AIR QUALITY MONITORING STUDY

4th Community Meeting: August 11, 2020 at 6:30p – 8:00p via Zoom

Kumar Jensen
Chief Sustainability & Resilience Officer
City Manager’s Office
City of Evanston

Jacob Persky, MPH, CIH
Principal, Co-Founder
RHP Risk Management Inc.

Frank Pagone, Ph.D.
Senior Associate, Health Sciences
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Associate Professor
UIC School of Public Health

Ashley Mcilwee
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Ashley Mcilwee
Senior Environmental Health Practitioner
City of Evanston
Questions During Presentation

There are three ways to ask questions:

1. Type your question into the chat box on Zoom
2. Email sustainability@cityofevanston.org
3. Or, if you are on phone, to wait until the Q&A portion of the event and ask then
MEETING AGENDA

1. Welcome 6:30 – 6:45pm
2. Study Presentation 6:45 – 7:30pm
3. Questions & Answers 7:30 – 8:00pm
TRANSFER STATION

Address: 1711 Church St., Evanston, IL
Owner and operator: Advanced Disposal
Waste accepted: Household waste and construction and demolition debris
Vehicles onsite: Private vehicles, construction and demolition contractor vehicles, trash trucks and 18-wheelers
Hours of operation: Monday – Friday, 6:30am–3:30pm; Saturday, 7–10am; Sunday, closed
Purpose of this meeting is to provide a summary of study findings, answer questions about the report, and discuss recommendations for next steps.

The Objective of the study was to measure for ambient air pollutants that we expected may be present based upon TEX recommendations.

Study Results and Raw Data were published publicly in early June and are available on the City of Evanston project webpage.
STUDY TIMELINE

• Community Meeting 1: May 2, 2019
• Equipment Deployed: May 8-15, 2019
• Data Collection Began: May 18, 2019
• Community Meeting 2: August 29, 2019
• Community Meeting 3: October 24, 2019
• Data Collection Ends: November 13, 2019
• Study Report Released: June 9, 2020
• Community Meeting 4: August 11, 2020
Final Community Meeting
August 11, 2020

City of Evanston Air Quality Monitoring Study

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Presentation Outline

• Review of Project Background
  – Site Locations, Study Parameters, and Monitoring Equipment

• Summary of Study Results
  – 6 Perspectives for Data Analysis
  – Weight of Evidence (WOE) Scoring

• Recommendations

• Next Steps
Anticipated Results

- Determination of ambient air concentrations for measured air pollutants (using AQMesh and MultiRAE Pro monitors) at four neighborhood sites and at the control site (e.g., maximum, minimum, mean, standard deviation of measured concentrations);
- Assessment of whether neighborhood-level concentrations are statistically significantly higher than those measured at the control site;
- Analysis of wind direction during the sampling period to gain insight into air monitoring sites upwind and downwind of the waste transfer station facility;
- Further analysis of data to explore whether there is increased air pollution burden on the community due to activities at the waste transfer station by evaluating air pollution data upwind and downwind of the facility; and
- Assessment of the impact of traffic-related variables (e.g., vehicle type, vehicle count) on local air quality by mining the data from the traffic study and local air monitoring study.
The study will not result in:

- Assessment of whether the local air quality is in compliance with USEPA’s National Ambient Air Quality Standards (NAAQS);
- Assessment of performance of study monitors (sensors) against the USEPA-approved Federal Reference Monitors (FRMs) or Federal Equivalent Monitors (FEMs) used in EPA air monitoring stations across the country;
- Assessment of how local air quality measurements compare against air quality measurements obtained by IEPA at air monitoring stations across Cook County, IL using USEPA-approved air monitoring instruments;
- Assessment of the meaning and significance of local air quality measurements from public health or health risk perspectives; and
- Assessment of whether the waste transfer station facility is in compliance (or in violation of) with its operating permit requirements.
Site Locations
Study Area vs. Control
Equipment – AQMesh

- **Small sensor** air quality monitor for measuring indoor and outdoor air quality.
- Use small sensor technology combined with data processing from extensive global comparisons with reference data.
### Equipment – AQMesh

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitric oxide (NO)</td>
<td>0 to 4,000 ppb</td>
<td>ppb or µg/m³</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>0 to 4,000 ppb</td>
<td>ppb or µg/m³</td>
</tr>
<tr>
<td>Ozone</td>
<td>0 to 1,800 ppb</td>
<td>ppb or µg/m³</td>
</tr>
<tr>
<td>Enclosure Temperature</td>
<td>-20 to 100 °C</td>
<td>°C</td>
</tr>
<tr>
<td>Atmospheric Pressure</td>
<td>500 – 1,500 mb</td>
<td>mb</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>0-100%RH</td>
<td>%RH</td>
</tr>
<tr>
<td>Total Particulate&lt;sup&gt;2&lt;/sup&gt;</td>
<td>&lt; 30 µm</td>
<td>µg/m³</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0 to 500 µg/m³</td>
<td>µg/m³</td>
</tr>
<tr>
<td>PM10</td>
<td>0 to 1,000 µg/m³</td>
<td>µg/m³</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>0 to 6,000 ppb</td>
<td>ppb or µg/m³</td>
</tr>
<tr>
<td>Sulfur dioxide (SO₂)</td>
<td>0 to 10,000 ppb</td>
<td>ppb or µg/m³</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Noise</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Response</td>
<td>Accuracy</td>
<td>Level</td>
</tr>
<tr>
<td>20Hz – 20kHz</td>
<td>± 1dB</td>
<td>35dB SPL to 100dB SPL</td>
</tr>
</tbody>
</table>

- Site 4 and site 5 (control site) were configured to also include wind-speed and wind-direction recording capabilities.
Equipment – MultiRAE Pro

- Industry-leading **wireless device** for monitoring chemical hazards and is the only multi-threat direct-read monitor with parts-per-billion precision.
Traffic Study

• **Road tubes** were placed for 30-days.

• Traffic study:
  – Speed
  – Vehicle class
  – Traffic volume by direction
  – Study area and nearby the control site
Monitoring Equipment

1. Lyons St.
   West side of waste transfer station

2. Lyons St.
   Northeast side of waste transfer station

3. Private Property
   East side of waste transfer station

4. Church St.
   South side of waste transfer station

5. Control site
   Twiggs Park
Study Objectives

– measure ambient air concentrations of pollutants/parameters of interest identified by the TEX project team; and

– determine whether the measured concentrations for any of the target pollutants/parameters of interest demonstrate probable source-attribution to site operations at the waste transfer station.
Results

• The data was organized six different ways and assessed from several perspectives to view the data through various “lenses”.

Weight of Evidence (WOE)

Lens 1
Time Series Analysis

Lens 2
Study Area vs. Control Comparison

Lens 3
Operational vs. Non-Operational Facility Hours Comparison

Lens 4
Wind Direction Analysis

Lens 5
Data Outlier Analysis

Lens 6
Traffic Influence Analysis
Excluded Data

• Some data was purposefully excluded for analysis purposes.

• 15 reasons listed in report Appendix A.2
  – Fireworks, grilling, painting, tuckpointing, sensor failure, etc.

• 93% of data was included in analysis.
Lens 1 – Time Series Analysis

- A graph of the data showing the results on a timeline

**Time series analysis** involves analyzing time series data to extract meaningful characteristics.
Lens 1 – Time Series Analysis

Box plot graphs for each parameter across the entire study duration were also generated for each of the five stations for comparative analysis.
The comparison of concentrations measured at the study area monitoring stations vs. those at the control station.

**Exposure Ranking Index of Stations vs Control Station for Formaldehyde (HCHO)**

\[
\text{Exposure Ranking Index} = \frac{\text{Station}}{\text{Control Station}}
\]

- “Exposure Ranking Index” greater than 1 indicates the results of the monitoring station are greater than the control station.
- “Exposure Ranking Index” less than 1 indicates the results of the monitoring station are less than the control station.
- “Exposure Ranking Index” equal to 1 indicates the results of the monitoring station are the same as the control station.
Lens 2 – Study Area vs. Control Site

Percent Change = \frac{\text{Station} - \text{Control Station}}{\text{Control Station}} \times 100
Lens 3 – Operational vs. Non-Operational Facility Hours Comparison

The comparison of concentrations measured during the operational hours of the waste transfer station vs. those measured during the non-operational facility hours.

**Operating Hours**
- Monday – Friday: 6:30 AM – 3:30 PM
- Saturday: 7:00 AM – 10:00 AM
- Closed Sunday

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**Table: NO Ratio (Station 4 / Station 5)**

<table>
<thead>
<tr>
<th>Lens 3: Operational vs. Non-Operational Hours</th>
<th>Lens 3A: Elevated and Non-Operational at Station 1 and Station 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Elevated Avg. ER at Station 1,</td>
<td>Operational Elevated and Higher Avg. ER than Non-Operational</td>
</tr>
<tr>
<td>Station 2, and Station 4.</td>
<td>at Station 2 and Station 4.</td>
</tr>
</tbody>
</table>

**Graph:**

- **Exposure Ranking Index**
  - “Exposure Ranking Index” greater than 1 indicates the results of the monitoring station are greater than the control station.
  - “Exposure Ranking Index” less than 1 indicates the results of the monitoring station are less than the control station.
  - “Exposure Ranking Index” equal to 1 indicates the results of the monitoring station are the same as the control station.
Lens 4 – Wind Direction Analysis

At Station 4, an analysis was performed to determine whether the data collected “downwind” of the waste transfer station was statistically similar or different than values recorded when Station 4 was “not downwind” during facility operating hours only.

<table>
<thead>
<tr>
<th>Carbon Monoxide (CO) (ppb)</th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>1-Way Test, ChiSquare Approximation (Prob&gt;ChiSq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downwind</td>
<td>7769</td>
<td>155.32</td>
<td>184.99</td>
<td>219.11</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Not Downwind</td>
<td>56853</td>
<td>187.57</td>
<td>227.59</td>
<td>185.53</td>
<td></td>
</tr>
</tbody>
</table>
Lens 5 – Data Outlier Analysis

Examined the data set with a focus on the high concentration events (i.e., spikes/peaks) to understanding time periods associated with higher air pollutant concentrations in the study area.

<table>
<thead>
<tr>
<th>Station</th>
<th>CO High Threshold</th>
<th>Number of Outliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station 1</td>
<td>1082.18</td>
<td>1104</td>
</tr>
<tr>
<td>Station 2</td>
<td>1015.5</td>
<td>736</td>
</tr>
<tr>
<td>Station 3</td>
<td>892.41</td>
<td>997</td>
</tr>
<tr>
<td>Station 4</td>
<td>1037.94</td>
<td>957</td>
</tr>
<tr>
<td>Station 5</td>
<td>990.65</td>
<td>1137</td>
</tr>
</tbody>
</table>
Lens 6 – Traffic Influence Analysis

- Assessment of impact of traffic-related emissions on local air quality.

Five (5) road-tube sites were selected to be nearby each of the 5 air monitoring stations.

Sought to determine whether a positive or inverse effect on concentration was apparent as truck or all-vehicle traffic volume increased or decreased.

1 Low positive correlation = 0.30 to 0.50
**Weight of Evidence (WOE)**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde (CH₂O)</td>
<td>Statistical significant difference.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean greater than Control Station Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elevated ER value at all stations</td>
<td>Positive and above 20% at all Stations</td>
<td></td>
<td>Station Level: 1) 0.29 ppm 2) 0.79 ppm 3) 0.19 ppm 4) 0.19 ppm 5) 0.017 ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statistical significant difference.</td>
<td>Mean operational is higher than non-operational mean</td>
<td>Operational Elevated Avg. ER at all Stations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean operational is higher than non-operational mean</td>
<td>Operational Elevated and Higher Avg. ER than Non-Operational at all Stations</td>
<td>Statistical Significant Difference. Higher Average Not Downwind</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DW Outliers</td>
<td>+6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>Statistical significant difference.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean greater than Control Station Mean</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Station Level: 1) 9.92 ppb 2) 5.61 ppb 3) 6.79 ppb 4) 10.25 ppb 5) 6.79 ppb</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Statistical significant difference.</td>
<td>Mean operational is higher than non-operational mean</td>
<td>Statistical Significant Difference. Higher Average Not Downwind</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>DW Outliers</td>
<td>+3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Possible site influence positive score of +1 point was assigned.

No supporting information no score was assigned (e.g., 0 points).

Less concern than those at the Control Station negative score of -1 point was assigned.

+1 Point, -1 Point, 0 Points or no evidence (no color)
Weight of Evidence (WOE)

Table 2: WOE Scoring Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Lens 2</th>
<th>2A ERI</th>
<th>2A %C</th>
<th>Lens 2B</th>
<th>Lens 3</th>
<th>Lens 3A</th>
<th>Lens 4</th>
<th>Lens 5</th>
<th>Lens 6</th>
<th>WOE Score Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulfide (H₂S)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+1</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Methyl Mercaptan (CH₃SH)</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>+1</td>
<td>0</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>Formaldehyde (CH₂O)</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>+6</td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOC)</td>
<td>+1</td>
<td>0</td>
<td>0</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td>+3</td>
</tr>
<tr>
<td>Nitric Oxide (NO)</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td>+6</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>+1</td>
<td>0</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td></td>
<td>+4</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>+1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td>+1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>Particulate Matter (PM₂.₅)</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>Particulate Matter (PM₁₀)</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td>-4</td>
</tr>
<tr>
<td>Particulate Matter (PMTOTAL)</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+1</td>
<td>-1</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
<td>-2</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>+1</td>
<td>-1</td>
<td>0</td>
<td>+1</td>
<td>0</td>
<td>-1</td>
<td>+1</td>
<td>0</td>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO₂)</td>
<td>+1</td>
<td>0</td>
<td>0</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
<td>+1</td>
<td>1</td>
<td>0</td>
<td>+5</td>
</tr>
<tr>
<td>Noise (dB)</td>
<td>+1</td>
<td>0</td>
<td>0</td>
<td>+1</td>
<td>+1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>+2</td>
</tr>
</tbody>
</table>

Lens 2: Study Area vs Control
Lens 2A: Exposure Ranking Index (ERI)
Lens 2B: Percent Change (%C)
Lens 2B: Upper 95% Mean Confidence Limit

Lens 3: Operational vs. Non-Operational Hours
Lens 3A: ER Operational vs. Non-Operational Hours
Lens 4/5: Wind Direction and DW Outliers (Station 4)
Lens 6: Traffic Influence Analysis

Color key:
1st Tier Parameters
2nd Tier Parameters
Deprioritized Parameters
## Findings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Weight of Evidence (WOE) Score Total</th>
<th>Prioritization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde (CH$_2$O)</td>
<td>+6</td>
<td>1$^{\text{st}}$ Tier Parameters</td>
</tr>
<tr>
<td>Nitric Oxide (NO)</td>
<td>+6</td>
<td></td>
</tr>
<tr>
<td>Sulfur Dioxide (SO$_2$)</td>
<td>+5</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO$_2$)</td>
<td>+4</td>
<td></td>
</tr>
<tr>
<td>Volatile Organic Compounds (VOCs)</td>
<td>+3</td>
<td>2$^{\text{nd}}$ Tier Parameters</td>
</tr>
<tr>
<td>Noise (dB)</td>
<td>+2</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>Methyl Mercaptan (CH$_3$SH)</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulfide (H$_2$S)</td>
<td>0</td>
<td>Deprioritized Parameters</td>
</tr>
<tr>
<td>Ozone (O$_3$)</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (PM$_{\text{TOTAL}}$)</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (PM$_{2.5}$)</td>
<td>-4</td>
<td></td>
</tr>
<tr>
<td>Particulate Matter (PM$_{10}$)</td>
<td>-4</td>
<td></td>
</tr>
</tbody>
</table>
Recommendations

1. Formaldehyde and nitric oxide are the air quality parameters of greatest interest and should be prioritized in any future work.

2. Sulfur dioxide, carbon monoxide, Volatile Organic Compounds, methyl mercaptan, nitrogen dioxide, and noise present lesser supporting evidence but may still warrant further investigation.

3. We recommend deprioritizing hydrogen sulfide, fine, and course particulate matter (PM2.5, PM10), and ozone parameters which appear to be related to regional air quality rather than local air quality.

4. To better understand whether the collected data represents harmful levels with the potential for adverse human health effects, follow-up studies should be conducted to validate and apply the existing data.
   - Co-location Studies (FRM/FEM)
   - Determination of Scaling Factors
   - VOC Speciation (e.g. toxic air pollutants listed in the Clean Air Act)
Discussion

1. Over 112 million data points collected → “more testing” is not a top priority.

2. Focus on using the existing data in additional ways to answer questions that arise from this study.
   - Data validation → human health risk assessment (informs priorities for mitigation measures)
   - Comparative analysis to other data sets from the Chicagoland region (provides context)

3. The data analysis was structured to answer a specific set of questions.
   - There are other ways to evaluate the data.
   - There are many additional interesting and relevant questions that may be answered by the existing data set.
   - Support validation and further research on this data set.
City’s Next Steps

1. City staff are preparing a letter of request for assistance to the State and Federal Environmental Protection Agencies (EPA)
2. Letter of request for mobile formaldehyde monitoring equipment from Federal EPA
3. Explore assistance to have additional analysis completed on collected data
Questions and Answer Section

There are three ways to ask questions:
1. Type your question into the chat box on Zoom
2. Email sustainability@cityofevanston.org
3. Or, if you are on phone, to wait until the Q&A portion of the event and ask then
Follow-up Contact Information

www.cityofevanston.org/transferstation

1. Meeting recording
2. Study report
3. Raw and prepared study data

Staff Contact:
Kumar Jensen, Chief Sustainability and Resilience Officer

kjensen@cityofevanston.org or 847-448-8199
Supplemental pre-prepared slides

- Explanation of Censored Data
- Lens 1
  - Time series, by parameter, by station location.
  - Box plots, by parameter, by station location.
- Lens 2
  - CO and formaldehyde study area vs. control. NO ERI
- Lens 3 – PM$_{2.5}$ operational vs. non-operational
- Lens 4 – Wind direction H$_2$S, formaldehyde, NO
- Lens 5 – Data outliers H$_2$S, formaldehyde
- Lens 6 – Traffic analysis for CO
Censored Data

• It is not possible to measure “zero”

• When “nothing is measured”, using “zero” as a mathematical placeholder is a poor choice for performing statistical analyses.

• Generally accepted techniques exist.
Censored Data

Illustrative example of concept. Not actual project data.
24-Hour Concentrations of Methyl mercaptan (CH₃SH) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Methyl mercaptan (CH$_3$SH) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Methyl mercaptan (CH₃SH) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Methyl mercaptan (CH₃SH) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Carbon Monoxide (CO) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Carbon Monoxide (CO) at Station 2 – Lyons/Ashland for the Entire Study Duration

Study Date

Concentration (ppb)

Station 2 - Lyons/Ashland
24-Hour Concentrations of Carbon Monoxide (CO) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Carbon Monoxide (CO) at Station 4 – Church Street for the Entire Study Duration

Concentration (ppb)

Study Date


Station 4 - Church Street
24-Hour Concentrations of Carbon Dioxide (CO) Across All Stations for the Entire Study Duration

Concentration (ppb)

Study Date

Station 5 - Twiggs Park (Control)
24-Hour Concentrations of Hydrogen Sulfide (H₂S) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Hydrogen Sulfide ($H_2S$) at Station 2 – Lyons/Ashland for the Entire Study Duration

**Study Date**

- Concentration (ppm)
- Station 2 - Lyons/Ashland
24-Hour Concentrations of Hydrogen Sulfide (H$_2$S) at Station 3 – Church Street Village for the Entire Study Duration

Concentration (ppm)

Study Date

Station 3 - Church Street Village
24-Hour Concentrations of Hydrogen Sulfide (H₂S) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Hydrogen Sulfide (H₂S) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Formaldehyde (HCHO) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Formaldehyde (HCHO) at Station 2 – Lyons/Ashland for the Entire Study Duration
24-Hour Concentrations of Formaldehyde (HCHO) at Station 3 – Church Street Village for the Entire Study Duration

Concentration (ppm)

Study Date

Station 3 – Church Street Village
24-Hour Concentrations of Formaldehyde (HCHO) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Formaldehyde (HCHO) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Nitric Oxide (NO) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Nitric Oxide (NO) at Station 2 – Lyons/Ashland for the Entire Study Duration
24-Hour Concentrations of Nitric Oxide (NO) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Nitric Oxide (NO) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Nitric Oxide (NO) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Noise Levels at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Noise Levels at Station 2 – Lyons/Ashland
for the Entire Study Duration
24-Hour Noise Levels at Station 3 – Church Street Village for the Entire Study Duration

Noise Level (dB)

Study Date

Station 3 – Church Street Village
24-Hour Noise Levels at Station Station 4 – Church Street
for the Entire Study Duration
24-Hour Noise Levels at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Ozone (O₃) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Ozone (O₃) at Station 2 – Lyons/Ashland for the Entire Study Duration
24-Hour Concentrations of Ozone (O₃) at Station 3 – Church Street Village for the Entire Study Duration

[Graph showing the concentration of ozone over time, with dates on the x-axis and concentration in ppb on the y-axis.]
24-Hour Concentrations of Ozone ($O_3$) at Station 4 – Church Street for the Entire Study Duration

- **Concentration (ppb)**
- **Study Date**

Station 4 - Church Street
24-Hour Concentrations of Ozone (O₃) at Station 5 – Twiggs Park (Control) for the Entire Study Duration

Concentration (ppb)

Study Date

Station 5 - Twiggs Park (Control)
24-Hour Concentrations of Particulate Matter 2.5 (PM 2.5) at Station 1 – Lyons/Darrow for the Entire Study Duration

[Graph showing concentration data over time]
24-Hour Concentrations of Particulate Matter 2.5 (PM 2.5) at Station 2 – Lyons/Ashland for the Entire Study Duration
24-Hour Concentrations of Particulate Matter 2.5 (PM 2.5) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Particulate Matter 2.5 (PM 2.5) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Particulate Matter 2.5 (PM 2.5) at Station 5 – Twiggs Park (Control) for the Entire Study Duration

Study Date

Concentration (μg/m³)
24-Hour Concentrations of Particulate Matter 10 (PM 10) at Station 1 – Lyons/Darrow for the Entire Study Duration

Concentration (ug/m3)

Study Date

Station 1 – Lyons/Darrow
24-Hour Concentrations of Particulate Matter 10 (PM 10) at Station 2 – Lyons/Ashland for the Entire Study Duration

Study Date

Concentration (µg/m³)

Station 2 – Lyons/Ashland
24-Hour Concentrations of Particulate Matter 10 (PM 10) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Particulate Matter 10 (PM 10) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Particulate Matter 10 (PM 10) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Particulate Matter Total (PM Total) at Station 1 – Lyons/Darrow for the Entire Study Duration
24-Hour Concentrations of Particulate Matter Total (PM Total) at Station 2 – Lyons/Ashland for the Entire Study Duration
24-Hour Concentrations of Particulate Matter Total (PM Total) at Station 3 – Church Street Village for the Entire Study Duration

Concentration (ug/m3)

Study Date


Station 3 – Church Street Village
24-Hour Concentrations of Particulate Matter Total (PM Total) at Station 4 – Church Street Village for the Entire Study Duration

![Graph showing concentration levels over time for Station 4 - Church Street.](image-url)
24-Hour Concentrations of Particulate Matter Total (PM Total) at Station 5 – Twiggs Park (Control) Village for the Entire Study Duration
24-Hour Concentrations of Sulfur Dioxide (SO₂) at Station 1 – Lyons/Darrow for the Entire Study Duration

Concentration (ppb)

Study Date

Station 1 - Lyons/Darrow
24-Hour Concentrations of Sulfur Dioxide (SO$_2$) at Station 2 – Lyons/Ashland
for the Entire Study Duration

Study Date

Concentration (ppb)

Station 2 - Lyons/Ashland
24-Hour Concentrations of Sulfur Dioxide (SO$_2$) at Station 3 – Church Street Village for the Entire Study Duration
24-Hour Concentrations of Sulfur Dioxide (SO₂) Across All Stations for the Entire Study Duration

Study Date

Station 4 - Church Street
24-Hour Concentrations of Sulfur Dioxide (SO₂) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
24-Hour Concentrations of Volatile Organic Compounds (VOC) at Station 1 – Lyons/Darrow for the Entire Study Duration

Study Date

Concentration (ppb)
24-Hour Concentrations of Volatile Organic Compounds (VOC) at Station 2 – Lyons/Ashland for the Entire Study Duration

Concentration (ppb)

Study Date

Station 2 – Lyons/Ashland
24-Hour Concentrations of Volatile Organic Compounds (VOC) at Station 3 – Church Street Village for the Entire Study Duration

Concentration (ppb)

Study Date

24-Hour Concentrations of Volatile Organic Compounds (VOC) at Station 4 – Church Street for the Entire Study Duration
24-Hour Concentrations of Volatile Organic Compounds (VOC) at Station 5 – Twiggs Park (Control) for the Entire Study Duration
Threshold Max: 1082.18
Threshold Max: 0.25
Threshold Max: 2.53
Formaldehyde Concentration Across All Stations

Concentration [ppm]
Threshold Max: 116.29 ug/m3
Threshold Max: 80.08 ppb
PM2.5 Concentration Across All Stations

Threshold Max: 90.72 ug/m³
Threshold Max: 116.29 ug/m3
PM TOTAL Concentration Across All Stations

Threshold Max: 138.98 µg/m³
Threshold Max: 16.36 ppb
Threshold Max: 65 ppb
LENS 2 - Supplemental

Carbon Monoxide (CO) Control Site Comparisons

Oneway Analysis of Concentration (ppb) By Site Name

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>25</td>
</tr>
<tr>
<td>STNW0001</td>
<td>96.42</td>
</tr>
</tbody>
</table>

Quantiles

<table>
<thead>
<tr>
<th>Level</th>
<th>Minimum</th>
<th>10%</th>
<th>25%</th>
<th>Median</th>
<th>75%</th>
<th>90%</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>25</td>
<td>212.97</td>
<td>233.98</td>
<td>267.37</td>
<td>326.09</td>
<td>407.39</td>
<td>9684.15</td>
</tr>
<tr>
<td>STNW0001</td>
<td>96.42</td>
<td>242.138</td>
<td>266.82</td>
<td>301.01</td>
<td>364.15</td>
<td>452.15</td>
<td>12752.04</td>
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Means and Std Deviations

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Err</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>233899</td>
<td>259.43422</td>
<td>155.93361</td>
<td>0.3224237</td>
<td>298.60228</td>
<td>330.06616</td>
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<tr>
<td>STNW0001</td>
<td>233828</td>
<td>334.50846</td>
<td>146.26035</td>
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<td>334.00563</td>
<td>335.10120</td>
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</table>

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

<table>
<thead>
<tr>
<th>Level</th>
<th>Count</th>
<th>Score Sum</th>
<th>Expected Score</th>
<th>Score</th>
<th>Score (Mean-Mean)/Std</th>
<th>2-Sample Test, Normal Approximation</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>233899</td>
<td>4.7e+10</td>
<td>5.5e+10</td>
<td>5.5e+10</td>
<td>267620</td>
<td>S = 0.258e+10, Z = 170.9355, Prob &gt;</td>
</tr>
<tr>
<td>STNW0001</td>
<td>233828</td>
<td>6.3e+10</td>
<td>5.5e+10</td>
<td>5.5e+10</td>
<td>170.956</td>
<td>S = 4.272e-10, Z = 233.605, Prob &gt;</td>
</tr>
</tbody>
</table>

Oneway Analysis of Concentration (ppb) 2 By Site Name 2

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>25</td>
</tr>
<tr>
<td>STNE0002</td>
<td>25</td>
</tr>
</tbody>
</table>

Quantiles

<table>
<thead>
<tr>
<th>Level</th>
<th>Minimum</th>
<th>10%</th>
<th>25%</th>
<th>Median</th>
<th>75%</th>
<th>90%</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>25</td>
<td>212.97</td>
<td>233.98</td>
<td>267.37</td>
<td>326.09</td>
<td>407.39</td>
<td>9684.15</td>
</tr>
<tr>
<td>STNE0002</td>
<td>25</td>
<td>156.35</td>
<td>182</td>
<td>217.91</td>
<td>283.58</td>
<td>371.146</td>
<td>10691.45</td>
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</table>

Means and Std Deviations

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Err</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>233899</td>
<td>299.43422</td>
<td>155.93361</td>
<td>0.3224237</td>
<td>298.80228</td>
<td>300.06616</td>
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<tr>
<td>STNE0002</td>
<td>230083</td>
<td>250.22719</td>
<td>151.47144</td>
<td>0.3157828</td>
<td>249.62097</td>
<td>250.84083</td>
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</tbody>
</table>

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

<table>
<thead>
<tr>
<th>Level</th>
<th>Count</th>
<th>Score Sum</th>
<th>Expected Score</th>
<th>Score</th>
<th>Score (Mean-Mean)/Std</th>
<th>2-Sample Test, Normal Approximation</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>233899</td>
<td>6.5e+10</td>
<td>5.4e+10</td>
<td>5.4e+10</td>
<td>277550</td>
<td>S = 4.272e-10, Z = 233.605, Prob &gt;</td>
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<tr>
<td>STNE0002</td>
<td>230083</td>
<td>4.3e+10</td>
<td>5.3e+10</td>
<td>5.3e+10</td>
<td>185677</td>
<td>S = -4.272e-10, Z = -233.605, Prob &gt;</td>
</tr>
</tbody>
</table>
Formaldehyde (HCHO) Control Site Comparisons

Oneway Analysis of Concentration (ppm) By Site Name

Quantiles

<table>
<thead>
<tr>
<th>Level</th>
<th>Minimum</th>
<th>10%</th>
<th>25%</th>
<th>Median</th>
<th>75%</th>
<th>90%</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.05</td>
<td>0.04</td>
<td>0.05</td>
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<tr>
<td>STNW0001</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.05</td>
<td>0.09</td>
<td>0.54</td>
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</table>

Means and Std Deviations

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Std Err Mean</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>249085</td>
<td>0.0171845</td>
<td>0.00325825</td>
<td>0.0001473</td>
<td>0.0158958</td>
<td>0.0174733</td>
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<tr>
<td>STNW0001</td>
<td>266097</td>
<td>0.0290571</td>
<td>0.0326457</td>
<td>0.0001017</td>
<td>0.0298758</td>
<td>0.0329564</td>
</tr>
</tbody>
</table>

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

<table>
<thead>
<tr>
<th>Level</th>
<th>Count</th>
<th>Score Sum</th>
<th>Expected Score</th>
<th>Score Mean</th>
<th>(Mean-Mean0)/Std0</th>
</tr>
</thead>
<tbody>
<tr>
<td>STCN0005</td>
<td>249085</td>
<td>5.8e+10</td>
<td>6.4e+10</td>
<td>230858</td>
<td>-157.75</td>
</tr>
<tr>
<td>STNW0001</td>
<td>256047</td>
<td>5.6e+10</td>
<td>6.9e+10</td>
<td>264348</td>
<td>157.76</td>
</tr>
</tbody>
</table>

2-Sample Test, Normal Approximation

| S | Z   | Prob>|Z| |
|---|-----|-----|-----|
| 5.75e+10 | -157.76 | <.0001* |

1-Way Test, ChiSquare Approximation

<table>
<thead>
<tr>
<th>ChiSquare</th>
<th>DF</th>
<th>Prob&gt;ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>24000.419</td>
<td>1</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>
LENS 2 - Supplemental
LENS 3 - Supplemental

Operational vs Non-Operational Concentration of Particulate Matter 2.5 (ug/m³)

STNW0001: Station 1 – Lyons/Darrow
STNE0002: Station 2 – Lyons/Ashland
STSE0003: Station 3 – Church Street Village
STSW0004: Station 4 – Church Street
STCN0005: Station 5 – Twiggs Park (Control)
# LENS 4 - Supplemental

## Appendix A.6 – Lens 4: Wind Direction Analysis

<table>
<thead>
<tr>
<th>Station 4</th>
<th>N</th>
<th>Median</th>
<th>Mean</th>
<th>Std Dev.</th>
<th>1-Way Test, ChiSquare Approximation (Prob&gt;ChiSq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulfide (H₂S) (ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downwind</td>
<td>7620</td>
<td>0.05</td>
<td>0.051</td>
<td>0.086</td>
<td>0.2418</td>
</tr>
<tr>
<td>Not Downwind</td>
<td>55770</td>
<td>0.05</td>
<td>0.050</td>
<td>0.010</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde (HCHO) (ppm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downwind</td>
<td>7620</td>
<td>0.005</td>
<td>0.025</td>
<td>0.063</td>
<td>0.0017</td>
</tr>
<tr>
<td>Not Downwind</td>
<td>55770</td>
<td>0.005</td>
<td>0.026</td>
<td>0.045</td>
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<tr>
<td>Nitric Oxide (NO) (ppb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downwind</td>
<td>7770</td>
<td>1.55</td>
<td>13.34</td>
<td>87.65</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Not Downwind</td>
<td>56857</td>
<td>2.76</td>
<td>15.31</td>
<td>61.39</td>
<td></td>
</tr>
</tbody>
</table>
Hydrogen Sulfide (H₂S) Outliers

<table>
<thead>
<tr>
<th>Column</th>
<th>10% Quantile</th>
<th>90% Quantile</th>
<th>Low Threshold</th>
<th>High Threshold</th>
<th>Number of Outliers</th>
<th>Outliers (Count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STNW0001</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>16</td>
<td>0.1 0.2 0.4(2)</td>
</tr>
<tr>
<td>STN0002</td>
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<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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<td>0.1 0.3 0.5 0.6(2)</td>
</tr>
<tr>
<td>STS0003</td>
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</tr>
<tr>
<td>STSW0004</td>
<td>0.05</td>
<td>0.6143</td>
<td>-1.6313</td>
<td>2.2917</td>
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<td>3.13 6.3 9.4</td>
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<tr>
<td>STCN0005</td>
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</tbody>
</table>

Formaldehyde (HCHO) Outliers

<table>
<thead>
<tr>
<th>Column</th>
<th>10% Quantile</th>
<th>90% Quantile</th>
<th>Low Threshold</th>
<th>High Threshold</th>
<th>Number of Outliers</th>
<th>Outliers (Count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STNW0001</td>
<td>0.005</td>
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<td>STN0002</td>
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</table>
LENS 6 - Supplemental

### Multivariate

#### Correlations

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<th>CO (ppb) Station 4</th>
<th>Total Truck Count (WEST EB/WB)</th>
<th>Total Count (WEST EB/WB)</th>
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<td>1.0000</td>
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</tbody>
</table>

The correlations are estimated by Row-wise method.

#### Scatterplot Matrix

- **CO (ppb) Station 4**
- **Total Truck Count (WEST EB/WB)**
- **Total Count (WEST EB/WB)**

#### Nonparametric: Spearman's $\rho$

| Variable                        | by Variable        | Spearman $\rho$ | Prob>|p| |
|---------------------------------|--------------------|-----------------|------|
| Total Truck Count (WEST EB/WB)  | CO (ppb) Station 4 | -0.0739         | <.0001* |
| Total Count (WEST EB/WB)        | CO (ppb) Station 4 | -0.1291         | <.0001* |
| Total Count (WEST EB/WB)        | Total Truck Count (WEST EB/WB) | 0.6189         | <.0001* |