Appendix W
Dispersion Modeling Analysis for Bay Shore Power Plant
2010 SO_2 NAAQS Recommended Designation

Introduction

The United States Environmental Protection Agency (U.S. EPA) established a new National Ambient Air Quality Standard (NAAQS) for SO_2 on June 22, 2010, of 75 ppb, as the 99th percentile of maximum daily values, averaged over three years. In addition, U.S. EPA revoked the primary annual and 24-hour standards.

Pursuant to the third round of designations and in accordance with the August 21, *2015 Data Requirements Rule for the 2010 1-Hour Sulfur Dioxide (SO2) Primary National Ambient Air Quality Standard (NAAQS); Final Rule*, Ohio EPA is submitting a designation recommendation for the First Energy Bay Shore Power Plant source area. This document supports Ohio's recommended designation of the Bay Shore source area based on refined dispersion modeling.

Per U.S. EPA's guidance (February 2016 *Draft SO_2 NAAQS Designations Modeling Technical Assistance Document* (herein referred to as "Modeling TAD"), "The primary objective of the modeling would be to determine whether an area currently meets the SO_2 NAAQS, and thereby indicate the designation process for the area". Ohio EPA is including this refined dispersion modeling analysis as a portion of the five-factor approach recommended by U.S. EPA in defining designation areas.

The dispersion modeling analysis was conducted for the 2012-2014 period, using actual hourly variable emissions from the Bay Shore plant, as well as the BP Husky facility, located approximately 2.5 kilometers to the southwest of the Bay Shore plant. An additional source, Chemtrade Refinery Solutions, was also included in the modeling domain, as this facility is co-located with the BP Husky facility. This modeling was done per the Modeling TAD, in which U.S. EPA recommends modeling the most recent 3 years of available actual emissions.

Temporally varying emissions were modeled to determine the contribution of emissions from each source in the modeling domain. Ohio EPA used variable emissions at the finest temporal scale available for each unit included in the modeling domain. Hourly variable emissions data for the 2012-2014 period were submitted to Ohio EPA by First Energy for all SO_2 sources at the Bay Shore plant. As described in Ohio's designation modeling protocol (Appendix B of the State of Ohio 2010 Revised Sulfur Dioxide National Ambient Air Quality Standard, Recommended Area Designations, Round 3 submittal), Part 75 emissions reporting data was used for the majority of hourly emissions, with data substitutions for some hours, as described in the modeling protocol. The BP Husky facility does not, for the majority of SO_2 sources, collect data at the hourly level. As such, the finest temporal scale for most units at the BP Husky facility was a daily average emission rate. Annual SO_2 emissions from 2014 were modeled for the Chemtrade facility. This facility emitted 28.8 tons in 2012, 12.3 tons in

2013, and 34.57 tons in 2014. This minor facility was conservatively modeled with the highest emissions rate (34.57 TPY) from amongst those years.

Modeling Approach

Per U.S. EPA's Modeling TAD,

> "Since the purpose here pertains to designations, this guidance supports analyses of existing air quality rather than analyses of emissions limits necessary to provide for attainment. Consequently, the guidance in this TAD differs in selected respects from the guidance published in Appendix W. These differences include:
>
> - Placement of receptors only in areas where it is feasible to place a monitor vs. all ambient air locations (NSR, PSD, and SIP)
> - Use of the most recent 3 years of actual emissions (designations) vs. maximum allowable emissions (NSR, PSD, and SIP)
> - Use of 3 years of meteorological data (designations) vs. one to five years (NSR, PSD, and SIP)
> - Use of actual stack height for designations using actual emissions vs. Good Engineering Practice (GEP) stack height for other regulatory applications (NSR, PSD, and SIP)"

Ohio EPA incorporated the differences listed above and followed Appendix W guidance where applicable to modeling for designation purposes. The averaging period for the 2010 SO_2 NAAQS is the 99th percentile of maximum monitored daily values, averaged over three years. Per the Modeling TAD, three years of National Weather Service data is sufficient to allow the modeling to simulate a monitor. Thus, the modeled form of the standard is expressed as the 99th percentile of maximum daily values averaged over three years (herein referred to as "design value") for the purposes of designation.

The recommended dispersion model for modeling for SO_2 designations is the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) modeling system. There are two input data processors that are regulatory components of the AERMOD modeling system: AERMET, a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts, and AERMAP, a terrain data preprocessor that incorporates complex terrain using United States Geological Survey (USGS) Digital Elevation Data. Additionally, Ohio EPA utilized the AERMINUTE module to incorporate 1-minute ASOS meteorological data into the hourly surface input file. Ohio EPA utilized the most up-to-date versions of AERMOD and the associated preprocessors available at the time of the attainment modeling analyses. These are as follows: AERMOD version 15181, AERMET version 15181, AERMINUTE version 14337, and AERMAP version 11103. All dispersion modeling for this submittal was conducted following Ohio EPA's designations modeling protocol, submitted on July 1, 2016. AERMOD and all associated preprocessors were run in the default regulatory mode.

Meteorological Data

In order to generate meteorological input data for use with AERMOD, AERMET, along with AERMINUTE and AERSURFACE preprocessing for the modeling domain was conducted to generate the surface (.sfc) and profile (.pfl). Ohio EPA used the AERMINUTE pre-processing module. This module accepts as input 1-minute ASOS meteorological surface observations, calculates an hourly average for each hour in the modeled time period, and substitutes any missing values from the co-located ISHD surface data. Use of AERMINUTE reduces the number of calm hours present in the input files, and these enhanced hourly files are therefore considered more representative of local meteorological conditions.

Meteorological data from 2012-2014 from surface station #4848 located at the Toledo Executive Airport (KTDZ) and the Toledo, Ohio upper air station (station #4830) located at the Detroit/Pontiac Airport were used in these analyses. These sites were determined to be representative of Lucas County, OH and the Bay Shore and BP Husky facilities. Additional surface stations were initially considered for these analyses, but were eliminated based on the orientation of both the surface station and the explicitly modeled facilities with respect to the shoreline of Lake Erie. AERSURFACE was run using twelve sectors and monthly surface characteristics, centered on the location of the surface meteorological station. Monthly precipitation values, years 2012-2014 from the Toledo International Airport were compared to the 30 year climatological averages to inform monthly surface characteristics. A composite wind-rose of annual trends and distribution of wind directions, years 2012-2014 from the surface station are shown in Figure 1, below.

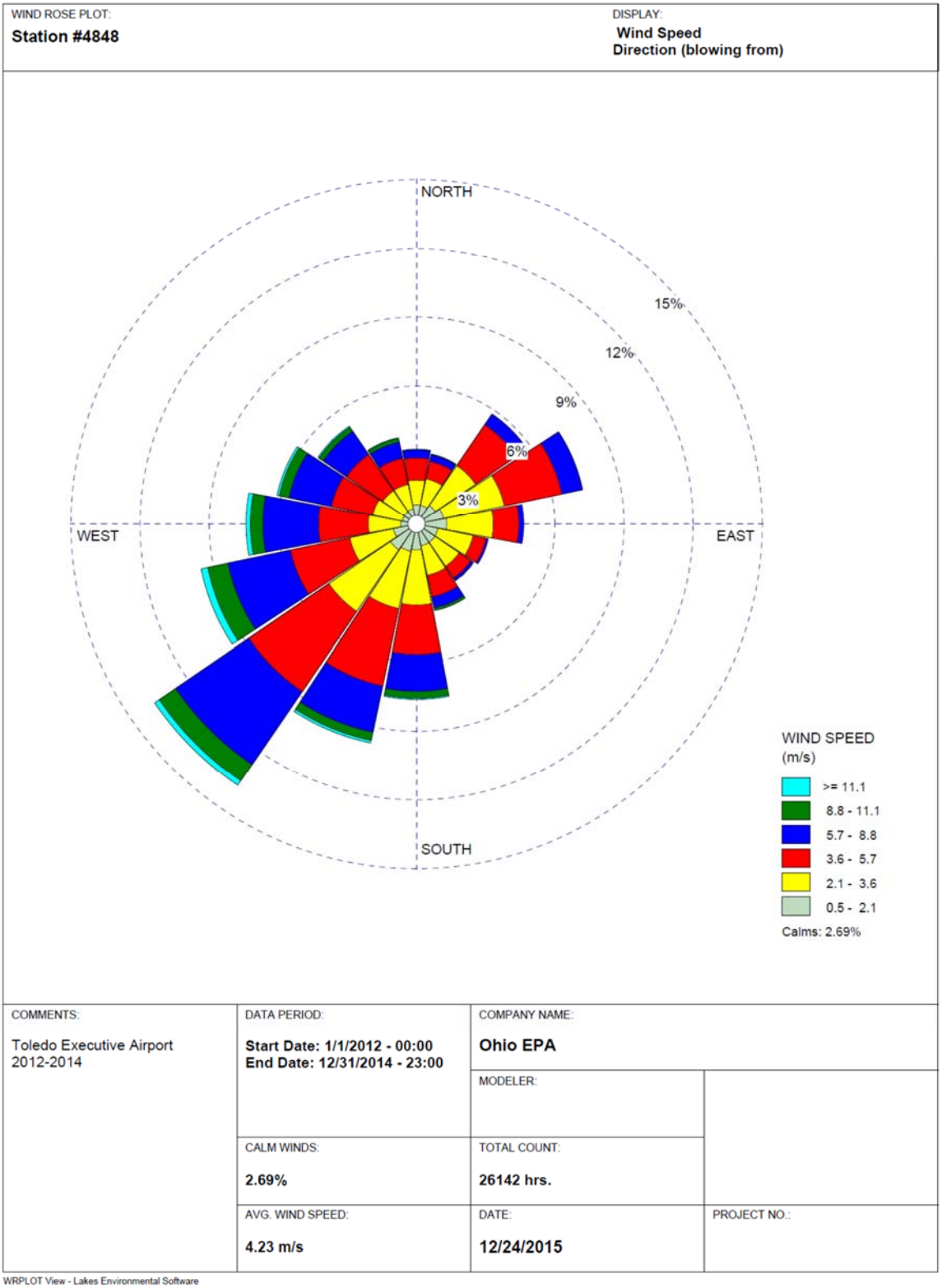

Figure 1: Wind rose, years 2012-2014, Toledo met station.

The predominant wind directions were used, in part, to inform which facilities within 50 kilometers to Bay Shore plant may potentially impact ambient SO_2 concentrations in the Bay Shore source area not accounted for by background and therefore necessitate inclusion in the dispersion modeling analysis. As shown in Figure 1, the predominant winds in the source area originate from the southwest, with a significant contribution from northeasterly winds. Figure 2 shows the location of all facilities within 50 kilometers, as well as a composite wind rose, years 2012-2014, from the Toledo meteorological station.

Figure 2: SO_2 sources within 50 km of the Bay Shore Power Plant, with 2012-2014 composite wind rose.

Considering the predominant wind directions, Ohio does not conclude that the emissions from those large sources located in Michigan (J.R. Whiting, Gerdau MacSteel Monroe, and DTE Monroe), north-northeast of the Bay Shore plant, impact ambient SO_2 concentrations in Lucas County[1]. This conclusion is further supported by the pending closure of the J.R. Whiting plant in April of 2016, as well as the significant distance between the Bay Shore plant and the DTE Monroe and Gerdau MacSteel facilities.

1 Ohio EPA anticipates emissions from the DTE Monroe plant will not cause or contribute to violations in Lucas County. However, the DTE Monroe plant will likely be analyzed separately under U.S. EPA's Data Requirements Rule in the future by the Michigan Division of Environmental Quality.

Ohio does not conclude that emissions from these sources impact ambient SO_2 concentrations beyond the background level accounted for in the refined dispersion modeling analysis. Wind direction data and proximity suggests that emissions from BP Husky would potentially impact ambient SO_2 concentrations, and therefore this source was explicitly modeled. Predominant wind directions indicate also that emissions from the facilities in Ottawa and Sandusky Counties to the southeast would not impact the source area beyond what is accounted for by background concentration.

Ohio concludes that the primary sources of SO_2 in the Bay Shore source area are the Bay Shore and BP Husky facilities, and that the impact of those facilities within 50 kilometers not explicitly modeled or shutdown prior to the January 13, 2017 deadline for submittal of recommended designations are represented adequately and conservatively by the background concentration included in the modeling analysis.

Background

Ohio EPA applied background concentrations of SO_2 to all modeled results under all scenarios. As described in Appendix O of the State of Ohio 2010 Revised Sulfur Dioxide National Ambient Air Quality Standard, Recommended Area Designations, Round 3 submittal, Ohio EPA utilized a seasonally and hourly variable background for the Bay Shore source area. This was done to account for the strong seasonal and hourly variation of SO_2 observed at monitor 39-095-0008. Background concentrations are shown in Figure 3.

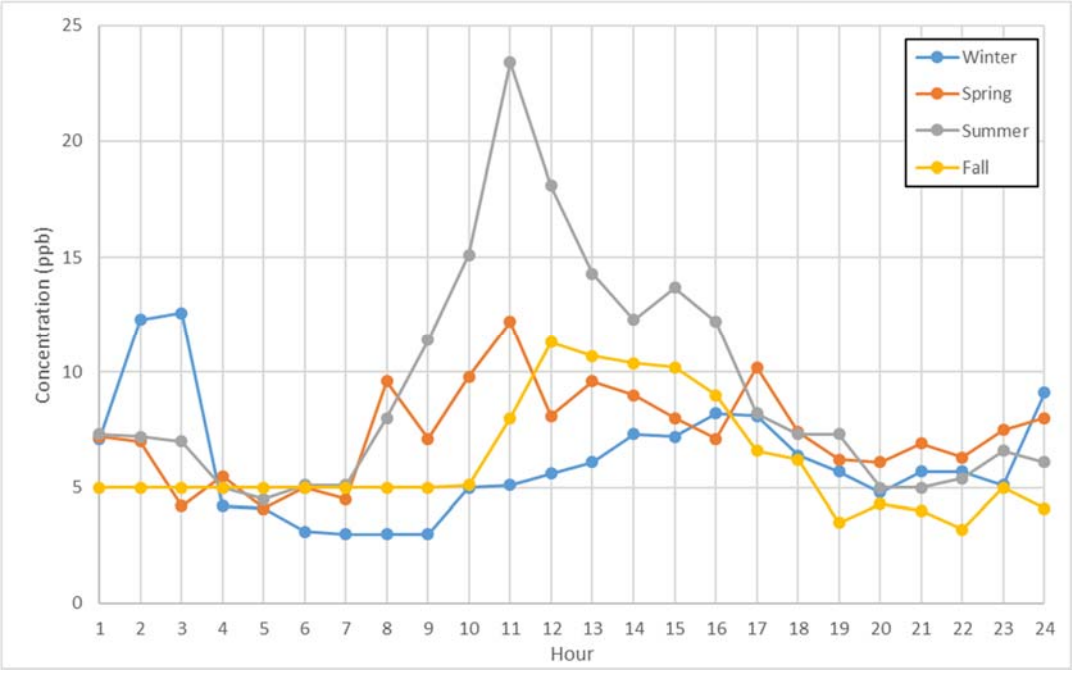

Figure 3: Hourly and seasonally variable SO_2 background, derived from air quality monitor 39-095-0008.

Emission Sources

The singular SO_2 emission source at the Bay Shore plant was included in the designation modeling analysis as a single egress point. This unit is a circulating fluidized bed pet-coke fired boiler. The coal fired boilers located at the Bay Shore plant permanently ceased operation in September of 2012, and were therefore not included in Ohio EPA's modeling analysis (Appendix X of the State of Ohio 2010 Revised Sulfur Dioxide National Ambient Air Quality Standard, Recommended Area Designations, Round 3 submittal). Variable emissions for all sources, with the exception of the coker drum at the BP Husky facility, were included in the model via the HOUREMIS input pathway, years 2012-2014. As described above, total emissions from the Chemtrade facility were modeled as a single egress point with a fixed emission rate and the average flow and temperatures reported for this facility. Ohio EPA utilized the 1-hour SO_2 design value output option internal to the AERMOD code to simplify post processing and eliminate the need to generate large hourly output files. Ohio EPA included background as a separate source in the model, to simplify the analysis of the seasonally variable backgrounds used in the modeling domain. The relevant release point parameters for the emission units included in the analysis are presented in Table 1, below. All emissions sources included in the modeling were treated as point sources, with the exception of the coker drum at the BP Husky facility, which was modeled as a volume source.

	Source ID	Source Description	Easting (X)	Northing (Y)	Base Elevation	Stack Height	Temperature	Exit Velocity	Stack Diameter	SO2
			(m)	(m)	(m)	(m)	(K)	(m/s)	(m)	(lb/hr)
Bay Shore	B006	Circulating fluidized bed (CFB) boiler	297049.00	4618409.00	177.08	91.440	Variable	Variable	3.6576	Variable
Chemtrade	CT0102	Chemtrade (P001 and P002)	295617.89	4617350.64	178.31	36.576	349.82	12.29	1.2009	7.89
BP Husky	BPB001	Hydrogen Plant Reformer Furnace	295952.19	4616914.65	177.79	56.388	Variable	Variable	2.56	Variable
	BPB005	Reformer 2 Regeneration Gas Heater	296011.69	4617041.15	178.02	21.336	Variable	Variable	1.143	Variable
	BPB006	Reformer 2 Furnace	296011.69	4617007.15	178.09	45.720	Variable	Variable	2.7432	Variable
	BPB008	Isocracker 2 Feed Heater	295996.29	4616923.35	178.24	45.720	Variable	Variable	1.372	Variable
	BPB009	Isocracker 2 Stabilizer Reboiler	296076.59	4616946.35	178.31	45.720	Variable	Variable	1.829	Variable
	BPB013	Reformer 1 Regen Heater	295724.99	4616868.05	177.77	11.461	Variable	Variable	0.762	Variable
	BPB015	Reformer 1 Preheater	295708.09	4616900.55	177.70	36.576	Variable	Variable	3.557	Variable
	BPB017	Coker 2 Furnace	295749.99	4617072.25	176.78	41.148	Variable	Variable	1.3106	Variable
	BPB018	FCC Preheater	295717.39	4616976.55	177.19	35.052	Variable	Variable	1.8898	Variable
	BPB019	Crude/Vac 2 Furnace	295829.59	4617076.55	177.39	44.196	Variable	Variable	2.5908	Variable
	BPB029	ADHT Heater	295858.49	4616856.75	177.39	30.480	Variable	Variable	1.0668	Variable
	BPB030	West BGOT Heater	295959.79	4616872.15	177.87	43.282	Variable	Variable	1.2192	Variable
	BPB032	Coker 3 Furnace	295609.99	4617074.85	176.82	53.340	Variable	Variable	3.048	Variable
	BPB033	East BGOT Heater	295996.25	4616889.36	178.24	30.480	Variable	Variable	1.524	Variable
	BPB034	East Alstom Boiler	295649.09	4617000.45	177.09	30.785	Variable	Variable	1.905	Variable
	BPB035	West Alstom Boiler	295636.09	4616991.75	177.09	30.785	Variable	Variable	1.905	Variable
	BPB036	Reformer 3 Heater	296036.47	4617182.16	178.00	65.532	Variable	Variable	3.7582	Variable
	BPB053	Tank heaters (T115 & T116)	296773.03	4616954.44	178.20	14.630	Variable	Variable	0.9144	Variable
	BPB903	asphalt tank heater (T175, T176)	296777.46	4616954.44	178.24	14.630	Variable	Variable	0.9144	Variable
	BPP007	FCCU/CO Boiler	295663.59	4616987.35	177.09	75.286	Variable	Variable	3.353	Variable
	BPP009	SRU 1	295438.59	4617024.46	177.64	69.494	Variable	Variable	1.0668	Variable
	BPP037	SRU #2 & #3	295471.09	4617061.16	177.35	53.340	Variable	Variable	1.524	Variable
	BPP003	East Hydrocarbon Flare	296067.97	4617030.16	178.31	105.313	Variable	Variable	0.7824	Variable
	BPP004	West Hydrocarbon Flare	295717.13	4617026.82	176.78	104.729	Variable	Variable	2.3177	Variable
	BPP049	East Acid Gas Flare	296068.38	4617029.93	178.31	54.563	Variable	Variable	0.4712	Variable
	BPP050	TRP SRU Acid Gas Flare	295441.13	4617067.69	177.61	54.563	Variable	Variable	0.4712	Variable
	BPP051	SRU#1 Acid Gas Flare	295405.27	4617024.28	177.70	54.563	Variable	Variable	0.4712	Variable
	Source ID	**Source Description**	**Easting (X)**	**Northing (Y)**	**Base Elevation**	**Release Height**	**Horizontal Dim.**	**Vertical Dim**	**Stack Diameter**	**SO2**
	P036_BP	Coker 3 Drum	295643.29	4617064.65	176.78	4.572	6.8048	0.5671	NA	0.137

Table 1: Modeled source parameters, Bay Shore source area, 2012-2014

Ohio EPA, via outreach and consultation with the Bay Shore plant, identified erroneous emissions data resulting from faults in the continuous emissions monitors at the facility, Part 75 data substitutions, and other sources of erroneous emissions data. Similar outreach was conducted for the BP Husky facility.

Table 2 presents 2014 SO_2 emissions for all sources greater than 1 TPY of SO_2 within 50 kilometers of Bay Shore plant. There were 18,645.81 TPY of actual SO_2 emissions in 2014 from sources with emissions greater than 1 TPY within 50 kilometers of the Bay Shore plant. Figure 1 shows the location of the Bay Shore and BP Husky facilities, as well as those facilities located within 50 kilometers of the Bay Shore plant, as described here. 5,335.55 TPY of actual 2014 SO_2 emissions originated from sources located in Ohio. Ohio EPA explicitly modeled emissions from the Bay Shore plant (2,002.42 tons), the BP Husky facility (1,618.25 tons), and the much smaller Chemtrade Refinery Solutions facility (34.57 tons), which account for approximately 69% of 2014 emissions from Ohio sources located within 50 kilometers of the Bay Shore plant.

The next largest source of 2014 SO_2 emissions in the Ohio portion of the Bay Shore source area is the Graymont Dolime facility (809.73 tons). This facility is located 21.55 kilometers to the southeast of the Bay Shore plant, and emissions from this source are unlikely to cause a significant concentration gradient above that of background in the areas impacted by emissions from the Bay Shore plant, given the distance between the facilities and the prevailing winds of the source area (Figure 2). The remaining sources located in Ohio, Pilkington North America (405.89 tons, 14 kilometers from Bay Shore), Libbey Glass (130.01 tons, 7 kilometers from Bay Shore), and Toledo Refining (176.5 tons, 7.6 kilometers from Bay Shore), were considered via Ohio EPA's background concentration. These sources are located such that the impact of these sources would be reflected by monitored SO_2 concentrations recorded at monitoring site 39-095-0008, from which Ohio EPA determined the representative background concentrations for the Bay Shore source area (Figure 4). Further, the largest of these remaining sources, Pilkington North America, is located 14 kilometers from Bay Shore. Given this distance and the relatively low emissions from this facility, it is unlikely that impacts from this facility, beyond what is accounted for by background would occur. It should also be noted here that the maximum impacts of the explicitly modeled sources occurred less than 1 kilometer distant from the facilities, and that the extent of significant impacts is limited to a small area around the facilities.

Figure 4: Location of background monitor 39-095-0008 and significant sources in the Bay Shore source area.

In addition to those sources in Ohio, Ohio EPA worked with the Michigan Division of Environmental Quality to identify those sources in Michigan within 25 kilometers of the Bay Shore plant. The largest of these sources, the J.R. Whiting plant (6,439 tons), is located 11 kilometers to the north-northwest of the Bay Shore plant. This facility permanently shutdown all coal fired boilers April 15, 2016. As such, this facility's emissions were not included for further consideration in the modeling domain. In addition to this facility, Ohio EPA identified the DTE Monroe Power Plant (6,286 tons) and the Gerdau MacSteel Monroe facility (23.6 tons) as additional SO_2 sources. These facilities are located approximately 23 km to the north-northeast of the Bay Shore plant. Given this distance and the prevailing winds of the source area, it is unlikely that those areas where Bay Shore emissions have significant impacts are impacted by emissions from these sources. Therefore, Ohio EPA did not include these sources in the modeling domain.

Examination of the composite wind rose (Figure 2 above) from the Toledo Executive Airport meteorological station would indicate that the predominant wind directions are primarily from the southwest, with significant contribution from northeasterly winds. This is consistent with the diurnal and annual variation of wind directions driven by the proximity of the meteorological station to Lake Erie.

State	County	Facility ID	Facility Name	2014 SO2 Emissions (TPY)	Distance from Bay Shore (km)
OH	Lucas	0448020006	FirstEnergy Generation LLC, Bay Shore Plant	2,002.42	--
OH	Lucas	0448020007	BP-Husky Refining LLC	1,618.25	2.5
OH	Lucas	0448010246	Toledo Refining Company, LLC.	176.50	7.6
OH	Lucas	0448010066	Libbey Glass Inc.	130.01	7.0
OH	Lucas	0448000012	Johns Manville/Plant #1	109.60	29
OH	Lucas	0448020014	Chemtrade Refinery Solutions	34.57	1.9
OH	Lucas	0448011196	The Andersons, Inc.	17.36	11
OH	Lucas	0448030014	Stoneco Plant #110	3.18	23
OH	Lucas	0448010737	City of Toledo Water Reclamation	1.63	4
			Lucas Total	***4,093.52***	
OH	Ottawa	0362000079	Graymont Dolime (OH), Inc.	809.73	22
OH	Ottawa	0362000009	Materion Brush	15.19	29
OH	Ottawa	0362010118	Port Clinton Landfill	2.63	40
			Ottawa Total	***827.55***	
OH	Wood	0487010012	Pilkington North America, Inc.	405.89	14
OH	Wood	0387040084	Bower's Asphalt and Paving	3.65	13
OH	Wood	0387000377	Troy Energy LLC	2.82	24
OH	Wood	0387000259	Evergreen Recycling	2.12	12
			Wood Total	***414.48***	
MI	Wayne	N5986	Carleton Farms Landfill	20.62	45
			Wayne Total	***20.62***	
MI	Monroe	B2846	J. R. Whiting	6,439.30	11

State	County	Facility ID	Facility Name	2014 SO2 Emissions (TPY)	Distance from Bay Shore (km)
MI	Monroe	B2816	DTE Electric Company - Monroe Power Plant	6,286.29	23
MI	Monroe	B1877	Guardian Industries	539.34	45
MI	Monroe	B7061	Gerdau MacSteel Monroe	23.66	23
MI	Monroe	N6837	Rock Recyclers	1.05	43
			Monroe Total	***13,289.64***	
			Grand Total	***18,645.81***	

Table 2: 2014 annual SO_2 emissions, Bay Shore Plant and nearby sources.

Analysis

The designation modeling analysis consisted of a single modeling run, years 2012-2014. The results of this analysis are to be used to inform the designation process for the area surrounding the Bay Shore plant. Additionally, Ohio EPA conducted a separate modeling run to assess the impact of the Bay Shore, BP Husky, and Chemtrade facilities on receptors located within the fenceline of each facility.

Receptors

A total of 32,069 receptors were included in the modeling domain for the purposes of designations modeling. A smaller receptor grid, consisting of 195 receptors, was utilized for the analysis of inside the fenceline impacts, uniformly spaced at 150 meters. The designations modeling grid consisted of several nested receptor grids, with increased spacing for grids located further from the sources. 50 meters spacing was used along the fencelines of both the Bay Shore and BP Husky facilities, and a 50 meters spacing to 2 kilometers from these fencelines was used. The dense grid around the facility was informed by screen modeling to ensure that the point of maximum impact would be located within this densely-spaced grid. 100 meters spacing was used within 4 kilometers of the fenceline, 250 meters spacing was used to 7 kilometers from the fenceline, and a 500 meters spacing was used to 12 kilometers from the fenceline. Beyond 12 kilometers, a 1,000 meters spacing was used to 25 kilometers distant. 2,500 meter and 5,000 meter spacing were used to a distance of 35 and 50 kilometers, respectively. Figure 5 shows the location of the facilities as well as the receptor grid used. For clarity, receptors beyond 25 kilometers are not shown.

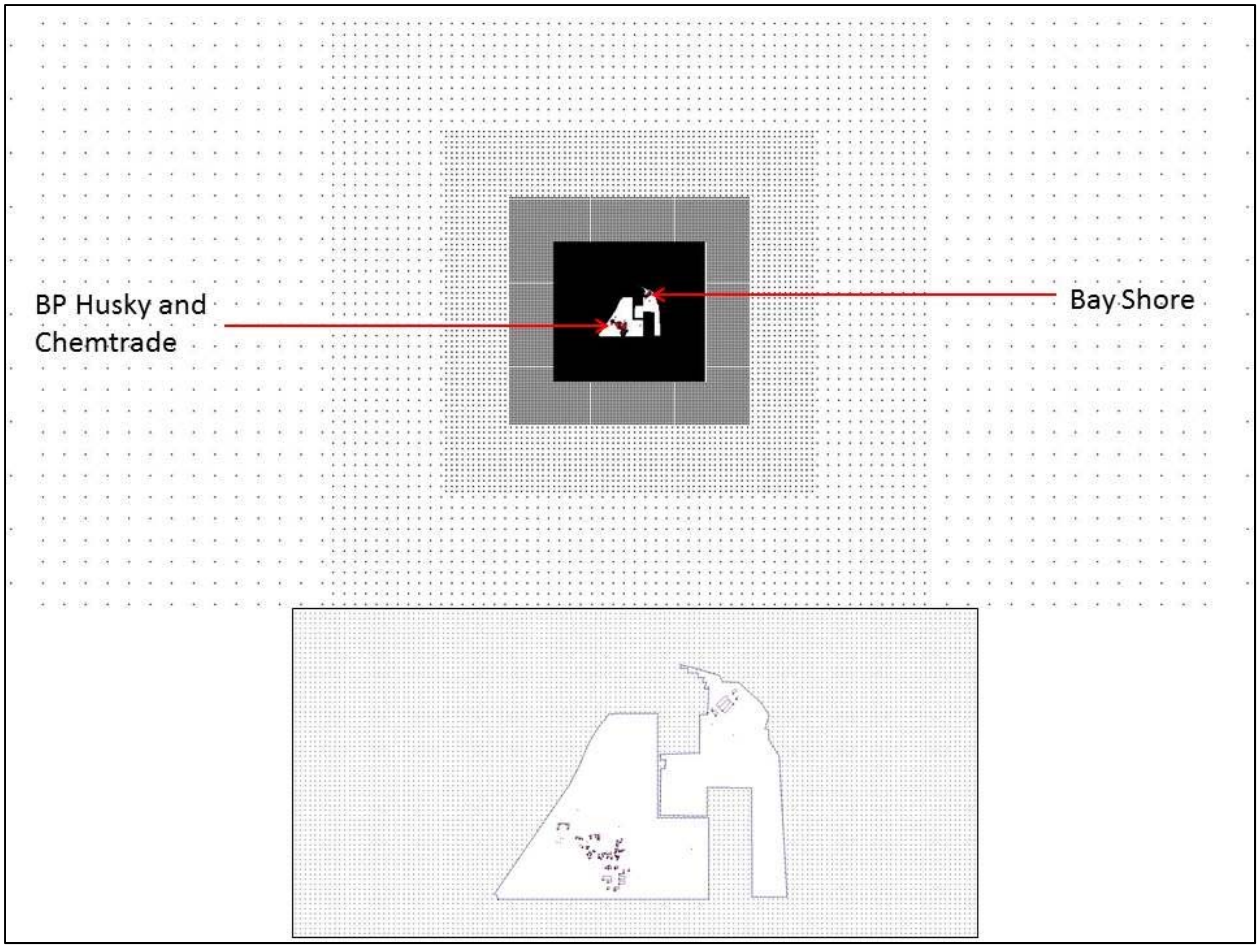

Figure 5: Bay Shore and BP Husky facilities and receptor grid. Dense grid and fencelines, inset.

Results

The dispersion modeling analysis evaluated the impact of the Bay Shore and BP Husky facilities as a design value when modeled using hourly variable SO_2 emissions. Any maximum impact exceeding 196.2 $\mu g/m^3$ would represent a modeled exceedance, as seasonal and hourly varying backgrounds were included as a source in the modeling domain. For this analysis, the maximum modeled 3-year design value, years 2012-2014, was 175.29812 $\mu g/m^3$. Thus, no exceedance of the standard was modeled. The results of this analysis are shown in Figure 6. Note that for clarity, only design values of 150 $\mu g/m^3$ or greater are displayed.

Figure 6: Maximum SO_2 impacts, Bay Shore and BP Husky facilities, 2012-2014. Concentrations in μg/m^3.

The maximum modeled concentration, 175.29812 ug/m3, or 67.01 ppb including background, was modeled approximately 940 meters from the egress point at the Bay Shore plant. The primary contributor to the maximum design value was emissions from the Bay Shore plant.

In addition to the designations modeling, Ohio EPA conducted a modeling exercise to determine the impact of the individual facilities on ambient air quality within the fenceline of the other's facility. For this analysis, meteorological data, emissions, and model input parameters were identical to those used for the full designations modeling analysis, including background. Ohio EPA modeled no exceedance of the standard under multiple scenarios: cumulative impacts of all facilities, individual facility impacts, and combinations of cumulative impacts from pairs of facilities. The largest inside-the-fenceline design value observed under all modeled scenarios was 169.40486 μg/m^3 including background. This value was modeled as the combined impact of all units in the modeling domain. This would indicate that emissions from an individual facility or combination of facilities in the modeling domain will not cause or contribute to an exceedance of the standard inside the fenceline of another facility.

The dispersion modeling analysis for the designation of the area surrounding the Bay Shore plant including emissions from the BP Husky facility and a seasonally varying

background demonstrates no modeled exceedances of the 2010 SO_2 standard based on the 2012-2014 period. Ohio EPA's analysis also demonstrates that these facilities neither cause nor contribute to modeled exceedances of the standard within the facility fencelines. Further, dispersion modeling performed with the AERMOD model accounts for multiple aspects of the five-factor analysis emphasized by U.S. EPA in designating areas. As such, Ohio EPA asserts that the modeling results presented here should carry significant weight in the designation process.