GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

Richard E. Dunn, Director

Air Protection Branch
4244 International Parkway
Suite 120
Atlanta, Georgia 30354
404-363-7000

MEMORANDUM

November 19, 2019

To: James Boylan
Thru: Byeong-Uk Kim
From: Henian Zhang
Subject: **Modeling Analysis for Ethylene Oxide**
Kendall Patient Recovery U.S., LLC, Augusta, Richmond County, GA

GENERAL INFORMATION

Air dispersion modeling of ethylene oxide was conducted by the Georgia Environmental Protection Division (GA EPD) to assess the impacts of ethylene oxide emissions from sources at Kendall Patient Recovery U.S., LLC (hereafter KPR) on ambient air surrounding the facility. Although this modeling is not for issuance of an air quality permit, GA EPD followed the procedures described in GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*[1] (hereafter "Georgia Air Toxics Guideline").

Computer models are used to predict the concentrations of toxic air pollutants (TAPs) being analyzed using facility information provided by the source and other information developed by GA EPD staff. The modeling results are compared to the 15-min, 24-hour, and annual Acceptable Ambient Concentrations (AACs). GA EPD's 15-min and 24-hour AACs are derived from OSHA permissible exposure limits. GA EPD's annual AACs are derived from U.S. EPA's risk values which are found in EPA's Integrated Risk Information System (IRIS) database. Appendix B contains detailed calculations for the annual, 24-hour, and 15-min ethylene oxide AACs.

GA EPD uses AACs as a screening tool to ensure that public health is protected. No further evaluation is needed if the modeled concentrations are below the corresponding AAC. If the modeled concentration is above the AAC, GA EPD requires the company to consider a reduction in pollutant emission rates, additional controls, and/or an increase in stack heights, followed by a site specific risk assessment.

After performing a site specific risk assessment, if it is infeasible for the applicant to comply with the AAC, the Director at his/her discretion may approve control technology which reflects the maximum degree of reduction in emissions of hazardous air pollutants that the Director determines is achievable by the source, provided that such control technology is no less effective than the level of emission control which is achieved in practice by the best controlled similar source.

This memo discusses modeling results and the input data used to perform the ethylene oxide dispersion modeling. The modeled maximum ground-level concentrations (MGLCs) for the 15-min and 24-hour averaging periods were below their corresponding AACs. The modeled annual averaged ground-level concentrations across the 5-year period (AAGLCs) at the three closest residential areas exceeded the annual AAC. The results are summarized in the following sections of this memorandum.

[1] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/toxic-impact-assessment-guideline

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018)[2] were generated by GA EPD. Surface measurements were obtained from the Daniel Field Airport, Augusta, GA. Upper air observations were obtained from the Atlanta Regional Airport – Falcon Field, Peachtree City, GA. These measurements were processed using the AERSURFACE (v13016), AERMINUTE (v15272), and AERMET (v18081) with the adjusted surface friction velocity option (ADJ_U*).

2. **Source Data** – Emission release parameters and emission rates were provided by KPR and reviewed by the GA EPD Stationary Source Permitting Program (see Appendix A for details). Emission rates from the most conservative year (2017) were used. Fugitive emissions from the storage shed (FE1 in Appendix A) were modeled as a volume source. Based on recent sampling results provided by Alternative Construction & Environmental Solutions, Inc., KPR calculated an average emission rate of 0.025 lbs/yr from the storage shed. Therefore, the original emission rate shown for FE1 in Appendix A (69 lbs/yr) was replaced with 2 lbs/yr (a conservative upper-bound estimate for 0.025 lbs/yr) in the modeling.

3. **Receptor Locations** – Discrete receptors with 25-meter intervals were placed along the property boundary with more receptors placed in the south to capture the irregular shape of the boundary. Receptors extend outwards from the fence line at 100-meter intervals on a Cartesian grid to approximately 3 km and at 200-meter intervals from approximately 3 km to approximately 6 km. Additional receptors were placed at the three closest residential areas. This domain (approximately 12 km by 12 km) is sufficient to capture the maximum impact. All receptor locations are represented in the Universal Transverse Mercator (UTM) projections, Zone 17, North American Datum 1983.

4. **Terrain Elevation** – Topography was found to be generally flat in the site vicinity. Terrain data from the USGS 1-sec National Elevation Dataset (NED) were extracted to obtain the elevations of all sources, buildings, and receptors by the AERMAP terrain processor (v18081).

5. **Building Downwash** – The potential effect for building downwash was evaluated via the "Good Engineering Practice (GEP)" stack height analysis and was based on the building parameters submitted by KPR (Table 6 in Appendix A) using the BPIPPRM program (v04274). Building G's horizontal dimension was slightly modified to be more consistent with what was observed in Google Earth. The UTM coordinates for Point 1, Point 5, and Point 6 were changed to (408547.20, 3695463.29), (408520.77, 3695444.84), and (408518.77, 3695450.00), respectively. The BPIPPRM model was used to derive building dimensions for the downwash assessment and the assessment of cavity-region concentrations.

AIR TOXICS ASSESSMENT

The impacts of facility-wide ethylene oxide emissions were evaluated according to the Georgia Air Toxics Guideline. The annual, 24-hour, and 15-min AACs were reviewed based on U.S. EPA Integrated Risk Information System (IRIS) Risk Based Air Concentration (RBAC), OSHA Total Weight Average (TWA), and OSHA Permissible Exposure Limit (PEL) according to the Georgia Air Toxics Guideline. For this assessment, GA EPD used the annual AAC derived according to the Georgia Air Toxics Guideline (see Appendix B for details). The EPA's 2014 National Air Toxic Assessment (NATA) used a higher annual

[2] https://epd.georgia.gov/air-protection-branch-technical-guidance-0/air-quality-modeling/georgia-aermet-meteorological-data

AAC value (see Appendix C for details). The modeled 1-hour, 24-hour, and annual ground-level concentrations were calculated using the AERMOD dispersion model (v19191).

Table 1 summarizes the MGLCs and the AAC levels. The 15-min MGLC is based on the 1-hour MGLC multiplied by a factor of 1.32. The 15-min MGLC was below its corresponding AAC. The 24-hour averaged MGLC did not exceed the 24-hour AAC anywhere in the modeling domain (including nearby business areas). However, the annual MGLC (located along the western property boundary) exceeded its corresponding AAC. Figure 1 shows the spatial distribution of the AAGLCs. Figure 2 shows a close-up of Figure 1 with the closest three residential areas labeled (R1, R2, and R3). R2 represents a single residential home; however, R1 and R3 represent the closest residential home within a group of homes or subdivisions. A site specific risk assessment shows that the AAGLCs at the three closest residential areas exceed the annual AAC (Table 2).

Table 1. Modeled MGLCs and their Respective AACs.

Averaging period	MGLC (μg/m^3)	AAC (μg/m^3)
Annual	0.0618	0.00033
15-min	1.85	900
24-hour	0.38	1.43

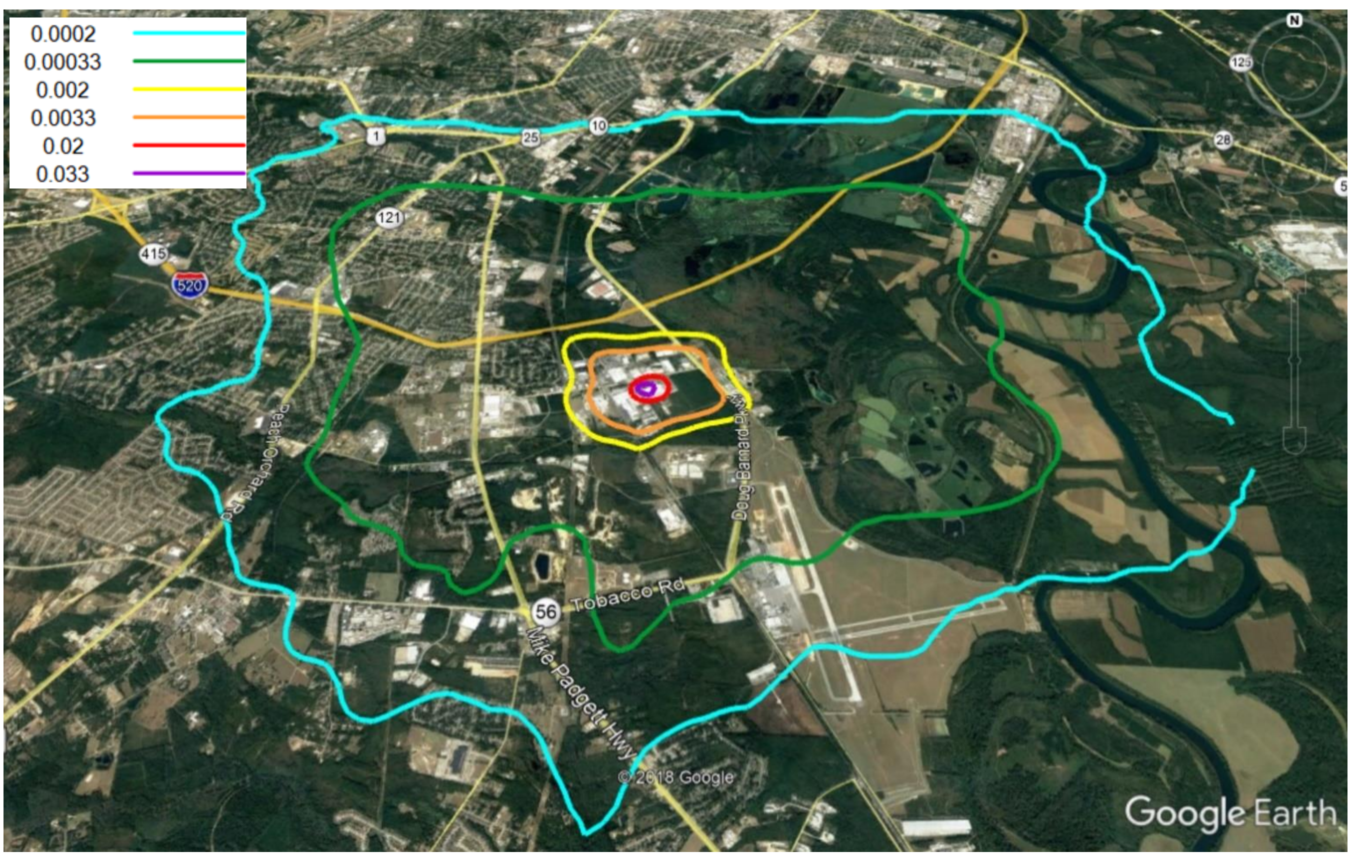

Figure 1. Contours of modeled annual ground-level concentrations (in μg/m^3) averaged over 5 years overlaid on a Google Earth map.

Figure 2. A close-up of Figure 1 with the closest residential areas labeled (R1, R2, and R3).

Table 2. Risk Analysis for Residential Areas with Modeled AAGLCs.

Residential Areas	Receptor UTM Zone:17		AAGLC* (μg/m³)	Averaging Period	AAC (μg/m³)	Ratio of AAGLC (μg/m³) to AAC (μg/m³)
	Easting (meter)	Northing (meter)				
R1	407,396.85	3,695,571.91	0.00162	Annual	0.00033	4.9
R2	409,967.00	3,694,392.40	0.00064			1.9
R3	406,732.10	3,693,980.91	0.00052			1.6

*AAGLC is the annual averaged ground-level concentrations across the 5-year period.

CONCLUSIONS

The dispersion modeling analysis for ethylene oxide show exceedances of the annual AAC. A site specific risk assessment shows that the modeled annual average ground-level concentrations at the three closest residential areas are above the annual AAC (1.6 – 4.9 times). The modeled 15-min and 24-hour maximum ground-level concentrations did not exceed their respective AACs.

Appendix A

Emissions and Model Input Parameters

Kendall Patient Recovery LLC - Augusta

Table 1: Actual Data Parameter Used in Calculations

Year	Source	Batches per Year[2]	Amount EtO Used Per Batch (lbs)	EtO Consumed[3,4] (lbs/batch)	Control Device Efficiency[5] (%)
2018	Sterilizer A and B	818	134	50.4	0.997
	R&D Mini Sterilizer[1]	14	0.37	0.37	0.997
2017	Sterilizer A and B	967	134	48.4	0.997

Notes

1. R&D mini sterilizer use in 2018 only. (Unit is exempt from permitting)

2. Facility inputs based on Production Input Factors provided by facility for calendar year. Sterilization chamber size equivalent to 53 foot semi-trailer. (1 cycle = 1 semi trailer shipment)
EtO used per batch based on sterilization specifications. EtO is recoved during first vacuum pumpdown to Recovery Tank. Subsequent purges are sent to control device.

3. "Consumed" refers to the loss of EtO through various factors including: fugitive losses, condensate stream losses and losses via product transfer off-site.

4. EtO Consumed (lbs/year) = EtO Consumed (lbs/batch) * Batches Per Year (batches/year)

5. Control Device Efficiency provided in "Source Test Review Report" Cover Letter dated December 8, 2009.

Table 2: Breakdown of EtO Losses for Actual Calculations

Year	EtO Consumed[3,4] (lbs/yr)	Losses Via Sterilization Chamber Room[6,7] (lb/yr)	Losses Via Product[8] (lb/yr)	Losses Via Condensate Peak Shaver[9] (lb/yr)	Fugitive Losses via Connection Points (FE1)[10] (lb/yr)	EtO Routed to Catalytic Oxidizer[11] (lb/yr)
2018	41,205	61	6	412	62	40,664
2017	46,800	61	7	468	69	46,195

Notes

6. The losses via sterilization chamber are based on EtO monitor measurements from inside Sterilation Process Room.

7. See Table 3 for breakdown of emissions according to release point.

8. The losses via product are estimated using concentrations measured inside trucks that transport the product.

9. Engineering estimate, based on process water sampling and analysis for EtO and ethylene glycol. Results indicated none-detect. However some degradation is theoretically possible, hense assumed to be 1%. EtO in condensate is not emitted to the air.

10. Sterilization facility fugitive leak emissions occur during cylinder changeouts and are also from pump seals, valves, flanges, vessel hatches, door gaskets, etc. outside the sterilization room. Calculated based on number of cylinder changeouts (0.5 lb EtO loss per cylinder change) and estimated 10 pounds per year of fugitive losses from valve/flange leaks.

11. EtO routed to Peak-Shaver absorber then to Catalytic Oxidizer (lbs/year) = EtO Consumed (lbs/year) - (Mass Lost to Product Each Year (lbs/year) + Total Fugitive Losses (lbs/year) + Pounds Lost Via Condensate (lbs/year))

Table 3: Allocation of Losses Via Sterilization Chamber Room

Stack ID	Release Point Name	Stack Percent of Annual Volumetric Flow from Room (%)	Emissions[13] (lbs/yr)	
			2018	2017
S-1	Sterilizer A Chamber Vent	0.2	0.1	0.1
S-2	Sterilizer A Point Source Vent	10.9	6.7	6.7
S-3	Sterilizer B Chamber Vent	0.2	0.1	0.1
S-4	Sterilizer B Point Source Vent	10.9	6.7	6.7
S-5	Exhaust Fan A	22.5	13.7	13.7
S-6	Exhaust Fan B	22.5	13.7	13.7
S-7	Exhaust Fan C	22.5	13.7	13.7
S-8	Wall Exhaust Fan	10.5	6.4	6.4

Notes:

12. Calculated from data on "Stack Data" tab.

13. Emissions assumed to be weighted ratio based on volumetric stack flow.
Emissions (lbs/yr) = Losses (lb/yr) * (stack volumetric flow/total volumetric flow from sterilization room)

Table 4: Catalytic Oxidizer Stack Emissions (Stack CO)

Source	Year	EtO Routed to Catalytic Oxidizer[11] (lb/yr)	Control Device Efficiency[5] (%)	Actual/Typical EtO Emissions[14] (lb/yr)	Potential EtO Emissions[15] (tpy)
Sterilizer A and B[16]	2018	40,664	0.997	122.0	1.02
Sterilizer A and B[16]	2017	46,195	0.997	138.6	1.02

Notes:

14. EtO Emissions From Stack (lbs/year) = (1 - (Control Device Efficiency (%) / 100)) * EtO Routed to Catalytic Oxidizer (lbs/year)

15. Potential Emissions based on permit application.

16. Source includes anticipated emissions from exempt R&D mini-sterilizer.

Table 5. Stack Info

Stack ID	Emission Release Type	Stack Type	Source Description	UTM Coordinate - Easting (m)[1]	UTM Coordinate - Northing (m)[1]	Stack Height (ft.)[2]	Stack Inside Diameter (ft.)[3,4,5]	Stack Inside Area[6,7,8] (ft^2)	Volumetric Flow Rate (cfm)[9,10,11,12,13]	Stack Exit Gas Velocity (ft/s)[14,15,16,17]	Exhaust Temp (F)[18]	Annual Exhaust Run Time (hours)[19]
S-CO	Point	Vertical	Sterilization Catalytic Oxidizer	408349.058512	3695485.39117	36.50	2.50	4.91	14,991	51	200	8,760
S-1	Point	Vertical	Sterilizer A Chamber Vent	408348.264761	3695479.27928	41.00	0.58	0.27	577	36	80	1,000
S-2	Point	Vertical	Sterilizer A Point Source Vent	408348.820387	3695477.85053	34.33	1.50	1.77	3,784	36	80	8,760
S-3	Point	Vertical	Sterilizer B Chamber Vent	408346.359757	3695469.91301	41.00	0.58	0.27	577	36	80	1,000
S-4	Point	Vertical	Sterilizer B Point Source Vent	408347.629759	3695472.53239	34.33	1.50	1.77	3,784	36	80	8,760
S-5	Point	Vertical	Exhaust Fan A	408345.407255	3695473.72302	28.50	3.21	8.09	7,800	16	80	8,760
S-6	Point	Vertical	Exhaust Fan B	408347.629759	3695474.75490	28.50	3.21	8.09	7,800	16	80	8,760
S-7	Point	Vertical	Exhaust Fan C	408349.614138	3695475.78677	28.50	3.21	8.09	7,800	16	80	8,760
S-8	Point	Horizontal	Wall Exhaust Fan	408333.104105	3695475.78677	9.58	2.63	5.44	3,631	0.003	80	8,760

Notes:

1. Used figures in additional information to support 2008 SIP application and figures provided by facility to plot a point on Google Earth to determine locations. Coordinates are in NAD 1983 UTM Zone 17N.
2. From permit application (catalytic oxidizer vent) and provided by KPR.
3. From permit application (catalytic oxidizer) and provided by KPR.
4. For Exhaust Fans A-C, the equivalent diameter was derived by first finding the actual exhausting area (total area - area of motor) and then solving for the diameter assuming a circular stack.
5. Wall Exhaust Fan is a non-circular fan.
Diameter (ft) = sqrt ((4*Area)/Pi)
6. Area of Circular Exhaust Vents = Pi * (Diameter/2)^2
7. For Exhaust Fans A-C, the exhausting area is equal to the total area minus the area of the motor in the center.
8. For Wall Exhaust Fan, the area is equal to the length (28 in.) * width (28 in.)
9. Catalytic Oxidizer Stack Volumetric Flow Rate (cfm) = Stack Exit Gas Velocity (ft/s) * Area (ft^2) * 60 (second/min)
10. Exhaust Fan A, B, C (S-5, S-6, S-7) Volumetric Flow Rate (cfm) based on fan curve for Cook Exhaust Fan @ 2 hp.
11. Sterilizer A & B Point Source Vent (S-2, S-4) Volumetric Flow Rate (cfm) based on 2 hp Dayton fan 1WBW9 model (http://www.solutionsforair.com/products/item.aspx?itemnumber=1WBW9) average volumetric flowrate for this model fan.
12. Wall Exhaust Flow Rate (cfm) based on average volumetric flowrate for this model fan: Greenheck Fan model BSQ-180-15 (https://quick-delivery.greenheck.com/centrifugal-inline-fan-model-bsq-180-belt-drive-1-1-2hp-208-230-460v-3ph-motor--drives-unassembled-2832-4430-cfm-bsq-180-15x-3-qd-dr1)
13. Sterilizer Chamber A & B vent (S-1, S-3) Volumetric Flow Rate (cfm) calculated based on estimated stack exit gas velocity and known stack cross-sectional area.
14. Catalytic Oxidizer Velocity is based on 2008 permit application
15. Sterlizer A & B Chamber Vent (S-1, S-3) Velocities (ft/s) assumed to be equal to the velocity of the Point Source Vents (S-2, S-4).
16. Horizontal exhaust fan vertical velocity based on EPD AERMOD guidance at 0.001 m/s (0.003 ft/s).
17. All other velocities (ft/s) = Volumetric Flow Rate (cfm)/Area(ft^2) /60 (sec/min)
18. Catalytic oxidizer exhaust temperature from permit application. Other temperatures estimated based on temperature of room.
19. Exhaust 8,760 hours per year except where noted. Chamber vents exhaust approximately 1 hour per sterilization cycle (approximately 1,000 hours per year).

Total Annual Flow from Sterilization Room (cf)	18,254,506,518	cf per year
	516,909,574	m3 per year
n (moles of air)	2.10E+10	moles per year
Average room EtO concentration	0.03	ppm
n (moles of EtO)	630	moles per year
mass of EtO (g)	27,768	grams EtO per year
mass of EtO (lb)	61	lb EtO per year

Kendall Patient Recovery LLC - Augusta

Table 6. Building Detail

Building Section ID	Building Section Name		UTM Coordinates Easting (m)[1]	Northing (m)[1]	Roof Height (ft.)[2]
Main Bldg	-	Point 1	408520.774899	3695444.84345	25.00
		Point 2	408471.244800	3695543.90364	
		Point 3	408328.131388	3695473.57725	
		Point 4	408377.986348	3695371.98170	
A	Admin Wing	Point 1	408428.693734	3695523.53131	16.50
		Point 2	408419.565466	3695541.40148	
		Point 3	408414.201544	3695539.13620	
		Point 4	408404.739740	3695558.41570	
		Point 5	408441.758669	3695577.09003	
		Point 6	408452.117729	3695557.30578	
		Point 7	408440.834120	3695552.69773	
		Point 8	408449.885216	3695534.00115	
B	Chiller Room	Point 1	408475.177514	3695536.97980	20.50
		Point 2	408486.118401	3695542.49622	
		Point 3	408493.929429	3695525.95856	
		Point 4	408483.519640	3695520.43712	
C	Loading Dock-East	Point 1	408488.006946	3695510.50058	24.00
		Point 2	408505.891203	3695520.06733	
		Point 3	408510.987253	3695511.31234	
		Point 4	408492.581600	3695502.77950	
D	Section D	Point 1	408497.007023	3695493.31847	24.00
		Point 2	408503.143247	3695496.26828	
		Point 3	408510.570970	3695481.31732	
		Point 4	408504.624182	3695477.33673	
E	Alcohol Tanks	Point 1	408516.294650	3695482.76713	25.00
		Point 2	408529.108677	3695489.76980	
		Point 3	408533.199205	3695479.99534	
		Point 4	408520.134570	3695474.57810	
F	Section F	Point 1	408510.040232	3695467.31227	24.00
		Point 2	408517.913808	3695471.43297	
		Point 3	408523.975818	3695459.50274	
		Point 4	408515.769542	3695455.30604	
G	AD & CalAg	Point 1	408545.199289	3695465.29180	25.00
		Point 2	408564.276620	3695428.55779	
		Point 3	408516.596143	3695407.53736	
		Point 4	408501.594849	3695434.56215	
		Point 5	408518.202901	3695450.63323	
		Point 6	408520.774899	3695444.84345	
H	Loading Dock-South	Point 1	408505.388190	3695426.45252	24.00
		Point 2	408501.594849	3695434.56215	
		Point 3	408476.547143	3695422.28902	
		Point 4	408480.044479	3695414.35963	
I	Section I	Point 1	408444.612784	3695405.82239	24.00
		Point 2	408433.915845	3695400.06786	
		Point 3	408439.969908	3695387.05706	
		Point 4	408451.409345	3695392.62713	
J	Back Dock	Point 1	408381.498407	3695353.80440	18.00
		Point 2	408375.982148	3695364.74795	
		Point 3	408397.335411	3695375.24664	
		Point 4	408403.029614	3695364.57001	
K	Shed	Point 1	408358.899537	3695303.71321	10.00
		Point 2	408354.628885	3695312.34348	
		Point 3	408365.483460	3695317.50386	
		Point 4	408369.576169	3695309.14050	
L	Boiler House	Point 1	408326.246839	3695366.70533	25.00
		Point 2	408336.834499	3695372.22159	
		Point 3	408327.136558	3695392.59616	
		Point 4	408315.659179	3695386.99093	
M	Cyclinder Shed	Point 1	408280.515267	3695473.02679	10.00
		Point 2	408287.366106	3695476.22978	
		Point 3	408290.569095	3695470.53557	
		Point 4	408283.629285	3695467.24361	
N	Loading Dock-West	Point 1	408373.753006	3695369.44170	14.00
		Point 2	408377.986348	3695371.98170	
		Point 3	408350.681293	3695427.01515	
		Point 4	408346.130451	3695424.79264	
O	Penthouse-A	Point 1	408410.071551	3695418.68957	30.50
		Point 2	408421.289907	3695423.87542	
		Point 3	408433.915845	3695400.06786	
		Point 4	408423.300744	3695395.40619	
P	Penthouse-B	Point 1	408444.361620	3695434.03544	40.00
		Point 2	408451.029133	3695437.42211	
		Point 3	408456.849978	3695425.88626	
		Point 4	408449.018296	3695422.39375	
Q	Penthouse-C	Point 1	408449.018296	3695477.10969	41.00
		Point 2	408459.813317	3695482.61304	
		Point 3	408465.951663	3695470.86551	
		Point 4	408454.627473	3695465.78550	
R	Penthouse-D	Point 1	408492.092548	3695456.68382	40.00
		Point 2	408496.960891	3695446.20630	
		Point 3	408504.051739	3695449.80464	
		Point 4	408498.442561	3695459.96466	
S	Bubble	Point 1	408366.948487	3695493.19615	19.00
		Point 2	408374.198085	3695496.84740	
		Point 3	408370.017660	3695505.41992	
		Point 4	408362.715145	3695501.76866	

Notes:

Coordinates are in NAD 1983 UTM Zone 17N

Appendix B

GA EPD Calculation of the Annual, 24-hour, and 15-min AACs for Ethylene Oxide

GA EPD Calculation of the Annual, 24-hour, and 15-min AAC for Ethylene Oxide

According to the GA EPD's *Guideline for Ambient Impact Assessment of Toxic Air Pollutant Emissions*, the annual, 24-hour, and 15-min AAC for ethylene oxide are calculated as following:

Annual AAC

In the EPA Integrated Risk Information System (IRIS)[3], the Inhalation Unit Risk (IUR) for ethylene oxide is 3×10^{-3} per $\mu g/m^3$. Since ethylene oxide is carcinogenic to humans, it belongs to Group A[4] with a cancer risk of 1/1,000,000. Therefore, the annual AAC is calculated as:

$$\text{Annual AAC} = \text{Cancer Risk} / \text{IUR} = (1/1{,}000{,}000)/(0.003/\mu g/m^3)$$

Annual AAC = 0.00033 $\mu g/m^3$

24-hour AAC

The OSHA 8-hour Time Weighted Average (TWA) permissible exposure limit (PEL) for ethylene oxide is 1 ppm. To convert the TWA PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(1\ \text{ppm} \times 44.05\ \text{g/mol}) / (24.45\ \text{L/mol}) = 1.8\ mg/m^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25^{o}C and 760 mmHg. After converting the 8-hour average weekly exposure to a 24-hour average weekly exposure and applying a safety factor of 300 for known human carcinogens, the 24-hour AAC is calculated as:

$$\text{24-hour AAC} = \frac{1.8\ mg/m^3 \times 1000\ \mu g/mg \times (8\ \text{hours/day} \times 5\ \text{days/week})}{300\ (\text{safety factor}) \times (24\ \text{hours/day} \times 7\ \text{days/week})}$$

24-hour AAC = 1.43 $\mu g/m^3$

15-min AAC

The OSHA 15-min PEL for ethylene oxide is 5 ppm. To convert the PEL from ppm to mg/m^3, the following conversion formula from the guidance is used:

$$(5\ \text{ppm} \times 44.05\ \text{g/mol}) / (24.45\ \text{L/mol}) = 9\ mg/m^3$$

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25^{o}C and 760 mmHg. After applying a safety factor of 10 for acute sensory irritants, the 15-min AAC is calculated as:

$$\text{15-min AAC} = (9\ mg/m^3 \times 1000\ \mu g/mg) / 10\ (\text{safety factor})$$

15-min AAC = 900 $\mu g/m^3$

[3] https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/1025_summary.pdf
[4] https://www.epa.gov/fera/risk-assessment-carcinogenic-effects

Appendix C

EPA Calculation of the Annual AAC
for Ethylene Oxide

EPA Calculation of the Annual AAC for Ethylene Oxide

According to EPA's IRIS, inhalation unit risk (IUR) for ethylene oxide (EtO) is $3x10^{-3}$ per $\mu g/m^3$ (as discussed in Appendix B). However, because of the elevated risk due to the mutagenic mode of action through early-life exposures, EPA multiplied the IUR by 1.6:

Modified IUR for EtO = $3x10^{-3}$ per $\mu g/m^3$ x 1.6 = $0.005/\mu g/m^3$

EPA's NATA used (100/1,000,000) individual risk for the purpose of determining "acceptable risk" (AR) in their national assessment.

AR Exposure Concentration = Cancer Risk / IUR = $(100/1{,}000{,}000)/(0.005/\mu g/m^3)$ **= 0.02 $\mu g/m^3$**