Air Dispersion Modeling Analysis
For Verifying Compliance with the
One-Hour NO₂ NAAQS:
JBS Swift Beef Company
Greeley, Colorado

Prepared by:
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1. INTRODUCTION

I hold an M.A. (2012) degree in Geography from California State University, Northridge, where I specialized in GIS and air dispersion modeling. I have broad experience as a consultant. I have performed numerous air quality modeling analyses using AERMOD and other air dispersion models, prepared meteorological data using AERMET, performed health risk assessments, and created many detailed maps and graphics. I have experience preparing analyses of various emission types from many sources and facilities including natural gas and coal-fired power plants, agricultural fields, and mobile sources. My curriculum vitae can be downloaded here.

The Center for Biological Diversity recently asked me to perform a Tier 3 NO2 modeling analysis of JBS Swift Beef Company in Greeley, Colorado. JBS currently has a draft construction permit out for public comment.
2. MODELING METHODOLOGY

The one-hour NO$_2$ NAAQS takes the form of a three-year average of the 98th-percentile of the annual distribution of daily maximum one-hour concentrations, which cannot exceed 100 ppb.$^1$ The one-hour NO$_2$ NAAQS of 100 ppb equals 188 µg/m$^3$. The 98th-percentile of the annual distribution of daily maximum one-hour concentrations corresponds to the eighth-highest value at each receptor for a given year.

The USEPA describes a three-tiered screening process for modeling NO$_2$:

“Tier 1 – assume full conversion of NO to NO$_2$, where total NO$_x$ concentrations are computed with a refined modeling technique specified in Section 4.2.2 of Appendix W.

Tier 2 – multiply Tier 1 results by empirically derived NO$_2$/NO$_x$ ratios, with 0.75 as the national default ratio for annual NO$_2$ (Chu and Meyer, 1991) and 0.80 as the national default ratio for hourly NO$_2$ (Want, et al, 2011; Janssen, et al, 1991), as recommended in U.S. EPA, 2011.

Tier 3 – detailed screening methods may be used on a case-by-cases basis. At this time, OLM (Cole and Summerhays, 1979) and the PVMRM (Hanrahan, 1999) are considered to be appropriate as detailed screening techniques.”$^3$

For this analysis, I implemented a Tier 3 modeling approach. I modeled using USEPA’s AERMOD program, version 19191, obtained from the Support Center for Regulatory Atmospheric Modeling (SCRAM) website. AERMOD is the USEPA preferred air dispersion model for determining air impacts within 50 kilometers of air pollution emission sources.$^4$ Version 19191 is the latest version of the AERMOD model.

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$^1$ USEPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO$_2$ National Ambient Air Quality Standard, March 1, 2011.

$^2$ The ppb to µg/m$^3$ conversion is found in the source code to AERMOD v. 12060, subroutine Modules. The conversion calculation is $100/0.5319 = 188.0$ µg/m$^3$.

$^3$ USEPA, Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO$_2$ National Ambient Air Quality Standard, September 30, 2014

$^4$ USEPA, Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions, Appendix W to 40 CFR Part 51, November 9, 2005.
a. Ozone Background Concentration

Tier 3 NO₂ modeling requires background levels of ozone. In my modeling analysis, I used a seasonal - hourly background concentration profile provided by CDPHE with data from the Weld County Tower ozone monitor. The data is from years 2017 – 2019.

b. NO₂ Chemistry

I used the Tier 3 NO₂ Ozone Limiting Method (OLM) with an equilibrium ratio of 0.9 and an in-stack ratio (ISR) of 0.1579 for all sources at the JBS Swift Beef Company facility. This value is the highest ISR value found for boilers on EPA’s NO2 ISR database, and it is a very conservative value that would be applicable for all the boilers at the JBS facility.

c. Meteorology

CDPHE provided me with two sets of meteorological data. One set is five years of surface data (1993-1997) from the Kodak station in Windsor, CO, processed with AERMET v19191. The Kodak station is approximately 15 kilometers west of the JBS facility. Upper air data is from the Denver Stapleton Airport (KDEN) station in Denver, CO. The other set is 2009 data from the Fort St. Vrain station in Platteville, CO, also processed with AERMET v19191. Fort St. Vrain is approximately 25 kilometers southwest of the JBS facility. I was given datasets both with and without adjusted u* for each station. I modeled all four meteorology scenarios.

d. Source Locations

The coordinates and base elevations for most sources at the JBS Swift Beef Company facility can be found in the corresponding Air Pollutant Emissions Notices (APENs). For those APENs that did not include this information, the location was estimated from a Google Earth image of the facility and the terrain elevation was assumed to be the same across the entire plant given that the terrain is graded.

e. Building Downwash

I did not consider the downwash effect on JBS facility’s emissions in my analysis because there was no information available for the coordinates and dimensions of the buildings and structures at the plant.
f. Receptor Grid

I modeled a grid of 1,608 receptors with 50-meter spacing centered at the JBS Swift Beef Company facility, outside the apparent fence line of the facility, and extending 1 km in each direction. Terrain elevations were processed with AERMAP v18081 using 1/3 arc-sec resolution USGS NED files.

g. Emissions

I modeled emissions derived from information in the APENs (AIRS ID 123-0018) and the permit (95WE757). The facility has the potential to emit close to 100 tpy of NOₓ, which would make it a major source given its location in a serious ozone nonattainment zone. However, the company has accepted an annual NOₓ emission limit of 33 tpy, thus becoming a synthetic minor source. This emission limit would force some of the emissions units (i.e., pieces of equipment) to either operate at less than full capacity or less than full time (i.e., 8750 hours/year). However, the permit does not include any restriction on the operating schedule or on the operating mode of the units (i.e., load percentage of full capacity), so these units are capable of operating at full capacity for 24 hours/day for many days of the year without exceeding the annual NOₓ emissions limit. Therefore, because this modeling exercise is for an hourly ambient air standard, to account for those hours and days in which the units can operate at full capacity, the maximum allowable hourly emissions were used to model the 1-hr NO₂ NAAQS. These maximum hourly emission rates were calculated as described below based on the rating of the unit, the heat content of the fuel, and the CDPHE-approved emissions factor as reported in the corresponding APENs:

BOILER 001:

\[
21 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.259 \text{ g/s}
\]

ROTARY DRYER 003 (Low NOₓ burner):

\[
30 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 50 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.1855 \text{ g/s}
\]

ROTARY BLOOD DRYER 004:

\[
3 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.037 \text{ g/s}
\]
STEAM UNIT #2 006:

\[ 62.756 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.7759 \text{ g/s} \]

BOILER 011 (low NO\textsubscript{x} burner):

\[ 51.7 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 50 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.3196 \text{ g/s} \]

STEAM UNIT #4 013:

\[ 62.756 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.7759 \text{ g/s} \]

STEAM UNIT #3 017:

\[ 61.236 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.757 \text{ g/s} \]

STEAM UNIT #5 018:

\[ 62.756 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.7759 \text{ g/s} \]

BONE DRYER 019:

\[ 30 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 100 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.3709 \text{ g/s} \]

EVAPORATOR 020 (Low NO\textsubscript{x} burner):

\[ 9.9 \text{ MMBTU/hr} \times 1 \text{ MMSCF/1020 MMBTU} \times 50 \text{ lbs/MMSCF} \times 454 \text{ g/lb} \times 1 \text{ hr/3600 sec} = 0.0612 \text{ g/s} \]

h. Stack Parameters

Stack parameters were extracted from the APENs. Four sources were not included in the modeling because the APENs did not include any stack parameters: Units with Airs ID 123-

<table>
<thead>
<tr>
<th>Source</th>
<th>UTM Easting</th>
<th>UTM Northing</th>
<th>NOx Emission Rate (g/s)</th>
<th>Release Height (m)</th>
<th>Temp. (degrees K)</th>
<th>Exit Velocity (m/s)</th>
<th>Stack Diameter (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler 001</td>
<td>526215.83</td>
<td>4476937.80</td>
<td>0.259</td>
<td>7.62</td>
<td>449.82</td>
<td>4.13</td>
<td>0.6096</td>
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<tr>
<td>Rotary Dryer 003</td>
<td>526226.00</td>
<td>4476953.00</td>
<td>0.1855</td>
<td>11.2776</td>
<td>394.26</td>
<td>4.79</td>
<td>1.58</td>
</tr>
<tr>
<td>Rotary Blood Dryer 004</td>
<td>526195.48</td>
<td>4476961.03</td>
<td>0.037</td>
<td>12.192</td>
<td>366.48</td>
<td>7.55</td>
<td>0.6604</td>
</tr>
<tr>
<td>Steam Unit #2 006</td>
<td>526215.13</td>
<td>4476943.57</td>
<td>0.7759</td>
<td>6.7056</td>
<td>449.82</td>
<td>8.26</td>
<td>0.9144</td>
</tr>
<tr>
<td>Boiler 011</td>
<td>526232.00</td>
<td>4476921.00</td>
<td>0.3196</td>
<td>6.7056</td>
<td>449.82</td>
<td>6.096</td>
<td>0.9144</td>
</tr>
<tr>
<td>Steam Unit #4 013</td>
<td>526221.44</td>
<td>4476932.15</td>
<td>0.7759</td>
<td>6.7056</td>
<td>449.82</td>
<td>7.19</td>
<td>0.9144</td>
</tr>
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<td>Steam Unit #3 017</td>
<td>526224.83</td>
<td>4476932.94</td>
<td>0.757</td>
<td>6.7056</td>
<td>449.82</td>
<td>6.096</td>
<td>0.9144</td>
</tr>
<tr>
<td>Steam Unit #5 018</td>
<td>526229.31</td>
<td>4476937.39</td>
<td>0.7759</td>
<td>6.7056</td>
<td>449.82</td>
<td>7.19</td>
<td>0.9144</td>
</tr>
<tr>
<td>Bone Dryer 019</td>
<td>526264.64</td>
<td>4477008.97</td>
<td>0.3709</td>
<td>11.2776</td>
<td>394.26</td>
<td>4.79</td>
<td>0.9144</td>
</tr>
<tr>
<td>Evaporator 020</td>
<td>526216.99</td>
<td>4476886.19</td>
<td>0.0612</td>
<td>7.3152</td>
<td>354.82</td>
<td>3.25</td>
<td>0.4572</td>
</tr>
</tbody>
</table>

### i. Background Concentrations

There are 303 facilities within a 20-kilometer radius of the JBS Swift Beef Company. Those 303 facilities emit a total of 3,128 tpy of NOx and most include multiple emissions sources making for approximately 2,000 individual sources to be modeled. Modeling this large number of sources is an extremely time-consuming task. This modeling exercise does not include any nearby sources and instead I have added a conservative background level to the impacts caused by the JBS facility as indicated by CDPHE.

I modeled with a seasonal - hourly background concentration profile provided by CDPHE with data from the CAMP monitoring site in Globeville. The data is from years 2017-2019.
3. MODELING RESULTS

Each of the four meteorology scenarios that I modeled indicated NO₂ levels in exceedance of the 1-hour NO₂ NAAQS of 100 ppb or 188 µg/m³. Neither the meteorology station location nor the use of adjusted u* significantly changed the concentration nor location of the peak modeled results. The following results are in accordance with EPA’s guidance that NO₂ concentrations should be modeled as the highest eighth high value, which corresponds to the 98th percentile of the maximum daily concentration averaged across the years of meteorological data. The results include conservative background NO₂ concentrations.

- Four emissions sources at the JBS facility were not included because of the lack of data in the corresponding APENs. Adding these sources will increase the emissions and the modeled impact.

- The downwash effect caused by the JBS buildings and structures were not included because of the lack of information about the dimensions of these buildings. The downwash effect tends to create areas of higher concentrations in the vicinity of the facility and therefore the impacts are expected to be higher.

- There are 20 facilities in the immediate vicinity of the JBS facility, within a 5-kilometer radius, emitting 355 tpy of NOₓ. Among those facilities are included two large ones: the DCP Lucerne Gas Plant which emits 188 tpy of NOₓ, and the Leprino Foods Company which emits 57 tpy of NOₓ. The background concentrations would generally account for the transport of emissions from the larger area and therefore would account for the contribution of the majority of the nearby facilities, but it is unlikely to account for the combined impact.

<table>
<thead>
<tr>
<th>Nitrogen dioxide (NO₂)</th>
<th>Facility highest 98th percentile concentration (µg/m³)</th>
<th>XUTM (m)</th>
<th>YUTM (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meteorology Scenario</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kodak/KDEN 1993-1997 with adj u*</td>
<td>224.95</td>
<td>526186</td>
<td>4476732</td>
</tr>
<tr>
<td>Kodak/KDEN 1993-1997 without adj u*</td>
<td>223.35</td>
<td>526136</td>
<td>4476732</td>
</tr>
<tr>
<td>Ft. St. Vrain/KDEN 2009 with adj u*</td>
<td>230.56</td>
<td>526286</td>
<td>4476732</td>
</tr>
<tr>
<td>Ft. St. Vrain/KDEN 2009 without adj u*</td>
<td>222.40</td>
<td>526286</td>
<td>4476732</td>
</tr>
</tbody>
</table>
of emissions coming from facilities that are located in very close proximity of the JBS plant. Including these 20 facilities in the model along with an adequate background would likely result in higher impacts.