisted pair cable. Distances up to 4000 feet are supported.

Internet and IP Networks

Campbell Scientific offers several interfaces that enable the CR1000 to communicate with a PC via TCP/IP.

Radios

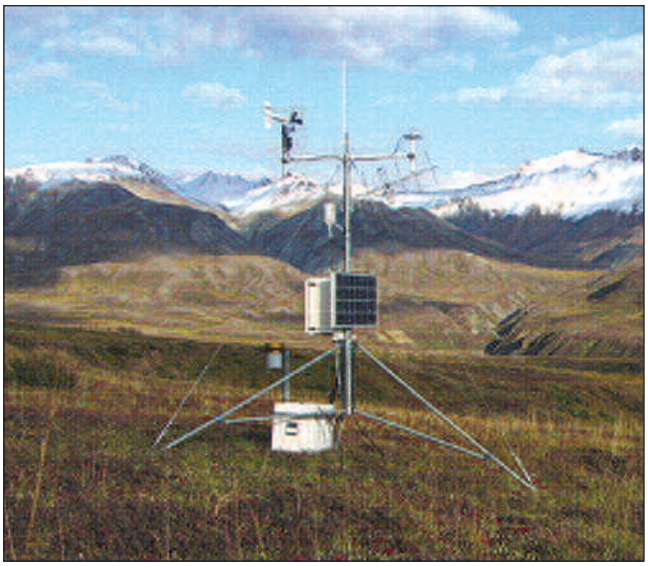
Radio frequency (RF) communications are supported via narrowband UHF, narrowband VHF, spread spectrum, or meteor burst radios. Line-of-sight is required for all of our RF options.

Telephone Networks

The CR1000 can communicate with a PC using landlines, cellular CDMA, or cellular GPRS transceivers. A voice synthesized modem enables anyone to call the CR1000 via phone and receive a verbal report of real-time site conditions.

Satellite Transmitters

Our NESDIS-certified GOES satellite transmitter provides one-way communications from a Data Collection Platform (DCP) to a receiving station. Campbell Scientific also offers an Argos transmitter that is ideal for high-latitude applications.



This weather station at Denali National Park, Alaska, transmits data via a GOES satellite transmitter.

Channel Expansion

4-Channel Low Level AC Module

The LLAC4 is a small peripheral device that allows customers to increase the number of available low-level ac inputs by using control ports. This module is often used to measure up to four anemometers, and is especially useful for wind profiling applications.

Synchronous Devices for Measurement (SDMs)

SDMs are addressable peripherals that expand the datalogger's measurement and control capabilities. For example, SDMs are available to add control ports, analog outputs, pulse count channels, interval timers, or even a CANbus interface to the system. Multiple SDMs, in any combination, can be connected to one datalogger.

Multiplexers

Multiplexers increase the number of sensors that can be measured by a CR1000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR1000.



The CR1000 is compatible with the AM16/32B (shown above) and AM25T multiplexers.

Software

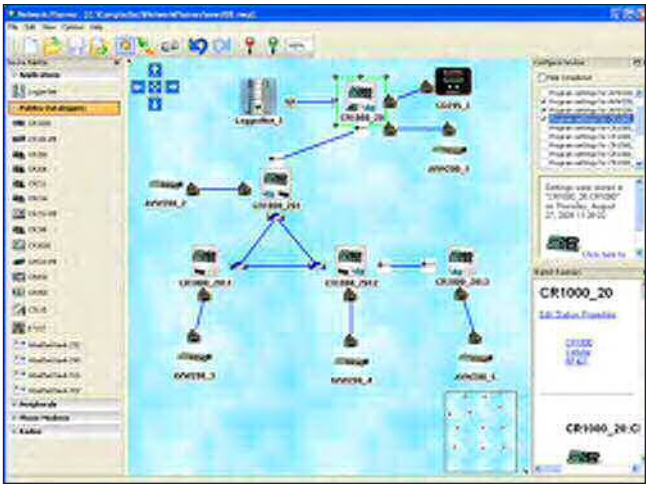
Starter Software

Our easy-to-use starter software is intended for first time users or applications that don't require sophisticated communications or datalogger program editing. SCWin Short Cut generates straight-forward CR1000 programs in four easy steps. PC200W allows customers to transfer a program to, or retrieve data from a CR1000 via a direct communications link.

At www.campbellsci.com/downloads you can download starter software at no charge. Our ResourceDVD also provides this software as well as PDF versions of our brochures and manuals.

Datalogger Support Software

Our datalogger support software packages provide more capabilities than our starter software. These software packages contains program editing, communications, and display tools that can support an entire datalogger network.

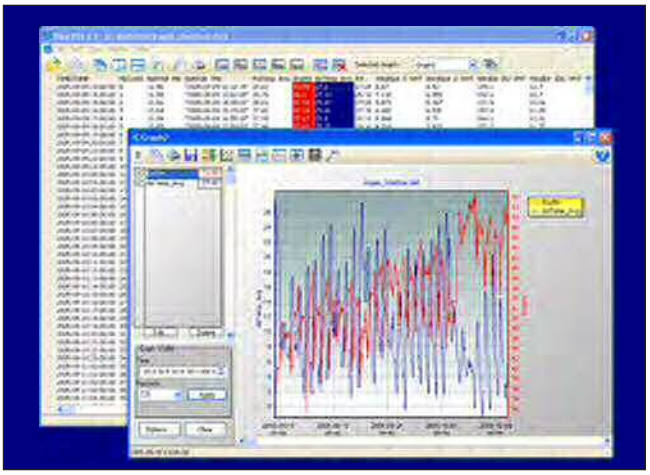


The Network Planner, included in LoggerNet 4 or higher, generates device settings and configures the LoggerNet network map for PakBus networks.

PC400, our mid-level software, supports a variety of telemetry options, manual data collection, and data display. For programming, it includes both Short Cut and the CRBasic program editor. PC400 does not support combined communication options (e.g., phone-to-RF), PakBus® routing, or scheduled data collection.

RTDAQ is an ideal solution for industrial and real-time users desiring to use reliable data collection software over a single telecommunications medium, and who do not rely on scheduled data collection. RTDAQ's strength lies in its ability to handle the display of high speed data.

LoggerNet is Campbell Scientific's full-featured datalogger support software. It is referred to as "full-featured" because it provides a way to accomplish almost all the tasks you'll need to complete when using a datalogger. LoggerNet supports combined communication options (e.g., phone-to-RF) and scheduled data collection.



Both LoggerNet and RTDAQ use View Pro to display historical data in a tabular or graphical format.

Applications

The measurement precision, flexibility, long-term reliability, and economical price of the CR1000 make it ideal for scientific, commercial, and industrial applications.

Meteorology

The CR1000 is used in long-term climatological monitoring, meteorological research, and routine weather measurement applications.



Our rugged, reliable weather station measures meteorological conditions at St. Mary's Lake, Glacier National Park, MT.

Sensors the CR1000 can measure include:

- cup, propeller, and sonic anemometers
- tipping bucket rain gages
- wind vanes
- pyranometers
- ultrasonic ranging sensor
- thermistors, RTDs, and thermocouples
- barometric pressure sensors
- RH sensors
- cooled mirror hygrometers

Agriculture and Agricultural Research

The versatility of the CR1000 allows measurement of agricultural processes and equipment in applications such as:

- plant water research
- canopy energy balance
- machinery performance
- plant pathology
- crop management decisions
- food processing/storage
- frost prediction
- irrigation scheduling
- integrated pest management



This vitaculture site in Australia integrates meteorological, soil, and crop measurements.

Wind Profiling

Our data acquisition systems can monitor conditions at wind assessment sites, at producing wind farms, and along transmission lines. The CR1000 makes and records measurements, controls electrical devices, and can function as PLCs or RTUs. Because the datalogger has its own power supply (batteries, solar panels), it can continue to measure and store data and perform control during power outages.

Typical sensors for wind assessment applications include, but are not limited to:

- sonic anemometers
- three-cup and propeller anemometers (up to 10 anemometers can be measured by using two LLAC4 peripherals)
- wind vanes
- temperature sensors
- barometric pressure
- wetness
- solar radiation



Photo courtesy npower renewables

A Campbell Scientific system monitors an offshore wind farm in North Wales.

For turbine performance applications, the CR1000 monitors electrical current, voltage, wattage, stress, and torque.

Soil Moisture

The CR1000 is compatible with the following soil moisture measurement technologies:

- Soil moisture blocks are inexpensive sensors that estimate soil water potential.
- Matric water potential sensors also estimate soil water potential but are more durable than soil moisture blocks.
- Time-Domain Reflectometry Systems (TDR) use a reflectometer controlled by a CR1000 to accurately measure soil water content. Multiplexers allow sequential measurement of a large number of probes by one reflectometer, reducing cost per measurement.
- Self-contained water content reflectometers are sensors that emit and measure a TDR pulse.
- Tensiometers measure the soil pore pressure of irrigated soils and calculate soil moisture.

Air Quality

The CR1000 can monitor and control gas analyzers, particle samplers, and visibility sensors. It can also automatically control calibration sequences and compute conditional averages that exclude invalid data (e.g., data recorded during power failures or calibration intervals).

Road Weather/RWIS

Our fully NTCIP-compliant Environmental Sensor Stations (ESS) are robust, reliable weather stations used for road weather/RWIS applications. A typical ESS includes a tower, CR1000, two road sensors, remote communication hardware, and sensors that measure wind speed and direction, air temperature, humidity, barometric pressure, solar radiation, and precipitation.

Water Resources/Aquaculture

Our CR1000 is well-suited to remote, unattended monitoring of hydrologic conditions. Most hydrologic sensors, including SDI-12 probes, interface directly to the CR1000. Typical hydrologic measurements:

- **Water level** is monitored with incremental shaft encoders, double bubblers, ultrasonic ranging sensors, resistance tapes, strain gage pressure transducers, or vibrating wire pressure transducers. Vibrating wire transducers require an AVW200-series or another vibrating wire interface.
- **Ionic conductivity** measurements use one of the switched excitation ports from the CR1000.
- **Samplers** are controlled by the CR1000 as a function of time, water quality, or water level.
- **Alarm and pump actuation** are controlled through digital I/O ports that operate external relay drivers.



A turbidity sensor was installed in a tributary of the Cedar River watershed to monitor water quality conditions for the city of Seattle, Washington.

Vehicle Testing

This versatile, rugged datalogger is ideally suited for testing cold and hot temperature, high altitude, off-highway, and cross-country performance. The CR1000 is compatible with our SDM-CAN interface and GPS16X-HVS receiver.



Vehicle monitoring includes not only passenger cars, but airplanes, locomotives, helicopters, tractors, buses, heavy trucks, drilling rigs, race cars, and motorcycles.

The CR1000 can measure:

- **Suspension**—strut pressure, spring force, travel, mounting point stress, deflection, ride
- **Fuel system**—line and tank pressure, flow, temperature, injection timing
- **Comfort control**— fan speed, ambient and supply air temperature, refrigerant pressures, solar radiation, ac on and off, time-to-comfort, blower current
- **Brakes**—line pressure, pedal pressure and travel, ABS, line and pad temperature
- **Engine**—pressure, temperature, crank position, RPM, time-to-start, oil pump cavitation
- **General vehicle**—chassis monitoring, road noise, vehicle position and speed, steering, air bag, hot/cold soaks, wind tunnels, traction, CANbus, wiper speed and current, vehicle electrical loads

Other Applications

- Eddy covariance systems
- Wireless sensor/datalogger networks
- Mesonet systems
- Avalanche forecasting, snow science, polar, high altitude
- Fire weather
- Geotechnical
- Historic preservation

CR1000 Specifications

Electrical specifications are valid over a -25° to +50°C, non-condensing environment, unless otherwise specified. Recalibration recommended every two years. Critical specifications and system configuration should be confirmed with Campbell Scientific before purchase.

PROGRAM EXECUTION RATE

10 ms to one day @ 10 ms increments

ANALOG INPUTS (SE1-SE16 or DIFF1-DIFF8)

8 differential (DF) or 16 single-ended (SE) individually configured. Channel expansion provided by multiplexers.

RANGES and RESOLUTION: Basic resolution (Basic Res) is the A/D resolution of a single conversion. Resolution of DF measurements with input reversal is half the Basic Res.

Range (mV)[1]	DF Res (µV)[2]	Basic Res (µV)
±5000	667	1333
±2500	333	667
±250	33.3	66.7
±25	3.33	6.7
±7.5	1.0	2.0
±2.5	0.33	0.67

[1]Range overhead of ~9% on all ranges guarantees that full-scale values will not cause over range.
[2]Resolution of DF measurements with input reversal.

ACCURACY[3]:
±(0.06% of reading + offset), 0° to 40°C
±(0.12% of reading + offset), -25° to 50°C
±(0.18% of reading + offset), -55° to 85°C (-XT only)

[3]Accuracy does not include the sensor and measurement noise. Offsets are defined as:
Offset for DF w/input reversal = 1.5·Basic Res + 1.0 µV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 µV
Offset for SE = 3·Basic Res + 3.0 µV

ANALOG MEASUREMENT SPEED:

Integration Type/ Code	Integration Time	Settling Time	Total Time[5] SE w/ No Rev	Total Time[5] DF w/ Input Rev
250	250 µs	450 µs	~1 ms	~12 ms
60 Hz[4]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[4]	20.00 ms	3 ms	~25 ms	~50 ms

[4]AC line noise filter.
[5]Includes 250 µs for conversion to engineering units.

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±2.5 mV input range; digital resolution dominates for higher ranges.
250 µs Integration: 0.34 µV RMS
50/60 Hz Integration: 0.19 µV RMS

INPUT LIMITS: ±5 Vdc

DC COMMON MODE REJECTION: >100 dB

NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.

INPUT CURRENT: ±1 nA typical, ±6 nA max. @ 50°C; ±90 nA @ 85°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):
±0.3°C, -25° to 50°C
±0.8°C, -55° to 85°C (-XT only)

ANALOG OUTPUTS (Vx1-Vx3)

3 switched voltage, sequentially active only during measurement.

RANGE AND RESOLUTION: Voltage outputs programmable between ±2.5 V with 0.67 mV resolution.

V_x ACCURACY: ±(0.06% of setting + 0.8 mV), 0° to 40°C
±(0.12% of setting + 0.8 mV), -25° to 50°C
±(0.18% of setting + 0.8 mV), -55° to 85°C (-XT only)

V_x FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 2500 mv square waves for exciting vibrating wire transducers.

CURRENT SOURCING/SINKING: ±25 mA

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: Ratiometric measurements of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Precise, dual polarity excitation for voltage excitations eliminates dc errors. Offset values are reduced by a factor of two when excitation reversal is used.

VOLTAGE RATIO ACCURACY[6]: Assuming excitation voltage of at least 1000 mV, not including bridge resistor error.

±(0.04% of voltage reading + offset)/V_x

[6]Accuracy does not include the sensor and measurement noise. The offsets are defined as:
Offset for DF w/input reversal = 1.5·Basic Res + 1.0 µV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 µV
Offset for SE = 3·Basic Res + 3.0 µV

PERIOD AVERAGE

Any of the 16 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading + resolution), where resolution is 136 ns divided by the specified number of cycles to be measured.

INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	Input Range (±mV)	Signal (peak to peak)[7] Min. (mV)	Signal (peak to peak)[7] Max (V)	Min Pulse Width (µV)	Max[8] Freq (kHz)
1	250	500	10	2.5	200
10	25	10	2	10	50
33	7.5	5	2	62	8
100	2.5	2	2	100	5

[7]With signal centered at the datalogger ground.
[8]The maximum frequency = 1/(twice minimum pulse width) for 50% of duty cycle signals.

PULSE COUNTERS (P1-P2)

2 inputs individually selectable for switch closure, high frequency pulse, or low-level ac. Independent 24-bit counters for each input.

MAXIMUM COUNTS PER SCAN: 16.7×10^6

SWITCH CLOSURE MODE:
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open w/o being counted

HIGH-FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 µs time constant.

LOW-LEVEL AC MODE: Internal AC coupling removes AC offsets up to ±0.5 Vdc.
Input Hysteresis: 12 mV RMS @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

Sine Wave (mV RMS)	Range(Hz)
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

DIGITAL I/O PORTS (C1-C8)

8 ports software selectable, as binary inputs or control outputs. Provide edge timing, subroutine interrupts/wake up, switch closure pulse counting, high frequency pulse counting, asynchronous communications (UARTs), SDI-12 communications, and SDM communications.

HIGH-FREQUENCY MAX: 400 kHz

SWITCH CLOSURE FREQUENCY MAX: 150 Hz

EDGE TIMING RESOLUTION: 540 ns

OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1

OUTPUT RESISTANCE: 330 ohms

INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V

INPUT HYSTERESIS: 1.4 V

INPUT RESISTANCE: 100 kohm with inputs <6.2 Vdc
220 ohm with inputs ≥6.2 Vdc

SERIAL DEVICE/RS-232 SUPPORT: 0 TO 5 Vdc UART

SWITCHED 12 VDC (SW-12)

1 independent 12 Vdc unregulated source is switched on and off under program control. Thermal fuse hold current = 900 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

CE COMPLIANCE

STANDARD(S) TO WHICH CONFORMITY IS DECLARED: IEC61326:2002

COMMUNICATIONS

RS-232 PORTS:
9-pin: DCE (not electrically isolated) for battery-powered computer or non-CSI modem connection.
COM1 to COM4: Four independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rates: selectable from 300 bps to 115.2 kbps.
Default Format: 8 data bits; 1 stop bits; no parity
Optional Formats: 7 data bits; 2 stop bits; odd, even parity

CS I/O PORT: Interface with CSI telecommunication peripherals

SDI-12: Digital control ports 1, 3, 5, and 7 are individually configured and meet SDI-12 Standard version 1.3 for datalogger mode. Up to ten SDI-12 sensors are supported per port.

PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals

PROTOCOLS SUPPORTED: PakBus, Modbus, DNP3, FTP, HTTP, XML, POP3, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM

SYSTEM

PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core RUNNING AT 7.3 MHz)

MEMORY: 2 MB of Flash for operating system; 4 MB of battery-backed SRAM for CPU usage, program storage and final data storage.

RTC CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional.

RTC CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc

EXTERNAL BATTERIES: 12 Vdc nominal (power connection is reverse polarity protected)

INTERNAL BATTERIES: 1200 mAh lithium battery for clock and SRAM backup that typically provides three years of backup

TYPICAL CURRENT DRAIN:
Sleep Mode: ~0.6 mA (0.9 mA max.)
1 Hz Sample Rate (1 fast SE meas.): 1 mA
100 Hz Sample Rate (1 fast SE meas.): 16.2 mA
100 Hz Sample Rate (1 fast SE meas. w/RS-232 communication): 27.6 mA
Optional Keyboard Display On (no backlight): add 7 mA to current drain
Optional Keyboard Display On (backlight on): add 100 mA to current drain

PHYSICAL

DIMENSIONS: 23.9 x 10.2 x 6.1 cm (9.4 x 4 x 2.4 in.); additional clearance required for cables and leads.

WEIGHT (datalogger + base): 1 kg (2.1 lb)

WARRANTY

3 years against defects in materials and workmanship.

Copyright © 2004, 2012
Campbell Scientific, Inc.
Printed October 2012

Wind Speed and Direction Sensors

05103 Wind Monitor, 05106 Wind Monitor-MA, 05305 Wind Monitor-AQ

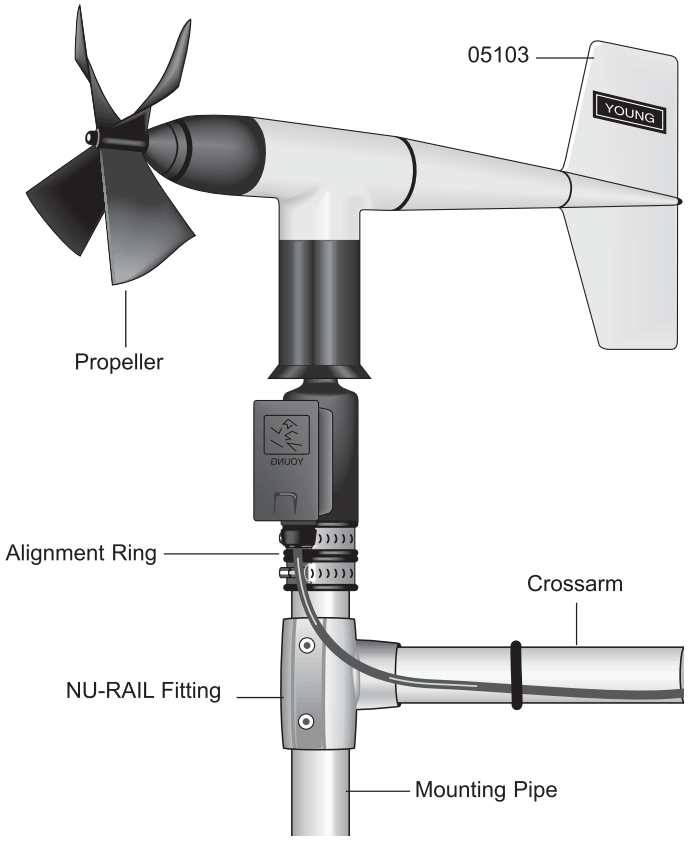
RM Young's Wind Monitors are light-weight instruments that measure wind speed and direction. Their design emphasizes simplicity and lightweight construction. The Wind Monitors are made out of rigid UV-stabilized thermoplastic with stainless steel and anodized aluminum fittings. The thermoplastic material resists corrosion from sea air environments and atmospheric pollutants. The Wind Monitors use stainless steel precision-grade ball bearings for the propeller shaft and vertical shaft bearings. Cabled for use with our dataloggers, the Wind Monitors are compatible with all of our contemporary dataloggers and many of our retired dataloggers (e.g., 21X, CR23X).

Wind Speed

The wind speed sensor for all the Wind Monitors is a helicoid-shaped, four-blade propeller. Rotation of the propeller produces an ac sine wave that has a frequency directly proportional to wind speed. The ac signal is induced in a transducer coil by a six-pole magnet mounted on the propeller shaft. The coil resides on the non-rotating central portion of the main mounting assembly, eliminating the need for slip rings and brushes.

Wind Direction

All of the Wind Monitors use a potentiometer to measure wind direction. The datalogger applies a known precision excitation voltage to the potentiometer element. The output signal is an analog voltage directly proportional to the azimuth angle.



This 05103 Wind Monitor is attached to a crossarm via a 17953 NU-RAIL fitting and a mounting pipe (shipped with the sensor).

Model Descriptions

05103 Wind Monitor

The 05103 Wind Monitor is a sturdy instrument for measuring wind speed and direction in harsh environments. Its simplicity and corrosion-resistant construction make it ideal for a wide range of wind measuring applications.

05106 Wind Monitor-MA

The 05106 Wind Monitor-MA is a robust instrument designed for offshore and marine applications. It features waterproof bearing lubricant and a sealed, heavy-duty cable pigtail instead of the standard junction box.

Model Descriptions (continued)

05305 Wind Monitor-AQ

The 05305 Wind Monitor-AQ is a high performance wind speed and direction sensor designed specifically for air quality measurements. It provides a lower starting threshold, faster response, and higher accuracy than the other wind monitors. However, to achieve the superior performance, the 05305 is less ruggedly constructed. The Wind Monitor-AQ meets or exceeds the requirements published by the following regulatory agencies:

- U.S. Environmental Protection Agency—Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) and On-Site Meteorological Instrumentation Requirements to Characterize Diffusion from Point Sources
- U.S. Nuclear Regulatory Agency—NRC Regulatory Guide 1.23 Meteorological Programs in Support of Nuclear Power Plants
- American Nuclear Society—Standard for Determining Meteorological Information at Nuclear Power Plants



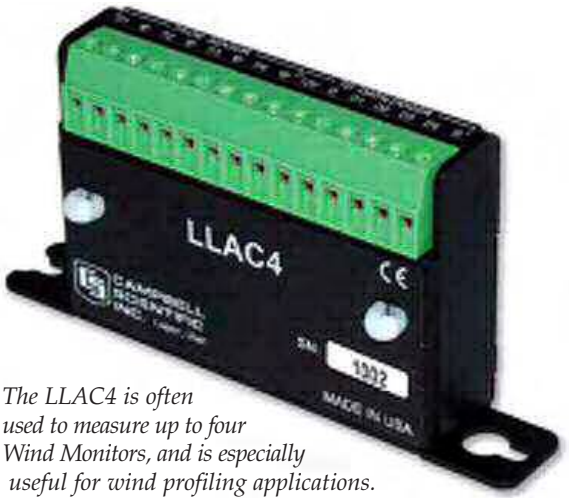
The 05305 Wind Monitor-AQ provides high accuracy measurements, typically for air quality applications.

Mounting

The Wind Monitors can be attached to a CM202, CM204, or CM206 crossarm via a NU-RAIL fitting or CM220 Right Angle Mounting Bracket. Alternately, the Wind Monitors can be attached to the top of our stainless-steel tripods via the CM216 Sensor Mounting Kit.

Wind Profile Studies

Wind profile studies measure many wind sensors. For these applications, the LLAC4 4-Channel Low Level AC Conversion Module can be used to increase the number of Wind Monitors measured by one datalogger. The LLAC4 allows datalogger control ports to read the wind speed sensor's ac signals instead of using pulse channels. Dataloggers compatible with the LLAC4 are the CR200-series (ac signal ≤1 kHz only), CR800, CR850, CR1000, CR3000, and CR5000.



The LLAC4 is often used to measure up to four Wind Monitors, and is especially useful for wind profiling applications.

Ordering Information

Wind Monitors

05103-L_	Wind Monitor with user-specified lead length. Specify the lead length, in feet, after the L. For example, 05103-L13 order a 13 ft lead length.
05106-L_	Wind Monitor-MA for marine applications with user-specified lead length. Specify the lead length, in feet, after the L. For example, 05106-MA-L13 order a 13 ft lead length.
05305-L_	Wind Monitor-AQ for air quality applications with user-specified lead length. Specify the lead length, in feet, after the L. For example, 05305-L13 order a 13 ft lead length.

Mounts

17953	1" x 1" NU-RAIL Fitting for attaching the Wind Monitor to a crossarm, such as a CM202, CM204, or CM206 crossarm.
CM220	Right Angle Mounting Bracket for attaching the Wind Monitor to a crossarm, such as a CM202, CM204, or CM206.
CM216	Sensor Mounting Kit for attaching sensor to atop a CM110, CM115, or CM120 stainless-steel tripod.



An innovative method of discouraging interference from birds is shown in this photo of a wind measurement station at St. Peter and St. Paul Rocks (Brazil). The station was located in the mid-Atlantic during the SEQUAL (Seasonal Equatorial Atlantic Experiment) field program. Photo courtesy Dr. Silvia L. Garzoli (Director of the Physical Oceanography Division of the Atlantic Oceanographic and Meteorological Laboratory of NOAA).

Wind Profile Accessory

LLAC4	4-Channel Low-Level AC Conversion Module

Recommended Lead Lengths

These lead lengths assume the sensor is mounted atop the tripod/tower via a CM202 crossarm.

CM6	CM10	CM110	CM115	CM120	UT10	UT20	UT30
10'	13'	13'	19'	24'	13'	24'	34'

	05103 ***05103-10***	***05106*** ***05106-10*** ***05106C*** ***05106C-10***	***05305*** ***05305-10***
Wind Speed			
Range:	0-100 m/s (0-224 mph)	0-100 m/s (0-224 mph)	0-50 m/s (0-112 mph)
Accuracy:	±0.3 m/s (±0.6 mph)	±0.3 m/s (±0.6 mph)	±0.2 m/s (±0.4 mph)
Starting Threshold:	1.0 m/s (2.2 mph)	1.1 m/s (2.4 mph)	0.4 m/s (0.9 mph)
Distant Constant (63% Recovery):	2.7 m (8.9 ft)	2.7 m (8.9 ft)	2.1 m (6.9 ft)
Output:	A/C Voltage (3 pulses per revolution) 1800 RPM 90 Hz = 8.8 m/s (19.7 mph)	A/C Voltage (3 pulses per revolution) 1800 RPM 90 Hz = 8.8 m/s (19.7 mph)	A/C Voltage (3 pulses per revolution) 1800 RPM 90 Hz = 9.2 m/s (20.6 mph)
Wind Direction			
Range:	0-360° Mechanical, 0-355° Electrical (5° Open)	0-360° Mechanical, 0-355° Electrical (5° Open)	0-360° Mechanical, 0-355° Electrical (5° Open)
Accuracy:	±3°	±3°	±3°
Starting Threshold at 10° Displacement:	1.1 m/s (2.2 mph)	1.1 m/s (2.2 mph)	0.5 m/s (1.0 mph)
Delay Distance (50% Recovery):	1.3m (4.3 ft)	1.3m (4.3 ft)	1.2m (3.9 ft)
Damping Ratio:	0.25	0.25	0.45
Damped Natural Wavelength:	7.2m (23.6 ft)	7.2m (23.6 ft)	4.4m (14.4 ft)
Output:	Analog D/C Voltage from 10kohm Potentiometer	Analog D/C Voltage from 10kohm Potentiometer	Analog D/C Voltage from 10kohm Potentiometer
Power	Switched Excitation supplied by the Datalogger	Switched Excitation supplied by the Datalogger	Switched Excitation supplied by the Datalogger

	05103 ***05103-10***	***05106*** ***05106-10*** ***05106C*** ***05106C-10***	***05305*** ***05305-10***
Operating Temperature	-50°C to 50°C, assuming non-riming conditions	-50°C to 50°C, assuming non-riming conditions	-50°C to 50°C, assuming non-riming conditions
Dimensions			
Overall:	37 cm H by 55 cm L (14.6 " H by 21.7 " L)	37 cm H by 55 cm L (14.6 " H by 21.7 " L)	38 cm H by 65 cm L (15.0 " H by 25.6 " L)
Main Housing Diameter:	5 cm (2.0 ")	5 cm (2.0 ")	5 cm (2.0 ")
Propeller Diameter:	18 cm (7.1 ")	18 cm (7.1 ")	20 cm (7.9 ")
Mounting Pipe:	34 mm (1.34 ") OD; Standard 1.0 " IPS Schedule 40	34 mm (1.34 ") OD; Standard 1.0 " IPS Schedule 40	34 mm (1.34 ") OD; Standard 1.0 " IPS Schedule 40
Weight			
Sensor:	1.5 kg (3.2 lbs)	1.5 kg (3.2 lbs)	1.1 kg (2.5 lbs)
Shipping (Approximate):	2.3 kg (5.5 lbs)	2.3 kg (5.5 lbs)	2.3 kg (5.5 lbs)
Cable	Supplied by CSC Standard Length 3.3m (10 ft) Custom Lengths Available	Supplied by RMY / CSC Standard Length 3.3m* (10 ft) Custom Lengths Available * 05106C Standard Length 1m (3.3 ft) + Custom Length (with Connectors)	Supplied by CSC Standard Length 3.3m (10 ft) Custom Lengths Available

copyright 1991, 2007
Campbell Scientific, Inc.
Printed March 2007

HC2-S3-L

Temperature & Relative Humidity Probe

CAMPBELL SCIENTIFIC®
WHEN MEASUREMENTS MATTER

The HC2-S3-L, manufactured by Rotronic Instrument Corp., measures air temperature with a Pt100 IEC751 1/3 class B and measures relative humidity (RH) based on the HygroClip2 technology. Each HygroClip2 probe is 100% interchangable and can be swapped in seconds without any loss of accuracy, eliminating the downtime typically required for the recalibration process.



Sensor Mounts

When exposed to sunlight, the HC2-S3-L must be housed in a 41003-X or 43502 radiation shield. To attach the 41003-X to a CM202, CM204, or CM206 crossarm, place the 41003-X 's u-bolt in the bottom holes. To attach the radiation shield directly to a tripod mast, tower mast, or tower leg, place the u-bolt in the side holes.

Ordering Information

HC2-S3-L	Temperature and RH Probe with 6 ft. lead length
41003-X	10-Plate Gill Radiation Shield
43502	Motorized aspirated radiation shield
R41046DS-15	Adaptor

Specifications

Relative Humidity

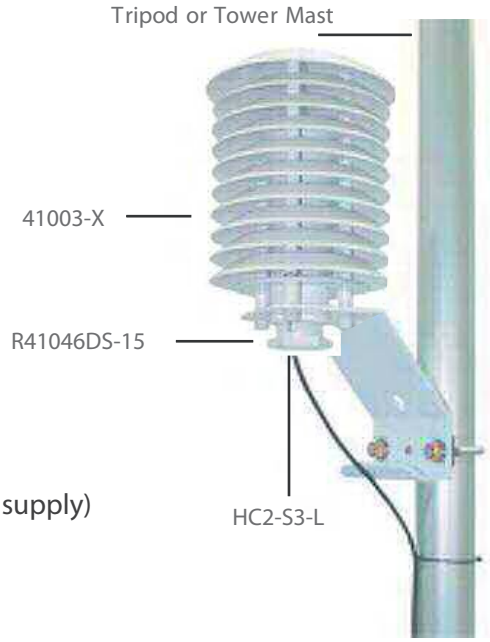
Operating range:	0 to 100% RH
Accuracy @23°C:	±0.8% RH
Output:	0 - 1 VDC
Typical Long- Term Stability:	Better than ±1% RH per year

Temperature

Measurement Range:	-40° to +60°C or -50° to +50°C: ±0.1°C (@0°C)
Temperature Accuracy:	-50° to +60°C: ±0.4°C (worst case)
Output:	0 - 1 VDC

General

Supply Voltage:	5 to 24 VDC (typically powered by datalogger's 12 VDC supply)
Current Consumption:	< 4 mA
Diameter:	0.59" (15.00 mm)
Length:	6.6" (168 mm)
Housing Material:	Polycarbonate

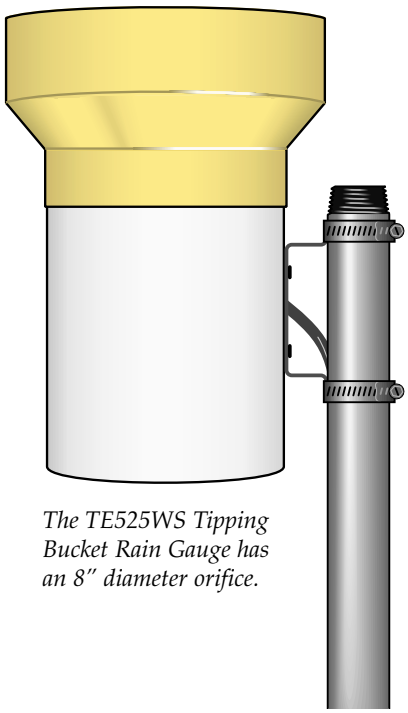


Rain Gauges

Models TE525WS, TE525, TE525M

The TE525 series tipping bucket rain gauges are manufactured by Texas Electronics. Both the TE525WS and TE525 measure in 0.01 inch increments; the TE525M measures in 0.1 mm increments. These gauges funnel precipitation into a bucket mechanism that tips when filled to a calibrated level. A magnet attached to the tipping mechanism actuates a switch as the bucket tips. The momentary switch closure is counted by the pulse-counting circuitry of Campbell Scientific dataloggers.

The TE525WS and TE525 are compatible with Campbell Scientific's CS705 Snowfall Conversion Adapter which allows you to measure the water content of snow. The TE525 requires a recalibration when the CS705 is added or removed; the TE525WS does not. The TE525M is not compatible with the CS705. For more information about the CS705, refer to the CS705 product literature.



The TE525WS Tipping Bucket Rain Gauge has an 8" diameter orifice.

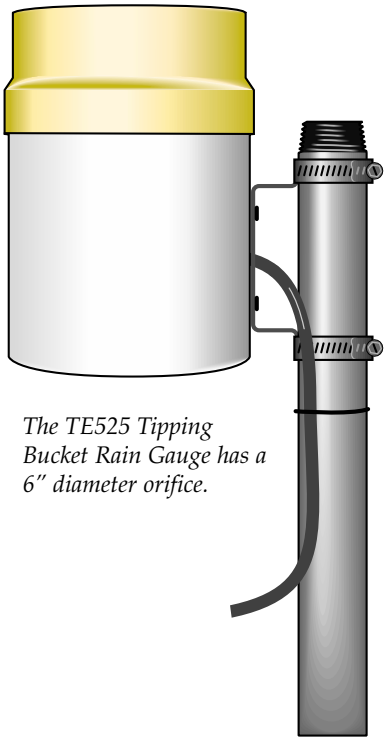
Mounting

The gauge mounts to a user-supplied threaded pole. Accurate measurements require the gauges to be level.

Ordering Information

TE525WS-L__	8-inch diameter; 0.01 inch tips; user-specified lead length.* Enter lead length (in feet) after L.
TE525-L__	6-inch diameter; 0.01 inch tips; user-specified lead length.* Enter lead length (in feet) after L.
TE525M-L__	24.5 cm diameter; 0.1 mm tips; user-specified lead length.* Enter lead length (in feet) after L.

To measure frozen precipitation with the TE525WS please consider the CS705 Snowfall Conversion Adapter.



The TE525 Tipping Bucket Rain Gauge has a 6" diameter orifice.

**A 25' lead length is recommended for most applications, e.g. TE525WS-L25.*

CAMPBELL SCIENTIFIC
CANADA CORP
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

Specifications

Sensor type: Tipping bucket/magnetic reed switch

Material: Anodized aluminum

Temperature: 0° to +50°C

Resolution: 1 tip

Cable: 2-conductor shielded cable

	TE525WS	TE525	TE525M	
Rainfall per tip:	0.01" (0.254 mm)	0.01" (0.254 mm)	0.004" (0.1 mm)	
Orifice diameter:	8" (20.3 cm)	6.06" (15.4 cm)	9.66" (24.5 cm)	
Height:	10.5" (26.7 cm)	9.5" (24.1 cm)	11.5" (29.21 cm)	
Weight:	2.5 lbs. (1.1 kg)	2.5 lbs. (1.1 kg)	2.7 lbs. (1.2 kg)	
Accuracy:				
Up to 1 inch/hr:	±1%	±1%	Up to 10 mm/hr:	±1%
1 to 2 inch/hr:	+0, -2.5%	+0, -3%	10 to 20 mm/hr:	+0, -3%
2 to 3 inch/hr:	+0, -3.5%	+0, -5%	20 to 30 mm/hr:	+0, -5%

CAMPBELL SCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655
www.campbellsci.ca

Copyright © 1990, 2002
Campbell Scientific, Inc.
Printed March 2002

AirLink® GX400 Multipurpose Intelligent Gateway

Fully Featured for Mobile and Fixed Environments

RUGGED VERSATILITY

The AirLink GX400 multi-purpose intelligent gateway is ideal for a myriad of machine-to-machine applications. A small, rugged form factor and multiple interfaces give the GX400 the versatility for location-aware applications in mobile and fixed environments at an affordable price.

EXPANDABLE, FLEXIBLE, MODULAR PLATFORM

The GX400 achieves high performance and reliability, and offers GPS, 3G mobile broadband connectivity, and ALEOS intelligence. An expansion slot enables the easy addition of I/O and communications ports, providing unparalleled flexibility and versatility. The existence of the expansion slot on the GX400 enables feature additions without comprehensive design changes and/or further certification.

The GX400 is designed for use in mobile environments (AVL/tracking, field service, public safety) or fixed/portable settings (industrial, utilities, security, enterprise, point-of-sale). A “one device fits all” solution allows customers to deploy and manage the same device for multiple applications, simplifying deployment and management.

RUGGED INTELLIGENCE

ALEOS™ embedded intelligence, powers AirLink devices, and supports 24/7 always-on availability, persistent connectivity, end-to-end security, real-time two-way data exchange, and remote device management. ALEOS features over 700 configurable parameters, including machine, routing and location protocols, security, events reporting and much more.

REMOTE MANAGEMENT

ALEOS facilitates the comprehensive remote management capabilities of our AirLink device management tools to enable remote configuration, administration, and control of deployments of any size, from one device to thousands.

INTELLIGENCE ON THE EDGE MADE EASY

The new ALEOS Application Framework is a powerful embedded software environment that helps accelerate M2M solutions development. By leveraging ALEOS embedded intelligence for foundational M2M features, ALEOS AF provides the best of both worlds by supporting both out-of-the-box configuration with a programming environment to build customized solutions.

ALEOS AF enables developers to concentrate their development resources on building their specific application.



KEY BENEFITS:

- Persistent, reliable network connectivity
- Versatile for M2M applications, including mobile and fixed solutions
- High performance and reliability at a mid-tier price
- Remote management, control and configuration
- Easy installation and seamless integration with legacy equipment
- Application Framework for developing custom M2M applications



POWERED BY: ALEOS™

SIERRA WIRELESS™ | AirLink®

AirLink® GX400 Multipurpose Intelligent Gateway

Technical Specifications

PRODUCT FEATURES

- ALEOS Embedded Intelligence
- Comprehensive device management and configuration
- Highly configurable with easy to use interface
- AirLink Configurable Rules Engine
- ALEOS Application Framework for custom M2M application development
- Expansion card slot
- Rugged design
- Multiple connection options
- Robust ARM 11-class processor
- 5 Year Warranty

SECURITY

- Onboard IPsec SSL VPN Client
- VPN Pass-Through (AH protocols)
- GRE Tunneling
- MAC Address Filtering
- IP Filtering
- Port Filtering
- SSH
- HTTPS

GPS TECHNOLOGY

- Precision GPS
- Time to First Fix: 39 sec.
- Garmin FMI support
- Accuracy: 3M 68% CEP

TECHNOLOGY

- HSPA+ with fallback to: HSPA, HSDPA, UMTS, EDGE, GPRS

or

- EV-DO Rev. A with fallback to: CDMA EV-DO (Rev. 0), CDMA 1xRTT

BANDS

- Quad-Band HSUPA 850, 900, 1900, 2100 MHz
- Quad-Band GSM/GPRS 850, 900, 1800, 1900 MHz

or

- Dual Band EV-DO Rev. A 800, 1900 MHz

ENVIRONMENTAL

- Operating Temperature: -30°C to +70°C / -22°F to +158°F
- Storage Temperature: -40°C to +85°C / -40°F to +185°F

DIMENSIONS

- 143 mm x 96 mm x 44 mm 5.6 in x 3.8 in x 1.7 in
- 341 grams 12 oz

STANDARDS/APPROVALS

- FCC, Industry Canada
- RoHS Compliant
- CE, E-Mark
- Mil-Spec 810-F, IP64
- Class 1 Div 2
- Carrier Specific Approvals

HOST INTERFACES

- 10/100 Base-T RJ45 Ethernet
- RS-232 Serial Port
- USB On The Go
- 1 Digital I/O Port
- Wi-Fi access point or client (optional expansion card)
- 3 SMA Antenna Connectors (RF, GPS, Rx Diversity)



APPLICATIONS:

- Field Service
- Energy + Utilities
- Security Surveillance
- Retail / Point-of-Sale
- Infrastructure Monitoring
- Digital Signage
- Automatic Vehicle Location



APPLICATION INTERFACES

- TCP/IP, UDP/IP, DHCP, HTTP, NMEA, TAIP, TSIP, GPS

LED INDICATORS

- Network
- Signal Strength
- Activity
- Power/GPS

Sierra Wireless, the Sierra Wireless logo, AirLink, ALEOS and the red wave design are trademarks of Sierra Wireless. Other registered trademarks that appear on this brochure are the property of the respective owners.
© 2012 Sierra Wireless, Inc. www.sierrawireless.com

SIERRA WIRELESS™ | AirLink®

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

ENC10/12, ENC12/14, ENC14/16, ENC16/18

Fiberglass Weather-Resistant Enclosures



Rugged, Versatile

Campbell components mount easily and securely

Overview

Campbell Scientific offers fiberglass-reinforced polyester enclosures for housing our dataloggers and peripherals. Dataloggers and peripherals housed in an enclosure with desiccant are protected from water and most pollutants.

Benefits and Features

- Weather resistant to protect instruments
- Backplate designed so that Campbell Scientific components mount easily and securely
- White, UV-stabilized enclosure reflects solar radiation—reducing temperature gradients inside the enclosure without requiring a separate radiation shield

Enclosure Supply Kit

The enclosure supply kit is included with these enclosures. The assembled equipment aids in mounting your equipment inside the enclosure as well as monitoring relative humidity and sealing the enclosure. The kit consists of desiccant packs, humidity indicator card, cable ties, putty, screws, grommets, PVC plug, and a Phillips-head screwdriver.

Cable-Entry Option Details

Conduit(s)

Multiple cables can be routed through one conduit. A plug included in the 7363 enclosure supply kit can reduce the conduit's internal diameter to 0.5 in. (1.3 cm). The enclosure supply kit also contains the putty used to seal each conduit.

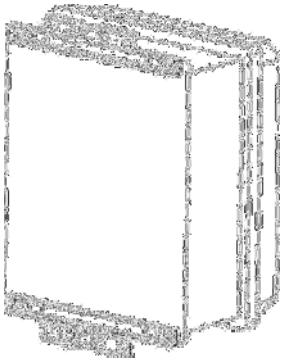
Entry Seals

Cable entry seals have a more water-tight seal than the conduits. Each entry seal is compressed around one cable. A small vent is included to equalize pressure with the atmosphere. The entry seals come in three sizes that accept the following cable diameters:

- Large—6 to 13 mm (0.24 to 0.51 in.)
- Medium—5.8 to 10 mm (0.23 to 0.39 in.)
- Small—3 to 7 mm (0.12 to 0.28 in.)

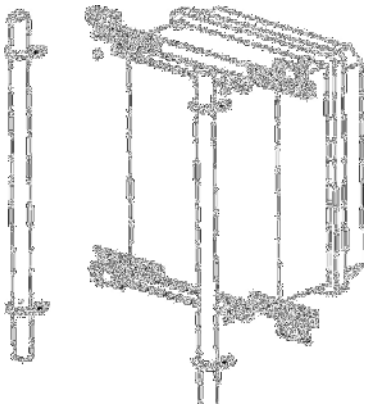
The number of cable entry seals provided depends on the enclosure model:

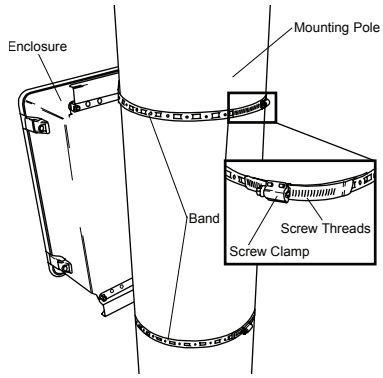
- ENC10/12—(1) medium, (2) small
- ENC12/14—(2) medium, (2) small
- ENC14/16—(2) large, (2) medium, (2) smalll
- ENC16/18—(2) large, (2) medium, (2) small



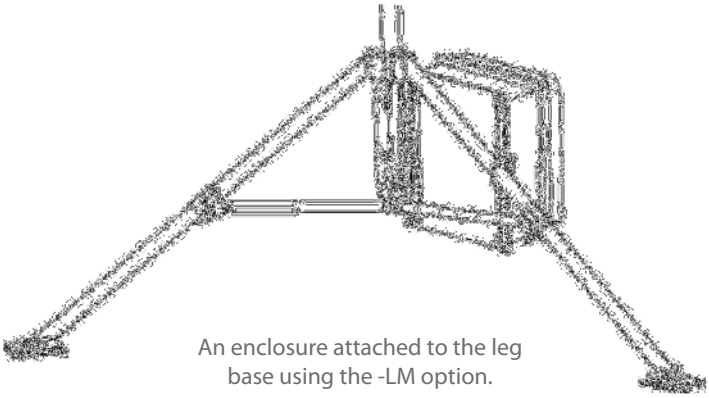
At left is an enclosure with the *-MM* mount option. The bracket is ready to be attached to a mast or user-supplied vertical pipe with a 1.25-in. to 2.1-in. outer diameter.

At right is an exploded view of the -TM option. It shows the bracket components and how the enclosure attaches to a tower.





At left shows the -PM option, where the enclosure is mounted to a large diameter pole via band clamps.



An enclosure attached to the leg base using the -LM option.

Ordering Information

Fiberglass Enclosures

ENC10/12	Weather-Resistant 10 x 12 inch Enclosure. Includes an internal plate punched with a grid of one-inch-on-center holes for mounting devices.
ENC10/12R	Weather-Resistant 10 x 12 inch Enclosure with raised lid. Includes an internal plate punched with a grid of one-inch-on-center holes for mounting devices.
ENC12/14	Weather-Resistant 12 x 14 inch Enclosure. Includes an internal plate punched with a grid of one-inch-on-center holes for mounting devices.
ENC14/16	Weather-Resistant 14 x 16 inch Enclosure. Includes an internal plate punched with a grid of one-inch-on-center holes for mounting devices.
ENC16/18	Weather-Resistant 16 x 18 inch Enclosure. Must choose a backplate option (see below).

Enclosure Hole Options

-SC	One Conduit for cable entry.
-DC	Two horizontally-arranged 1.5-in. diameter conduits for cable entry.
-VC	Two vertically-arranged 1.5-in. diameter conduits for cable entry (available for the ENC16/18 only).
-ES	Individual-Cable Entry Seals. The number of cable entry seals provided depends on the enclosure model (see page 1 for details)

Enclosure Mounts Options

Besides the options listed below, special brackets are also available for attaching enclosures to CTS Towers, Rohn Towers, Aluma Towers, or - fi . fi .

- MM	Tripod Mast Mounting for attachment to the mast of one of our tripods or to a user-supplied pipe with a 1.25-in. to 2.1-in. outer diameter.
-LM	Tripod Leg Mounting. This option allows an ENC10/12, ENC12/14, or ENC14/16 to be attached to the leg base of a CM106, CM110, CM115, or CM120 tripod. For the ENC16/18 enclosure, this option allows the enclosure to be attached to the leg base of a CM106 tripod.
-TM	Tower Mounting for attachment to a UT10, UT20, or UT30 tower (see note at bottom of page).
-PM	Pole Mounting for attachment to a large-diameter pole with a 4 to 10 in. outer diameter.

Backplate Options for ENC16/18 only

-SB	Standard Backplate with a grid of one-inch-on-center holes for mounting devices.
-EB	Backplate and sideplate. Both plates include a grid of one-inch-on-center holes for mounting devices.

Note: *E - M fi U 10 . U 20 U 30 :*

(1) .
(2) fl fl 17 .
(3) .

Ordering Information Continued

Antenna Cable/Bulkhead Installations

Th ff . Th y -

19332 Compatible with the type N-to-type N antenna cable used with the RF320-series radios, RF310-series radios, and GOES satellite transmitters.

19335 Compatible with the type N-to-RPSMA antenna cable used with the RF401-series spread spectrum radios, CR200(X)-series dataloggers, or AVW200-series Interfaces.

19334 Compatible with the type N-to-SMA antenna cable used with the RF450 radio or RavenXT-series cellular modems.

19333 Compatible with the type N-to-TNC antenna cable used with the retired Raven100-series or retired Redwing100-series digital cellular modems.

19336 Compatible with the type SMA-to-SMA antenna cable used with the GPS device included with our GOES satellite transmitters.

Other Campbell-Installed Accessories

28701 Enclosure Desiccant and Document Holder Installed in Enclosure Lid. It contains a zipped bag for two-packs of desiccant and an open pocket for documents.

27814 CD100 Mountable Display with Keypad Installed in Enclosure Lid. The CD100 provides the same operation and functionality as the CR1000KD, allowing both data entry and display without opening the enclosure. It is typically used with our CR800 and CR1000 dataloggers.

18132 CD295 DataView II Display Installed in Enclosure Lid. The CD295 displays real-time data only, and is used with PakBus® dataloggers (i.e., CR200(X), CR800, CR850, CR1000, CR3000).

18132 CD294 DataView Display Installed in Enclosure Lid. The CD294 displays real-time data only, and is used with mixed-array dataloggers (e.g., CR510, CR10X).

18166 Door Open Indicator Installed in Enclosure. This small accessory monitors when the door of the enclosure is open. The switch is monitored with a datalogger control port.

Miscellaneous Accessories

10525 User-installed two-pack desiccant holder that mounts to the inside of the enclosure lid.

CS210 Enclosure Humidity Sensor contains an Elan HM2000-series precision bulk polymer relative humidity sensor.

6714 Replacement Desiccant 4 Unit Bag (Qty 20).

28960 Enclosure Stack Mounting Kit.

18165 User-installed door open indicator. This small accessory monitors when the door of the enclosure is open. The switch is monitored with a datalogger control port.



CD 00 fl

66



—



CS 0

RH

3 %

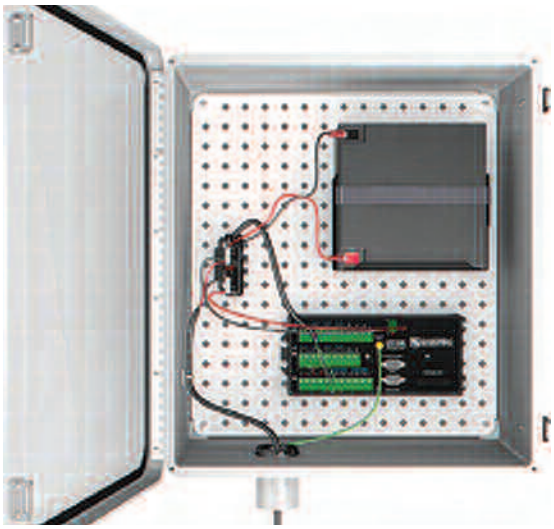


8960

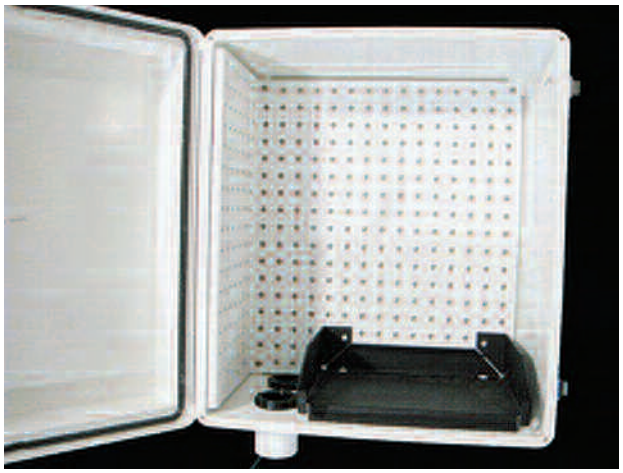
ff

Specifications

	ENC10/12	ENC12/14	ENC14/16	ENC16/18
Can House	CR200(X)-series datalogger, power supply, and a small peripheral. A CR800, CR850, or CR1000 can also be housed if using the 28960 stack bracket kit.	CR200(X)-series, CR800, CR850, CR1000, or CR3000 datalogger, a power supply, and one or more peripherals, depending on the footprint	CR200(X)-series, CR800, CR850, CR1000, CR3000, or CR5000 datalogger, power supply, and one or more peripherals (depending on the peripheral's footprint).	CR200(X)-series, CR800, CR850, CR1000, CR3000, or CR5000 datalogger, power supply, and two or more peripherals (depending on the peripheral's footprint).
Color	White (reflects solar radiation, reducing temperature gradients inside the enclosure without using a separate radiation shield)			
Construction	Fiberglass-reinforced polyester enclosure with door gasket, external grounding lug, stainless-steel hinge, and lockable hasps			
Classification	NEMA 4X (before being modified for cable entry)			
Dimensions	25.4 x 30.5 x 11.4 cm (10 x 12 x 4.5 in.)	30.5 x 35.6 x 14 cm (12 x 14 x 5.5 in.)	35.6 x 40.6 x 14 cm (14 x 16 x 5.5 in.)	40.6 x 45.7 x 22.9 cm (16 x 18 x 9 in.)
Weight	4.1 kg (9.0 lb)	5 kg (11.2 lb)	6 kg (13 lb)	7.7 kg (17 lb)



An ENC16/18 houses a CR1000 datalogger, CH200 Regulator, and BP24 battery pack. This enclosure has a -SC enclosure hole option.



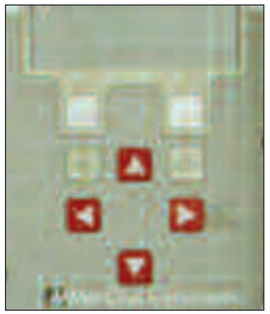
This ENC16/18 has the -VC enclosure hole option and the -EB backplate option, which includes a backplate and sideplate.



The above enclosure shows the horizontal arrangement of the conduits when the *-DC* enclosure hole option is chosen.

© 2012
Campbell Scientific, Inc.
October 31, 2012

Specifications



Specifications

Concentration Ranges (Auto-ranging)	0-0.5, 0-1, 0-10 0-65 mg/m3
Laser	670 nm, 5 mW
Sensitivity	0.001mg/m3
Sample Period	1 sec
Sample Flow Rate	2 LPM
Pump Type	Diaphram 10,000 hr
Accuracy	8% of NIOSH 0600
Precision	0.003 mg/m3 or 2% reading
Particle Size Sensitivity Range	0.1-100 micron
Long term Stability	5% reading
Sensor Type	Forward Light Scatter
Average Period	1 – 60 minutes
Display	4X20 LCD
Internal Battery (Optional)	12 VDC 12 Amp-Hr, lead acid
Power Consumption	350mA (no heater) 1.1 A (w/heater)
Internal Battery Operation, no heater	>30 Hours
with heater	10 Hours
Battery Type	Lead Acid
Size	10.5 (267) X 9.25 (235) X 5.7 (145) inches (mm)
MOI Service Period	2 yrs
Programmable Auto-Zero	15min to 24 hours
Programmable Auto-Span	15min to 24 hours
Traceable Testing	Gravimetric
Sample Line Heater	Configurable RH Con trolled
Outputs	Analog 0-1,0-2.5, 0-5VDC, RS232
Data Storage Capacity	12000 Records
Temperature Compensation	Standard
Temperature Range	-10 deg to 50 deg C
RH Measurement	Internal
Ambient Temperature	-30 deg to 50 deg C
Ambient Pressure	1040 to 600 mbars
Alarm	Contact Closure
Available Cut Points	TSP, PM10, PM2.5, PM1

Standard Equipment
Universal Voltage Power Supply
Battery Charger Internal
47 mm Filter Holder
Comet Software
TSP Inlet
Inlet Heater
Digital Output Cable
Instruction Manual

Options
PM10, PM2.5, PM1 Sharp-Cut Cyclone
Extra 47 mm Filter Holders
Aluminum Tripod
MicroMet Software
Radio Modem
Phone Modem
Satellite
Wind Speed/Direction Sensor
Ambient RH
External Battery Cable
Battery

Met One Instruments, Inc.
Sales & Service: 1600 Washington Boulevard, Grants Pass, Oregon 97526 • Tel 541/471-7111, Fax 541/471-7116
Regional Sales & Service: 3206 Main Street, Suite 106, Rowlett, Texas 75088 • Tel 972/412-4747, Fax 972/412-4716
http://www.metone.com

11/08

E-SAMPLER™



The New Standard in Real-Time Aerosol Monitoring

The E-SAMPLER is the most feature-packed light-scatter Aerosol Monitor available. Whatever your monitoring needs, the E-sampler will provide accurate, dependable and relevant data.

Features
- Programmable Auto-Zero
- Programmable Auto-Span
- Auto-ranging (1 to 65000 ∝m/m3)
- Automatic Flow Control Protocol
- Internal Battery (30 Hours Operation without heater & 10 Hours with heater.)
- Laser-Diode Precise Optical Engine
- Integral 47mm Analysis Filter
- Ambient Pressure and Temperature
- Internal Datalogger
- PM_{10}, $PM_{2.5}$, PM_1, TSP Monitoring
- Aluminum Weatherproof Enclosure
- Sheath-Air protected Optics
- Completely Self-Contained
- No Tools Filter Replacement

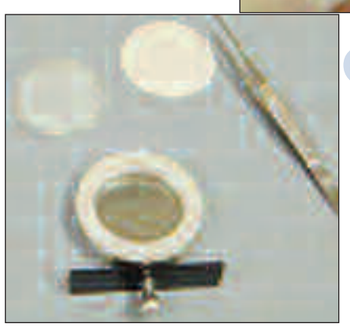
Applications
- Ambient Air Monitoring
- Remediation Site Perimeter Monitoring
- Indoor Air Quality Monitoring
- Source Monitoring
- Visibility Monitoring
- Mobile Monitoring

Met One Instruments, Inc.

E-SAMPLER™

Dual Technology
The E-SAMPLER is a dual technology instrument that combines the unequalled real-time measurement of light scatter with the accuracy standard of filter methods. The simple filter loading process testifies to the seamless blending of both technologies. Filters can be extracted and replaced in less than one minute and filter medium can be selected based on laboratory analysis. Particulate loading on the filter does not reduce performance due to the Met One actual flow control protocol. Ambient temperature and pressure are measured and actual flow is calculated and controlled by the E-SAMPLER microprocessor independent of filter loading change.





Principle
The E-SAMPLER provides real-time particulate measurement through near-forward light scattering. An internal rotary vane pump draws air at 2 LPM into the sensing chamber where it passes through visible laser light. Aerosols in the air scatter light in proportion to the particulate load in the air. Scattered light is collected by precise glass optics and focused on a PIN diode. Rugged state of the art electronics measure the intensity of the focused light and output a signal to the CPU. The output is linear to concentrations greater than 65,000 ug/m3. Every E-SAMPLER is factory calibrated using polystyrene latex spheres of known index of refraction and diameter at multiple points to validate linearity.

Maintenance
Each E-SAMPLER has two internal filters (not the 47mm Analysis Filter) to protect sensitive optics and prevent damage to the flow components. Both filters are accessible from

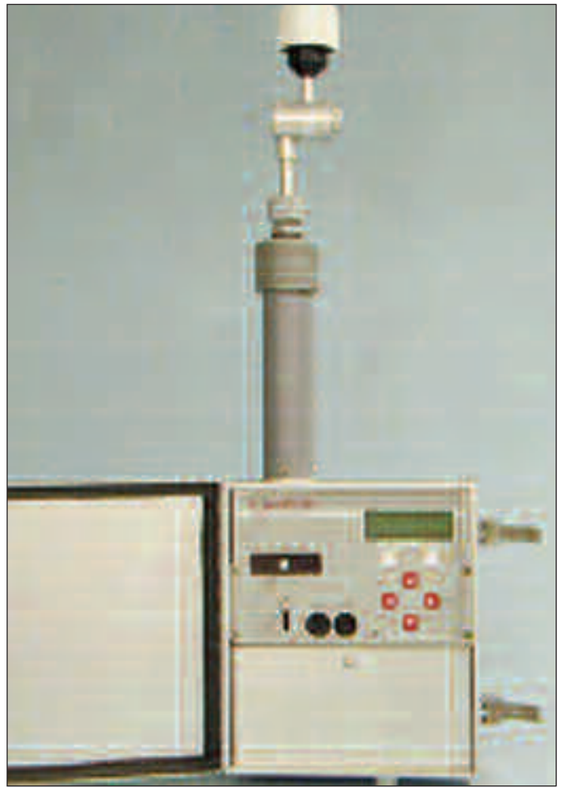


the front panel. Coin slots enable these filters to be removed and checked or replaced without any tools. Filter life for both will exceed 1 year in the harshest of conditions. All E-SAMPLERS have sheath air from the internal filters that continually curtain the optics. This sheath air protection allows the E-SAMPLER to

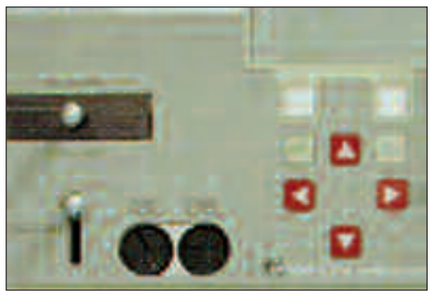


continuous aerosol monitoring

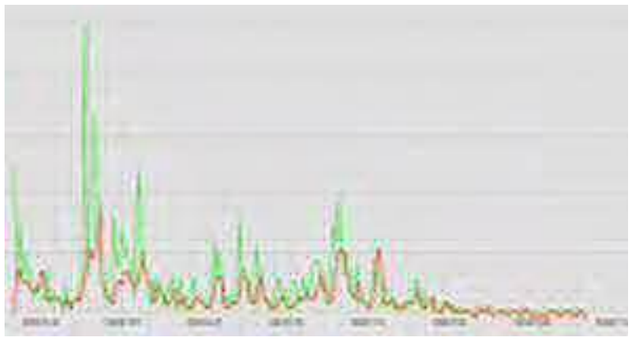
be used in adverse environments without performance degradation. Even in harsh conditions the E-SAMPLER will operate to specifications for 2 years without need of recalibration.



Operation
The E-SAMPLER is rugged, portable and easy to use. The all aluminum enclosure is not only rugged but provides electronic stability by filtering potential RF interference. Set-up is a snap with the quick connect system which works with the EX-905 tripod. For other mounting applications, holes are provided to fasten to any structure. Simply turning the monitor on will start a sample using the most recent parameters. The unit will continue to operate until user intervention or battery failure. Auto-Zero and Auto-Span ensure that the data collected will be of the highest quality. Both Zero and Span can be operated manually or individually programmed at varying time bases (15 minutes to 24 hours). The E-SAMPLER can also be configured for start/stop times, recording periods, averaging time and other parameters.



Data Collection and Software
Optional MicroMet Plus is a complete communications, data collection and data reporting tool. This software supports modem, radio, direct connection and generates summary reports as well as recordings and charts. Comet software included which provides easy to use terminal access to E-Sampler data.



APPENDIX F – DUST FALL MONITORING GUIDANCE

DRAFT

Section G

AIR CONSTITUENTS - INORGANIC

© Her Majesty the Queen in
Right of the Province of British Columbia
2009
All Rights Reserved.

TABLE OF CONTENTS

SECTION G Air Constituents - Inorganic

Particulate - Total 2
Particulate - Total Ashed 4
Particulate - Total Combustible 5
Particulate - Insoluble 6
Particulate - Insoluble Ashed 8
Particulate - Soluble 10
Particulate - Soluble Ashed 12
Particulate - Soluble – Anions and Cations by Ion Chromotography 14
Particulate - Metals - ICP 16
Particulate - Phosphate 19
Precipitation - Acidity, Alkalinity, pH 22
Precipitation - Anions - Ion Chromatography 31
Precipitation - Cations - Ion Chromatography 35
Total Particulate - PM10 - HiVol 39
Total Particulate – PM10/PM02 - 47 mm - HiVol 43
Total Particulate - PM02 - HiVol 45
Total Particulate - Teflon - HiVol 47
Total Particulate - HiVol - Metals - ICP 49
Total Particulate – HiVol - Anions - Ion Chromatography 54
Total Particulate - HiVol - Sodium - Ion Chromatography 58
Sulfation Index 61
Fluoridation Index 64

Particulate - Total

Parameter Particulate – Total**:** Gravimetric

Analytical Method and EMS Code
a) Gravimetric intermediate results **TP-T X484**
b) Loading results **TP-T CAL1**

Introduction A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary The Total Particulate is the sum of Insoluble Particulate and the Soluble Particulate.

MDL 0.1 mg for intermediate result

Units
a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix Particulate

Sample Handling and Preservation If the temperature during the sampling period is below $0^{\circ}C$, either isopropanol or 50% V/V isopropanol/water is used as the solution in the canister.

Principle or Procedure

Field Preparation

a) Add 500 mL of the collection medium to the 10.4 cm diameter polyethylene canister (canister must have a tight fitting, waterproof lid). Usually deionized water, to which 2.0 mL diluted algae inhibitor has been added, is used. However, if the temperature during the sampling period is below $0^{\circ}C$, either isopropanol or 50% V/V isopropanol/water is used. The algae inhibitor is obtained commercially and diluted 1:100 before use (Note: algae inhibitor must be added to all analytical blanks).

b) Ship the prepared canisters to the field.

Laboratory Preparation

a) Transfer the sample quantitatively to a 2 litre beaker, filtering through a 20 mesh sieve to remove extraneous materials such as leaves, twigs and bugs. If the collection medium was isopropanol, use 50 to 100 mL deionized water in the transfer process.

b) Reduce the sample volume to about 200 mL by evaporating on a hot plate.

c) Allow the sample to cool, proceed to further analyses of the requested parameters i.e., step 4 of Particulate Soluble and/or Particulate Insoluble procedures.

Calculation

Total Particulate, mg = $P_1 + P_2$

where: P_1 = Insoluble Particulate in mg
P_2 = Soluble Particulate in mg.

Quality Control

Retain at least four of the canisters so that they may subsequently be used in the determination of the various blank values.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories
July 9, 1997:	Conversion to EMS code; unit correction as confirmed by E. Tradewell and N. Peppin
July 14, 1997:	Term "Dustfall" replaced by "Particulate" on request of E. Tradewell
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Total Ashed

Parameter

Particulate - Total Ashed

Analytical Method and EMS Code

a) Gravimetric intermediate result **ASHT X484**
b) Loading result **ASHT CAL1**

Introduction

A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary

The Total Ashed Particulate is the sum of the Insoluble Ashed and Soluble Ashed Particulate.

MDL

0.1 mg for intermediate results

Units

a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix

Particulate

Principle or Procedure

Calculation

Total Ashed Particulate = $P_1 + P_2$

where: P_1 = Insoluble Ashed Particulate

P_2 = Soluble Ashed Particulate

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories/
July 9, 1997:	SEAM code replaced by EMS code; units correction
July 14, 1997:	Term "Dustfall" replaced by "Particulate" on request from E. Tradewell
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Total Combustible

Parameter

Particulate - Total Combustible

Analytical Method and EMS Code

a) Gravimetric intermediate result **CP-T X484**
b) Loading result **CP-T CAL1**

Introduction

A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary

The Total Combustible Particulate is the difference between the Total Particulate and the Total Ashed Particulate.

MDL

0.1 mg for intermediate results

Units

a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix

Particulate

Principle or Procedure:

Calculation

Total Combustible Particulate = $P_1 - P_2$

where: P_1 = Total Particulate
P_2 = Total Ashed Particulate

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 9, 1997:	SEAM code replaced by EMS code; units correction
July 14, 1997:	Term “Dustfall” replaced by “Particulate” on request from E. Tradewell.
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Insoluble

Parameter Particulate Insoluble

Analytical Method and EMS Code
a) Gravimetric intermediate results **TP-I X484**
b) Loading results **TP-I X175**

Introduction A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary The prepared sample (see Particulate-Total procedure) is passed through a 0.45 µm membrane filter. The residue retained by the filter after drying to a constant weight at 105°C constitutes the insoluble particulate intermediate results with units of mg. This value is then converted to a loading unit of $mg/dm^2/d$.

MDL 0.1 mg for intermediate results

Units
a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix Particulate

Principle or Procedure:

Apparatus
a) Filtration apparatus, one litre vacuum flask fitted with a filtration assembly
b) Porcelain crucibles, 35 mL
c) Drying oven
d) Muffle furnace
e) Desiccator with desiccant
f) Analytical balance

Procedure
a) Ignite a clean porcelain crucible at 550°C in the muffle furnace for 1 hour; cool for 3 hours in a desiccator, then weigh.

b) Weigh a 0.45 µm filter (Gelman HT 450, 47 mm diameter). Place filter in desiccator.

c) Carefully place the 0.45 µm filter in the filtration apparatus.

d) Filter the prepared sample (see Particulate-Total). Note: Wash the sample container with deionized water to ensure all the sample is passed through the filter.

e) Transfer the filtrate quantitatively to a 500 mL bottle, dilute to volume, and then transfer to a polyethylene container for further analysis.

f) Return the filter and retained residue to the porcelain crucible; dry for 3 hours in an oven at 105°C; cool in desiccator and weigh.

Calculations

Insoluble Particulate, mg = $\{(W_1 - W_2) - C\}$

where W_1 = weight of filter + crucible + residue in mg
W_2 = weight of filter + crucible in mg
C = weight contribution from blank in mg

Loading calculation: units of $mg/dm^2/d$

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 14, 1997:	SEAM code replaced by EMS code; units; minor editing revisions; term "Dustfall" replaced by "Particulate" on request of E. Tradewell.
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Insoluble Ashed

Parameter

Particulate – Insoluble Ashed

Analytical Method and EMS Code

a) Gravimetric Intermediate results **AP-I X484**
b) Loading results **AP-I X175**

Introduction

A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary

The prepared sample (see Particulate-Total procedure) is passed through a 0.45 µm membrane filter. The residue after ignition at 550°C constitutes the ashed insoluble particulate.

MDL

0.1 mg for intermediate result

Units

a) Intermediate results: mg
b) Loading results: $mb/dm^2/d$

Matrix

Particulate

Principle or Procedure

Apparatus

a) Filtration apparatus, one litre vacuum flask fitted with a filtration assembly
b) Porcelain crucibles, 35 mL
c) Muffle furnace
d) Desiccator with desiccant
e) Analytical balance

Procedure

a) Ignite a clean porcelain crucible at 550°C in the muffle furnace for 1 hour; cool for 3 hours in a desiccator, then weigh.

b) Weigh a 0.45 µm filter (Gelman HT 450, 47 mm diameter). Place filter in desiccator.

c) Carefully place the 0.45 µm filter in the filtration apparatus.

d) Filter the prepared sample (see Particulate-Total procedure). Note: Wash the sample container with deionized water to ensure all the sample is passed through the filter.

e) Return the filter and retained residue to the porcelain crucible; dry for 3 hours in an oven at 105°C; cool in desiccator and weigh.

f) Transfer the crucible and filter to a muffle furnace.

g) Heat at 550°C for 1 hr, cool for 3 hr in a desiccator and then weigh, W1.

Calculations

Ashed Insoluble Particulate = $\{(W_1 - W_2) - C\}$

where W_1 = weight of filter + crucible + residue in mg, (after ashing)
W_2 = weight of filter + crucible in mg, (after ashing)
C = weight contribution from blank in mg

Loading calculation to units of $mg/dm^2/d$

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 15, 1997:	SEAM code replaced with EMS code; units correction; minor editing corrections; term "Dustfall" replaced by "Particulate" on request of E. Tradewell
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Soluble

Parameter Particulate Soluble

Analytical Method and EMS Code
a) Gravimetric intermediate results **TP-S X484**
b) Loading results **TP-S X175**

Introduction A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory plus loading calculation.

Method Summary The prepared sample (see Particulate Total procedure) is passed through a 0.45 µm membrane filter. A portion of the filtrate is then evaporated on an oven; the portion which dries to constant weight at 105°C constitutes the soluble particulate.

MDL 0.1 mg for intermediate results

Units
a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix Particulate

Principle or Procedure:

Apparatus
a) Inert crucibles, 100 mL (e.g. nickel, porcelain, platinum)
b) Drying oven
c) Steam Bath
d) Desiccator with desiccant
e) Analytical balance

Procedure

a) Ignite a clean porcelain crucible at 550°C in the muffle furnace for 1 hour; cool for 3 hours in a desiccator, then weigh.

b) Weigh a 0.45 µm filter (Gelman HT 450, 47 mm diameter). Place filter in desiccator.

c) Carefully place the 0.45 µm filter in the filtration apparatus.

d) Filter the prepared sample (see Particulate-Total procedure). Note: Wash the sample container to ensure all the sample is passed through the filter.

e) Return the filter and retained residue to the porcelain crucible; dry for 3 hours in an oven at 105°C; cool in desiccator and weigh.

f) Transfer the filtrate quantitatively to a 500 mL beaker, dilute to volume, and then transfer to a polyethylene container.

g) Dry a clean platinum crucible to constant weight at 550°C; cool in a desiccator and then weigh.

h) Measure 2 x 50 mL of the prepared filtrate into the crucible.

i) Evaporate overnight (24-48 hours) in an oven at 105°C; cool in a desiccator and weigh.

Calculations

$$\text{Soluble particulate, mg} = \frac{V_1}{V_2}\{(W_1 - W_2) - C\}$$

where V_1 = mL filtrate diluted (at step 6)
V_2 = mL filtrate evaporated
W_1 = weight of crucible + residue in mg
W_2 = weight of crucible in mg
C = weight contribution from blank in mg.

This is followed by a loading calculation to units of $mg/dm^2/d$.

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 15, 1997:	SEAM code replaced with EMS code; units correction; minor editing corrections; term "Dustfall" replaced by "Particulate" at request of E. Tradewell.
January 5, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Soluble Ashed

Parameter Particulate - Soluble Ashed

Analytical Method and EMS Code
a) Gravimetric intermediate results **AP-S X484**
b) Loading results **AP-S X175**

Introduction A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory followed by loading calculation.

Method Summary The prepared sample (see Particulate-Total procedure) is passed through a 0.45 µm membrane filter. A portion of the filtrate is then evaporated in a oven; the portion which ignites to constant weight at 550°C constitutes the ashed soluble particulate. It should be noted that if the ashed soluble particulate procedure is completed, this will preclude phosphorus and metal analysis.

MDL 0.1 mg particulate

Units
a) Intermediate results: mg
b) Loading results: $mg/dm^2/d$

Matrix Particulate

Principle or Procedure:

Apparatus
a) Inert crucibles, 100 mL (e.g. nickel, porcelain)
b) Muffle Furnace
c) Desiccator with desiccant
d) Analytical balance

Procedure
a) After completing step 9 in the Particulate Soluble procedure transfer the crucible to a muffle furnace.
b) Heat at 550^0C for 1 hr; cool for 3 hr in a desiccator and then weigh.

Calculation

$$\text{Soluble Ashed Particulate, mg} = \frac{V_1\{(W_1 - W_2) - C\}}{V_2}$$

where:
V_1 = mL filtrate diluted
V_2 = mL filtrate evaporated
W_1 = weight of platinum crucible + residue, mg
W_2 = weight of platinum crucible, mg
C = weight of contribution from blank, mg.

This is followed by a loading calculation.

Quality Control

A blank should be carried through all steps of the procedure.

References

a) American Society of Testing and Materials. Annual Book of ASTM Standards; Part 26. Philadelphia, (1974).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 23, 1997:	SEAM code replaced with EMS code; units correction; minor editing corrections; term "Dustfall" replaced by "Particulate" on request of E. Tradewell.
January 6, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Particulate - Soluble – Anions and Cations by Ion Chromotography

Parameter

NO3-: Nitrate-Soluble
SO4-: Sulphate-Soluble
Cl-S: Chloride-Soluble
Na-S: Sodium-Soluble
NH4-: Ammonium-Soluble
K--S: Potassium Soluble

Analytical Method

Ion Chromatography-Anion

EMS codes

	Intermediate Results		Loading Results
NO3-	5068	NO3-	5049
SO4-	5068	SO4-	5049
Cl-S	5068	Cl-S	5049
Ca-S	5070	Ca-S	5061
Na-S	5071	Na-S	5061
K--S	5071	K--S	5061
NH4-	5071	NH4-	5061
Mg-S	5070	Mg-S	5061

Introduction

A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory, followed by a loading calculation.

Method Summary

A portion of filtrate from the Particulate-Total procedure made up to 500 mL is analyzed by Ion Chromatography, then converted to loading units.

MDL

0.1 mg/L for intermediate results

Units

a) Intermediate results: mg/L
b) Loading results: $mg/dm^2/d$

Matrix

Particulate

Principle or Procedure

Analyze an aliquot of prepared sample (see Particulate-Total) by Ion Chromatography in accordance with the procedures for Anions - Ion Chromatography - Precipitation **or** Cations - Ion Chromatography-Precipitation.

Quality Control

A blank should be carried through all steps of the procedure.

Revision History

April 30, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories. Note regarding alternative methods added.
July 11, 1997:	SEAM codes replaced by EMS codes; units correction; term “Dustfall” replaced by “Particulate” on request of E. Tradewell
January 8, 1998:	EMS codes verified; magnesium added.

December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Also reference in Note 2 changed to current edition of Lab Manual.

Note 1:	**While anions and cations are usually reported for water samples on an elemental basis, for air samples, the convention is to report on an ion weight basis. Thus, ammonia is reported as mg/L and mg/dm^2/d as NH4 and nitrate is reported as mg/L and mg/dm^2/d as NO3.**

Note 2:	**Note that the listed anions and cations may alternatively be analyzed according to any relevant procedure specified in this edition of the BC Environmental Laboratory Manual.**

Particulate - Metals - ICP

Parameters Arsenic, Cadmium, Copper, Lead, Zinc.

Analytical Method Acid Digestion - ICP Analysis.

EMS Code See following page.

Introduction An aliquot of prepared air particulate sample (see the Particulate-Total procedure) is digested by nitric perchloric acid digestion procedure.

Method Summary Following acid digestion, aqueous solutions of metals are converted to aerosols in the nebulizer of the ICP and injected directly into a high temperature plasma (6000 to 8000°K). This highly efficient ionization produces ionic emission spectra at wavelengths specific to the elements of interest which can be monitored either simultaneously or sequentially.

MDL The following MDL concentrations (see table) are extrapolated from aqueous solutions. For instrument and analytical method MDL values, see Section C – Metals. A constant ratio (within rounding) of 11.77 has been used to convert mg/L to $mg/dm^2/d$.

Matrix Ambient Air Particulates

Interferences and Precautions See Section C – Metals, paragraph 2.4.4.

Stability Samples are stable

Procedure Reagents

a) Nitric Acid, Concentrated, analytical
b) Perchloric acid, 70%, analytical

Procedure

a) Place an aliquot of prepared sample (see Particulate-Total, Particulate-Insoluble, and Particulate-Soluble procedures) into a calibrated 75 mL digestion tube, add two mL HNO3 and heat cautiously to oxidize any organic matter; do not take to dryness.

b) Cool, then add 3.75 mL HClO4. Heat until dense white fumes are present. Final conditions are 5% HClO4.

c) Cool and make up to 75 ml with deionized water.

d) Filter through Whatman #41 filter paper and collect the filtrate in a 250 mL polyethylene bottle, and bring to volume (record this volume for calculations).

e) Analyze for As, Cd, Cu, Pb, Zn by ICP by procedures given in Section C - Metals.

f) For particulate metals soluble only step 5 is required.

EMS Codes

Element		EMS Code (nitric/perchloric acid digestion	EMS Code (aqua regia digestion)	MDL
Arsenic - Soluble	Intermediate Loading	**AS-S 5038** **AS-S 5039**	**AS-S 6038** **AS-S 6039**	0.08 mg/L 0.005 mg/dm^2/d
Arsenic - Insoluble	Intermediate Loading	**AS-I 5038** **AS-I 5039**	**AS-I 6038** **AS-I 6039**	0.08 mg/L 0.005 mg/dm^2/d
Arsenic – Total	Intermediate Loading	**AS-T 5038** **AS-T 5039**	**AS-T 6038** **AS-T 6039**	0.08 mg/L 0.005 mg/dm^2/d
Cadmium - Soluble	Intermediate Loading	**CD-S 5038** **CD-S 5039**	**CD-S 6038** **CD-S 6039**	0.004 mg/L 0.0001 mg/dm^2/d
Cadmium - Insoluble	Intermediate Loading	**CD-I 5038** **CD-I 5039**	**CD-I 6038** **CD-I 6039**	0.004 mg/L 0.0001 mg/dm^2/d
Cadmium - Total	Intermediate Loading	**CD-T 5038** **CD-T 5039**	**CD-T 6038** **CD-T 6039**	0.004 mg/L 0.0001 mg/dm^2/d
Copper - Soluble	Intermediate Loading	**CU-S 5038** **CU-S 5039**	**CU-S 6038** **CU-S 6039**	0.004 mg/L 0.0005 mg/dm^2/d
Copper - Insoluble	Intermediate Loading	**CU-I 5038** **CU-I 5039**	**CU-I 6038** **CU-I 6039**	0.004 mg/L 0.0005 mg/dm^2/d
Copper - Total	Intermediate Loading	**CU-T 5038** **CU-T 5039**	**CU-T 6038** **CU-T 6039**	0.004 mg/L 0.0005 mg/dm^2/d
Lead - Soluble	Intermediate Loading	**PB-S 5038** **PB-S 5039**	**PB-S 6038** **PB-S 6039**	0.06 mg/L 0.01 mg/dm^2/d
Lead - Insoluble	Intermediate Loading	**PB-I 5038** **PB-I 5039**	**PB-I 6038** **PB-I 6039**	0.06 mg/L 0.01 mg/dm^2/d
Lead - Total	Intermediate Loading	**PB-T 5038** **PB-T 5039**	**PB-T 6038** **PB-T 6039**	0.06 mg/L 0.01 mg/dm^2/d
Zinc - Soluble	Intermediate Loading	**ZN-S 5038** **ZN-S 5039**	**ZN-S 6038** **ZN-S 6039**	0.01 mg/L 0.001 mg/dm^2/d
Zinc - Insoluble	Intermediate Loading	**ZN-I 5038** **ZN-I 5039**	**ZN-I 6038** **ZN-I 6039**	0.01 mg/L 0.001 mg/dm^2/d
Zinc - Total	Intermediate Loading	**ZN-T 5038** **ZN-T 5039**	**ZN-T 6038** **ZN-T 6039**	0.01 mg/L 0.001 mg/dm^2/d

Calculation

From the results obtained in mg/L from the ICP analysis, select the calculation method appropriate to the reporting requirements.

mg Metal = CV

where: C = mg/L Metal in sample
V = sample volume in liters

Quality Control

To ensure accuracy and precision, quality control blanks, duplicates, and spikes must be incorporated into the analysis scheme. It should be noted that a wide variety of certified reference materials for water are available and are appropriate for soluble particulate metals analysis. Suitable reference materials for insoluble particulates are less available.

References

None listed.

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories; and at their request, a note was added regarding substitution of aqua regia digestion for perchloric acid digestion procedure
January 8, 1998:	SEAM code replaced with EMS code; term "Dustfall" replaced with "Particulate" on request of E. Tradewell; EMS codes confirmed
February 17, 1998:	EMS code for intermediate results revised to eliminate redundant variables; revised MDLs per Dr. D. Jeffery
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Reference to 1994 Manual deleted. Also preference for aqua regia digestion over percholric acid digestion noted.

Note: Aqua regia digestion is preferred in place of the nitric/perchloric acid digestion procedure. Note that these different procedures have been assigned different EMS codes.

Particulate - Phosphate

Parameter

Phosphate Total Insoluble
Phosphate Total Soluble

Analytical Method

Dig: Auto Color Ascorbic Acid

EMS Code

	Intermediate Results	Loading Results
Insoluable	**PP-I 5139**	**PP-I 5132**
Soluable	**PP-S 5139**	**PP-S 5135**

Introduction

A 10.4 cm (4.1") diameter polyethylene canister containing a collection medium is exposed to the ambient air for a period of approximately 30 days. The sample subsequently undergoes gravimetric and/or chemical analysis in the laboratory.

Method Summary

The prepared sample (see Particulate-Total procedure) is passed through a 0.45 µm membrane filter. The organic material in the sample undergoes a sulfuric acid persulfate digestion. This oxidizes the organically bound phosphorus to phosphate. The digestion with acid also hydrolyses polyphosphates to ortho phosphate. The ortho phosphate released by digestion and hydrolysis plus the ortho phosphate originally present in the sample is then reacted with ammonium molybdate to form heteropoly molybdophosphoric acid. Finally, the molybdophosphoric acid is reduced by ascorbic acid to a blue coloured complex which is measured colorimetrically at 880 nm. It is to be noted that at the concentration sulfuric acid used in the method, silica does not interfere.

MDL

0.003 mg/L P for intermediate results

Units

a) Intermediate results: mg/L
b) Loading results: $mg/dm^2/d$

Matrix

Particulate

Interferences and Precautions

a) Arsenic at levels above 0.10 mg/ L interferes by producing a blue colour

b) Mercury (II) at levels above 1.0 mg/ L interferes by giving a precipitate in the reducing step

Principle or Procedure

Apparatus

a) Culture tubes , 50 mL
b) Autoclave
c) An automated system (Technicon TrAAcs, or equivalent) consisting of
   1) sampler
   2) manifold
   3) proportioning pump

4) heating bath set at 37° C
5) colorimeter equipped with 30 mm flow cell and 880 nm filters
6) data collection system

Reagents

a) Strong Acid solution: To 600 mL Deionized water, add 150 mL conc H_2SO_4. Cool and add 2 mL conc HNO_3 and dilute to one litre.

b) Potassium Persulfate; reagent grade.

c) Ammonium Molybdate solution: Dissolve 10g ammonium molybdate, $(NH_4)_6MO_7O_{2\ 4} \bullet 4H_2O$, in one litre Deionized water. Add 120 mL conc H_2SO_4 a little at time with mixing; cool. Add 0.6 g potassium antimonyl tartrate, $K\ (SbO)C_4H_4O_6 \bullet {}^1/_2\ H_2O$, after first dissolving it in about 30 mL Deionized water. Finally, dilute to 2 litres with Deionized water.

d) Stock Ascorbic Acid solution: Dissolve 4.0 g ascorbic acid, $C_6H_8O_6$, in a mixture of 100 mL acetone and 100 mL Deionized water. Add 4 mL of wetting agent (Levor IV). Store at 4°C and prepare monthly or if signs of discolouration appear.

e) Working Ascorbic Acid solution: Add 20 mL of stock ascorbic acid solution to 100 mL Deionized water. Prepare daily.

f) Background Matrix Solution: Add 30 ml of the strong acid solution to approximately 1.5 L.

g) Stock Phosphate solution (1000 mg/L P): Dissolve 4.393 g pre-dried potassium dihydrogen phosphate, KH_2PO_4, in Deionized water and dilute to one litre.

h) Working Phosphate solution (10 mg/L P): Dilute 10 ml stock phosphate solution to one litre with Deionized water. Preserve by adding 2 mL chloroform and store at 4°C.

i) Standards Phosphate solutions: Suitable aliquots of the working solution are diluted to prepare the appropriate standards (0.02, 0.05, 0.1, 0.25, and 0.5 mg/L P).

Procedure

a) 1) Phosphate Total :
Total phosphate samples are diluted 2:1 just before loading them onto autoanalyzer.

2) Phosphate Total Soluble:
A 50 mL aliquot of the sample from step 6 of procedure TP-S5040 is digested by the total phosphorus digest method. No additional blanks are required here.

b) Regular blanks, standards and quality control samples are digested with these samples.

c) Add 25 mL of sample and standards to 50 mL test tubes.

d) To each add 0.5 mL strong acid solution and 0.1 g potassium persulfate.

e) Autoclave each at 15 psi (121°C) for 30 min. Allow the chamber pressure to drop to atmospheric pressure (without the aid of venting) before removing the samples.

f) Allow to cool and filter, unless the sample is clear.

g) Establish a baseline after all reagents have pumped through and the system is stable.

h) Adjust the gain so that the top standard (0.50 mg/L P) gives a peak height of 80%-95% full scale.

i) Run the sample and standards at 95 per hour on a TrAAcs 800 and 60/hr on an AAII (or equivalent equipment).

j) Monitor baseline drift, sensitivity drift, and carryover, and correct if necessary.

Calculation

The total phosphate concentrations are read directly from the printout, after a calibration curve is prepared from the peak heights obtained with the standard solutions. The sample concentrations are then determined by comparing the sample peak heights with the calibration curve. Baseline drift, sensitivity drift, and carryover corrections are made on the TrAAcs 800 computer system. The final step is a loading calculation.

Precision

Authentic samples at concentrations of 0.1403 and 0.4321 mg/ L P gave coefficients of variation of 1.0 and 1.6% respectively.

Accuracy

An authentic sample at a concentration of 0.3390 mg/ L P gave a relative error of -1.6%.

Quality Control

Each batch should contain a 10% level each of blank and duplicate samples with a minimum of one each per batch.

References

a) J. Murphy and J.P. Riley. Anal. Chim. Acta 27, 31 (1962).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 8, 1998:	SEAM code replaced by EMS code: term “Dustfall” replaced by “Particulate” on request of E. Tradewell; EMS codes confirmed; unavailable reference deleted.
February 16, 1998:	EMS code for intermediate results revised to eliminate redundant variables.
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Reference to out of print 1994 Manual deleted.

Precipitation - Acidity, Alkalinity, pH

Parameters and EMS Codes

Acidity: Free	**AC-F 5063**
Acidity to pH 8.3	**AC83 5062**
Alkalinity Total	**AK-T 5062**
pH (Rain)	**pH-- 5065**

Analytical Method

Electrometer/Grans Plot.

Introduction

The sample is first titrated for acidity and alkalinity, the Gran's function is calculated, then this procedure is followed by the measurement of several anions and cations by ion chromatography.

Method Summary

A glass electrode, calibrated with a pH 4.10 H_2SO_4 buffer, is used with a digital pH/mV meter to measure sample pH. Acidity is then determined on the same aliquot by titration with µL increments of 0.01N NaOH. The volume of NaOH added to the sample is plotted against the Gran's function, calculated from the readings obtained during the titration (see examples on following pages). Equivalence point for strong acidity is obtained by extrapolating the Gran's functions to the volume axis. Total alkalinity is determined in a similar manner using 0.01N H_2SO_4 .

MDL

Acidity free	0.1 µeq/L
Acidity to pH 8.3	0.1 µeq/L
Alkalinity total	0.1 µeq/L

Matrix

Precipitation (fog, rain, snow, surface water)

Interferences and Precautions

Coating of the electrode with oily or particulate matter and temperature effects are interferences.

Sample Handling and Preservation

Samples are collected with a rain sampler*, and submitted unfiltered and unpreserved. An additional pH sample drawn in a 60 mL syringe may be collected. Sample bottles should be filled leaving no head space, if sample collected from a water body. Samples should be kept at 4°C until analyzed.

***Note: Precipitation depth has EMS code PRED 5066 and MDL 0.0001 m.**

Stability

Samples are unstable due to loss of gases or absorption of atmospheric gases. Titrations should be completed within 72 hours of sampling and as soon as possible after the sample container has been opened.

Principle or Procedure

Apparatus

a) Digital pH meter, with MV scale, readable to at least the second decimal place in the pH mode.
b) Glass electrode, currently using a "low ionic strength" electrode (Radiometer PHC 2701). An equivalent electrode may be used.
c) Magnetic stirrer and stirring bar.
d) Microliter pipettes (e.g. Eppendorf) in sizes 10, 20, 50, 100 µL fixed volumes.

Reagents

a) Standard reference buffers of pH 4.10 and 6.97, low ionic strength buffers from Orion or equivalent buffers.

b) Deionized water, boiled to remove carbon dioxide, and kept covered with limited headspace, as much as possible. Boiled deionized water should be freshly prepared each week, and be used for all reagents.

c) Potassium biphthalate solution (0.005 N) - dry 15 to 20 g of primary standard, $KHC_8H_4O_4$ (100 mesh) at 120°C. Cool in a desiccator. Weigh accurately 1 g to the nearest mg, transfer to a 1 L flask, and dilute to volume with deionized water.

d) Sodium hydroxide (0.01 N) - dissolve 0.4 g NaOH in 1 L distilled water, cool, and filter. Store protected from CO_2. Standardize by differential titration of 40.00 mL $KHC_8H_4O_4$ solution to the inflection point.

Calculate the normality of the NaOH as follows:

$$\text{Normality} = \frac{A \times B}{204.2 \times C}$$

where A = weight of $KHC_8H_4O_4$ in 1 L
B = mL $KHC_8H_4O_4$ in the titration
C = mL NaOH used

Procedure

a) Allow all samples and buffers to reach laboratory temperature within 0.5°C, before analysis. Record laboratory temperature on datasheet.

b) Set the temperature compensator to the temperature of the samples.

c) Make all pH measurements as follows:
   1) Pipette a 40.00 mL aliquot of pH 6.97 buffer solution/or sample into a 50 mL beaker.
   2) Place a magnetic stir bar, carefully cleaned, into the beaker and place the beaker on a magnetic stirring apparatus. Insert the pH electrode into the sample.
   3) Stir the sample slowly for approximately 15 sec.
   4) Turn the stirrer off, allow the pH reading to stabilize (1 min) and record the reading (or make the appropriate adjustment).

d) Set the calibration control with the pH 6.97 reference buffer.

e) Rinse the electrode thoroughly in deionized water.

f) Adjust the slope control using the standard reference buffer pH 4.10.

g) Rinse the electrode thoroughly with deionized water.

h) Measure the pH of a rainfall sample using the procedure in (3) above.

i) Measure the acidity as follows:

1) Stir sample for 15 sec.
2) Turn stirrer off, allow pH reading to stabilize (45 sec) and record reading.
3) Use an Eppendorf pipette to add 10µl standard 0.01 N NaOH; repeat steps (1) and (2).
4) Continue incremental additions of 0.01 N NaOH to establish required titration curves. The capacity of the Eppendorf pipette may be varied as required.

j) After all analyses are completed, store the electrode immersed in pH 4.10 buffer.

Calculations

a) Calculate Gran's functions (Φ) for each point as follows.

Strong Acidity

$\Phi ë = (V_O + V)10^{-pH + C} = (Ve' - V)K1$

where V_O = initial sample vol (40.00 mL.)
V = mL 0.01 NaOH added.
C = arbitrary constant (7)
Ve'= equivalence point (strong acidity)

Free Acidity

$= 10^{-pH}$

b) Plot Gran's function vs. volume of NaOH added (mL). Extrapolate data points representing strong acidity component to the volume axis. Note that a minimum of three points and a correlation coefficient of at least 0.9995 is required for extrapolation.

c) Calculate the strong acidity component as follows:

Strong Acidity (µeq/L) = $N \bullet (Ve'/40.00) \times 10^6$.

where: Ve' = volume axis intercept (mL); and N = normality of the NaOH.

Total Alkalinity is determined by carrying out a procedure which is a mirror image of the procedure for total acidity. Gran's titration is carried out using standard 0.01N H_2SO_4 instead of 0.01N NaOH. Prepare the standard 0.01N H_2SO_4 as follows:

a) Sodium carbonate solution (0.05N) - dry 3 to 5 g primary standard Na_2CO_3 at 250°C for 4 hours and cool in a desiccator. Weigh

accurately 0.1 g to the nearest mg, transfer to a 500 mL volumetric flask, and dilute to volume with deionized water.

b) Standard sulfuric acid (0.01N) - dilute an ampoule of analytical concentrate to 1N with deionized water, then further dilute to 0.01 N. Standardize by potentiometric titration of 20.00 mL 0.05N Na_2CO_3 solution to the inflection point. Calculate the normality of the H_2SO_4 as follows:

$$\text{Normality} = \frac{A \times B}{53.00 \times C}$$

Where A = weight of Na_2CO_3 in one litre
B = mL Na_2CO_3 used in the titration
C = mL H_2SO_4 used

Precision and Accuracy

The precision and accuracy of the pH measurement is ±0.01 pH unit. The acidity procedure yielded mean precision values (expressed as relative standard deviations) of 1.4% for strong acidity on the intervals 24-97 µeq H+/l.

Quality Control

Determine electrode precision by making 10 replicate measurements of a known reference solution. Average of these ten measurements must be within 0.1 pH units of the reference value. The standard deviation of these measurements should be less than 0.03 pH units. Record this data along with electrode reference number in an accumulating database. This test of precision should be carried once every three months, or whenever a new electrode is introduced.

References

a) Standard Methods for the Examination of Water and Wastewater, 18th ed., APHA, AWWA, WPCF, Washington, DC (1992).
b) McQuaker Neil R., Paul D. Kluckner and Douglas K. Sandberg. 1983 "Chemical analysis of acid precipitation: pH and acidity determinations", Environmental Science and Technology, vol 17, no. 7, July 1983, p. 431 - 435.

Revision History

April 30, 1997:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 9, 1997:	SEAM codes converted to EMS codes; out-of-print references deleted
January 9, 1998:	EMS codes confirmed; edit changes confirmed with E. Tradewell
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Reference to out of print manual deleted.

ACIDITY TITRATION EXAMPLE and GRAN FUNCTION CALCULATION

Sample #: ######
Conc. of base: 0.0103 N
Volume titrated 40.0 ml
Total Point: 13

Point	Vol. added	pH	Gran's function
1	0.00	4.780	0.664D+04
2	0.02	4.920	0.481D+04
3	0.04	5.120	0.304D+04
4	0.06	5.410	0.156D+04
5	0.08	5.770	0.681D+03
6	0.10	6.070	0.341D+03
7	0.15	7.200	0.636D+02
8	0.19	8.640	0.175D+04
9	0.21	8.530	0.136D+04
10	0.23	8.870	0.298D+04
11	0.25	9.080	0.484D+04
12	0.50	10.030	0.434D+05
13	0.75	10.310	0.832D+05

Tritration Results

Strong acidity =	19.0 µeq/L
Equivalence point Vol =	0.07
Equivalence point pH =	5.62
d[H+]/dCb =	-.875
Free Acidity =	16.6 µeq/L
Free/Strong acidity:	0.875
Acidity to pH 8.3 =	43.1 µeq/L
Eq. Vol. @ pH 8.3 =	0.17 ml
Weak acidity =	26.5 µeq/L

EXAMPLE OF ALKALINITY TITRATION and GRAN FUNCTION CALCULATION

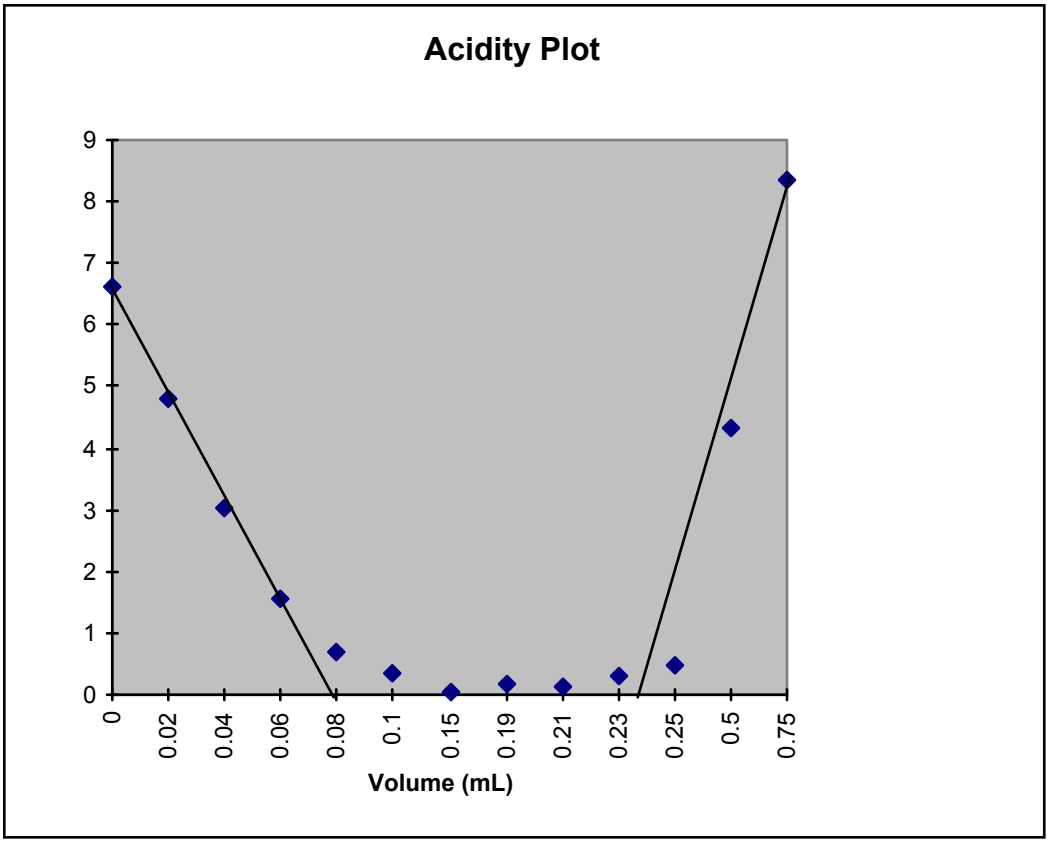
Sample #: #####
Conc. of acid: 0.0102 N
Volume titrated 40.0 ml
Total Point: 21

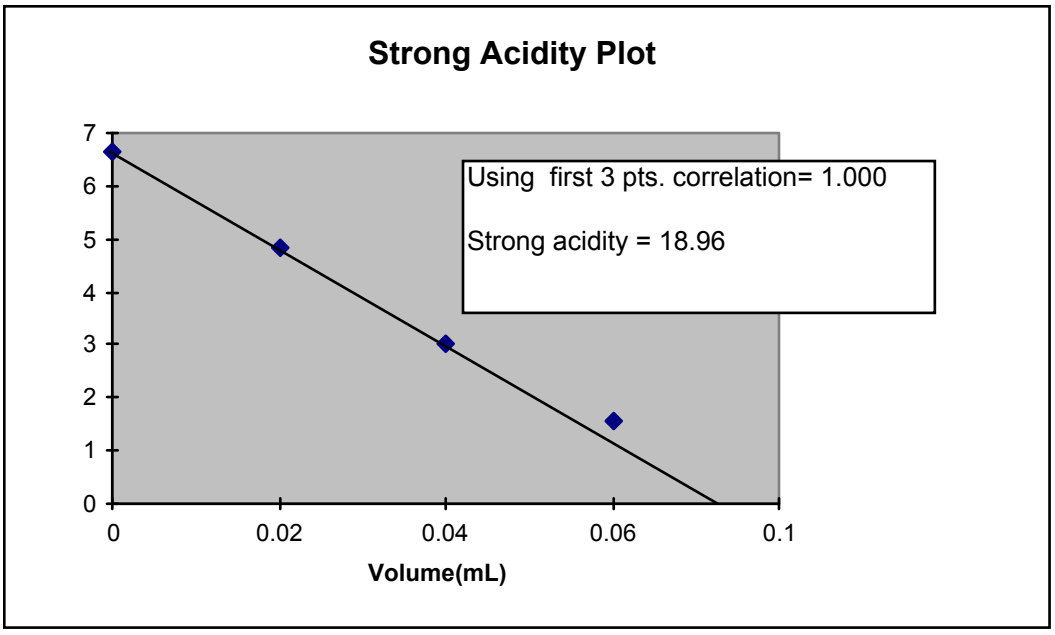
Point	Vol. added	pH	Gran's function
1	0.00	7.570	0.607D+02
2	0.02	7.560	0.000D+00
3	0.04	7.380	0.000D+00
4	0.06	7.300	0.000D+00
5	0.08	7.250	0.000D+00
6	0.10	7.180	0.000D+00
7	0.20	6.960	0.441D+02
8	0.40	6.640	0.926D+02
9	0.60	6.360	0.177D+03
10	0.80	6.090	0.332D+03
11	0.90	5.920	0.492D+03
12	0.95	5.820	0.620D+03
13	1.00	5.720	0.781D+03
14	1.05	5.590	0.106D+04
15	1.10	5.450	0.146D+04
16	1.15	5.270	0.221D+04
17	1.20	5.070	0.351D+04
18	1.25	4.880	0.544D+04
19	1.75	4.030	0.390D+05
20	2.25	3.740	0.769D+05
21	2.75	3.570	0.115D+06

Titration Results

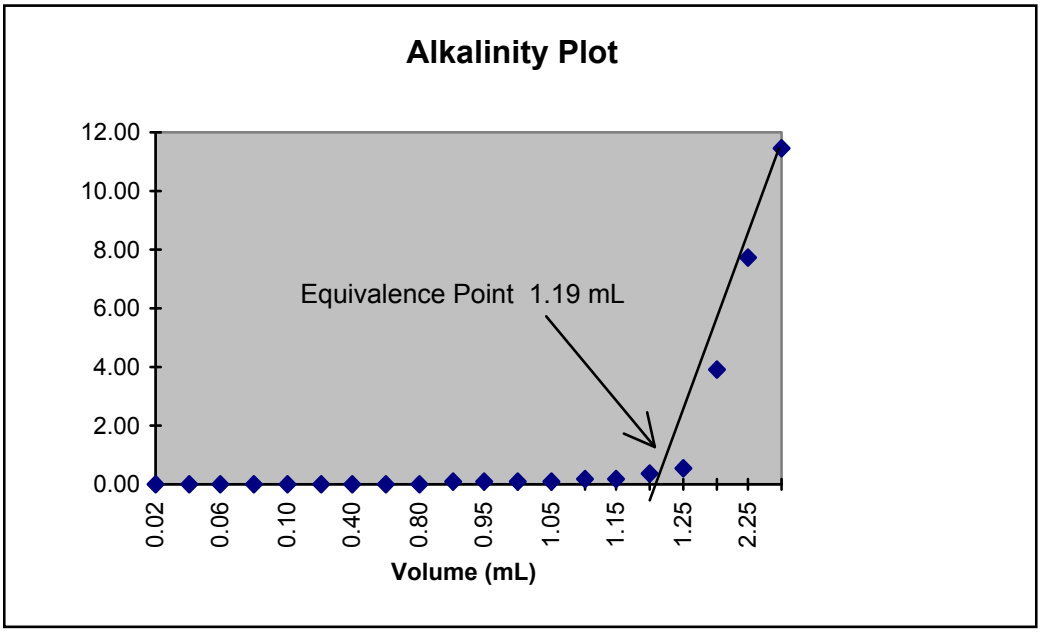
Alkalinity = 304.6 µeq/L
Equivalence point Vol = 1.19
Equivalence point pH = 5.09
d[H+]/dCa = 0.703

ACIDITY PLOT FROM EXAMPLE DATA





ALKALINITY PLOT FROM EXAMPLE DATA



PRECIPITATION CHEMISTRY EXAMPLE REPORT

LABORATORY NAME
LABORATORY ADDRESS
TELEPHONE: (XXX) XXX-XXXX FAX: (XXX) XXX-XXXX

LRTAP MONITORING REPORT: PRECIPITATION

REPORT DATE:	Dec 16/94		
FORM NUMBER:	0	Sampling Time (Start):	Dec 16/94-0000
SAMPLE NUMBER:	94000000	Sampling Time (End):	Dec 16/94-0000

Site: MDC

CATIONS	**mg/L**	**ueq/L**	**ANIONS**	**mg/L**	**ueq/L**	**OTHER**	**mg/L**
AMMONIUM	<0.01	<0.6	NITRATE	<0.01	<0.2	PHOSPHATE	<0.009
SODIUM	<0.01	<0.4	CHLORIDE	<0.01	<0.3	ALUMINUM	<0.02
POTASSIUM	<0.01	<0.3	FLUORIDE	<0.04	<2.1		
CALCIUM	<0.02	<1.0	SULPHATE	<0.02	<1.6		
MAGNESIUM	<0.02	<1.6	ALKALINITY		-		
FREE ACIDITY	0.1						
TOTAL	0.1						
SUM+ / SUM-							

---

	ueq/L at equiv. point	**mg/L CaC03 equiv.**	**Approximate pH**
STRONG ACIDITY	-	-	-
pH 8.3 ACIDITY	0.0	0.0	-
TOTAL ALKALINITY	-	-	-
pH MEASURED	7.00	-	-

	SAMPLER GAUGE	**MOE**	**AES GAUGE**
PRECIPITATION DEPTH (mm)	0.0	-	0.0
COLLECTION EFFICIENCY (%)	-	-	-

COMMENTS:

Precipitation - Anions - Ion Chromatography

Parameters and EMS Codes	Nitrate-Soluble	**NO3- 5068**
	Sulphate-Soluble	**SO4- 5068**
	Chloride-Soluble	**CI-S 5068**

Analytical Method Ion Chromatography-Anion

Introduction Precipitation samples are collected and shipped to the laboratory unpreserved. The sample is first titrated for acidity and alkalinity, the Gran's function is calculated, then several anions and cations are measured. Ion balance is also calculated.

Method Summary An ion chromatograph equipped with a conductivity detector is used to determine several common anions from a single sample injection. Samples and standards are "spiked" with concentrated carbonate / bicarbonate solution to give the sample the same background as the eluent used (avoiding a "water dip" effect). The anions of interest are separated through an anion "guard" and anion "separator" column. An anion micro membrane suppressor following the separator columns is used to reduce the background eluent conductivity by converting the carbonate and bicarbonate species to carbonic acid, while enhancing the conductivity of the ions of interest by converting these ions to there corresponding acids. A conductivity detector senses the sample species in direct proportion to their initial concentration. Note that nitrate is reported as mg NO_3/L and sulphate as mg SO_4/L.

MDL
0.01 mg/L Nitrate
0.01 mg/L Chloride
0.01 mg/L Sulphate

Matrix Water

Interferences and Precautions Interferences can be caused by substances with retention times similar to overlapping those of the ion of interest. Large amounts of an anion can interfere with peak resolution of an adjacent anion. The most common interference is due to extremely high concentrations of dissolved carbonate or weak organic acid.

Principle or Procedure

Apparatus

a) An ion chromatography system consisting of:
   1) selectable eluent supply
   2) high pressure, pulseless pump
   3) sample injection port and sample loop
   4) anion guard and separator columns
   5) anion micro membrane suppressor
   6) conductivity detector
   7) data station

8) auto sampler

Reagents

a) Concentrated Stock Eluent: Dissolve 15.12 g sodium bicarbonate ($NaHCO_3$) and 18.02 g sodium carbonate (Na_2CO_3) with Deionized water into a 1 L flask. Dilute to volume and store in a 1 litre poly bottle.

b) Working Eluent Solution: Dilute 10.0 mL of concentrated stock eluent to 1L in a volumetric flask. (1.8 m$\underline{M}$ $NaHCO_3$ / 1.7 m$\underline{M}$ Na_2CO_3) Filter before use.

c) Regenerent Solutions: 0.025 $\underline{N}$ Sulphuric acid (H_2SO_4) - Dilute 26.8 mL concentrated sulphuric acid to one liter to prepare a 1.00 $\underline{N}$ H_2SO_4 solution. Dilute 25.0 mL of this solution to one liter.

d) Stock Chloride Standard Solution: Dry 2 to 3 g of sodium chloride (NaCl) at 120°C for 2 hours and cool in a desiccator. Dissolve 1.648 g NaCl in deionized water and dilute to 1.0 liter (1.00 mL =1.00 mg Cl). Store in a poly bottle under refrigeration.

e) Stock Nitrate Standard Solution: Dissolve 1.630 g anhydrous potassium nitrate (KNO_3) in deionized water and dilute to 1liter (1.00 mL = 1.00 mg NO_3). Store in a poly bottle under refrigeration.

f) Stock Sulphate Standard Solution: Dissolve 1.479 g anhydrous sodium sulphate (Na_2SO_4) in deionized water and dilute to 1 liter (1.00 mL = 1.00 mg SO_4). Store in a poly bottle under refrigeration.

Procedure

a) Allow all samples and standards to reach laboratory temperatures before analysis.

b) Establish a constant background conductivity using the following instrument conditions:

Eluent:	0.0018 $\underline{M}$ $NaHCO_3$ / 0.0017 $\underline{M}$ Na_2CO_3;
Separator:	4 x 50 Anion Precolumn (Guard) Dionex IONPac®-AG4-SC; 4 x 250 Anion Separator Column Dionex IONPac®-AS4-SC;
Suppressor:	Anion Micro Membrane Suppressor Dionex AMMS-1;
Eluent Flow :	2.0 mL/min.;
Operating Pressure:	900 psi,
Regenerent:	0.025 $\underline{N}$ H_2SO_4;
Regenerent Flow :	2.0 - 3.0 mL/min.;
Backgrd. Conduct.	12 - 16 µS;
Injection Volume:	25 µL;
Detector Range:	Auto-range

c) Pipette 5.0 mL of each sample or standard solution into a 5 mL autosampler vial (Dionex Polyvial™) , then add 50 µL of concentrated stock eluent. Cap vial with a 0.22 µm filter cap and shake. Load into an autosampler.

d) Run a blank and at least a four point calibration curve of composite standards for each detector range. The calibration curve should include at least one calibration point for each decade of the concentration range. Calibration should be run daily when the analysis is run.

e) Run samples through the chromatograph with standards after every five samples.

Calculations

Calibration curves are programmed into the data station to be read directly off the chromatogram in terms of peak heights and in units of mg/L of anions in the filtrate.

Precision

RSD = 1.18% at 31.0 mg NO_3-N/L (water)
= 1.49% at 98.5 mg SO_4 /L (water)
= 2.89% at 10.0mg Cl/L (water)

Accuracy

100.7% at 31.0 mg NO_3-N/L (water)
104% at 98.5 mg SO_4 /L (water)
98.2% at 10.0 mg Cl/L (water)

Quality Control

a) Record the old and new standard concentrations, along with preparation dates, in a QC record sheet. New standards should be within 5% of old standards, unless previous information suggests old standards have deteriorated. Record this information on QC record sheet as a comment.

b) Record and plot the mid-range check standard run between every fifth sample. Maintain this record in such a manner to allow comparison between runs. If limiting the ions to record, do at least Cl. When sufficient data is recorded, determine control limits. For the interim, control limits of ± 10% should be used.
Note: This is not an independent reference standard. This check is to monitor within run drift.

c) Run an independent reference standard prepared from an alternate salt with addition of flouride, nitrite, bromide, phosphate to check peak resolution and column integrity.

References

a) J.P. Smith, D. Grodjean and J.N. Pitts, J.Air Pollut. Contr. Assoc. 28, 930 (1978).
b) Dionex Corporation,. Basic Ion Chromatography. 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A.
c) Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 18th edition, 1992.

Revision History	April 1, 1996:	Initial draft
	October 29, 1996:	Procedure vetted by private sector laboratories. Note regarding alternative methods added.
	July 11, 1997:	Minor editing; replace SEAM code with EMS code
	January 9, 1998:	EMS codes confirmed
	December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Reference to out of print manual deleted.

Note 1: While anions and cations are usually reported for water samples on an elemental basis, for air samples, the convention is to report on an ion weight basis. Thus, ammonia is reported as mg/L as NH4 and nitrate is reported as mg/L as NO3.

Note 2: Note that the listed anions and cations may alternatively be analyzed according to any relevant procedure specified in this edition of the BC Environmental Laboratory Manual.

Precipitation - Cations - Ion Chromatography

Parameters and EMS Codes	Sodium	**Na-S 5071**
	Ammonium	**NH4- 5071**
	Potassium	**K--S 5071**
	Magnesium	**Mg-S 5070**
	Calcium	**Ca-S 5070**

Analytical Method Ion Chromatography

Introduction Precipitation samples are collected and shipped to the laboratory unpreserved. The sample is first titrated for acidity and alkalinity, the Gran's function is calculated, then several anions and cations are measured. Ion balance is also calculated.

Method Summary An ion chromatograph equipped with a conductivity detector is used to determine several cations from a single sample injection. All samples are filtered through a 0.22 µm fritted glass filter prior to injection. The cations of interest are separated through a cation "guard" and cation "separator" column with a methane sulphonic acid eluent. After the cations are separated they exit at various times from the column in a background of eluent. A self regenerating membrane suppressor is attached to the end of the column to neutralize the acid before detection and form the corresponding hydroxide. Note that ammonium is reported as mg NH_4/L

MDL
0.01 mg/L Na
0.01 mg/L NH_4
0.01 mg/L K
0.01 mg/L Mg
0.01 mg/L Ca

Matrix Water

Interferences and Precautions

Interferences can be caused by substances with retention times similar to overlapping those of the ion of interest. Significant concentrations of previously eluted cations may cause masking problems.

Principle or Procedure

Apparatus

a) An ion chromatograph consisting of:
   1) selectable eluent supply
   2) high pressure, pulseless pump
   3) chromatography module
   4) cation guard and separator columns
   5) cation membrane suppressor
   6) conductivity detector
   7) data station

Reagents

a) Methane sulphonic acid stock (2.0 M): Weigh 96.1 g methane sulphonic acid and dilute to 500 mL with Deionized water.

b) Eluent (0.02 M): dilute 10.0 mL of 2.0 M methane sulphonic acid stock to 1L. Filter through a 0.45 um nylon membrane filter.

c) Regenerent solution: deionized water.

d) Ammonium standard 1000 mg/L: Dissolve 2.965 g predried ammonium chloride (analytical grade) in 1 L Deionized water.1mL= 1mg NH_4

e) Calcium standard 1000 mg/L: Dissolve 2.497 g predried calcium carbonate (analytical grade) in 1 L of 400 mN hydrochloric acid.

f) Magnesium standard 1000 mg/L: Dissolve 4.952 g predried magnesium sulphate (analytical grade) in 1 L of 400 mN hydrochloric acid.

g) Potassium standard 1000 mg/L: Dissolve 1.907 g predried potassium chloride (analytical grade) in 1 L Deionized water.

h) Sodium standard 1000 mg/L: Dissolve 2.542 g predried sodium chloride (analytical grade or better) in 1 L Deionized water.

(Note: New standards should always be checked against old stock standards. A log of these comparison results should be maintained).

Procedure

a) Allow all samples and standards to reach laboratory temperature before analysis.

b) Establish a constant background conductivity using the following instrument conditions:

Eluent:	0.020 M methane sulphonic acid
Regenerant:	Deionized water
Separator:	4x50 Cation Precolumn (Guard) Dionex IONPac-CS12 4X250 Cation Separator Column Dionex IONPac-CS12
Suppressor:	Cation Self Regenerating Suppressor Dionex CSRS-1
Eluent Flow Rate:	1.0 mL/min.
Operating Pressure:	900 psi.
Regenerent Flow rate:	10 mL/min.
Regenerent Current:	200 mA
Background Conductivity:	0.5 - 2 uS
Injection Volume:	25 uL

c) Run a blank and at least a four point calibration curve of composite standards for each detector range. The calibration curve should include at least one calibration point for each decade of the concentration range. Calibration should be run daily when the analysis is run.

d) Run samples through the chromatograph with standards after every five samples.

Calculations

Calibration curves are programmed into the data station to be read directly off the chromatogram in terms of peak heights.

Precision

In a laboratory study, authentic samples gave the following coefficients of variations (C.V.):

Cation	Standard (mg/L)	C.V. (%)	Standard (mg/L)	C.V. (%)
Na	0.08	3.7	0.16	3.5
NH4	0.20	1.3	0.40	2.0
K	0.20	1.8	0.40	2.8
Mg	0.10	2.5	0.20	2.7
Ca	0.20	2.8	0.40	1.5

Quality Control

a) Record the old and new standard concentrations, along with preparation dates, in a QC record sheet. New standards should be within 5% of old standards, unless previous information suggest old standards have deteriorated. Record this information on QC record sheet as a comment.

b) Record and plot the mid range check standard run between every fifth sample. Maintain this record in such a manner to allow comparison between runs. If limiting the ions to record, do at least Ca and K. When sufficient data is recorded, determine control limits. For the interim, control limits of ± 10% should be used.
Note: This is not an independent reference standard. This check is to monitor within run drift.

c) Confirm all standards with an alternate salt.

References

a) Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF, 18th edition, 1992.
b) Dionex Corporation,. Basic Ion Chromatography, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A.
c) Dionex Corporation,. Self-Regenerating Controller Users Guide, Document No.034720, 1228 Titan Way, Sunnyvale, CA. 94088-3603,U.S.A. October 1992.
d) Dionex Corporation,. Installation Instructions and Troubleshooting Guide for the Cation Self-Regenerating Suppressor-1 (4mm), Document No. 034651, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A. June 1993.
e) Dionex Corporation, Installation Instructions and Troubleshooting Guide for the IONPAC CS12 Analytical Column, Document No.034657, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A. March 1992.

Revision History	April 1, 1996:	Original draft
	October 29, 1996:	Procedure vetted by private sector laboratories. Note regarding alternative methods added.
	July 13, 1997:	Minor editing; SEAM code replaced with EMS code
	January 9, 1998:	EMS codes confirmed; Ca MDL updated.
	December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Reference to out of print manual deleted.

Note 1: While anions and cations are usually reported for water samples on an elemental basis, for air samples, the convention is to report on an ion weight basis. Thus, ammonia is reported as mg/L as NH4 and nitrate is reported as mg/L as NO3.

Note 2: Note that the listed anions and cations may alternatively be analyzed according to any relevant procedure specified in this edition of the BC Environmental Laboratory Manual.

Total Particulate - PM10 - HiVol

Parameter Particulate < 10µm (PM10).

Analytical Method Part. HiVol Teflon.

EMS Code **PM10 5305**

Introduction A measured volume of ambient air is drawn through an inlet that passes only particles less than 10 µm. The particulate which is collected on a 0.3µm teflon coated borosilicate glass fibre filter constitutes PM10 particulate.

Method Summary PM10 is the designation for particulate matter in the atmosphere that has an aerodynamic diameter of 10 micrometers (µm) or less. A high volume (HV) PM10 sampler draws a known volume of ambient air at a constant flow rate through a size selective inlet and through one or more filters. Particles in the PM10 size range are then collected on the filter(s) during the specified 24 hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected PM10 sample.

MDL 2 $\mu g/m^3$

Matrix Ambient Air Particulate

Interferences and Precautions Damage to filters (holes), misalignment or leaking gaskets in filter assembly can result in loss of particulate.

Sample Handling and Preservation

Filters are shipped flat in white 10" x 12" envelopes with the opening on the 12" axis. The envelope and filter are both stamped with a unique identifying number. A kraft paper wrapper folded in three on the long axis is also shipped. Filters should NOT be folded before sampling. The shipping envelopes are stamped "DO NOT BEND PRIOR TO USE".

The sampling surface of the filter appears like soft blotting paper. The non-sampling surface has a sheen and appears to be a woven fabric.

For return to the laboratory, filters should be gently folded once along the long axis, with the particulate surface inward. The filter should be placed inside the brown paper wrapper and re-inserted in the same envelope in which it was shipped.

If unable to return filters for analysis within 10 days of sampling, store exposed filters at 4°C or less. Return filters for reweighing within 30 days of sampling.

Stability Most samples are stable for long periods of time.

Procedure

Apparatus

a) Controlled environment room: temperature 20°C ± 3°C, humidity 30-40% ± 5%(24 hour average).

b) Analytical balance, 5 decimal place.

Reagents

a) Filters: Pallflex TX40HI20WW EMFAB, 8" x 10" (20.3 cm x 25.4 cm), or equivalent.

Procedure

a) Inspect filters for pinholes, tears, lumps, or creases using light box. Any filters with these defects should not be used. Remove any fibres from edge of filter. Do not use any filters that have begun to de-laminate.

b) Gently stamp filters and envelopes with an identification number taking care to keep the number stamp on the outer edge of the filter, not in the sampling area. Stamp impression should be on the glossy under surface of the filter.

c) Equilibrate filters in controlled environment for 72 hours. Note: Teflon coated filters take longer to equilibrate than normal glass fibre filters which can be equilibrated in 24 hours.

d) Pre-weigh the filters, and record in log. Filters may be rolled loosely for weighing if desired.

e) Ship the filters flat in envelopes to the field.

f) On return of filters from field, equilibrate for 72 hours. If necessary, gently remove any insects embedded in the filters with Teflon tipped tweezers. If more than 6 insects are found discard the filter. Recover any dislodged material from the filter using a soft camel hair brush to sweep out envelope. This constitutes part of the sample.

Note any irregularities in the filters at this time. If the following irregularities are found, reject the filter.

1) Hole or tear in filter except if on fold.
2) Sample area misaligned such that sample has been lost (filter misaligned, FMA).
3) Leakage of particulate at margins (gasket leak, margin not clear, MNC).
4) Filter sampled wrong side up.
5) Sampling time less than 18 hours or greater than 30 hours. Enter a comment in the report indicating 'time range failure' (TRF). If filters are explicitly marked "SPECIAL STUDY" other time ranges are acceptable.

If the following irregularities are found, they should be noted on the report but the analysis completed:

1) Marks on surface (MOS) of the filter after sampling.
2) Filter misaligned (FMA) so no margin visible.
3) Sampling surface against envelope, wrapper or time chart .

Record all of the above comments in comment section of the report.

g) Weigh the filters to the nearest 1 mg after equilibration. Record the weight.

h) Archive the filters for a period of 2 years.

Calculation

PM10 Particulate in $\mu g/m^3$ =

$$\frac{\text{(final weight) - (initial weight) x Conversion factor}}{\text{time of exposure, hr.}}$$

where conversion factor = 1000 x 35320 /(40 x 60)

note: 1000 is µg/mg,
35320 is cu ft/m^3 & mg/g
40 is standard flow rate in cu ft/min
60 is min./hr.

Precision

The standard deviation on duplicate weighings of 8" x 10" (20.3 x 25.4cm) teflon filters returned from the field after sampling is 1 mg.

Quality Control

a) Laboratory Equipment:

1) Balance:

i) Initial: 3 to 5 weights in the range of the filter weights should weigh to ± 0.0005 g of nominal weights.

ii) On-going: a standard weight should be weighed daily and every two hours when the balance is in use. Record weights, date, time, and operators initials. Weights should be ± 0.0005 g of nominal weights. Failure requires re-calibration.

iii) Annual calibration and certification of balance by a certified tester.

2) Constant humidity:

i) A reading with a wet/dry bulb sling psychrometer to be taken and recorded every 6 months. Reading to be ± 6% of desired reading.

ii) On-going humidity should be <40% and not vary by more than ± 5%. Record humidity daily. Design humidity is 35%.

3) Temperature should be kept between 15 and 30°C, and should not vary more than ± 3°C. Target temperature is 20°C.

b) Assessment of data accuracy

1) Field duplicates: co-located samplers should give results ± 15%.

2) Lab duplicates: prior to shipping to field, randomly select and re-weigh 4 in every set of 50 un-exposed filters. Record initial weight, re-weight, date and time of each, and initial the record. The re-weigh should be done between 3 and 24 hours after the initial weighing. Re-weigh the entire batch if any re-weighs differ by more than ± 5 mg (0.005 g) from the original weight. Plot an x-bar R chart of data as a control chart. Interim warning limits and control limits ± 3.0 mg and ± 4.5 mg. Out of control points

indicate a need to re-calibrate the balance, improve operation procedure, or failure to control humidity and temperature.

3) Trip duplicates: For every batch of 50 (unexposed) filters, 4 filters, chosen at random, are sent to the field as trip blanks. On return, these unexposed filters are conditioned and reweighed. The re-weigh should be done between 3 and 48 hours after the initial weighing. Re-weigh the entire batch if any re-weighs differ by more than ± 5 mg (0.005 g) from the original weight. Plot an x-bar R chart of data as a control chart. Interim warning limits and control limits ± 3.3 mg and ± 5.0 mg. Out of control points, in absence of out of control points in b. above indicate a lack of proper impaction of particulate in field, a failure to properly handle filters in field or laboratory causing a loosening of particulate, or a need to improve operation procedure.

Samples which fail this test should be recorded as "FAILED DUPLICATE WEIGHT TEST".

References

a) Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Specific Methods, EPA/600/R-94/038b, April 1994, Section 2.11.0 (January 1990).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 12, 1998:	EMS code confirmed; out of print reference deleted
December 31, 2000:	Minor editing; Supplement #2 merged with main Lab Manual. At request of E. Tradewell, note added regarding storage and return of exposed filters.
November 4 ,2002:	Conditioning criteria (humidity) specs updated

Total Particulate – PM10/PM02 - 47 mm - HiVol

Parameter and EMS Codes	Total Particulate (PM10)	**PM10 5306**
	Total Particulate (PM02)	**PM02 5306**

Analytical Method 47mm HiVol Teflon filter

Introduction A measured volume of air is drawn through a 47 mm filter using a Partisol Model 2000 air sampler.

Method Summary Air particulate is trapped on a pre-weighed Teflon filter. The weight change after sampling is used to calculate the particulate in $\mu g/m^3$.

MDL A detection limit of 6 $\mu g/m^3$ is based on duplicate weighing of triplicates weighings of exposed filters (July - August 1996) returned from the field. This was revised in June 2000 to $2\mu g/m^3 \pm .6$

Matrix Ambient Air Particulate.

Interferences and Precautions Damage to the filter such as cracks or pinholes that allow particulate to escape during sampling may reduce the reported values. Failure to protect sampling surface during shipment may cause loss of particulate.

Sample Handling and Preservation Use non-serrated forceps to handle filters. Store and transport filters in cassettes housed in petri dishes. On initial use and after each return from field use, filter cassette holders should be rinsed in deionized water, soaked for at least 1 hr. in clean dilute FL70 detergent solution, rinsed with deionized water at least 8 times, and air dried in a dust free environment.

Procedure

Apparatus

a) Pallflex TX40 HI20-WW 47mm filters
b) Cassette filter holder (Partisol series 2000, part #59-002388)
c) Balance, with resolution of 0.01 mg
d) Non-serrated forceps

Procedure

a) Inspect each filter visually for integrity and apply the criteria given in Procedure paragraph 6, of Total Particulate - PM10 - HiVol (EMS code PM10 5305).

b) Equilibrate the 47 mm filters before use as follows:
   1) Label and number both covers of each petri dish .
   2) Place the petri dish cover under the bottom half of the dish.
   3) Place each inspected filter into a separate dish.
   4) Record the filter number, relative humidity, temperature, date and time at the beginning of equilibration.
   5) Equilibrate each filter for at least 24 hours (Teflon filters usually require 72 hours to equilibrate) at a constant humidity 30- 40% ± 5%, and constant temperature of 20°C ± 2°C. The PM02 filters

should be equilibrated at a humidity of 30 - 40 % ± 5% and constant temperature 20° C ± 2° C.

c) Weigh each filter three times, and record its mass in grams. The average of these three weights is the initial weight.

d) Ship the filters to the field in petri dishes.

e) On return of filters from the field, equilibrate for 72 hours and weigh each filter three times, and record its mass in grams. The average of these three weights is the final weight. PM02 filters should be re-weighted within ten days after end of sampling period. If unable to process within this time period store at 4° C or less and re-weigh within thirty days of sampling.

Calculation

Particulate in $\mu g/m^3$ =

$$\frac{1{,}000{,}000 \times (\text{average 3 final weights,g}) - (\text{average 3 initial weights,g})}{\text{time of exposure in hours}}$$

where: 1,000,000 is µg/g and flow rate is 1 m^3/hr

Precision

Standard deviation on duplicate weighings of 47 mm Partisol filters returned from the field after sampling is 2.3 $\mu g/m^3$ for results in range 11 to 66 $\mu g/m^3$. Estimated coefficient of variation is 9%.

Quality Control

a) Balance Weights: record weight of a 1, 2, and 5 g nominal weight Class S weight, initially and every two hours during weighing periods. Limits for acceptance of weights should conform to balance manufacturer's specifications.

b) Prior to shipping filters to field repeat the weighing process for 4 in 50 or 4 in a weighing set (which ever is smaller). Average of triplicate weights initial and repeat weighing must agree to within 1 mg.

c) After return of filters from the field, repeat the weighing process for 4 in 50 or 4 in a set. Average of triplicate weights initial and repeat must agree to within 1 mg.

Reference

a) Quality Assurance Handbook for Air Pollution Measurement Systems Volume II: Ambient Air Specific Methods, PA/600/R-94/038b, April 1994, Addendum 2.11.
b) Operating Manual, Partisol 2000 Air Sampler, p.3-1 to 3-9, Rupprecht and Patachnick, Albany, New York, December 1993, version 1.00.

Revision History

April 30, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 12, 1998:	EMS codes confirmed
June 24, 1998:	PM02 procedures revised
December 31, 2000:	Minor editing; Supplement #2 merged with main Lab Manual.
November 4, 2002:	Conditioning criteria (temp. & humidity) specs updated

Total Particulate - PM02 - HiVol

Parameter PM 2.5µm HiVol (PM02).

Analytical Method Tot. Part. HiVol-Teflon (8 x 10 filter).

EMS Code **PMO2 5305**

Introduction A measured volume of ambient air is drawn through an inlet that passes only particles less than 2.5 µm. The particulate which is collected on a 0.3 micron teflon coated borosilicate glass fibre filter constitutes PM02 particulate.

Method Summary PM-2.5 is the designation for particulate matter in the atmosphere that has an aerodynamic diameter of 2.5 micrometers (µm) or less. A high volume (HV) PM 2.5 sampler draws a known volume of ambient air at a constant flow rate through a size selective inlet and through one or more filters. Particles in the PM 2.5 size range are then collected on the filter(s) during the specified 24 hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected PM02 sample.

MDL 2 $\mu g/m^3$

Matrix Ambient Air Particulate

Interferences and Precautions Damage to filters (holes), misalignment or leaking gaskets in filter assembly can result in loss of particulate.

Sample Handling and Preservation

Filters are shipped flat in white 10" x 12" envelopes with the opening on the 12" axis. The envelope and filter are both stamped with a unique identifying number. A kraft paper wrapper folded in three on the long axis is also shipped. Filters should NOT be folded before sampling. The shipping envelopes are stamped "DO NOT BEND PRIOR TO USE".

The sampling surface of the filter appears like soft blotting paper. The non-sampling surface has a sheen and appears to be a woven fabric.

For return to the laboratory, filters should be gently folded once along the long axis, with the particulate surface inward. The filter should be placed inside the brown paper wrapper and re-inserted in the same envelope in which it was shipped.

Stability Conditioned filters shipped from Laboratory should be used within thirty days of preparation date. Filters should be weighted with ten days of sampling date. If unable to process with ten days of sampling, store at 4^0C or less and reweight within thirty days of sampling.

Apparatus

a) Controlled environment room: temperature 20° C ± 2° C. Humidity 30 - 40% ± 5 (24 hour average).

Principle or Procedure

See Total Particulate - PM10 - HiVol.

Revision History

March 20, 1995:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 12, 1998:	EMS codes confirmed; E. Tradewell confirmed filter size
June 24, 1998:	Updated using new EPA protocols.
December 31, 2000:	Minor editing; Supplement #2 merged with main Lab Manual.

Total Particulate - Teflon - HiVol

Parameter	Particulate: Total
Analytical Method	Tot. Part. HiVol Teflon (8 x 10 filter)
EMS Code	**TP-T 5305**
Introduction	A measured volume of ambient air is drawn through a high volume sampler and is collected on a 0.3µm Teflon coated borosilicate glass fibre filter. The collected material constitutes total particulate.
Method Summary	A high volume (HV) sampler draws a known volume of ambient air at a constant flow rate through one or more filters. Particles are then collected on the filter(s) during the specified 24 hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected total particulate sample.
MDL	2 $\mu g/m^3$
Matrix	Ambient Air Particulate
Interferences and Precautions	Damage to filters (holes), misalignment or leaking gaskets in filter assembly can result in loss of particulate.
Sample Handling and Preservation	Filters are shipped flat in white 10" x 12" envelopes with the opening on the 12" axis. The envelope and filter are both stamped with a unique identifying number. A kraft paper wrapper folded in three on the long axis is also shipped. Filters should NOT be folded before sampling. The shipping envelopes are stamped "DO NOT BEND PRIOR TO USE". The sampling surface of the filter appears like soft blotting paper. The non-sampling surface has a sheen and appears to be a woven fabric. For return to the laboratory, filters should be gently folded once along the long axis, with the particulate surface inward. The filter should be placed inside the brown paper wrapper and re-inserted in the same envelope it was shipped in.
Stability	Most samples are stable for long periods of time.
Principle or Procedure	See Total Particulate - PM10 - HiVol

Revision History	April 11, 1995:	Initial Draft
	October 29, 1996:	Procedure vetted by private sector laboratories.
	January 12, 1998:	EMS codes confirmed; E. Tradewell confirmed filter size
	December 31, 2000:	Minor editing; Supplement #2 merged with main Lab Manual.

Total Particulate - HiVol - Metals - ICP

Parameters The HiVol metals package now includes a total of 25 metals. See table on following page for EMS codes and for detection limits.

Analytical Method Strong Acid Digestion; ICP Analysis.

EMS Code See following page.

Introduction Either nitric /perchloric acid digestion or aqua regia digestion is used to bring the metals into solution. The metal content is then determined by ICP analysis.

Method Summary Following acid digestion, aqueous solutions of samples are converted to aerosols in the nebulizer of the ICP and transported to a high temperature plasma (6000 to 8000°K). This excitation source produces atomic and ionic emission spectra at wavelengths specific to the elements of interest which can be determined either simultaneously or sequentially.

MDL The following MDL concentrations are extrapolated from aqueous solutions at the normal operating conditions. For instrument and method MDL values see Section C - Metals.

Matrix Ambient Air Particulates.

Interferences and Precautions The normal field exposure limit is 24 hours. In order to achieve better detection limits longer exposure times may be used. The laboratory requisition should indicate special test, exposure time, so lab staff will accept this data. For further discussion, see elsewhere in this manual.

Sample Handling and Preservation Do not touch the sampling surface or use talced gloves when handling filters, as this may cause Zn contamination. Unused portions of filters are archived in paper envelopes.

Stability Samples are stable

Procedure

Apparatus

a) Filter cutter, 4.6 cm diameter, stainless steel

Reagents

a) Nitric Acid, Concentrated, analytical
b) Perchloric acid, 70%, analytical

Table of EMS Codes and Recommended Detection Limits for HiVol metals package
(units = mg/L of digestate, unless shown otherwise**)**

Element		**EMS Code (nitric/perchloric acid digestion**	**EMS Code (aqua regia digestion)**	**MDL**
Silver - Total	Intermediate Loading (24 hr)	**AG-T 5038 AG-T 5312**	**AG-T 6038 AG-T 6040**	0.003 mg/L 0.002 ug/m^3
Arsenic - Total	Intermediate Loading (24 hr)	**AS-T 5038 AS-T-5312**	**AS-T 6038 AS-T 6040**	0.2 mg/L 0.1 ug/m^3
Boron – Total	Intermediate Loading (24 hr)	**B--T 5038 B--T 5312**	**B--T 6038 B--T 6040**	3.0 mg/L 2.0 ug/m^3
Beryllium - Total	Intermediate Loading (24 hr)	**BE-T 5038 BE-T 5312**	**BE-T 6038 BE-T 6040**	0.0002 mg/L 0.0001 ug/m^3
Bismuth - Total	Intermediate Loading (24 hr)	**BI-T 5038 BI-T 5312**	**BI-T 6038 BI-T 6040**	0.024 mg/L 0.01 ug/m^3
Cadmium - Total	Intermediate Loading (24 hr)	**CD-T 5038 CD-T 5312**	**CD-T 6038 CD-T 6040**	0.06 mg/L 0.03 ug/m^3
Cobalt - Total	Intermediate Loading (24 hr)	**CO-T 5038 C0-T 5312**	**CO-T 6038 CO-T 6040**	0.003 mg/L 0.002 ug/m^3
Chromium - Total	Intermediate Loading (24 hr)	**CR-T 5038 CR-T 5312**	**CR-T 6038 CR-T 6040**	0.02 mg/L 0.01 ug/m^3
Copper - Total	Intermediate Loading (24 hr)	**CU-T 5038 CU-T 5312**	**CU-T 6038 CU-T 6040**	0.6 mg/L 0.4 ug/m^3
Manganese - Total	Intermediate Loading (24 hr)	**MN-T 5038 MN-T 5312**	**MN-T 6038 MN-T 6040**	0.01mg/L 0.008 ug/m^3
Molybdebum - Total	Intermediate Loading (24 hr)	**MO-T 5038 MO-T 5312**	**MO-T 6038 MO-T 6040**	0.004 mg/L 0.002 ug/m^3
Nickel - Total	Intermediate Loading (24 hr)	**NI-T 5038 NI-T 5312**	**NI-T 6038 NI-T 6040**	0.02 mg/L 0.01 ug/m^3
Phosphorus - Total	Intermediate Loading (24 hr)	**P--T 5038 P--T 5312**	**P--T 6038 P--T 6040**	0.04 mg/L 0.02 ug/m^3
Lead - Total	Intermediate Loading (24 hr)	**PB-T 5038 PB-T 5312**	**PB-T 6038 PB-T 6040**	0.5 mg/L 0.3 ug/m^3
Antimony - Total	Intermediate Loading (24 hr)	**SB-T 5038 SB-T 5312**	**SB-T 6038 SB-T 6040**	0.14 mg/L 0.09 ug/m^3

Table of EMS Codes and Recommended Detection Limits for HiVol metals package

(units = mg/L of digestate, unless shown otherwise)

Element		EMS Code (nitric/perchloric acid digestion	EMS Code (aqua regia digestion)	MDL
Selenium - Total	Intermediate Loading (24 hr)	**SE-T 5038** **SE-T 5312**	**SE-T 6038** **SE-T 6040**	0.02 mg/L 0.01 ug/m^3
Silicon - Total	Intermediate Loading (24 hr)	**SI-T 5038** **SI-T 5312**	**SI-T 6038** **SI-T 6040**	0.11 mg/L 0.07 ug/m^3
Tin – Total	Intermediate Loading (24 hr)	**SN-T 5038** **SN-T 5312**	**SN-T 6038** **SN-T 6040**	0.03 mg/L 0.02 ug/m^3
Strontium - Total	Intermediate Loading (24 hr)	**SR-T 5038** **SR-T 5312**	**SR-T 6038** **SR-T 6040**	0.17 mg/L 0.1 ug/m^3
Tellurium - Total	Intermediate Loading (24 hr)	**TE-T 5038** **TE-T 5312**	**TE-T 6038** **TE-T 6040**	0.02 mg/L 0.01 ug/m^3
Titanium - Total	Intermediate Loading (24 hr)	**TI-T 5038** **TI-T 5312**	**TI-T 6038** **TI-T 6040**	0.07 mg/L 0.04 ug/m^3
Thallium - Total	Intermediate Loading (24 hr)	**TL-T 5038** **TL-T 5312**	**TL-T 6038** **TL-T 6040**	0.03 mg/L 0.02 ug/m^3
Vanadium - Total	Intermediate Loading (24 hr)	**V--T 5038** **V--T 5312**	**V--T 6038** **V--T 6040**	0.005 mg/L 0.003 ug/m^3
Zinc - Total	Intermediate Loading (24 hr)	**ZN-T 5038** **ZN-T 5312**	**ZN-T 6038** **ZN-T 6040**	0.17 mg/L 0.1 ug/m^3
Zirconium - Total	Intermediate Loading (24 hr)	**ZR-T 5038** **ZR-T 5312**	**ZR-T 6038** **ZR-T 6040**	0.006mg/L 0.004 ug/m^3

Procedure

a) Use the filter cutter to remove 2 discs from the HiVol filter, two blank portions from an unexposed filter should be analyzed separately.

b) Add the filter discs to 75 mL calibrated digestion tubes.

c) Add two mL HNO3 and heat cautiously to oxidize any organic matter; do not take to dryness.

d) Cool, then add 3.75 mL HClO4, heat until dense white fumes are present.

e) Cool and make up to 75 mL with deionized water, final matrix = 5% HClO4.

f) Filter through Whatman #41 filter paper and collect the filtrate in a 250 mL polyethylene bottle.

g) Analyze for As, Cd, Cu, Pb, Zn by ICP by procedures given in Section – C.

Calculation:

From the results obtained in mg/L from the ICP analysis, select the calculation method appropriate to the reporting requirements.

a) Total µg on digested portion of filter:

$$\mu g = \mu g/mL \times 75\ mL$$

b) Total µg on filter:

$$\mu g = \frac{mg}{L} \times 0.075\ L \times \frac{0.043\ m^2}{0.003322\ m^2} \times \frac{1000\ \mu g}{mg}$$

c) Total $\mu g/m^3$ based on flow rate of the sampler and exposure time of the filter:

$$\mu g/m^3 = \frac{mg}{L} \times 0.075L \times \frac{0.043\ m^2}{0.003322\ m^2} \times \frac{1\ Min.}{1.1355\ m^3} \times \frac{1\ hr.}{60\ Min} \times \frac{1}{\#\ hrs} \times \frac{1000\ \mu g}{mg}$$

or: $\mu g/m^3 = mg/L \times \frac{14.249}{\#hours}$

where: 0.075 L = volume of digestate
$0.043 m^2$ = total area of filter exposed
$0.003322 m^2$ = area of filter analyzed (2 discs 4.6 cm diameter)
$1.1355\ m^3$/Min. = flow rate
hours = number of hours filter exposed.

Accuracy

The recovery of Cd, Pb, and Zn from Standard reference filters was 102%, 99%, and 103%, respectively with coefficient of variation of 4, 12 and 2%. The concentration ranges were 1 to 10, 7 to 300 and 10 to 100 µg/filter for Cd, Pb, and Zn.

Quality Control

Digest two filter blanks with each batch of 35 or fewer filters, plus two sample filters in duplicate for each batch. Blank results should be less than twice the MDL, otherwise the digestion must be repeated. Duplicate filter digests should agree within ±30%. Blanks and duplicates should be recorded in a database. When sufficient data is available, a duplicate control chart should be constructed for each metal.

References

None listed.

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories; and at their request, a note was added regarding substitution of aqua regia digestion for perchloric acid digestion procedure.

January 12, 1998:	EMS codes added and confirmed; minor editing.
March 19, 1998:	Table reformatted for clarity.
December 31, 2000:	Minor editing; Supplement #2 merged with main Lab Manual. Reference to the 1994 Lab Manual deleted. Preference for use of aqua regis digestion noted.

Note: Aqua regia digestion is preferred over the nitric/perchloric acid digestion procedure. Note that these different procedures have been assigned different EMS codes.

Total Particulate – HiVol - Anions - Ion Chromatography

Parameter

Nitrate-Soluble
Sulphate-Soluble
Chloride-Soluble

Analytical Method

Water Extr; Ion Chr.-Anion.

EMS Code

	Intermediate	Loading
Nitrate-Soluble	**NO3- 5068**	**NO3- 5022**
Sulphate-Soluble	**SO4- 5068**	**SO4- 5022**
Chloride-Soluble	**CL-S 5068**	**CL-S 5022**

Units

a) Intermediate results: mg/L
b) Loading results: $\mu g/m^3$

Introduction

Ambient air is sampled on a HiVol air filters (teflon) using the procedure entitled "Total Particulate - Teflon - HiVol".

Method Summary

Discs cut from the HiVol filter are extracted with deionized water and the resulting anions are separated and measured using an ion chromatograph yielding intermediate results with units of mg/L. (See Anions – Ion Chromatography – Precipitation, methods NO3- 5068, SO4- 5068, and Cl-S 5068.) Values are then connected to units of $\mu g/m^3$.

MDL

	Intermediate
Nitrate-Soluble	0.01 mg/L as NO_3
Sulphate-Soluble	0.01 mg/L as SO_4
Chloride-Soluble	0.01 mg/L

Matrix

Ambient Air Particulates

Interferences and Precautions

Interferences can be caused by substances with retention times similar to those of the ion of interest. Large amounts of an anion can interfere with peak resolution of an adjacent anion. Note that unlike water samples, Nitrate is reported on an ion weight basis, i.e., as mg NO_3/L and $\mu g\ NO_3/m^3$.

Principle or Procedure

Apparatus

a) Filter cutter, 4.6 cm diameter
b) Oscillating hot plate
c) An ion chromatography system consisting of:
    1) selectable eluent supply
    2) high pressure, pulseless pump
    3) sample injection port and sample loop
    4) anion guard and separator columns
    5) anion micro membrane suppressor

6) conductivity detector
7) data station
8) auto sampler

Reagents

a) Concentrated Stock Eluent: Dissolve 15.12 g sodium bicarbonate ($NaHCO_3$) and 18.02 g sodium carbonate (Na_2CO_3) with deionized water into a 1.000 L flask. Dilute to volume and store in a 1 liter poly bottle.

b) Working Eluent Solution: Dilute 10.0 mL of concentrated stock eluent to 1.000 L in a volumetric flask. (1.8 mm $NaHCO_3$ / 1.7 m$\underline{M}$ Na_2CO_3) Filter before use.

c) Regenerent Solutions: 0.025 $\underline{N}$ Sulphuric acid (H_2SO_4) - Dilute 26.8 mL concentrated sulphuric acid to one liter to prepare a 1.00 $\underline{N}$ H_2SO_4 solution. Dilute 25.0 mL of this solution to one liter.

d) Stock Chloride Standard Solution: Dry 2 to 3 g of sodium chloride (NaCl) at 140°C for 2 hours and cool in a desiccator. Dissolve 1.648 g NaCl in deionized water and dilute to 1.0 liter (1.00 mL =1.00 mg Cl). Store in a poly bottle under refrigeration.

e) Stock Nitrate Standard Solution: Dissolve 1.630 g anhydrous potassium nitrate (KNO_3) in deionized water and dilute to 1.0 liter (1.00 mL = 1.00 mg NO_3). Store in a poly bottle under refrigeration.

f) Stock Sulphate Standard Solution: Dissolve 1.479 g anhydrous sodium sulphate (Na_2SO_4) in deionized water and dilute to 1.0 liter (1.00 mL = 1.00 mg SO_4). Store in a poly bottle under refrigeration.

Procedure

a) Use a filter cutter to remove 3 discs from the hi vol (teflon) filters.

b) Add the exposed filter discs to a 200 mL. tall plastic beaker.

c) Add 50 mL deionized water.

d) Extract at room temperature for 2 hours, with swirling, using the oscillating hot plate.

e) Filter using Whatman No. 40 filter paper and collect the filtrate into a 100 mL flask.

f) Quantitatively transfer the extract to a 100 mL. volumetric flask and dilute to volume with deionized water.

Determine the anion concentrations according to the procedures for an anion scan given below:

1) Allow all samples and standards to reach laboratory temperatures before analysis.
2) Establish a constant background conductivity using the following instrument conditions:

Eluent:	.0018 M $NaHCO_3$ / 0.0017 M Na_2CO_3
Separator:	4 x 50 Anion Precolumn (Guard) Dionex IONPac®-AG4-SC 4 x 250 Anion Separator Column Dionex IONPac®-AS4-SC
Suppressor:	Anion Micro Membrane Suppressor Dionex AMMS-1
Eluent Flow:	2.0 mL/min.
Operating Pressure:	900 psi
Regenerent:	0.025 N H_2SO_4
Regenerent Flow:	2.0 - 3.0 mL/min.
Backgrd. Conduct:	12 - 16 µS
Injection Volume:	25 µL

3) Pipette 5.0 mL of each sample or standard solution into a 5 mL autosampler vial (Dionex Polyvial™) , then add 50 µL of concentrated stock eluent. Cap vial with a 0.22 µm filter cap and shake. Load into the autosampler.

4) Run a blank and at least a four point calibration curve of composite standards for each detector range. The calibration curve should include at least one calibration point for each decade of the concentration range. Calibration should be run daily when the analysis is run.

5) Run samples through the chromatograph with standards after every five samples.

Calculations

Calibration curves are programmed into the data station to be read directly off the chromatogram in terms of peak heights and in units of mg/L of anions in the filtrate. Subtract blanks before calculations.

a) To convert the results of anions in the filtrate to air sampled.

$$\mu g/m^3 = \frac{mg}{L} \times 0.100\ L \times \frac{0.043\ m^2}{0.003322\ m^2} \times \frac{1\ Min.}{1.1355\ m^3} \times \frac{1\ hr.}{60\ Min.} \times \frac{1}{\#\ hrs} \times \frac{1000\ \mu g}{mg}$$

where: 0.100 L = volume of filtrate
$0.043\ m^2$ = total area of filter exposed
$0.003322\ m^2$ = area of filter analyzed (2 discs 4.6 cm diameter)
$1.1355\ m^3$/Min. = flow rate
hrs = number of hours filter exposed.

Simplified: $\mu g/m^3$ anion X = mg/L x $\frac{18.999}{\#\ hrs}$ anion

b) To convert the results of anions in filtrate to High Vol filters:

mg anion X = CV,

where: C = mg/L anion X in the filtrate
V = 0.100 L of filtrate.

Precision

RSD = 1.18% at 31.0 mg NO_3/L (water)
RSD = 1.49% at 98.5 mg SO_4 /L (water)
RSD = 2.29 % at 10.0 mg Cl/L (water)

Accuracy

100.7% at 31.0 mg NO_3/L (water)
104% at 98.5 mg SO_4 /L (water)
98.2% at 10.0 mg Cl/L (water)

Quality Control

Digest two filter blanks or reagent blanks with each batch of 35 or less filters, and two sample filters in duplicate for each batch. The filter blanks may be high; therefore data should be blank subtracted. Duplicate filter digests should agree within ± 30%.

References

a) J.P. Smith, D. Grodjean and J.N. Pitts, J.Air Pollut. Contr. Assoc. 28, 930 (1978).

Revision History

April 30, 1996:	Initial Draft
October 29, 1996:	Procedure vetted by private sector laboratories.
July 14, 1997:	Minor editing; MDL code for µg/m3; SEAM code replaced by EMS code; Intermediate EMS codes added
January 12, 1998:	EMS codes confirmed
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Units added. Reference to out of print manual deleted.

Note 1: While anions and cations are usually reported for water samples on an elemental basis, for air samples, the convention is to report on an ion weight basis. Thus, ammonia is reported as mg/L and µg/m3/d as NH4 and nitrate is reported as mg/L and µg/m^3 as NO3.

Note 2: Note that the listed anions and cations may alternatively be analyzed according to any relevant procedure specified in this edition of the BC Environmental Laboratory Manual.

Total Particulate - HiVol - Sodium - Ion Chromatography

Parameter Sodium - Soluble

Analytical Method Ion Chromatography – HiVol extrn

EMS Code
a) Intermediate results **NA-S 5318**
b) Loading results **NA-S 5018**

Introduction Ambient air is sampled on a HiVol air filters (teflon) using the procedure entitled "Total Particulate - HiVol - Teflon"

Method Summary Discs cut from the HiVol filter are extracted with deionized water and the soluble sodium is determined on an ion chromatograph. The sodium is separated from other ions through a cation 'guard' and cation 'separator' column with a methane sulphonic acid eluent. A self regenerating membrane suppressor is attached to the end of the column to neutralize the acid before detection.

MDL 0.01 mg/L Na (intermediate result)

Units
a) Intermediate result: mg/L
b) Loading: $\mu g/m^3$

Matrix Ambient Air Particulates

Interferences and Precautions

Interferences can be caused by substances with retention times similar to those of the ion of interest.

Principle or Procedure

Apparatus
a) Filter cutter, 4.6 cm diameter
b) Oscillating hot plate
c) An ion chromatograph consisting of:
   1) selectable eluent supply
   2) high pressure, pulseless pump
   3) chromatography module
   4) cation guard and separator columns
   5) cation membrane suppressor
   6) conductivity detector
   7) data station

Reagents
a) Methane sulphonic acid stock (2.0 M): Weigh 96.1 g methane sulphonic acid and dilute to 500 mL with Deionized water.

b) Eluent (0.02 M): dilute 10.0 mL of 2.0 methane sulphonic acid stock to 1L. Filter through a 0.45 µm nylon membrane filter.

c) Sodium standard 1000 mg/L: Dissolve 2.542 g predried sodium chloride (Analar) in 1 L deionized water.

Procedure

a) Use the filter cutter to remove 3 discs from the hi vol (teflon) filters. Carry two blanks through all steps of the procedure.

b) Add the exposed filter discs to a 200 mL tall plastic beaker.

c) Add 50 mL deionized water and let stand.

d) Filter using Whatman No. 40 filter paper, quantitatively transfer to a 100 mL volumetric flask and dilute to volume with deionized water, and collect the filtrate.

e) Allow all samples and standards to reach laboratory temperature before analysis.

f) Establish a constant background conductivity using the following instrument conditions:

Eluent:	0.020 M methane sulphonic acid
Regenerant:	Deionized water
Separator:	4x50 Cation Precolumn (Guard) Dionex IonPac CG12 4X200 Cation Separator Column Dionex ionPac CS12
Suppressor:	Cation Self Regenerating Suppressor Dionex CSRS-1
Eluent Flow Rate:	1.0 mL/min.
Operating Pressure:	900 psi
Regenerent Flow rate:	10 mL/min.
Regenerent Current:	200 mA
Background Conductivity:	2-6 µS
Injection Volume:	25 µL

g) Load extract into auto-sampler.

h) Run a blank and a four point calibration curve of standard for each detector range.

i) After thirty samples, rerun a new calibration curve.

Calculations

A calibration curve is normally programmed into the data station to be read directly off the chromatogram in terms of peak heights and in units of mg/L of sodium in the filtrate. Subtract blanks before calculations.

a) To convert the results of sodium in the filtrate to air sampled:

$$\mu g/m^3 = \frac{mg}{L} \times 0.100\ L \times \frac{0.043\ m^2}{0.003322\ m^2} \times \frac{1\ Min.}{1.1355\ m^3} \times \frac{1\ hr.}{60\ min.} \times \frac{1}{\#\ hrs} \times \frac{1000\ \mu g}{mg}$$

where:
0.100 = volume of filtrate
0.043 m^2 = total area of filter exposed
0.003322 m^2 = area of filter analyzed (2 discs 4.6 cm in diameter)
1.1355 m^3 = flow rate
hrs = number of hours filter exposed

Simplified: $\mu g/m^3$ Na = mg/L x $\frac{18.999}{\text{\# hrs}}$ Na

b) To convert the results of sodium filtrate to High Vol. filters:

mg Na = CV,

where:
C = mg/L Na in the filtrate,
V = 0.100 L of filtrate.

Precision

In the ministry's contract laboratory, authentic samples gave the following coefficients of variations (C.V.) 3.7 % at 0.8 mg/L and 3.5% at 0.16 mg/L.

Quality Control

Digest two filter blanks or reagent blanks with each batch of 35 or fewer filters, and two sample filters in duplicate for each batch. The filter blanks may be high; therefore data should be blank subtracted.

References

a) Dionex Corporation. Basic Ion Chromatography, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A.
b) Dionex Corporation. Self-Regenerating Controller Users Guide, Document No.034720, 1228 Titan Way, Sunnyvale, CA. 94088-3603,U.S.A. October 1992.
c) Dionex Corporation. Installation Instructions and Troubleshooting Guide for the Cation Self-Regenerating Suppressor-1 (4mm), Document No. 034651, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A. June 1993.
d) Dionex Corporation. Installation Instructions and Troubleshooting Guide for the IONPAC CS12 Analytical Column, Document No.034657, 1228 Titan Way, Sunnyvale, CA. 94088-3603, U.S.A. March 1992.
e) J.P. Smith, D. Grosjean and J.N. Pitts, J. Air Pollut. Contr. Assoc. 28, 930 (1978).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories. Note regarding alternative methods added.
January 12, 1998:	EMS codes added; minor editing
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual. Erroneous EMS code (for loading) corrected.

Note: Note that the sodium may alternatively be initially analyzed according to any relevant procedure specified in this edition of the BC Environmental Laboratory Manual.

Sulfation Index

Parameter

Sulfation Index.

Analytical Method

Turbidimetric Analysis: Intermediate Result.
Turbidimetric Analysis: Loading Result

EMS Code

a) Intermediate results **SUFI 5000**
b) Loading results **SUFI 5001**

Introduction

A lead oxide plate is exposed to ambient air for a period of 30 days. During this time sulfur dioxide and sulfur trioxide in the are collected by lead oxide as the result of both oxidation and absorption processes and converted to lead sulfate.

Method Summary

The lead oxide plates undergo extractions and the sulfate ion is converted to a barium sulfate suspension under controlled conditions. The resulting turbidity is determined using a spectrophotometer and compared to a curve prepared from standard sulfate solutions.

MDL

0.02 mg SO3/plate or 0.5 mg/L SO3

Units

Intermediate result: mg/L as SO3
Loading result: $mg/dm^2/d$

Matrix

Lead oxide paste

Interferences and Precautions

Care must be taken to ensure that the plates are prepared in a uniform manner and that the paste will adhere to the bottom of the plate.

Sample Handling and Preservation

Plates should be handled with care to avoid dislodging the dried absorbent paste.

Principle or Procedure

Apparatus

a) Test tubes, 23 x 200 mm
b) Vortex mixer
c) UV/visible double beam spectrophotometer
d) Spectrophotometric cells, 5 cm, glass or quartz

Reagents

a) Sulfation Plates:
   1) Add 500 mL 10% ethanol and 5.0 g glass fibre filters to a Waring
   2) blender.
   3) Blend for 1 hour and then add 2.5 g gum tragacanth.
   4) Blend for a further 10 minutes and then add 100 g Lead oxide (PbO_2).
   5) Blend for 10 minutes and then adjust the blending speed so that it is just sufficient to maintain a mixing action.

6) Add 5.0 mL of the prepared suspension to each 48 mm plastic petri dish - approximately 75 plates may be prepared.
7) Dry overnight at 60°C.
8) Add a drop of chloroform to the centre of the plate and apply pressure till dry, to provide adhesion of the material to the petri dish.
9) Place covers on the petri dishes.

b) Sodium phosphate buffer (1000 mg/L with respect to phosphate): dissolve 4.0g Na_3PO_4. 12 H_2O in deionized water and dilute to one litre.

c) Acid reagent: to 100 mL of glacial acetic acid add 30 mL concentrated HCl. Dilute to 200 mL with deionized water.

d) Barium chloride crystal, reagent grade.

e) Stock sulfur solution (100 mg/L S): dissolve 0.5499 g K_2SO_4 in deionized water and dilute to one litre.

Procedure

Note: carry a blank through all steps of the procedure

a) Quantitatively transfer the exposed lead oxide plate to a 250 mL beaker.

b) Add 50 mL buffer solution.

c) Allow to extract overnight and then heat to boiling temperature and hold for 2 minutes.

d) Cool. Filter through Whatman # 40 filter paper and collect the filtrate.

e) Transfer to a 100 mL volumetric flask and dilute to volume with deionized water.

f) Prepare a series of standards (1.0, 2.0, 3.0, 4.0, 6.0, 8.0, 10.0, 12.0 mg/L S) by pipetting 1, 2, 3, 4, 6, 8, 10, 12 mL of stock solution into 100 mL volumetric flasks and diluting to volume. Also prepare a reagent blank.

g) Pipette 25.0 mL sample, standard and blanks into 24 x 200 mm test tubes.

h) Add 2.0 mL acid reagent.

i) Mix on a Vortex mixer.

j) Add 0.5 g Barium Chloride crystals.

k) Cover the tubes with Parafilm®.

l) Mix on Vortex mixer to dissolve the barium chloride.

m) Allow to stand for 30 minutes and then invert 6 times. Immediately read the absorbance of the solutions at 420 nm using 5 cm cells.

Calculation

Prepare a calibration curve from the readings of the standard solutions. Determine the concentration of sulfur in the samples by comparing the "sample - blank" reading with the calibration curve.

mg SO_3 = 2.5 CVF

where: C = mg/L Sulphur in extract,
V = litres extract as diluted,
F = reactivity factor for lead oxide.

Precision

A study of replicate plates exposed to ambient air for intervals of 14 to 21 days gave a relative standard deviation of 5.2 %.

Quality Control

Carry a reagent blank and an unexposed plate through all steps of the procedure.

References

a) N. A. Huey, J. Air Poll. Contr. Assoc. 8, 610 (1968).
b) A. J. Lynch, N. R. McQuaker, & M. Gurney. Environ. Sci. and Technol. 12, 169 (1978).

Revision History

April 1, 1996:	Initial draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 13, 1998:	Minor editing and EMS codes confirmed.
February 16, 1998:	Revision of EMS codes to eliminate redundant code for intermediate results; MDLs updated.
December 31, 2000:	Minor editing; Supplement #2 merged into main Lab Manual.

Fluoridation Index

Parameter Fluoridation Index**.**

Analytical Method Specific Ion Electrode (Intermediate results)
Specific Ion Electrode (Loading results)

EMS Code
a) Intermediate results **FLRI 5003**
b) Loading results **FLRI 5004**

Introduction A calcium oxide plate is exposed to ambient air for a period of 30 days. During this time fluoride in the ambient air is collected as calcium fluoride.

Method Summary The plates undergo an extraction and the fluoride which is isolated is determined using the selective ion electrode procedure.

MDL Intermediate results: 0.1 mg/L F
Loading results: 0.05 µg/dm^2/d

Matrix Calcium oxide paste

Interferences and Precautions The plate extract may suppress the response of the ion selective electrode, to correct for this results are calculated by 3 point standard addition method.

Sample Handling and Preservation Plates should be handled with care to avoid dislodging the dried absorbent paste.

Stability Expected to be stable

Precision A study of replicate plates exposed to ambient air for intervals of 14 to 21 days gave a relative standard deviation of 5.9%.

Principle or Procedure

Apparatus Expanded scale digital ion analyzer fitted with a double junction reference electrode and a fluoride selective ion electrode.

Reagents

a) Fluoridation Plates:
   1) Add 500 mL deionized water and 5.0 g glass fibre filters to a Waring Blender
   2) Blend for 1 hour and then add 50 g of calcium oxide
   3) Blend for a further 10 minutes and then adjust the blending speed so it is just sufficient to maintain mixing action
   4) Add 3.5 mL of the prepared suspension to a 48 mm plastic petri dish. Approximately 100 plates may be prepared
   5) Dry overnight at room temperature
   6) Add a drop of chloroform to the centre of each plate and apply pressure until dry, to provide adhesion of the material to the plate

7) Place the covers on the petri dishes
8) Retain at least four plates from each batch to be used as blanks

b) Hydrochloric acid, concentrated.

c) Hydrochloric acid, 6N: Dilute 500 mL of concentrated HCl to 1 L with deionized water.

d) Sodium hydroxide 6N: Dissolve 240 g NaOH in deionized water and dilute to 1 L with deionized water.

e) Total ionic strength adjustment buffer (TISAB): Dissolve 116 g of sodium chloride in approximately 1 L of deionized water. Add 114 mL of glacial acetic acid and 50 mL of CDTA stock solution. Adjust the pH to 5.8 by adding 10N sodium hydroxide. Adjust to volume with deionized water, in a 2 L volumetric flask.

f) CDTA Stock Solution: dissolve 36 g of CDTA (1,2 cyclohexylenediamine tetra acetic acid) in 200 mL of 1 N NaOH.

g) Fluoride solution I (1000 mg/L F): dissolve 2.210 g of anhydrous NaF in deionized water and dilute to 1 L.

h) Fluoride solution II (50 mg/L): dilute 50 mL fluoride solution I to 1000 mL with deionized water.

i) Stabilization solution: dissolve 0.5 g gum arabic in 100 mL 1 + 1 glacial acetic acid, and filter. Keep refrigerated.

Procedure

a) Quantitatively transfer the exposed Calcium oxide plate to a 150 mL polyethylene beaker.

b) Use deionized water to adjust the final volume to about 40 mL and then add 1.0 mL concentrated HCl. Also prepare at least two blank unexposed plates in the same manner as the sample.

c) Allow to extract overnight.

d) Use 6 N HCl or 6 N NaOH as required to adjust the pH to slightly acidic. Adjust volume to 50 mL.

e) Pipette two aliquots of sample and spike with 0.5 mL and 1.0 mL respectively with fluoride solution II. (0.5 mg/L and 1.0 mg/L).

f) Add TISAB in 1:1 ratio with sample.

g) Analyze the samples and the above spiked samples using a fluoride selective ion electrode.

h) Calculate the result from the spike additions and the raw fluoride results. Results should be blank corrected.

Quality Control

Carry at least two blank unexposed plates and a reagent blank through all steps of the procedure.

References

a) A.J. Lynch, N.R. McQuaker and M. Gurney, Environ. Sci. Technol. 12, 169 (1978).

Revision History

April 1, 1996:	Initial Draft
October 29, 1996:	Procedure vetted by private sector laboratories.
January 13, 1998:	Minor editing; EMS codes verified.
March 20, 1998:	Revision of EMS code to eliminate redundant variable for intermediate results.
December 31, 2000	Minor editing; Supplement #2 merged with main Lab Manual.

FLUORIDATION PLATES

Extracted by: _____

100mL of samples that includes 50 mL TISAB

Date Extracted _____

units: mg/L except where show otherwise

Sample Number	Raw Result	0.5 mg/L Spike Result	1.0 mg/L Spike Result	Days of Sampling	Average Percent Recovery	Concentration Standard Additions	Blank correction mg/L	Final Result, from ug
								unit correct:
Blank A	0.217	0.594	1			0.282	average	mg/l x1000 ug/mg x0.05
spike recovery		75%	78%		77%		0.329	gives ug per plate.
Blank B	0.291	0.645	1.13		Avg. blank	0.376		
spike recovery		71%	84%		77%			
sample #26672	0.656	1.14	1.7			0.652	0.323	16.14
spike recovery		97%	104%		101%			
sample #28210	0.403	0.872	1.44			0.408	0.079	3.94
spike recovery		94%	104%		99%			
								Corrections for days of sampling not shown since data not available

APPENDIX G – DUST COMPLAINT MANAGEMENT FORM

DRAFT

APPENDIX – DUST COMPLAINT MANAGEMENT FORM

DUST COMPLAINT MANAGEMENT TRACKING	
Incident #	
FSD personnel completing form	
Name:	
Title:	
Date:	
Complainant information	
Resident location:	
Resident name:	
Resident phone #:	
Resident email address:	
Date and time complaint received:	
Reason for the complaint (visual / cosemetic or health related)	
Source and timing of dust	
Date and time of dust occurrence:	
Specific nature of complaint / source of dust:	
Onsite / rail traffic activities at time of complaint:	
Anemometer data at the time of the complaint:	
General weather conditions during the time of the complaint	
Opacity reading when the complaint was received	
Particulate matter monitoring readings when the complaint was received	
Investigative actions	
Investigations of dust source:	

DUST COMPLAINT MANAGEMENT TRACKING	
Anemometer / weather data at the time of the investigation:	
Resolution	
Actions taken (where feasible) to eliminate future occurrences:	
Follow up with resident :	
Status post follow up (resolved to resident satisfaction Y/N):	
Date file closed:	

APPENDIX IX

HEALTH EFFECTS ASSOCIATED WITH EXPOSURE TO PARTICULATE MATTER

1.0 POTENTIAL SHORT AND LONG TERM HEALTH EFFECTS OF FUGITIVE DUST AND DIESEL EMISSIONS

The following sections provide information on the potential short and long term health effects of PM, CO, NO_2 and SO_2. This information is provided for informational purposes only. As presented in Section 7.0, based on predicted air concentrations of PM, CO, NO_2 and SO_2 less than or equal to the ambient air quality objectives/guidelines, including the most stringent provincial and federal guidelines, it has been concluded that fugitive dust and diesel emissions associated with the Project are not anticipated to have significant effects on ambient area quality in the area. The ambient air quality objectives/guidelines have been derived to be protective of health effects, including for sensitive sub-populations, and therefore exposure to air concentrations less than the objectives/guidelines would not be expected to result in unacceptable health risks.

1.1 Particulate Matter

WHO (2006) summarized that long-term exposure to particulate matter concentrations had the potential to lead to a marked reduction in life expectancy, primarily due to increased cardio-pulmonary and lung cancer mortality. In addition, increases in lower respiratory symptoms and reduced lung function in children, and chronic obstructive pulmonary disease and reduced lung function in adults, were likely long-term health outcomes associated with exposures to elevated $PM_{2.5}$ concentrations (SENES, 2005; WHO, 2006). Susceptibility to PM pollution appears to vary with health and age; however, there is evidence to suggest that elderly subjects, and subjects with pre-existing heart and lung disease, are more susceptible to the effects of PM on mortality and morbidity (e.g. hospitalization and emergency room visits) (WHO, 2006). Additionally, more symptoms, larger lung function changes and increased use of medication are reported for asthmatics exposed to elevated ambient PM (WHO, 2006).

Table VIII-1 below summarizes both the short and long-term health effects associated with exposure to PM.

Table VIII-1. Summary of Health Effects Associated with Exposure to Particulate Matter (SENES, 2005)

Effects Related to Short-term Exposure	Effects Related to Long-term Exposure
Lung inflammatory reactions	Increase in lower respiratory symptoms
Respiratory symptoms	Reduction in lung function in children
Adverse effects on the cardiovascular system	Increase in chronic obstructive pulmonary disease
Increase in medication usage	Reduction in lung function in adults
Increase in hospital admissions	Reduction in life expectancy (due to cardiopulmonary mortality and lung cancer)

WHO (2006) summarized that long-term exposure to particulate matter concentrations had the potential to lead to a marked reduction in life expectancy, primarily due to increased cardio-pulmonary and lung cancer mortality. Epidemiological studies on large populations have not identified a threshold concentration below which ambient PM has no effect on health (SENES, 2005; WHO, 2006; CCME, 2004). It is noted that although a range of thresholds may exist within the population, depending on the type of health effect and the susceptibility of subgroups, no threshold for adverse effects at the population level and for the most sensitive subgroups has been identified (SENES, 2005). Both WHO (2006) and SENES (2005) indicate that as threshold levels have not been identified, the air quality guidelines reflect concentrations below which increased mortality outcomes due to exposure to PM air pollution are not expected, including for sensitive sub-populations.

1.1.1 Potential Carcinogenicity of Coal Dust

Concerns regarding the potential carcinogenicity of coal dust have also been raised. The International Agency on Cancer Research (IARC) (1997) indicates that there have been no epidemiological studies on cancer risks in relation to coal dust, with the exception of limited occupational exposure studies evaluating high level exposures to coal miners to coal mine dust. The findings of the occupational studies have been inconsistent, and IARC (1997) indicates that there is no consistent evidence supporting an exposure-response relationship. IARC (1997) has indicated there is inadequate evidence in humans for the carcinogenicity of coal dust.

Carcinogenicity of coal dust has been tested in animal studies using rodents exposed via inhalation or injection (IARC, 1997). In these studies, the incidence of tumours did not increase compared to control animals (IARC, 1997).

1.2 CARBON MONOXIDE

When inhaled, carbon monoxide can readily diffuse across membranes (e.g., alveolar, capillary, and placental) (WHO, 2000). Haemoglobin is a vital protein found in red blood cells that is used to transport oxygen throughout an organism. Absorbed CO binds with haemoglobin in the blood to form carboxyhaemoglobin (COHb) (WHO, 2000). Carbon monoxide has a significantly higher affinity for haemoglobin (200 to 250 times higher) compared to oxygen, which means that exposure to even relatively small amounts of CO results in reduced oxygen-carrying capacity of the blood (WHO, 2000).

At low concentrations, acute CO exposure can cause severe hypoxia, resulting in both reversible neurological deficits and delayed, irreversible neurological damage (WHO, 2000). Such neurobehavioural effects can include impaired coordination and reduced athletic and cognitive performance. The health effects of CO exposure are most notable in tissues with high oxygen requirements such as the brain, heart, skeletal muscles, and the developing foetus (WHO, 2000). Subjects with coronary disease have demonstrated a decrease in the time to onset of angina, following exposure to CO (WHO, 2000). Exposure to CO can also result in ventricular arrhythmias, cardiovascular mortality and the early course of myocardial infarction (heart attack) (WHO, 2000). In addition, CO exposure has been responsible for acute accidental and suicidal deaths (WHO, 2000).

Table VIII-2 below summarizes both the short and long-term health effects associated with exposure to CO.

Table VIII-2. Summary of Health Effects Associated with Exposure to Carbon Monoxide (from WHO, 2000)

Effects Related to Short-term Exposure	Effects Related to Long-term Exposure
Reversible, short-lasting neurological deficits	Reduction in athletic performance
Irreversible, delayed neurological damage	Increase in hospital admissions for cardiac diseases
Aggravates cardiac symptoms	Reduction in life expectancy (cardiovascular mortality and myocardial infarction)
Asphyxiation	
Acute accidental and suicidal death	

Environmental exposure and endogenous production of CO results in COHb concentrations of approximately 0.5% to 1.5%, while pregnant women can experience COHb levels of up to 2.5%, due to increased endogenous CO production (WHO, 2000). Guidelines for an one hour average exposure of 30 mg/m^3 and an eight hour average exposure of 10 mg/m^3 were selected by WHO (2000) to ensure a COHb level of 2.5% is not exceeded in sensitive populations (i.e., non-smoking groups with coronary artery disease or foetuses of non-smoking women).

1.3 NITROGEN DIOXIDE

Inhalation exposure to NO_2 usually results in mild irritation to the upper respiratory tract; however, when NO_2 enters into solution in the moist alveolar spaces of the lungs, more serious pulmonary damage can occur (CDC, 1979).

Exposure to NO_2 can result in mucosal irritation (eyes, nose and throat), chemical pneumonitis, acute pulmonary edema or death, depending on the duration of exposure and concentration of NO_2 (CDC, 1979). Short-term health effects following exposure to NO_2 can result in decreased pulmonary function and increases bronchial reactivity, both of which are generally more evident in asthmatics (WHO, 2000). WHO (2006) summarized that long-term exposure to NO_2 concentrations had the potential to lead to both reversible (biochemical) and irreversible (cellular structure) effects, primarily in the lungs but also in the spleen, liver, and blood. In addition, increased susceptibility to bacterial and viral lung infections were likely long-term health outcomes associated with exposures to elevated NO_2 concentrations (WHO, 2006). Repeated lung infections in children can cause future lung damage and children are at risk of increased respiratory illness with exposure to NO_2 (WHO, 2000).

Table IX-3 below summarizes both the short and long-term health effects associated with exposure to NO2.

Table VIII-3. Summary of Health Effects Associated with Exposure to Nitrogen Dioxide (from WHO, 2006 and 2000)

Effects Related to Short-term Exposure	Effects Related to Long-term Exposure
Reduction in pulmonary function	Reduction in lung function in children
Reduction in forced expiratory volume in asthmatics	Increase in bronchitic symptoms of asthmatic children
Increase in bronchial reactivity	Reversible and irreversible lung effects
Irritation to the eyes, nose and throat	Increase in susceptibility to bacterial and viral lung infections

The available studies indicate that there is no clearly defined dose-response relationship for health effects caused by NO_2 exposure (WHO, 2000). A 0.5 uncertainty factor was applied to the lowest observed effect level (375 µg/m^3 to 565 µg/m^3) based on small changes in lung function and changes in airway responsiveness following NO_2 exposure, resulting in a one hour average objective of 200 µg/m^3 (WHO, 2000). Chronic exposure can result in long-term health effects and therefore, an annual average guideline of 40 µg/m^3 has been proposed (WHO, 2000). This value is based on the potential for direct toxic effects of chronic NO_2 exposure at low concentrations (WHO, 2000). In addition, during epidemiological studies NO_2 is often used as a marker for other combustion-generated pollutants and it is difficult to attribute health effects solely to NO_2 exposure when there are other correlated co-pollutants present; therefore, retaining a conservative annual NO_2 guideline is considered prudent and health-protective (WHO, 2006).

1.4 SULPHUR DIOXIDE

Inhalation exposure to SO_2 usually results rapid onset of irritation to mucous membranes due to the formation sulphurous acid upon contact with moist mucous (CDC, 1974).

Exposure to SO_2 can result in the onset of adverse health effects within minutes of the commencement of inhalation exposure. Symptoms of exposure include reductions in forced expiratory volume, increases in airway resistance and wheezing or shortness of breath (WHO, 2000). The onset of effects occurs rapidly and extending the duration of exposure does not increase the effects. Exercise has been shown to increase the penetrative depth of SO_2 into the respiratory tract (WHO, 2000). Long-term effects have shown increased mortality as a result of cardiovascular and respiratory effects, and increased hospital admissions for respiratory causes and pulmonary disease (WHO, 2000).

Table VIII-4 below summarizes both the short and long-term health effects associated with exposure to SO_2.

Table VIII-4. Summary of Health Effects Associated with Exposure to SO2 (from WHO, 2006 and 2000)

Effects Related to Short-term Exposure	Effects Related to Long-term Exposure
Reductions in forced expiratory volume	Increase in mortality from cardiovascular and respiratory effects
Increase in airway resistance	Increase in hospital admissions
Irritation to mucous membranes	
wheezing	
Shortness of breath	

The available studies indicate that there is no clearly defined dose-response relationship for health effects caused by SO_2 exposure and a clearly defined exposure threshold is not evident (WHO, 2000). Although individuals with asthma are more sensitive, there is a large range of sensitivity to SO_2 exposure throughout the general population (WHO, 2000). To be protective of the most sensitive population, guidelines for SO_2 were developed considering the minimum concentrations associated with adverse effects in asthmatics (WHO, 2000). WHO (2006) reports that there is uncertainty in the causality between SO_2 and adverse effects, which may be attributed to other factors such as ultrafine particles or another correlated pollutant. WHO (2006) recommends a more stringent 24-hour guideline (20 $\mu g/m^3$) compared to previous WHO values in order to provide greater protection as precautionary approach.

1.5 REFERENCES

CCME, 2004. Human Health Effects of Find Particulate Matter: Update in Support of the Canada-Wide Standards for Particulate Matter and Ozone. Prepared for the Canadian Council for Ministers of the Environment. Revised in July 2004.

CDC, 1974. Criteria for a recommended standard: Occupational exposure to sulfur dioxide. U.S. Department of Health, Education, and Welfare. National Institute for Occupational Safety and Health Publication No. 74-111.

CDC, 1979. A guide to work-relatedness of disease. Revised Edition. U.S. Department of Health, Education, and Welfare. National Institute for Occupational Safety and Health Publication No. 79-116.

IARC, 1997. World Health Organization International Agency for Research on Cancer, IARC Mongraphs on the Evaluation of Carcinogenic Risks to Humans. Volume 68, Summary of Data Reported and Evaluation; Coal Dust. Available on-line at http://monographs.iarc.fr/ENG/Monographs/vol68/volume68.pdf .

SENES, 2005. Development of Options for a New Provincial $PM_{2.5}$ Air Quality Objective, Summary Report. SENES Consultants Ltd. Prepared for British Columbia Lung Association. December 2005.

WHO, 2000. Air Quality Guidelines for Europe, Second Edition. WHO Regional Publications, European Series, No. 91, Copenhagen.

WHO, 2006. WHO air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. Summary of risk assessment. WHO Press, World Health Organization, Geneva.

APPENDIX X

METRO VANCOUVER WILDLIFE LIST (HECTARESBC 2013)

Metro Vancouver Wildlife List for Fraser Surrey Docks (HectaresBC 2013)

English Name (Latin Name)	Class
Coastal Tailed Frog (Ascaphus truei)	Amphibians
Ensatina (Ensatina eschscholtzii)	Amphibians
Northwestern Garter Snake (Thamnophis ordinoides)	Amphibians
Northwestern Salamander (Ambystoma gracile)	Amphibians
Oregon Spotted Frog (Rana pretiosa)	Amphibians
Red-legged Frog (Rana aurora)	Amphibians
Western Redback Salamander (Plethodon vehiculum)	Amphibians
Western Toad (Bufo boreas)	Amphibians
American Bittern (Botaurus lentiginosus)	Birds
American Coot (Fulica americana)	Birds
American Goldfinch (Carduelis tristis)	Birds
American Kestrel (Falco sparverius)	Birds
Band-tailed Pigeon (Patagioenas fasciata)	Birds
Barn Owl (Tyto alba)	Birds
Barn Swallow (Hirundo rustica)	Birds
Belted Kingfisher (Megaceryle alcyon)	Birds
Bewick's Wren (Thryomanes bewickii)	Birds
Black Swift (Cypseloides niger)	Birds
Black-throated Gray Warbler (Dendroica nigrescens)	Birds
Blue-winged Teal (Anas discors)	Birds
Brown Creeper (Certhia americana)	Birds
Caspian Tern (Hydroprogne caspia)	Birds
Chestnut-backed Chickadee (Poecile rufescens)	Birds
Cinnamon Teal (Anas cyanoptera)	Birds
Cliff Swallow (Petrochelidon pyrrhonota)	Birds
Common Goldeneye (Bucephala clangula)	Birds
Common Nighthawk (Chordeiles minor)	Birds
Double-crested Cormorant (Phalacrocorax auritus)	Birds
Eastern Kingbird (Tyrannus tyrannus)	Birds
Evening Grosbeak (Coccothraustes vespertinus)	Birds
Great Blue Heron (Ardea herodias)	Birds
Great Blue Heron, fannini subspecies (Ardea herodias fannini)	Birds
Green Heron (Butorides virescens)	Birds
Harlequin Duck (Histrionicus histrionicus)	Birds
Killdeer (Charadrius vociferus)	Birds
Lesser Scaup (Aythya affinis)	Birds
Mourning Dove (Zenaida macroura)	Birds
Northern Goshawk (Accipiter gentilis)	Birds
Northern Harrier (Circus cyaneus)	Birds
Northern Pintail (Anas acuta)	Birds
Northern Pygmy-Owl (Glaucidium gnoma)	Birds
Northern Rough-winged Swallow (Stelgidopteryx serripennis)	Birds
Olive-sided Flycatcher (Contopus cooperi)	Birds
Pacific-slope Flycatcher (Empidonax difficilis)	Birds
Peregrine Falcon, anatum subspecies (Falco peregrinus anatum)	Birds
Pied-billed Grebe (Podilymbus podiceps)	Birds
Pigeon Guillemot (Cepphus columba)	Birds
Pileated Woodpecker (Dryocopus pileatus)	Birds
Purple Finch (Carpodacus purpureus)	Birds
Purple Martin (Progne subis)	Birds
Red Crossbill (Loxia curvirostra)	Birds
Red-eyed Vireo (Vireo olivaceus)	Birds

Rock Wren (Salpinctes obsoletus)	Birds
Ruffed Grouse (Bonasa umbellus)	Birds
Rufous Hummingbird (Selasphorus rufus)	Birds
Sandhill Crane (Grus canadensis)	Birds
Short-eared Owl (Asio flammeus)	Birds
Sooty Grouse (Dendragapus fuliginosus)	Birds
Swainson's Thrush (Catharus ustulatus)	Birds
Tree Swallow (Tachycineta bicolor)	Birds
Vaux's Swift (Chaetura vauxi)	Birds
Violet-green Swallow (Tachycineta thalassina)	Birds
Virginia Rail (Rallus limicola)	Birds
Western Screech-Owl, kennicottii subspecies (Megascops kennicottii kennicottii)	Birds
Western Screech-Owl (Megascops kennicottii)	Birds
Western Wood-Pewee (Contopus sordidulus)	Birds
Willow Flycatcher (Empidonax traillii)	Birds
Wilson's Snipe (Gallinago delicata)	Birds
Wilson's Warbler (Wilsonia pusilla)	Birds
Wood Duck (Aix sponsa)	Birds
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	Birds
Yellow Warbler (Dendroica petechia)	Birds
Dun Skipper (Euphyes vestris)	Butterflies
Great Arctic (Oeneis nevadensis)	Butterflies
Johnson's Hairstreak (Callophrys johnsoni)	Butterflies
Propertius Duskywing (Erynnis propertius)	Butterflies
Autumn Meadowhawk (Sympetrum vicinum)	Dragonflies
Beaverpond Baskettail (Epitheca canis)	Dragonflies
Black Petaltail (Tanypteryx hageni)	Dragonflies
Blue Dasher (Pachydiplax longipennis)	Dragonflies
Emma's Dancer (Argia emma)	Dragonflies
Grappletail (Octogomphus specularis)	Dragonflies
Sinuous Snaketail (Ophiogomphus occidentis)	Dragonflies
American Marten (Martes americana)	Mammals
American Shrew Mole (Neurotrichus gibbsii)	Mammals
Big Brown Bat (Eptesicus fuscus)	Mammals
Californian Myotis (Myotis californicus)	Mammals
Grey Wolf (Canis lupus)	Mammals
Hoary Bat (Lasiurus cinereus)	Mammals
Keen's Myotis (Myotis keenii)	Mammals
Little Brown Myotis (Myotis lucifugus)	Mammals
Long-legged Myotis (Myotis volans)	Mammals
Long-tailed weasel, altifrontalis subspecies (Mustela frenata altifrontalis)	Mammals
Mountain Beaver, rufa subspecies (Aplodontia rufa rufa)	Mammals
North American Porcupine (Erethizon dorsatum)	Mammals
Pacific Water Shrew (Sorex bendirii)	Mammals
Silver-haired Bat (Lasionycteris noctivagans)	Mammals
Snowshoe Hare, washingtonii subspecies (Lepus americanus washingtonii)	Mammals
Southern Red-backed Vole, occidentalis subspecies (Myodes gapperi occidentalis)	Mammals
Townsend's Big-eared Bat (Corynorhinus townsendii)	Mammals
Trowbridge's Shrew (Sorex trowbridgii)	Mammals
Yuma Myotis (Myotis yumanensis)	Mammals
Black Gloss (Zonitoides nitidus)	Molluscs, Non-Marine
Oregon Forestsnail (Allogona townsendiana)	Molluscs, Non-Marine
Pacific Sideband (Monadenia fidelis)	Molluscs, Non-Marine
Puget Oregonian (Cryptomastix devia)	Molluscs, Non-Marine
Rocky Mountain Fingernailclam (Sphaerium patella)	Molluscs, Non-Marine

Scarletback Taildropper (Prophysaon vanattae)	Molluscs, Non-Marine
Western Floater (Anodonta kennerlyi)	Molluscs, Non-Marine
Western Pearlshell (Margaritifera falcata)	Molluscs, Non-Marine
Western Thorn (Carychium occidentale)	Molluscs, Non-Marine
Winged Floater (Anodonta nuttalliana)	Molluscs, Non-Marine
Northern Alligator Lizard (Elgaria coerulea)	Reptiles And Turtles
Rubber Boa (Charina bottae)	Reptiles And Turtles
Western Painted Turtle (Chrysemys picta)	Reptiles And Turtles
Western Painted Turtle - Pacific Coast Population (Chrysemys picta pop. 1)	Reptiles And Turtles

APPENDIX XI

PLANTS WITH SPECIAL STATUS

Plants with special status that may occur in the vicinity of FSD (CDC 2013)

Latin Name	English Name	BC List	SARA	COSEWIC
Lupinus rivularis	streambank lupine	Red	1-E (Jan 2005)	E (Nov 2002)
Fissidens pauperculus	poor pocket moss	Red	1-E (Jun 2003)	E (May 2011)
Bidens amplissima	Vancouver Island beggarticks	Blue	1-SC (Jun 2003)	SC (Nov 2001)
Brotherella roellii	Roell's brotherella	Red	-	E (Nov 2010)
Acorus americanus	American sweet-flag	Blue	-	-
Alsia californica	-	Blue	-	-
Amblystegium varium	-	Blue	-	-
Anagallis minima	chaffweed	Blue	-	-
Andreaea schofieldiana	-	Blue	-	-
Atrichum flavisetum	-	Blue	-	-
Brachythecium holzingeri	-	Blue	-	-
Bryum canariense	-	Blue	-	-
Bryum schleicheri	-	Blue	-	-
Callicladium haldanianum	-	Blue	-	-
Callitriche heterophylla var. *heterophylla*	two-edged water-starwort	Blue	-	-
Caltha palustris var. *radicans*	yellow marsh-marigold	Blue	-	-
Carex scoparia	pointed broom sedge	Blue	-	-
Carex vulpinoidea	fox sedge	Blue	-	-
Cryptogramma cascadensis	Cascade parsley fern	Blue	-	-
Cuscuta campestris	field dodder	Blue	-	-
Diphyscium foliosum	-	Blue	-	-
Discelium nudum	-	Blue	-	-
Elatine rubella	three-flowered waterwort	Blue	-	-
Eleocharis parvula	small spike-rush	Blue	-	-
Eleocharis rostellata	beaked spike-rush	Blue	-	-
Elodea nuttallii	Nuttall's waterweed	Blue	-	-
Epipterygium tozeri	-	Blue	-	-
Fissidens ventricosus	-	Blue	-	-
Glyceria leptostachya	slender-spiked mannagrass	Blue	-	-
Helenium autumnale var. *grandiflorum*	mountain sneezeweed	Blue	-	-
Hygroamblystegium fluviatile	-	Blue	-	-
Hygrohypnum alpinum	-	Blue	-	-
Hypericum scouleri ssp. *nortoniae*	western St. John's-wort	Blue	-	-
Isoetes nuttallii	Nuttall's quillwort	Blue	-	-
Juncus oxymeris	pointed rush	Blue	-	-
Lilaea scilloides	flowering quillwort	Blue	-	-
Lindernia dubia var. *anagallidea*	false-pimpernel	Blue	-	-
Mimulus breviflorus	short-flowered monkey-flower	Blue	-	-
Myriophyllum hippuroides	western water-milfoil	Blue	-	-
Myriophyllum ussuriense	Ussurian water-milfoil	Blue	-	-
Orthotrichum cupulatum	-	Blue	-	-
Orthotrichum striatum	-	Blue	-	-
Physcomitrium pyriforme	-	Blue	-	-
Platyhypnidium riparioides	-	Blue	-	-
Pleuropogon refractus	nodding semaphoregrass	Blue	-	-
Ptychomitrium gardneri	-	Blue	-	-
Rubus nivalis	snow bramble	Blue	-	-
Rupertia physodes	California-tea	Blue	-	-
Sidalcea hendersonii	Henderson's checker-mallow	Blue	-	-
Sphagnum contortum	-	Blue	-	-
Verbena hastata var. *scabra*	blue vervain	Blue	-	-
Warnstorfia pseudostraminea	-	Blue	-	-

Alopecurus carolinianus	Carolina meadow-foxtail	Red	-	-
Andreaea sinuosa	-	Red	-	-
Brachythecium reflexum var. *pacificum*	-	Red	-	-
Carex interrupta	green-fruited sedge	Red	-	-
Claytonia washingtoniana	Washington springbeauty	Red	-	-
Erigeron philadelphicus var. *glaber*	salt marsh Philadelphia fleabane	Red	-	-
Eutrochium maculatum var. *bruneri*	Joe-pye weed	Red	-	-
Helianthus nuttallii ssp. *rydbergii*	Nuttall's sunflower	Red	-	-
Juncus brevicaudatus	short-tailed rush	Red	-	-
Lindernia dubia var. *dubia*	yellowseed false pimpernel	Red	-	-
Myriophyllum pinnatum	green parrot's-feather	Red	-	-
Navarretia intertexta	needle-leaved navarretia	Red	-	-
Physcomitrium immersum	-	Red	-	-
Pohlia cardotii	-	Red	-	-
Pseudephemerum nitidum	-	Red	-	-
Steerecleus serrulatus	-	Red	-	-
Wolffia borealis	northern water-meal	Red	-	-

APPENDIX XII

WILDLIFE WITH SPECIAL STATUS

Wildlife with special status that may occur in the vicinity of FSD (CDC 2013)

Scientific Name	English Name	BC List	SARA	COSEWIC	(English)
Rana aurora	Northern Red-legged Frog	Blue	1-SC (Jan 2005)	SC (Nov 2004)	amphibians
Anaxyrus boreas	Western Toad	Blue	1-SC (Jan 2005)	SC (Nov 2012)	amphibians
Nearctula sp. 1	Threaded Vertigo	Red	1-SC (Jul 2012)	SC (Apr 2010)	gastropods
Deroceras hesperium	Evening Fieldslug	Red	-	DD (Nov 2003)	gastropods
Carychium occidentale	Western Thorn	Blue	-	-	gastropods
Monadenia fidelis	Pacific Sideband	Blue	-	-	gastropods
Pristiloma johnsoni	Broadwhorl Tightcoil	Blue	-	-	gastropods
Prophysaon vanattae	Scarletback Taildropper	Blue	-	-	gastropods
Zonitoides nitidus	Black Gloss	Blue	-	-	gastropods
Danaus plexippus	Monarch	Blue	1-SC (Jun 2003)	SC (Apr 2010)	insects
Omus audouini	Audouin's Night-stalking Tiger Beetle	Red	-	C (Jul 2011)	insects
Speyeria zerene bremnerii	Zerene Fritillary, *bremnerii* subspecies	Red	-	-	insects
Callophrys eryphon sheltonensis	Western Pine Elfin, *sheltonensis* subspecies	Blue	-	-	insects
Epitheca canis	Beaverpond Baskettail	Blue	-	-	insects
Sympetrum vicinum	Autumn Meadowhawk	Blue	-	-	insects
Sorex bendirii	Pacific Water Shrew	Red	1-E (Jun 2003)	E (Apr 2006)	mammals
Eumetopias jubatus	Steller Sea Lion	Blue	1-SC (Jul 2005)	SC (Nov 2003)	mammals
Myotis keenii	Keen's Myotis	Blue	3 (Mar 2005)	DD (Nov 2003)	mammals
Lepus americanus washingtonii	Snowshoe Hare, *washingtonii* subspecies	Red	-	-	mammals
Myodes gapperi occidentalis	Southern Red-backed Vole, *occidentalis* subspecies	Red	-	-	mammals
Sorex rohweri	Olympic Shrew	Red	-	-	mammals
Corynorhinus townsendii	Townsend's Big-eared Bat	Blue	-	-	mammals
Sorex trowbridgii	Trowbridge's Shrew	Blue	-	-	mammals
Chrysemys picta pop. 1	Painted Turtle - Pacific Coast Population	Red	1-E (Dec 2007)	E (Apr 2006)	turtles
Actinemys marmorata	Western Pond Turtle	Red	1-X (Jan 2005)	XT (May 2012)	turtles

APPENDIX XIII

EXPERT LETTERS

South Fraser
Health Region

June 17, 1998

Mr. Verne Kucy
Manager
Environmental Services Division
Corporation of Delta
4450 Clarence Taylor Crescent
Delta, BC V4K 3W4

Dear Mr. Kucy;

This letter is in response to your request (dated May 11, 1998) for comments from Boundary Health Unit related to "the potential health impacts related to the coal port, ferry traffic or any other identifiable sources based on available air quality data or relevant health information."

This request was made in response to complaints received by Delta Council from the public regarding suspected pollution by coal dust. There was also some media interest in this issue; a Delta Councillor expressed concern in the Vancouver Sun, April 6, 1998 about pollution, specifically coal dust, originating from Westshore Terminals. Apparently this Councillor has expressed concern related to asthma in Tsawassen children and the possible link to coal dust.

In response to this, Mr. Parsonnage, an Environmental Health Officer with this health unit, conducted an on-site review at Westshore Terminals. His report is enclosed for your information. I believe you have also received separate response from Westshore Terminals directly.

It is the intent of this letter to provide information related to respiratory disease patterns in Delta compared to other areas in this region (ie. Langley and Surrey) and the province. This information has been summarized in the March 1997 document entitled: "Respiratory Disease Patterns in the Fraser Macro Area, BC: Focus on South Fraser Valley Health Region (Boundary Health Unit). This document was prepared by the Non-Communicable Disease Epidemiology Department of the Preventive Health Branch, Ministry of Health. Sections of this document are attached.

In general, while there is some variation, data related to asthma and respiratory diseases do not indicate a significant problem in the South Fraser Valley (SFV) or in Delta compared to the rest of the province. Graphs depicting age-adjusted hospitalization rates as well as age-adjusted death rates and ratios for respiratory diseases and specifically asthma are attached. It is important to adjust for age when comparing these rates in different areas since deaths due to respiratory diseases will be affected by differences in age distribution in different communities.

South Fraser Health Region
Boundary Health Unit
14265 - 56 Avenue
Surrey, BC V3X 3A4
Phone: (604) 572-2600
FAX: (604) 594-0949

From these graphs it can be seen that hospitalisation rates for diseases of the respiratory system and specifically for asthma in the SFV and in Delta residents are not significantly different from the rest of the province (see Graphs 1 and 2). Hospitalisations due to the respiratory system and due to asthma in Delta are lower than in other residents of this region.

Annual death rates, adjusted for age, due to respiratory diseases and specifically due to asthma in SFV have been comparable to those in the rest of the province (see Graphs 3 and 4). Furthermore age standardised death rates due to respiratory diseases overall and specifically asthma in Surrey, Delta and Langley are also comparable (see Table 1).
The standardised mortality ratio (SMR) gives the ratio of the number of deaths observed in a given population due to a specific cause (such as respiratory disease) compared to the expected number in a reference population (such as the province of BC). The SMR for respiratory diseases is significantly lower for the SFV overall compared to the rest of the province (see Graph 3). The SMR for asthma is also low in the SFV compared to the rest of the province.

Finally, in Delta, the SMR for respiratory diseases is lower compared to the province (see Graph 5). Deaths due to asthma in Delta are not significantly different from expected (see Graph 6).

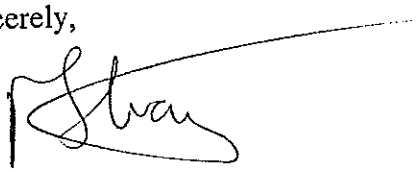
Thus, data available related to hospitalisation and death due to respiratory diseases in general and asthma in particular do not point to a concern in Delta over other areas of this region or the province.

In addition, the investigation conducted by our Environmental Health Officer indicates that it is unlikely that there is any health risk to residents of South Delta from the operation of Westshore Terminals. The prevailing winds are directed away from residential areas. Total dustfall levels measured at Westshore Terminals fall within BC provincial and WCB guidelines. Total dustfall levels that have been measured at English Bluff School in Tswassen are comparable to those recorded at sampling sites in other residential areas of the GVRD.

Total dustfall, of which coal dust is a portion, includes particle sizes of 2-200 microns with 10-20 micron particles typical. Quantification of particles below 10 microns in diameter (PM10) are of greater interest when a health concern related to respiratory diseases is postulated and these are not currently measured in this area. However, available evidence related to asthma and respiratory diseases does not point to a concern in Delta compared to the rest of the province.

We hope this information is of some assistance in addressing your concerns. If you require additional information or clarification, please do not hesitate to contact Mr. Bill Rogers, Chief Environmental Health Officer, or myself at 572-2600.

Sincerely,



Robert A. Strang MD, FRCPC
Associate Medical Health Officer

Table 1

Age Standardized Mortality Rates*
South Fraser Valley Health Region, 1991-95

	M	F	Total
Pneumonia and Influenza	1.77	1.48	1.61
Chronic Respiratory Disease	2.06	1.32	1.67
Asthma	0.10	0.14	0.12
Diseases of the Respiratory System	4.53	3.39	3.91
Lung Cancer	3.93	2.98	3.43

	Langley	Surrey	Delta
	LHA 35	LHA 36	LHA 37
Pneumonia and Influenza	1.58	1.65	1.53
Chronic Respiratory Disease	1.64	1.73	1.46
Asthma	0.09	0.12	0.14
Diseases of the Respiratory System	3.82	4.00	3.73
Lung Cancer	4.36	3.19	3.31

* Rates per 10,000 population.

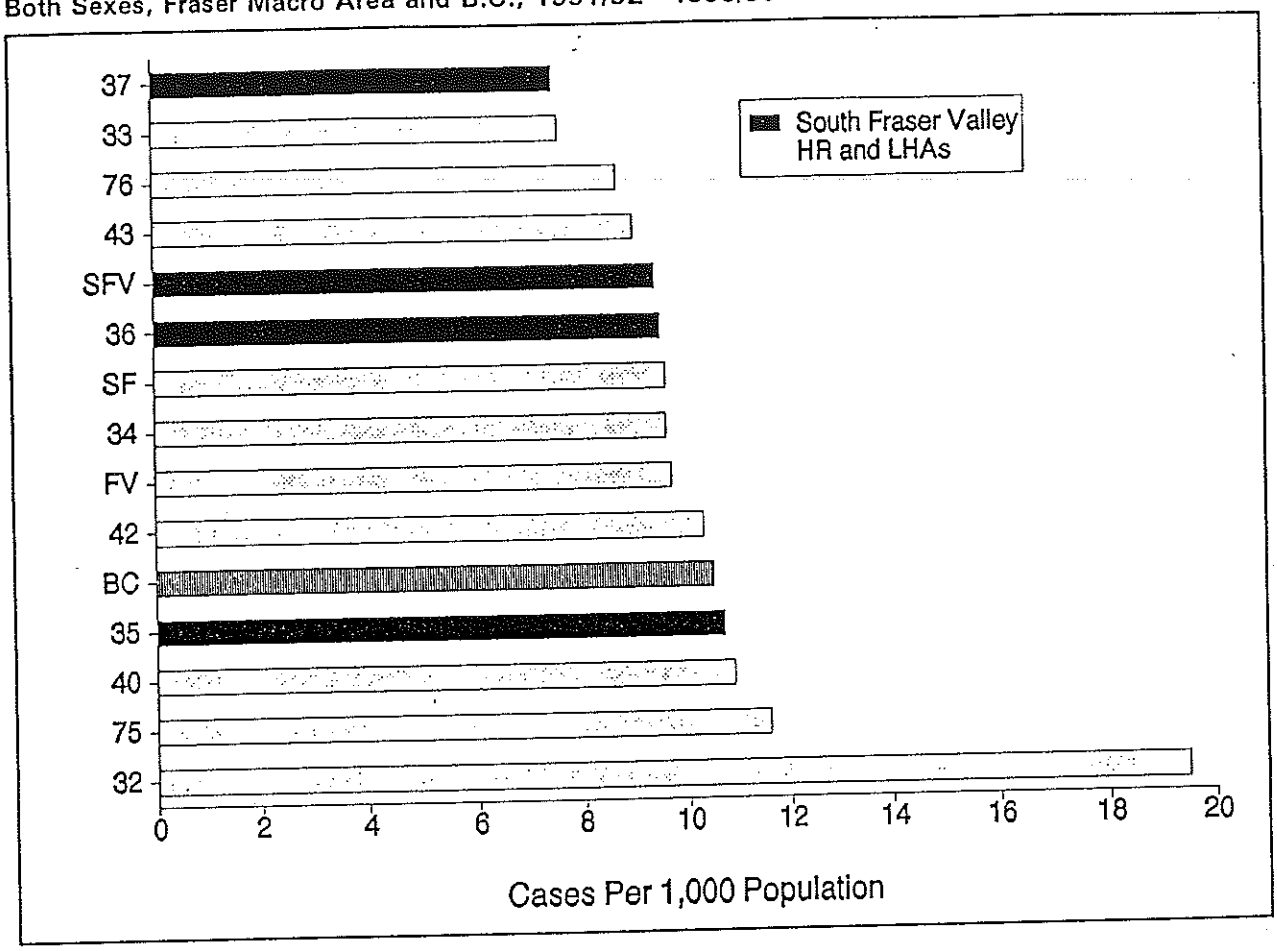
March 18, 1997

Source: Information and Resource Management
B.C. Vital Statistics Agency

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Graph 1

**Cumulative Age-Standardized Hospitalization Rates,
Diseases of the Respiratory System, (ICD9 460-519),
Both Sexes, Fraser Macro Area and B.C., 1991/92 - 1995/96**



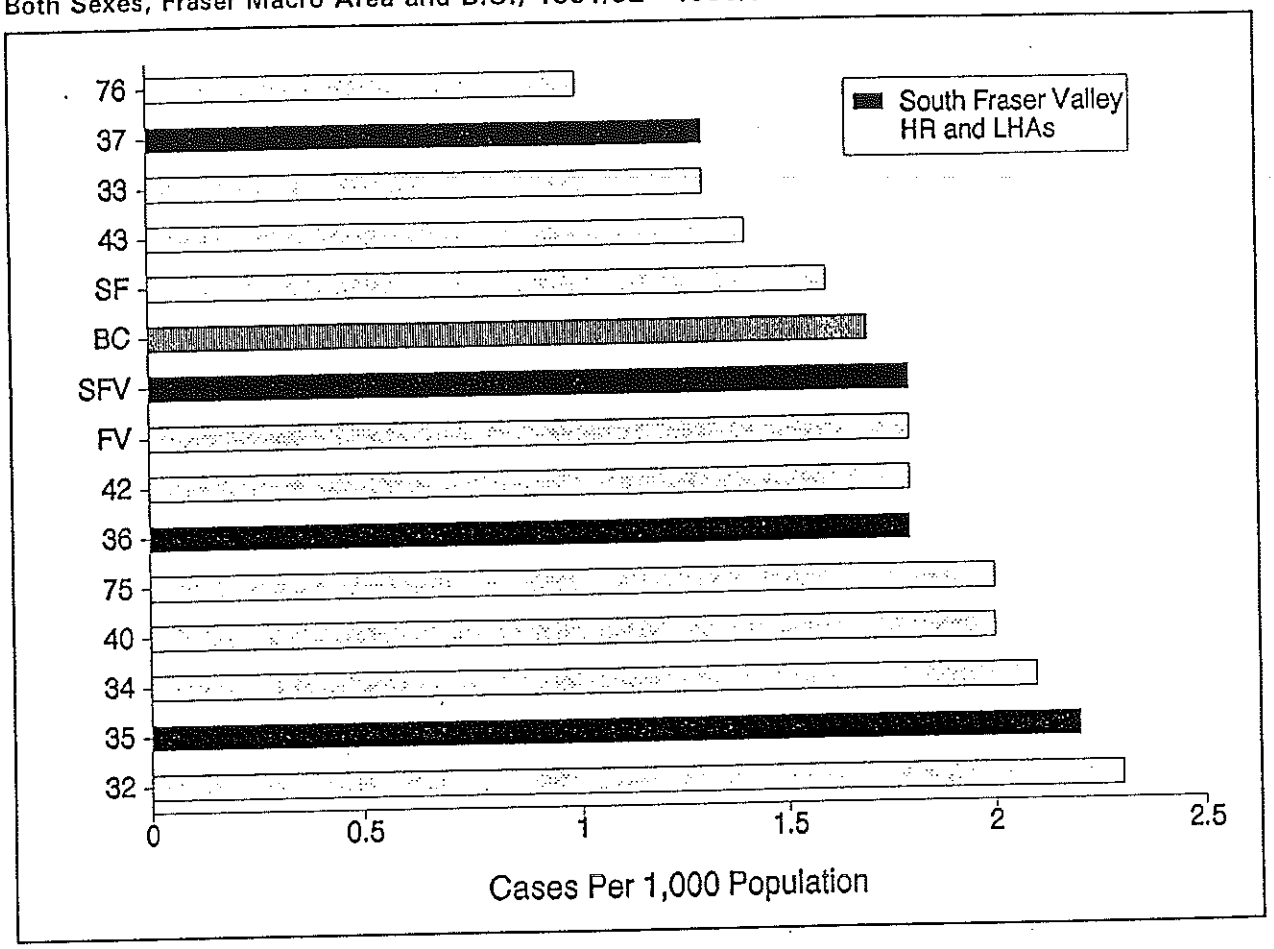
March 18, 1997

Source: Morbidity Database
Information Systems, Inpatient Programs

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Graph 2

Cumulative Age-Standardized Hospitalization Rates,
Asthma (ICD9 493),
Both Sexes, Fraser Macro Area and B.C., 1991/92 - 1995/96



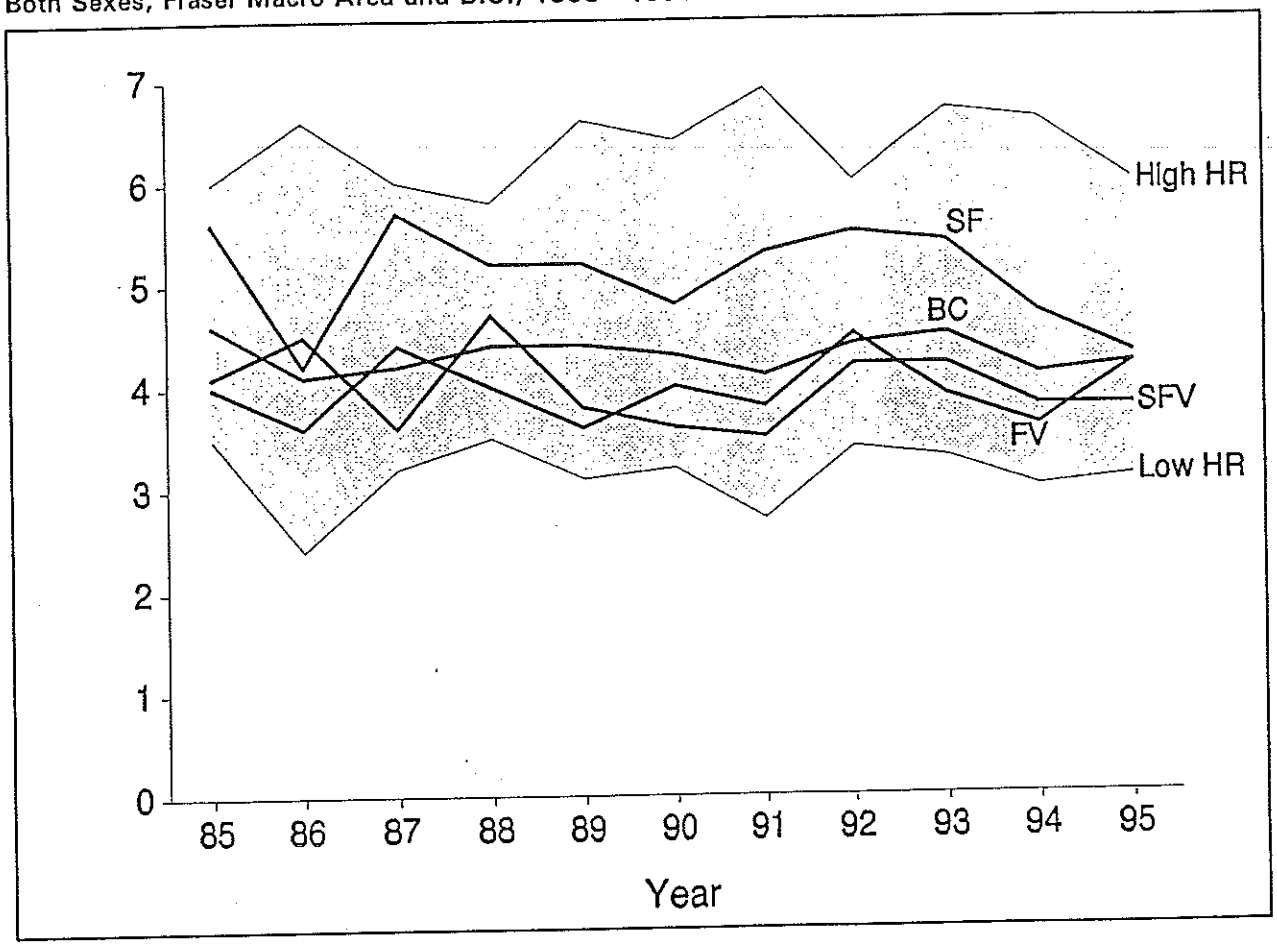
March 18, 1997

Source: Morbidity Database
Information Systems, Inpatient Programs

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Graph 3

Annual Age-Standardized Mortality Rates,
Diseases of the Respiratory System, (ICD9 460-519),
Both Sexes, Fraser Macro Area and B.C., 1985 - 1995



Shaded area represents the range in values for all HRs in the Province.

Source: Information and Resource Management,
B.C. Vital Statistics Agency

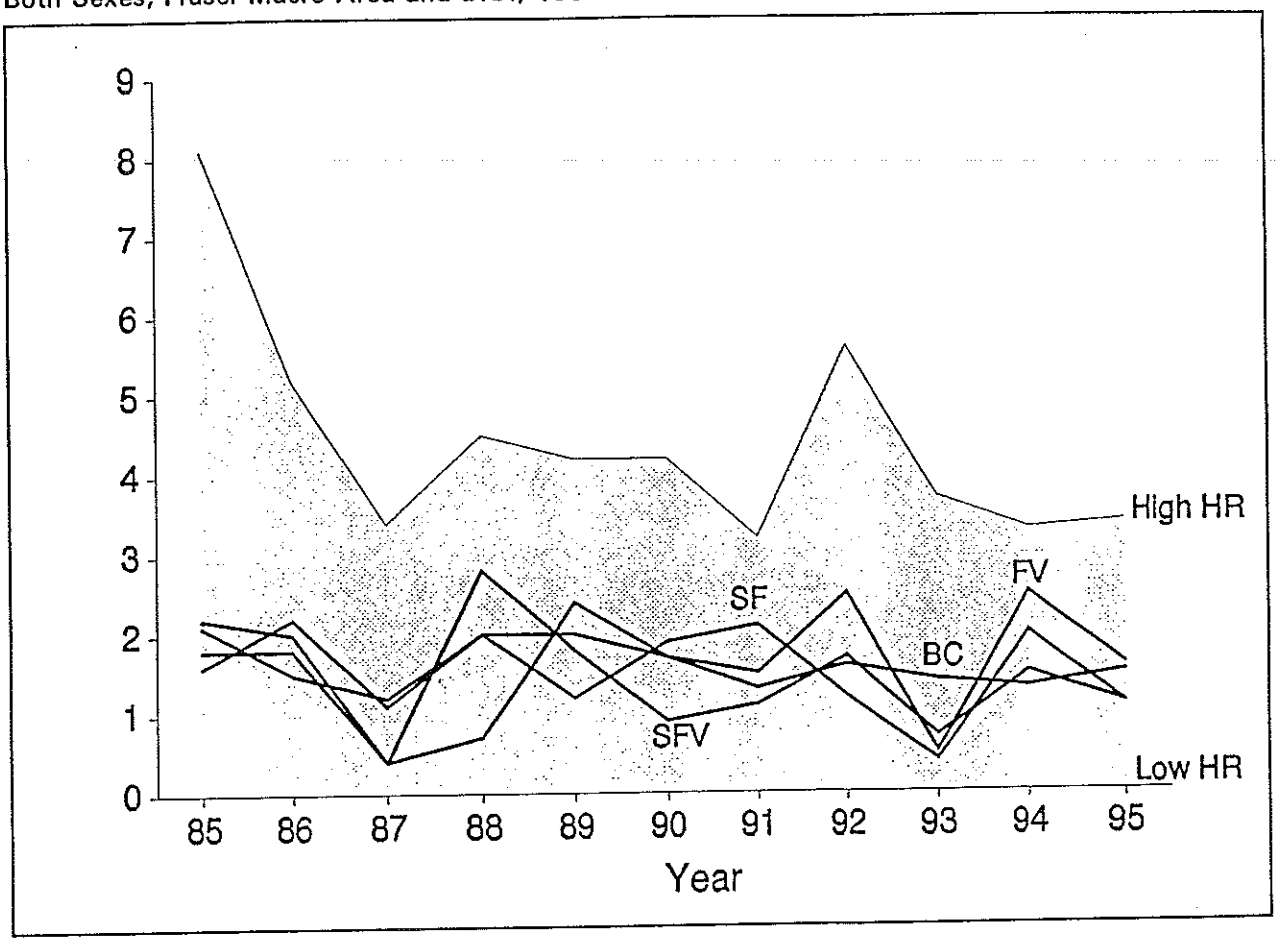
March 18, 1997

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Note:
SF = Simon Fraser
SFV = South Fraser Valley
FV = Fraser Valley

Graph 4

Annual Age-Standardized Mortality Rates,
Asthma (ICD9 493),
Both Sexes, Fraser Macro Area and B.C., 1985 - 1995



Shaded area represents the range in values for all HRs in the Province.

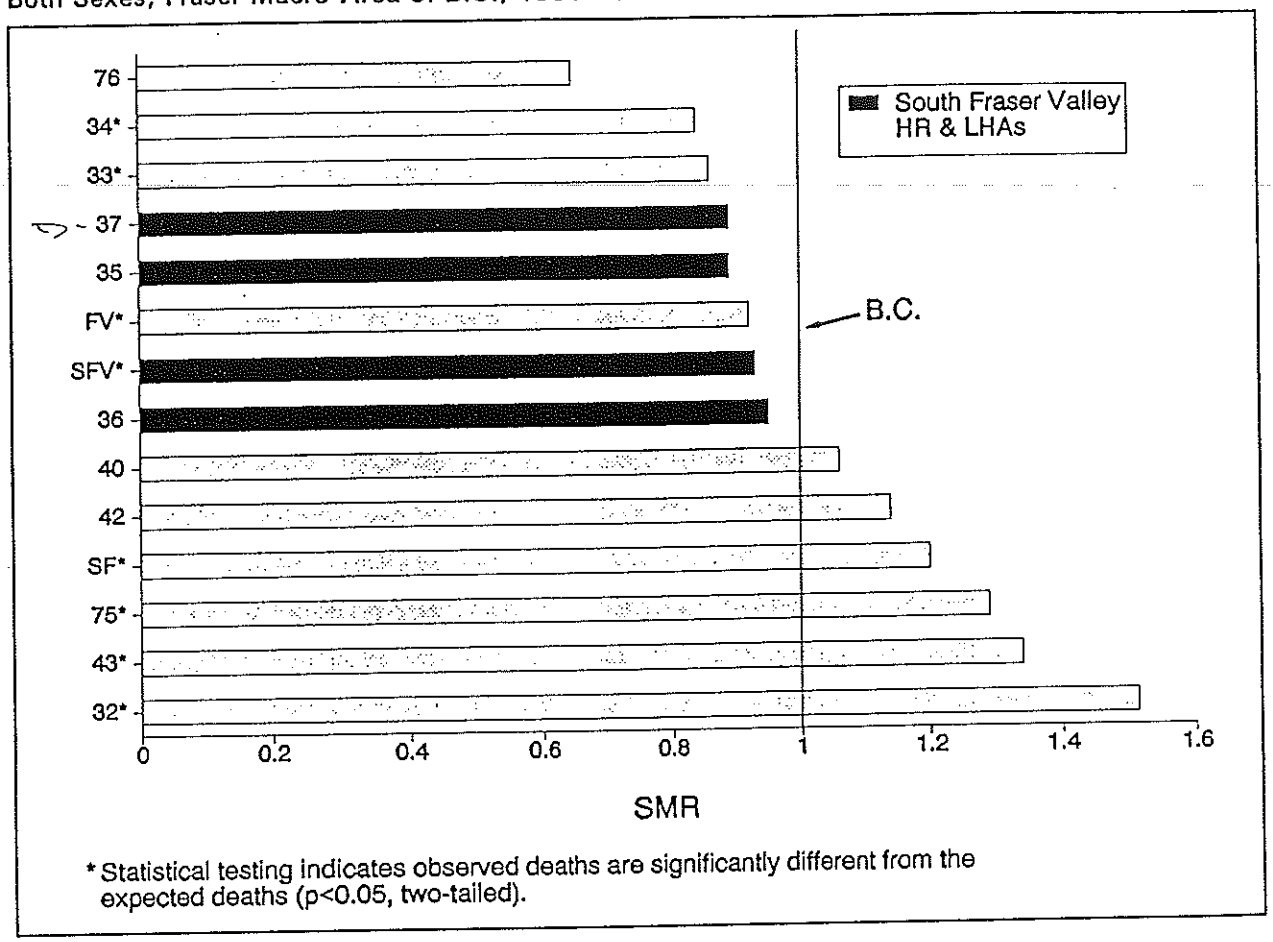
Source: Information and Resource Management,
B.C. Vital Statistics Agency

March 18, 1997

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Graph 5

Standardized Mortality Ratio,
Diseases of the Respiratory System (ICD9 460-519),
Both Sexes, Fraser Macro Area of B.C., 1991 - 1995



Source: Information and Resource Management,
B.C. Vital Statistics Agency

March 18, 1997

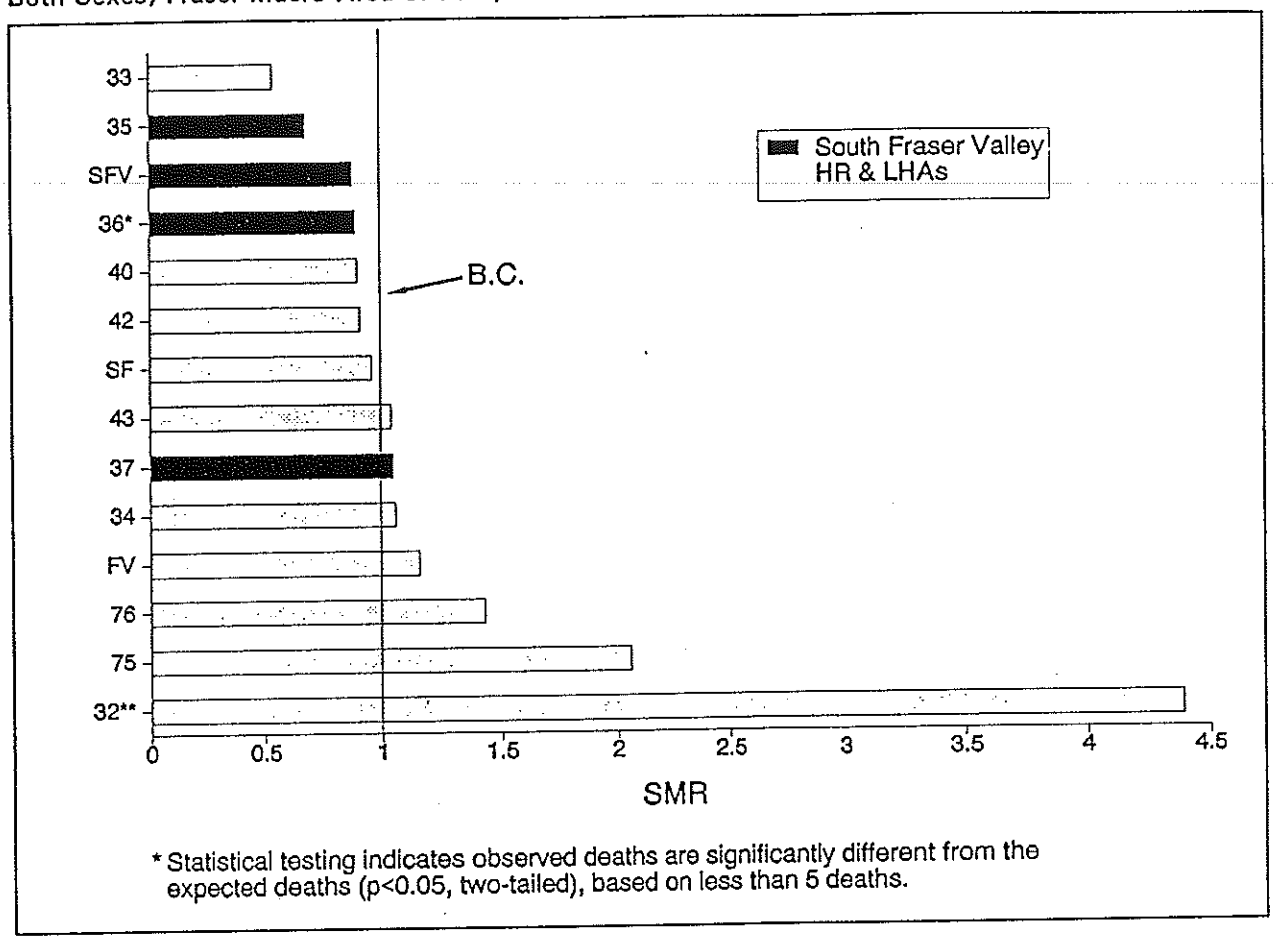
Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

Note:

35 = Langley
36 = Surrey
37 = Delta

Graph 6

Standardized Mortality Ratio,
Asthma (ICD9 493),
Both Sexes, Fraser Macro Area of B.C., 1991 - 1995



Source: Information and Resource Management,
B.C. Vital Statistics Agency

March 18, 1997

Prepared by Non-Communicable Disease Epidemiology,
Public and Preventive Health Division

35 = Langley
36 = Surrey
37 = Delta

July 16. 2013

Mr Jeff Scott
President and CEO
Fraser Surrey Docks LP
11060 Elevator Road
Surrey, British Columbia
V3V 2R7

Mr Scott:

RE: Expert Opinion Regarding Potential Health Impact From Fugitive Coal Dust From Coal Trains

I am pleased to provide my expert opinion regarding the concerns which have been raised regarding the potential adverse human health effects from fugitive coal dust from the proposed coal operations at Fraser Surrey Docks (FSD).

Expert Opinion

In my expert opinion, the proposed FSD coal handling operations do not pose a risk of adverse health effects in neighboring communities; I have come to this conclusion on the basis of several lines of evidence. Levelton consultants have completed a comprehensive air dispersion model to predict the coal dust levels, which could result from the proposed FSD coal operations. The Levelton model has predicted a coal dust value for the nearest residential receptor of 20 ug/m^3, predicted from all sources from the facility (combustion emissions and fugitive coal dust)

The Levelton predicted coal dust value of 20 ug/m^3 is **20 – 50** times lower than the occupational exposure limits established by the American Conference of Governmental Industrial Hygienists (ACGIC) in the US or by the Government of British Columbia, as established under its WorkSafe program. The Levelton predicted coal dust value of 20 ug/m^3 is also up to 150 times lower than the Australian Threshold Limit Value (TLV) of 3 mg/m^3 · A TLV is the concentration in

air to which it is believed that workers can be occupationally exposed daily, over an entire lifetime, without an adverse effect.

In a recent assessment carried out by SENES Consultants on behalf of Port Metro Vancouver, SENES Consultants concluded that the total contribution of fugitive coal dust to 24-hour average PM2.5 concentrations at track-side would be less than 2 μg/ m^3, even on a day with six moderate to heavy dusting coal trains. SENES also noted that "…. at a distance of 10 m from the tracks, the concentrations would be further reduced to a level of impact which falls within the 'noise' level of PM2.5 sampling instruments" meaning that the impact would be indistinguishable from background concentrations. Coal dust air levels of 2 μg/m^3 as reported by SENES Consultants, would correspond to concentrations 200 times to almost 500 times *less* than occupational safe levels established by British Columbia's WorkSafe program.

The International Agency for Research on Cancer concluded that there is *inadequate evidence of carcinogenicity* of coal dust in humans or in experimental animals.

On the basis of the forgoing, it is my expert opinion that the proposed FSD coal handling operations do not pose a risk of adverse health effects in neighboring communities.

Background

In order to evaluate my expert opinion, the following description of my formal education , technical background and experience may be helpful. I hold a PhD from Queen's University , conferred in 1977. I then took up a post doctoral fellowship at the laboratories of the Environmental Toxicology Section of the Health Protection Branch, Health Canada. Over the next 16 years, I took on assignments of progressive seniority and responsibility at Health Canada, including Chief of the Pesticides Division, Chief of the Product Safety Division, Chief of the Tobacco Control Section and Director of the Bureau of Veterinary Drugs. All of these assignments

focused exclusively on human exposures to toxic chemicals, and risk assessments to characterize the potential adverse impact of these exposures on human health. In 1993, I was appointed Executive Director of the Canadian Network of Toxicology Centres and tenured Professor of Toxicology in the Department of Environmental Biology at the University of Guelph. I currently hold the rank of Professor Emeritus of Toxicology in the School of Environmental Sciences at the University of Guelph.

Among other current appointments, I am an adjunct professor of toxicology at the Chulabhorn Graduate and Research Institutes, Bangkok , Thailand; an expert advisor to the World Health Organization Joint Expert Committee on Food Additives, and; a member of the US EPA Human Studies Review Board. I have advised governments both nationally and internationally on a broad range of topics related to human exposure to toxic chemicals and adverse health outcomes. Several Courts and review boards have recognized me as an expert witness in matters relating to the assessment of toxic chemicals and the risks to humans posed by exposure to these substances. I am a Fellow of the Academy of Toxicological Sciences. The expert opinions I have formulated below therefore reflect 36 years of experience in toxicological health hazard and risk assessment of a broad range of toxic chemicals.

In order to assess the potential for human exposure to fugitive coal dust, and resulting adverse health effects, from the proposed FSD coal operations, I would like to introduce the internationally accepted and widely practiced risk assessment paradigm on which my assessment is based.

Risk Assessment Paradigm

The risk assessment paradigm, first introduced by the US National Academy of Sciences in 1983 (NAS, 1983) and subsequently updated in 2009 (NAS, 2009) establishes a scientifically robust and disciplined approach to estimating risk of adverse human health effects from exposure to potentially toxic substances such as coal dust. It is based on a dictum first articulated almost 500 years ago by the

German Swiss physician Paracelsus, considered as the father of modern toxicology, who proposed that all things are poisons and that only the dose distinguishes a poison from a remedy. This principle can be seen to hold true for virtually all substances encountered in the human environment. Consider for example the simple pleasure of a freshly brewed cup of coffee. Starbuck's freshly brewed coffee contains approximately 180 mg – 415 mg of caffeine, depending on size and specific variety of the beverage (http://www.energyfiend.com/the-complete-guide-to-starbucks-caffeine) ; toxic levels of caffeine are known to be in the range of several grams, typically in the 10 gram range – 25-50 times greater than the typical human exposure in a cup of Starbuck's coffee. Similarly, while a physician may prescribe the proprietary cholesterol lowering drug LIPITOR at doses from 10 - 80 mg/day, elevated exposure to the drug is known to be associated with potentially severe, and in some cases life threatening, liver toxicity. LIPITOR is one of the most widely prescribed drugs in the world with a remarkable safety profile despite its potential toxicity . These examples clearly illustrate the point made by Paracelsus that it is not the toxicity of the chemical *per se* that alone determines the risk to human health but also, importantly, the overall exposure, as defined by the frequency, intensity and duration of that exposure. This phenomenon, which is the basis of my expert opinion regarding fugitive coal dust, can be characterized by the following simplified expression:

RISK= Hazard X Exposure

It will be evident that as exposure to coal dust declines, risk also declines concomitantly. Moreover, as exposure approaches zero, so too does risk approach zero as well. Indeed, the basis for achieving risk reduction targets for most potentially toxic contaminants in air, water and food, in Canada and around the world is typically through exposure mitigation.

Simply stated, the risk assessment paradigm predicts that the risk of an adverse health effect can be conveniently expressed as the intrinsic characteristics of the chemical substance considered in the context of human exposure to that substance. A practical and effective means of reducing the risk of toxicity in humans is simply to mitigate exposure to a level where adverse effects are no longer anticipated. This is essentially the approach utilized internationally by governments and international agencies (such the Government of British Columbia, the World Health Organization and the International Agency for Research on Cancer) to establish and adopt "safe" levels of exposure in humans for a wide variety of chemical exposures, including prescription drugs, pesticide residues in food and environmental contaminants, such as fugitive coal dust in air, soil and water. Indeed, this approach to establishing safe levels of exposure is the cornerstone of the risk assessment paradigm and the foundation to the international acceptance of the paradigm for setting regulatory standards. Importantly, this approach is also the basis on which the Government of British Columbia WorkSafe program has established occupational limits for exposure to a wide variety of substances, including coal dust.

Human Exposure to Coal Dust

Coal dust has been studied for decades and the serious health effects, including coal workers' pneumoconiosis and progressive massive fibrosis, in miners with high exposures to coal dust over many decades are well established. While these data confirm that high exposure levels to coal dust over many, many years can lead to serious adverse health outcomes, it is important to be aware that the exposure circumstances to coal dust associated with the FSD proposal bear no similarity to the exposure conditions and risks known to be linked to serious adverse health outcomes in miners.

Several avenues of scientific evidence are available to examine the non-occupational residential and by-stander exposures, which could arise from the FSD proposal. In 2012, Levelton Consultants modeled exposures that might result from the proposed

activities (Levelton, 2012). Levelton have reported a maximum predicted 1-hr PM_{10} concentration (at the nearest residential receptor) of 20 ug/m^3, for both fugitive coal dust and combustion related emissions associated with the project and does not include background. In contrast, Worksafe BC's occupational exposure limits (Time Weighted Average) are either 400 or 900 ug/m3 (depending on the type of coal). The estimated coal dust levels that might result from the FSD proposal would be 20 – 50 times ***lower*** than the acceptable occupational limits recently established by the Government of British Columbia. In this regard, it is important to note that occupational exposure limits are set on the basis of exposure for 8 hrs /day, 5 days/week and over an entire working lifetime which are not expected to result in adverse health effects.

It may also be of interest to consider coal dust levels in mines where workers may be exposed throughout their working life. Jennings and Flahive (2005) have recently reviewed various aspects of coal mining related adverse health outcomes and exposure to ambient inhalable and respirable coal dust levels. The authors reported Threshold Limit Values (TLV) imposed by Polish authorities for coal dust with varying silica content ranged from 0.3 mg/m^3 to 2 mg/m^3, for respirable particles, depending on silica content, to 2 mg/m^3 to 10 mg/m^3 for inhalable particles, also dependent on silica content. Jennings and Flahive also report that Australian authorities have imposed a time weighted average TLV of 3 mg/m^3 while in the USA, the ACGIH has established a TLV of of 0.4 mg/m^3 (respirable) for anthracite and 0.9 mg/m^3 (respirable) for bituminous coal , the same limits adopted for occupational exposures in British Columbia. As noted earlier, these legal limits adopted in BC are 20 to 150 times ***higher*** than the (modeled) levels predicted from the Levelton study.

In addition to the modeled analysis of fugitive coal dust emissions carried out by Levelton, as described above, a recent assessment (Senes Consultants, 2012) of potential human exposure (and hence, risk) to fugitive coal dust, carried out by SENES Consultants under contract to Port Metro Vancouver, may also be relevant to the health assessment of the proposed FSD coal operation. In their assessment, SENES

Consultants summarized previously conducted monitoring studies on coal trains travelling to Roberts Bank. The monitoring studies reviewed and reported by SENES Consultants were conducted at track-side in Agassiz for a period of one month. SENES Consultants reported that the monitoring data indicated that the contribution of coal trains to ambient total suspended particulate (TSP), sometimes also known as particulate matter or PM, "…..beside the railway tracks on a day with up to six moderate-to-heavy dusting coal trains was only on the order of 20-30 $\mu g/m^3$ over a 7-hour monitoring period at a distance of 4.5 m from the tracks." SENES Consultants also noted that "….total PM concentrations over a 24-hour averaging period would be much lower still because the contribution of these trains would be averaged over 24 hours instead of 7 hours. Thus, the total PM contribution could be on the order of 6-9 $\mu g/ m^3$ on a 24-hour basis." It is important to be aware that the PM2.5 fraction (the respirable fraction) in fugitive coal dust emissions is typically around 2%. It is noteworthy that for "…. samples collected on days with high coal dust emissions from trains, up to 20% of the total PM concentration may consist of coal dust as PM2.5, meaning that the total contribution of fugitive coal dust to 24-hour average PM2.5 concentrations at track-side would be less than 2 $\mu g/ m^3$, even on a day with six moderate to heavy dusting coal trains." The SENES Consultants report further opined that "…. at a distance of 10 m from the tracks, the concentrations would be further reduced to a level of impact which falls within the 'noise' level of PM2.5 sampling instruments, meaning that the impact would be indistinguishable from background concentrations. The recent SENES Consultants report concluded that the 1984/85 study at Agassiz remains as the best estimate of the impact of fugitive coal dust from trains delivering coal to Roberts Bank. Although the monitoring studies reported by SENES Consultants were specific to Roberts Bank, these findings are very relevant to the proposed FSD coal operations. It is also important to note that the Roberts Bank studies were carried out more than 25 years ago and that modern day coal dust mitigation measures being proposed by FSD would be expected to reduce fugitive coal dust emissions even further. Importantly, track side coal dust air levels of 2 $\mu g/m^3$ as reported by SENES Consultants, would correspond to concentrations 200 times to almost 500 times *less* than occupational safe levels established by British Columbia's WorkSafe program.

Coal Dust and Risk of Cancer

Concerns have been raised regarding the potential carcinogenicity of coal dust. This issue has been reviewed by the International Agency for Research on Cancer (IARC); IARC is an agency of the World Health Organization. The objective of IARC reviews, in general, is to prepare, with the help of working groups comprised of internationally recognized experts, and to publish in the form of monographs, critical reviews and evaluations of evidence on the carcinogenicity of a wide range of human exposures. It is widely accepted that monographs are recognized as an authoritative source of information on the carcinogenicity of a wide range of human exposures. A survey of users conducted by IARC in 1988 indicated that various governments and agencies in 57 countries consult the monographs.

The potential carcinogenicity of coal dust has been reviewed by IARC in 1997 (IARC, 1997); this review has not been subsequently updated by IARC. While noting a large body of published literature concerning cancer risks potentially associated with employment as a coal miner, including a small number of exposure-response associations with coal mine dust, IARC reported that epidemiological investigations on cancer risks in relation to coal dust per se have not been reported. Studies of cancers of the lung and stomach among coal miners have received the greatest attention. Interpretation of these studies has, however, been difficult due to the absence of information on levels of the specific components of coal mine dust such as coal, quartz, and metals. Results from studies that investigated coal mine dust and lung cancer in highly exposed occupational populations (miners) have not been consistent; some studies revealed excess risks, while other studies indicated lower lung cancer risks in coal miner populations. While an increased risk of stomach cancer among coal miners has been more consistently observed, the absence of consistent findings regarding increasing risk as a function of increasing exposure (in terms of intensity, frequency and duration), raises serious questions about the reliability of these findings. Moreover, coal dust was evaluated for its carcinogenicity, both separately and in combination with diesel particle aerosols, by inhalation in rats with no reported increase in cancer. Similarly, in another study involving intrapleural injection of coal dust, no increase in

the incidence of thoracic tumors was observed. In this context, IARC have also noted that exposure of laboratory rats to coal dust by inhalation or orally did not produce any evidence of mutagenicity (evidence of mutagenicity is taken to be an important line of evidence supporting carcinogenicity).

IARC has not concluded that coal dust is a human carcinogen. Rather, IARC has concluded that there is *inadequate evidence of carcinogenicity* of coal dust in humans or in experimental animals.

In my expert opinion, the proposed FSD coal handling operations do not pose a risk of adverse health effects in neighboring communities; I have come to this conclusion on the basis of several lines of evidence. Levelton consultants have completed a comprehensive air dispersion model to predict the coal dust levels which could result from the proposed FSD coal operations. The Levelton model has predicted a coal dust value for the nearest residential receptor of 20 ug/m^3, predicted from all sources from the facility (combustion emissions and fugitive coal dust)

The Levelton predicted coal dust value of 20 ug/m^3 is **20 – 50** times lower than the occupational exposure limits established by the ACGIH in the US or by the Government of British Columbia, as established under its WorkSafe program. The Levelton predicted coal dust value of 20 ug/m^3 is also up to 150 times lower than the Australian TLV of 3 mg/m^3 .

In a recent assessment carried out by SENES Consultants on behalf of Port Metro Vancouver, SENES Consultants concluded that the total contribution of fugitive coal dust to 24-hour average PM2.5 concentrations at track-side would be less than 2 µg/ m^3, even on a day with six moderate to heavy dusting coal trains. SENES also noted that "…. at a distance of 10 m from the tracks, the concentrations would be further reduced to a level of impact which falls within the 'noise' level of PM2.5 sampling instruments" meaning that the impact would be indistinguishable from background concentrations. Coal dust air levels of 2 µg/m^3 as reported by SENES Consultants, would correspond to concentrations

200 times to almost 500 times *less* than occupational safe levels established by British Columbia's WorkSafe program.

The International Agency for Research on Cancer concluded that there is *inadequate evidence of carcinogenicity* of coal dust in humans or in experimental animals.

On the basis of the forgoing, it is my expert opinion that the proposed FSD coal handling operations do not pose a risk of adverse health effects in neighboring communities.

Leonard Ritter, PhD
Fellow, Academy of Toxicological Sciences

REFERENCES

IARC (International Agency for Research on Cancer). IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Vol 68. Silica, Some Silicates, Coal Dust and Para-Aramid Fibrils. Lyon, France. 1997

Jennings, Martin and Martyn Flahive. Review of Health Effects Associated with Exposure to Inhalable Coal Dust. Coal Services Pty Ltd. October 2005.

Levelton Consultants Ltd. Fraser Surrey Docks Direct Coal Transfer Facility:Air Dispersion Modeling Assessment. Prepared for Fraser Surrey Docks. File EE12-1611-00. Richmond , British Columbia. Oct 2012.

NAS. US National Academy of Sciences. Science and Decisions: Advancing Risk Assessment. Washington, DC. 2009.

NAS. US National Academy of Sciences. Risk Assessment in the Federal Government: Managing the Process. Washington, DC. 1983

SENES Consultants. Air Quality Assessment Deltaport Terminal, Road and Rail Improvement Project. Final Report. Prepared for Port Metro Vancouver. Vancouver, British Columbia. 2012.

342 Rosehill Wynd
Tsawwassen, BC
V4M 3L9

16 July 2013

Fraser Surrey Docks
11060 Elevator Road
Surrey, BC
V3V 2R7

Attention: Mr. Jeff Scott, President and CEO

Re: Opinion Regarding the Potential Health Impacts from Fugitive Coal Dust from Train and Barge Transport

Dear Sir:

Please accept this letter as my opinion regarding the potential adverse effects of exposure to coal dust as a result of coal transport by train and barge. The letter is intended to provide additional information on this sensitive subject with respect to Fraser Surrey Dock's (FSD) proposal to develop coal shipping facilities at its current location on the Fraser River.

Opinion Summary

Based upon my education, relevant experience and the information reviewed my professional opinion is the coal handling and shipping facilities proposed by Fraser Surrey Docks will not place residents of adjacent communities at risk of adverse health effects. This opinion has been arrived at carefully after a review of available data and reports relevant to this matter.

The principal reasons for this include the following:

- Coal is not classified as a Dangerous Good by Transport Canada and it has been safely transported and handled in the Lower Mainland and Vancouver Region for decades;
- Predictions of particulate matter from the operations are below local, provincial and federal ambient air quality objectives;
- Measured particulate matter from trains transporting coal did not indicate current ambient air quality objectives would be exceeded for particulate matter;
- Covering agents will be applied to rail cars to minimize dust and the agents are safe for use;
- In 1998, the South Fraser Health Region, after a review of health data related to asthma and respiratory diseases, did not indicate a significant problem in the South Fraser Valley (SFV) or in Delta, in the vicinity of Westshore coal terminal, compared to the rest of the province; and
- Fraser Surrey Docks will implement Best Management Practices at its operation for controlling dust and its generation.

Soleil

342 Rosehill Wynd
Tsawwassen, BC
V4M 3L9

Credentials and Experience

In writing this letter I feel it important to provide a brief summary of my education and experience so that those reading it are able to evaluate my opinion. I hold a M.Sc. (1975) and Ph.D. (1978) from the University of Guelph in Ontario. My research focused on the effects of heavy metals on fish physiology and toxicology. Prior to completion of my Ph.D. I accepted a position at an engineering consulting firm where I worked on a number of mining related projects and associated impact assessments. In 1978 I relocated to British Columbia and have resided in North Vancouver, Abbotsford and Tsawwassen. Upon relocating to BC I was retained by BC Hydro to evaluate the re-distribution of trace elements from the proposed Hat Creek Coal-fired powerplant. As my role in that project ended I accepted a postdoctoral position at Simon Fraser University where I pursued research on the effects of acid rain, mercury, pesticides and other environmental contaminants. I subsequently accepted a position at BC Hydro as a Biological Studies coordinator where I worked in a number of roles with the most notable being a Technical Advisor to the Canadian Electricity Association. In this role, I participated in the review of a large study which investigated the distribution of trace elements from coal burning.

For the past 27 years I have been employed as an environmental consultant by two prominent firms in BC and currently operate my own independent consulting business in Tsawwassen. Over these years I have been involved in numerous impact assessments for mining projects and the power industry where coal is consumed to produce power. I have been conducting environmental compliance and management system audits at coal fired powerplants in Alberta and am presently assisting one of those plants with its environmental initiatives. Other related work has included co-authorship of a study prepared for Environment Canada on mercury control technologies at coal fired powerplants. I have been accepted as an expert witness in a number of tribunals and in the Supreme and Provincial Courts of BC where I provided expert opinions regarding the effects of environmental contaminants on the environment. In addition, I have conducted risk assessments where exposures to various substances were of concern to the public and the environment. I am a registered Professional Biologist in BC and Alberta and have more than 36 years' experience in consulting, teaching and research. I remain involved as a graduate student supervisor with Royal Roads University.

Background to Opinion

For several months the proposal to receive and ship coal by FSD has been in the public eye and the concerns pertaining to the potential health effects of exposure to fugitive coal dust have been highlighted. It is understandable concerns have been expressed regarding exposure to coal dust given the problems encountered in the past by underground coal miners after many years of direct exposure. Exposure to coal dust in such conditions has led to the development of worker's pneumoconiosis (black lung disease), chronic obstructive pulmonary disease (COPD), bronchitis, asthma, emphysema and silicosis. It must be pointed out these illnesses occur only after very prolonged exposure usually many years and in no way can workplace exposure scenarios be compared with the possible exposure to levels of fugitive coal dust occurring below air quality objectives such as those predicted by Levelton (2012) for the proposed FSD facility.

The FSD facility on the Fraser River will directly transfer coal from trains to barges where it will

subsequently be shipped to Texada Island. Fugitive coal dust potentially arising from coal handling and related site activities excluding background was modeled by Levelton (2012) for averaging periods of one hour, 24 hours and annually. The resulting one-hour coal dust concentration for the PM_{10} (particulate matter 10 micron size) fraction for the closest resident to the FSD facility was 20.4 ug/m^3. There is no air quality objective for a one-hour averaging period, however this model result is about 44 times less than the time weighted average (TWA) concentration of 900 ug/m^3 considered the maximum allowable level for workers exposure to bituminous coal for 8 hours a day 5 days a week for a working lifetime (WorksafeBC, ACGIH). PM_{10} results for a 24-hour averaging period for the closest resident ranged from 1.28 to 1.81 ug/m^3, which is less than 25 times Metro Vancouver's air quality objective of 50 ug/m^3. Predicted annual averages were more than 150 times less than the annual air quality objective of 8 ug/m^3. These predicted values when added to background levels do not result in any exceedences to air quality objectives established by Metro Vancouver, the Province of British Columbia or the Federal government.

Coal dust and its potential health effects related to operations at Westshore Terminals were previously investigated in 1998 by Dr. Robert Strang of the South Fraser Health Region. Reviewing the history and findings of this investigation are important because they have direct relevance to some of the issues being discussed in this opinion letter. An on-site review of Westshore operations was undertaken in response to complaints from Delta Council about coal dust. The letter prepared by Dr. Strang provided information related to respiratory disease patterns in Delta compared to other areas in the region. The results of the review of the medical data led to the following conclusions: *"In general, while there is some variation, data related to asthma and respiratory diseases do not indicate a significant problem in the South Fraser Valley (SFV) or in Delta compared to the rest of the province."* and, *"....data available related to hospitalization and death due to respiratory diseases in general and asthma in particular do not point to a concern in Delta over other areas of this region or the province."*

The Safe Transport and Handling of Coal

In considering the potential effects of coal dust on health it is necessary to discuss some of its properties and the handling methods used for its transportation. Coal is a brown to black combustible material, basically an organic rock formed from decayed plant material under pressure over millions of years. There are four types of coal ranked by its thermal properties from lowest to highest: Lignite, Sub-Bituminous, Bituminous and Anthracite. The first three coal types are considered "thermal" as they are used for producing power. The type of coal to be handled by FSD is sub-bituminous or thermal coal.

Inhaled and respired coal dust particles as discussed earlier may lead to lung disease in occupational settings because of their physical presence in the lung but exposure to levels below air quality objectives should not be of concern. Coal dust particles have properties unique to themselves but they do not initiate the types of effects associated with ultrafine particles coming from vehicle combustion processes.

Concern has been expressed that rail cars travelling through residential areas will release dust particles. Few studies have examined this in detail although a helpful study in forming an

opinion was conducted in 1984-1985 in Agassiz, BC (reported in SENES, 2012). SENES indicates the study examined the impact of six moderate-to-heavy dusting coal trains on ambient air quality beside the rail line. Total particulate matter levels were found to be in the order of 20 to 30 ug/m^3 over a 7-hour monitoring period as measured 4.5 m from the tracks. The $PM_{2.5}$ fraction was estimated to be in the order of 2.5% of the total PM measured and on days with high emissions from trains upwards of 20% of the total PM could be PM2.5 or a range from 0.5 to 6 ug/m^3 $PM_{2.5.}$ These levels are below both the MetroVancouver and provincial 24-hour and annual average air quality objectives of 25 and 8 ug/m^3 respectively.

It is probable the trains examined in the 1984-1985 study did not utilize a cover product to minimize dust generation and that the measured total PM could, therefore, be considered a case reflective of what residents might be exposed to in the absence of any covering material. The results of the study indicate $PM_{2.5}$ levels would be below today's air quality objectives for $PM_{2.5}$ and that by covering the rail cars a further reduction in $PM_{2.5}$ levels could reasonably be expected. The results of that study as discussed by SENES (2012) concluded that the *"the total contribution of fugitive coal dust to 24-hour average PM2.5 concentrations at track-side would be less than 2 ug/m^3, even on a day with six moderate-to-heavy dusting coal trains. At a distance of 10 m from the tracks, the concentrations would be further reduced to a level of impact which falls within the 'noise' level of $PM_{2.5}$ ……indistinguishable from background."* It is reasonable to infer from these findings that coal dust generated from passing trains without a cover product are not likely to exceed air quality objectives. With a cover product, the potential for generating any dust to the levels reported in the 1984-1985 study is not probable.

Cover or topping products to minimize dust generation on rail cars with coal are considered non-toxic and are biodegradable. There are a number of formulations which are similar in action and properties and they are not considered dangerous goods by Transport Canada. The formulations are proprietary but information for safe handling, environmental fate and other properties are available on their respective Material Safety Data Sheets (MSDS). The cover materials remain with the coal during shipment and they are simply processed with the coal during handling. These products are safe and have proven to be both safe and effective in their intended application.

Coal will be placed on barges at the FSD facility and shipped to Texada Island where the coal would be transferred to ships for sea-transport. Levelton (2012) modeled a representative worst case scenario where coal is located on a barge in the middle of the Fraser River near the proposed FSD facility. Levelton chose a one-hour averaging period for the predictive modeling because it is more reflective of barge operations. The resulting PM_{10} levels for a 1-hour averaging period are between 0.04 and 0.02 ug/m^3 at the shore. Although there are no air quality objectives for a 1-hour averaging period these predicted levels are below the annual average air quality objective of 20 ug/m^3. Consequently, air quality and health impacts due to generated dust from barges loaded with coal are predicted to be negligible.

In my analysis I have also considered that Fraser Surrey Docks is proposing implementation of a number of Best Management Practices (BMPs) to control dust levels in its operations. These practices include but are not necessarily limited to the following:

- Enclosing dock components (coal receiving pits, conveyor system);
- Water for suppressing dust at all transfer points;
- Coal load profiling to remove uneven surfaces that could produce dust;
- Operate in suitable wind conditions to avoid and minimize potential dust generation;
- Minimize drop heights when handling coal; and
- Application of anti-dust products on road surfaces.

The combined application of these BMPs along with measures taken during rail shipments will reduce the potential for coal dust generation. In addition, available information indicates that coal can be transported and handled safely without risking the health of adjacent communities.

My Opinion

Based upon the above discussion and the information reviewed I have concluded, the coal handling facility proposed by Fraser Surrey Docks and the associated transport of coal to and from the facility will not place adjacent communities or individuals at risk to adverse health effects.

There are a number of reasons why I have formed this opinion including:

- Coal is not considered a dangerous good by Transport Canada and it has been safely transported throughout the Lower Mainland for decades;

- Cover products for coal in rail cars minimizes dust generation and the products are safe as applied according to their MSDS;

- Particulate matter resulting from six moderate-to-heavy coal dusting trains was measured in a 1984-1985 study and the calculated PM2.5 levels would be less than the 24-hour and annual average air quality objectives;

- The air dispersion model employed by Levelton (2012) predicted particulate matter concentrations more than 44 times lower than occupational exposure limits established by WorkSafeBC and the ACGIH;

- Levelton's model also predicted particulate matter concentrations for 24-hour and annual averaging periods at the nearest resident to be below air quality objectives provided by Metro Vancouver and the province;

- The South Fraser Health Region concluded in 1998 that data related to asthma and respiratory diseases do not indicate a significant problem in the South Fraser Valley (SFV) or in Delta compared to the rest of the province; and,

- FSD will apply best management practices (BMPs) for controlling dust on its site and these measures will include; enclosed unloading, water sprayers and misters at transfer points and car wash-downs before leaving the site.

342 Rosehill Wynd
Tsawwassen, BC
V4M 3L9

Closure

The coal handling facility proposed by Fraser Surrey Docks has received a great deal of attention by members of the community, municipalities and regulatory agencies. These concerns have been well expressed and have warranted a comprehensive review in order to evaluate if adequate information exists for determining the potential health risk associated with coal transport and handling. After careful review of this information I believe the transport and handling of coal as proposed will not pose adverse health risk to residents of adjacent communities.

Should you require any further information please feel free to contact the undersigned at (604) 240 – 0990 and twatson@soleil-consulting.ca.

Sincerely

Soleil Environmental Consultants Ltd.



Tom A. Watson, Ph.D., R.P.Bio. (BC), P. Biol. (AB)
Senior Environmental Scientist
President

Material Reviewed and Considered

American Conference of Governmental Industrial Hygienists (ACGIH). Threshold limit values (TLVs) adopted by the ACGIH).

Levelton Consultants Ltd. 2012. Fraser Docks Direct Coal Transfer Facility: Air Dispersion Modelling Assessment. Prepared for Fraser Surrey Docks. File EE12-1611-00. Richmond, British Columbia.

South Fraser Health Region. 1989. Letter from Dr. Robert Strang to Mr. Verne Kucy regarding the potential health impacts related to the coal port, ferry traffic or any other identifiable sources based on air quality data or relevant health information. 9pp.

WorksafeBC. Has adopted the TLV approach and has established limits as part of the *Occupational Health and Safety Regulation* (Section 5.48).

MEMORANDUM

Levelton Consultants Ltd.

150-12791 Clarke Place
Richmond, BC V6V 2H9
Canada
Tel: 604 278-1411
Fax: 604 278-1042
E-Mail: info@levelton.com
Web Site: www.levelton.com

To: **Jeff Scott**
President and CEO
Fraser Surrey Docks LP
11060 Elevator Road
Surrey, BC V3V 2R7

File: EE12-1611-00

Date: July 16th, 2013

From: **Chris Koscher, B.Sc.(Hons.), EP**

SUBJECT: Professional opinion on fugitive coal dust from coal handling facilities and transportation of coal by rail on ambient air quality and health

Introduction

This letter presents a compilation of evidence and the author's professional opinion on the impact of fugitive coal dust from coal handling facilities and transportation of coal by rail on ambient air quality and health. Where possible, this submission focusses on studies conducted locally, to best represent probable impacts in the Lower Fraser Valley, British Columbia.

Summary

The studies referenced herein suggest that coal dust from coal handling facilities and rail transportation has a minimal impact to ambient air quality.

Based on Metro Vancouver air quality data, fine particulate matter concentrations ($PM_{2.5}$) in Tsawwassen, Ladner, and Delta, communities surrounding Westshore Terminals Limited Partnership coal facility in Delta, are found to be the same or less than other areas within the Lower Fraser Valley. In North Vancouver, the site of Neptune Bulk Terminals (Canada) Limited, which handles coal and other products, fine particulate matter concentrations ($PM_{2.5}$) are consistent with other monitoring stations within the Central Burrard Inlet Area.

Monitoring carried out in 1984 and 1985 on coal trains travelling to Roberts Bank measured total suspended particulate matter (TSP) beside the railway tracks in Agassiz. Based on the study up to 20% of the TSP may be coal dust as $PM_{2.5}$. At a distance of 10 m from the tracks it was concluded that the

concentrations of $PM_{2.5}$ from passing trains would be indistinguishable from background concentrations. This study is considered to be the best estimate of fugitive coal dust from trains travelling through the Lower Fraser Valley and is consistent with another study presented below from Australia.

Studies reporting the health effects of environmental exposure to coal dust are limited, but well-documented occupational evidence indicates that adverse health effects are usually seen after prolonged exposure (on the order of decades) to very high concentrations of coal dust (approximately forty or more times the ambient air quality objective for $PM_{2.5,}$ at 25 $\mu g/m^3$). In short, given the available evidence, the ambient air quality and community health impacts from transporting and handling elevated volumes of coal, relative to the present, are likely to be negligible.

Based on our current understanding of Fraser Surrey Docks coal handling project, and the studies presented herein, it is my professional opinion that the project will not cause adverse air quality or health impacts on communities within the Lower Fraser Valley.

Ambient Air Quality Objectives in British Columbia

The current ambient air quality objectives for particulate matter (PM), including total suspended particulate (TSP), particles with an aerodynamic diameter less than ten microns (PM_{10}), and particles with an aerodynamic diameter less than two and a half microns ($PM_{2.5}$) in British Columbia are shown in Table 1. There is no known special provision for ambient coal dust in British Columbia, or any other community jurisdiction in Canada.

Table 1 - Summary of Relevant Air Quality Objectives[1,2]

	British Columbia Objective *			Federal Objective **			Metro Vancouver Objective ($\mu g/m^3$)	Most Stringent Objective ($\mu g/m^3$)
	Level A ($\mu g/m^3$)	Level B ($\mu g/m^3$)	Level C ($\mu g/m^3$)	Maximum Desirable ($\mu g/m^3$)	Maximum Acceptable ($\mu g/m^3$)	Maximum Tolerable ($\mu g/m^3$)		
PM (TSP)								
24-hour Maximum	150	200	260	-	120	400	-	120
Annual Mean	60	70	75	60	70	-	-	60
PM_{10}								
24-hour Maximum	-	50	-	-	-	-	50	50
Annual Mean	-	-	-	-	-	-	20	20
$PM_{2.5}$								
24-hour Maximum	25			30			25	25
Annual Mean	8***			-			8***	8

*Concentrations given at 20ºC, 101.3 kPa, dry basis
**Concentrations given at 25ºC, 101.3 kPa, dry basis
***Planning goal of 6 $\mu g/m^3$

Coal-Handling Facility Emissions

There are two main coal-handling facilities in the Lower Fraser Valley region of the province: Westshore Terminals Limited Partnership in Delta, BC, and Neptune Bulk Terminals (Canada) Limited in North Vancouver, BC.

Air quality modelling and monitoring studies conducted in the Delta area of the Lower Fraser Valley region of the province have shown that current and proposed increased coal handling (through Westshore Terminals Limited Partnership of Deltaport) has not had deleterious impacts on air quality in that area.

A report composed by SENES Consultants Limited in 2012[3] for the Deltaport Terminal, Road and Rail Improvement Project (DTRRIP) located at Roberts Bank in Delta, BC calculated the current fugitive coal dust emissions from the facility on air quality in Tsawwassen based on a current throughput of 24.7 million tonnes per year (mtpa), as well as the proposed 42% increase to 35 mtpa. The results of the predictions are shown in Table 2, and outline total fugitive emissions for TSP, PM_{10}, and $PM_{2.5}$ when incorporating wind erosion of stockpiles, as well as through material handling only. Notably, all current

[1] British Columbia Ministry of Environment. Air Quality Objectives and Standards. 2009. Available from: http://www.bcairquality.ca/reports/pdfs/aqotable.pdf
[2] Metro Vancouver. Integrated Air Quality and Greenhouse Gas Management Plan. 2011. Available from: http://www.metrovancouver.org/about/publications/Publications/IntegratedAirQualityGreenhouseGasManagementPlan-October2011.pdf
[3] SENES Consultants Limited. Final Report: Air Quality Assessment - Deltaport Terminal, Road and Rail Improvement Project. 2012.

and proposed emissions levels are well below the relevant BC Ambient Air Quality Objectives (BC AAQO).

Table 2 – Summary of Estimated Current and Proposed Future PM Contributions from Deltaport Coal Handling Facilities

Pollutant (µg/m^3)		Incorporating Wind Erosion	Material Handling Only
TSP	Current Contribution	4	1.5
	Proposed Future Contribution	5.4	2.2
PM_{10}	Current Contribution	2.6	1.1
	Proposed Future Contribution	3.6	1.6
$PM_{2.5}$	Current Contribution	1	0.4
	Proposed Future Contribution	1.4	0.6

Furthermore, the DTRRIP report predicted that total $PM_{2.5}$ concentrations at site T39, the Metro Vancouver ambient air quality monitoring station in Tsawwassen, including all emission sources, would range from 8.7 – 9.1 µg/m^3 under average operating conditions, and 9.6 – 11.2 µg/m^3 under peak operating conditions. This is still less than 50% of the BC AAQO, and due to changes in controls and operating procedures under the expansion, would represent a *decrease* from current levels of approximately 0.5 and 2 µg/m^3 during average and peak output, respectively.

The air quality assessment conducted for Fraser Surrey Docks Facility for Port Metro Vancouver in 2012[4] predicted $PM_{2.5}$ results similar to that from the DTRRIP study at the nearest residential as compared to concentrations predicted at site T39. It should be noted that currently more refined modelling is being conducted for the Metro Vancouver air permit process. However, it is Levelton's professional opinion that the results and conclusions of the refined study will be consistent with those of the previous study conducted for Port Metro Vancouver in 2012.

Ambient Air Quality near Coal Handling Facilities

A 2006 report from the Greater Vancouver Regional District (GVRD, now Metro Vancouver) reported on the air quality in the Ladner and Tsawwassen area of Delta from 2004-2006.[5] The study found that Tsawwassen and Delta met all AAQO, and specifically noted that annual $PM_{2.5}$ was less than 50% of the GVRD ambient objective of 12 µg/m^3 (at the time), and the average 24-hour $PM_{2.5}$ levels were 5 µg/m^3, with most measurements also below half of the AAQO (exceptions were during a Burns Bog fire episode). Highest $PM_{2.5}$ concentrations were found in Ladner, the urban centre of the study area. Delta and Tsawwassen were determined to have better air quality, in terms of concentrations of criteria air

[4] Levelton Consultants Ltd. Fraser Surrey Docks Direct Coal Transfer Facility: Direct Coal Transfer Facility: Air Dispersion Modelling Assessment. 2012.
[5] Greater Vancouver Regional District. Delta Air Quality Monitoring Study June 2004 – March 2006. 2006. Available from: http://www.metrovancouver.org/about/publications/Publications/DeltaAirQualityMonitoringStudy.pdf

contaminants, than neighbouring municipalities in the region.
An earlier study by the GVRD in Tsawwassen in 2002[6] on particulate matter similarly showed that $PM_{2.5}$ and PM_{10} levels in Tsawwassen were well below AAQO set by the GVRD, and provincial and national standards. Further, PM levels in Tsawwassen were shown to be comparable to other areas of the region (Richmond) or lower (Pitt Meadows).

A more recent study on air quality in the Burrard Inlet by Metro Vancouver (2012)[7] included monitoring locations in close proximity (within 50 – 250 m) of Neptune Terminals, a facility that handles coal, among other products (potash, agri-bulk and vegetable oils). The study concluded that $PM_{2.5}$ levels were periodically elevated in the Burrard Inlet area, exceeding the 24-hour objective of 25 $\mu g/m^3$ during a winter inversion episode and a regional summertime air quality advisory period) while there were no $PM_{2.5}$ exceedances at any other Lower Fraser Valley network stations outside the Central Burrard Inlet Area during those times. Elevated $PM_{2.5}$ concentrations during evenings in winter are suspected by Metro Vancouver to be caused by residential wood smoke. In general, concentrations at the monitoring stations closest to Neptune Terminals were of the same order of magnitude as other monitors within the Central Burrard Inlet Area.

Rail Emissions

The DTRRIP report did not include modelling of coal dust emissions from rail transport, but did rely on the best available evidence for the Lower Fraser Valley region of the province on coal dust impacts from rail. Monitoring studies conducted on coal travelling to Roberts Bank in 1984-1985[8] for one month in Agassiz found that the contribution from coal trains to ambient TSP on a day with six moderate to heavy emitting trains, representing a peak scenario, (associated with train speed, precipitation) was on the order of 20-30 $\mu g/m^3$ over seven hours, at a distance of 4.5 m from the train tracks. Over a twenty-four averaging period, the TSP contribution from the coal trains would be approximately 6-9 $\mu g/m^3$ (representing only 5-7.5% of the most stringent AAQO). SENES Consultants further estimated the percentage of $PM_{2.5}$ in coal dust to be 2-20%. Under the assumption that 20% of this coal dust was in the $PM_{2.5}$ fraction, an upper estimate of an increase in $PM_{2.5}$ levels less than 2 $\mu g/m^3$ would be observed over a twenty-four hour period, which would further diminish with distance from the rail tracks. At a distance of 10 m from the tracks, it was concluded that the $PM_{2.5}$ concentrations would be further reduced to a level that would fall within 'noise levels' of $PM_{2.5}$ sampling instruments and thus would be indistinguishable from background concentrations.

A 2008 report prepared Connell Hatch and Katestone for Queensland Rail Limited in Australia entitled Interim Report: Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems[9], compiled data from other studies and estimated emissions from coal trains in that region. This report referenced a 2003 study conducted in Portugal (by Ferreira *et*

[6] Greater Vancouver Regional District. Tsawwassen Particulate Air Quality Study, 2002. Available from: http://www.metrovancouver.org/about/publications/Publications/TsawwassenAirQualityStudy.pdf
[7] Metro Vancouver. The Burrard Inlet Local Area Air Quality Study. 2012.

[8] ESL 1986.
[9] Connell Hatch and Katestone. Interim Report: Environmental Evaluation of Fugitive Coal Dust Emissions from Coal Trains Goonyella, Blackwater and Moura Coal Rail Systems. 2008.

al.)[10] which measured emission rates of coal dust to be 9.6 g/km/rail car, for uncontrolled coal wagons. Variables that influenced emission rates included train speeds, transport distances, and meteorological conditions. Utilizing this emission rate in dispersion modelling, Connell Hatch and Katestone predicted the maximum one-hour concentration for TSP would be approximately 300 – 400 µg/m^3 at a distance of 10 m from the rail line, a value that would be reduced over a twenty-four hour averaging period.

A monitoring program conducted over a six month period in 2007 at Callemondah by SIMTARS[11], referenced by Connell Hatch and Katestone, found the highest average and maximum concentration for TSP were 25 and 800 µg/m^3, for a five-minute averaging period measured 10 m from the track. On an annual basis, about 0.2% of the one-hour values (or 19 hours per year) exceeded 100 µg/m^3. This number of exceedances would decrease significantly if averaged over a twenty-four hour period, which is what the AAQO are based on.

In total, the Connell Hatch and Katestone report reviewed six ambient air quality monitoring studies adjacent to rail lines transporting coal summarized their own monitoring, concluding that the measurements did not find the potential for health impacts inside or outside the rail corridor when compared against ambient air quality objectives (50-150 µg/m^3 for TSP in Australia) and did not predict exceedances of those standards to be observed at a distance greater than 10 m from the tracks.

Conclusion

Based on our current understanding of Fraser Surrey Docks coal handling project, and the studies presented herein, it is my professional opinion that the project will not cause adverse air quality or health impacts on communities within the Lower Fraser Valley.

Yours truly,
LEVELTON CONSULTANTS LTD.



per: Chris Koscher, B.Sc. (Hons.), EP
Senior Air Quality Specialist

[10] Ferreira AD, Viegas DX and Sousa ACM (2003), "Full-scale measurements for evaluation of coal dust release from train wagons with two different shelter covers", Journal of Wind Engineering and Industrial Aerodynamics 91 (2003) 1271-1283.
[11] SIMTARS – Department of Natural Resources and Mines (2008), "Gladstone Airborne Coal Dust Monitoring: Complete Report, QRNational Coal.

APPENDIX XIV

VANHOOK STATEMENT (2012)

BEFORE THE
SURFACE TRANSPORTATION BOARD

STB Finance Docket No. 35557

REASONABLENESS OF BNSF RAILWAY COMPANY
COAL DUST MITIGATION TARIFF PROVISIONS

VERIFIED STATEMENT OF WILLIAM VANHOOK

My name is William VanHook. I am recently retired from BNSF Railway Company ("BNSF") as Assistant Vice President and Chief Engineer-Systems Maintenance and Planning for BNSF. From 2005 through my retirement in April 2012, I was responsible for coordinating and overseeing the implementation of BNSF's program for curtailing coal dust losses in transit. I previously submitted verified statements in the proceeding *Petition of Arkansas Electric Cooperative Corporation for a Declaratory Order*, STB Docket No. 35305 ("*Coal Dust I*"). In my previous testimony, I described the measures that BNSF took from 2005 to May 2010 to understand the impact of coal dust on the safety and reliability of Powder River Basin ("PRB") coal transportation. I also described BNSF's efforts to keep its shippers informed of BNSF's coal dust study and our investigation into approaches for curtailing in-transit coal dust losses in the PRB.

I am submitting this verified statement to describe the studies and tests carried out in the PRB that led BNSF to adopt the specific approach to coal dust mitigation that is reflected in the safe harbor provisions in BNSF's Coal Loading Rule contained as Exhibit 1 to BNSF's Counsel Argument. I also explain why compliance with the safe harbor provisions in BNSF's Coal Loading Rule will effectively reduce in-transit coal dust losses without undue cost or burdens on our shippers, who will benefit from the increased reliability of BNSF's coal transportation

network and from the additional coal that will be available to them at their electricity generating facilities because it is not lost during transit.

I. BNSF's Preliminary Studies Showed That Grooming The Profile Of The Loaded Coal And Applying A Topper To The Loaded Coal Would Effectively Reduce Coal Dust Losses In Transit.

I explained in detail in my testimony in *Coal Dust I* that BNSF undertook an extensive study of coal dust in the aftermath of two back-to-back coal train derailments in the PRB in the spring of 2005. From 2005 through 2009, BNSF thoroughly studied the causes of coal dust losses from loaded cars, the impact of coal dust losses on the integrity of track ballast in the PRB, methods for reducing coal dust losses in transit, and ways to monitor coal dust losses from individual trains.[1]

I also explained that we worked extensively with our coal shippers and PRB coal mines during this process. The National Coal Transportation Association ("NCTA"), an organization of coal shippers, mines, and rail equipment manufacturers that deals with a range of issues involving coal transportation, formed committees to look into coal dust issues, and we met many times with the NCTA committees to discuss developments in our coal dust study and to address questions, thoughts, and concerns by NCTA's members. *Coal Dust I*, VanHook Op. VS at 8-12. We carried out a number of studies directly at the urging of NCTA members. In my prior testimony, I noted that we spent over $4 million on coal dust study efforts from 2005 through 2009, which included nearly $2 million on efforts to respond to NCTA members' questions.[2] In the subsequent efforts since March 2010 that are discussed below, I estimate that BNSF has

[1] Verified Statement of William VanHook in Support of BNSF Railway Company's Opening Evidence, *Petition of Arkansas Elec. Coop. Corp. for a Declaratory Order*, STB Fin. Docket No. 35305, at 3-22 (filed Mar. 16, 2010) ("*Coal Dust I*, VanHook Op. VS").

[2] *Coal Dust I*, VanHook Op. VS at 9.

spent an additional $2.5 million on consultants alone to study and field test methods for curtailing in-transit coal dust losses.

At the outset of our coal dust study, we retained two consulting firms to help us understand the extent of the coal dust problem in the PRB and to investigate possible solutions: Simpson Weather Associates ("SWA") and Conestoga-Rovers & Associates ("CRA"). SWA had worked extensively in the 1990s with Norfolk Southern to develop a coal dust remediation program for coal moving to export facilities on the Eastern Seaboard. The approach that SWA had developed for Norfolk Southern involved a combination of (1) grooming the top of the coal when the coal is loaded into railcars at the mine, and (2) applying chemical topper agents to the groomed coal. BNSF decided to investigate the feasibility of adopting such an approach in the PRB.

Load Profile Grooming

With the help of the President of SWA, Dr. G. David Emmitt, we identified an aerodynamic load profile in the shape of a breadloaf for PRB coal that would minimize the effect of wind, which causes coal dust to blow out of a moving car. The profile is set out in Appendix A of BNSF's Coal Loading Rule. *See* Counsel's Exhibit 1. The Verified Statement of E. Daniel Carré, SWA, Assistant Director—Environment & Energy Division, and Mark Murphy, CRA, Vice President/Principal, which is being submitted with BNSF's Opening Evidence in this proceeding, describes in more detail the development of the load profile by SWA and BNSF's subsequent efforts to assist mines to adopt modified loading chutes that would allow coal to be loaded in conformance with the proper load profile for PRB coal.

In 2005 and 2007, we conducted tests to determine the extent to which the proper grooming of coal would reduce coal dust losses. The tests showed that while grooming the coal

load profile on its own would on average reduce coal dust losses, the data did not indicate that grooming would produce consistent or sufficient reductions in coal dust. As Exhibit 1 shows, of { } Exhibit 1 at 9, 13, 16.[3] In 2007, we supplemented these early tests by looking at coal dust deposited in dust collector jars set up on the side of the PRB rail lines, which are pictured in Exhibit 2 on page 2. We looked at the amount of coal dust in the dust collectors during a period of time when no grooming was conducted and compared that to the amount of coal dust in the dust jars during a period when the PRB mines had all begun to groom coal but had not begun applying any topper agents. While this was not a rigorous test, as shown in Exhibit 2, the reduction in coal dust deposits was relatively modest, about { }. Exhibit 2 at 3.[4]

Topper Application

Topper agents have long been used to curtail coal dust from stationary coal stockpiles and from loaded coal cars in transit. Norfolk Southern used topper agents in its efforts to control coal dust in the East. As explained by Messrs. Carré and Murphy in their verified statement, toppers are broadly used outside the United States to address coal dust losses from railcars in transit. *See* Carré-Murphy VS at 12-14. Topper agents form a pliable crust over the top of the loaded coal that keeps the wind from blowing coal dust out of a coal car or off the top of a coal stockpile. Most topper agents are non-toxic, environmentally safe, and easy to use. I have been informed

[3] Passive collectors are described in further detail below. Exhibit 1 to this verified statement is an excerpt from Exhibit 5 to my opening verified statement filed in *Coal Dust I.* Confidential materials are designated by a single bracket – "{" – and Highly Confidential materials are designated with double brackets – "{{".

[4] Exhibit 2 is an excerpt from Exhibit 19 to my opening verified statement filed in *Coal Dust I.*

by our shippers that they performed laboratory testing on the toppers we evaluated, and they determined that the toppers do not affect the heat generating capacity of the coal to which they are applied, and they do not have adverse effects on boilers at their electric generating facilities.

There is a well-established and active commercial market for coal dust suppression products, including products that are specifically designed to be applied to coal in loaded rail cars. Since I began coordinating BNSF's program for curtailing coal dust losses in transit, the market for in-transit dust suppressants has noticeably increased in size, as manufacturers have improved their existing products, increased marketing efforts, and developed new products. I have attached to this statement at Exhibit 3 the commercial materials of several vendors of coal dust suppression chemicals to illustrate the extent and depth of this market. As described in the materials included in Exhibit 3, the dust suppression products available from suppliers of topper agents include the following:

- AKJ's CTS-100 is "comprised of all organic components . . . and [it] continues to draw moisture from the air to maintain dust control even days after initial application." AKJ Industries, Rail Car, CTS-100, Exhibit 3 at 1.

- Applied Australia's veneer forms "a specially designed membrane film for the suppression of dust during the transport and storage of coal." The chemical is "readily biodegradable" and contains a "[n]on-solvent, non hazardous formulation that does not effect the further processing of coal." *Applied 3152C: Dust Membrane Technology (DMT)*, Exhibit 3 at 2.

- Benetech provides a broad range of dust control services, including encrusting agents that "are designed to produce a semi-permanent shell over your material . . . [and] provide excellent pile sealing, slope control and rail car topper solutions." Benetech, *Dust Suppression: Improving Safety and Emissions*, Exhibit 3 at 5.

- Dupont's Dusgon Dust Suppression Agents can "effectively suppress dust all year round," including dust from railcars and stockpiles. The Dusgon products are "non hazardous, simple and easy to apply." *Dupont Dusgon™ Dust Suppression Agents*, Exhibit 3 at 8.

- Midwest has a long history of coal dust toppers used to suppress in-transit dust. Midwest began spraying loaded coal cars for in-transit dust suppression in 1994 in the PRB. *Midwest: Coal Car Topping – Dust Control for Coal in Transit*, Exhibit 3 at 11.

- MinTech has been { } and its MinTopper S+0150 "[t]ypically provides 90 – 180 days residual dust suppression." MinTech Enterprises, *MinTopper™ S+0150*, Exhibit 3 at 40; *see also* { } Exhibit 3 at 50.

- Nalco's topper agents have been used on {{ }} Exhibit 3 at 80, 85, 87.

- Rantec's Capture 3000 is a {{ }} Exhibit 3 at 99.

BNSF carried out several tests in the PRB of the effectiveness of topper agents in 2005 and 2006. These early tests were the precursor to the large-scale tests that BNSF carried out in the Super Trial and employed a test protocol that is similar to the protocol we used in the Super Trial. I describe the test protocol in detail below in my discussion of the Super Trial. The preliminary tests we carried out showed that the application of topper agents could substantially reduce coal dust losses in transit. The results of these preliminary tests in 2005 and 2006 showed an average in-transit dust reduction from treated cars that ranged from { } as compared to untreated cars.[5] *See* Exhibit 4 at 8.

---

[5] { } Exhibit 4 at 4-7. Exhibit 4 contains an excerpt from Exhibit 5 to my opening verified statement in *Coal Dust I.*

Coal shippers, through the NCTA, also carried out tests on the effectiveness of topper agents to suppress coal dust. In 2008, we helped NCTA carry out a series of field tests in the PRB on coal trains loaded by Peabody, a coal producer that owns three PRB mines. {

} reduction. *See* Exhibit 5 at 5, which summarizes the results of the passive collectors from the field tests performed by NCTA and Peabody in 2008.[6] Indeed, Midwest's toper agent achieved { } *See* Exhibit 3 at 22. NCTA also commissioned Exponent, Inc., an engineering consulting firm, to carry out additional tests on the effectiveness of topper agents in 2008. As explained in more detail by Messrs. Carré and Murphy, Exponent found that the use of topper agents on groomed coal loads can {

}

II. In 2010-2011, BNSF Carried Out Extensive Laboratory And Field Tests To Identify The Most Effective Topper Agents That Are Commercially Available.

By 2009, our preliminary studies were complete, and we concluded that it was time to begin implementing coal dust mitigation measures. BNSF established its first coal dust tariff, which was the subject of the proceedings in *Coal Dust I*. In addition, BNSF responded to requests from its shippers to help them identify the most effective topper agents available for use in controlling in-transit coal dust by organizing and conducting a large scale field test of coal dust remediation measures, which was subsequently referred to as the Super Trial. The objective

[6] The report from Exponent Inc., which describes the tests carried out by NCTA and Peabody, is on the CD attached herein to BNSF's Opening Evidence and Argument. The report was included on the CD filed with BNSF's Reply Evidence and Argument in the materials for the Verified Statement of Dr. G. David Emmitt in *Coal Dust I*.

of the Super Trial was to test the effectiveness of selected chemical agents in the suppression of coal dust, both topper agents and chemicals applied to coal before loading called body treatments, and to develop information that would assist our coal shippers to choose among the various products available in the market for coal dust suppression.

The Super Trial was a collaborative effort between BNSF, PRB mines, and PRB coal shippers. In addition, Union Pacific Railroad Company, the co-owner of the Joint Line, participated in the Super Trial. We invited all BNSF shippers and mines to participate in the Super Trial tests. Thirteen shippers agreed to have the tests carried out with their coal. More than 36 million tons of coal were ultimately committed for testing. Three coal producers volunteered to have topper agents tested at four mines. Several other shippers and mines participated in the Super Trial by attending the Super Trial meetings and receiving Super Trial data, even though their trains were not tested.

Before the Super Trial began, in December 2009, we met with interested shippers and mines to seek their input on the tests that we were proposing to carry out. We described for the participants the testing protocols and procedures that we were planning to implement. We shared the test plan with shippers, which I have attached to this statement at Exhibit 6, and solicited their feedback. We subsequently met with the shipper and mine participants in large group meetings on four separate occasions between March and October of 2010 to discuss planning and progress and to address questions. Exhibit 7 contains the agendas for those meetings. *See* Exhibit 7 (agendas for meetings in March, May, August, and October 2010). At the meetings, we reviewed results from the tests to date, provided updates about testing, and responded to questions. In addition to the information distributed and discussed at in-person meetings, we provided regular reports and updates to the Super Trial participants and distributed

extensive data regarding the test trains. Exhibit 8 contains an e-mail to shippers in April 2010, which illustrates the amount of data and results we shared regularly with the participants in the Super Trial. We also shared with each shipper that volunteered tons in the Super Trial the results for their trains tested in the Super Trial.

At the outset of the Super Trial, a Selection Committee consisting of shippers and mines was created to determine which topper agents and body treatment chemicals would be tested in the Super Trial after BNSF selected the first few chemicals to get the Super Trial started. The Selection Committee appointed { } as the Chair and Co-Chair of the committee. The Selection Committee included employees from several other PRB coal shippers, including { }, as well as from coal producers, including { }. The Selection Committee operated independently of BNSF. Our role in the Selection Committee was limited, and we had no voting rights. To illustrate the scope of issues addressed by the Selection Committee, Exhibit 9 includes an agenda from the Super Trial Selection Committee meeting on March 25, 2010.

Laboratory Tests

The first part of the Super Trial consisted of laboratory tests by BNSF's Technical Research & Development ("TR&D") Department in Topeka and by BNSF's consultants at SWA on the toppers to be evaluated. These tests were carried out before any field tests were done. SWA performed various lab tests to determine whether the particular chemical being tested had the ability to form a pliable crust that could reduce in-transit coal dust. SWA studied each topper agent for the strength of the crust, penetration depth, the ability of the chemical to stabilize the coal surface, and the ability of the chemical to withstand rain, hot and cold temperatures, and wind exposure. Exhibit 10 contains a SWA test report for Nalco's Dustbind Plus. BNSF's

TR&D Department in Topeka tested the chemicals to determine whether they had properties that could be dangerous or damaging to railcars. For example, BNSF's TR&D Department looked at whether the chemical would have an impact on painted surfaces and whether it would corrode aluminum. The TR&D Department's tests also examined the product's pH and whether it would dry tack free, or non-sticky to the touch. Attached at Exhibit 11 is a TR&D report for Nalco's Dustbind plus.

In some cases, the lab tests identified problems or concerns with particular chemical agents, and we worked with the chemical vendors to see whether the issues we identified could be resolved. For example, {

}

Passive Collector Tests

The primary focus of the Super Trial was a series of field tests of PRB trains using passive collectors to identify the most effective topper agents that are commercially available to control coal dust in transit. The use of passive collectors to measure coal dust losses in transit was discussed in *Coal Dust I*. *See Coal Dust I*, VanHook Op. VS at 8; *Coal Dust I*, Emmitt Op. VS at 12. As explained in that proceeding, a passive collector is a device that is mounted on the rear sill of an individual coal car. The collector allows air containing dust particles to pass through the device as the train moves while depositing the dust in a container inside the collector

that can be removed at the end of the train trip. A picture of a passive collector is attached at Exhibit 12 at 4.

Passive collectors are used to measure the relative amount of coal dust losses from treated and untreated cars. To carry out the passive collector tests, half of the cars on a particular test train were treated with the dust suppressant, and half of the cars were untreated. The passive collectors were mounted on the rear top chord of 7 of the treated cars and 7 of the untreated cars of the test train. Dust collected in each of the passive collectors was gathered by the consultants assisting BNSF in the Super Trial and sent to BNSF's TR&D laboratory in Topeka, where the dust was dried and weighed. The amount of coal dust collected from treated and untreated cars was then compared to determine the extent to which coal dust was reduced by the application of a topper. 115 trains were tested using these procedures.

Test trains using passive collectors were also equipped with portable weather stations that measure wind, air temperature, coal surface temperature, and precipitation. The precipitation monitors were important because they allowed us to exclude trains from the tests that moved during rain storms. Water naturally suppresses coal dust, so the results of the passive collector tests would be distorted by including trains that experienced significant rain.

Attached as Exhibit 12 is a report of the Super Trial results that BNSF sent to all of its PRB coal shippers in February 2011. BNSF also posted the report on its website, which is available at www.bnsf.com/customers/pdf/coal-super-trial.pdf. As explained in Exhibit 12, the passive dust collector tests showed that there was a 73% to 93% reduction in coal losses depending on the topper agent being tested. *See* Exhibit 12 at 7. Exhibit 13 contains a summary of the test results on each chemical tested in the Super Trial, which we sent to shippers in November 2010. We also discussed the passive collector results with shippers at the in-person

meetings during the Super Trial. Three topper agents achieved 85% or more reduction in coal dust losses on average during the Super Trial as measured by the passive collectors: Nalco DustBind Plus (93%); Midwest Soil Sement (92%); and AKJ CTS-100 (85%). *See* Exhibit 12 at 7. Exhibit 14 has the results from the passive collector tests for Nalco's DustBind Plus from September 2010.

After the Super Trial tests were completed, shippers and mines sponsored passive collector tests for two additional topper agents, Rantec Capture 3000 and MinTech MinTopper S+0150. The tests were carried out in August and September 2011 using the same basic procedures as those used in the Super Trial. The passive collector results showed that when railcars were treated with MinTech's MinTopper S+0150 and Rantec's Capture 3000, coal dust losses were reduced on average by { } respectively.

Based on the results of the passive collector tests in the Super Trial and the subsequent field tests, BNSF's safe harbor tariff provision currently approves the use of five topper agents that were shown to reduce coal dust losses by at least 85%. One of the topper agents, AKJ, is approved in two forms: concentrate to be mixed with water and pre-mixed with water. *See* Appendix B to BNSF's Coal Loading Rule, attached at Counsel's Exhibit 1. BNSF recognizes that other products may also prove to be effective in reducing in-transit coal dust losses, and we have encouraged further testing as additional products become available. Moreover, the safe harbor contains a provision allowing shippers to seek safe harbor treatment for other dust mitigation approaches if the shippers can show that the proposed measures will reduce coal dust losses by at least 85%, the benchmark we used to identify the safe harbor toppers that are now included on the approved topper list. As we begin to move toward broader compliance with BNSF's coal dust loading rule, I expect that market demand will lead to the availability of new

dust remediation products and methodologies. For example, I understand that in summer 2012,

{

}

Trackside Monitor Data

As BNSF explained in *Coal Dust I*, BNSF has set up trackside monitors at certain fixed locations along the Joint Line and BNSF's Black Hills Subdivision. The trackside monitors are towers equipped with weather monitors and a sophisticated optical monitor that measures dust in the air as a train passes. The optical monitors determine the total amount of dust in the air over the time period that the train passes the monitor and reports the dust level as an Integrated Dust Value ("IDV.2").

I will not get into the details here about how the monitors work or how coal dust is measured by the optical monitors. The optical monitors were not used in the Super Trial to identify the effectiveness of individual topper agents, and they are not otherwise relevant to BNSF's safe harbor. Nevertheless, the data that were collected by the trackside monitors over the course of the Super Trial are useful for diagnostic purposes and confirmed the effectiveness of topper agents in reducing in-transit coal dust losses from treated trains as compared to untreated trains. Trackside monitor readings were taken from more than 1,000 trains during the Super Trial. As shown in the Super Trial Report contained at Exhibit 12 and discussed in the Verified Statement of Messrs. Carré and Murphy, the IDV.2 level for the 90th percentile of trains was substantially lower for treated trains than for untreated trains on the Joint Line and Black Hills Subdivision. *See* Carré-Murphy VS at 16.

Alternative Coal Dust Mitigation Approaches

The Super Trial and follow up tests also looked at the effectiveness of two alternative in-transit coal dust suppression methods, the use of body treatments and compaction. Neither approach was shown to significantly reduce coal dust.

Several shippers have their mine agents apply a body treatment chemical to all of the shipper's coal before it is loaded into rail cars. The purpose of the body treatment is to reduce coal dust in the handling of the coal when the coal arrives at the plant, particularly in the unloading of coal where substantial amounts of dust are produced. My understanding is that PRB mines and shippers must comply with a number of environmental, health, and safety regulations relating to coal dust. A number of the shippers participating in the Super Trial wanted to know whether the body treatments that mines were applying and that were already used for coal dust suppression at their electric generating facilities would also be effective in reducing coal dust in transit. BNSF agreed to assist in testing the effectiveness of certain body treatments during the Super Trial.

As shown in the Super Trial Report, there was no statistically significant reduction in coal dust losses in transit where the coal had been treated with the tested body treatment chemicals as compared to the untreated coal. *See* Exhibit 12 at 7. The trackside monitor tests similarly showed only a limited reduction in coal dust losses from the use of body treatment chemicals. While disappointing, these results were not surprising in the context of in-transit dust suppression. The topper agents work by forming a crust over the loaded coal, which keeps the air movement from dislodging coal dust particles. In contrast, body treatments do not form a crust over the loaded coal. The body treatment helps prevent coal from breaking down into smaller particles throughout the entire volume of coal in the coal car, but it does not prevent the

wind from blowing particles that have already formed in the mining and car loading process from being blown out of the loaded cars in transit.

Several Super Trial participants also wanted BNSF to assist in testing the effectiveness of compaction technology, where coal that has been loaded in a rail car is compacted into a smaller and denser volume using a combination of vibrating plates and a profiling plow. The vibrating plates are intended to settle coal farther down in the car, shift finer particles towards the bottom of the car, and compact the coal down to the car's top chord. Compaction field tests were carried out in June through July 2011 using passive collectors.

The results of the tests demonstrated that compaction was not effective in reducing in-transit coal dust losses. Compacted cars actually had more in-transit coal dust losses compared to uncompacted cars. The problem appeared to be that the compaction process itself created substantial additional amounts of coal dust by crushing coal lumps, concentrating much of the dust at the top of the loaded car, which was therefore susceptible to the wind.

The results of these alternative tests confirmed our conclusion that the approach set out in the safe harbor provision of BNSF's Coal Loading Rule – use of topper agents applied to groomed coal cars – is the only currently feasible approach to reducing coal dust from loaded cars in transit. We are hopeful that other approaches will be developed, and BNSF's safe harbor provisions expressly provide that we will add those approaches to the safe harbor when and if they are shown to effectively reduce coal dust losses. For now, however, no one has identified a viable and commercially feasible alternative to the measures that are set out in the safe harbor for controlling coal dust losses in transit.

III. The Measures Set Out In The Safe Harbor Are Straightforward And Cost-Effective.

The application of topper agents along with coal load profiling is a feasible means of dealing with the coal dust problem. All PRB mines have already installed loading chutes capable of producing groomed loads. The equipment needed to apply the toppers is not very sophisticated or complex to use. Indeed, all of the major PRB mines now have the facilities necessary to apply topper agents to their customers' coal. The chemical toppers are widely available. The mines are just waiting for their shippers to instruct them to start complying with BNSF's Coal Loading Rule.

Compliance with the safe harbor will effectively reduce coal dust losses in transit without imposing substantial costs on the shippers. The costs of complying with BNSF's safe harbor are modest and would not add significantly to the total delivered cost of coal for use at coal-fired electric generating facilities. While BNSF is not involved directly in the procurement of topper agents for use at the mines, the information available to BNSF indicates that the cost to apply toppers is generally in the range of {{ }}.[7] These costs include the costs for the infrastructure used to apply the toppers.[8] The cost to apply toppers is far lower than the cost estimates that were made in *Coal Dust I*. In *Coal Dust I*, WCTL's witness Mr. Crowley estimated the cost of applying toppers could be as much as {{ }}[9] I would expect the cost of toppers to come down further as more shippers begin fully complying with BNSF's Coal

---

[7] The mines are currently using approved topper agents from MinTech, AKJ, and Midwest, and costs of those topper agents are included in Exhibit 15.

[8] The infrastructure used to apply toppers is relatively simple. I understand that one mine received an estimate for an indoor spray facility in the amount of {{ }}

[9] *Coal Dust I*, Crowley Op. VS at 6.

Loading Rule and additional suppliers of topper agents and additional topper agents enter the market.

These costs are a small fraction of the cost per ton of delivered coal. To illustrate, a typical coal movement of about {{ }} would likely have a delivered cost of coal around {{ }} If the application of a topper agent costs approximately {{ }} – the average of the costs identified above – topper costs would be less than {{ }} of the delivered cost of the coal.

Moreover, any attempt to estimate the costs associated with the application of topper agents should take into account the fact that application of toppers will keep the shipper's coal in the rail cars and available for use in producing electricity. One of the chemical vendors whose topper agent has been approved for use in the safe harbor, {{

}} *See* Exhibit 3 at 82.

IV. Conclusion

The actions contemplated by the safe harbor provision in BNSF's Coal Loading Rule are commercially feasible and cost-effective ways to address coal dust losses from railcars in transit in the PRB. In-transit coal dust losses in the PRB needs to be brought under control, and BNSF's safe harbor sets out a reasonable means of dealing with the coal dust problem.

I declare under penalty of perjury that the foregoing is true and correct. Further, I certify that I am qualified and authorized to file this Verified Statement.

Executed on September 28TH, 2012

William VanHook