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Pinnacle Renewable Energy Inc.
Technical Assessment Report
Lavington, BC

Final Report – Rev.1

Air Dispersion Modelling Study
RWDI # 1400749
December 9 2014

SUBMITTED TO

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EXECUTIVE SUMMARY

Study Objectives

Pinnacle Renewable Energy Inc. (Pinnacle) is proposing to operate a new pellet plant located in Lavington, BC, to the north of the existing Tolko Lavington sawmill site. The pellet plant will produce pellet fuel from sawdust and shavings from the adjacent sawmill and will draw fiber via truck deliveries from other sawmills in the region. A new rail spur is proposed to the north of the existing Tolko track space to accommodate the loading of up to thirty-five (35) rail cars for the new plant to transport the product, with a load out rate of approximately 7 to 12 cars per day. In support of Pinnacle's permit application, Pinnacle retained RWDI to complete an air dispersion modelling study of emissions from their proposed operations.

The primary concern related to air quality effects from the plant is emissions of particulate matter (PM) (i.e., airborne particles), which may impair local air quality and result in deposition of dust. All major sources of PM associated with site operations at Pinnacle were included in the study. The size fractions considered were particulate matter less than 10 µm (PM_{10})[1] and particulate matter less than 2.5 µm ($PM_{2.5}$)[2].

The air dispersion modelling study was conducted using the CALMET/CALPUFF modelling system which is a recommended model under the *Guidelines for Air Dispersion Modelling in British Columbia* (British Columbia Ministry of Environment [BC MOE] 2008) for studies of this type. The study considered stack emissions from two (2) belt dryers and a baghouse filtration system on both the hammermill and pelletmill.

This study addresses the potential effect of emissions of the criteria air contaminants (CACs i.e., contaminants for which there are ambient air quality objectives) PM_{10} and $PM_{2.5}$ on local air quality.

Ambient air quality criteria are developed by environment and health authorities. These criteria are based on scientific studies that consider the influence of the contaminant on such receptors as humans, wildlife, vegetation, as well as aesthetic qualities such as visibility. British Columbia and Canadian ambient air quality objectives for PM_{10} and $PM_{2.5}$ were used to provide context for baseline ambient air quality and for predicted changes in ambient concentrations between the proposed Pinnacle facility operations in the local study area.

Methodology

A 20 km by 20 km study area was centered on the proposed Pinnacle facility. The study area is sufficiently large to capture the spatial extent of model predicted concentrations that represents 10% of the relevant ambient air quality objectives for the pollutants in question, as per *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008). Any potential air quality effects due to emissions from the facility are expected to occur within this study area.

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[1] *PM_{10} is particulate matter with particle diameter of less than 10 µm*
[2] *$PM_{2.5}$ is particulate matter with particle diameter of less than 2.5 µm*

Topography around the Pinnacle site is spatially varied, resulting in complex wind flow patterns. Therefore, a refined dispersion model, capable of simulating complex wind flow patterns was selected. The CALMET/CALPUFF dispersion modelling system was selected for this assessment. CALMET is a meteorological model that develops hourly three-dimensional meteorological fields of wind and temperature used to drive pollutant transport within CALPUFF. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that simulates the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and deposition. CALPUFF can use three-dimensional meteorological fields developed by the CALMET model or simple, single-station winds in a format consistent with the meteorological files used to drive the ISCST3 steady-state Gaussian model. Dispersion modelling was conducted using the full 3-D CALMET mode because it has the ability to simulate the changes in mixing height and boundary layer mechanics that result from the variable land cover characterization and terrain in the air quality dispersion modelling study area.

As per the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008), the 98th to 100th percentile of historical monitoring data was added to maximum predicted concentrations. The $PM_{2.5}$ 24-hour average background concentration was based on the 98th percentile of representative ambient air quality observations from BC MOE's Vernon Science Centre station. The $PM_{2.5}$ annual average background concentration was based on the average of all representative ambient air quality observations. The closest BC MOE stations to the study area did not measure PM_{10} concentrations in 2013, and thus, the background PM_{10} concentrations were estimated based on $PM_{2.5}$ data.

Emission Sources

Emissions from activities at Pinnacle were used as inputs to the dispersion model to predict ambient concentrations of CACs. Source of emissions considered were from two (2) belt dryers and a baghouse filtration system on both the hammermill and pelletmill. Emission estimates were made using conservative assumptions under maximum operating conditions. Therefore, the predicted concentrations of PM_{10} and $PM_{2.5}$ are expected to represent a worst-case scenario. Project emissions were estimated using information provided by Pinnacle and stack testing results.

Results

For the Pinnacle facility, the maximum predicted PM_{10} and $PM_{2.5}$ concentrations (without background) were lower than the most stringent air quality objectives. The maximum predicted 24-hour PM_{10} concentration was 15.6 μg/m^3, which is 31.3% of the most stringent air quality objective. Maximum predicted 24-hour and annual $PM_{2.5}$ concentrations were 7.25 μg/m^3 and 2.67 μg/m^3, respectively, which are 29.0% and 33.4% of the corresponding most stringent air quality objectives, respectively.

All maximum predicted PM_{10} and $PM_{2.5}$ concentrations with background added were below the corresponding ambient air quality objectives, except for the annual average $PM_{2.5}$ concentration. The predicted maximum annual $PM_{2.5}$ concentration with background added of 10.4 μg/m^3 exceeded the most stringent ambient air quality objective of 8 μg/m^3 and the BC planning goal of 6 μg/m^3. The representative 24-hour PM_{10} and $PM_{2.5}$ background concentrations contribute 62.2% and 67.2% of the ambient air quality objective, respectively. The representative annual $PM_{2.5}$ background concentration contributes 96.9% of the ambient air quality objective.

The annual $PM_{2.5}$ concentration predicted at Lavington School of 8.21 µg/m^3 exceeded the annual $PM_{2.5}$ objective of 8 µg/m^3 based on a background concentration of 7.75 µg/m^3. The school is located approximately 150 m west of the Pinnacle fenceline. There were no exceedances predicted at the other sensitive receptors modelled in the study area.

Figures showing the spatial distribution of maximum predicted concentrations are provided in Appendix C of the report. The greatest PM_{10} concentrations were predicted to occur along the western property boundary. The greatest 24-hour and annual $PM_{2.5}$ concentrations were both predicted to along the eastern boundary. In viewing these results, it should be further understood that the majority of the maximum predicted concentrations associated with the Pinnacle pellet plant can be attributed to the dryers. The emissions concentration used to predict the maximum ambient concentrations of annual $PM_{2.5}$ was 8.6 mg/m^3 compared to the actual European test data of 0.4 mg/m^3 (Müller-BBM 2007).

Combined Emissions Assessment

Pinnacle pellet plant will produce pellet fuel from sawdust and shavings from the existing Tolko Lavington sawmill located directly to the south. Due to the close proximity of two facilities, there is the potential for combined effects on ambient air quality due to emissions from Tolko.

The predicted concentrations of annual $PM_{2.5}$ for the Tolko current scenario (without background) were greater than the most stringent air quality objectives. However, following upgrades to the shavings stacks, proposed scenario concentrations of annual $PM_{2.5}$ (without background) were expected to be lower than the most stringent air quality objectives.

Conclusions

Model results for Pinnacle pellet plant alone show that the maximum predicted concentrations within the 20 km by 20 km local study area without background were less than the most stringent ambient objectives. All maximum predicted PM_{10} and $PM_{2.5}$ concentrations with background included were less than the most stringent ambient objectives, except for the annual average $PM_{2.5}$ concentration. There were also no predicted exceedances of the objectives predicted at the sensitive receptors in the study area, with the exception of annual $PM_{2.5}$ (with background included) at Lavington School.

The results for the Pinnacle plant alone represent a conservative estimate of potential impacts to air quality. A measure of the model conservatism is shown in Figure 6.1 which show the dryer emissions actually used in the modelling compared to both the manufacturers guaranteed emissions and the emissions from the stack testing report used to set the size fraction in the modelling. The model used 15 mg/m^3, while the manufacturer has guaranteed 10 mg/m^3, and the stack testing report shows a value less than 1 mg/m^3. This suggests that actual emissions may be an order of magnitude lower than those used in the modelling.

The combined effect of the reduction of emission from the Tolko upgrade and the proposed Pinnacle emissions is a predicted decrease in annual $PM_{2.5}$ concentration for the majority of the study area with some minor increases (0.04 µg/m^3) in the area of the eastern property boundary, approximately 375 m south of Highway 6. In general, predicted $PM_{2.5}$ concentrations due to emissions from the upgraded

Tolko facility and the proposed Pinnacle facility combined are expected to be less than the current Tolko facility alone. Overall, it is expected that air quality in the area would improve as a result of the combined project. The expected change at Lavington School, was predicted to be -3.07 µg/m3.

The proposed Pinnacle facility will have the ability to process harvest residuals. Consumption of this material for pellets will divert it from being disposed of through slash burning, which is likely a contributor to the existing background PM concentration observed in the study area. Reduction of slash burning, through diversion of harvest residual to the proposed plant, will therefore potentially further reduce PM emissions and background PM concentration in the air-shed. Pinnacle has also committed to participate in, and support the development of an air-shed management committee that will seek to take actions based on good science that will continuously improve the local air quality.

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Appendices

1. INTRODUCTION

Pinnacle Renewable Energy Inc. (Pinnacle) is proposing to operate a new pellet plant located in Lavington, BC, to the north of the existing Tolko Lavington sawmill site. The pellet plant will produce pellet fuel from sawdust and shavings from the adjacent sawmill and will draw fiber via truck deliveries from other sawmills in the region. A new rail spur is proposed to the north of the existing Tolko track space to accommodate the loading of up to thirty-five (35) rail cars for the new plant to transport the product, with a load out rate of approximately 7 to 12 cars per day. In support of Pinnacle's permit application, Pinnacle retained RWDI to complete an air dispersion modelling study of emissions from their proposed operations.

The primary concern related to air quality effects from the plant is emissions of particulate matter (PM) (i.e., airborne particles), which may influence local air quality and result in deposition of dust. All major sources of PM associated with site operations at Pinnacle were included in the study. The size fractions considered were particulate matter less than 10 μm (PM_{10})[1] and particulate matter less than 2.5 μm ($PM_{2.5}$)[2].

The air dispersion modelling study was conducted using the CALMET/CALPUFF modelling system which is a recommended model under the *Guidelines for Air Dispersion Modelling in British Columbia* (British Columbia Ministry of Environment [BC MOE] 2008) for studies of this type. The study considered stack emissions from two (2) belt dryers and a baghouse filtration system on both the hammermill and pelletmill.

1.1 Contaminants and Ambient Air Quality Criteria

This study addresses the potential effect of emissions of the criteria air contaminants (CACs i.e., contaminants for which there are ambient air quality objectives) PM_{10} and $PM_{2.5}$ on local air quality.

Ambient air quality criteria are developed by environment and health authorities. These criteria are based on scientific studies that consider the influence of the contaminant on such receptors as humans, wildlife, vegetation, as well as aesthetic qualities such as visibility. British Columbia and Canadian ambient air quality objectives for PM_{10} and $PM_{2.5}$ are listed in Table 1-1. These criteria were used to provide context for baseline ambient air quality and for predicted changes in ambient concentrations between the proposed Pinnacle facility operations in the local study area.

[1] PM_{10} is particulate matter with particle diameter of less than 10 μm
[2] $PM_{2.5}$ is particulate matter with particle diameter of less than 2.5 μm

Table 1-1: British Columbia and Canadian Ambient Air Quality Objectives for Particulate Matter (in micrograms per cubic metre)

<table>
<tr><th rowspan="3">Contaminant</th><th rowspan="3">Averaging Period</th><th colspan="4">Objectives/Standards (µg/m³)</th></tr>
<tr><th colspan="3">British Columbia[(1)]</th><th rowspan="2">Canadian Ambient Air Quality Standards[(2)]</th></tr>
<tr><th>BC Level A</th><th>BC Level B</th><th>BC Level C</th></tr>
<tr><td rowspan="2">PM_{10}</td><td>24-Hour</td><td colspan="3">50</td><td>--</td></tr>
<tr><td>Annual</td><td colspan="3">--</td><td>--</td></tr>
<tr><td rowspan="2">$PM_{2.5}$</td><td>24-Hour</td><td colspan="3">25[(a)]</td><td>27 to 28[(c)]</td></tr>
<tr><td>Annual</td><td colspan="3">8[(b)]</td><td>8.8 to 10[(d)]</td></tr>
</table>

SOURCE: [(1)] BC MOE 2013 and [(2)] Government of Canada 2013.

NOTES: [(a)] Compliance based on 98th percentile value

[(b)] There is also a planning goal of 6 µg/m³

[(c)] CAAQS is 28 µg/m³ in 2015 and 27 µg/m³ in 2020; compliance based on annual 98th percentile value, averaged over three consecutive years

[(d)] CAAQS is 10.0 µg/m³ for 2015 and 8.8 µg/m³ for 2020; compliance based on the average over three consecutive years.

2. METHODOLOGY

Modelling was performed on a 20 km by 20 km study area surrounding the proposed Pinnacle facility as defined below. Emissions of PM_{10} and $PM_{2.5}$ are produced during operation of the belt dryers and baghouse filtration systems. Each phase of the product blending and hammering process, up to and including the delivery of the pellets to the rail load out system occurs within a totally enclosed conveyance system. As no emissions to the atmosphere are expected, these enclosed processes were not considered.

2.1 Spatial and Temporal Boundaries

A 20 km by 20 km study area, centered on the proposed Pinnacle facility, is illustrated in Figure 2.1. The study area is sufficiently large to capture the isopleth of model predicted concentrations that represents 10% of the relevant ambient air quality objectives for the pollutants in question, as per *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008). Any potential air quality effects due to emissions from the facility are expected to occur within this study area.

One year of hourly meteorological data comprising the period from January 1, 2011 to December 31, 2011 was used. The meteorological data fields required to drive dispersion modelling with CALPUFF were developed by the CALMET model initialized using Weather Research and Forecasting (WRF) prognostic model outputs. The 2011 year was chosen as the most recent year for which suitable WRF output was readily available for the for the study area.

2.2 Emission Estimation

Emissions were estimated for the operation of the twin belt dryers. Each dryer had two (2) dedicated stacks, for a total of four (4) stacks. Emission estimates of PM_{10} and $PM_{2.5}$ from the dryers were calculated based on a maximum PM concentration of 15 mg/Nm³, and a maximum flow rate of 236,108 Sm³/hr for each of the two dryers, based on the Stela document provided to Pinnacle dated March 31, 2014 (Stela 2014). The size fraction distributions of 0.86 and 0.57 for PM_{10} and $PM_{2.5}$, respectively, were based on the Müller-BBM stack testing report dated March 16, 2007 (Müller-BBM 2007).

Baghouse filtration systems were proposed to reduce the particulate matter PM concentrations emitted from both the hammermill and pelletmill at the Pinnacle facility. Emission estimates of PM_{10} and $PM_{2.5}$ were calculated based on a PM concentration of 15 mg/m³, and flow rates of 14 m^3/s and 34 m^3/s for the hammermill and pelletmill, respectively provided by Pinnacle (Reitsma 2014, pers. comm.). A maximum velocity of 20 m/s was adopted to mitigate potential noise from the project. The size fraction distributions of 0.98 and 0.74 for PM_{10} and $PM_{2.5}$, respectively were based on the previous Pinnacle stack testing at Pinnacle Williams Lake on September 16, 2009 (M^c^Call Environmental 2009).

2.3 Dispersion Modelling

Ambient concentrations of PM_{10} and $PM_{2.5}$ were predicted within the dispersion modelling study area. Dispersion modelling was conducted based on the emissions estimated for each source. Predicted concentrations of PM_{10} and $PM_{2.5}$ were compared to British Columbia and Canadian ambient air quality objectives, which are listed in Table 1-1.

The dispersion modelling methodology was based on the *Guidelines for Air Quality Dispersion Modelling in BC* (BC MOE 2008) and the modelling methodology discussed with MOE. A detailed model plan for the dispersion modelling study area was submitted for review by BC MOE.

Topography around the Pinnacle site is spatially varied, resulting in complex wind flow patterns. Therefore, a refined dispersion model, capable of simulating complex wind flow patterns was selected. The CALMET/CALPUFF dispersion modelling system was selected for this assessment. CALMET is a meteorological model that develops hourly three-dimensional meteorological fields of wind and temperature used to drive pollutant transport within CALPUFF. CALPUFF is a multi-layer, multi-species, non-steady-state puff dispersion model that simulates the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and deposition. CALPUFF can use three-dimensional meteorological fields developed by the CALMET model or simple, single-station winds in a format consistent with the meteorological files used to drive the ISCST3 steady-state Gaussian model. Dispersion modelling was conducted using the full 3-D CALMET mode because it has the ability to simulate the changes in mixing height and boundary layer mechanics that result from the variable land cover characterization and terrain in the air quality dispersion modelling study area.

2.3.1 CALMET

The development of the CALMET model is described in this section. CALMET version 6.334 was used in the study. More detailed information is provided in Appendix B.

2.3.1.1 Model Period

CALMET was run for a one-year period from January 1, 2011 to December 31, 2011. This represents the most recent period during which prognostic meteorological data from the Weather Research and Forecasting model were available (See Section 2.3.1.3). Consultations with the BC MOE confirmed this data was acceptable to use in the modelling (Adams 2014, pers. comm.).

2.3.1.2 Model Domain

The CALMET domain was chosen to be a 26 km by 26 km area surrounding the Pinnacle facility. Horizontal domain resolution was set at 500 m. In the vertical direction, 10 layers were chosen, with the top of the layers set as 20, 40, 80, 160, 300, 600, 1000, 1500, 2200 and 3300 m above ground level.

2.3.1.3 Prognostic Meteorology

CALMET was initialized for the one-year model period using the Weather Research and Forecasting (WRF) model. The WRF model is a mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs. It represents the latest numerical weather forecasting model to be adopted by the United States National Weather Service as well as the United States military and private meteorological services. The WRF model was run in a nested 12 km and 4 km configuration with the 4 km domain covering a 840 km x 840 km area centered over the Southern Interior in BC. The model was run using 35 vertical layers, with approximately 20 in the lowest 2000 m above ground level. Boundary and initial conditions were set using North American Regional Reanalysis (NARR) meteorological fields from National Centers for Environmental Protection (NCEP). Geophysical data for the model domains were derived from the United States Geological Survey (USGS) database supplied with the WRF model codes. The WRF model options were set in accordance with EPA recommendations for air quality simulations including one-way nesting, use of the Pleim-Xu and ACM2 surface and boundary layer physics modules, and analysis nudging in the parent domain.

2.3.1.4 Terrain and Land Cover Characterization

Terrain elevations were obtained from 1:50,000 scale Canadian Digital Elevation Data available from GeoBase (http://www.geobase.ca). Land cover characterization data information was obtained from the POSTEL Service Centre/MEDIAS-France global land cover dataset. The CALMET model requires gridded geophysical parameters including surface roughness length, albedo, Bowen ratio, soil heat flux, vegetation leaf area index, and anthropogenic heat flux. The parameters are provided in Appendix B. To more accurately represent the seasonally dependent geophysical parameters in the CALMET model, five seasons were specified:

- Season 1: Mid-summer with lush vegetation (June to August)
- Season 2: Autumn with cropland that has not yet been harvested (September to October)
- Season 3: Winter with freezing temperatures, no snow on ground (November)
- Season 4: Winter with sub-freezing temperatures, snow cover on ground (December to March)
- Season 5: Transitional spring with partially green short annuals (April to May)

2.3.1.5 Model Switch Settings

A list of the switch settings used in the CALMET model is provided in Appendix B. In general, model switch settings were chosen in accordance with the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008).

2.3.2 CALPUFF

The CALMET output was used as input to the CALPUFF version 6.42 model to predict the maximum potential PM_{10} and $PM_{2.5}$ concentrations resulting from estimated emissions.

2.3.2.1 Model Domain

The CALPUFF model domain was the same as the CALMET domain described in Section 2.3.1.2. Puff transport and dispersion is computed within the CALPUFF model for the entire model domain. Model predictions are reported at discrete receptor locations within the dispersion modelling study area.

2.3.2.2 Receptor Locations

In the CALPUFF model, a discrete set of receptor points are specified at which pollutant concentrations are predicted. A Cartesian nested grid of receptors was defined within the study area, as per the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008). Receptor spacing for the Cartesian grid is as follows:

- 20-m spacing along the property fenceline;
- 50-m spacing within 500 m of the Pinnacle sources;
- 250-m spacing within 2 km of the Pinnacle sources;
- 500-m spacing within 5 km of the Pinnacle sources; and
- 1,000-m spacing within 10 km of the Pinnacle sources.

Receptors within the facility site were removed. In addition, a number of special receptors were defined at some schools and senior care facilities in the study area. A list of these special receptors is provided in Appendix A. Receptor locations are shown in Figure 2.2.

Terrain elevations for all receptors included as input to the CALPUFF model were extracted from 1:50,000 scale Canadian Digital Elevation Data obtained from GeoBase.

2.3.2.3 Technical Dispersion Options

All technical options relating to the CALPUFF dispersion model were set according to the *Guidelines for Air Quality Dispersion Modelling in BC* (BC MOE 2008) or to model defaults. These include parameters and options such as the calculation of plume dispersion coefficients, the plume path coefficients used for terrain adjustments, exponents for the wind speed profile, and wind speed categories. A list of the technical options is shown in Appendix B.

2.3.2.4 Point Source Parameters

Emissions from the dryer and baghouse were modelled as constant point sources. Stack parameters including stack height, stack diameter, exit velocity, and exit temperature are summarized in Table 2-1. Locations of stacks were determined from site plans provided by Pinnacle. Source locations are shown in Figure 2.3.

The stack height and diameter of the dryer were obtained from manufacturer specifications, while the maximum flow rate and exit temperature were confirmed by Pinnacle. For the baghouse stacks, the heights were estimated based on the previous design at other Pinnacle facilities and the flow rates were confirmed by Pinnacle. The maximum velocity was designed to avoid excess noise and the exit temperature was obtained from stack testing data.

Table 2-1: Point source stack parameters

Emission Source	Description	Stack Height (m)	Stack Inner Diameter (m)	Exit Temperature (°C)	Exit Velocity (m/s)
DRY 1-4	Belt dryer stacks	20.0	2.03	45.0	11.0
HAMMER	Hammermill baghouse stack	30.5	0.94	51.2	20.0
PELLET	Pelletmill baghouse stack	30.5	1.47	51.2	20.0

2.3.2.5 Building Effects

Buildings located close to stacks (i.e., point sources) may influence the dispersion of emissions. As the stacks are relatively short compared to building height, the associated plumes may be influenced by building downwash. For this reason, building downwash effects were assessed in the dispersion modeling. The building dimensions that were used are summarized in Table 2-2. All data were provided by Pinnacle or estimated based on manufacture drawings.

Table 2-2: Building Parameters Used for Dispersion Modelling

Building		Rail Car Loading	Main Building	Hammer Mill	Shavings Storage	Sawdust Storage	Dryer1	Dryer2
Base Elevation	(m)	531	528	529	529	531	530	530
Height	(m)	19.5	17.7	12.5	13.0	13.6	7.5	7.5
Corner1	(mE)	350,093	350,096	350,126	350,231	350,244	350,134	350,153
	(mN)	5,566,662	5,566,744	5,566,757	5,566,753	5,566,694	5,566,712	5,566,712
Corner2	(mE)	350,093	350,094	350,126	350,182	350,184	350,133	350,152
	(mN)	5,566,656	5,566,696	5,566,751	5,566,754	5,566,696	5,566,666	5,566,666
Corner3	(mE)	350,104	350,118	350,144	350,181	350,183	350,139	350,158
	(mN)	5,566,656	5,566,696	5,566,750	5,566,730	5,566,667	5,566,666	5,566,667
Corner4	(mE)	350,105	350,120	350,143	350,231	350,243	350,141	350,159
	(mN)	5,566,662	5,566,744	5,566,756	5,566,728	5,566,665	5,566,712	5,566,712

2.3.3 Post-Processing of Model Results

Maximum ground-level concentrations of PM_{10} and $PM_{2.5}$ were predicted for each model run at each receptor. Post-processing of hourly model results was conducted to determine required results for comparison with ambient air quality objectives over various averaging periods. The CALPOST post-processor was used to extract required metrics from the resulting binary files.

2.3.3.1 Representative Background Concentrations

The *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008) require that representative background concentrations be added to concentrations predicted by dispersion modelling to account for other emission sources in the study area.

As per the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008), the 98^{th} to 100^{th} percentile of historical monitoring data is to be added to maximum predicted concentrations. This methodology is conservative as it assumes that the maximum predicted concentration and the background concentration would occur at the same time even though, by definition, concentrations equal to or greater than the 98^{th} percentile occur only 2% of the time and the maximum predicted concentration, by definition, would occur once during the modelled period.

The short-term $PM_{2.5}$ 24-hour average background concentration was based on the 98^{th} percentile of representative ambient air quality observations from BC MOE. The $PM_{2.5}$ annual average background concentration was based on the average of hourly observations.

The data from the BC MOE station (Vernon Science Centre) was considerably high. The annual $PM_{2.5}$ background from the BC MOE station was calculated to be 7.75 µg/m^3, in 2013, which is approximately 97% of the BC objective. As illustrated in Figure 2.1, the BC MOE station is located in a residential area approximately 2 km south of the city of Vernon and approximately 15 km west of the Pinnacle facility. As such, the background may contain more influences from urban activities such as mobile traffic or space heating.

There were no ambient air quality monitoring data for PM_{10} available within the study area. Background PM_{10} concentrations were estimated as 1.85 times the background PM2.5 concentrations (Lall et. al. 2004). Background concentrations calculated from the BC MOE station are presented in Table 2-3.

Table 2-3: Representative Background Concentrations (in micrograms per cubic metre)

Contaminant	Averaging Period	Background Concentration
PM_{10}	24-Hour	31.1
	Annual	14.4
$PM_{2.5}$	24-Hour	16.8
	Annual	7.75

2.4 Study Limitations

A number of limitations are inherent in the air quality study. These include limitations in emissions estimation and limitations in dispersion modelling.

Emissions were estimated based on project-specific activity data where available. Assumptions based on other Pinnacle facilities and permitted values were made when site-specific data were not available. The assumptions regarding the dryer PM size fractions were based on stack testing for a similar model.

By definition, air quality dispersion models can only approximate atmospheric processes. Many assumptions and simplifications are required to describe real phenomena in mathematical equations. Model uncertainties can result from:

- Simplifications and accuracy limitations related to source data.
- Extrapolation of meteorological data from selected locations to a larger region.
- Simplifications of model physics to replicate the random nature of atmospheric dispersion processes.

Models are reasonable and reliable in estimating the maximum predicted concentration that may occur at some time, somewhere within the model domain, as opposed to the exact concentration at a point at a given time. The accuracy is usually within the range of ±10% to ±40% of the observed maximum concentration (US EPA 2005).

3. EMISSION ESTIMATES

Estimated maximum hourly and annual average emissions for the worst-case scenario are presented in this section. Emissions were estimated following the methodology presented in Section 2.2.

3.1 Emission Inventory

The estimated total annual emissions of PM_{10} and $PM_{2.5}$ from the proposed Pinnacle facility for the January 2013 to January 2014 model period are based on two (2) dryer belts exhausting to four (4) dryer stacks and two (2) baghouse stacks on the hammermill and pelletmill operating continuously. Estimates of annual emissions are presented in Table 3-1. The largest sources of PM emissions were estimated to be from the dryers, followed by the baghouses.

Table 3-1: Annual Emissions (in tonnes per year)

Emission Source	PM_{10}	$PM_{2.5}$
Dryers	53.2	35.5
Baghouses	22.1	16.7
Total	**75.3**	**52.1**

Maximum hourly emissions estimated for the worst-case scenario were used as input to the model and are presented in Table 3-2. Emission sources with the greatest estimated maximum hourly emissions of PM were the dryers, followed by the baghouse.

Table 3-2: Maximum Hourly Emissions (in grams per second)

Emission Source	PM_{10}	$PM_{2.5}$
Dryers	1.69	1.12
Baghouse	0.70	0.53
Total	**2.39**	**1.65**

4. DISPERSION MODELLING RESULTS

This section describes predictions of PM_{10} and $PM_{2.5}$ in the study area. As discussed in Section 1.2, there are ambient air quality objectives for these CACs. The maximum ambient concentrations predicted by the CALPUFF model with all equipment operating based on a worst-case scenario are summarized in Table 4-1 and presented in Figures 4.1 to 4.3. Background values have not been added to these concentrations.

For the Pinnacle facility, the maximum predicted PM_{10} and $PM_{2.5}$ concentrations (without background) were lower than the most stringent air quality objectives. The maximum predicted 24-hour PM_{10} concentration was 15.6 µg/m^3, which is 31.3% of the most stringent air quality objective. Maximum predicted 24-hour and annual $PM_{2.5}$ concentrations were 7.25 µg/m^3 and 2.67 µg/m^3, respectively, which are 29.0% and 33.4% of the corresponding most stringent air quality objectives, respectively. The greatest PM_{10} concentrations were predicted to occur along the western property boundary. The greatest 24-hour and annual $PM_{2.5}$ concentrations were both predicted to occur along the eastern property boundary.

Table 4-1: Maximum Predicted Concentrations in the Air Quality Local Study Area – Without Background (in micrograms per cubic metre)

Contaminant	Averaging Period	Maximum Predicted Concentration	Most Stringent Air Quality Objective	Percentage of Objective (%)
PM_{10}	24-Hour	15.6	50	31.3%
$PM_{2.5}$	24-Hour	7.25	25	29.0%
	Annual	2.67	8	33.4%

NOTES: Compliance of $PM_{2.5}$ was based on the 98th percentile of results

The maximum predicted concentrations in the dispersion modelling study area including ambient background are presented in Figures 4.4 to 4.6, and in Table 4-2. All maximum predicted PM_{10} and $PM_{2.5}$ concentrations with background added were below the corresponding ambient air quality objectives, except for the annual average $PM_{2.5}$ concentration. The predicted maximum annual $PM_{2.5}$ concentration with background added of 10.4µg/m^3 exceeded the most stringent ambient air quality objective of 8 µg/m^3 and the BC planning goal of 6 µg/m^3. The representative 24-hour PM_{10} and $PM_{2.5}$ background concentrations contribute 62.2% and 67.2% of the ambient air quality objective, respectively. The representative annual $PM_{2.5}$ background concentration contributes 96.9% of the ambient air quality objective.

The annual $PM_{2.5}$ concentration predicted at Lavington School of 8.21 µg/m^3 exceeded the annual $PM_{2.5}$ objective of 8 µg/m^3 based on a background concentration of 7.75 µg/m^3. The school is located approximately 150 m west of the Pinnacle fenceline. There were no exceedances predicted at the other sensitive receptors modelled in the study area.

In viewing these results, it should be further understood that the majority of the maximum predicted concentrations associated with the Pinnacle pellet plant can be attributed to the dryers as illustrated in Figure 4.3b, and that the emissions concentration used to predict the maximum ambient concentrations of annual $PM_{2.5}$ was 8.6 mg/m^3 compared to the actual European test data of 0.4 mg/m^3 (Müller-BBM 2007). The concentrations of the hammermill and pelletmill are depicted in Figure 4.3a for comparison.

Table 4-2: Maximum Predicted Concentrations in the Air Quality Local Study Area – With Background Included (in micrograms per cubic metre)

Contaminant	Averaging Period	Background	Maximum Predicted Concentration (Background Incl.)	Most Stringent Air Quality Objective	Percentage of Objective (%)
PM_{10}	24-Hour	31.1	46.7	50	93.5%
$PM_{2.5}$	24-Hour	16.8	24.1	25	96.2%
	Annual	7.75	10.4	8	**130%**

NOTES: *"--"* Background values were not available in the study area.
Compliance of $PM_{2.5}$ was based on the 98th percentile of results
Values in **bold** indicate exceedances of the objectives

The spatial distribution of maximum predicted concentrations with background added, which show contours of constant concentration are presented in the form of isopleth maps provided in Appendix C. The greatest PM_{10} concentrations were predicted to occur along the western property boundary. The greatest 24-hour and annual $PM_{2.5}$ concentrations were both predicted to along the eastern boundary.

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5. COMBINED EMISSIONS ASSESSMENT

As briefly discussed in Section 1, the Pinnacle pellet plant will produce pellet fuel from sawdust and shavings from the existing Tolko Lavington sawmill located directly to the south. Due to the close proximity of two facilities, there is the potential for combined effects on ambient air quality due to emissions from Tolko. Emissions and modelling results from the current Tolko operating scenario, as well as, the scenario with proposed Tolko upgrades are presented in this section. For the current Tolko scenario, the shavings stacks were modelled based on the maximum permitted PM concentrations, as well as current stack parameters and configuration. The Tolko proposed scenario assumed the same two stacks would be exhausted to a baghouse system, which was expected to lower emissions. Figures representing the two scenarios, the change between the two scenarios and the change including Pinnacle emissions are also shown in Appendix C.

5.1 Tolko Emission Estimation

Emissions were estimated for the operation of the shavings stacks at Tolko. Current emissions of PM_{10} and $PM_{2.5}$ from the two shaving stacks were estimated based on the permitted PM concentration of 116 mg/m³, and maximum dryer flow rate of 14.4 m³/s and 22.9 m³/s based on information provided by Pinnacle (Reitsma 2014, pers. comm.). The stacks were vented horizontally, as confirmed from a photo provided by Pinnacle.

For the proposed scenario, Tolko agreed to vent the shavings stacks through a baghouse system (Harkies 2014, pers. comm.). The maximum proposed emission estimates of PM_{10} and $PM_{2.5}$ from the shaving stacks were assumed to be 15 mg/m³, same as the baghouses associated with the Pinnacle facility. The flow rates were assumed to be the same as the current scenario and the velocities were assumed to be a maximum of 20 m/s to avoid excessive noise. With the installation of the baghouse system, the height of the proposed shavings stack could be increased and both stacks could be combined and vented vertically through the baghouse. This proposed stack would also be relocated to the northeast corner of the shavings tent. For both scenarios, the size fraction distributions of 0.98 and 0.74 for PM_{10} and $PM_{2.5}$, respectively, were assumed. These values were based on a previous stack testing report for a Pinnacle baghouse dated September 16, 2009 (M^c^Call Environmental 2009).

5.2 Tolko Emission Inventory

The estimated total annual emissions of PM_{10} and $PM_{2.5}$ from the Tolko facility for current and proposed scenarios are presented in Table 5-1. Annual modelling results were scaled according to a conservative estimate of the actual operational time of 5,300 hours/year.

Table 5-1: Tolko Annual Emissions (in tonnes per year)

Emission Source	Current		Proposed	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Shavings Stack #1	31.1	23.4	10.4	7.8
Shavings Stack #2	49.4	37.3	-	-
Total	**80.5**	**60.7**	**10.4**	**7.8**

Maximum hourly emissions estimated for the worst-case scenario were used as input to the model and are presented in Table 5-2.

Table 5-2: Tolko Maximum Hourly Emissions (in grams per second)

Emission Source	Current		Proposed	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Shavings Stack #1	1.63	1.23	0.55	0.41
Shavings Stack #2	2.59	1.95	-	-
Total	**4.22**	**3.18**	**0.55**	**0.41**

5.3 Tolko Point Source Parameters

Emissions from the shavings stacks were modelled as constant point sources. Stack parameters including stack height, stack diameter, exit velocity, and exit temperature are summarized in Table 5-3 for the current and proposed scenarios. Locations of stacks were determined from site plans provided by Pinnacle and confirmed with Google Earth. Source locations are shown in Figure 2.3.

Table 5-3: Point source stack parameters

Emission Source	Description	Stack Height (m)	Stack Inner Diameter (m)	Exit Temperature (°C)	Exit Velocity (m/s)
Current					
T_CHIP	Shavings Stack #1	21.9	1.52	51.2	7.89
T_SHAVE	Shavings Stack #2	7.47	1.52	51.2	12.6
Proposed					
T_PLANE	Shavings Stack #1	18.0	1.54	51.2	20.0

NOTES: Current stacks were vented horizontally.

5.4 Building Effects

Building downwash effects of the Tolko shavings tower along with the Pinnacle buildings listed in Table 2-2 were assessed in the Tolko dispersion modeling. The Tolko tower dimensions were estimated based on Google Earth, and are summarized in Table 5-4.

Table 5-4: Building Parameters Used for Dispersion Modelling

Building		Tolko
Base Elevation	(m)	531
Height	(m)	21.9
Corner1	(mE)	350,202
	(mN)	5,566,619
Corner2	(mE)	350,212
	(mN)	5,566,619
Corner3	(mE)	350,213
	(mN)	5,566,625
Corner4	(mE)	350,202
	(mN)	5,566,625

5.5 Combined Results

This section describes predictions of annual $PM_{2.5}$ from the current and proposed Tolko scenarios and the combination of those predictions with annual $PM_{2.5}$ results for Pinnacle. Since only the annual $PM_{2.5}$ Pinnacle results (with background included) were predicted to exceed the objective, only the annual $PM_{2.5}$ for Tolko and the combined results are presented. The current scenario is shown in Figure 5.1 and the proposed scenario is shown in Figure 5.2. For both scenarios, the greatest annual $PM_{2.5}$ concentrations were predicted to occur along the eastern property boundary. Background values have not been added to these concentrations.

The maximum ambient concentrations predicted by the CALPUFF model for both Tolko scenarios are summarized in Table 5-5 along with the ambient air quality objective. For the current scenario, the maximum predicted annual $PM_{2.5}$ concentration was 6.95 $\mu g/m^3$, which is 86.9% of the corresponding most stringent air quality objective. For the proposed scenario, the maximum predicted annual $PM_{2.5}$ concentration was 0.46 $\mu g/m^3$, which is 5.70% of the corresponding most stringent air quality objective.

Table 5-5: Maximum Predicted Concentrations in the Air Quality Local Study Area from Tolko– Without Background (in micrograms per cubic metre)

Contaminant	Averaging Period	Maximum Predicted Concentration	Most Stringent Air Quality Objective	Percentage of Objective (%)
Current				
$PM_{2.5}$	Annual	6.95	8	86.9%
Proposed				
$PM_{2.5}$	Annual	0.46	8	5.70%

NOTES: Compliance of $PM_{2.5}$ was based on the 98th percentile of results
Values in **bold** indicate exceedances of the objectives

The difference between annual $PM_{2.5}$ in the two scenarios is depicted in Figure 5.3. The location of maximum decrease occurs along the eastern property boundary and the location of minimum decrease occurs approximately 16 km southeast of the property boundary. The change at Lavington School, located approximately 150 m west of the Pinnacle fenceline was predicted to be -3.53 µg/m³. Decreases in emissions were expected throughout most of the populated areas close to the facility as a result of the Tolko upgrade. The minimum and maximum decrease between the current and proposed Tolko scenarios is presented in Table 5-6.

To illustrate the combined effects from the Tolko upgrade and Pinnacle, the difference between annual $PM_{2.5}$ in the two scenarios with Pinnacle emissions added is depicted in Figure 5.4. The locations of maximum decrease and maximum increase occur along the eastern property boundary. The change at Lavington School, located approximately 150 m west of the Pinnacle fenceline was predicted to be -3.07µg/m³. Despite a possible increase of annual $PM_{2.5}$ in some locations, decreases in emissions were predicted in the majority of the populated neighbourhoods adjacent the facility, especially to the east and west, as a result of the Tolko upgrade. The maximum increase and maximum decrease between the current and proposed Tolko scenarios (with Pinnacle emissions added) is presented in Table 5-6.

Table 5-6: Maximum Change Between the Current and Proposed Tolko Scenarios

Contaminant	Averaging Period	Minimum Decrease / Maximum Increase	Maximum Decrease
Current and Proposed			
$PM_{2.5}$	Annual	-0.004	-6.53
Current and Proposed - with Pinnacle Emissions Added			
$PM_{2.5}$	Annual	0.04	-4.06

6. CONCLUSION

6.1 Model Performance and Context

The dispersion modelling study is expected to provide a reasonable upper bound for estimation of the influence of the project on local air quality. That is, the dispersion modelling study is expected to provide an estimation of the worst-case impact on air quality as a result of the project. The peak short term model concentration results from the combination of the worst-case scenario, specifically, the simultaneous operation of dryers and baghouses in conjunction with ambient background values that will at most be experienced 2% of the time. In reality it is unlikely that these conditions would occur concurrently throughout the year.

The results for the Pinnacle plant alone represent a conservative estimate of potential impacts to air quality. A measure of the model conservatism is shown in Figure 6.1 which show the dryer emissions actually used in the modelling compared to both the manufacturers guaranteed emissions and the emissions from the stack testing report used to set the size fraction in the modelling. The model used 15 mg/m^3, while the manufacturer has guaranteed 10 mg/m^3, and the stack testing report show value less than 1 mg/m^3. This suggests that actual emissions may be an order of magnitude lower than those used in the modelling.

Exceedances of ambient objective with background included are predicted only for annual average $PM_{2.5}$. The location of the station from which background data were used is located 15 km from the site and is much closer to the population center of Vernon. Model predicted $PM_{2.5}$ annual average results (without background) at the edge of the study domain toward the city of Vernon are well below 1 µg/m^3 and in fact even below 0.1 µg/m^3. This indicates that the proposed facility will have little contribution to annual average $PM_{2.5}$ concentration outside of the immediate area of the facility and negligible influence on annual average $PM_{2.5}$ in Vernon proper.

6.2 Summary of Results

Model results for Pinnacle pellet plant alone show that the maximum predicted concentrations within the 20 km by 20 km local study area without background were less than the most stringent ambient objectives. All maximum predicted PM_{10} and $PM_{2.5}$ concentrations with background included were less than the most stringent ambient objectives, except for the annual average $PM_{2.5}$ concentration. There were also no predicted exceedances of the objectives predicted at the sensitive receptors in the study area, with the exception of annual $PM_{2.5}$ (with background included) at Lavington School, located approximately 150 m west of the Pinnacle fenceline.

The combined effect of the reduction of emission from the Tolko upgrade and the proposed Pinnacle emissions is a predicted decrease in annual $PM_{2.5}$ concentration for the majority of the study area with some minor increases (0.04 µg/m^3) in the area of the eastern property boundary, approximately 375 m south of Highway 6. In general, predicted $PM_{2.5}$ concentrations due to emissions from the upgraded Tolko facility and the proposed Pinnacle facility combined are expected to be less than the current Tolko facility alone. Overall, it is expected that air quality in the area would improve as a result of the combined project. The expected change at Lavington School, was predicted to be -3.07μg/m3.

The proposed Pinnacle facility will have the ability to process harvest residuals. Consumption of this material for pellets will divert it from being disposed of through slash burning which is likely a contributor to the existing background PM concentration observed in the study area. A reduction in slash burning through diversion of harvest residuals to the proposed plant will therefore potentially further reduce PM emissions and background PM concentration in the airshed. Pinnacle has also committed to participate in, and support of the development of an air-shed management committee that will seek to take actions based on good science that will continuously improve the local air quality.

7. REFERENCES

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APPENDIX A
Sensitive Receptors

Appendix A: Sensitive Receptors

Sensitive Receptor	UTM Easting (m)	UTM Northing (m)	Elevation (m)
Lavington School	349,833	5,566,471	536
Coldstream Elementary	340,699	5,565,837	439
Kalamalka Secondary	339,617	5,565,851	424
Bloom Secondary	359,912	5,568,256	499
Inglis Elementary	359,818	5,568,601	498
Crossroads School	359,995	5,568,090	501
Coldstream Meadows Seniors Residence	341,841	5,565,206	460
Saddle Mountain Seniors Residence	360,219	5,568,235	498

APPENDIX B

CALMET and CALPUFF – Model Switch Settings

B.1 INTRODUCTION

This Appendix provides details on CALMET (Section B.2) and CALPUFF (Section B.4 inputs that are not provided in the main text of the Air Dispersion Modelling Study Report. Selected CALMET outputs are shown and briefly discussed in Section B.3 to demonstrate that CALMET produces meteorological inputs for CALPUFF that qualitatively agree with expected meteorological conditions.

B.2 CALMET INPUTS

This section presents the input parameters needed to run CALMET. These are divided into two broad categories: geophysical parameters, which specify surface properties as a function of season and land-use type, and model switch settings, which specify how CALMET will perform the meteorological processing.

B.2.1 Geophysical Parameters

Table B.1 to Table B.5 present land surface characteristics for surface roughness, albedo, Bowen ratio, leaf area index (LAI), and soil heat flux for each of the land use categories use in CALMET. Surface characteristic are varied temporally according to five seasons identified using climate normal data from Vernon Auto Station (Environment Canada 2014). The values for surface roughness, albedo, and Bowen ratio are mostly based on recommended values from the United States Environmental Protection Agency (US EPA) for the conterminous United States (US EPA 2008). Soil heat flux values are CALMET default values. Leaf area index is based on generic values for land-use type, which have been used previously for Canada (Zhang et al. 2002, 2003). Anthropogenic heat flux was calculated based on the anthropogenic heat flux provided in Boundary Layer Climates (Oke 1987) and scaled by population density as published by Statistics Canada (2011).

Table B.1: Seasonal Values of Surface Roughness Length by Land Cover Characterization Category (in metres)

Land Cover Characterization Category	Season 1 (Summer)	Season 2 (Autumn)	Season 3 (Winter 1)	Season 4 (Winter 2)	Season 5 (Spring)
Urban	0.54	0.54	0.50	0.50	0.52
Agricultural	0.20	0.20	0.02	0.01	0.03
Rangeland	0.15	0.15	0.02	0.01	0.03
Deciduous Forest	1.30	1.30	0.60	0.50	1.00
Coniferous Forest	1.30	1.30	1.30	1.30	1.30
Mixed Forest	1.30	1.30	0.95	0.90	1.15
Water	0.001	0.001	0.001	0.002(a)	0.001
Wetland(b)	0.20	0.20	0.20	0.10	0.20
Forested Wetland	0.70	0.70	0.60	0.50	0.70
Nonforested Wetland	0.20	0.20	0.20	0.10	0.20
Barren Land	0.05	0.05	0.05	0.05	0.05

Source: Modified from US EPA (2013)
Notes: (a) Value borrowed from “Perennial Snow or Ice”.
(b) Values based on emergent herbaceous wetlands.

Table B.2: Seasonal Values of Albedo by Land Cover Characterization Category

Land Cover Characterization Category	Season 1 (Summer)	Season 2 (Autumn)	Season 3 (Winter 1)	Season 4 (Winter 2)	Season 5 (Spring)
Urban	0.16	0.16	0.18	0.45	0.16
Agricultural	0.20	0.20	0.18	0.60	0.14
Rangeland	0.20	0.20	0.18	0.60	0.14
Deciduous Forest	0.16	0.16	0.17	0.50	0.16
Coniferous Forest	0.12	0.12	0.12	0.35	0.12
Mixed Forest	0.14	0.14	0.14	0.42	0.14
Water	0.10	0.10	0.10	0.70(a)	0.10
Wetland(b)	0.14	0.14	0.14	0.3	0.14
Forested Wetland	0.14	0.14	0.14	0.3	0.14
Nonforested Wetland	0.14	0.14	0.14	0.3	0.14
Barren Land	0.20	0.20	0.20	0.6	0.20

Source: Modified from US EPA (2013)
Notes: (a) Value borrowed from “Perennial Snow or Ice”.
(b) Values based on emergent herbaceous wetlands.

Table B.3: Seasonal Values of Bowen Ratio by Land Cover Characterization Category

Land Cover Characterization Category	Season 1 (Summer)	Season 2 (Autumn)	Season 3 (Winter 1)	Season 4 (Winter 2)	Season 5 (Spring)
Urban	0.80	1.00	1.00	0.50	0.80
Agricultural	0.50	0.70	0.70	0.50	0.30
Rangeland	0.50	0.70	0.70	0.50	0.30
Deciduous Forest	0.30	1.00	1.00	0.50	0.70
Coniferous Forest	0.30	0.80	0.80	0.50	0.70
Mixed Forest	0.30	0.90	0.90	0.50	0.70
Water	0.10	0.10	0.10	0.50[(a)]	0.10
Wetland[(b)]	0.10	0.10	0.10	0.50	0.10
Forested Wetland	0.20	0.20	0.30	0.50	0.20
Nonforested Wetland	0.10	0.10	0.10	0.50	0.10
Barren Land	1.50	1.50	1.5	0.50	1.50

Source: Modified from US EPA (2013)
Notes: (a) Value borrowed from “Perennial Snow or Ice”.
(b) Values based on emergent herbaceous wetlands.

Table B.4: Seasonal Values of Soil Heat Flux by Land Cover Characterization Category (in Watts per square metre)

Land Cover Characterization Category	Season 1 (Summer)	Season 2 (Autumn)	Season 3 (Winter 1)	Season 4 (Winter 2)	Season 5 (Spring)
Urban	0.25	0.25	0.25	0.15[(a)]	0.25
Agricultural	0.15	0.15	0.15	0.15	0.15
Rangeland	0.15	0.15	0.15	0.15	0.15
Deciduous Forest	0.15	0.15	0.15	0.15	0.15
Coniferous Forest	0.15	0.15	0.15	0.15	0.15
Mixed Forest	0.15	0.15	0.15	0.15	0.15
Water	1.00	1.00	1.00	1.00	1.00
Wetland	0.30	0.30	0.30	0.30	0.30
Forested Wetland	0.30	0.30	0.30	0.30	0.30
Nonforested Wetland	0.30	0.30	0.30	0.30	0.30
Barren Land	0.15	0.15	0.15	0.15	0.15

Source: CALMET defaults
Notes: (a) Value borrowed from “Perennial Snow or Ice”.

Table B.5: Seasonal Values of Leaf Area Index by Land Cover Characterization Category

Land Cover Characterization Category	Season 1 (Summer)	Season 2 (Autumn)	Season 3 (Winter 1)	Season 4 (Winter 2)	Season 5 (Spring)
Urban	0.30	0.20	0.10	0.00	0.20
Agricultural	2.00	1.50	1.00	0.00	1.00
Rangeland	1.00	1.00	1.00	1.00	1.00
Deciduous Forest	3.40	1.90	0.10	0.00	0.80
Coniferous Forest	5.00	5.00	5.00	5.00	5.00
Mixed Forest	4.50	3.50	2.30	2.30	3.30
Water	0.00	0.00	0.00	0.00	0.00
Wetland[(a)]	0.20	0.20	0.10	0.00	0.100
Forested Wetland	0.20	0.20	0.10	0.00	0.10
Nonforested Wetland	0.20	0.20	0.10	0.00	0.10
Barren Land	0.00	0.00	0.05	0.05	0.00

Source: Modified from Zhang et al. (2002, 2003)
Notes: (a) Values based on wetlands with plants

B.2.2 CALMET Model Switch Settings

Table B.6 shows the model switch settings used in CALMET Group 5. The settings were selected according to the *Guidelines for Air Quality Dispersion Modelling in British Columbia* (BC MOE 2008) or to model defaults. Table B.7 shows the model switch settings used in Group 6

Table B.6: CALMET Model Switch Settings Group 5 - Wind Field Options and Parameters

Parameter	Default	Project	Comments
IWFCOD	1	1	Diagnostic wind module used
IFRADJ	1	1	Froude number adjustment effects computed
IKINE	0	0	Kinematic effects not computed
IOBR	0	0	No adjustment to vertical velocity profile at top of model domain
ISLOPE	1	1	Slope flow effects computed
IEXTRP	-4	1	No extrapolation done
ICALM	0	1	Frequency of calms are realistic
BIAS	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Not used because initial guess set by prognostic outputs
RMIN2	4	-1	Surface observations not used
IPROG	0	14	Used WRF prognostic model output for initial guess field
ISTEPGS	3600	3600	Timestep (seconds) of the prognostic model input data
IGFMET	0	0	Use coarse CALMET fields as initial guess fields
LVARY	F	T	Surface observations not used
RMAX1	NA	5	Surface observations not used
RMAX2	NA	10	Upper air observations not used
RMAX3	NA	10	Over-water observations not used
RMIN	0.1	0.1	Small value used as recommended
TERRAD	NA	5	Identified from main terrain feature of influence
R1	NA	0.3	Surface observations not used
R2	NA	1	Upper air stations not used
RPROG	NA	4	Not used since IPROG = 14
DIVLIM	5×10^{-6}	5×10^{-6}	Not used since IKINE = 0
NITER	50	50	Not used since IKINE = 0
NSMTH	2,(mxnz-1)*4	2, 4, 4, 4, 4, 4, 4, 4, 4	Default number of passes in the smoothing procedure
NINTR2	99	99	Surface observations not used
CRITFN	1	1	Default critical Froude number used
ALPHA	0.1	0.1	Not used since IKINE = 0
FEXTR2	NZ*0	0, 0, 0, 0, 0, 0, 0, 0, 0, 0	Not used since IEXTRP = -4

Parameter	Default	Project	Comments
NBAR	0	0	Barriers not used
KBAR	NZ	10	Level (1 to NZ) up to which barriers apply
XBAR, YBAR, XEBAR, YEBAR	0, 0, 0, 0	0, 0, 0, 0	Not used since NBAR = 0
IDIOPT1	0	0	Surface temperatures computed internally
ISURFT	-1	-1	Diagnostic module surface temperatures based on 2-D spatially varying temperature field
IDIOPT2	0	0	Lapse rate computed internally
IUPT	-1	-1	Upper air stations not used
ZUPT	200	200	Lapse rate computed for default depth
IDIOPT3	0	0	Domain-averaged wind components computed internally
IUPWND	-1	-1	Upper air observations not used
ZUPWND	1, 1000	1, 1000	Default used
IDIOPT4	0	0	Observed surface wind components for wind field module
IDIOPT5	0	0	Observed upper air wind components for wind field module

Table B.7: CALMET model switch settings Group 6 - Mixing Height, Temperature and Precipitation Parameters

Parameter	Default	Project	Comments
CONSTB	1.41	1.41	Neutral, mechanical equation
CONSTE	0.15	0.15	Convective mixing height equation
CONSTN	2400	2400	Stable mixing height equation
CONSTW	0.16	0.16	Over water mixing height equation
FCORIO	1.0E-4	1.0E-04	Absolute value of Coriolis (1/s)
IAVEZI	1	1	Conduct spatial averaging
MNMDAV	1	1	Maximum search radius in averaging
HAFANG	30	30	Half-angle of upwind looking cone for averaging
ILEVZI	1	1	Layer of winds used in upwind averaging
IMIXH	1	1	Method to compute the convective mixing height
THRESHL	0	0	Threshold buoyancy flux required to sustain convective mixing height growth overland (W/m^3)
THRESHW	0.05	0.05	Threshold buoyancy flux required to sustain convective mixing height growth overwater (W/m^3)
IZICRLX	1	1	Flag to allow relaxation of convective mixing height to equilibrium value
TZICRLX	800	800	Relaxation time of convective mixing height to equilibrium value (s)
ITWPROG	0	2	Option for overwater lapse rates used in convective mixing height growth
ILUOC3D	16	16	Land use category ocean in 3D.DAT datasets
DPTMIN	0.001	0.001	Minimum potential temperature lapse rate in the stable layer above the current convective missing height (K/m)
DZZI	200	200	Depth of layer above current convective mixing height through which lapse rate is computed (m)
ZIMIN	50	50	Default minimum overland mixing height (m)
ZIMAX	3000	3000	Default maximum overland mixing height (m)
ZIMINW	50	50	Default minimum over-water mixing height (m)
ZIMAXW	3000	3000	Default maximum over-water mixing height (m)
ICOARE	10	10	COARE with no wave parameterization
DSHELF	0	0	Coastal/shallow water length scale
IWARM	0	0	COARE warm layer computation
ICOOL	0	0	COARE cool skin layer computation
IRHPROG	0	1	3D relative humidity from prognostic data
ITPROG	0	1	3D temperature from surface stations
IRAD	1	1	Default interpolation type

Parameter	Default	Project	Comments
TRADKM	500	500	Default radius of influence for temperature interpolation (km)
NUMTS	5	5	Surface observations not used
IAVET	1	1	Conduct spatial averaging of temperatures
TGDEFB	-.0098	-.0098	Default temperature gradient below the mixing height over water (K/m)
TGDEFA	-.0045	-.0045	Default temperature gradient above the mixing height over water (K/m)
JWAT1	-	99	No over water temperature interpolation used
JWAT2	-	99	No over water temperature interpolation used
NFLAGP	2	2	Method of interpolation
SIGMAP	100	100	Radius of Influence (km)
CUTP	0.01	0.01	Default minimum precipitation rate cut-off (mm/hr)

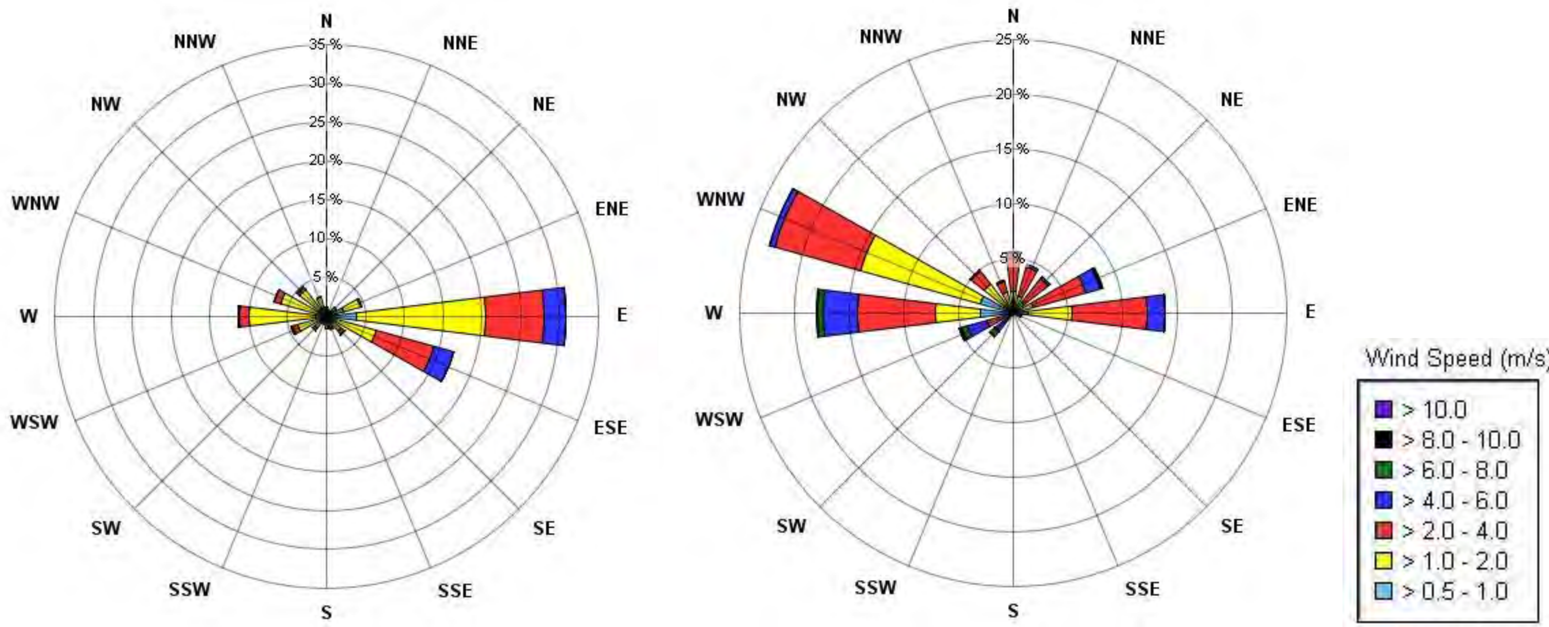
B.3 CALMET RESULTS

The CALMET model was assessed by reviewing various model outputs and, where possible, comparing to observations. These outputs include: surface wind roses for various monitoring locations, CALMET-derived stabilities and mixing heights and domain wind vector plots under various stability and flow regimes.

B.3.1 Surface Winds

The combined frequency distribution of wind speed and direction as observed and as modelled by CALMET at the Vernon Auto station are shown as wind roses in Figure B.1.

Observed and modelled surface wind roses show similar general patterns at Vernon Auto. The CALMET results show similar speed distributions to the observations and the predominant wind patterns for both are mostly east west. The CALMET model wind westerlies are slightly rotated to the north compared to the station and there is less of an easterly component that is seen in the observations. As with any station data, there is some possibly of local influences at station, and due to the CALMET gridding the grid center location at which the model wind field is calculated is not exactly the same as the station location, so some differences between model and observations are expected. Overall it seems that CALMET/WRF is capturing general patterns and the interpolations and terrain corrections conducted in the model likely mean the derived wind fields may be more indicative of the valley average.



Calms: 3.50%

Observed

Calms: 4.50%

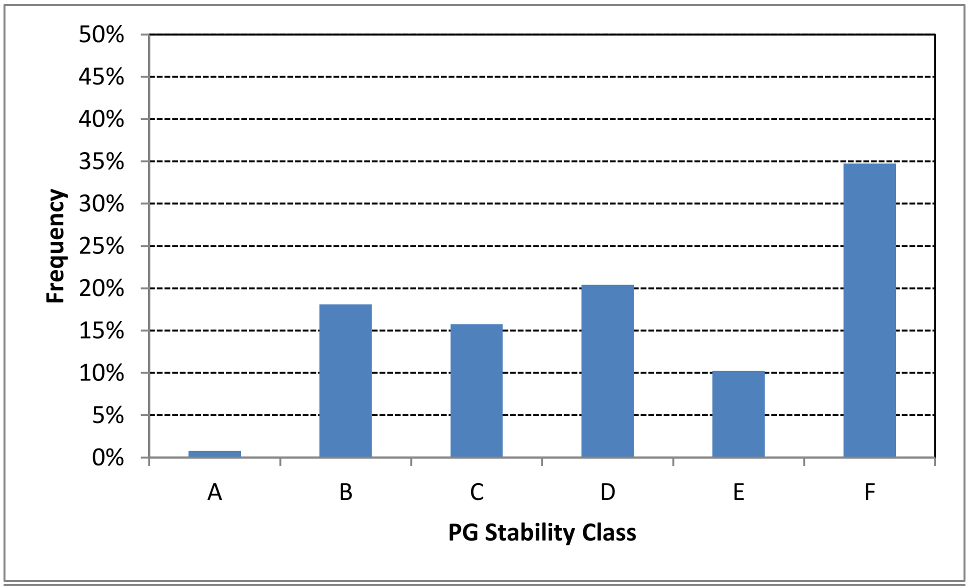
Modelled (CALMET/WRF)

Figure B.1: Observed and Modelled Wind Roses at Vernon Auto

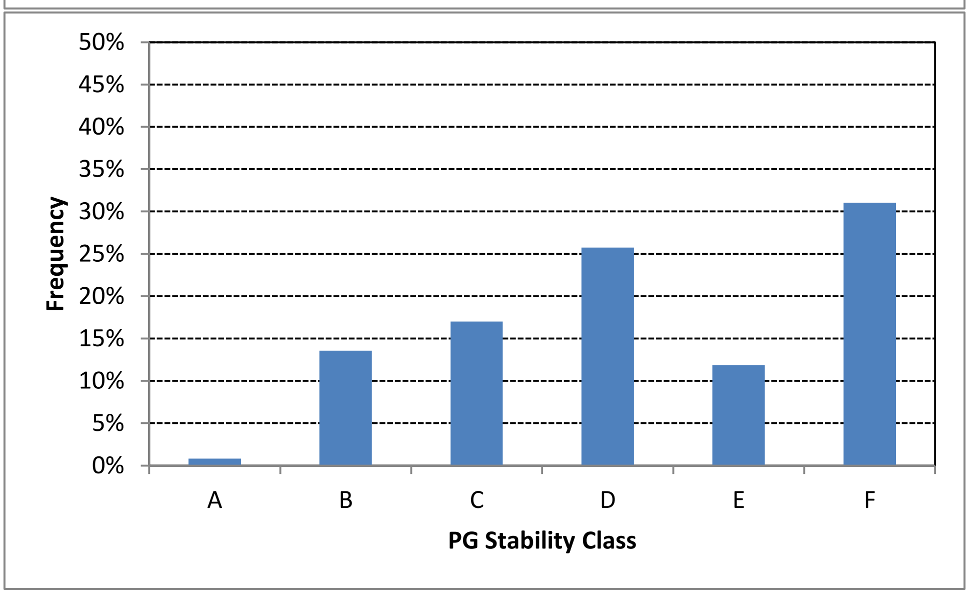
B.3.2 Pasquill-Gifford Stability Class

In CALMET, the Pasquill-Gifford (PG) stability scheme is used to classify atmospheric stratification in the boundary layer over land. These classes range from unstable (Classes A, B and C), through neutral (Class D) to stable (Classes E and F). Normally, unstable conditions are associated with daytime, ground-level heating, which results in thermal turbulence activity in the boundary layer. Stable conditions are primarily associated with night-time cooling, which results in the suppression of the turbulence levels and temperature inversion at lower levels. Neutral conditions are mostly associated with high wind speeds or overcast sky conditions. Though, according to the BC Guideline, PG Class is not directly used to calculate dispersion coefficients, the CALMET derived stability class is still useful parameter for assessing the ability of the model to capture low level turbulent dispersion.

The frequency distributions of CALMET-derived PG stability classes for Vernon Auto are shown in Figure B.2. For this location, the most frequent stability class is Class F or stable. This is a result of the large percentages of lower wind speeds seen in the wind roses shown above, as well as the frequency of overcast sky conditions particularly in winter. The next highest category is D, which are neutral conditions associated with higher winds speeds occurring throughout the year. Relatively high frequencies of B and C are associated with clear sky stable conditions in summer.



Vernon Auto

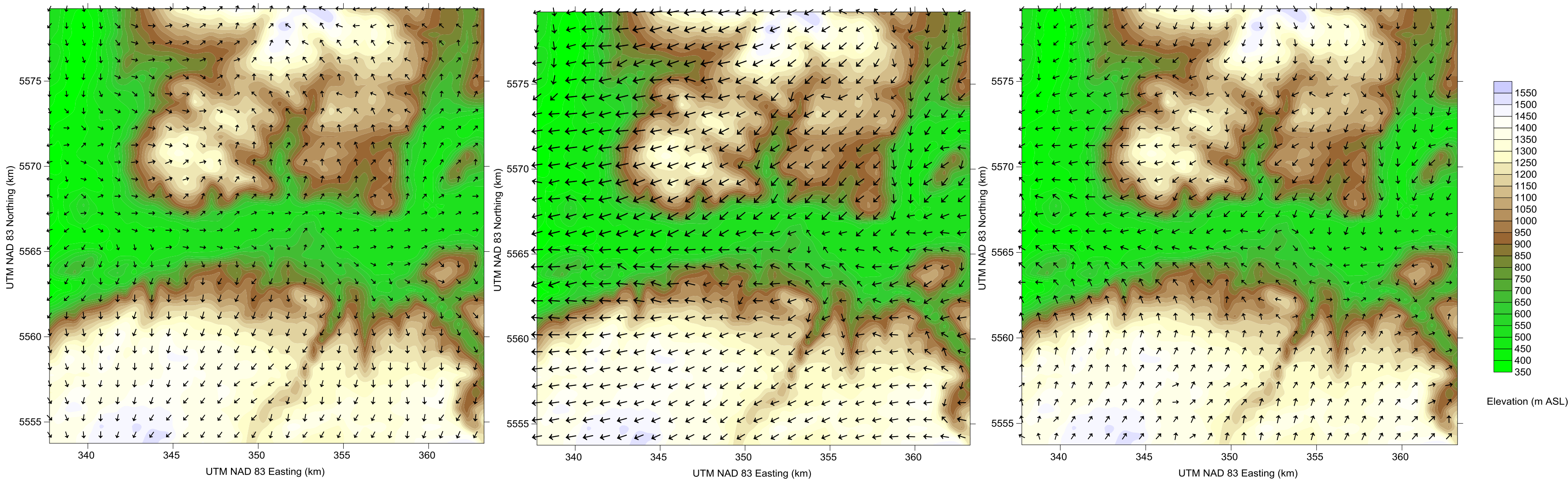


Pinnacle Facility

Figure B.2: Frequency of Modelled Pasquill-Gifford Stability Classes

B.3.3 Modelled Wind Fields

A common approach used to evaluate a meteorological model's ability to replicate wind flow patterns is through the use of wind field plots. Wind fields plots representing unstable, neutral, and stable conditions for the study area are illustrated in Figure B.3 to provide an overview of how CALMET performed under different conditions. In general, CALMET-derived wind fields follow the expected terrain flows under various stability and flow regimes, flowing up slope during unstable, daytime conditions and down slope during stable, night-time conditions. Under neutral conditions, the characteristic high wind speeds result in less noticeable terrain effects and wind fields are fairly uniform across the model domain.



Unstable — May 23, 2011 15:00

Neutral — February 24, 2011 3:00

Stable — January 2, 2011 2:00

Arrow lengths show relative wind speed from 0 to 12 m/s.

Figure B.3: Modelled wind fields at 10 m above ground level during unstable, neutral, and stable conditions

B.3.4 Mixing Heights

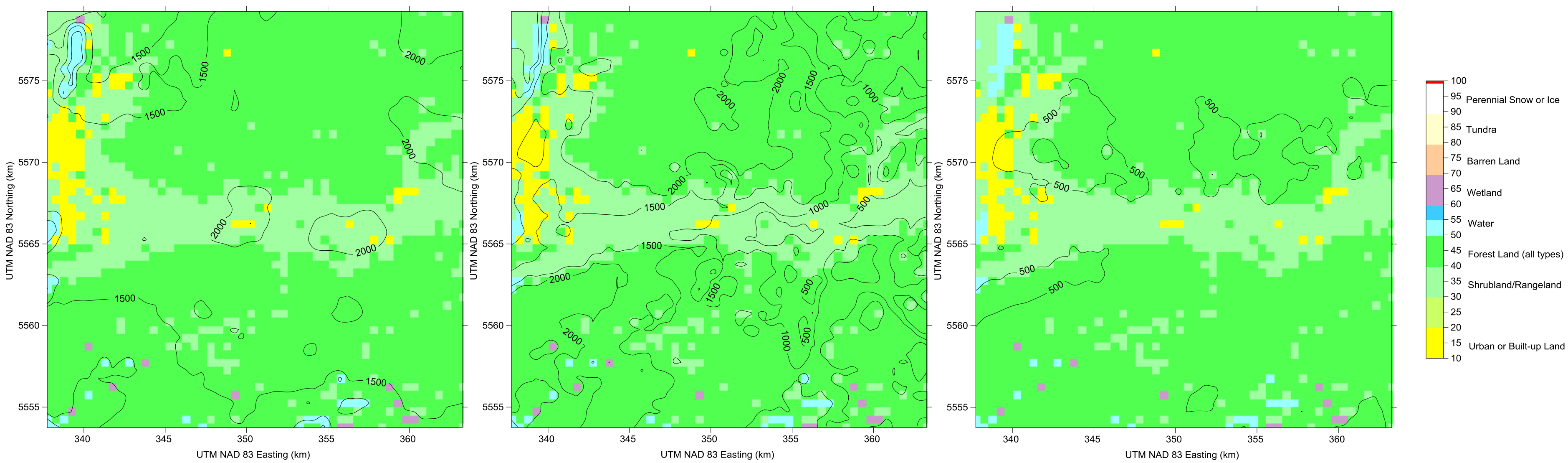
Mixing heights are estimated in CALMET through methods that are based on either surface heat flux (thermal turbulence) and vertical temperature profiles, or friction velocities (mechanical turbulence). Table B.7 shows the average modelled mixing heights by Pasquill-Gifford stability class. Overall, the highest mixing heights are associated with unstable conditions (Classes A, B and C), while the lowest mixing heights are associated with stable conditions (Classes E and F).

The spatial distribution of mixing heights under unstable, neutral, and stable conditions is shown in Figure B.4. Spatial changes in mixing height align with changes in the land use. Mixing height tends to be lowest over water and increases with distance more quickly in areas where surface roughness is greater (i.e., where surface elements are larger).

Diurnal variations in mixing heights at are shown in Figure B.5, respectively for a typical summer day (August 3) and a typical winter day (December 19 or January 2). Mixing heights tend to increase during the day and decrease during the night, although daytime mixing heights may be suppressed during stable winter conditions due to weak solar insolation, high reflectivity of snow covered surfaces, low wind speeds and synoptic subsidence.

Table B.8: Average modelled mixing height by Pasquill-Gifford Stability Class (in m)

Location	A	B	C	D	E	F
Vernon Auto	1,306	1,083	805	646	300	100
Pinnacle	1,191	1,045	965	826	673	211



Unstable

May 23, 2011 15:00

Neutral

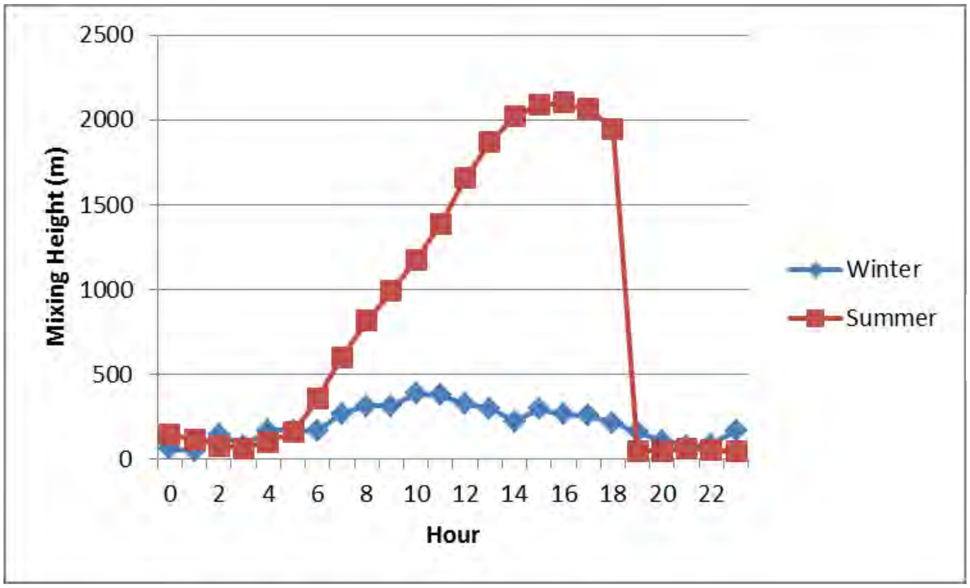
February 24, 2011 3:00

Stable

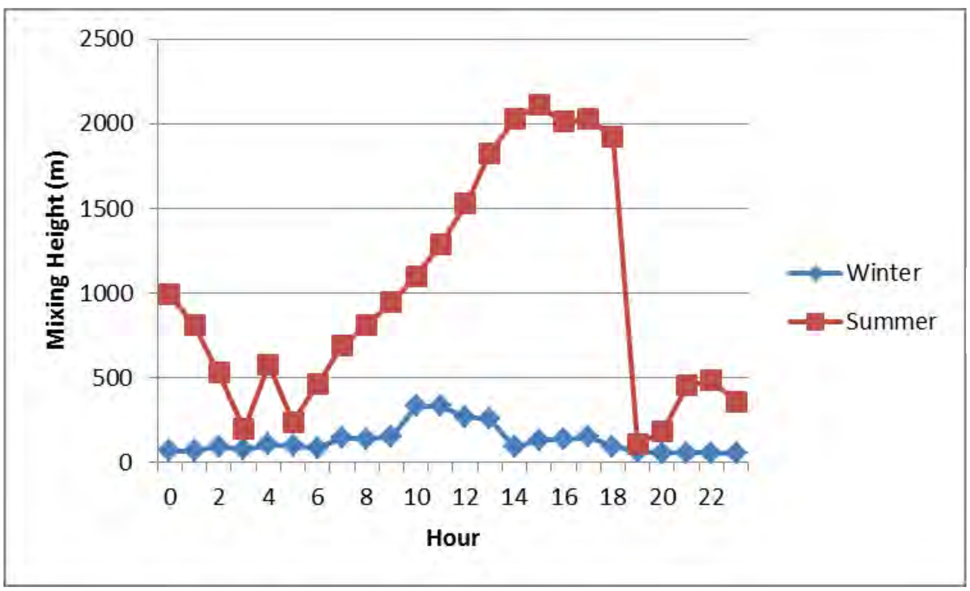
January 2, 2011 2:00

Contour intervals are 500 m.

Figure B.4: Modelled mixing heights (contour lines, labels in metres) overlaid on top of land cover characterization during unstable, neutral, and stable atmospheric conditions.



Vernon Auto



Pinnacle

Figure B.5: Diurnal variation of modelled mixing heights

B.4 CALPUFF INPUTS

All technical options relating to the CALPUFF dispersion model were set according to the *Guidelines for Air Quality Dispersion Modelling in BC* (BC MOE 2008) or to model defaults. These include parameters and options such as the calculation of plume dispersion coefficients, the plume path coefficients used for terrain adjustments, exponents for the wind speed profile, and wind speed categories. A list of the technical options is shown in Table B.9:.

Table B.9: CALPUFF model switch settings

Parameter	Default	Project	Comments
MGAUSS	1	1	Gaussian distribution used in near field
MCTADJ	3	3	Partial plume path adjustment
MCTSG	0	0	Sub-grid scale complex terrain not modelled
MSLUG	0	0	Near-field puffs not modelled as elongated
MTRANS	1	0	Final rise modelled
MTIP	1	1	Stack tip downwash used
MBDW	1	2	PRIME method used as recommended by guidelines
MSHEAR	0	0	Vertical wind shear not modelled
MSPLIT	0	0	Puffs are not split
MCHEM	1	0	Chemical transformation not modelled
MAQCHEM	0	0	Aqueous phase transformation not modelled
MWET	1	0	Wet removal not modelled
MDRY	1	0	Dry deposition not modelled
MTILT	0	0	Gravitational settling not modelled
MDISP	3	2	Near-field dispersion coefficients internally calculated from sigma-v, sigma-w using micrometeorological variables as recommended by guidelines
MTURBVW	3	0	Not used since MDISP = 2
MDISP2	3	2	Not used since MDISP = 2
MCTURB	1	1	Not used to compute turbulence sigma-v & sigma-w when MDISP = 3

Parameter	Default	Project	Comments
MROUGH	0	0	PG sigma-y, sigma-z not adjusted for roughness
MPARTL	1	1	Partial plume penetration of elevated inversion
MTINV	0	0	Strength of temperature inversion computed from default gradients
MPDF	0	1	PDF not used for dispersion under convective conditions as recommended for MDISP = 3
MSGTIBL	0	0	Sub-grid TIBL module not used for shoreline
MBCON	0	0	Boundary concentration conditions not modelled
MSOURCE	0	0	Individual source contributions not saved
MFOG	0	0	Do not configure for FOG model output
MREG	1	0	Do not test options specified to see if they conform to United States Environmental Protection Agency regulatory values

B.5 REFERENCES

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

Oke, T.R. 1987. *Boundary Layer Climates*. 2nd edition. London, UK: Routledge

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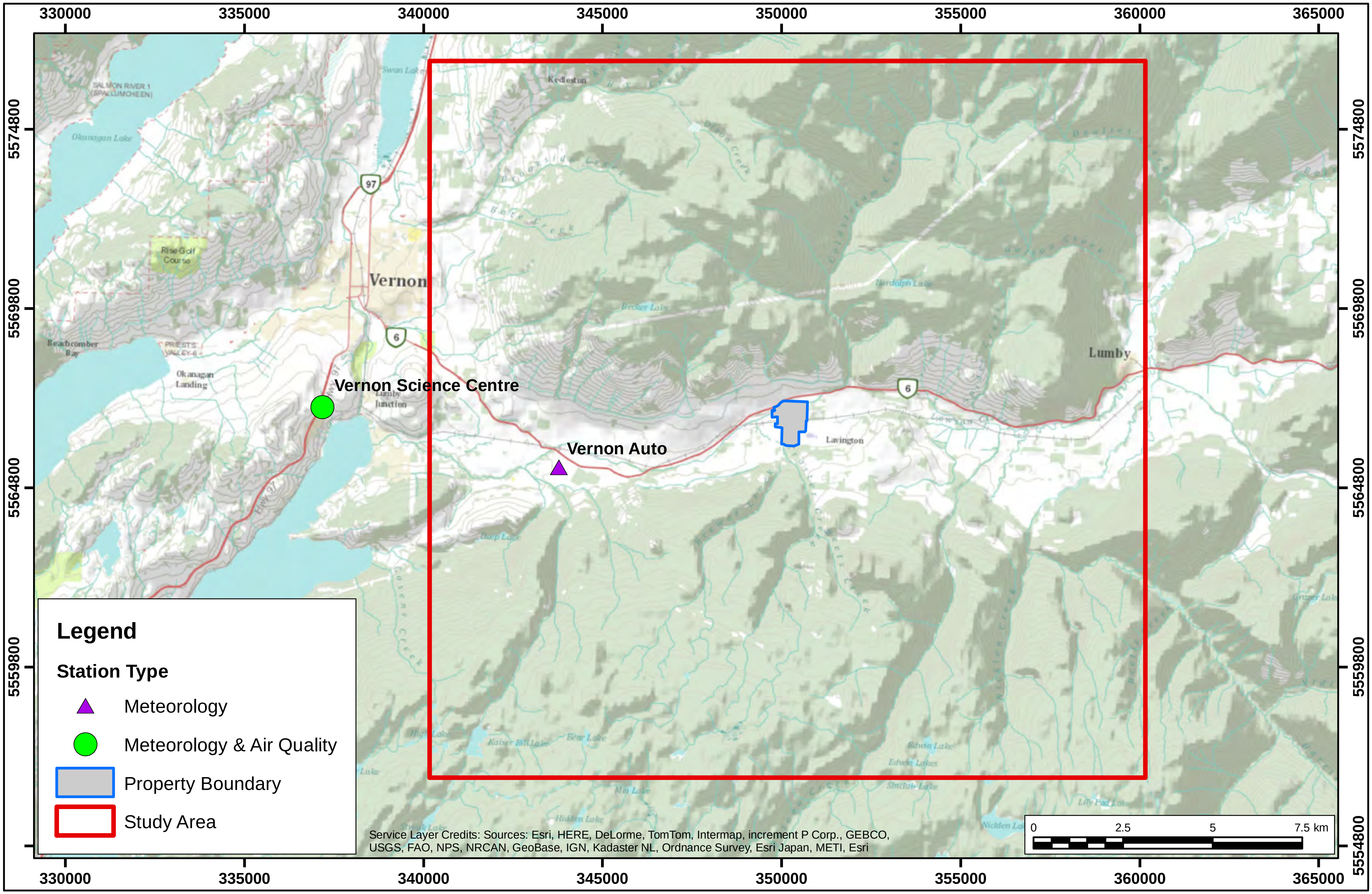
Zhang, L., Moran, M.D., Makar, P.A., Brook, J.R., and Gong, S. 2002. *Modelling gaseous dry deposition in AURAMS: a unified regional air-quality modelling system*. Atmospheric Environment 36: 537-560.

Zhang, L., Brook, J.R., and Vet, R. 2003. *A revised parameterization of gaseous dry deposition in air-quality models*. Atmospheric Chemistry and Physics 3: 2067-2082.

APPENDIX C
Figures



Locations of Meteorological and Air Quality Stations within the Study Area

Map Projection: NAD83 UTM 11N.

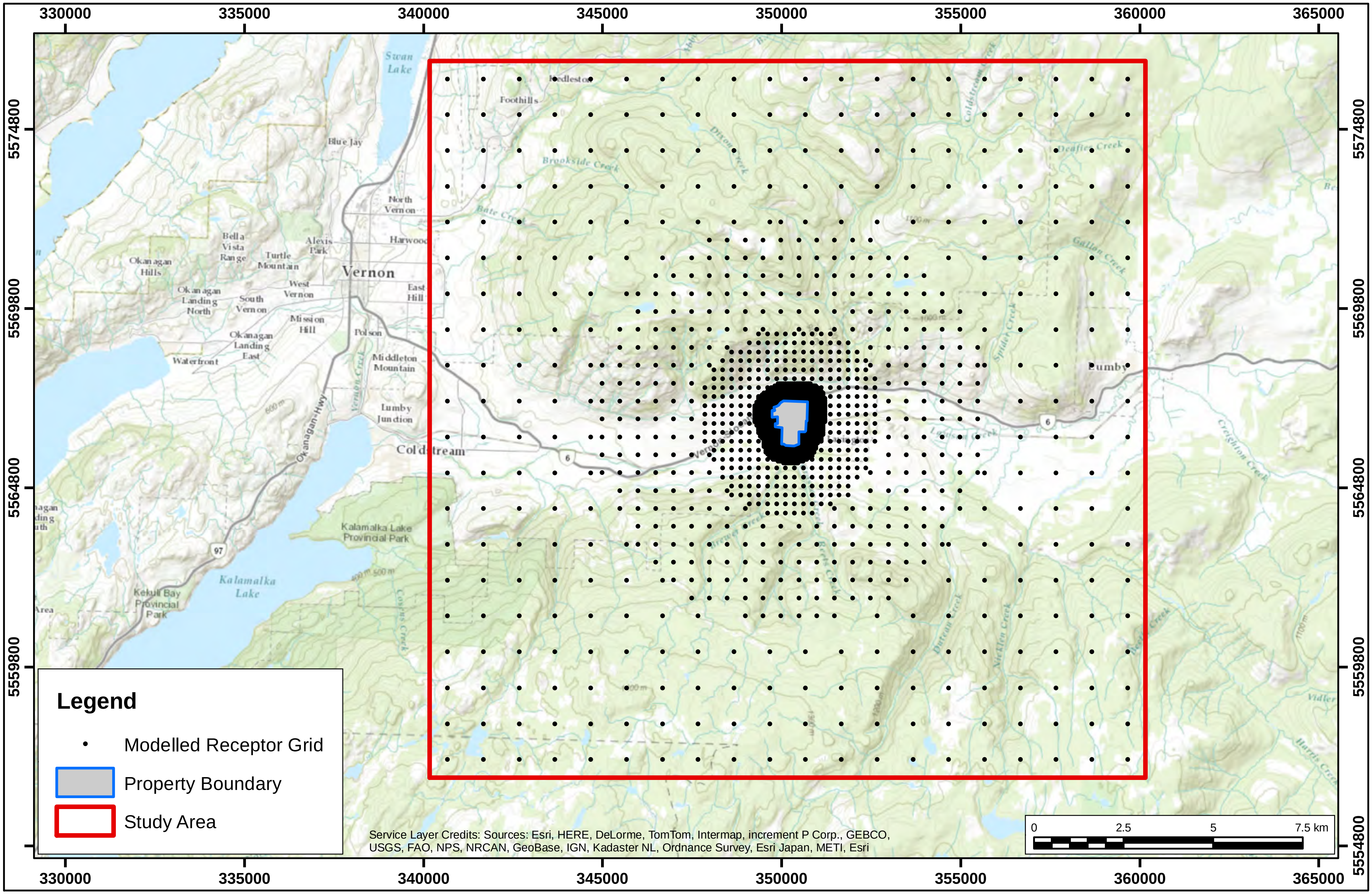
Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by:	NBN	Fig:	2.1
Approx. Scale:	1:150,000		
Date Revised:	Nov. 26, 2014		

RWDI



Modelled Receptor Grid

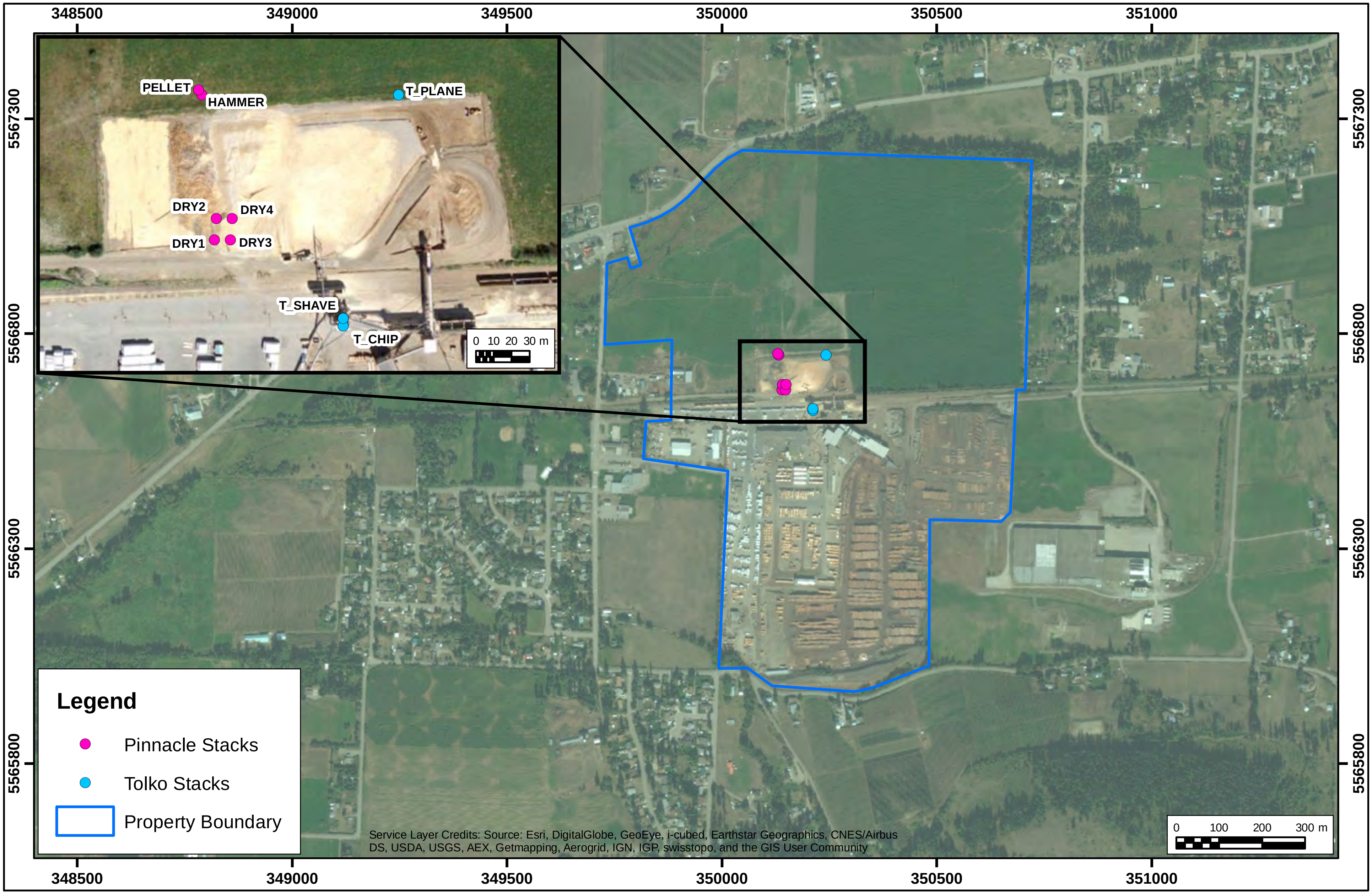
Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by:	NBN	Fig:	2.2
Approx. Scale:	1:150,000		
Date Revised:	Dec. 9, 2014		



Source Locations

Map Projection: NAD83 UTM 11N.

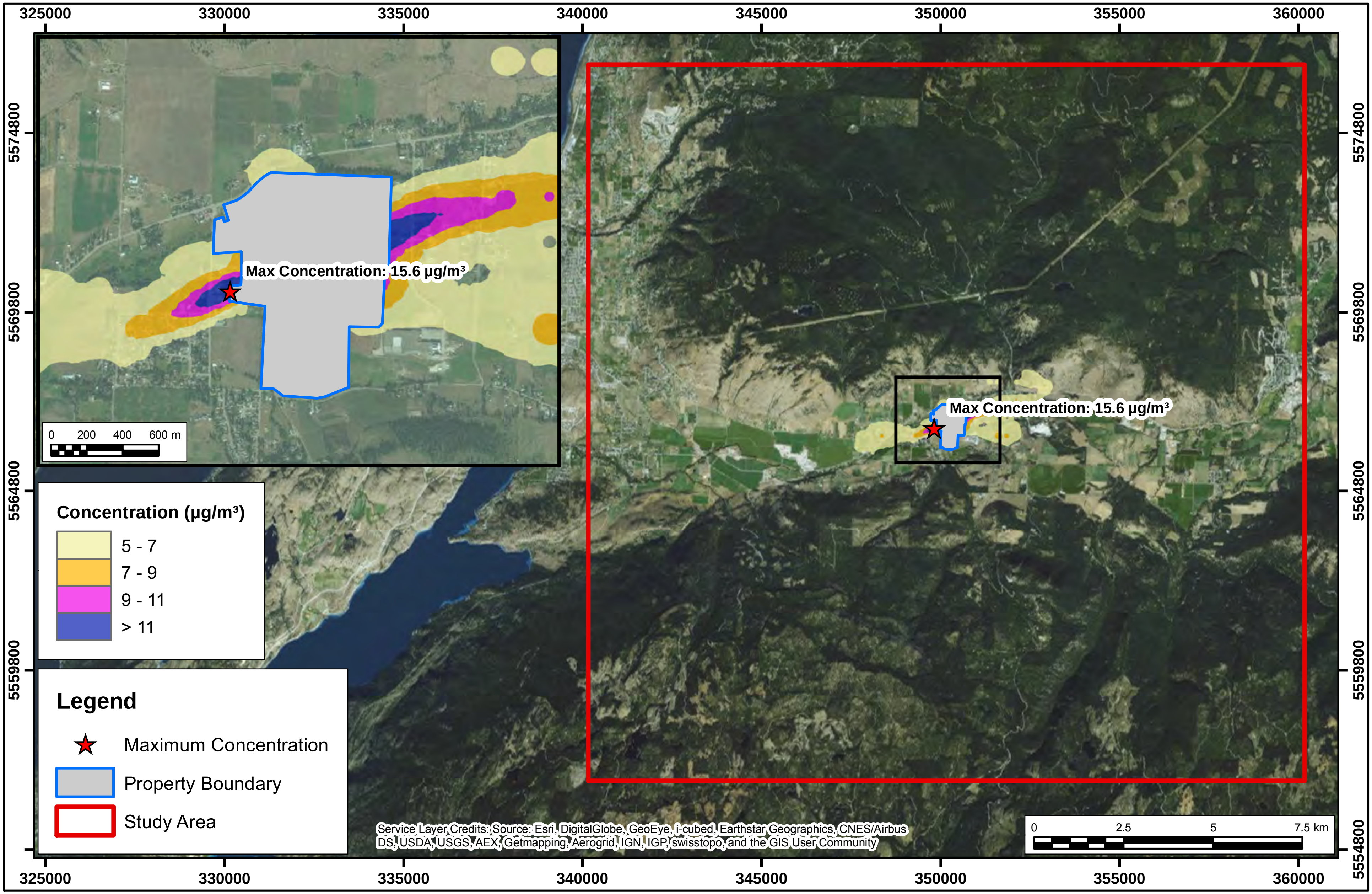
Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by: NBN	Fig: 2.3
Approx. Scale:	1:12,500
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted 24-hour Average PM_{10} Concentration with no Background

Pinnacle Facility

24-hr PM_{10} BC AQ Objective = 50 µg/m³.

Map Projection: NAD83 UTM 11N.

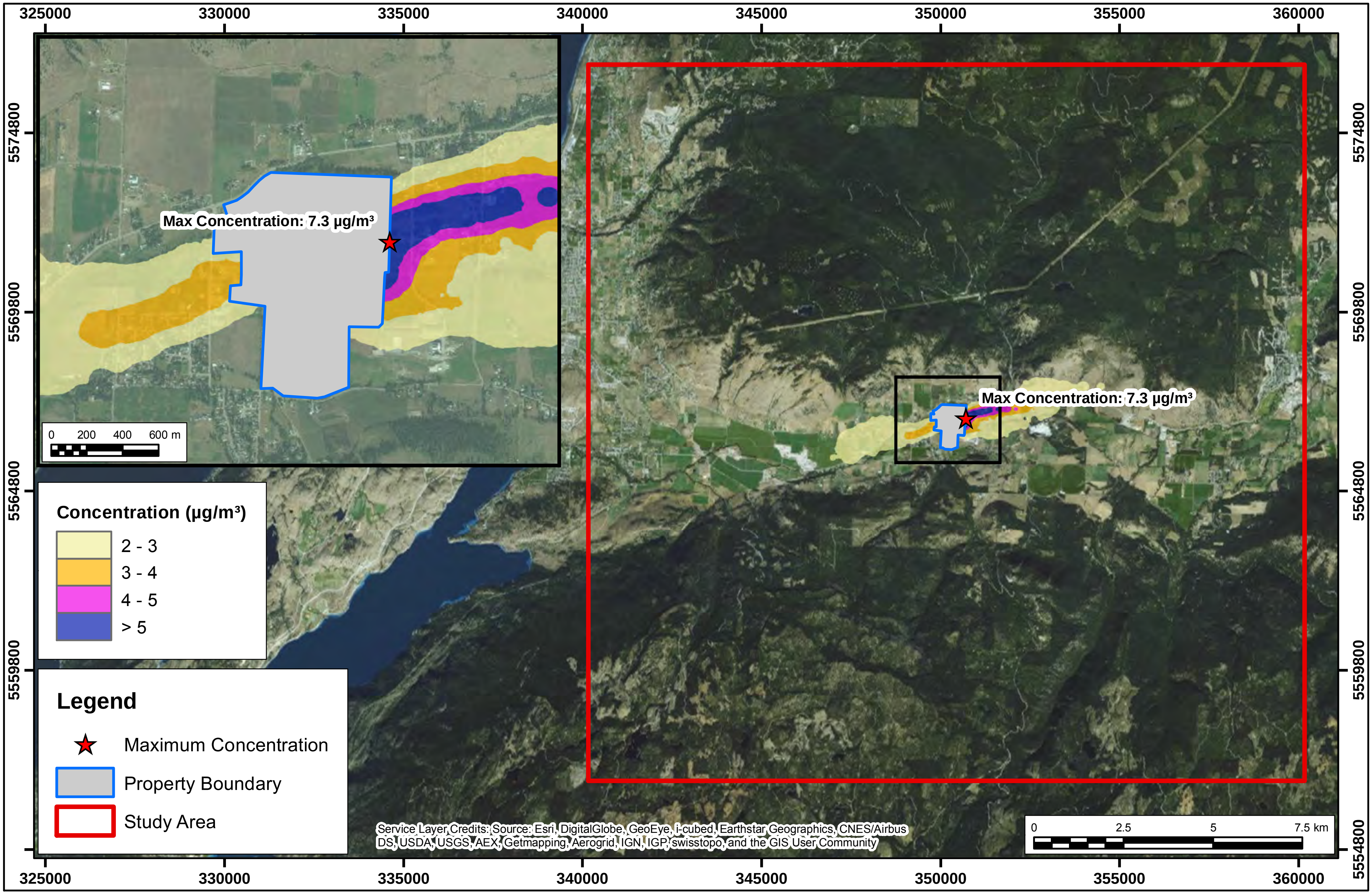
Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by: NBN	Fig: 4.1
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted 24-hour Average $PM_{2.5}$ Concentration with no Background

Pinnacle Facility

Map Projection: NAD83 UTM 11N.

24-hr $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 28 µg/m³;
BC AQ Objective: Level A = 25 µg/m³.

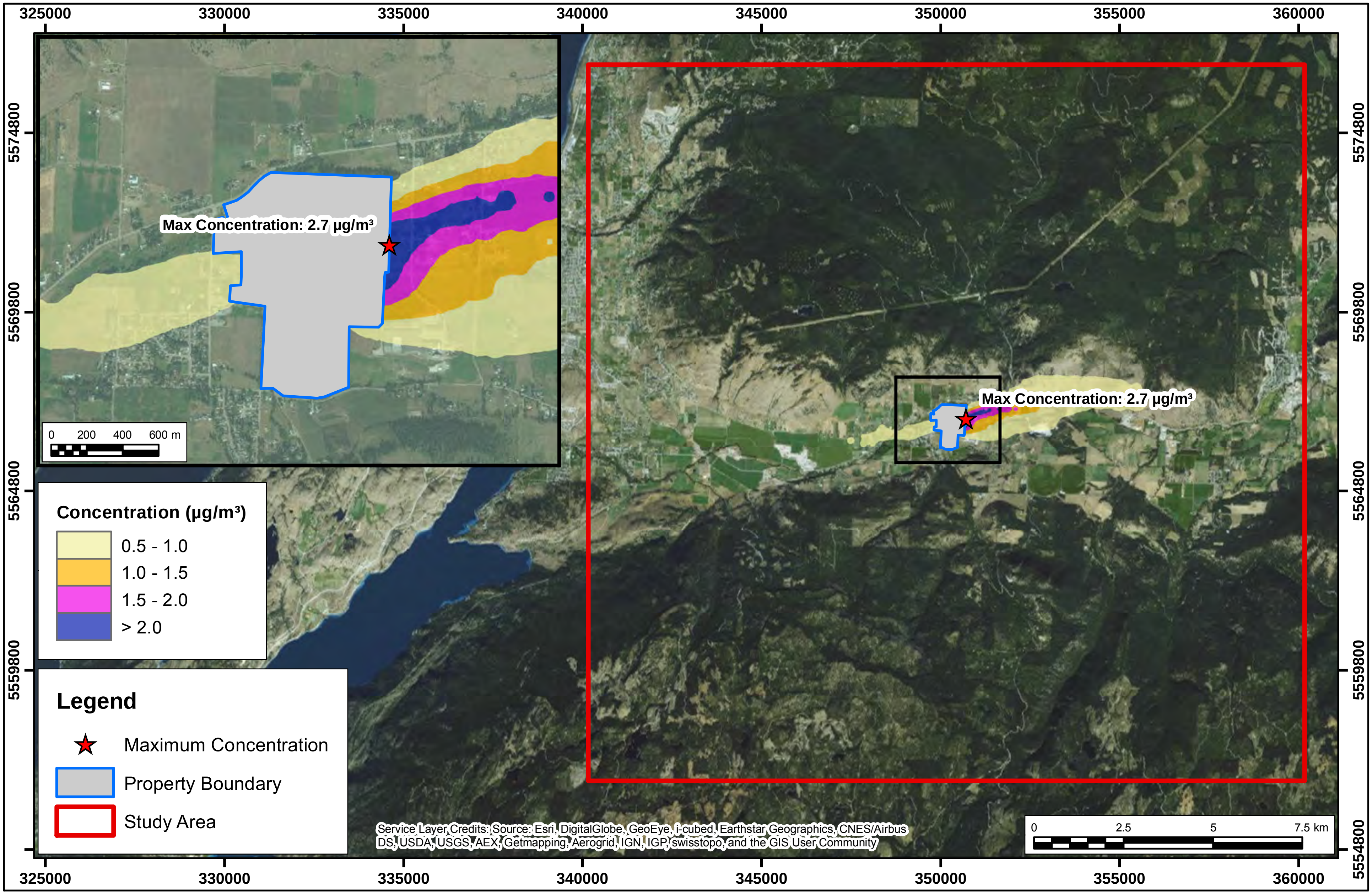
Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by:	NBN	Fig:	4.2
Approx. Scale:	1:150,000		
Date Revised:	Dec. 9, 2014		

RWDI



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Pinnacle Facility

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

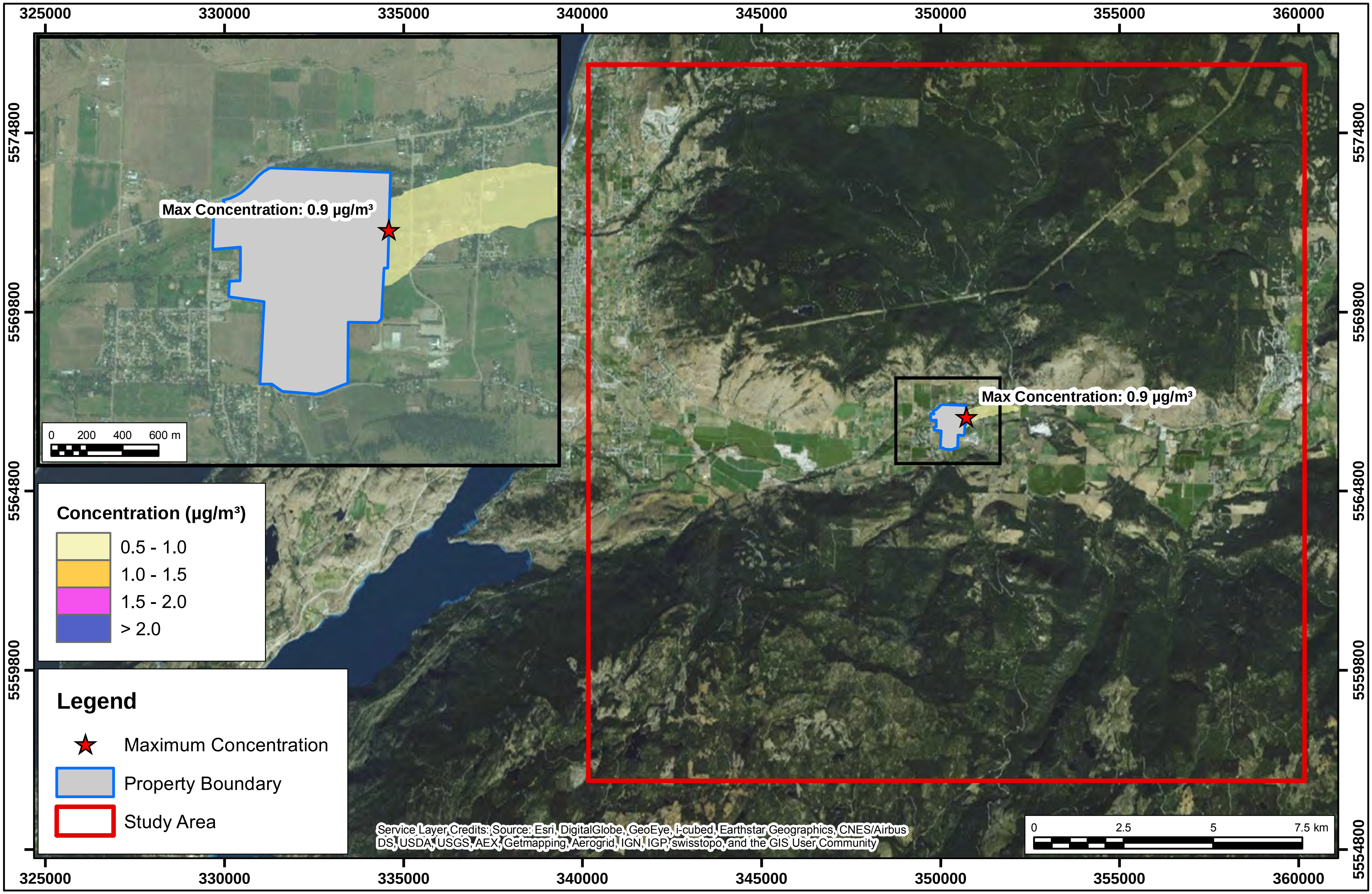
Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by: NBN	Fig: 4.3
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Pinnacle Pelletmill and Hammermill with Baghouses

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

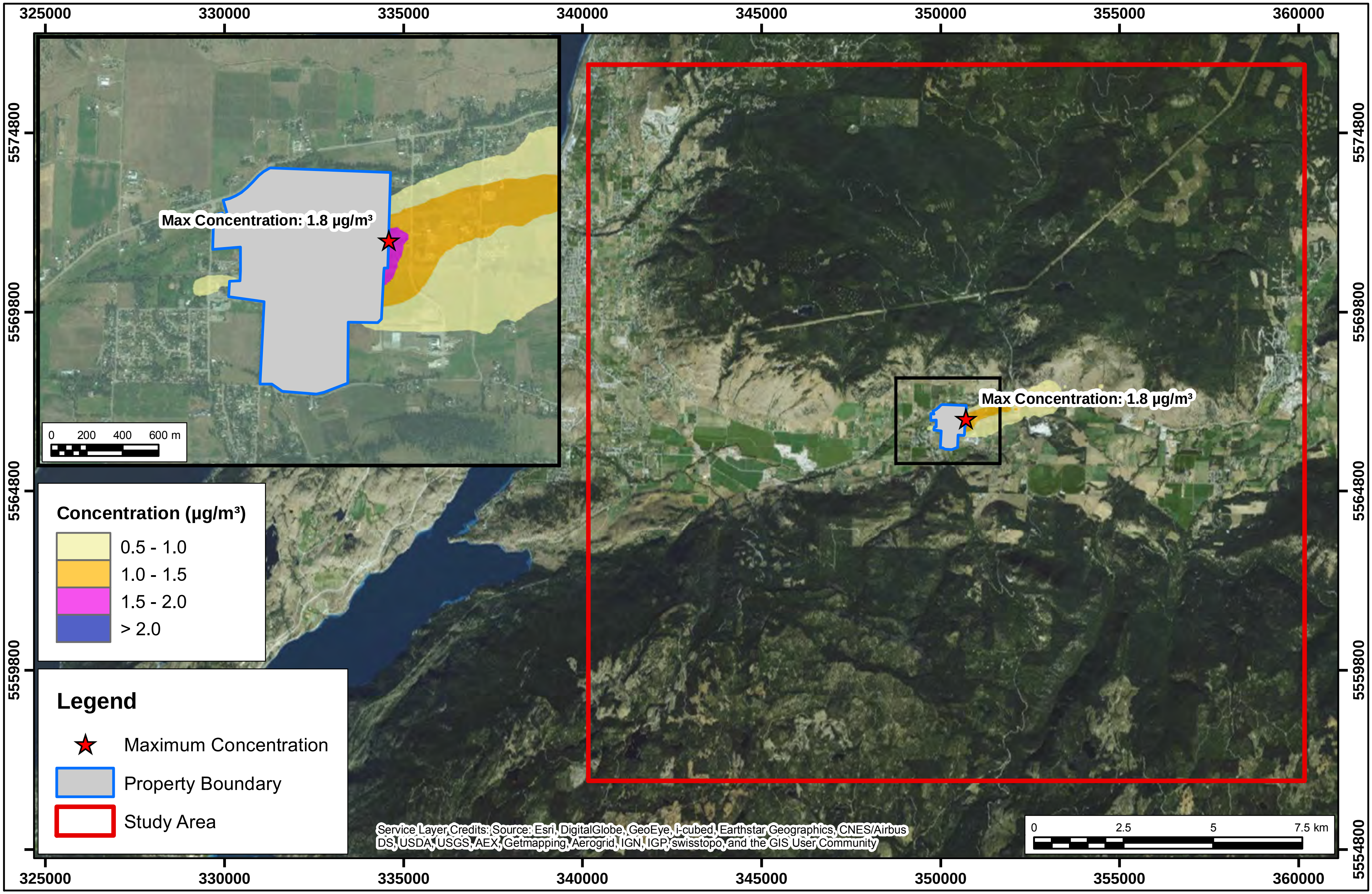
Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by: NBN	Fig: 4.3a
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Pinnacle Dryers

Map Projection: NAD83 UTM 11N.

Annual $PM_{2.5}$ Canadian Ambient
AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

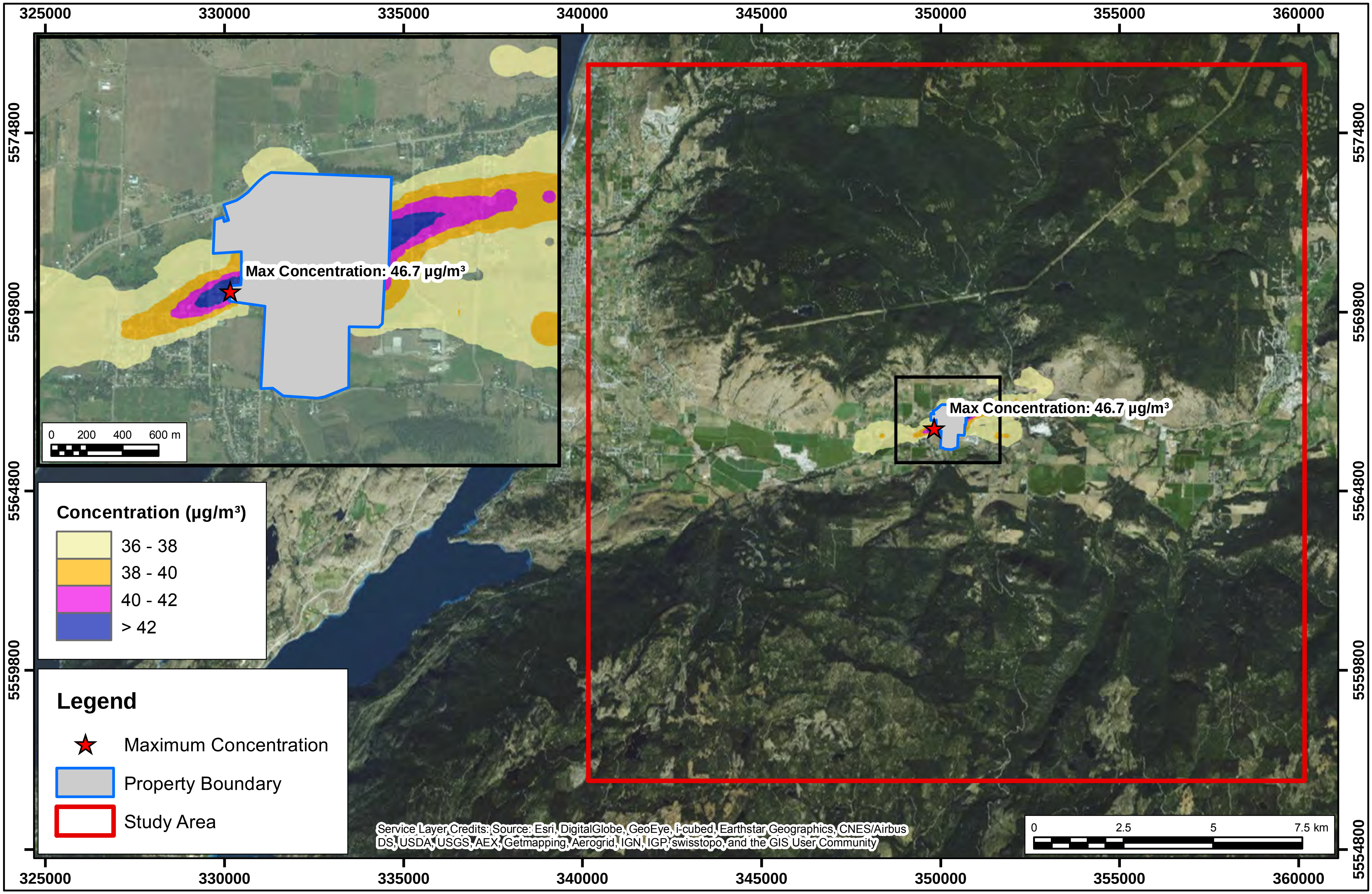
Pinnacle Renewable Energy Inc., Lavington, B.C.

True North

Project #1400749

Drawn by:	NBN	Fig:	4.3b
Approx. Scale:			1:150,000
Date Revised:			Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted 24-hour Average PM_{10} Concentration Including Background

Pinnacle Facility

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

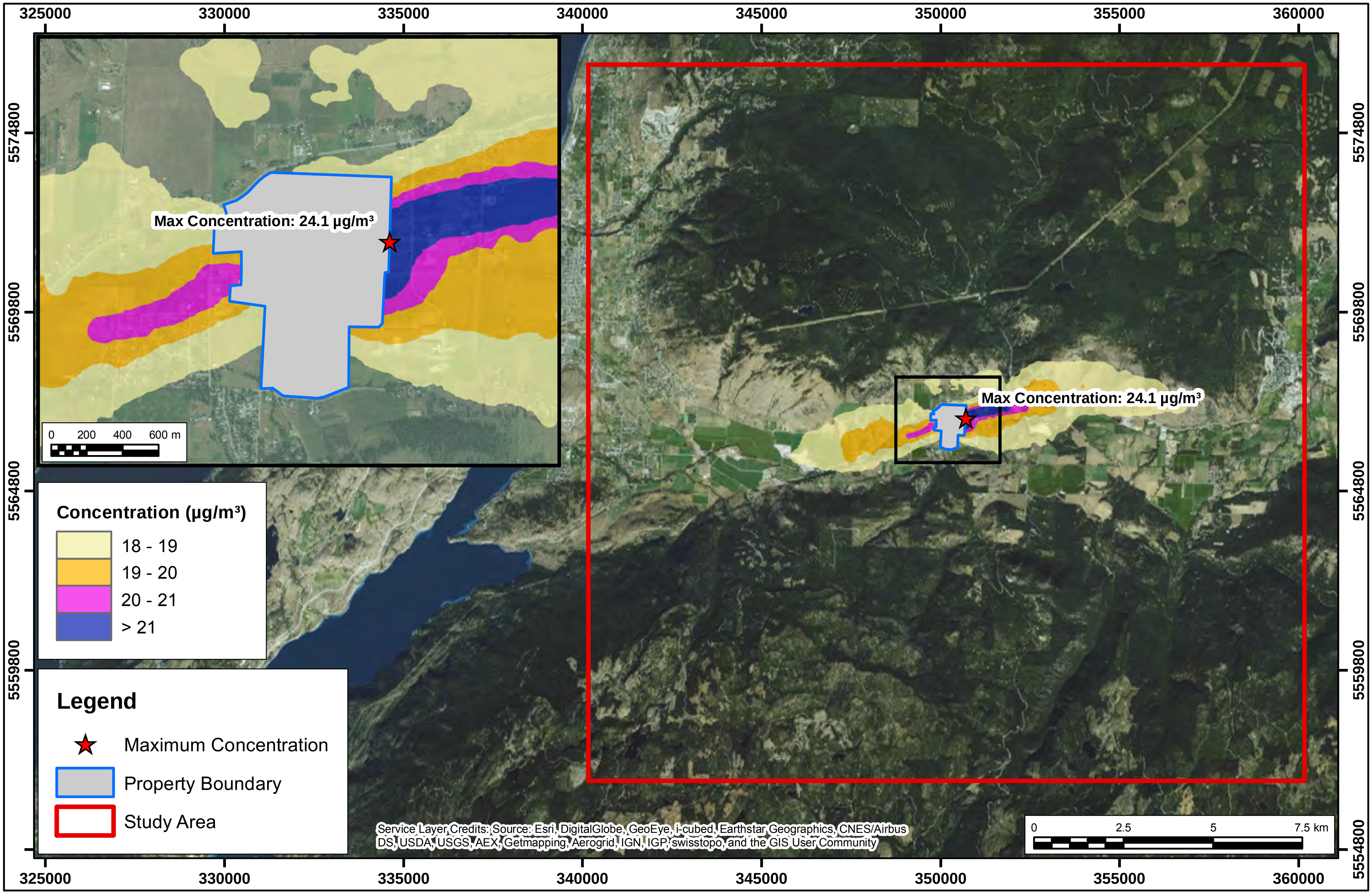
24-hr PM_{10} BC AQ Objective = 50 µg/m³.
Ministry of Environment background value of 31.1 µg/m³.

True North

Project #1400749

Drawn by:	NBN	Fig:	4.4
Approx. Scale:			1:150,000
Date Revised:			Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted 24-hour Average $PM_{2.5}$ Concentration Including Background

Pinnacle Facility

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

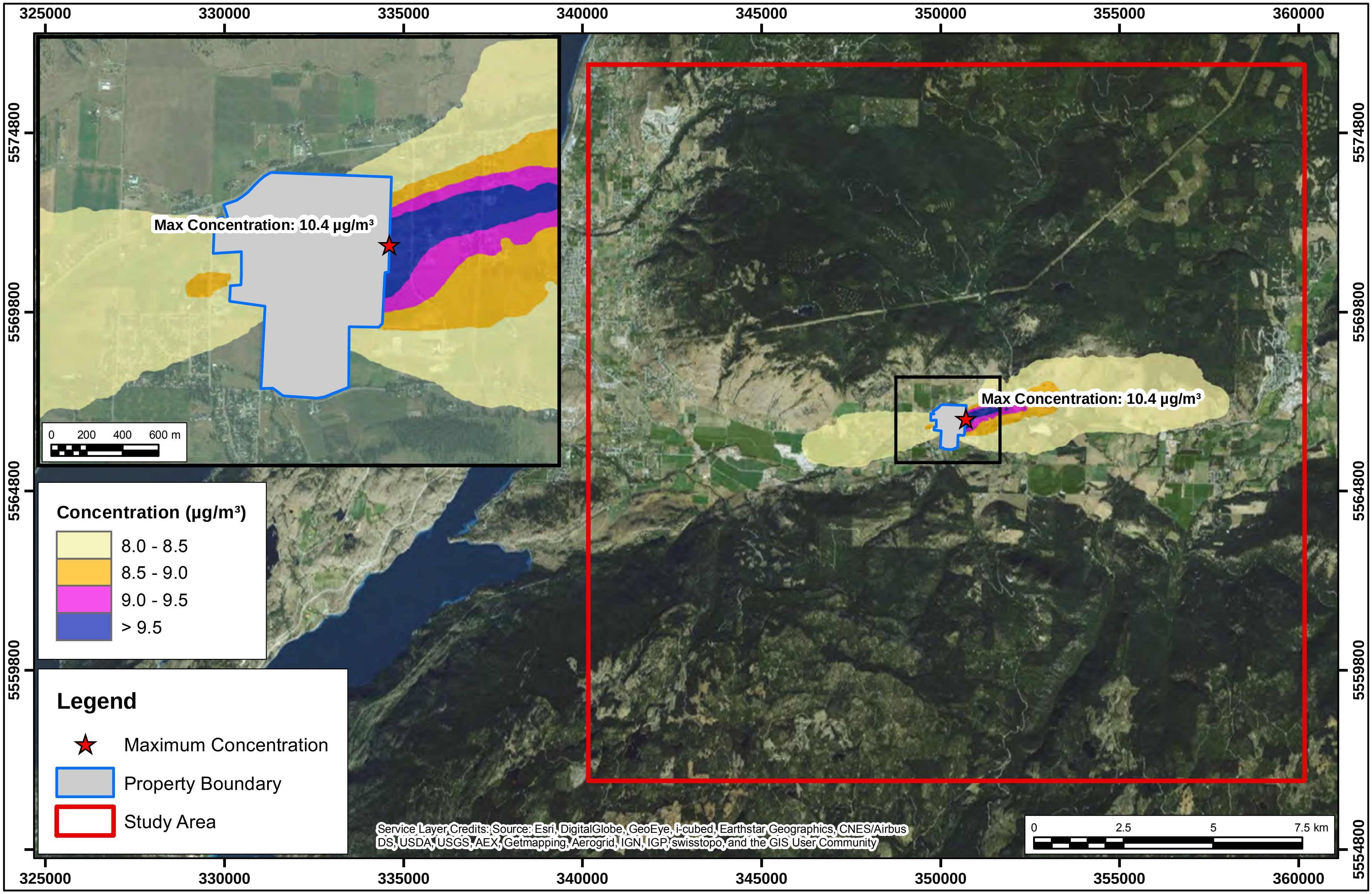
24-hr $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 28 µg/m³.
BC AQ Objective: Level A = 25 µg/m³.
Ministry of Environment background value of 16.8 µg/m³.

True North

Project #1400749

Drawn by: NBN	Fig: 4.5
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration Including Background

Pinnacle Facility

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

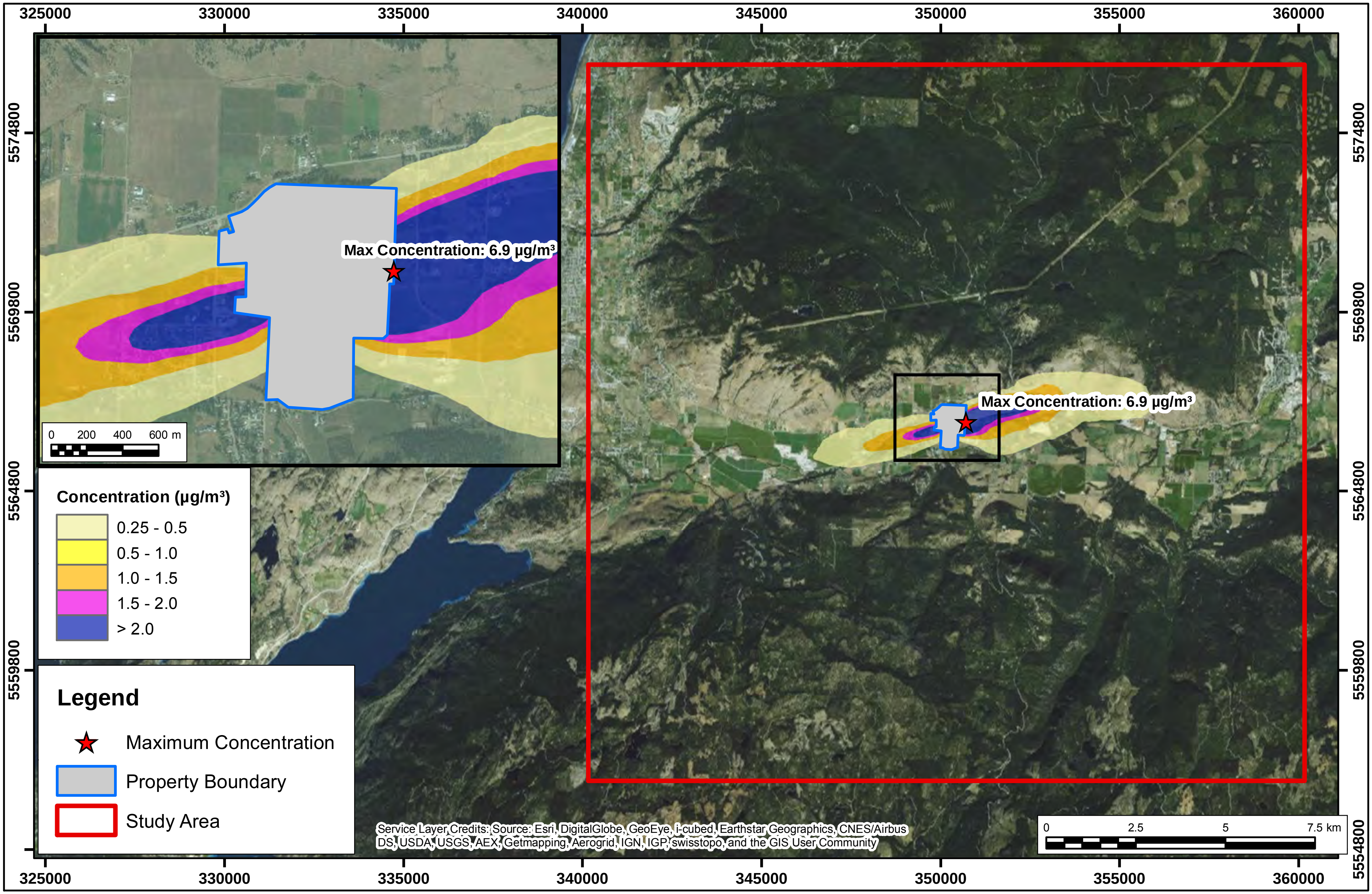
Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.
Ministry of Environment background value of 7.75 µg/m³.

True North

Project #1400749

Drawn by: NBN	Fig: 4.6
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014

RWDI



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Tolko Current Emission Scenario

Map Projection: NAD83 UTM 11N.

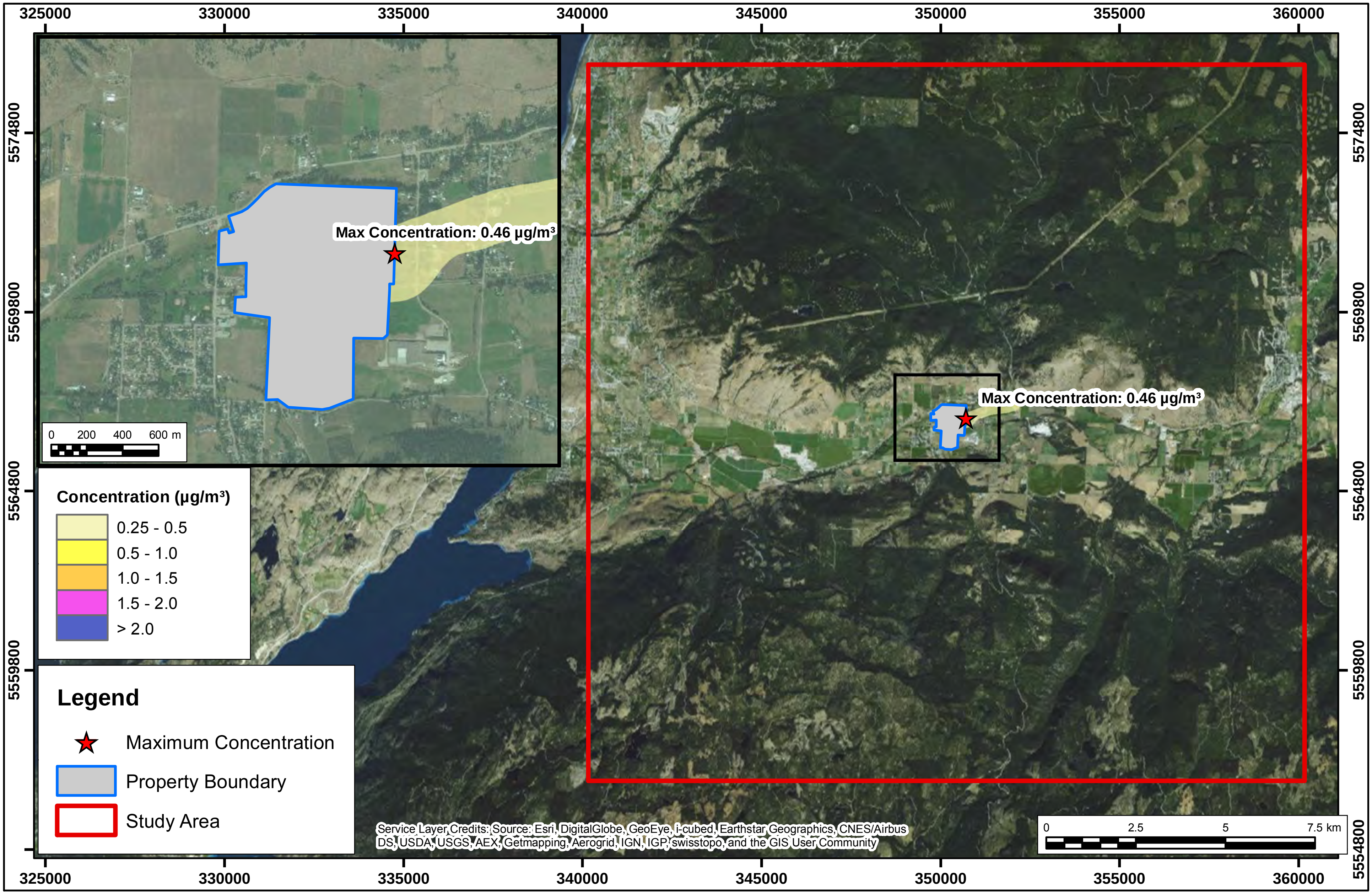
Pinnacle Renewable Energy Inc., Lavington, B.C.

Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by: JFV	Fig: 5.1
Approx. Scale:	1:150,000
Date Revised:	Nov. 28, 2014



Isopleth of Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Tolko Proposed Baghouse Emission Scenario

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

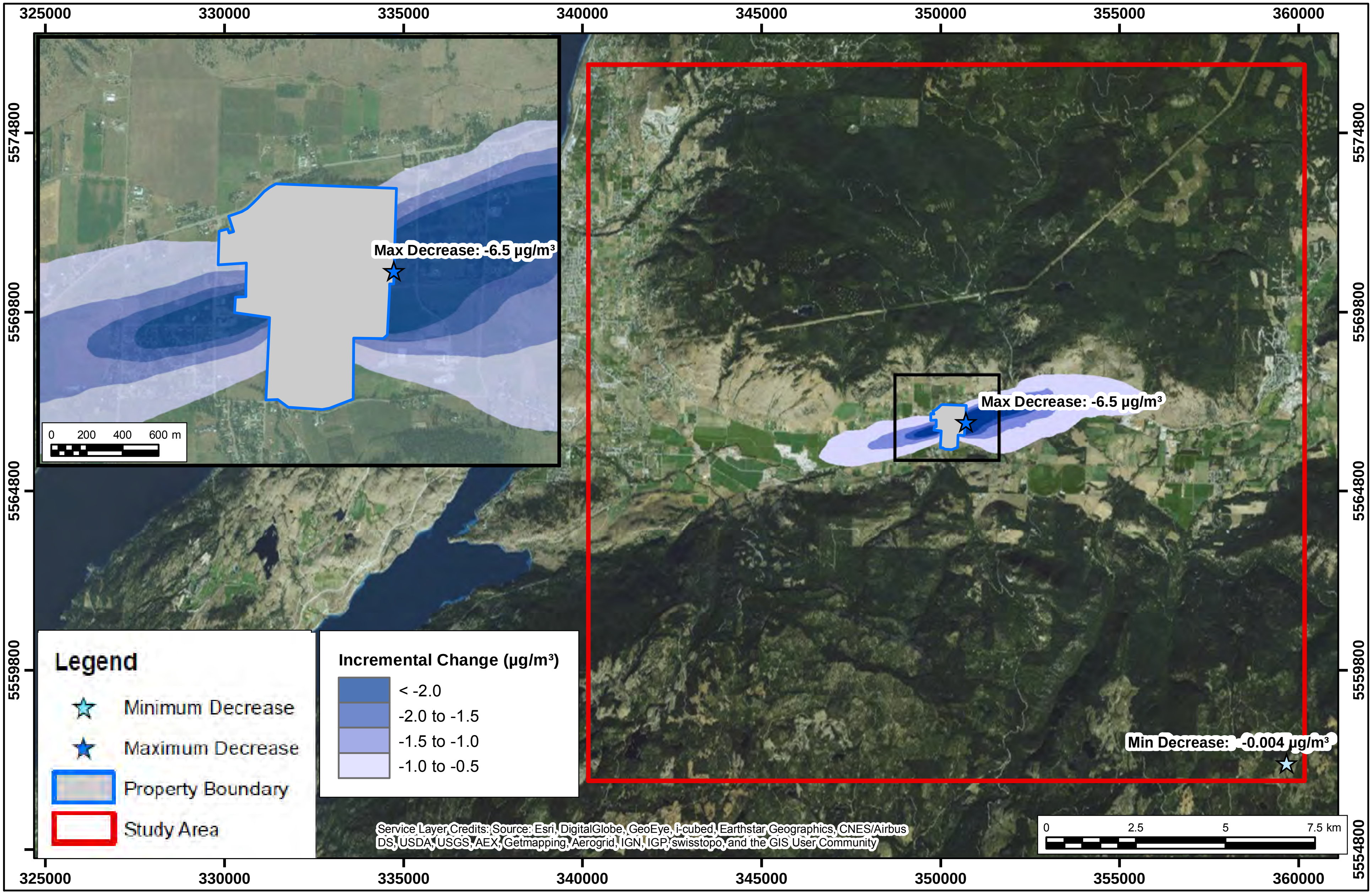
Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by: JFV	Fig: 5.2
Approx. Scale:	1:150,000
Date Revised:	Nov. 28, 2014

RWDI



Incremental Change in Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Tolko Proposed Baghouse Scenario - Tolko Current Emission Scenario

Map Projection: NAD83 UTM 11N.

Pinnacle Renewable Energy Inc., Lavington, B.C.

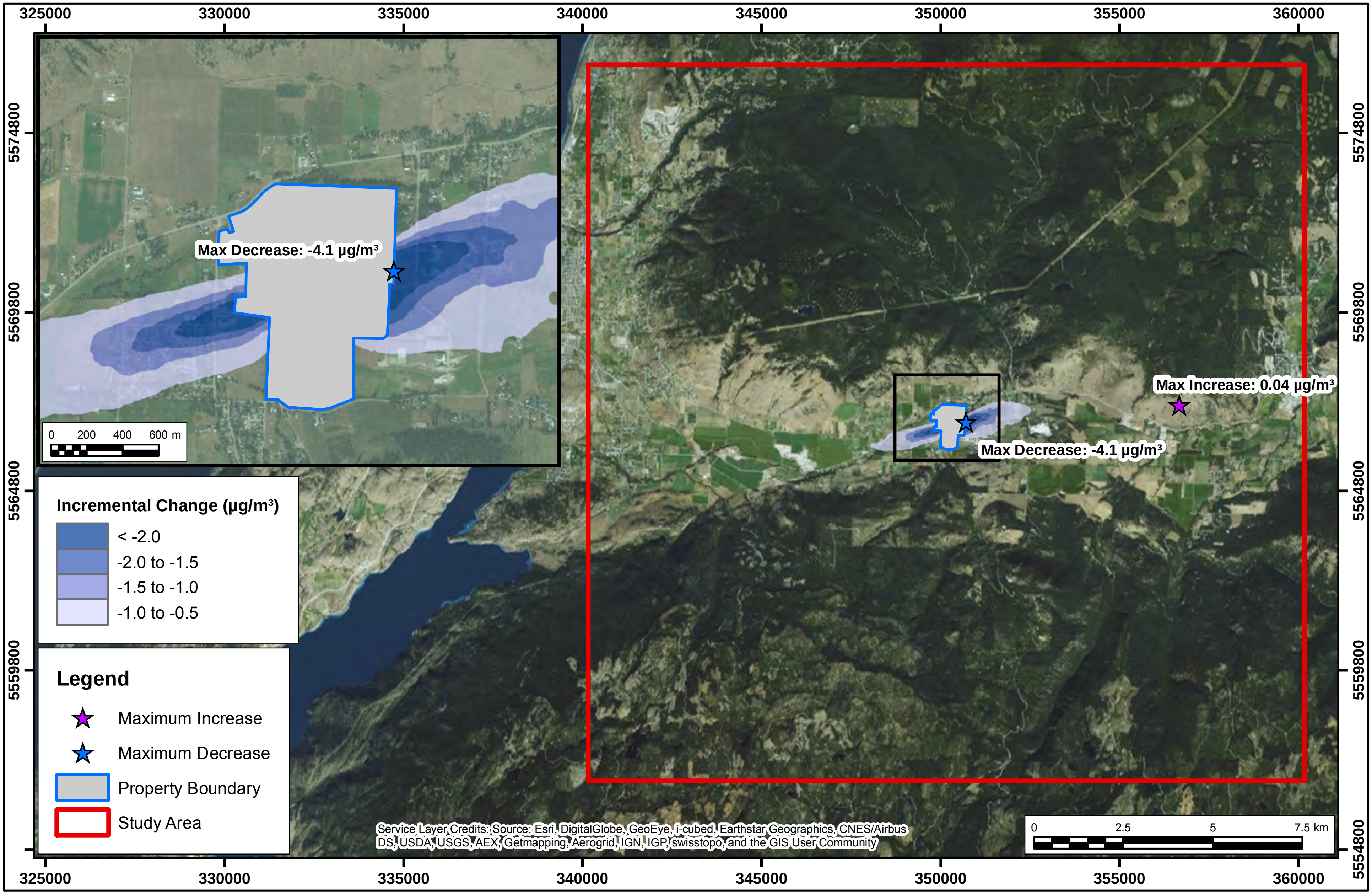
Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by:	JFV	Fig:	5.3
Approx. Scale:	1:150,000		
Date Revised:	Nov. 28, 2014		

RWDI



Incremental Change in Maximum Predicted Annual $PM_{2.5}$ Concentration with no Background Added

Tolko Proposed Baghouse Emission Scenario - Tolko Current Emission Scenario with Pinnacle Emissions Added

Map Projection: NAD83 UTM 11N.

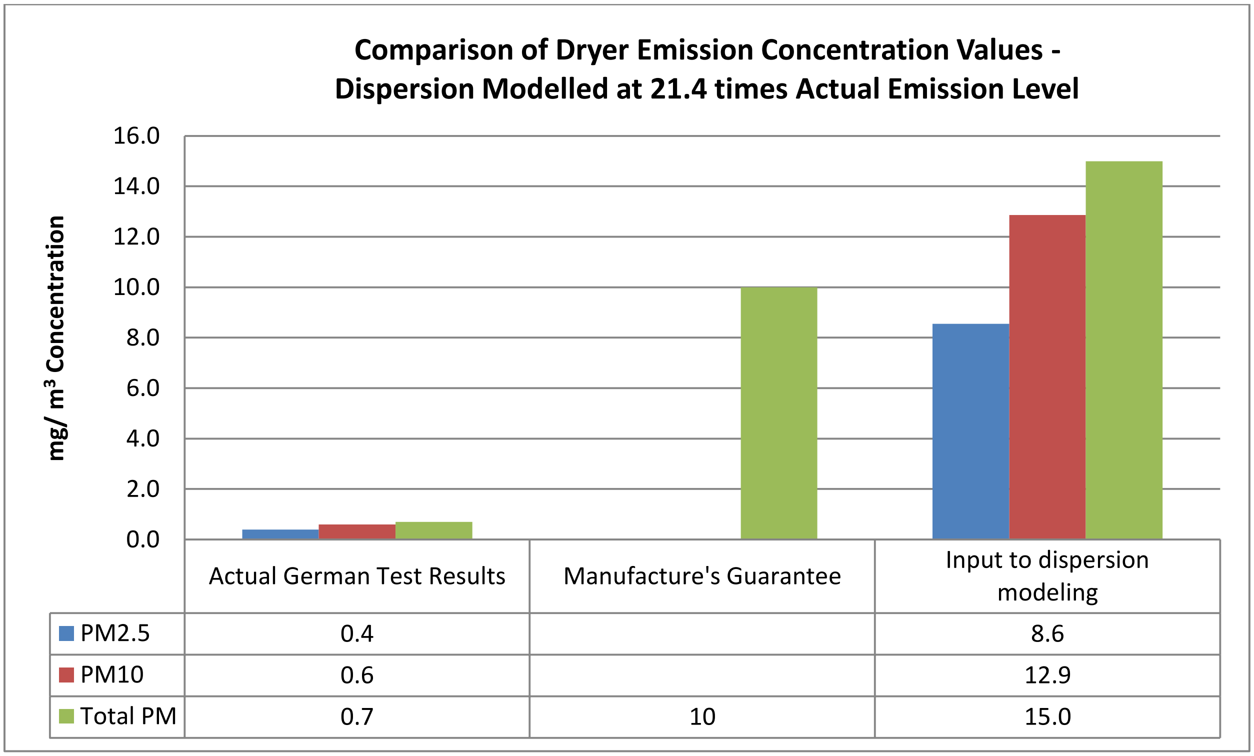
Pinnacle Renewable Energy Inc., Lavington, B.C.

Annual $PM_{2.5}$ Canadian Ambient AQ Standards (2015) = 10 µg/m³.
BC AQ Objective: Level A = 8 µg/m³.

True North

Project #1400749

Drawn by: NBN	Fig: 5.4
Approx. Scale:	1:150,000
Date Revised:	Dec. 9, 2014



	Actual German Test Results	Manufacture's Guarantee	Input to dispersion modeling
PM2.5	0.4		8.6
PM10	0.6		12.9
Total PM	0.7	10	15.0

Figure 6.1: **Comparison of Dryer Emission Concentration Values – Dispersion Modelled at 21.4 times Actual Emissions Level**