ETHYLENE OXIDE EMISSIONS IMPACT ASSESSMENT

Project Oasis – Tucson Arizona

Prepared By:

TRINITY CONSULTANTS
3495 Piedmont Road
Building 10, Suite 905
Atlanta, GA 30305
(678) 441-9977

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1. ETHYLENE OXIDE EMISSIONS IMPACT ASSESSMENT

BD is in the process of obtaining the necessary approvals for construction and operation of an ethylene oxide sterilization facility in Tucson, Arizona. Although not directly required as part of the air permitting process by the applicable air permitting regulatory authority, the Pima County Department of Environmental Quality (PDEQ), this modeling assessment is being provided for the air permitting record for the facility for future potential reference.

This assessment included dispersion modeling for ethylene oxide (EtO) from the Project Oasis facility.

1.1 Modeling Assessment

Modeling conducted was done with the AERMOD (v19191) dispersion model. Meteorological data utilized for the modeling assessment was obtained from the Arizona Department of Environmental Quality website.[1] Meteorological data utilized was processed using AERMET (v19191), with the adjusted surface friction velocity option (ADJ_U*). Five consecutive years of meteorological data (2014-2018) were utilized in the modeling assessment, with surface and upper air meteorological data from the Tucson International Airport utilized in the modeling analysis. Further information regarding the meteorological data utilized in this modeling assessment can be found in Section 1.1.5. This assessment was performed in accordance with the *Guideline*.[2]

1.1.1 Source Parameters

Ethylene oxide emissions were modeled as point sources from eight specific facility stack locations, three facility dry bed emissions control systems (representing 6 stacks) and 2 catalytic oxidation emissions control systems. For point sources, AERMOD requires the stack height (m), inside stack exit diameter (m), temperature (K), and exit gas velocity (m/s) to be specified. Table 1-1 provides a summary of the location and stack parameters used in the dispersion model for the point sources. The modeled emission rate for the facility is based on current facility potential emission estimates.

[1] http://www.azdeq.gov/aermet-data-files

[2] 40 CFR Part 51, Appendix W, the Guideline on Air Quality Models – January 2017 (https://www.epa.gov/scram/clean-air-act-permit-modeling-guidance)

Table 1-1. Point Source Parameters

Source	Description	Easting (meter)	Northing (meter)	Modeled Emissions (lb/yr)	Modeled Emissions (lb/hr)	Modeled Emissions (g/s)	Stack Height (ft)	Stack Height (m)	Stack Temperature (F)	Stack Temperature (K)	Exit Velocity (ft/s)	Exit Velocity (m/s)	Stack Diameter (ft)	Stack Diameter (m)
DB1A	WIP Ventilation	515,331.8	3,556,055.7	131.75	1.50E-02	1.90E-03	44	13.41	70	294.26	42.2	12.86	3.17	0.966
DB1B	WIP Ventilation	515,322.4	3,556,046.1	131.75	1.50E-02	1.90E-03	44	13.41	70	294.26	42.2	12.86	3.17	0.966
DB1C	WIP Ventilation	515,318.1	3,556,041.3	131.75	1.50E-02	1.90E-03	44	13.41	70	294.26	42.2	12.86	3.17	0.966
DB1D	WIP Ventilation	515,309.1	3,556,031.8	131.75	1.50E-02	1.90E-03	44	13.41	70	294.26	42.2	12.86	3.17	0.966
DB2	DLC Ventilation	515,338.0	3,556,062.2	79	9.02E-03	1.14E-03	44	13.41	70	294.26	50.6	15.42	3.17	0.966
DB3	Gas Rooms Ventilation	515,412.5	3,555,997.7	13	1.48E-03	1.87E-04	44	13.41	70	294.26	48.98	14.93	1.316	0.401
CATOX1	Process Emissions	515,450.4	3,556,022.4	44.8	5.11E-03	6.44E-04	50	15.24	135	330.37	31.3	9.54	2	0.610
CATOX2	Process Emissions	515,456.3	3,556,016.3	44.8	5.11E-03	6.44E-04	50	15.24	135	330.37	31.3	9.54	2	0.610

1.1.2 Land Use Classification

Classification of land use in the immediate area surrounding a facility is important in determining the appropriate dispersion coefficients to select for a particular modeling application. The selection of either rural or urban dispersion coefficients for a specific application should follow one of two procedures. These include a land use classification procedure or a population-based procedure to determine whether the area is primarily urban or rural. [3]

Of the two methods, the land use procedure is considered more definitive. The land use within the total area circumscribed by a 3-kilometer (km) radius circle around the facility was classified using the land use typing scheme proposed by Auer. If land use types 23 (Developed, Medium Intensity), or 24 (Developed, High Intensity) account for 50% or more of the circumscribed area, urban dispersion coefficients should be used; otherwise, rural dispersion coefficients are appropriate.

AERSURFACE (v20060) was used for the extraction of the land-use values in the domain. The results of the land use analysis evaluation were as follows.

Each USGS NLCD 2016 land use class was compared to the most appropriate Auer land use category to quantify the total urban and rural area. Table 1-2 summarizes the results of this land use analysis. As approximately 92.1% of the area can be classified as rural, rural dispersion coefficients were used. The AERSURFACE files are enclosed in Appendix A.

[3] 40 CFR Part 51, Appendix W, the Guideline on Air Quality Models (January 2017) – Section 7.2.1.1(b)(i)

Table 1-2. Summary of Land Use Analysis

Category ID	Category Description	Number of Grid Cells	Percent	Dispersion Class
11	Open Water	0	0.0%	Rural
21	Developed, Open Space	7,436	23.7%	Rural
22	Developed, Low Intensity	2,653	8.4%	Rural
23	Developed, Medium Intensity	1,655	5.3%	Urban
24	Developed, High Intensity	813	2.6%	Urban
31	Barren Land	1,148	3.7%	Rural
41	Deciduous Forest	0	0.0%	Rural
42	Evergreen Forest	0	0.0%	Rural
43	Mixed Forest	0	0.0%	Rural
52	Shrub/Scrub	17,523	55.8%	Rural
71	Grassland/Herbaceous	197	0.6%	Rural
81	Pasture/Hay	0	0.0%	Rural
82	Cultivated Crops	0	0.0%	Rural
90	Woody Wetlands	0	0.0%	Rural
95	Emergent Herbaceous Wetlands	0	0.0%	Rural
	Total	31,425	100%	
	Urban		7.9%	
	Rural		92.1%	

1.1.3 Building Downwash

The effects of building downwash for each of the stack emission points were evaluated in terms of the proximity of the stack to nearby structures. The purpose of this evaluation is to determine if stack discharges might become caught in the turbulent wakes of these structures leading to downwash of the plumes. Wind blowing around a building creates zones of turbulence that are greater than if the building were absent.

For these modeling analyses, the direction-specific building dimensions used as input to the AERMOD model were calculated using the U.S. EPA's BPIP PRIME, version 04274. BPIP PRIME is designed to incorporate the concepts and procedures expressed in the GEP Technical Support document, the Building Downwash Guidance document, and other related documents.[4]

For the BPIP analysis, the structure elevations (buildings and stacks) were estimating using the AERMAP processor (v18081). Terrain elevations from the USGS 1-arc second NED were used for AERMAP

[4] U.S. EPA, Office of Air Quality Planning and Standards, Guidelines for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised), Research Triangle Park, North Carolina, EPA 450/4-80-023R, June 1985.

processing. In all modeling analysis data files, the location of emission points and structures were represented in the UTM coordinate system, zone 12, NAD 83.

EPA has promulgated stack height regulations that restrict the use of stack heights in excess of "Good . Engineering Practice" (GEP) in air dispersion modeling analyses. Under these regulations, that portion of a stack in excess of the GEP height is generally not creditable when modeling to determine source impacts. This essentially prevents the use of excessively tall stacks to reduce ground-level pollutant concentrations.

This equation is limited to stacks located within five times the lesser dimension (5L) of a building structure. Stacks located at a distance greater than 5L from a building structure are not subject to the wake effects of the structure. The wind direction-specific downwash dimensions and the dominant downwash structures used in this analysis are determined using BPIP. In general, the lowest GEP stack height for any source is 65 meters by default.[5] The BPIP evaluation indicates that none of the stacks included within the modeling analysis exceed GEP stack height.

Input and output files from the BPIP downwash analysis are provided in the electronic files included in Appendix A.

1.1.4 Receptor Grid Coordinate System

Modeled concentrations were calculated at ground-level receptors placed along the Project Oasis facility property boundary, and on a variable Cartesian receptor grid. Property/ambient boundary receptors were spaced no more than 25 meters apart. Beyond the property boundary, receptors were placed with 100 meters spacing on a Cartesian grid extending outward from the facility. An approximately 10 km by 10 km modeling domain with a receptor spacing of 100 meters was created.

Also, six residential receptors, as identified from review of aerial imagery and data reviewed regarding land use classification information (industrial/commercial) from available online information, were also placed within the receptor grid system to provide predicted modeled impacts at the nearest residential areas. [6]

Receptor elevations and hill heights required by AERMOD were determined using the AERMAP terrain preprocessor (v18081). Terrain elevations from the USGS 1-arc second NED were used for AERMAP processing. In all modeling analysis data files, the location of receptors was represented in the UTM coordinate system, zone 12, NAD 83.

1.1.5 Meteorological Data Representativeness

The U.S. EPA's federal *Guideline on Air Quality Models*, codified at 40 CFR 51, Appendix W, states in Section 8.4.1, "Meteorological Input Data – Discussion":

> *The meteorological data used as input to a dispersion model should be selected on the basis of spatial and climatological (temporal) representativeness as well as the ability of the individual parameters selected to characterize the transport and dispersion conditions in the area of concern. The representativeness of the measured data is dependent on numerous factors including, but not limited to: (1) the proximity of the*

[5] 40 CFR 51.100(ii)

[6] https://webcms.pima.gov/cms/one.aspx?portalId=169&pageId=22235

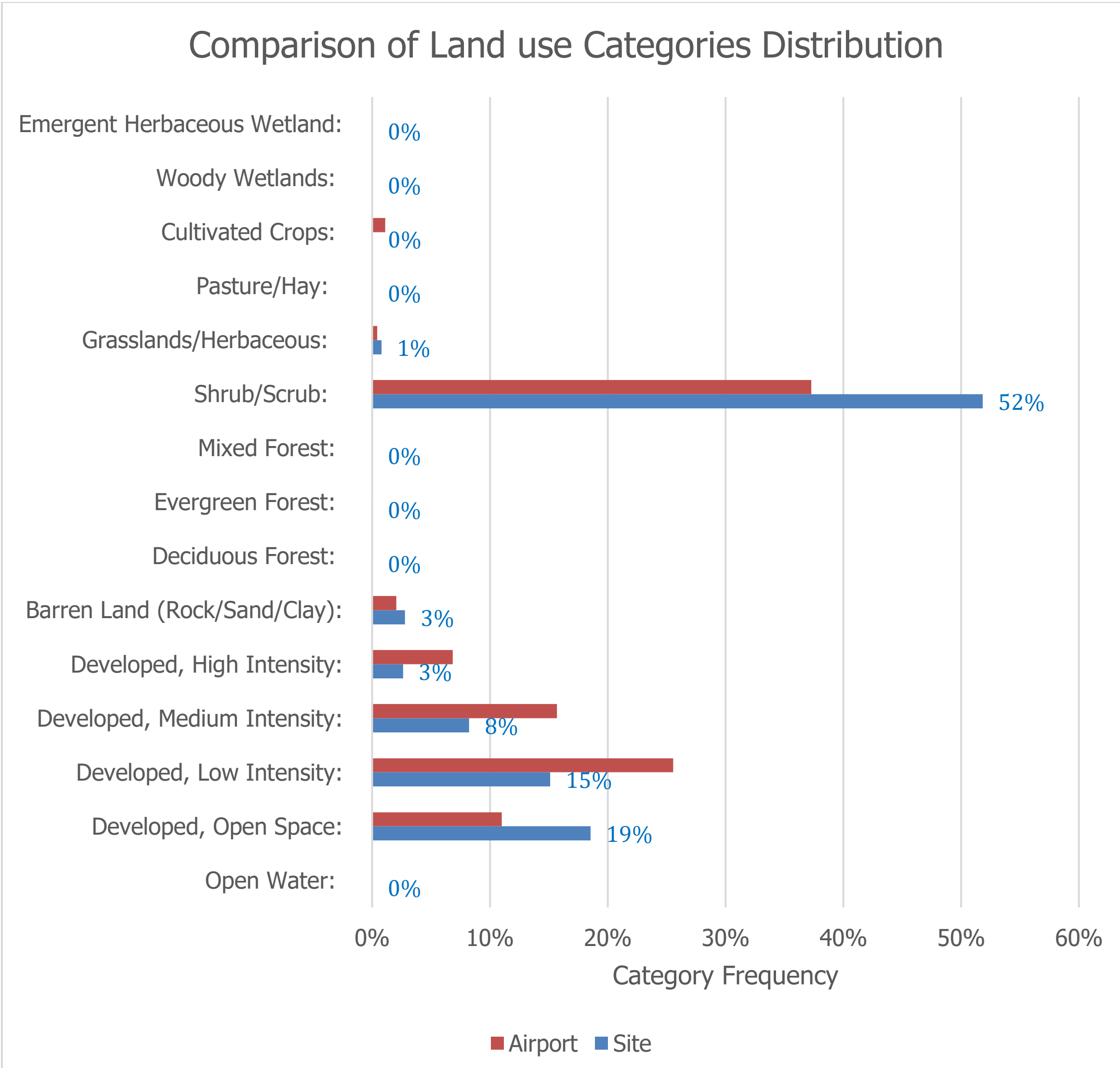
meteorological monitoring site to the area under consideration; (2) the complexity of the terrain; (3) the exposure of the meteorological monitoring site; and (4) the period of time during which data are collected.

The Project Oasis facility is located in Pima County, Arizona. 2014-2018 meteorological data for the Tucson International Airport surface station and upper air station, with the use of ADJ_U*. ADJ_U* is a regulatory default option that improves overall model performance during periods of low-wind/stable conditions by adjusting the surface frictional velocity (u*) in AERMET.

The Tucson International Airport meteorological station is located at 32.132 degrees (latitude) and -110.956 degrees (longitude) and is approximately 1 km west of the Facility. It is in the same geographic area of the subject facility and well placed to satisfy the proximity and terrain based representativeness considerations of Appendix W. The meteorological data period utilized, 2014-2018, provides 5 years of consecutive data sufficiently representative to evaluate all potential meteorological conditions that could occur at the Project Oasis facility.

An AERSURFACE analysis was completed to compare the surface characteristics around the facility's location and the chosen meteorological NWS station at the Tucson International Airport. AERSURFACE was executed for both the facility site and the NWS station using monthly temporal resolution and the default 1 km radius domain of twelve 30-degree sectors for the roughness surface length.

Figure 1-1. Comparison of Land Use Categories around the Facility and the Tucson International Airport NWS Station



Given the same geographic setting and relative proximity of the airport site and the Project Oasis facility, the land use categories around each site are very similar, with the majority of the land use around both areas defined as shrub/scrub areas. Table 1-3 below demonstrates and compares the numeric values for the Albedo, Bowen ratio, and Surface Roughness for both the airport NWS station and the subject facility.

Table 1-3. Summary of Land Use Analysis

Sector	Albedo								Albedo			
	Tucson International Airport				Site				Difference (%): Site - Airport			
	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Domain	0.21	0.2	0.2	0.2	0.22	0.21	0.21	0.21	5%	5%	5%	5%

Moisture Conditions	Bowen Ratio								Bowen Ratio			
	Tucson International Airport				Site				Difference (%): Site - Airport			
	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Average	2.05	1.31	1.56	2.05	2.56	1.42	1.84	2.56	20%	8%	15%	20%
Dry	4.36	2.88	3.26	4.36	5.21	3.01	3.61	5.21	16%	4%	10%	16%
Wet	0.99	2.88	3.26	4.36	1.11	3.01	3.61	5.21	11%	4%	10%	16%

Sector	Surface Roughness Length (m)								Surface Roughness Length (m)			
	Tucson International Airport				Site				Difference (%): Site - Airport			
	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
0 - 30	0.077	0.096	0.112	0.096	0.044	0.054	0.062	0.054	-75%	-78%	-81%	-78%
30 - 60	0.093	0.112	0.128	0.112	0.042	0.051	0.058	0.051	-121%	-120%	-121%	-120%
60 - 90	0.101	0.121	0.137	0.121	0.065	0.074	0.082	0.074	-55%	-64%	-67%	-64%
90 - 120	0.164	0.189	0.209	0.189	0.133	0.136	0.137	0.136	-23%	-39%	-53%	-39%
120 - 150	0.058	0.074	0.088	0.074	0.150	0.150	0.150	0.150	61%	51%	41%	51%
150 - 180	0.059	0.074	0.088	0.074	0.116	0.121	0.125	0.121	49%	39%	30%	39%
180 - 210	0.123	0.145	0.164	0.145	0.109	0.115	0.119	0.115	-13%	-26%	-38%	-26%
210 - 240	0.044	0.056	0.067	0.056	0.083	0.094	0.102	0.094	47%	40%	34%	40%
240 - 270	0.080	0.091	0.101	0.091	0.090	0.100	0.107	0.100	11%	9%	6%	9%
270 - 300	0.091	0.105	0.116	0.105	0.102	0.115	0.124	0.115	11%	9%	6%	9%
300 - 330	0.075	0.089	0.101	0.089	0.125	0.133	0.138	0.133	40%	33%	27%	33%
330 - 360	0.050	0.063	0.074	0.063	0.060	0.071	0.079	0.072	17%	11.3%	6%	13%
Average	0.085	0.101	0.115	0.101	0.093	0.101	0.107	0.101	9%	0%	-8%	0%

"DJF" means December, January, and February
"MAM" means March, April, and May
"JJA" means June, July, August
"SON" means September, October, November
(All AERSURFACE default settings)

The Albedo, Bowen Ratio, and Surface Roughness values for both sites are very comparable, as demonstrated in Table 1-3 above. Therefore, based on the similar geographic setting, the proximity of the NWS site, and the comparability of land use and surface characteristics between the two locations, the Tucson International Airport is determined to be sufficiently representative for use for the modeling analysis.

1.1.6 Derived Acceptable Ambient Concentration Levels

For this assessment, acceptable ambient concentration levels were derived for the annual averaging period. The acceptable ambient concentration level was considered as follows.

1.1.6.1 Annual Acceptable Concentration Levels

Annual acceptable concentration levels at the nearest residential receptors were considered to be results less than EPA's 100-in-a-million risk threshold level, developed as follows. [7]

The EPA defined IRIS value for inhalation unit risk (IUR) for ethylene oxide is 3 x 10^{-3} μg/m^3. [8] However, with elevated risk associated with the mutagenic mode of action through early life exposures, EPA multiplied the IUR by 1.6, to get a modified IUR of 5 x 10^{-3} μg/m^3.

EPA's National Air Toxics Assessment (NATA) utilized a 100-in-a-million risk threshold level for determining acceptable levels of risk. So, to derive the annual acceptable concentration;

Cancer Risk / IUR = 100/1,000,000/0.005 μg/m^3 = **0.02 μg/m^3**

1.1.7 Modeling Results

Using the source parameters specified in Table 1-1, and additional model setup as described above, AERMOD was executed for each of the five years of meteorological data to determine the maximum predicted modeled annual concentrations of ethylene oxide at each receptor location. Table 1-4 below summarizes the Maximum Ground Level Concentration (MGLC), occurring on the facility ambient air boundary (property boundary).

Table 1-4. Maximum Predicted Modeled Impacts – Project Oasis Facility

Year	Max Annual Concentration (μg/m^3)	EPA 100-in-a - Million Risk Threshold (μg/m^3)
2014	1.64E-01	2.0E-02
2015	1.55E-01	
2016	1.49E-01	
2017	1.49E-01	
2018	1.66E-01	

Analyses were also conducted to evaluate predicted modeled impacts at each of six identified residential receptors near the Project Oasis facility. Table 1-5 below summarizes the annual average maximum predicted modeled impacts at the residential receptor locations identified. Distance of residential receptors from the facility sources based on the distance of the receptor from the CATOX1 stack location at the facility.

[7] Annual impacts evaluated at nearest residential receptors for acceptable impacts, since the EPA derived IRIS value on which the acceptable concentration is based assumes a long-term lifetime based exposure at the indicated concentration level.

[8] https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf

Table 1-5. Maximum Predicted Modeled Impacts at Identified Residential Receptors – Project Oasis Facility

Residential Area	Easting (meter)	Northing (meter)	Max Annual Concentration (µg/m^3)	Averaging Period	EPA 100-in-a - Million Risk Threshold (µg/m^3)	Ratio of Result to EPA 100-in-a - Million Risk Threshold	Distance from the Facility Sources (km)
R1	514,958.3	3,555,543.6	3.80E-03	Annual	2.0E-02	0.19	0.69
R2	513,348.4	3,554,229.7	4.80E-04	Annual	2.0E-02	0.02	2.76
R3	514,210.8	3,554,082.2	6.00E-04	Annual	2.0E-02	0.03	2.30
R4	517,627.8	3,553,620.3	8.00E-04	Annual	2.0E-02	0.04	3.23
R5	515,210.6	3,558,528.6	3.63E-03	Annual	2.0E-02	0.18	2.52
R6	513,050.6	3,559,998.1	2.93E-03	Annual	2.0E-02	0.15	4.65

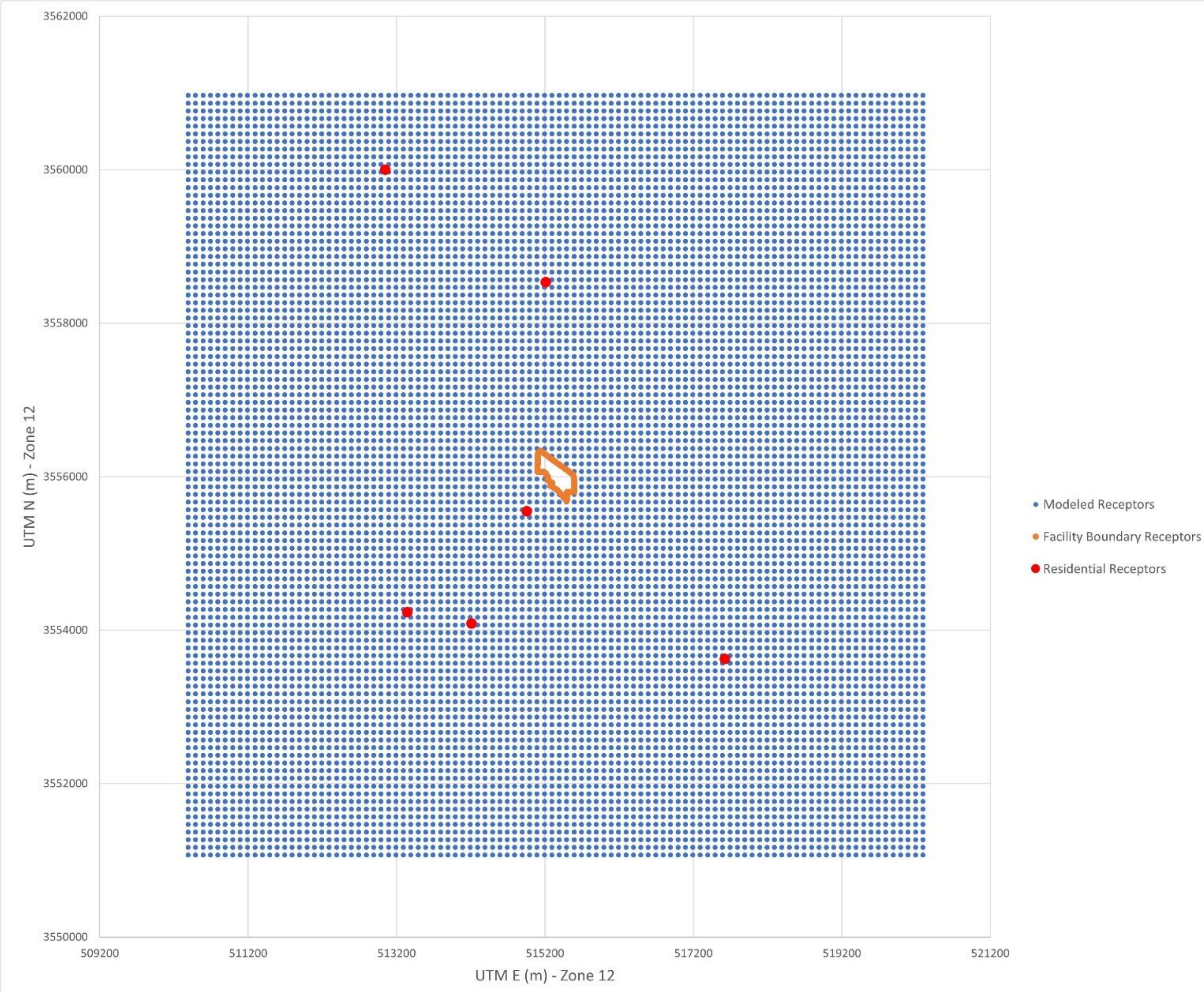
Predicted modeled impacts demonstrate that modeled risk from ethylene oxide concentrations at the nearest residential receptors near the Project Oasis facility do not exceed 100-in-a-million for an individual if that person was exposed to that concentration continuously for a lifetime. The 100-in-a-million risk threshold level referenced is the EPA derived individual risk threshold for determining an acceptable level of risk for annual ethylene oxide exposure (0.02 µg/m^3). [9]

All air dispersion modeling files are included in Appendix A.

A graphical representation of modeled receptors as part of this modeling assessment, can be found below in Figure 1-2.

[9] https://www.epa.gov/il/ethylene-oxide-emissions-frequent-questions

Figure 1-2. Project Oasis Modeling Domain



APPENDIX A. ELECTRONIC TOXICS MODELING FILES