

Ethylene Oxide in Utah

An overview of Utah DEQ efforts



UTAH DEPARTMENT of
ENVIRONMENTAL QUALITY
**AIR
QUALITY**



DAQ/UofU EtO Study

Monitoring Sites

Measurements near commercial sterilizer in Sandy and near airport + background sites

Seasonal Sampling

Eight weeks in the winter, eight weeks in the summer to assess meteorological differences (inversions)

Health Risk Analysis

Estimate health risk based on modeling and measurements

Medical device sterilization facilities

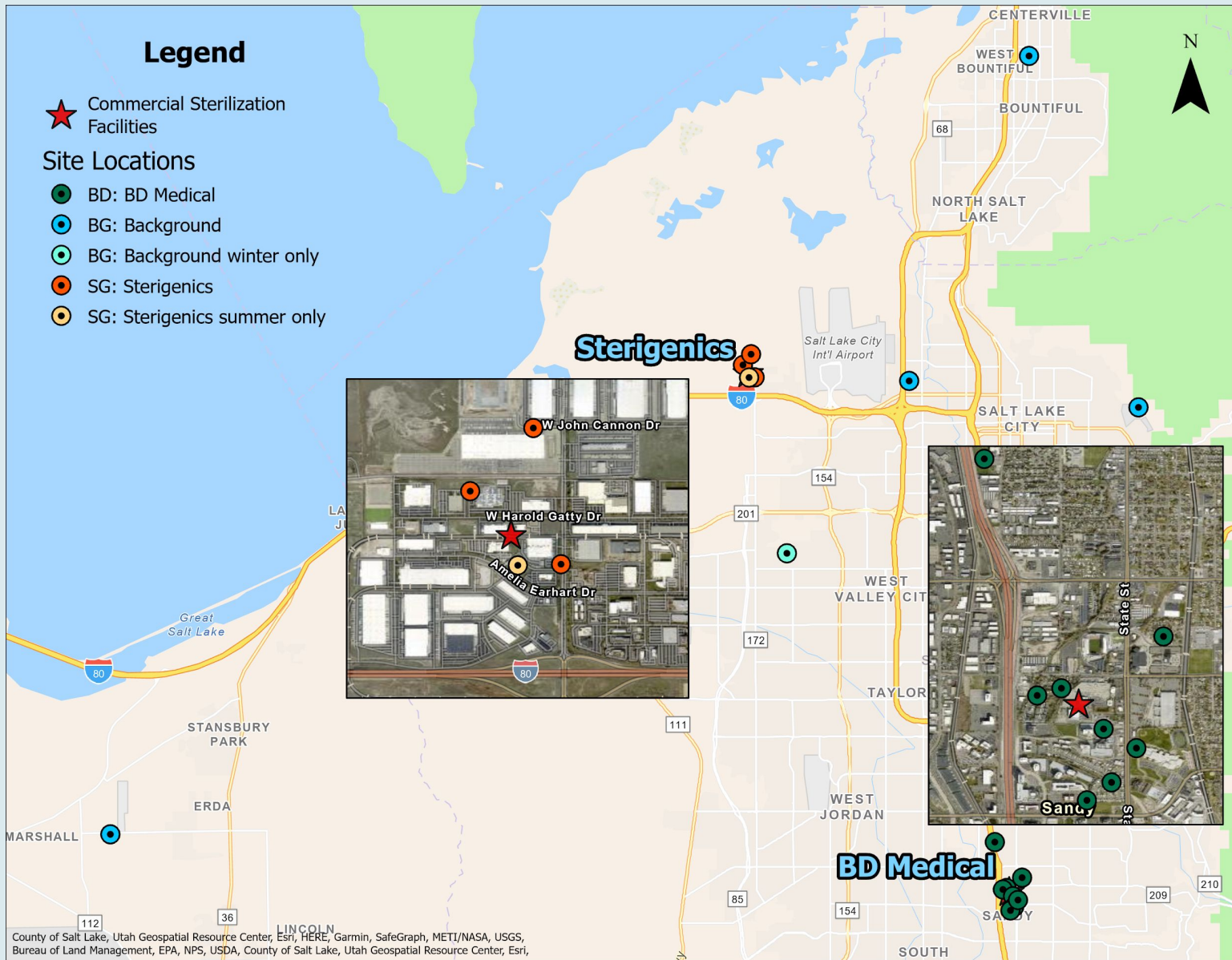
Two facilities in Salt Lake County.

EPA modeled an EtO exposure risk for residents near the BD Medical facility in Sandy, Utah.

Facility	Location	2021 Emissions (PTE) TPY	2021 Emissions (Actual) TPY	Fugitive Emissions (%)
BD Medical (BD)	Residential area in Sandy	0.24	0.35*	95
Sterigenics (SG)	Industrial area near airport (no permanent residents)	2.1	0.98	97

* BD Medical had a 12-month rolling limit for all HAPs emissions (not to exceed 1.77 TPY total)

Location of sampling sites



- 16 sampling sites
- “Background” sites (5 in winter, 4 in summer) > 2 miles from inventoried medical sterilization sources.
 - Rural site, Bountiful NAATTS station, canyon flows site, tech center, inland port
- Near-source monitoring of Sterigenics and BD Medical
 - Added SG4 in the summer near Fire Station 9
 - BD-8 is 1.5 miles from source, close to I-15

Sampling Methods

24-hour samples every 3 days for 8 weeks

- Winter sampling: January 8th to March 13th, 2021
- Summer sampling: July 10th to September 8th 2022



Canisters, timers, and inlets from ERG

Canisters - silonite, validated by ERG

Timers - ENTECH TM1200

Inlets - CS1200E flow restrictor, pressure gauge, restrictor

Lab analysis by ERG

Samples analyzed using TO-15



Sampling Challenges - Timers & Weather

Automated timers

- According to manufacturer, even a battery at 90% (missing one green dot on display) may not reliably actuate solenoid.
- Battery/solenoid issues exacerbated by cold temperatures
- Multiple samples lost during the winter campaign due to timer issues
 - Changed collection time to start and end at 3 pm (instead of midnight) hoping higher ambient temperatures would make a difference.

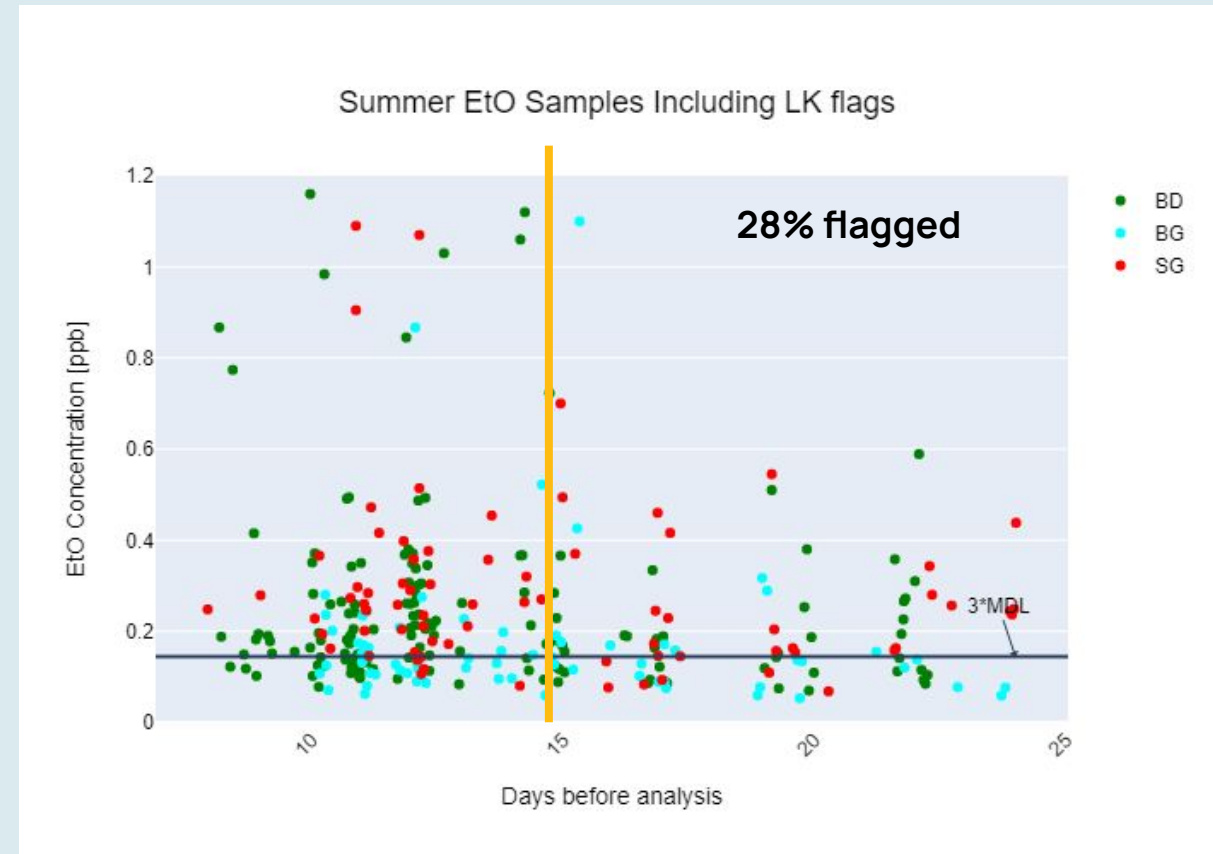
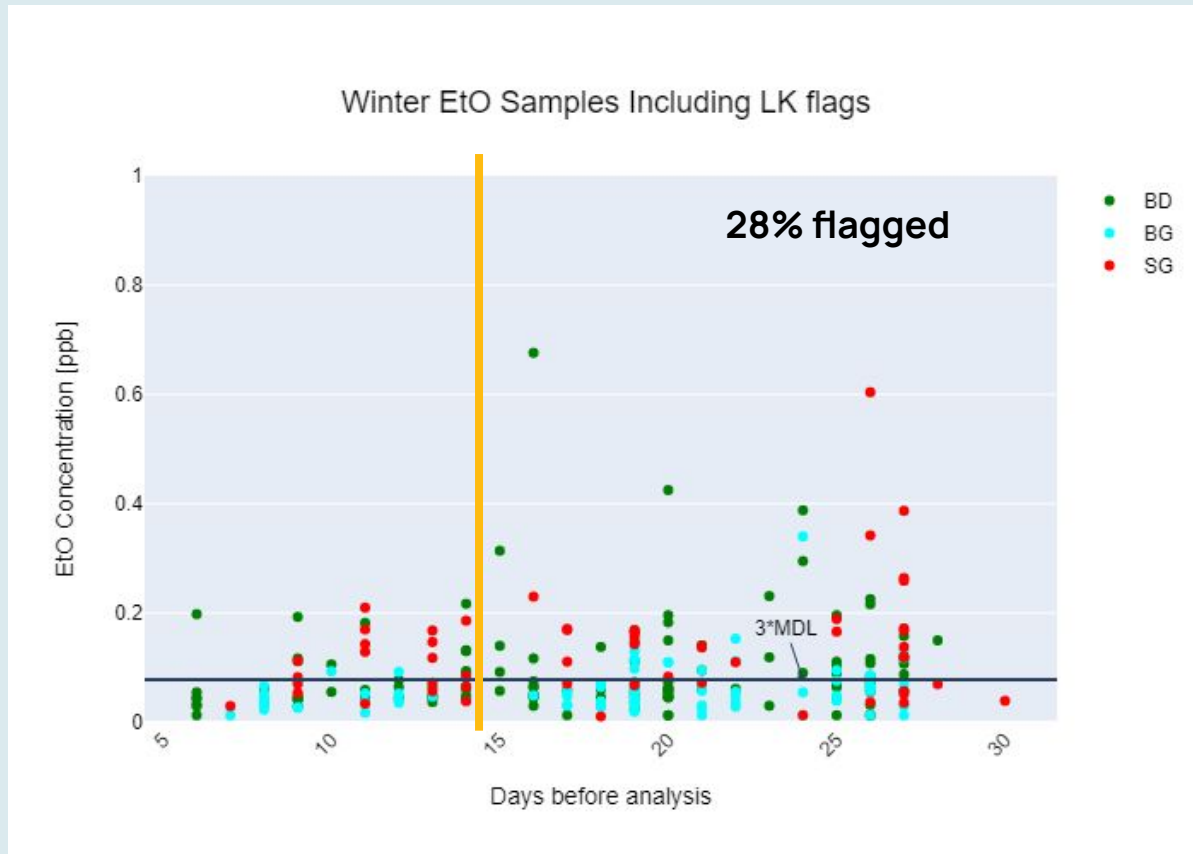
Weather

- Beyond cold temperatures, heavy rain impacted sample collection during the summer.
- Shipping delays during both seasons delayed sampling/sample recovery, and added to canister hold times



Sampling Challenges - Canister Growth?

- EPA recommendation for samples collected after Aug. 2022 - LK flag applied to all samples $> 3 \times \text{MDL}$
- This study - LK flag applied to samples with > 14 day hold time and concentrations $> 3 \times \text{MDL}$



Data QA/QC

Doing the best with
what we've got



VOID/Remove/Replace

Void all suspicious field samples.

Remove all lab-analyzed samples with lab pressure < 5 "Hg.

Determine if lab samples voided correctly.

Replace ND with $0.5 * MDL$.



Collocated Samples

Assess collocates using TADv4 recommendations.

Take average of passing collocates as one datapoint.

Retain flagging (LK) for exclusion later.



Seasonal Analysis

Determine site statistics for each sampling time period.

Assess seasonal differences, and spatial variability of background sites and near-sources sites.



Exclude LK flags

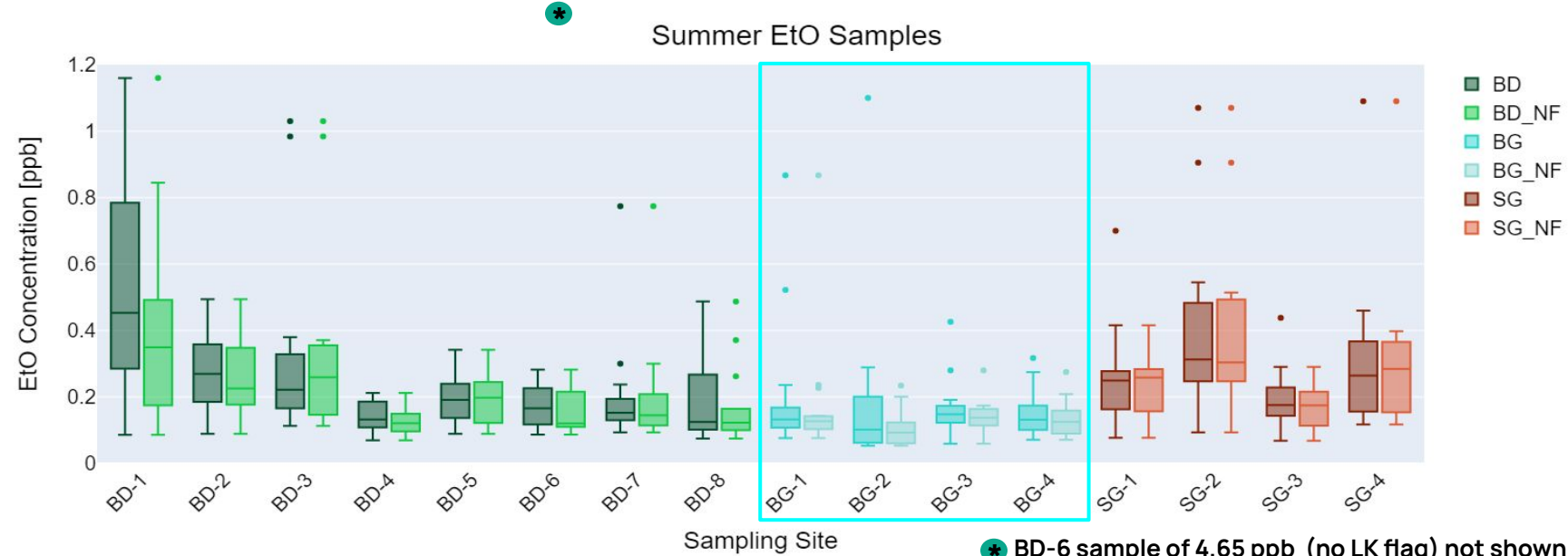
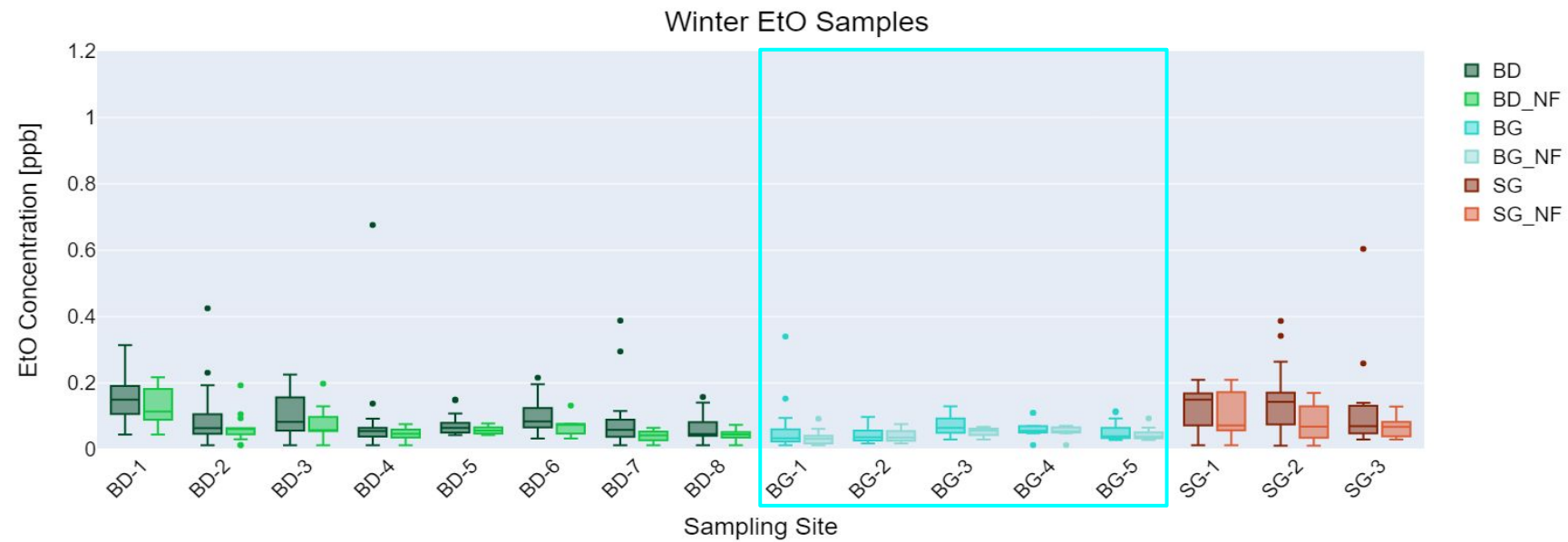
Repeat seasonal analysis after removing LK flagged samples.

Assess differences between site statistics with and without LK flags.

Site Results

Winter and summer results for each sampling location show wide variability.

- The Y-axis scale is consistent between plots.
- No flag (NF) data are lighter shades.
- Removing LK flags is more impactful in the winter than the summer, despite similar # of flagged samples in each season.
- The highest summer sampling value (4.65 ppb at BD-6) is excluded from the plot but included in all statistics.



Site Results - LK Flag Statistics

Are the distributions different?

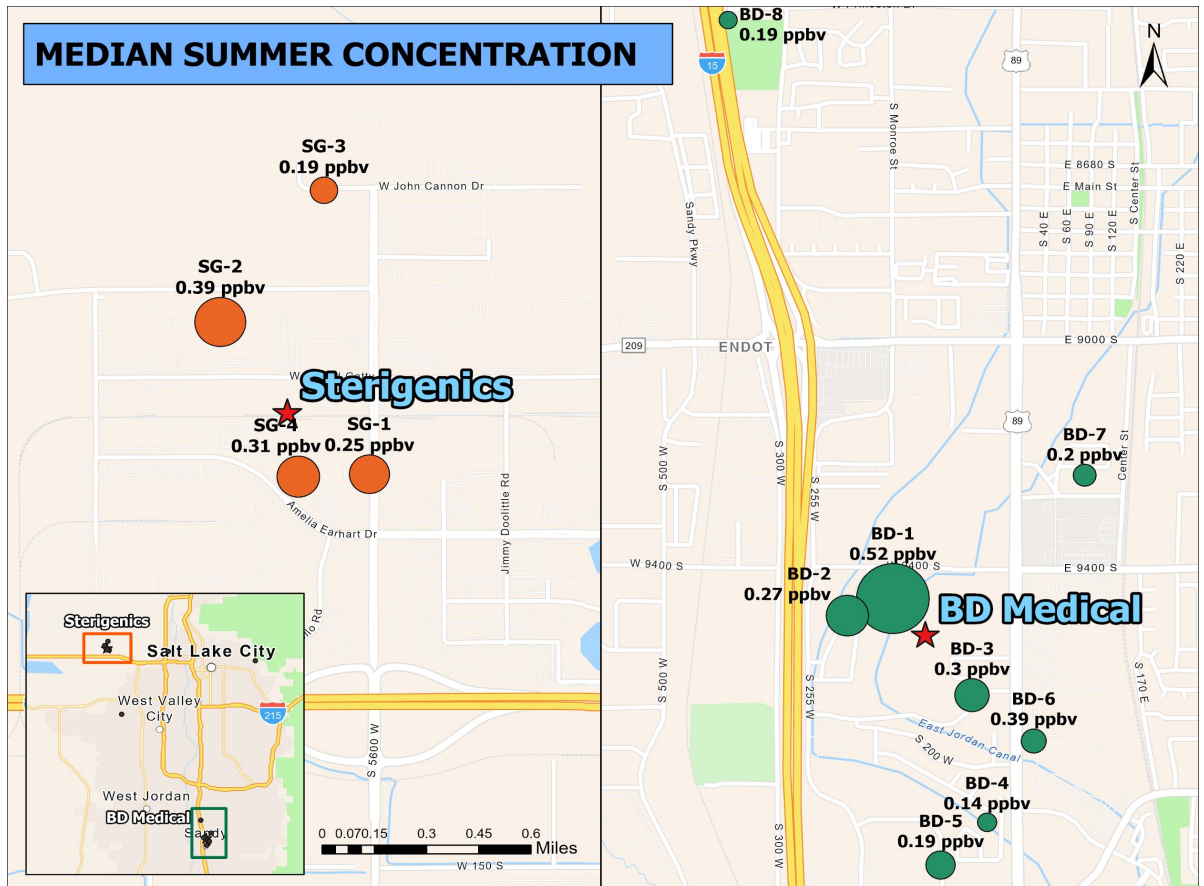
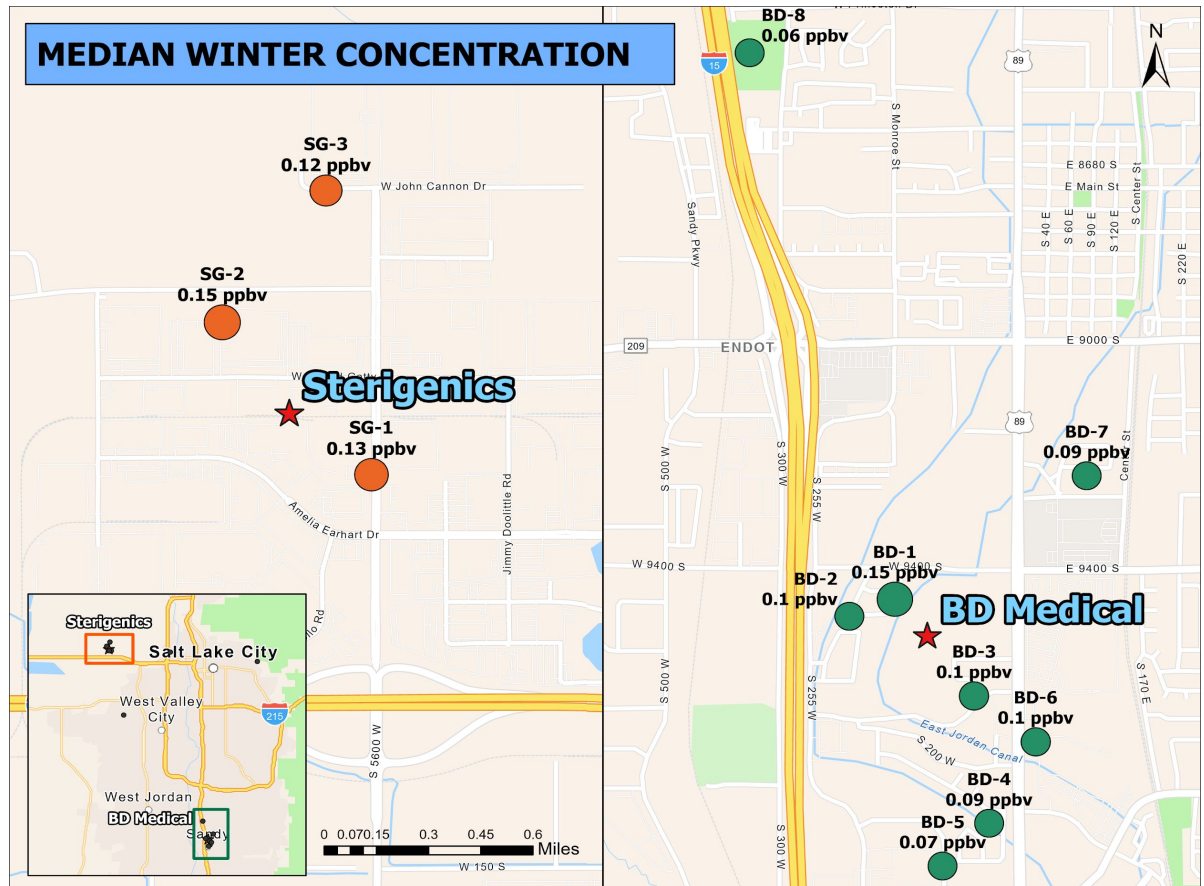
- All of the sites with LK flags or no LK flags (NF) come from statistically similar distributions (2-sample KS test)
- Data is generally not from a normal distribution (skewness), however, max samples is low (n=21 in winter, 20 in summer)
- The summer datasets are not statistically different (using 2-sample t-test w/ unequal variance)
 - Wintertime sites had more data removed due to LK flagging, and did have statistically different results at four sites.
- Overall story doesn't change when removing LK flags. Following plots include LK flags in dataset.

Group	range median	range median NF	range min	range max	range max NF	range 2-samp KS p-value
BD Winter	0.046, 0.150	0.042, 0.115	0.013, 0.045	0.015, 0.676	0.065, 0.217	0.205, 0.987
BD Summer	0.125, 0.453	0.120, 0.349	0.070, 0.113	0.212, 4.65	0.212, 4.65	0.621, 1.0
BG Winter	0.034, 0.065	0.032, 0.057	0.013, 0.030	0.098, 0.340	0.068, 0.093	0.0205, 1.0
BG Summer	0.101, 0.148	0.092, 0.137	0.053, 0.076	0.317, 1.100	0.234, 0.867	0.920, 1.0
SG Winter	0.071, 0.150	0.068, 0.073	0.011, 0.030	0.210, 0.604	0.129, 0.210	0.298, 0.726
SG Summer	0.176, 0.313	0.175, 0.304	0.068, 0.117	0.438, 1.09	0.290, 1.09	1.0, 1.0

Table range is max and min of statistic for all sites in the group (minimum BD group median is the lowest median out of the 8 BD sites)

Site Results - Spatial Distribution

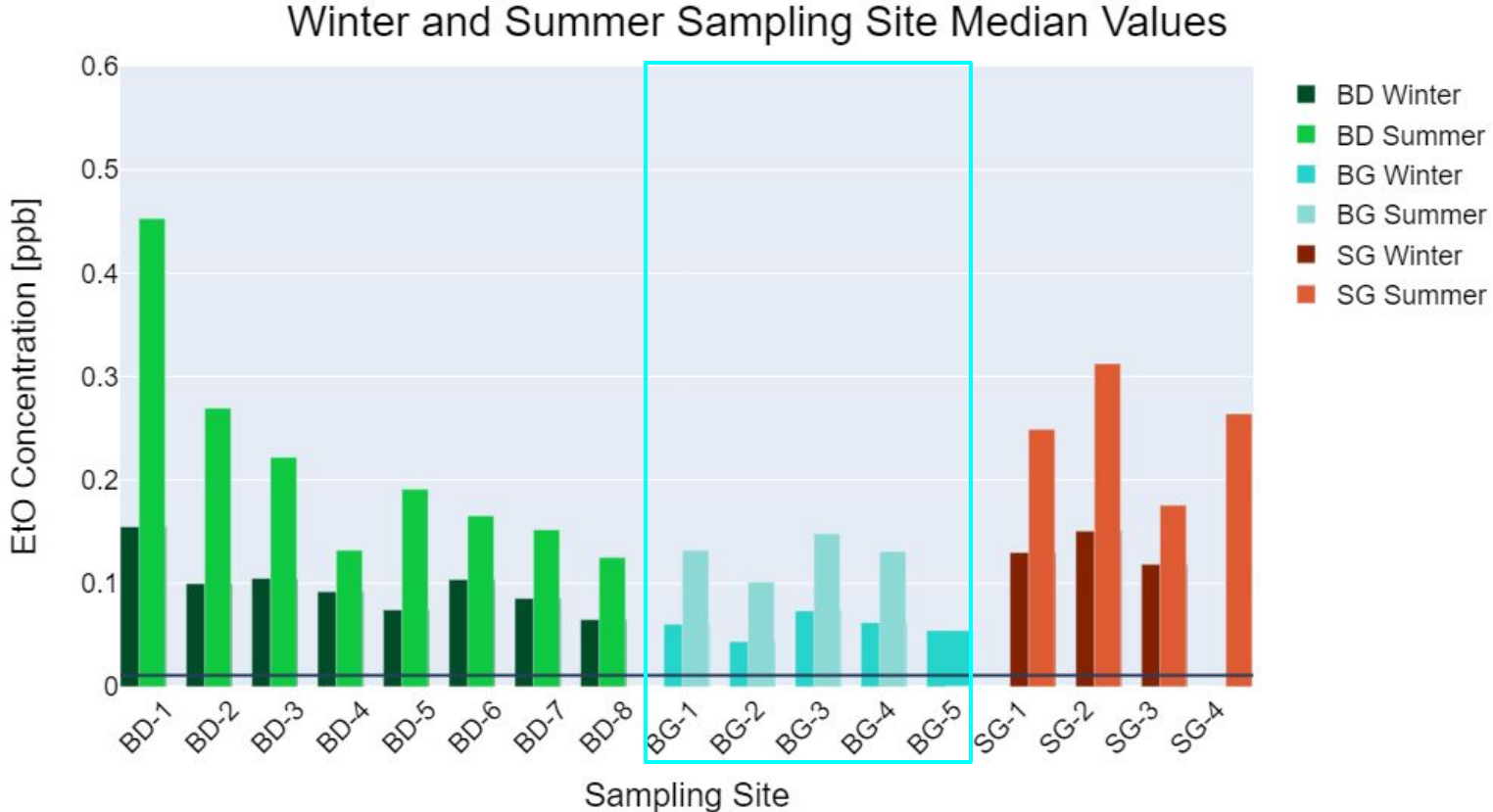
- Site median concentrations for summer and winter sampling.
- Sites closer to the facilities have higher median EtO and are consistent with prevailing wind directions and topography.
- Dots have different scale between figures, site median concentrations are included.



Site Results - Seasonal Differences

Medians during the summer and winter for each measurement site.

- Summer samples are always higher than winter samples.
- EtO concentrations are higher closer to the facilities and higher than background
- Background is variable.
 - BG-1 (canyon flows), is higher than BG-2 (rural town).
- Lifetime cancer risk (black line) well below site median values.



Conclusions + Ongoing & Future Work

There are many challenges and uncertainties with EtO sampling using canisters. However, **measurements confirm modeled regions of enhanced EtO.**

Summertime EtO values are significantly higher than wintertime values (~ factor of 2-3), even at background sites.

Rural background site differ from urban sites.

Ongoing Work

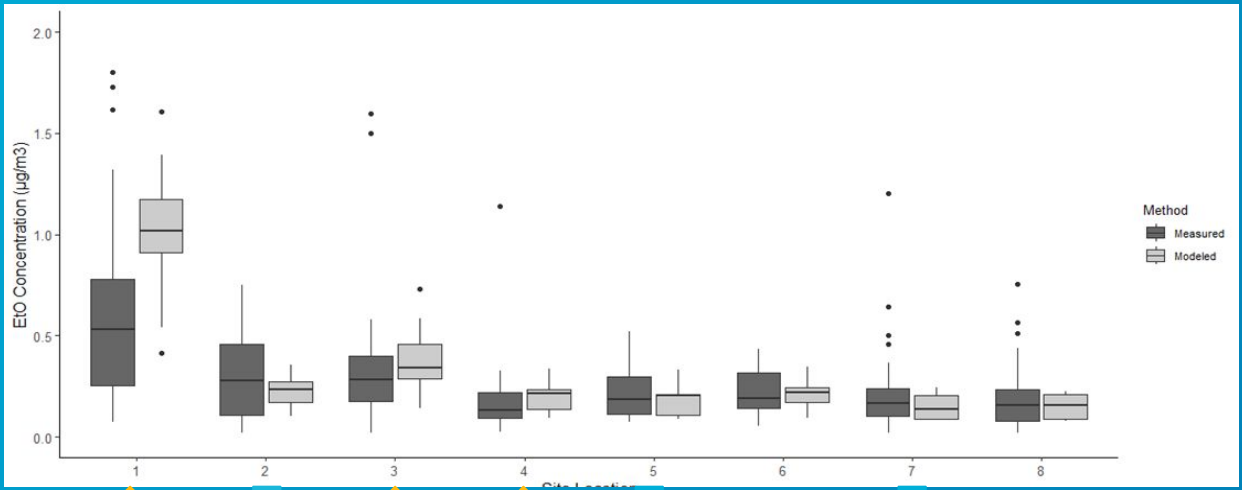
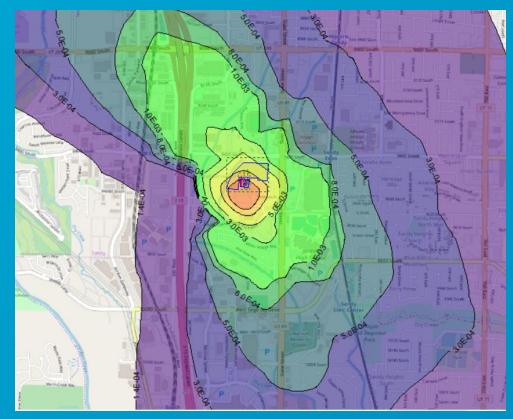
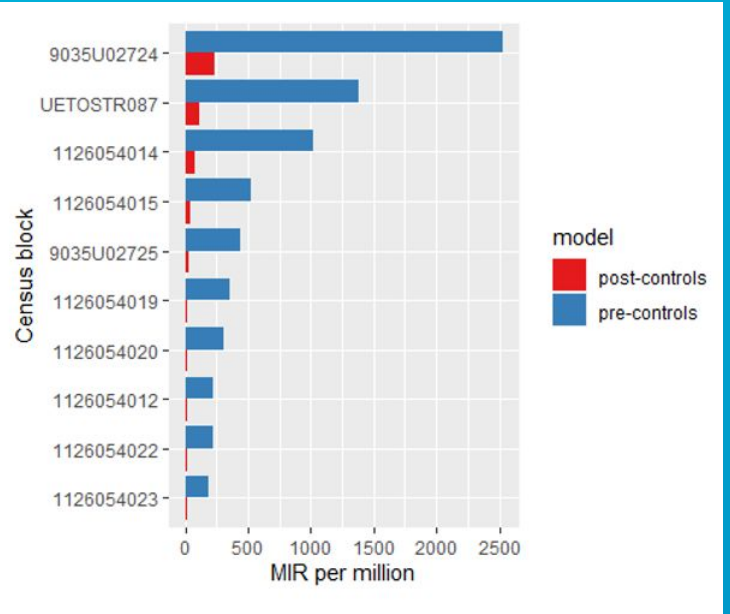
Risk assessment for pre and post control scenarios at BD Medical.

Modified risk assessment for SG facility.

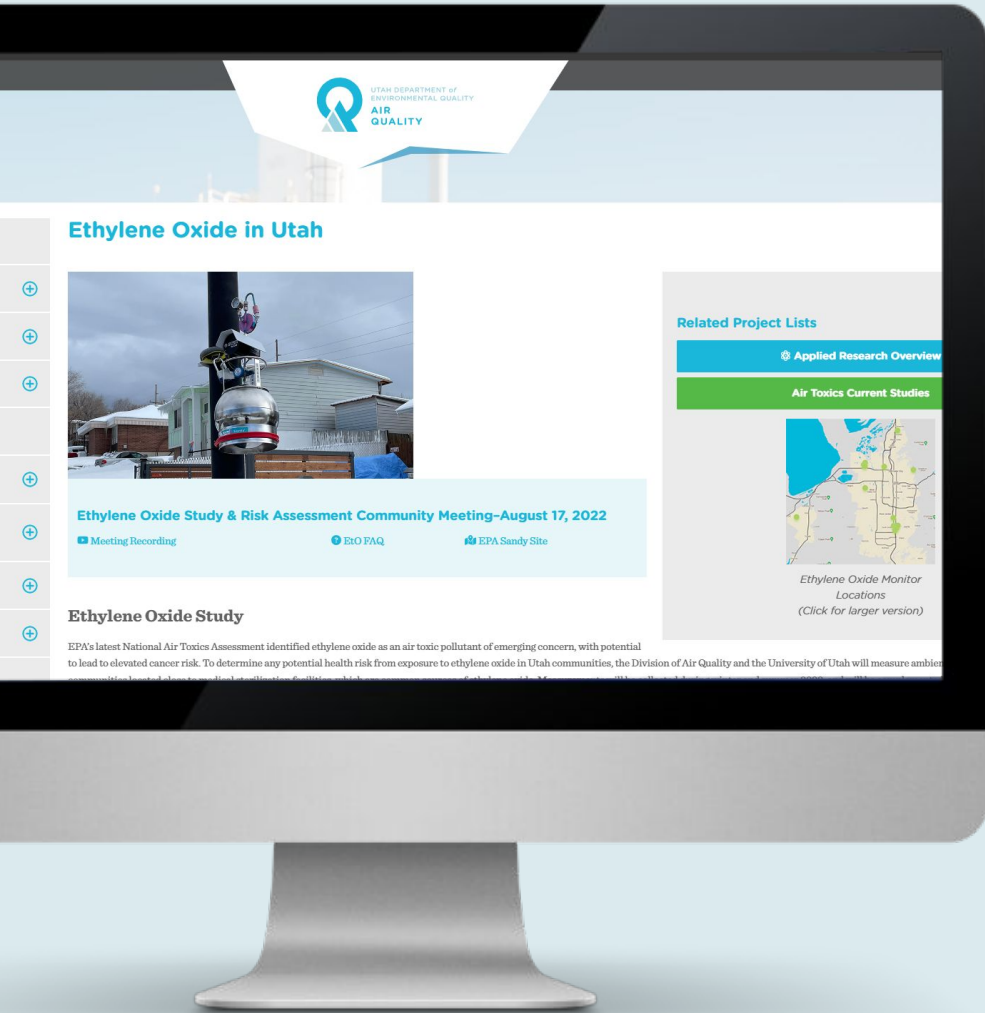
Modeled vs measured comparison for appropriate met year.

Future Work

Funded IRA grant for mobile VOC surveys in EJ areas of the Wasatch Front, including EtO surveys in the Sandy, UT community near BD Medical.




Community outreach & engagement




Air Quality Monitoring Study In Progress

DO NOT TAMPER WITH SAMPLER!!



Learn more about this study here: →



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deq.utah.gov/air-quality/ethylene-oxide-study

*DAQ Ethylene Oxide website
Multiple public meetings, two with
representatives from EPA (R8 and HQ)
Final report anticipated in fall 2023*

Our Expert Team

Utah Division of Air Quality

Monitoring section technicians: Shauna Ward, Luke Leclair Marzolf, Cristina Jaramillo, Michael Yang, Lucas Bohne, John Coombs, Kati Chachere, Amari Dolan-Caret, Sally Lloyd, Olivia Mondlock, Thad Baldwin

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Health modeling and cancer risk assessment, project design



Dr. Rachel Edie

UDAQ - Modeler, researcher
AERMOD pre-modeling, sampler maintenance, data analysis



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HEM 4 Modeling, statistical analysis

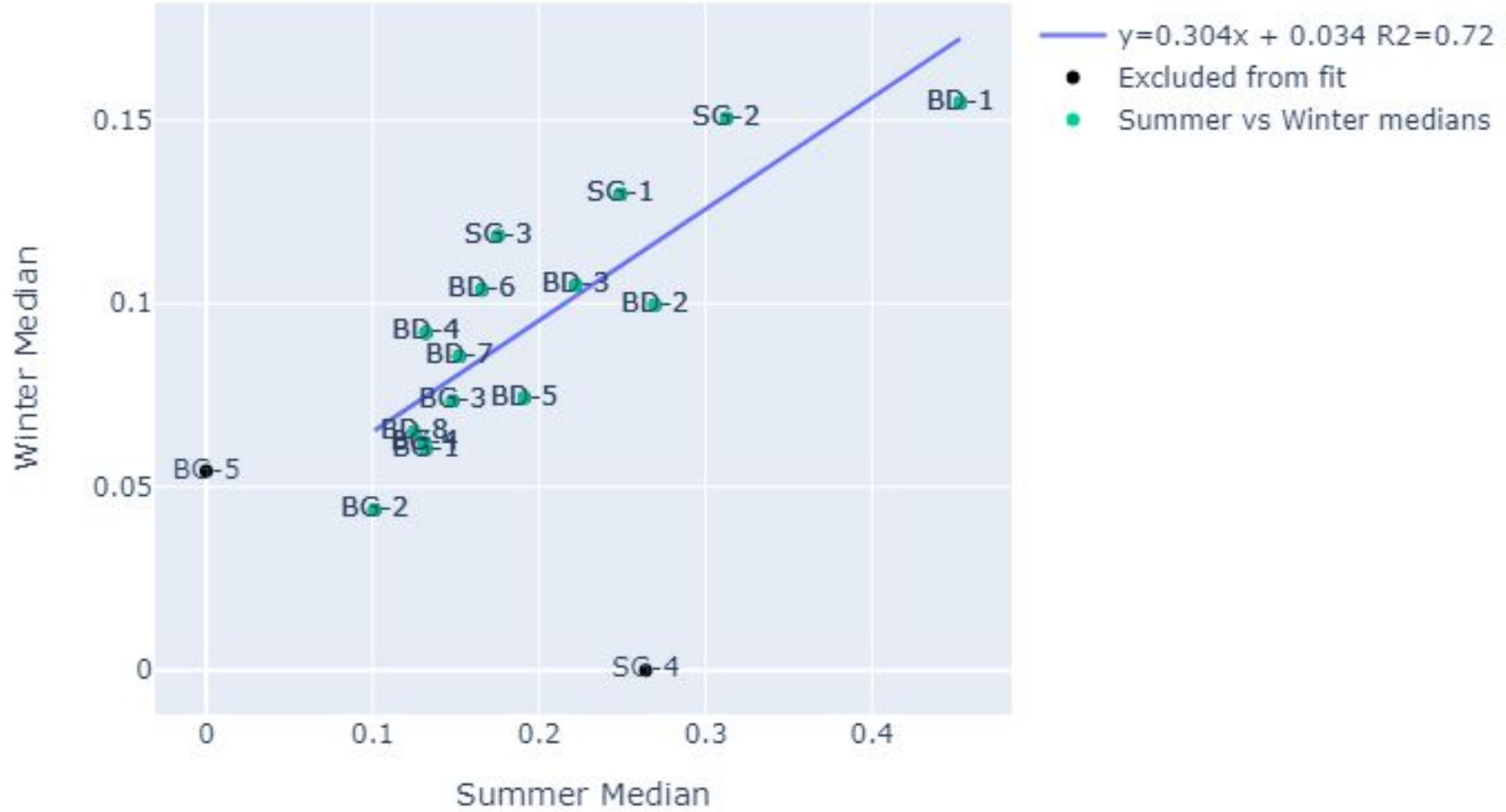
Questions?

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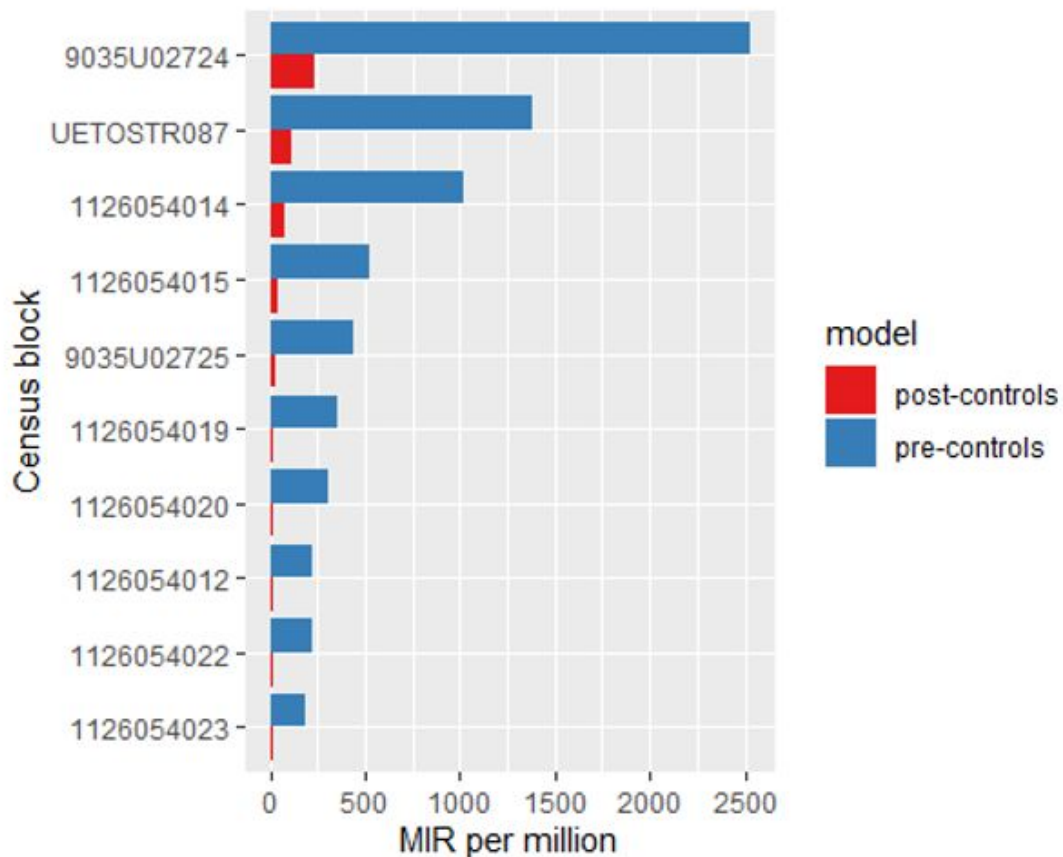
Extra Slides

Summer VS Winter Sample Medians at Each Site



			winter						sum.			
Sites	median all	median no flags	min all	max all	max no flags	two samp KS	median all	median no flags	min all	max all	max no flags	two samp KS
BD-1	0.150	0.115	0.045	0.314	0.217	0.987	0.453	0.349	0.086	1.160	1.160	0.621
BD-2	0.064	0.061	0.013	0.425	0.193	0.925	0.270	0.226	0.089	0.494	0.494	0.966
BD-3	0.083	0.057	0.013	0.226	0.198	0.897	0.222	0.259	0.113	1.030	1.030	1.000
BD-4	0.055	0.047	0.013	0.676	0.076	0.920	0.132	0.121	0.070	0.212	0.212	1.000
BD-5	0.065	0.057	0.043	0.150	0.078	0.498	0.191	0.198	0.089	0.342	0.342	0.999
BD-6	0.084	0.074	0.033	0.216	0.132	0.261	0.166	0.120	0.087	4.650	4.650	0.882
BD-7	0.059	0.042	0.013	0.388	0.065	0.205	0.152	0.145	0.093	0.774	0.774	0.988
BD-8	0.046	0.045	0.013	0.158	0.074	0.714	0.125	0.123	0.075	0.487	0.487	0.991
BG-1	0.034	0.032	0.013	0.340	0.092	0.944	0.132	0.127	0.076	0.867	0.867	0.920
BG-2	0.036	0.036	0.018	0.098	0.076	1.000	0.101	0.092	0.053	1.100	0.234	0.995
BG-3	0.065	0.057	0.030	0.130	0.068	0.205	0.148	0.137	0.059	0.426	0.280	1.000
BG-4	0.056	0.055	0.013	0.110	0.071	0.998	0.131	0.125	0.071	0.317	0.275	0.984
BG-5	0.039	0.038	0.029	0.115	0.093	0.996						
SG-1	0.150	0.073	0.013	0.210	0.210	0.726	0.249	0.258	0.077	0.700	0.416	1.000
SG-2	0.143	0.069	0.011	0.387	0.170	0.298	0.313	0.304	0.093	1.070	1.070	1.000
SG-3	0.071	0.068	0.030	0.604	0.129	0.714	0.176	0.175	0.068	0.438	0.290	1.000

Health Risk Assessment



Results for BD Medical facility only.

- HEM4 modeled cancer risk at top 10 highest receptor locations
- Analysis for 5 years of met data
 - Didn't see a significant difference between met years
- Model for pre controls and post controls (a 95% reduction in fugitive emissions with the installation of drybed controls on warehouse rooftop vents)
- Post-controls still exceed the 100 in 1 million cancer risk threshold.

Facility updates:

- BD medical has installed and tested the drybed system, but the first stack test failed (did not show 95% destruction efficiency).
- They have 30 days to re-test and pass

Modeled vs. Measured Comparison

Results for BD Medical facility only.

- Modeled values are statistically higher than measured values at BD1, BD3, and BD4 were statistically higher than measured values.
- Modeled values for BD2, BD5, and BD7 were statistically lower than measured values.

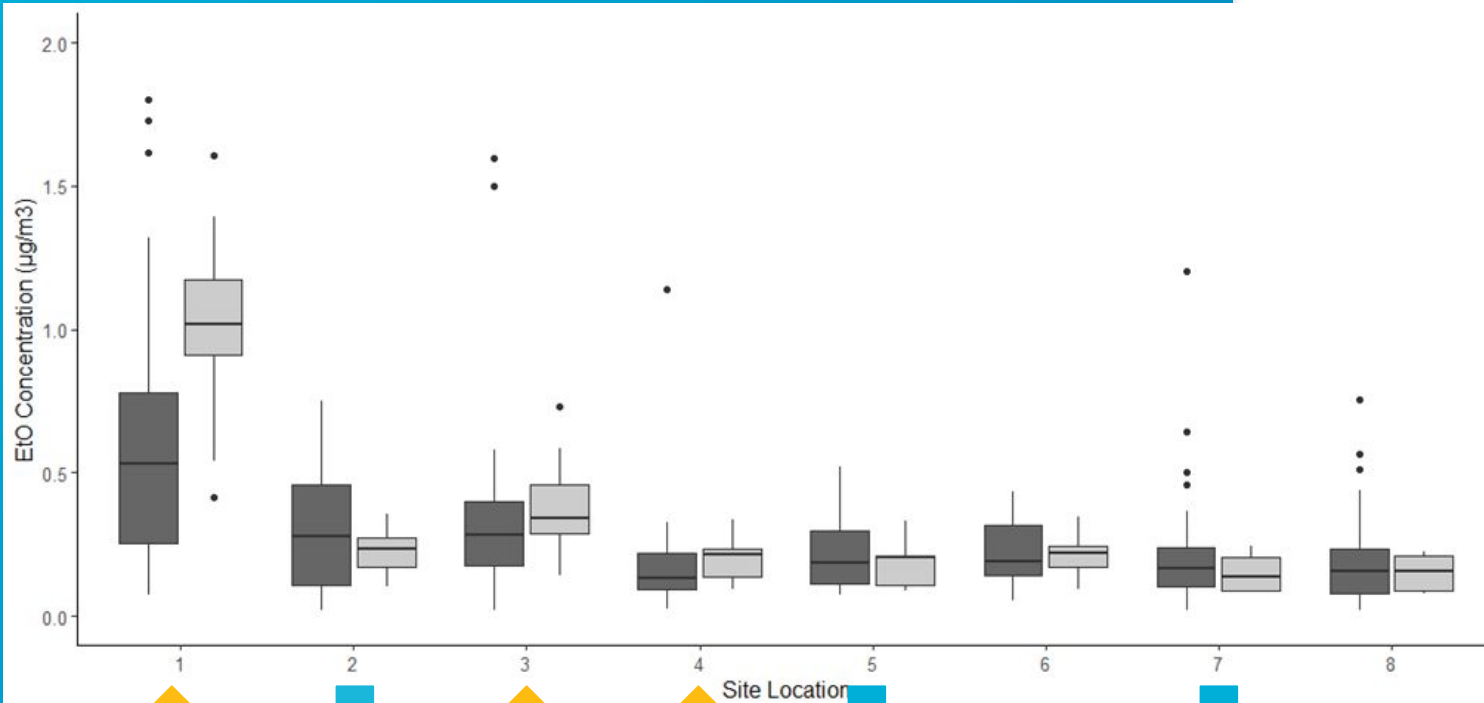
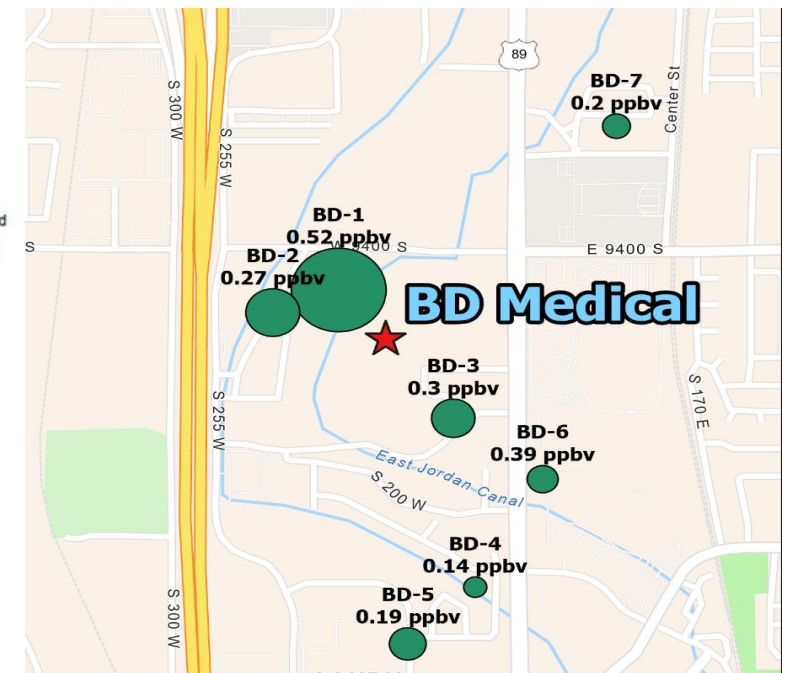


Figure 20. Ethene Oxide (EIO) concentration measured with passive, whole-air canisters and estimated from air dispersion modeling at 8 sites near the point source of emissions.



Modeled vs. Measured Comparison

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.

Site	n	Modeled Estimates	Canister Measurements	Wilcoxon p-values	
		Median ($\mu\text{g}/\text{m}^3$)	Median ($\mu\text{g}/\text{m}^3$)	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