GEORGIA
DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

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MEMORANDUM

December 9, 2019

To: James Boylan
Thru: Byeong-Uk Kim
From: Yan Huang
Subject: **Modeling Analysis for Ethylene Oxide**
Stepan Company, Winder, Barrow 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 Stepan Company (hereafter Stepan) 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 Occupational Safety and Health Administration (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 15-min, 24-hour, and annual 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 AACs. 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 four 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 Gilmer Memorial Airport, Gainesville, 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 (actual emissions from 2018) were provided by Stepan and reviewed by the GA EPD Stationary Source Permitting Program (see Table 1 and Table 2 of Appendix A for details). Emissions from the scrubber stack were modeled as a point source and fugitive emissions from unloading, storage, and alkoxylation were modeled as three volume sources.

3. **Receptor Locations** – Discrete receptors with 50-meter intervals were placed along the property. Receptors extend outwards from the property line at 100-meter intervals on a Cartesian grid to approximately 2 km, at 250-meter intervals to approximately 5 km, and 1 km intervals to approximately 10 km. Additional receptors were placed at the four closest residential areas. This domain (approximately 20 km by 20 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 Stepan (Table 3 in Appendix A) using the BPIPPRM program (v04274). 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 15-min, 24-hour, and annual AACs were reviewed based on OSHA Permissible Exposure Limit (PEL), OSHA Total Weight Average (TWA) PEL, and U.S. EPA IRIS Risk Based Air Concentration (RBAC) 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 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 MGLC did not exceed the 24-hour AAC anywhere in the modeling domain (including nearby business areas). However, the annual MGLC (located at the west corner of the property boundary) exceeded its corresponding AAC. Figure 1 shows the spatial distribution of the AAGLCs. Figure 2 shows a close-up

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

of Figure 1 with the closest four residential areas labeled (R1, R2, R3, and R4). R3 and R4 represent single residential homes; however, R1 and R2 represent the closest residential home within a group of homes or subdivisions. A site-specific risk assessment shows that the AAGLCs at the four 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)
15-min	5.87	900
24-hour	0.96	1.43
Annual	0.113	0.00033

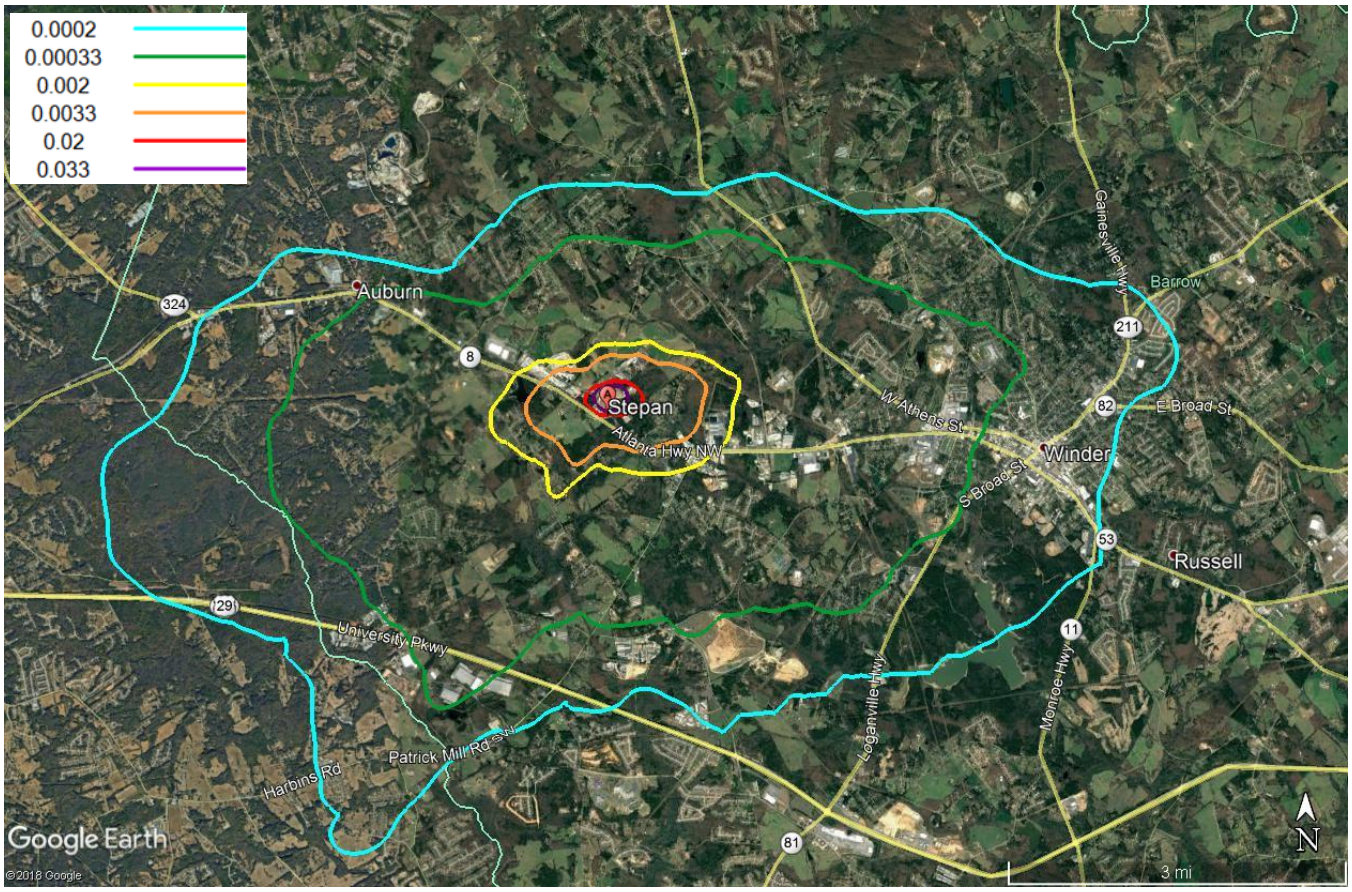

Figure 1. Contours of modeled annual averaged ground-level concentrations across the 5-year period (in μg/m^3) overlaid on a Google Earth map.

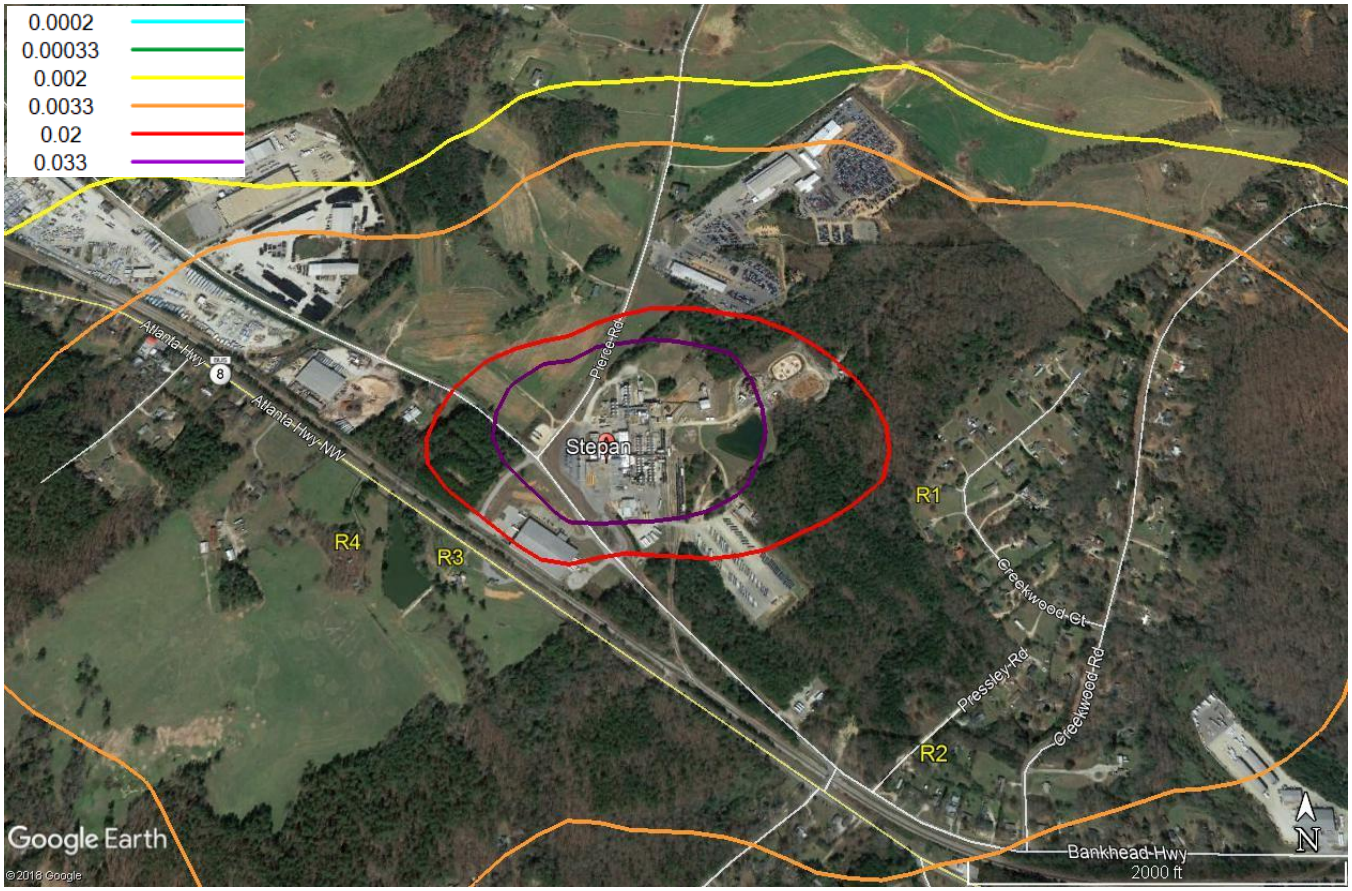

Figure 2. A close-up of Figure 1 with the closest residential areas labeled (R1, R2, R3, and R4).

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

Residential Areas	Receptor UTM Zone:17		Modeled AAGLC* ($\mu g/m^3$)	Averaging Period	AAC ($\mu g/m^3$)	Ratio of AAGLC ($\mu g/m^3$) to AAC ($\mu g/m^3$)
	Easting (meter)	Northing (meter)				
R1	243,044.00	3,765,421.00	0.01552	Annual	0.00033	47.0
R2	243,007.00	3,764,974.00	0.00453			13.7
R3	242,190.00	3,765,329.00	0.01284			38.9
R4	242,008.00	3,765,361.00	0.01034			31.3

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

CONCLUSIONS

The modeled 15-min and 24-hour maximum ground-level concentrations did not exceed their respective AACs. However, 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 across the 5-year period at the four closest residential areas are above the annual AAC (13.7 – 47.0 times).

Appendix A

Emissions and Model Input Parameters

Table 1 Emissions Summary

Emission Sources	Control Device	Any Hood/Cover/Rain Caps Over The Stacks Or Exhaust Fans?	Are The Ethylene Oxide Emissions Constant Or Do They Vary By Hour-Of-Day, Day-Of-Week, And/Or Season-Of-Year?	CY 2018 Emissions (tpy)	CY 2018 Emissions (g/s)
Point Source Emissions					
EO Scrubber	Scrubber	No	Vary - Batch Reaction	2.332E-02	6.708E-04
Fugitive Emissions					
Unloading	None	N/A		7.993E-04	2.299E-05
Storage	None	N/A		1.867E-02	5.371E-04
Alkoxylation	None	N/A	Vary – Batch Reaction	3.738E-02	1.075E-03

Table 2 Stack Parameters

Point Source

Source ID	Emission Release Type	Source Description	Easting (UTM Zone 17) m	Northing (UTM Zone 17) m	Elevation m	Stack Height m	Stack Temp K	Stack Velocity m/s	Stack Diameter m	EtO Emissions tpy
2SCR_EO	Point	EO Scrubber	242638	3765598.4	314.45	12.065	297	2.911	0.203	2.332E-02

Volume Sources

Volume Source ID	Emission Release Type	Source Description	Easting (UTM Zone 17) m	Northing (UTM Zone 17) m	Elevation m	Release Height m	Init. Lat. Dim. m	Init. Vert. Dim m	EtO Emissions tpy
UNLOAD	Volume	Unloading	242638.9	3765631	314.33	4.27	5.92	0.99	7.993E-04
STORAGE	Volume	Storage	242600.4	3765615.5	315.95	6.1	7.11	1.42	1.867E-02
ALKOXY	Volume	Alkoxylation	242549.6	3765608.8	317.69	3.06	3.6	0.71	3.738E-02

Table 3 Building Info

Index	Building Type	ID	Easting (UTM Zone 17) m	Northing (UTM Zone 17) m	Elevation m	Height m	X Length m
1	RECTANGLE	EO_MCC	242573.3	3765587.3	317.17	6.7056	5.5
2	RECTANGLE	MCC_DIKE	242470.1	3765578.1	320.86	4.572	3
3	RECTANGLE	CONDTANK	242590.1	3765627.4	316.19	2.4384	9.1
4	RECTANGLE	FIREPUMP	242698.7	3765575.1	312.22	4.572	8.7
5	RECTANGLE	SLUDGEP	242732.4	3765611.4	313.43	12.192	9.6
6	RECTANGLE	WWTANK	242711.6	3765624.1	314.86	4.572	4.6
7	RECTANGLE	WWPUMP	242713.6	3765633.2	315.63	6.096	6.1
8	RECTANGLE	EO_RAIL	242632.4	3765643.4	314.39	8.5344	10.2
9	RECTANGLE	TRUCKSCA	242451.8	3765575.4	321.31	8.2296	7.1
10	RECTANGLE	EO_TANK	242633.8	3765619.3	314.59	7.62	17.7
11	RECTANGLE	WWSHEDS1	242650.9	3765586.5	313.84	3.6576	6.9
12	RECTANGLE	WWSHEDS2	242659.1	3765586.1	313.47	3.6576	6.7
13	RECTANGLE	72JBL001	242495.8	3765429.8	317.82	6.58368	41

Index	Building Type	ID	Easting (UTM Zone 17) m	Northing (UTM Zone m	Elevation m	Height m	Radius m
1	CIRCLE	N2_TANK	242560.5	3765573.8	317.63	12.192	3.028206
2	CIRCLE	COOLINGT	242462.7	3765610.3	321.45	5.7912	3.839632
3	CIRCLE	BIOTANK	242726.2	3765648.1	316.21	10.0584	13.81589

Index	Building Type	ID	Easting (UTM Zone 17) m	Northing (UTM Zone 17) m	Elevation m	Height m
1	POLYGON	A_DIKE	242552.03	3765490.51	317.81	8.7884
2	POLYGON	AA_DIKE	242553.35	3765460.7	317.29	10.0457
3	POLYGON	B_DIKE	242551.2	3765512.47	317.92	8.7884
4	POLYGON	BB_DIKE	242550.73	3765530.45	317.89	8.6741
5	POLYGON	MAIN_BLG	242473.23	3765447.61	318.56	7.62
6	POLYGON	ENMOE005	242473.28	3765443.93	318.48	9.14
7	POLYGON	ENMOE007	242506.12	3765509.51	319.01	10.67
8	POLYGON	ENMOE009	242488.25	3765503.74	319.38	15.24
9	POLYGON	ENMOE00B	242480.99	3765469.29	318.94	18.29
10	POLYGON	C_DIKE	242532.95	3765472.42	317.72	13.4112
11	POLYGON	CC_DIKE	242521	3765459.61	317.5	10.0457
12	POLYGON	D_DIKE	242531.08	3765512.67	318.44	8.763
13	POLYGON	DD_DIKE	242530.85	3765530.12	318.59	8.6741
14	POLYGON	H_DIKE	242509.24	3765582.03	319.46	8.4582
15	POLYGON	HH_DIKE	242509.05	3765609.78	319.32	8.4836
16	POLYGON	I_DIKE	242509.98	3765630.9	318.97	9.7409
17	POLYGON	J_DIKE	242486.52	3765589.68	320.38	9.7028
18	POLYGON	M1_DIKE	242511.48	3765594.32	319.32	7.9248
19	POLYGON	M2_DIKE	242518	3765593.26	319.04	10.2616
20	POLYGON	OFFICE	242450.98	3765504.87	320.53	4.2164
21	POLYGON	OUT_LAB	242487.66	3765542.41	319.92	3.6576
22	POLYGON	R01_BLDG	242535.27	3765604.14	318.24	6.1214
23	POLYGON	DMS_STR	242524.63	3765635.1	318.22	5.5118
24	POLYGON	DMS_SCR	242525.4	3765655.68	317.86	13.8176
25	POLYGON	RX_CNTL	242548.89	3765581.57	317.95	4.6228
26	POLYGON	PILOT	242579.98	3765603.4	316.82	5.2578
27	POLYGON	L_DIKE	242527.09	3765591.76	318.66	12.192

Appendix B

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

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

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

15-min AAC

The OSHA 15-min permissible exposure limit (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:

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

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

$$\text{15-min AAC} = (9 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg}) / 10 \text{ (safety factor)}$$

15-min AAC = 900 µg/m³

24-hour AAC

The OSHA 8-hour Time Weighted Average (TWA) 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:

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

where, 44.05 is the molecular weight for ethylene oxide and 24.45 is the molar volume at 25°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:

$$\text{24-hour AAC} = \frac{1.8 \text{ mg/m}^3 \times 1{,}000 \text{ µg/mg} \times (8 \text{ hours/day} \times 5 \text{ days/week})}{300 \text{ (safety factor)} \times (24 \text{ hours/day} \times 7 \text{ days/week})}$$

24-hour AAC = 1.43 µg/m³

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 µg/m³

[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 3×10^{-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 = 3×10^{-3} per $\mu g/m^3 \times 1.6 = 0.005/\mu g/m^3$

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 µg/m^3**