Air Quality Modeling Results: Levels of Sulfur Dioxide in the Ambient Air Around TransAlta Centralia Generation Power Plant

Technical Report

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Introduction

In 2010, the Environmental Protection Agency (EPA) established a new federal 1-hour average National Ambient Air Quality Standard (NAAQS) for sulfur dioxides (SO_2). In 2015, EPA issued the SO_2 NAAQS Data Requirements Rule defining how states should evaluate levels of SO_2 in the ambient air around large industrial facilities or cluster of facilities. The results of the evaluation serve as a basis for EPA to designate each area as attainment (meeting the standard), nonattainment (not meeting the standard) or unclassifiable (not enough data to determine air quality status in the area). The rule offered a choice of three approaches: monitoring, modeling, or establishing a permit limit for the facility to not to exceed 2,000 short tons of SO_2 per year. Under the 2015 rule, EPA required states to submit results of the modeling analysis by January 13, 2017. A state may also recommend to EPA on how to designate the area based on the results of the evaluation.

The Washington State Department of Ecology (Ecology) identified TransAlta Centralia Generation Power Plant (TA), located at 913 Big Hanaford Road, Centralia, WA, as a facility that emitted more than 2,000 tons of SO_2 in 2015. Ecology selected air quality modeling as the tool to further characterize SO_2 levels around TransAlta. The 2015 rule specifies that states can model the most recent actual SO_2 emissions, or the maximum allowable emissions at the facility. Ecology, in consultation with the Southwest Clean Air Agency (SWCAA), elected to model air quality impacts based on the actual emissions rate.

Ecology's modeling analysis shows the SO_2 concentrations around the facility are well below the 75 parts per billion level of the standard. This document details the procedures, inputs and results of SO_2 modeling conducted at TA.

Figure 1: Google Street view of TransAlta- Centralia coal power plant, looking west

Modeling Analysis

After experimenting with AERSCREEN and AERMOD v15181, Ecology chose AERMOD v16216 to provide a more refined analysis of SO_2 impacts, given the two identical 143m tall and 9.1m diameter stacks and complex terrain surrounding the TA facility. Figures 1 and 2 show the facility location.

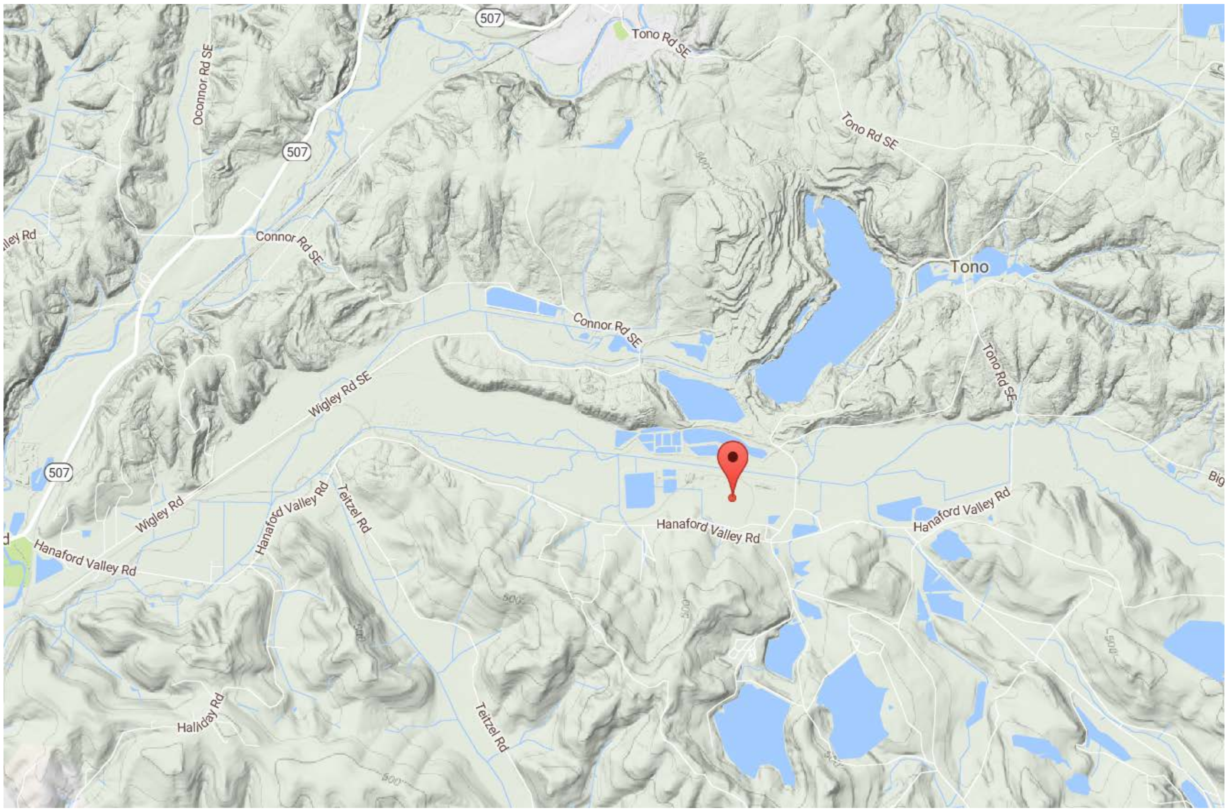

Figure 2: Google Terrain map of TransAlta- Centralia coal power plant

Meteorological Inputs

One year of meteorological data were collected on-site in 1994/ 1995, but the sensor was at 10m above ground level (AGL). Its windrose shown in Figure 3 is reasonably consistent with the valley terrain shown in Figure 2. However, no representative meteorological monitoring site nearby could characterize wind flows at the pollutant release height of 143m. As an alternative, Ecology obtained high resolution meteorological data produced by a mesoscale prognostic model. The University of Washington's Department of Atmospheric Sciences runs the Weather Research and Forecasting (WRF) model at a spatial resolution of 1.33km on a twice- daily basis. The configuration and performance of the UW- WRF system is described elsewhere[1,2]. Observational nudging was not used since UW-WRF ran in forecast mode. The model configuration did not remain static[3] over the time period considered here.

[1] http://www.atmos.washington.edu/wrfrt/info.html
[2] http://www.atmos.washington.edu/~qcreport/verification_index.psp?page=documentation
[3] http://www.atmos.washington.edu/mm5rt/log.html

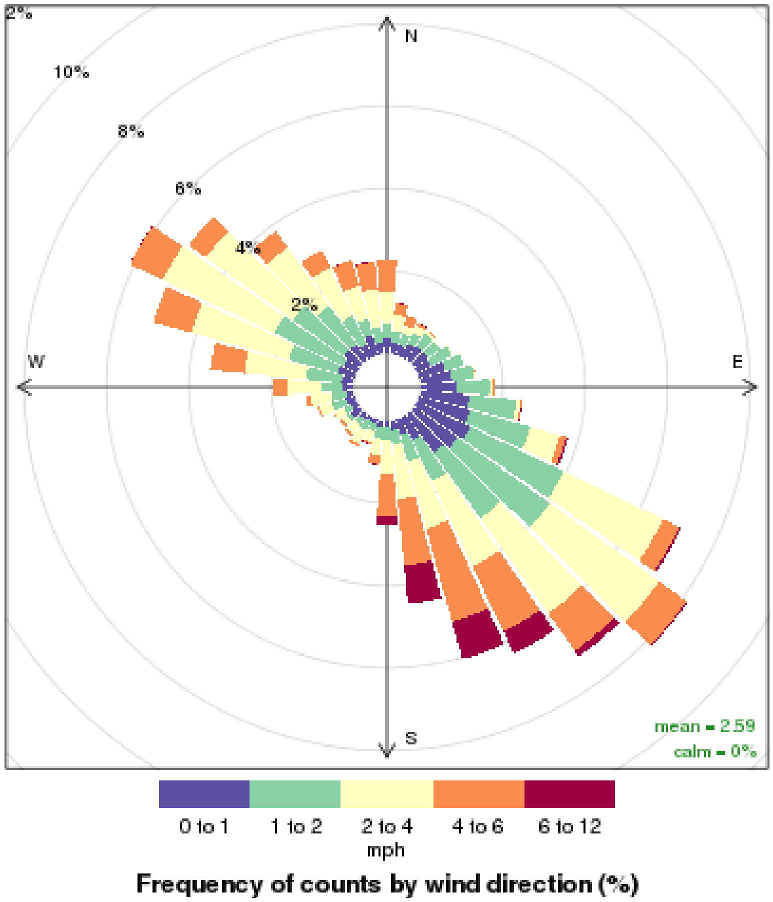

Figure 3: Windrose of 10m on-site data collected from April 1994- April 1995

Initially, Ecology located WRF files from 1 January 2014- 10 September 2016 (almost 2¾ years) and configured EPA's Mesoscale Model Interface Program (MMIF) v3.2 to produce the .SFC and .PFL files for direct use in AERMOD. However, it was brought to our attention that this was not the preferred MMIF configuration for regulatory applications. When we attempted to re-run MMIF and subsequently AERMET, the UW-WRF archive files were no longer easily accessible and we were only able to obtain one year of WRFOUT files. Since the initial MMIF-AERMOD modeling showed 2016 to have higher concentrations than 2014 and 2015, we opted to acquire the 2016 1.33km UW-WRF data in order to remain conservative in our analysis.

We ran MMIF to produce inputs to AERMET, with the PBL_RECALC parameter set to True. Mixing height calculations from WRF can be inaccurate since the PBL parameterization scheme assigns mixing heights to discrete UW-WRF vertical levels. Setting PBL_RECALC to true allows for PBL heights to be re-diagnosed and not constrained to UW-WRF levels. The PFL file contained 11 vertical levels, (2m, 10m, followed by nine levels interpolated using the tops of the following UW- WRF layers: 20, 40, 80, 160, 320, 640, 1200, 2000, 3000 and 4000m). MMIF was run on UW servers due to the large size of the WRFOUT files.

Ecology made some adjustments to the Stage 1, 2 and 3 AERMET input files produced by MMIF:

MMIF extracts vertical temperature differences but not cloud cover data from WRF. Therefore it is preferred if AERMET is supplied with cloud cover data from an observational site to properly process all the MMIF outputs. We obtained 2016 cloud cover data from the National Weather Service site at Centralia Airport (KCLS, about 15km from TA). We amended the Stage 1 and 2 input files to read and quality-check KCLS cloud cover data. Other parameters from the KCLS site were disregarded.

The METPREP section of the Stage 3 AERMET input file was supplied with the "METHOD REFLEVEL SUBNWS" option to process substituted KCLS cloud data. Further the "METHOD STABLEBL ADJ_U*" option was used to adjust anomalously low friction velocities during stable periods, thereby reducing model over-predictions. The ADJ_U* option is justified in this modeling application since it involves a tall stack situated in complex terrain. Terrain higher than the stack height is located >7km from the source.

The surface characteristics around the pseudo- on-site meteorological tower (which WRF- MMIF emulates) are derived from WRF rather than actual conditions. As such AERMET used MMIF's AERSURFACE output file.

The 10m windrose produced by WRF- MMIF- AERMET (Figure 4) is not completely inconsistent with the 1994/ 1995 on- site windrose shown in Figure 3; WRF might have smoothed out or mis-located localized terrain slightly, causing the shift from southeast to south surface winds. The upper levels mimic the typical southwest flow aloft. As such, we deemed the WRF- MMIF- AERMET meteorological data adequately representative of the area for this application.

When only one year of meteorological data are available, the SO_2 modeling Technical Assistance Document allows the .SFC and .PFL files to be replicated over three years, so design values can be calculated by running the model with actual emissions data. We altered the year in both files and the Julian date in the SFC file accordingly, to facilitate this.

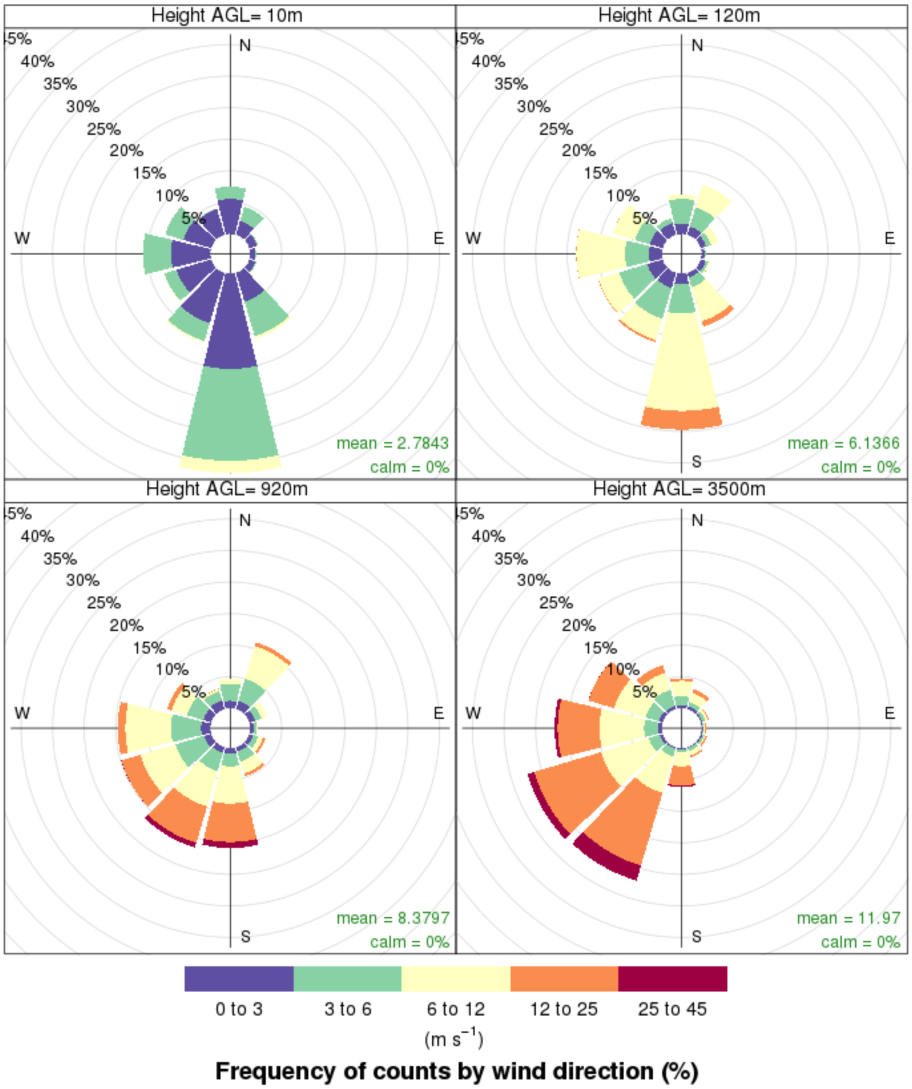

Figure 4: 2016 windroses at different heights over TransAlta, produced by 1.33km WRF- MMIF-AERMET

Emissions and Stack Parameters

Ecology used actual 2014- 2016 SO_2 hourly emission rates reported by the facility to EPA's Clean Air Markets Division database[4]. As emissions from the final quarter of 2016 were not yet uploaded, they were obtained directly from SWCAA. SWCAA also supplied us with hourly stack exit flowrates and temperatures for both emission units. SO_2 emissions from each of the 26,304 hours were modeled as-is: even unreasonably high rates characteristic of plant malfunction or large values substituted by the CAMD quality checks were nevertheless retained. Data substitution was conducted as follows, to ensure valid stack parameters were available for each of the hours modeled:

1. If $SO_2 > 0$, retain valid, non-zero stack exit velocities and temperatures. To minimize plume rise and remain conservative in our analysis, we used the lowest temperature and exit velocity reported by the two stacks, during that hour.

[4] https://ampd.epa.gov/ampd/

2. Non-zero stack temperatures had a lower and upper decile of 50ºC and 59ºC respectively. 50ºC was substituted when non-zero emissions rates were present and temperatures were absent.
3. Stack flowrates (and thus, exit velocities) are linearly related to plant operating load. We developed quarterly relationships using stack- specific flow data over the last 3 years and selected the smallest regression coefficients from all 8 linear fits, even though the respective slope and intercept applied to different stacks/ quarters. Missing exit velocities were filled in using this linear model, which keeps plume rise to a minimum.

Due to the tall stack that easily escapes downwash, this modeling disregarded on- site buildings.

The plant does not operate during some spring months due to low power demand. Figure 5 shows how the emissions and stack parameters change with time, and 6 shows the diurnal and seasonal fluctuations in emissions. Lower emissions during nighttime hours are clearly seen in Figure 6.

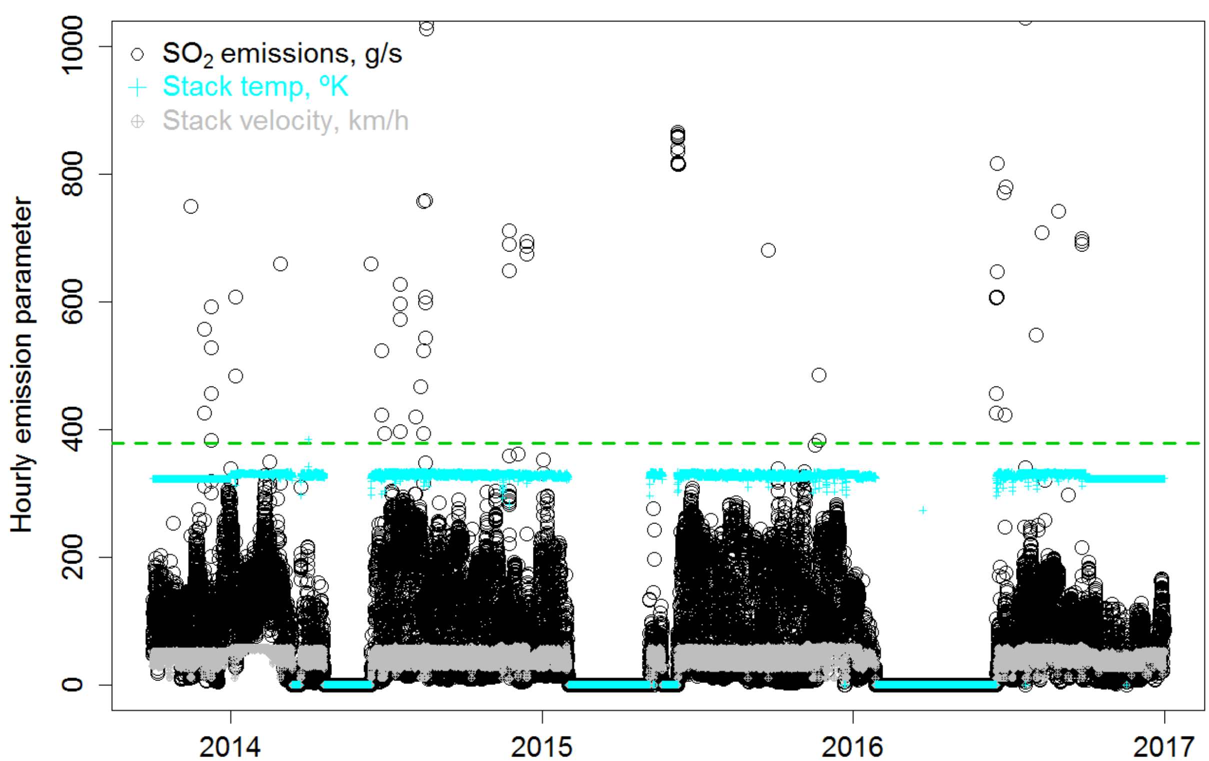

Figure 5: Hourly time series of TA stack parameters. Emissions above the dashed horizontal green line (3000 lb/hr), although retained in this analysis, are considered unreasonably high.

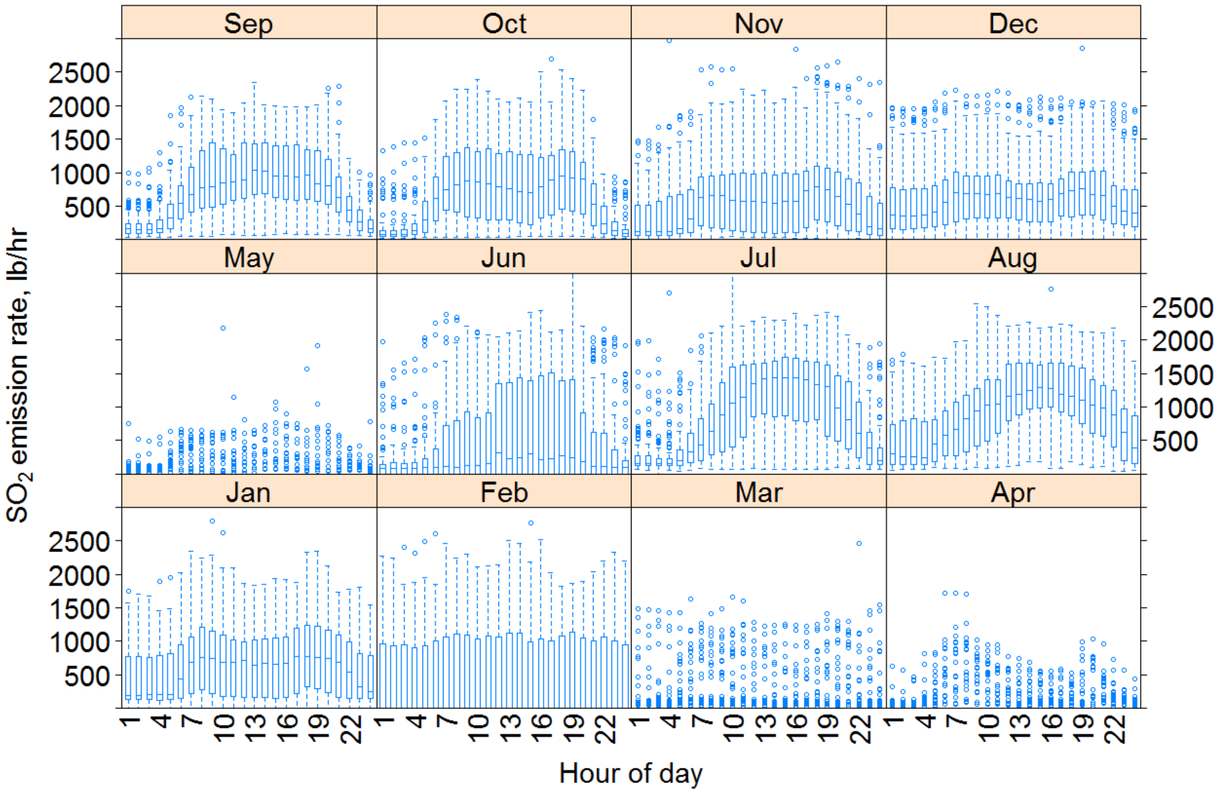

Figure 6: Boxplots of hourly TA SO_2 emission rates from 2014- 2016

Nearby Sources and Background SO_2 Concentrations

In an attempt to determine the significance of nearby sources, Ecology initially conducted AERSCREEN modeling using the 99th percentile of the actual 2014 emissions (2150 lb/hr). The model assumed flat terrain. Ecology also modeled SO_2 emissions from Cardinal Glass (46.6 tons/ yr, 25km to the southwest of TA). Cardinal Glass had a maximum impact less than 5 µg/m^3. This is much smaller than SO_2 from TA, even when TA's concentrations were potentially under-estimated by setting the land cover to "forested" (Figure 6). SO_2 sources in Longview and the Tacoma Tideflats are more than 50 km away and emit less than 10 tons of SO_2 annually. Therefore the regional background SO_2 concentration of 13 µg/m^3, obtained from http://www.lar.wsu.edu/nw-airquest/lookup.html, very likely accounts for all nearby SO_2 sources.

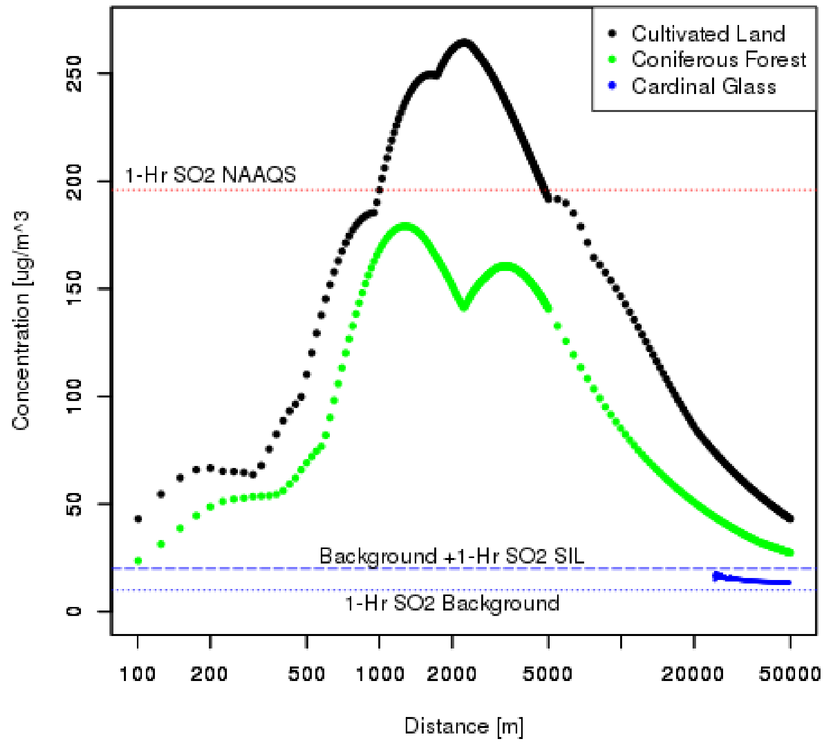

Figure 7: AERSCREEN results for TransAlta and Cardinal Glass SO_2

Modeling Domain

Since Figure 7 shows high concentrations occurring within 20km of the source, we approximately centered a 200m- spaced grid over a 50 km by 50 km domain on the TA facility (i.e. extending about 28km east of TA). AERMAP v11103 was used to process terrain data for a total of 62001 flagpole receptors 1.4m above ground level. We obtained the underlying 1/3 arc second terrain data with NLCD 2011 land cover, from MRLC[5]. Figure 8 shows the modeling domain and results.

AERMOD Results

Ecology added the 3-year average of the 99^{th} percentiles of the highest daily 1-hr SO_2 concentrations at each receptor for 2014-2016, to the static SO_2 background concentration of 13 µg/m³. Figure 8 shows the spatial distribution of model results, inclusive of background. The maximum impacted receptor had an SO_2 design value of 100.7 + 13 = 113.7 µg/m³, or about 44 ppb. The highest impacts occur within or just outside the property boundary, mostly during a few hours in 2016 when light winds and mildly stable conditions coincided with some combination of high emission rates, low stack temperatures or exit velocities.

[5] http://www.mrlc.gov/viewerjs/

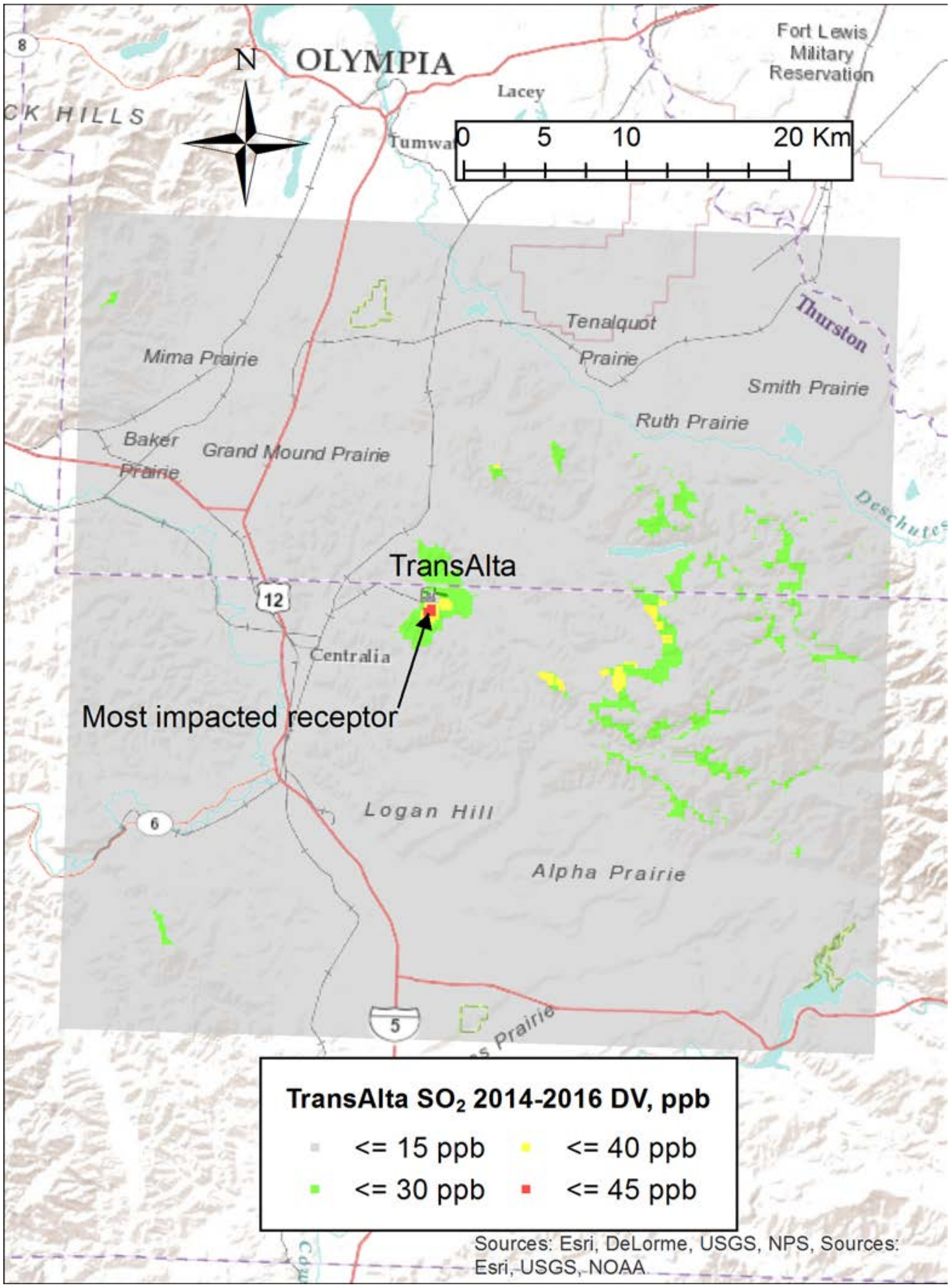

Figure 8: MMIF-AERMET- ADJ_U- AERMOD modeled 2014-2016 SO_2 design values (inclusive of background) around TransAlta.*

Conclusion: SO_2 NAAQS Compliance at TransAlta

Ecology modeled the actual 2014- 2016 SO_2 emissions from TransAlta using the WRF- MMIF v3.2- AERMET- ADJ_U*- AERMOD (v16216) system, making some conservative assumptions. The highest impacted receptor within the 50 x 50km modeling domain is located on elevated terrain about 8km east of the facility, and recorded a 3-year average of the 99th percentile concentration (i.e. design value) of 44 ppb inclusive of background.

This work shows the worst affected receptor is well below the SO_2 standard of 75ppb, confirming that TransAlta's Power Generation facility in Centralia, WA has complied with the 2010 1-hour SO_2 NAAQS.

Electronic files associated with this modeling (except WRFOUT files from the UW) are available on request.