Lathrop & Augusta SO_2 Monitor (13-051-1002) Dispersion Modeling for the 2010 1-Hour SO_2 NAAQS
September 8, 2015

The Lathrop & Augusta SO_2 monitor (13-051-1002) currently has a 2012-2014 design value of 78 ppb which is above the NAAQS level of 75 ppb. Therefore, the area surrounding this monitor has been identified for early designation. The Lathrop & Augusta SO_2 monitor is located in Savannah, GA (Chatham County).

In the past, the Lathrop & Augusta SO_2 monitor has recorded 1-hour daily maximum SO_2 values in excess of 75 ppb. In 2013, GA EPD performed air quality modeling and back trajectory analysis that clearly showed that International Paper - Savannah Mill (IP-Savannah) was the only significant SO_2 source contributing to exceedances of the NAAQS. IP-Savannah is located less than 2 km away from the Lathrop & Augusta SO_2 monitor. The details of this analysis are contained in a document titled "Analysis of 1-Hour SO_2 NAAQS Exceedances in Savannah and Rome" (December 23, 2013).

In early 2015, Georgia EPD requested that IP-Savannah submit a detailed modeling analysis characterizing the Mill's emission sources and model impacts. IP-Savannah submitted a dispersion modeling report and related modeling files prepared by AECOM, Inc. Georgia EPD reviewed the modeling report and files to ensure that the dispersion modeling has been conducted in accordance with the final Data Requirements Rule (DRR) and Modeling Technical Assistance Document (TAD) using the most recently available information. Based on this review, Georgia EPD made some adjustments to the modeling files that were submitted to insure the most reliable results were used in the analysis.

This report discusses the procedures used to review the supporting dispersion modeling and the modeling results are summarized.

INPUT DATA

Meteorological Data – Meteorological data was created for the monitoring site using AERMETv15181 for the period 2011-2013. The Lathrop & Augusta monitoring location contains on-site meteorological measurements for wind speed and wind direction. The other required surface meteorological fields were extracted from the Savannah International Airport ASOS site (SAV) and the upper air measurements were extracted from the Charleston, SC station (CHS). The data were compiled and provided to IP-Savannah by GA EPD. The AERMET processor was used to convert the NWS data into AERMOD model-ready meteorological data files using the AERSURFACE surface characteristics evaluation utility (13016).

Values of the surface characteristics (albedo, Bowen ratio, and surface roughness) surrounding the monitor site and the project site were derived for each of twelve 30-degree sectors over four seasons, in accordance with the AERMOD Implementation Guide (09078). GA EPD compared the above AERSURFACE generated surface characteristics, and found no significant differences in the albedo and Bowen ratio for the two sites. However, significant differences in the surface roughness were observed. Therefore, a meteorological dataset with the project site surface characteristics was used in the modeling.

This model was also used to evaluate surrounding land use within 3 kilometers. Based on the output from the AERSURFACE, approximately 40% of surrounding land use around the modeled facility was of urban land use types including Type 21 (Low Intensity Residential), Type 22 (High Intensity Residential), and Type 23 (Commercial/Industrial/Transportation). This is less than the 50% value considered appropriate for the use of urban dispersion coefficients. Based on the AERSURFACE analysis, it was concluded that the rural option would be used for the modeling summarized in this report.

Source Data – IP-Savannah has four significant SO_2 sources including No. 13 Power Boiler which is the Mill's largest source of SO_2 emissions and six intermittently operated SO_2 sources. Although the six stationary internal combustion engines at the Mill operate intermittently and fire ultra-low sulfur diesel fuel, they were included in the modeling at full operation in order to fully examine the Mill's impact on ambient SO_2 concentrations at the fence line and beyond. Stack exit temperature and stack exit flow data from similar engines at another IP Savannah mill were used. Five of the intermittent engines have horizontal stacks and were modeled using a default stack exit velocity of 0.001 m/s according to guidance from AERMOD Implementation Guide. Hourly actual emission rates, temperature, stack exit velocity, and flow rates were calculated for the four primary SO_2 sources at IP-Savannah for the same time period as the meteorological data (2011-2013). The calculated emissions and flow rates were compared to the values measured by CEMS units on each of the sources.

Receptor Locations – A Cartesian receptor grid extending to approximately 10 km from IP-Savannah was used in the modeling analysis to assess ground-level SO_2 concentrations. The discrete receptors were placed according to the following configuration based on the center of the plant:

- At property boundary ➔ 50 meters apart
- Property boundary – 4 km ➔ 100 meters apart
- 4 km – 10 km ➔ 500 meters apart

This domain is sufficient to capture the maximum impact. Receptors were removed over bodies of water and other areas where a monitor could not be placed. Finally, an additional receptor was added at the location of the SO_2 monitor. Figure 1 shows the property boundary for IP-Savannah Mill and Figure 2 shows the property boundary for the IP-Savannah wastewater treatment basin. Figure 3 shows the modeling receptor grid and receptors. All receptor locations are represented in the Universal Transverse Mercator projections, Zone 17, North American Datum 1983.

Terrain Elevation – Terrain data from USGS 1/3 arc-second/10-meter resolution National Elevation Dataset (NED) CONUS were extracted to obtain the elevations of all sources, buildings, and receptors by AERMAP terrain processor (version 11103). The resulting elevation data were verified by comparing contoured receptor elevations with USGS 7.5-minute topographic map contours.

Building Downwash – The effects of building downwash were incorporated into the AERMOD analysis. Direction-specific building parameters required by AERMOD were developed using the BPIP PRIME utility (version 04274). The GEP (Good Engineering Practice) analysis was performed for the IP-Savannah Mill to demonstrate compliance with stack height regulations (40 CFR Part 51) and to determine which emission sources are impacted by building wake and downwash effects. The building heights and projected widths were input into the model for each ten degrees of wind direction. These building heights and projected widths are the same as those used for the GEP stack height calculation.

Figure 1. IP-Savannah property boundary for the Mill.

Figure 2. IP-Savannah property boundary for the wastewater treatment basin.

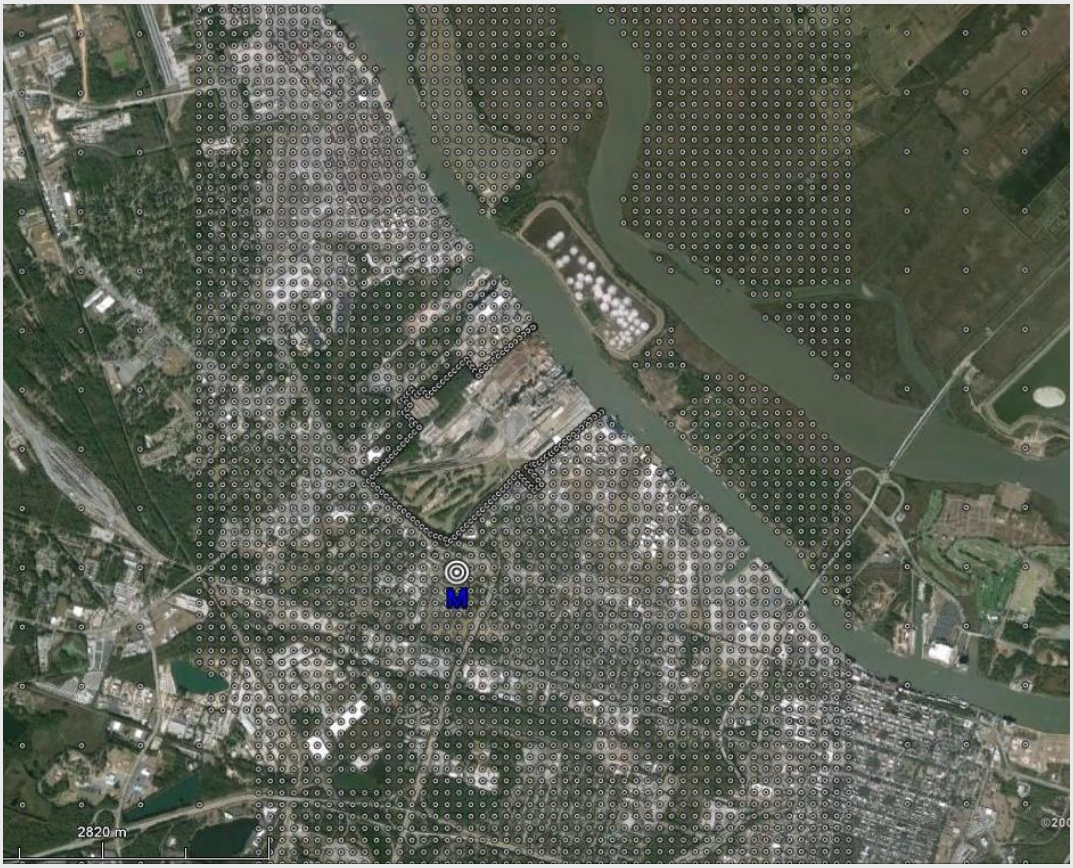

Figure 3. Modeling receptor grid with monitor location marked by blue 'M'.

1-Hour SO_2 NAAQS ASSESSMENT

As part of the 1-hour SO_2 NAAQS analysis, ambient background was added to modeled concentrations to assess compliance with the 1-hour SO_2 NAAQS. The seasonal hour of day background concentration for 1-hour SO_2 was provided by GA EPD. This background value is meant to include impacts from other sources surrounding the monitor. The seasonal hour of day background concentration was calculated for each of the four seasons using following steps:

1. For each year (2011-2013), SO_2 data was sorted by wind direction.
2. All SO_2 values corresponding to a wind direction between 0º and 45º were ignored.
3. For each year, the remaining SO_2 data was sorted by season; spring (March-May), summer (June-August), fall (September- November), and winter (December-February).
4. For each season, SO_2 data was sorted by hour of day.
5. For each year and season, the second highest SO_2 value was selected for each hour of the day.
6. The average over the three years of the second highest SO_2 value was calculated for each hour of the day for each season.

Table 1 and Figure 4 show the seasonal hour of day background concentration for 1-hour SO_2 used in the model.

Table 1. Seasonal hour of day SO_2 background concentration for 2011-2013 at 13-051-1002.

Hour of Day	Spring	Summer	Fall	Winter
0:00	7.1	4.2	4.5	12.2
1:00	6.2	4.7	4.8	9.2
2:00	5.6	3.5	4.9	18.2
3:00	3.9	3.5	6.7	8.2
4:00	6.0	4.4	6.9	10.5
5:00	6.5	4.6	7.2	10.9
6:00	6.8	8.2	6.4	8.4
7:00	8.6	12.4	5.9	9.1
8:00	16.5	9.1	15.3	10.4
9:00	14.8	19.0	25.8	21.2
10:00	12.4	15.1	19.4	19.7
11:00	15.8	14.4	18.3	20.3
12:00	10.2	11.1	13.4	16.9
13:00	15.1	7.4	14.2	17.4
14:00	9.5	14.4	17.1	12.2
15:00	8.5	4.9	11.6	9.4
16:00	6.2	6.6	12.0	8.6
17:00	6.3	9.4	9.3	8.0
18:00	6.5	4.6	10.4	12.0
19:00	7.1	5.8	9.3	8.7
20:00	6.8	7.6	6.9	10.3
21:00	7.2	6.2	8.3	9.0
22:00	7.8	5.4	5.1	7.6
23:00	4.8	6.6	6.3	10.1

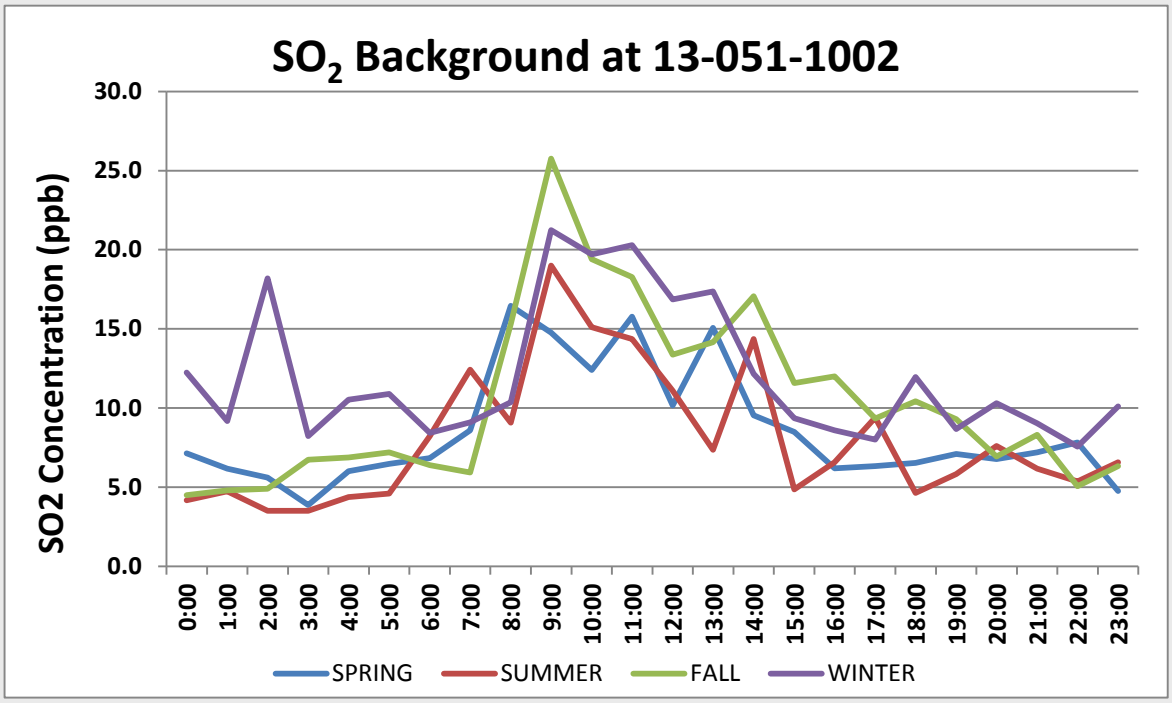

Figure 4. Seasonal hour of day SO_2 background concentration for 2011-2013 at 13-051-1002.

The highest four modeled values at the monitor for each year are shown in Table 2. The modeled design value concentration was calculated by AERMOD (version 15181) using actual hourly emissions including the seasonal hour of day background values from 2011-2013 and reflects the three-year

average of the 99th percentile ranked daily maximum 1-hour SO_2 concentration. Modeled concentrations at the monitor were typically less than the monitored values (Table 3). The highest 99th percentile modeled concentration in the modeling domain was 66 ppb, which is below the NAAQS of 75 ppb. The four highest modeled values in the modeling domain are presented in Table 4 and the location of the four highest modeled concentrations are shown in Figure 5. As seen in Figure 6, the 4th highest modeled maximum 1-hour concentration averaged over 3-years for SO_2 was located at approximately 1.97 kilometers south of IP-Savannah Mill.

Table 2. Ranked modeled SO_2 concentrations at the monitor for 2011-2013.

Rank	2011 (ppb)	2012 (ppb)	2013 (ppb)	3-year Average (ppb)
1st High	74	114	64	84
2nd High	69	54	58	60
3rd High	66	51	57	58
4th High	65	50	53	**56**

Table 3. Ranked monitored SO_2 concentrations for 2011-2013.

Rank	2011 (ppb)	2012 (ppb)	2013 (ppb)	3-year Average (ppb)
1st High	95	128	142	122
2nd High	94	112	118	108
3rd High	76	87	101	88
4th High	72	74	93	**79**

Table 4. Ranked modeled SO_2 concentrations at the location of maximum concentration for 2011-2013.

Rank	2011 (ppb)	2012 (ppb)	2013 (ppb)	3-year Average (ppb)	Receptor (lat,log)	Distance from IP Savannah Mill (Km)
1st High	104	139	62	101	32.0925,-81.1335	1.55
2nd High	68	83	85	78	32.0943,-81.1377	1.67
3rd High	66	63	74	67	32.0835,-81.1229	2.26
4th High	65	61	73	**66**	32.0862,-81.1229	1.97

Comparisons of the daily maximum monitored and modeled concentrations at the monitor and in the entire model domain are shown in Figure 7 – Figure 13 for the years 2011-2013. There is a minimum modeled concentration for each season due to the background value even if the model is predicting no concentration from IP-Savannah at the monitor. The quantile-quantile (Q-Q) plot in Figure 13 shows the comparison of the daily maximum measured SO_2 values at the monitor versus the daily maximum modeled concentration at the monitor. The model does not predict values at the monitor as high as the measured values. The quantile-quantile (Q-Q) plot in Figure 14 shows the comparison of the daily maximum measured SO_2 values at the monitor versus the daily maximum modeled concentration in the domain. The model predicts values in the domain that are higher than the measured values.

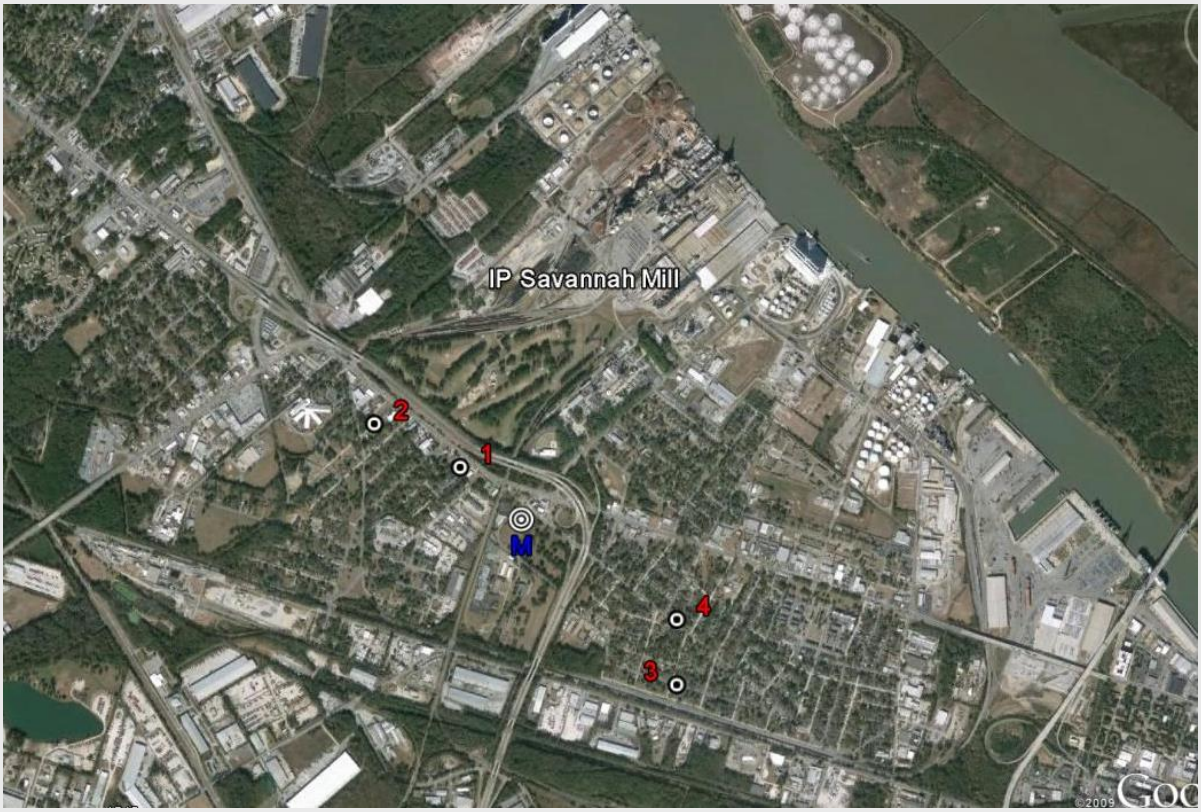

Figure 5. Google Earth map for ranked modeled concentrations at the location of maximum impact.

Figure 6. Concentration isopleth of the 4th highest daily maximum 1-hour SO_2 averaged over 3 years.

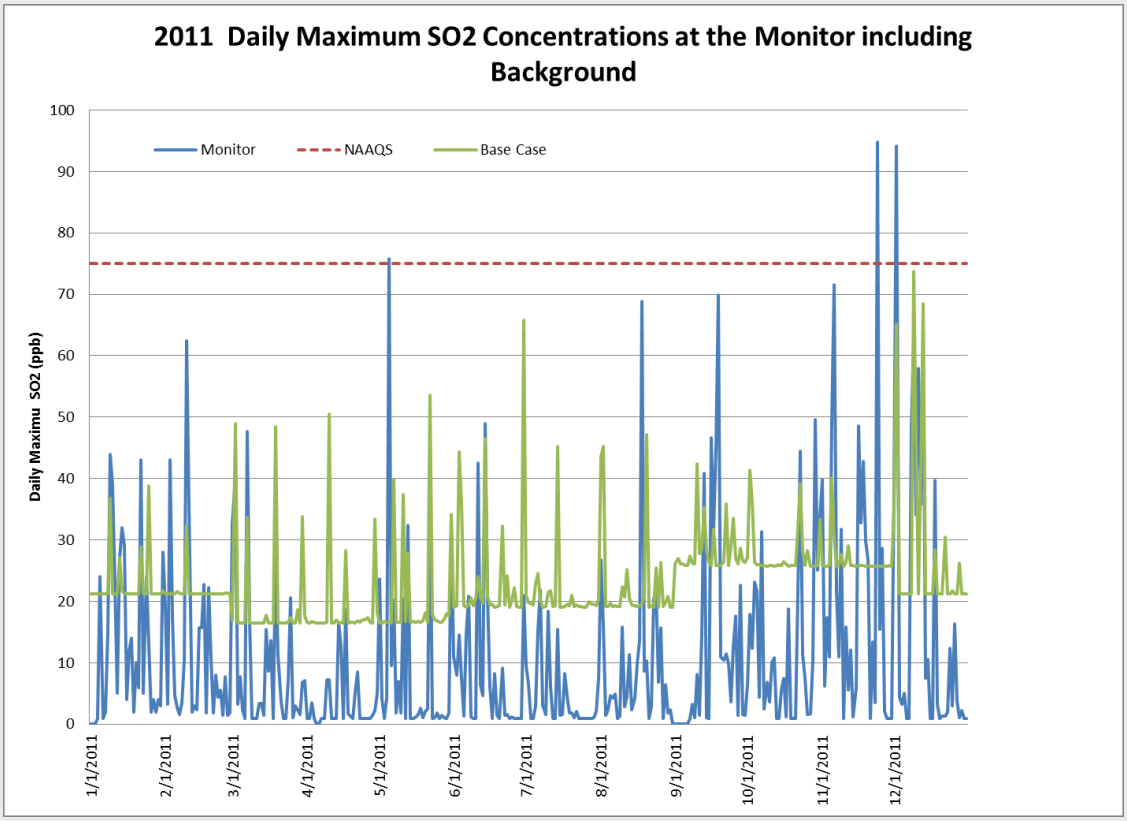

Figure 7. Comparison of 2011 daily maximum monitored and modeled concentrations at the monitor.

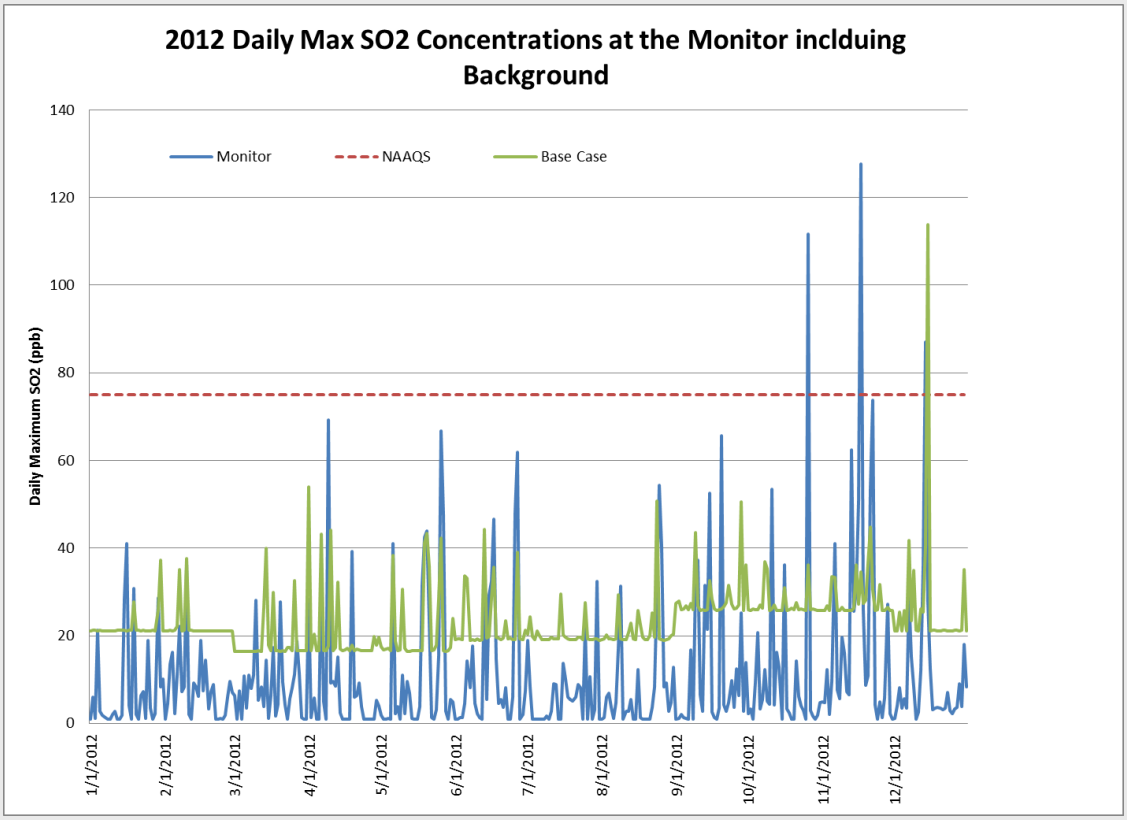

Figure 8. Comparison of 2012 daily maximum monitored and modeled concentrations at the monitor.

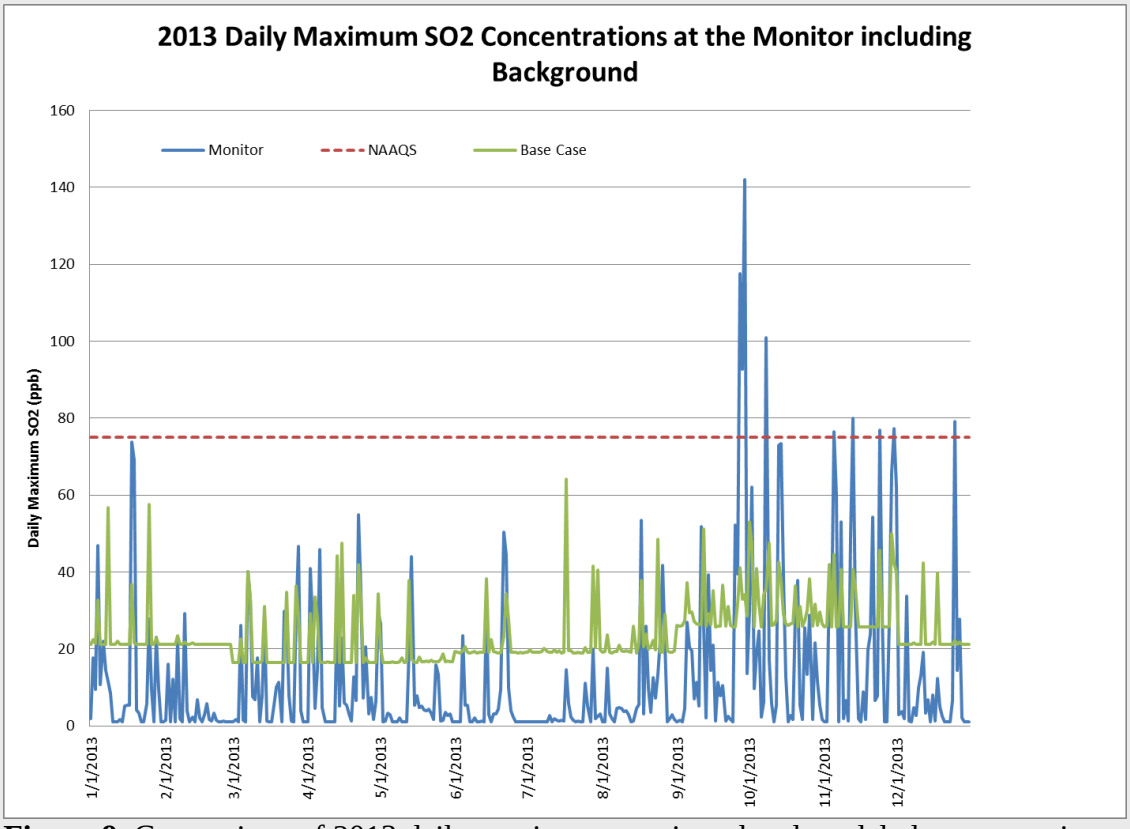

Figure 9. Comparison of 2013 daily maximum monitored and modeled concentrations at the monitor.

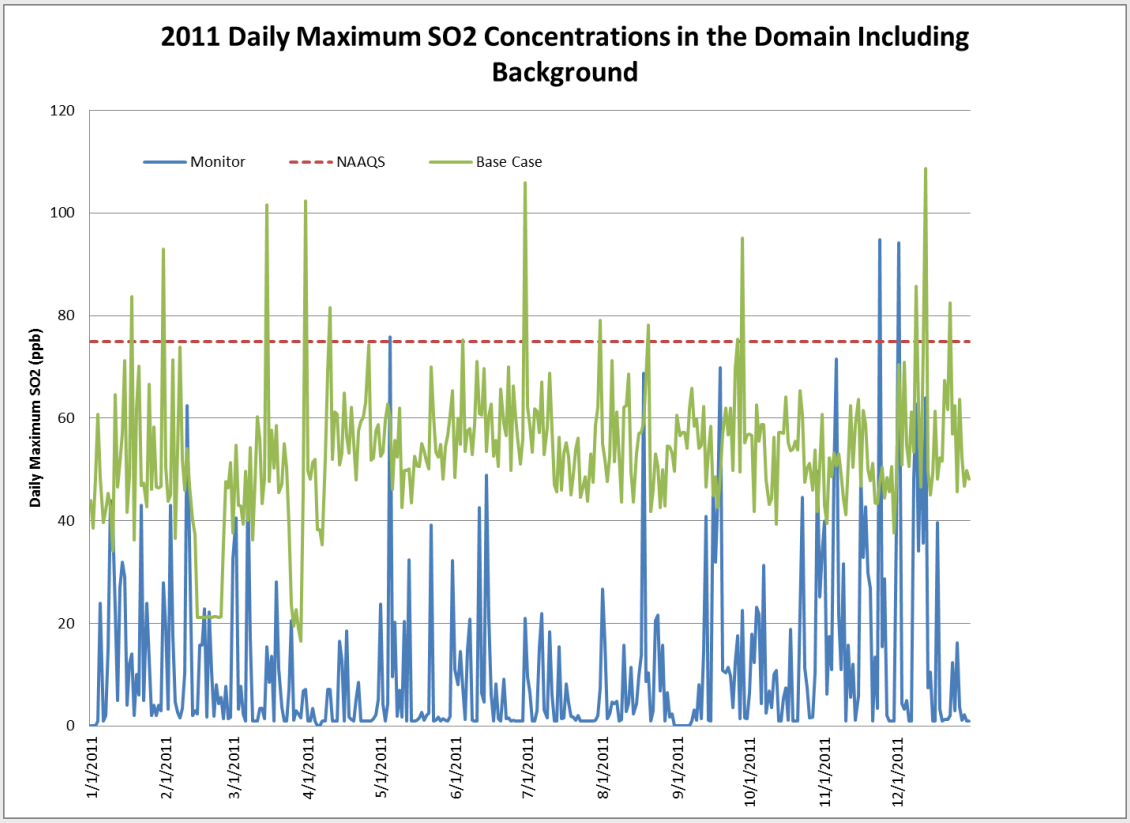

Figure 10. Comparison of 2011 daily maximum monitored and modeled concentrations in the domain.

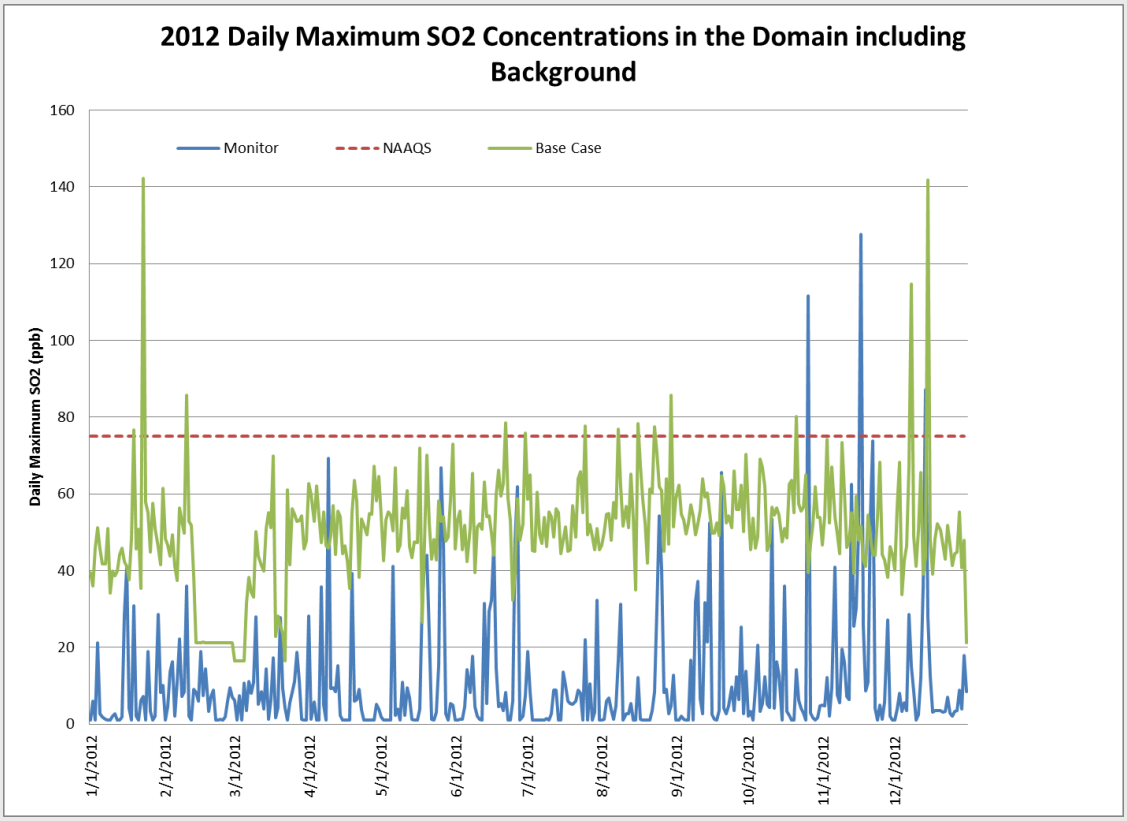

Figure 11. Comparison of 2012 daily maximum monitored and modeled concentrations in the domain.

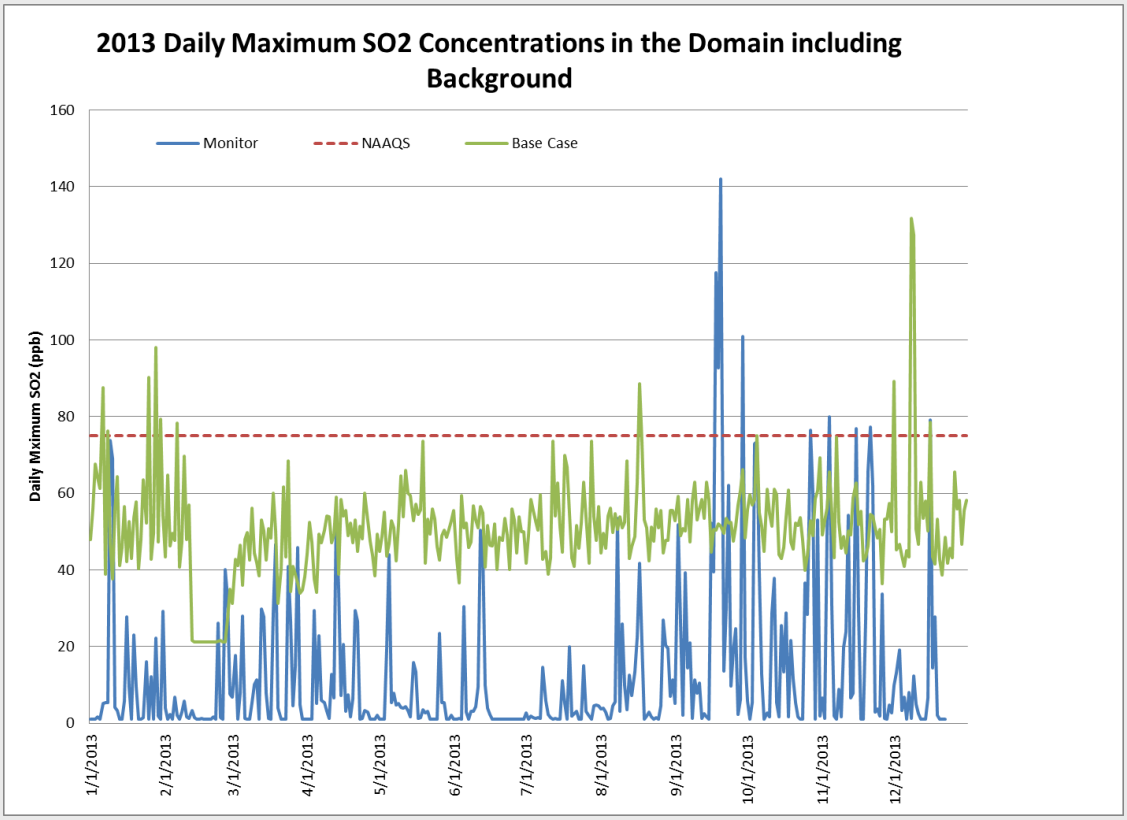

Figure 12. Comparison of 2013 daily maximum monitored and modeled concentrations in the domain.

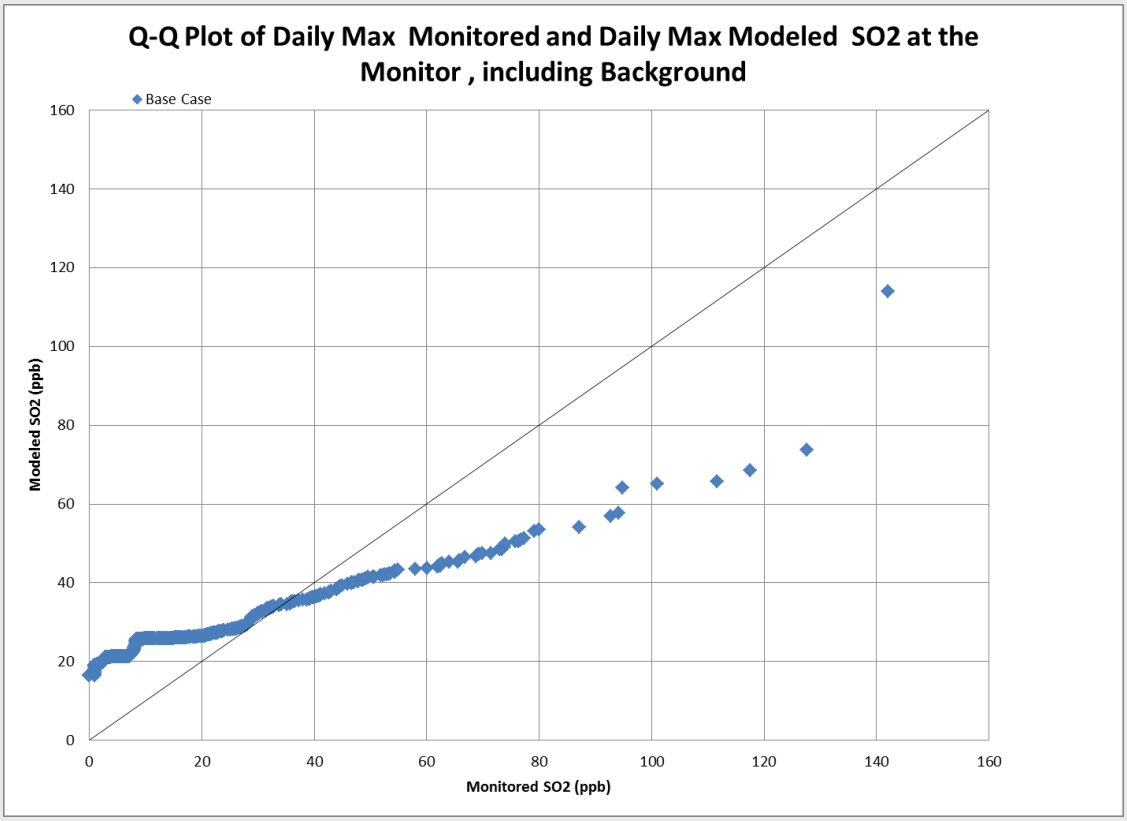

Figure 13. Daily maximum 1-hour SO_2 monitored vs. modeled values at the monitor.

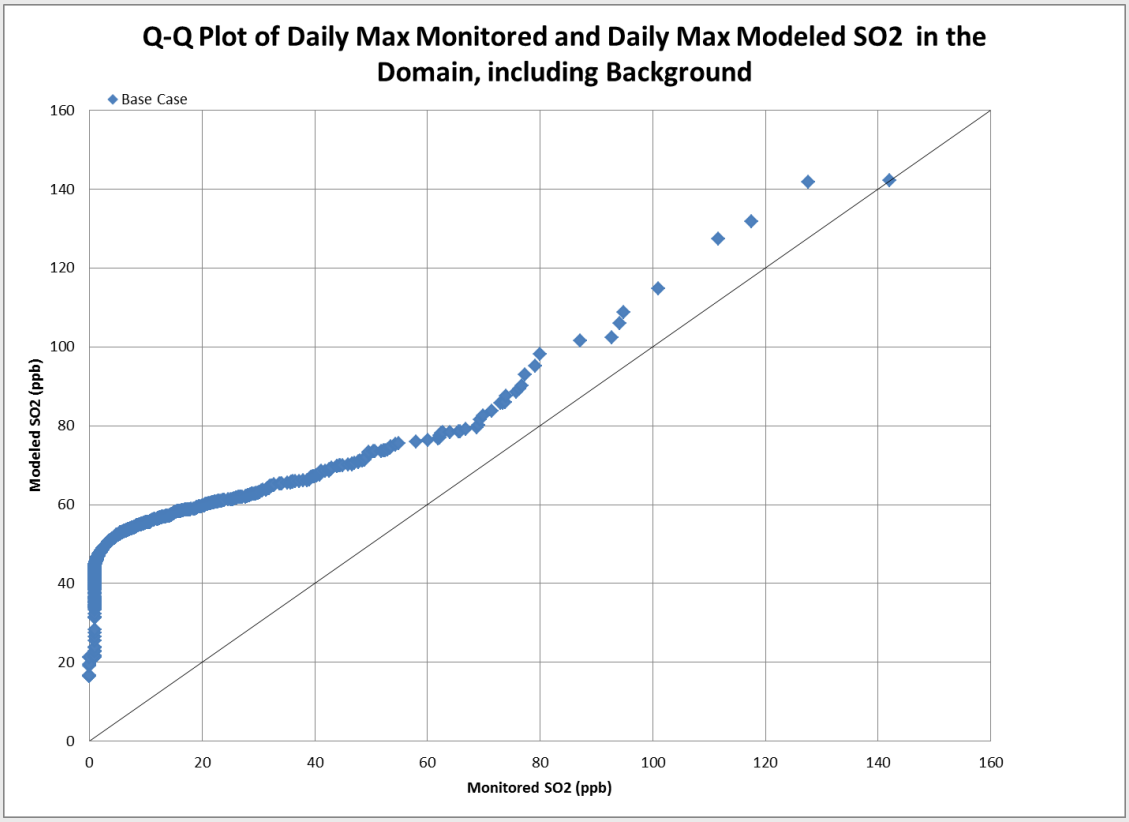

Figure 14. Daily maximum 1-hour SO_2 monitored vs. modeled values in the entire domain.

Ambient Monitoring Siting Assessment for 1-hour SO_2 NAAQS

Design values (DVs) were calculated by modeling with actual hourly SO_2 emissions (2011-2013) for IP-Savannah. The DVs are the 3-year average of each year's 4th highest daily 1-hour maximum SO_2 concentration, which is equivalent to the 99th percentile of daily 1-hour maximum concentrations. DVs provide a means to understanding the magnitude of ambient SO_2 concentrations across an area. Figure 15 shows the DVs for each modeled receptor. The red colors indicate higher DVs. The receptors with the top five (5) highest overall DVs are circled with mark 'X' in black, and are directly south of IP-Savannah. An additional analysis was performed to identify the receptors having the top 200, 100, 25, and 10 DVs. The results are shown in Figure 16.

In order to assess the frequency of occurrence of concentration maximum at a given receptor, an analysis was performed in AERMOD where the MAXDAILY option was used to output the maximum 1-hour concentration for each receptor for each day. This output was used to determine the number of days for which each receptor (with a minimum value of 60 ppb) was the overall highest 1-hour concentration over the 3 years that were modeled. A minimum threshold value of 60 ppb was applied since modeled values that are more than 20% below the NAAQS level should not be considered when trying to site a monitor for maximum impacts relative to the NAAQS. The results are shown in Figure17 and the receptor with the overall highest number of days (7 days) is circled with mark 'X' in black. The receptor with the highest frequency of having the daily 1-hour maximum concentrations is directly south of the IP-Savannah, but does not have a DV within the top 200.

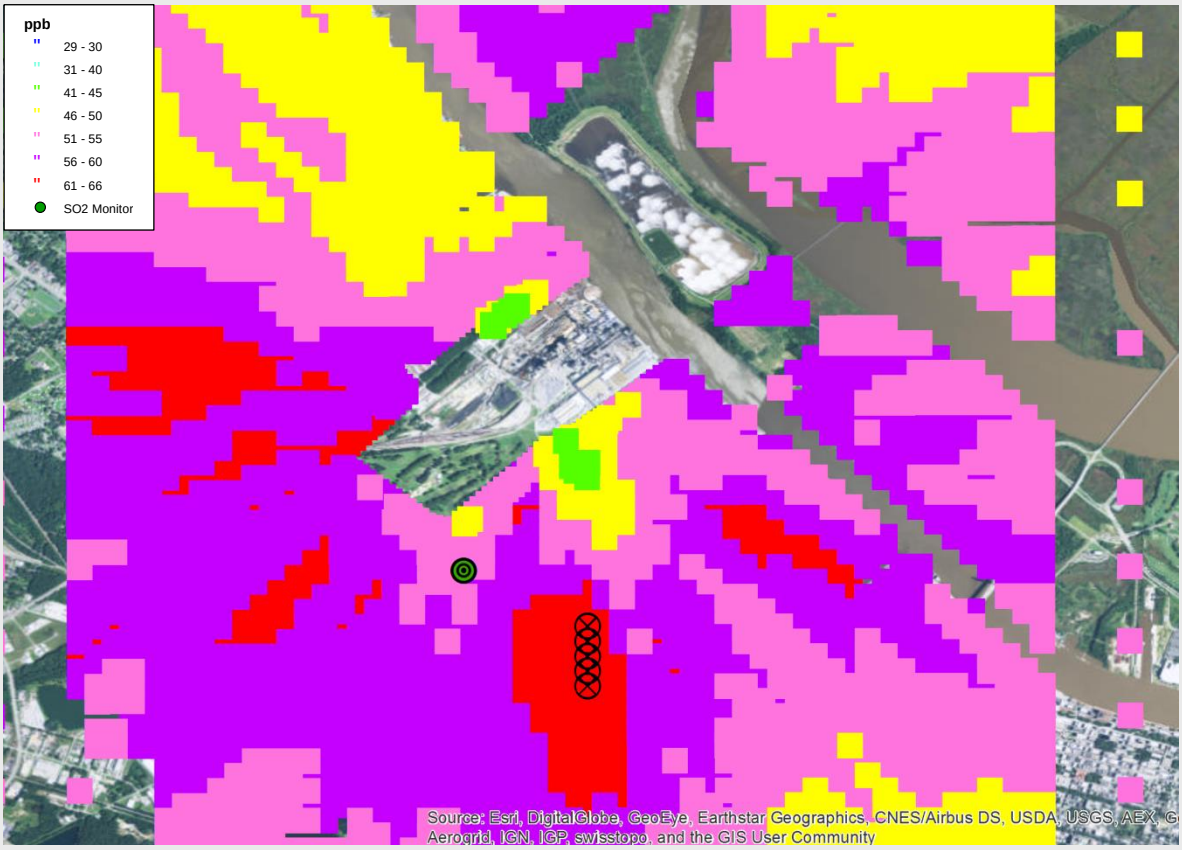

Figure 15. Design values near IP-Savannah. The top five (5) highest overall DVs are circled with mark 'X' in black.

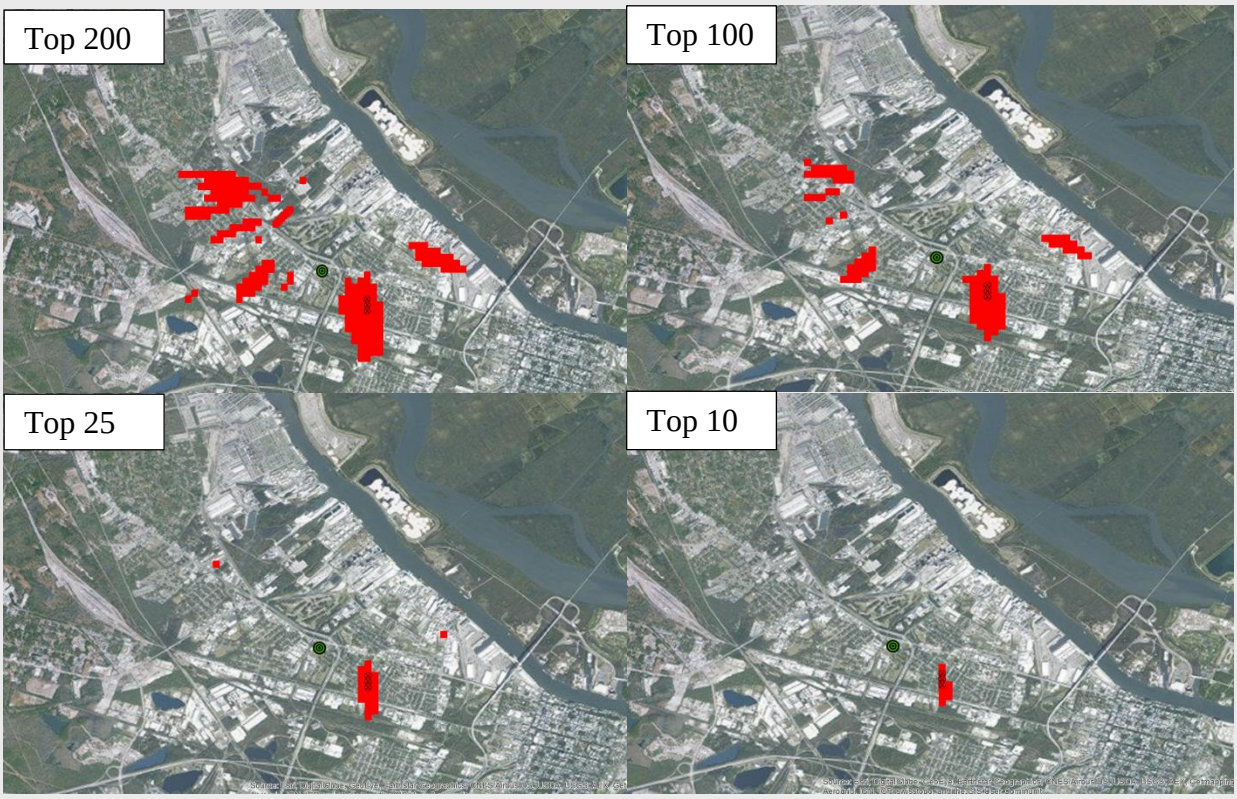

Figure 16. Locations of Top 200, 100, 25, and 10 normalized design values.

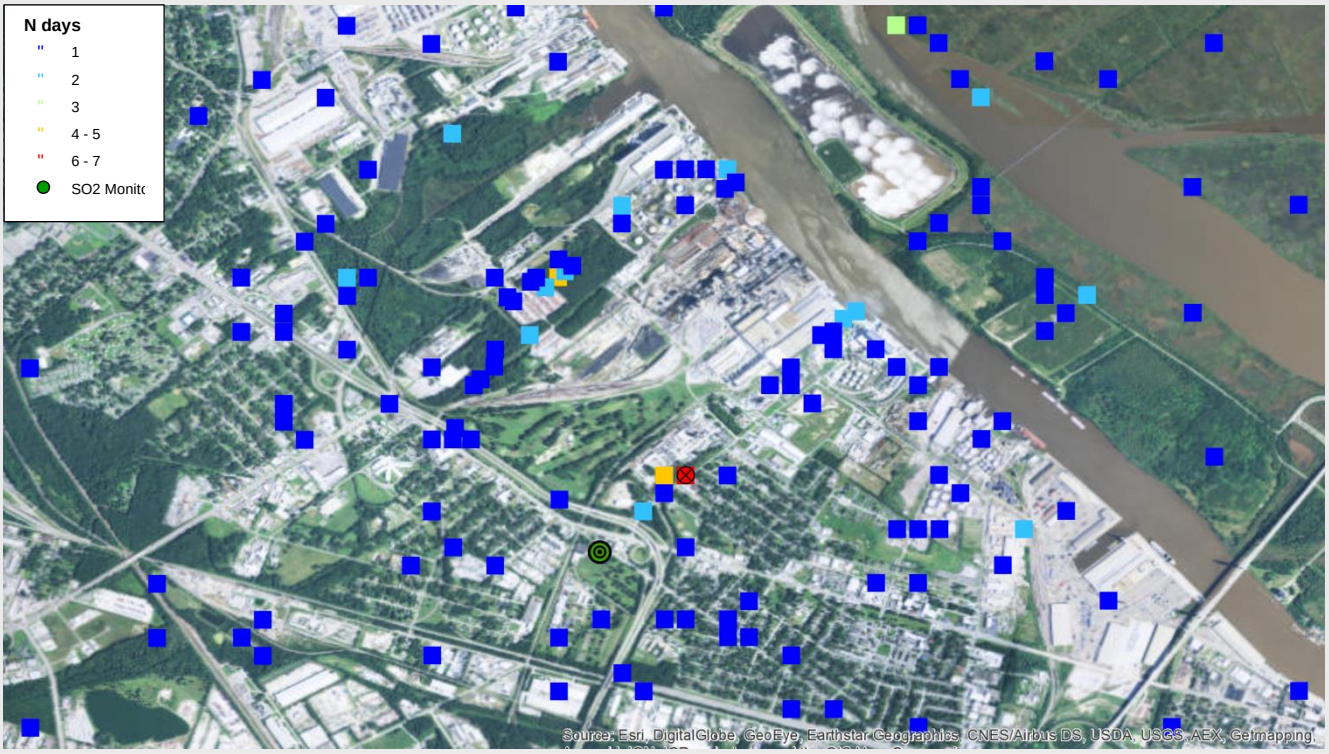

Figure17. Cumulative number of days that an individual receptor had the 1-hour daily maximum concentration among all receptors with a minimum threshold value of 60 ppb.

Figure 18 shows a relative prioritized placement of monitor locations for consideration using DVs and frequency of having the 1-hour daily maximum concentration (with a threshold value of 60 ppb). The scores are calculated by the sum of the rank of DVs and the rank of the number of days that the receptor had the 1-hour daily maximum concentration (with a threshold value of 60 ppb). Lower numerical scores indicate a higher probability of experiencing peak 1-hour SO_2 concentrations. The top 4 receptor locations are circled with mark 'X' in black and are directly south of IP-Savannah.

Although the current SO_2 monitor location is not exactly at the location with the lowest score, it is very close (less than 1 km). AERMOD is not designed to simulate the exact location of the maximum impact, but rather gives a distribution of probabilistic locations. Since there are no significant variations in the topography in the red arc, GA EPD feels that locating a SO_2 monitor anywhere within the red arc in Figure 18 would satisfy the requirement for measuring the maximum SO_2 impact. Since the current location of the Lathrop & Augusta SO_2 monitor (13-051-1002) falls within the red arc, GA EPD feels that this monitor is currently properly sited and can be used for future attainment demonstrations.

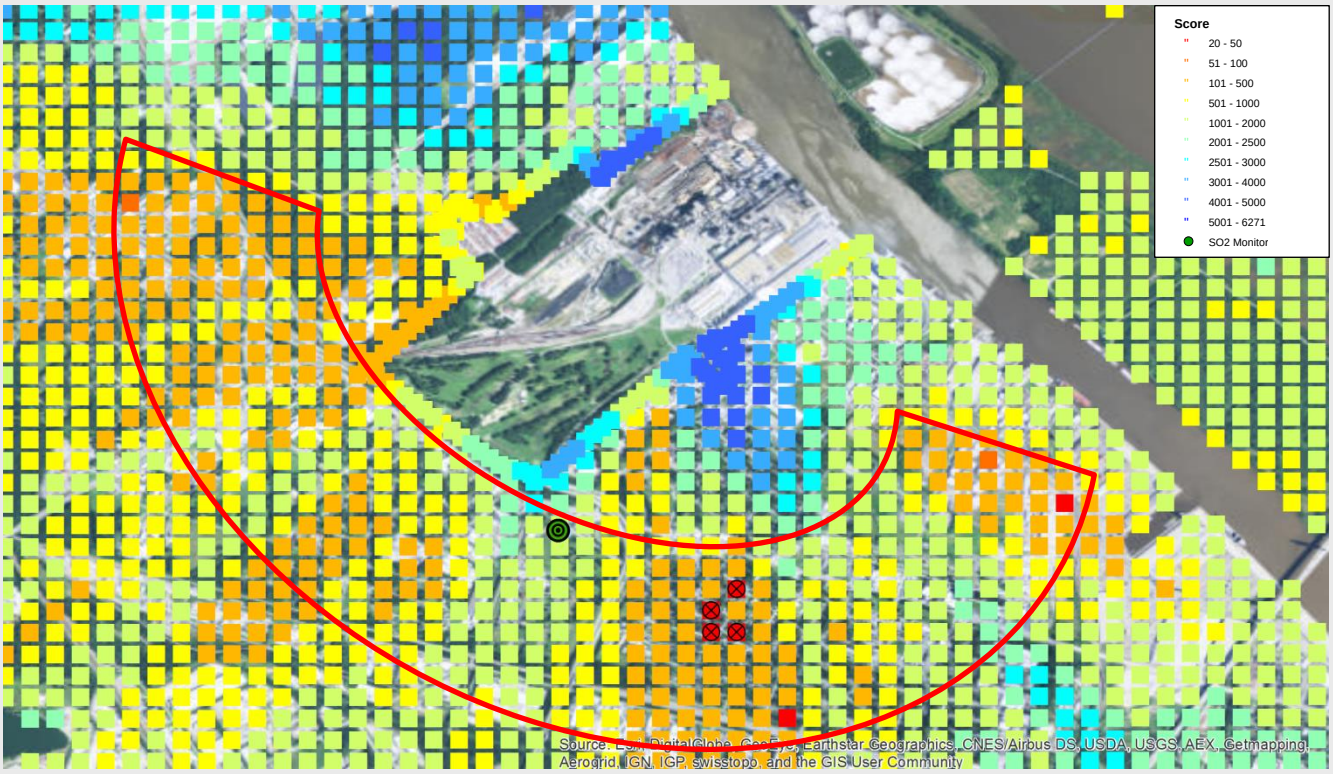

Figure 18. Scores reflecting DVs and frequency of having the 1-hour daily maximum in the domain. The red arc indicates locations where a SO_2 monitor could be placed to monitor maximum SO_2 impacts.

CONCLUSIONS

The Lathrop & Augusta SO_2 monitor (13-051-1002) dispersion modeling for the 2010 1-hour SO_2 NAAQS designations has been conducted in accordance with the final Data Requirements Rule (DRR) and Modeling Technical Assistance Document (TAD) using the most recently available information.

Based on the final modeling analysis, SO_2 emissions from IP-Savannah do not lead to any violations of the 1-hour SO_2 NAAQS. However, the modeling does indicate that SO_2 emissions from IP-Savannah can cause exceedances of the NAAQS. Since the Lathrop & Augusta SO_2 monitor is currently violating the NAAQS and IP-Savannah is the only significant SO_2 source contributing to exceedances of the NAAQS, GA EPD recommends that the land parcel including the IP-Savannah main mill and the area surrounding the Lathrop & Augusta SO_2 monitor (Jasper Spring Park) be designated nonattainment. Specifically, GA EPD recommends the following nonattainment area as shown in red outline in Figure 19 - Figure 21:

- The area of land bounded by the following description: south of the Savannah River, and east of Allen Blvd. and east of the western most part of Chip Mill Loop Road, and north of I-516, and west of the Seaboard Air Line Railway track extended to the Savannah River; and
- The area of land bounded by the following description: south of Augusta Avenue, and east of Old W. Lathrop Avenue, and north of Stratford Street, and east of the US-80/I-516 southbound entrance ramp.

Georgia EPD has demonstrated that the current location of the Lathrop & Augusta SO_2 monitor (13-051-1002) is representative of maximum SO_2 impacts. In early 2015, IP-Savannah changed from burning coal in the power boiler to burning natural gas (resulting in a 50% decrease in SO_2 emissions from IP-Savannah); therefore, it is very likely that this monitor will have a 2013-2015 design value which is below the NAAQS level of 75 ppb. Thus far in 2015, the 1^{st} high SO_2 value is 58 ppb and the 4^{th} high SO_2 value is 35 ppb. If the 99^{th} percentile 1-hour SO_2 maximum daily SO_2 concentration at the Lathrop & Augusta monitor is at or below 66 ppb, the 2013-2015 design value will not violate the NAAQS level of 75 ppb. In this case, Georgia EPD will early certify the SO_2 data at this monitor and immediately update our SO_2 designation recommendation from nonattainment to unclassifiable/attainment.

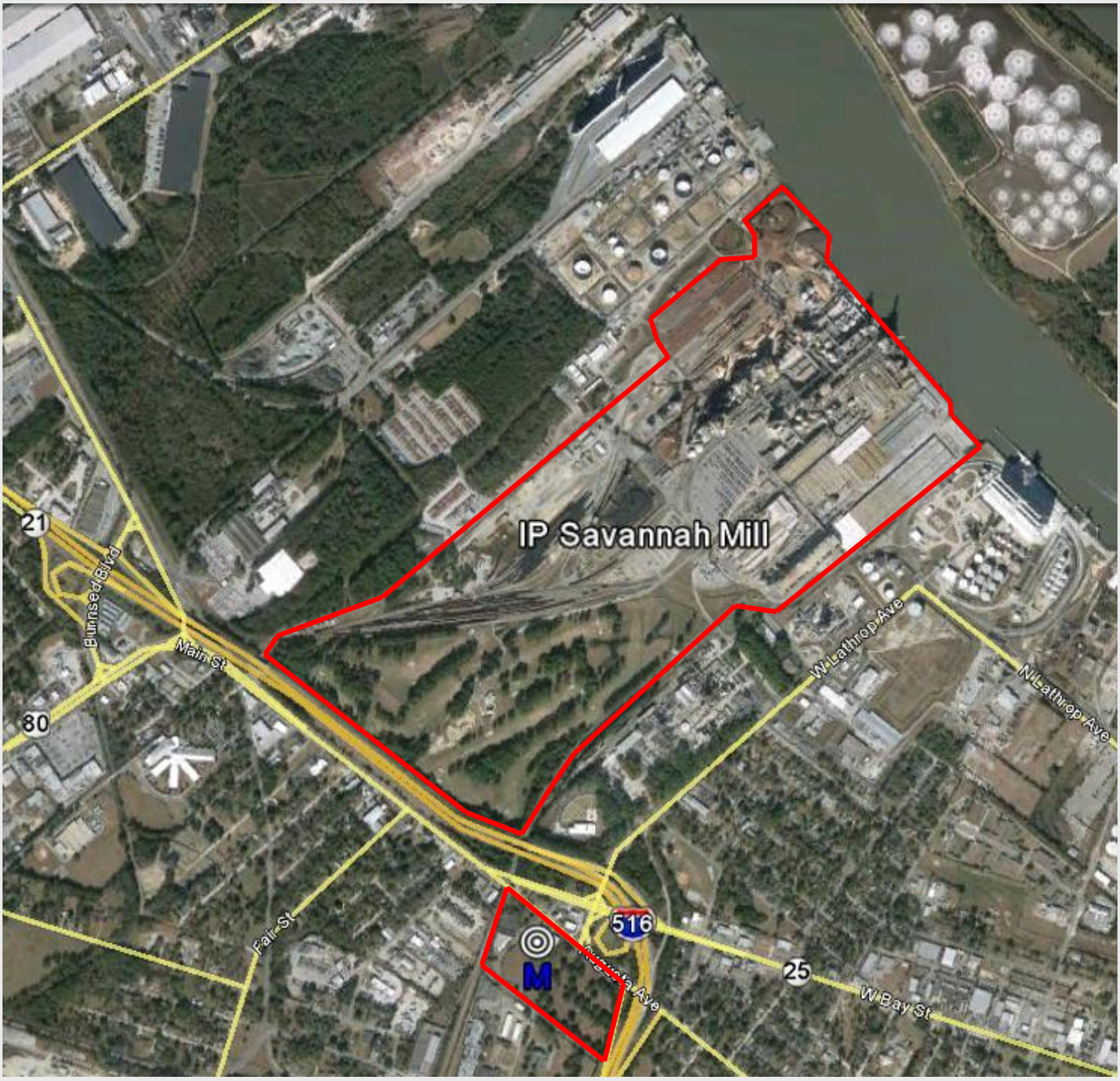

Figure 19. Google Earth map for nonattainment area recommendations for the IP-Savannah main mill and the area surrounding the Lathrop & Augusta SO_2 monitor (Jasper Spring Park).

Figure 20. Google Earth map blow-up for nonattainment area recommendations for the IP-Savannah main mill.

Figure 20. Google Earth map blow-up for nonattainment area recommendations for the area surrounding the Lathrop & Augusta SO_2 monitor (Jasper Spring Park).