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DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION

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MEMORANDUM

February 11, 2020

To: James Boylan
Thru: Byeong-Uk Kim
From: Henian Zhang
Subject: **Modeling Analysis for Ethylene Oxide**
Additional Controls as Described in Permit Application #27352
Becton, Dickinson and Company, Madison, Morgan 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 Becton, Dickinson and Company in Madison, GA (hereafter, BD-Madison), on ambient air surrounding the facility. The modeling evaluated the proposed BD-Madison project involving the addition of controls for fugitive emissions from the existing operations. The sources of fugitive emissions include the sterilization vessel rooms, the vessel aeration transfer corridors, the ethylene oxide dispensing rooms, and the work in progress area, where sterilized product is stored. 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

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

averaging periods were below their corresponding AACs. The modeled annual averaged ground-level concentrations across the 5-year period (AAGLCs) exceeded the annual AAC. However, the AAGLCs at the closest residential areas were below the annual AAC. The results are summarized in the following sections of this memorandum.

INPUT DATA

1. **Meteorological Data** – Hourly meteorological data (2014 to 2018)[2] were generated by GA EPD. Surface measurements were obtained from the Athens Ben Epps Airport, Athens, 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 BD-Madison and reviewed by the GA EPD Stationary Source Permitting Program (see Table A1 in Appendix A for details). The sterilization vessel vents, the vessel back vents, and the aeration cells, which all vent to an RTO, are not impacted by the project. The sterilization vessel rooms, the vessel aeration transfer corridors, and the ethylene oxide dispensing rooms will be controlled with a new dry bed system (System 1) and the work in progress area will be controlled with a separate new dry bed system (System 2). Each system will be required to reduce ethylene oxide emissions by a minimum of 99%. The facility-wide modeled ethylene oxide emission rate was 49.8 lbs/year.

3. **Receptor Locations** – Discrete receptors with 25-meter intervals were placed along the property line. Receptors extend outwards from the property line at 100-meter intervals on a Cartesian grid to approximately 5 km. This domain (approximately 10 km by 10 km) is sufficient to capture the maximum impact. All receptor locations are represented in the 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 BD-Madison 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).

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

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 exceeded its corresponding AAC. Figure 1 shows the spatial distribution of the AAGLCs with the closest residential areas labeled (R1, R2, R3 R4, R5, and R6). A site-specific risk assessment shows that the AAGLC at the closest residential areas did not 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	0.00227	0.00033
15-min	1.01	900
24-hour	0.0322	1.43

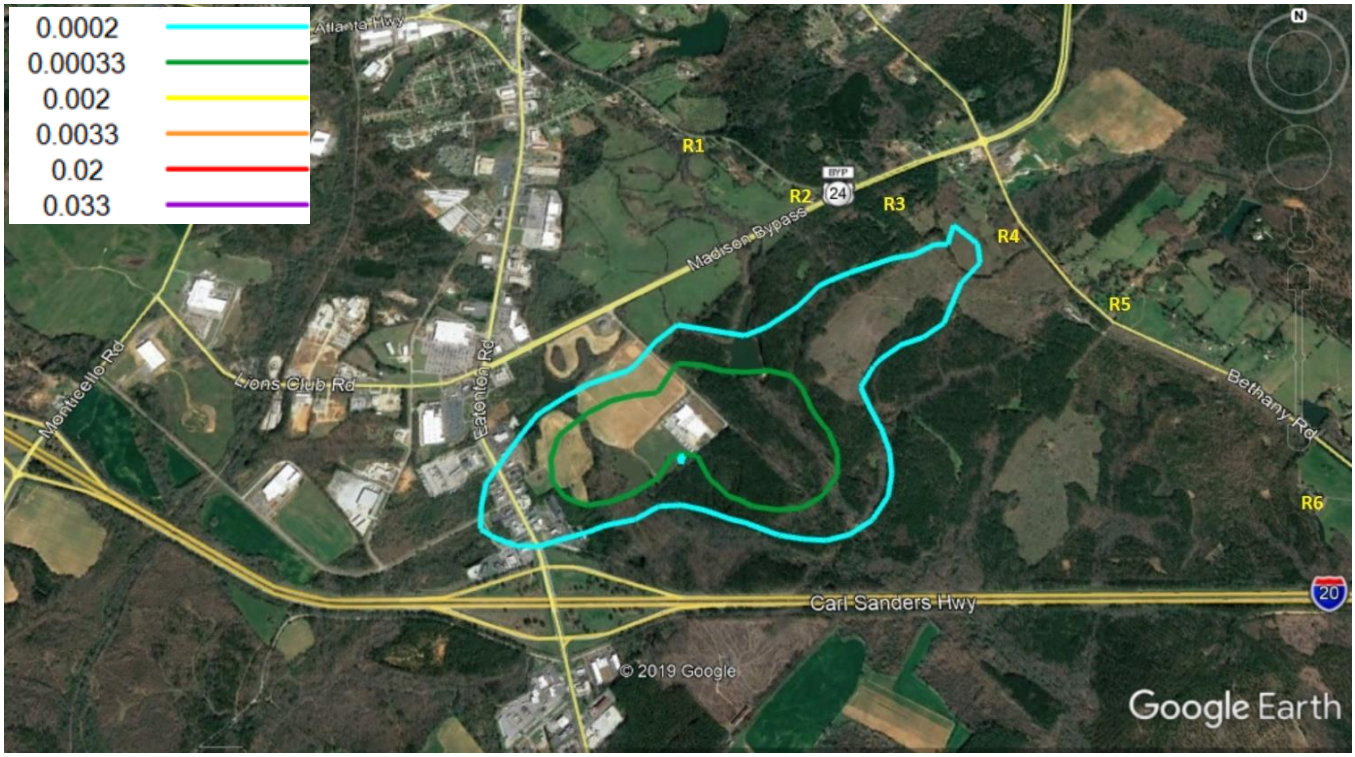

Figure 1. Contours of modeled annual averaged ground-level concentrations (in μg/m^3) across 5 years overlaid on a Google Earth map with the closest residential areas labeled (R1, R2, R3 R4, R5, and R6).

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

Residential Areas	Receptor UTM Zone:17		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	270,899.39	3717756.13	0.00008	Annual	0.00033	0.24
R2	271,433.03	3717474.53	0.00012			0.36
R3	271,875.72	3717411.61	0.00015			0.45
R4	272,423.92	3717211.89	0.00018			0.55
R5	272,813.00	3716885.25	0.00013			0.39
R6	273,487.20	3715958.17	0.00009			0.27

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

CONCLUSIONS

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

Appendix A

Emissions and Model Input Parameters

Table A1. Source Parameters

Source Parameters								
Source ID	Easting (m)	Northing (m)	Modeled Emission (lb/yr)	Modeled Emission (g/s)	Stack Height (m)	Stack Temperature (K)	Exit Velocity (m/s)	Stack Diameter (m)
RTO	270,841.52	3,716,316.63	13.4	1.93E-4	15.24	394.26	12.98	1.219
System1	270,881.85	3,716,272.66	1.2	1.75E-5	30.48	294.26	11.24	1.167
System2	270,878.40	3,716,269.30	35.2	5.07E-4	30.48	294.26	16.18	1.575

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 $3x10^{-3}$ 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 µg/m^3**