# A Comparison of Ambient Ethylene Oxide Concentrations from Modeling Estimates of Stack and Fugitive Emission Source to Canister-based Measurements in Salt Lake City

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## Introduction

- Ethylene Oxide (EtO) is a colorless, flammable gas at room temperature, procured by the catalytic oxidation of ethylene[1]
- EtO has alkylating properties used to sterilize medical devices and equipment[2]
- In 2016, epidemiological studies lead the EPA to updated the inhalation hazard unit for EtO due to more potent carcinogenic findings
- Chronic EtO exposure is associated with an increased risk of white blood cells related cancers, including non-Hodgkin lymphoma, myeloma, and leukemia[3]
- The Salt Lake City geography and metrological conditions may prevent EtO from being diluted in the ambient air after emitted
- Background environmental sources of EtO are unknow, but the EPA proposed automobile combustion and biological metabolic by-product as possible source emitters [4]

## Purpose

- To investigate how the method of measuring ambient EtO using the EPA's dispersion modeling techniques (AERMOD) compares to canister-based measurements
- If a discrepancy is found, a correction factor could be derived to aid in subsequent cancer risk assessment of the nearby community using human exposure modeling (HEM-4)

## Methods

- A local sterilization facility was identified as point source of ambient EtO emission in Salt Lake City
    - Fugitive and stack emission information was obtained
- New, whole-air passive canisters lined with silonite collected 24-hour samples of ambient EtO concentrations
    - 8 sites near the sterilization facility
    - 5 background sites
- Lab analyzed with the EPA's TO-15 Method using gas chromatography and mass spectrometry techniques
- Summer and Winter background values were computed and added to modeled estimates using Mean-of-the-Median values calculated from EtO concentrations measured at background canister sites

## Methods

- The American Meteorological Society – U.S. EPA Regulatory Model (AERMOD) used dispersion modeling to estimated EtO concentration outputs from the point sources' stack and fugitive emissions
- Measured and estimated concentrations of ambient EtO were compared with a Wilcoxon Signed-ranked test for paired, non-parametric datasets
    - 16 one-sided tests to determine directionality

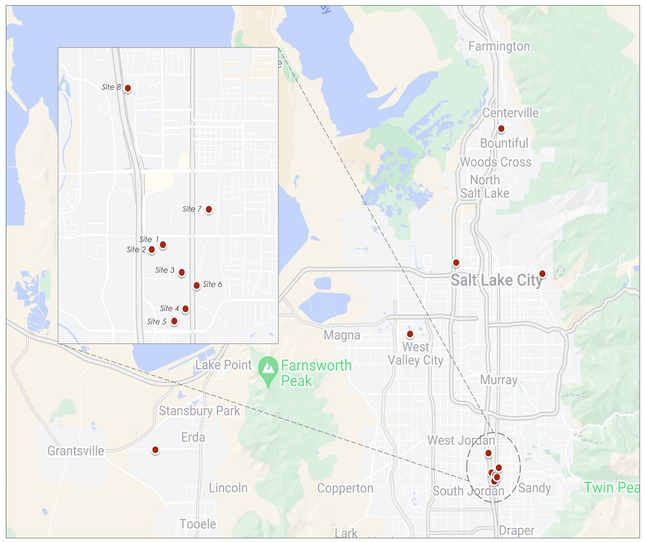


*Figure 1. Map showing where the canister-based measurements were taken across Utah's Salt Lake City. There are 8 sampling sites near the medical sterilization facility (see blown up image) and 5 background sites locations.*

## Results

- The background EtO value was approximately 2.5x greater for measured concentrations in summer compared to winter
- Background site 3, a residentially and industrially mixed location, showed the greatest EtO median concentration for both seasons

*Table 1. Background site medians and Mean-of-median values for winter and summer*

| | Winter (µg/m3) | | | Summer (µg/m3) | | |
|---|---|---|---|---|---|---|
| Site | n | Median | Mean-of-medians | n | Median | Mean-of-Medians |
| 1 | 19 | 0.0575 | | 19 | 0.2015 | |
| 2 | 18 | 0.0621 | | 14 | 0.1543 | |
| 3 | 19 | 0.1070 | 0.0779 | 15 | 0.2254 | 0.1962 |
| 4 | 16 | 0.0958 | | 19 | 0.1987 | |
| 5 | 15 | 0.0667 | | 0 | | |

## Results

- As the sites increase in distance from the point source, the median EtO concentrations generally decreased
- Of the 8 sites sampled around the point source, 6 of the AERMOD estimates were statistically different from the canister-based measurements
    - AERMOD estimates > canister measurements at sites 1, 3, and 4
    - AERMOD estimates < canister measurements at sites 2, 5, and 7
    - Sites 6 and 8 were not statistically significant in either direction

*Table 2. Wilcoxon Signed-ranked test results from comparing median concentrations of EtO estimated with AERMOD modeled to (less than or greater than) canister-based measurements. Significant p-values are noted.*

| | | Modeled Estimates | Canister Measurements | Wilcoxon p-values | |
|---|---|---|---|---|---|
| Site | n | Median (µg/m3) | Median (µg/m3) | Less than | Greater than |
| 1 | 29 | 1.0195 | 0.5296 | 0.99 | < 0.001* |
| 2 | 38 | 0.2343 | 0.2765 | 0.03* | 0.97 |
| 3 | 32 | 0.3420 | 0.2812 | 0.99 | 0.01* |
| 4 | 35 | 0.2131 | 0.1295 | 0.99 | < 0.01* |
| 5 | 37 | 0.2023 | 0.1855 | 0.01* | 0.99 |
| 6 | 36 | 0.2211 | 0.1919 | 0.22 | 0.78 |
| 7 | 37 | 0.1348 | 0.1665 | 0.05* | 0.95 |
| 8 | 34 | 0.1540 | 0.1536 | 0.24 | 0.77 |

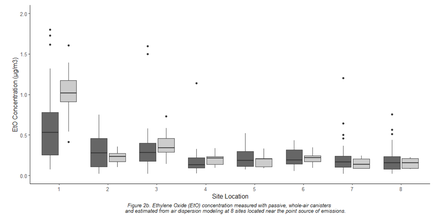


*Figure 2b. Ethylene Oxide (EtO) concentration measured with passive, whole-air canisters and estimated from air dispersion modeling at 8 sites located near the point source of emissions.*

## Conclusion

- After comparing the estimated EtO concentrations from dispersion modeling to canister-based measurements, 5 of the closest sites, and site 7, were statistically different.
- Because neither method indicated being more conservative than the other, a correction factor could not be derived for future cancer risk assessment modeling with the EPA's human exposure modeling
- A vast seasonal difference was found between background data, which deserves further investigation

## Acknowledgments

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## References

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