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Determining Pollution Culpability in the Community: A Case Study

Combining Community-based Monitoring and Backward Trajectory Modeling for Odor Evaluation and Culpability Analyses

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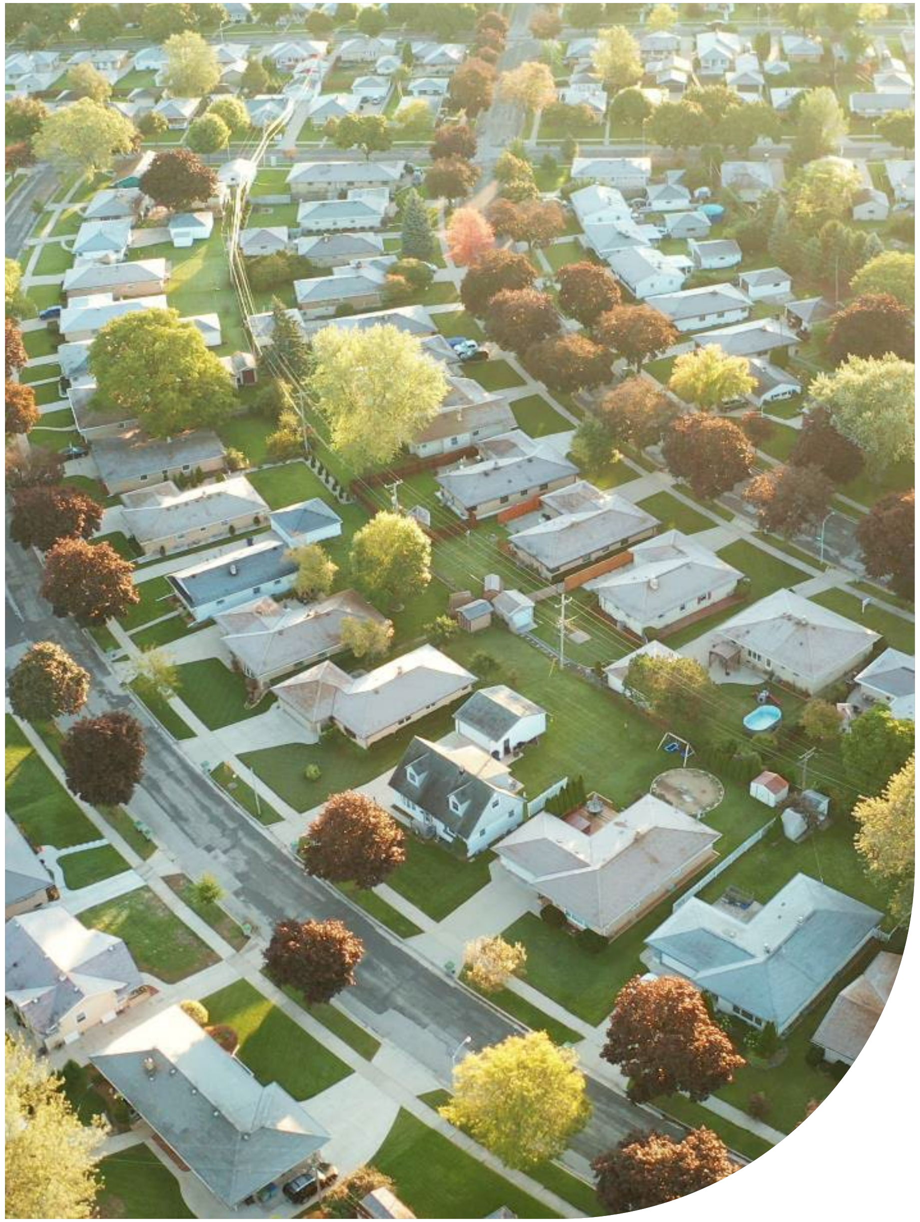
EPA NAAMC 2024
August 14, 2024

Content



Defining the Problem

Determining Pollution Culpability in the Community

Analysis Focus

This Case Study presents investigatory techniques and analysis for determining culpability of nuisance odor from a variety of sources in a community. The techniques applied here can be modified and used for a variety of different air pollutants depending on the objectives of the study.

Data Sources

Three sets of data sources were used to investigate the culpability of emissions sources on odor events.

Human-Reported Data	Human-reported odor data compiled by local agency provided date, time, and location of human-detected events
Monitored Hydrogen Sulfide Concentration Data	Continuous fence line and community air monitoring for H_2S (odor-causing compound) known to be emitted by several sources
Back Trajectory Modeling	Back trajectory modeling using HYSPLIT for dates and times of human-detected and monitored events to evaluate culpability

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Human Detected Odor Information

Odor is a perceived problem that is highly subjective by nature, and the impacts of odor are acute and immediately noticeable. It can be a complex task to quantify and measure odor. Human reports incorporated a variety of factors, including character, frequency, strength, and persistence of the odor.

Date/Time

Essential for gathering information such as meteorological conditions at the time of an odor event

Location

Provides information on the spatial relationship of the event to the source

Frequency

Used to pair the consistency of conditions that lead to an event

Persistence

Persistence allows for identifying the duration of an event.

Strength

Provides a sense of the relative concentration during the event.

Consistency

Useful to identify the type of odor present and matching it to the emission source.

Monitoring Network Continuous Data

A Fence line and Community monitoring network was established to determine observed concentrations of H_2S at the facility and beyond to track emission plumes and document odor events.

Community Network

Consisted of 11 low-range H_2S sensors (Acrulog H2S PPB) that were deployed at communities downwind or adjacent to the source. For control, one sensor was placed in predominant upwind location from the source.

1 Placement

Sensor is mounted to a pole at breathing height to estimate population exposure in residential communities.

2 Quality Control

Field spike and calibration occurred every two weeks. Data push every 10 minutes.

3 Data

Hourly and sub-hourly data are posted to a public website on a daily and monthly basis.

Back Trajectory Modeling Analysis

The Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT) published by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (ARL) was used to conduct backward trajectory analysis.

Backward Trajectories

Backward trajectories used to identify the path of origin for the air parcels arriving at time of event

Modeled Event Definition

Human detections (586 events)
or
Monitored H_2S concentrations above 5 ppb (3,211 events)

Point of Terminus (PoT)

Monitor or Human detection location at time of observation or event

Trajectory Elevation

Three starting elevations (10m, 100m, & 300m) above the PoT to account for atmospheric variability

Trajectory Duration

Six-hour trajectory duration was deemed a sufficient time to travel from source to communities

Meteorological Data

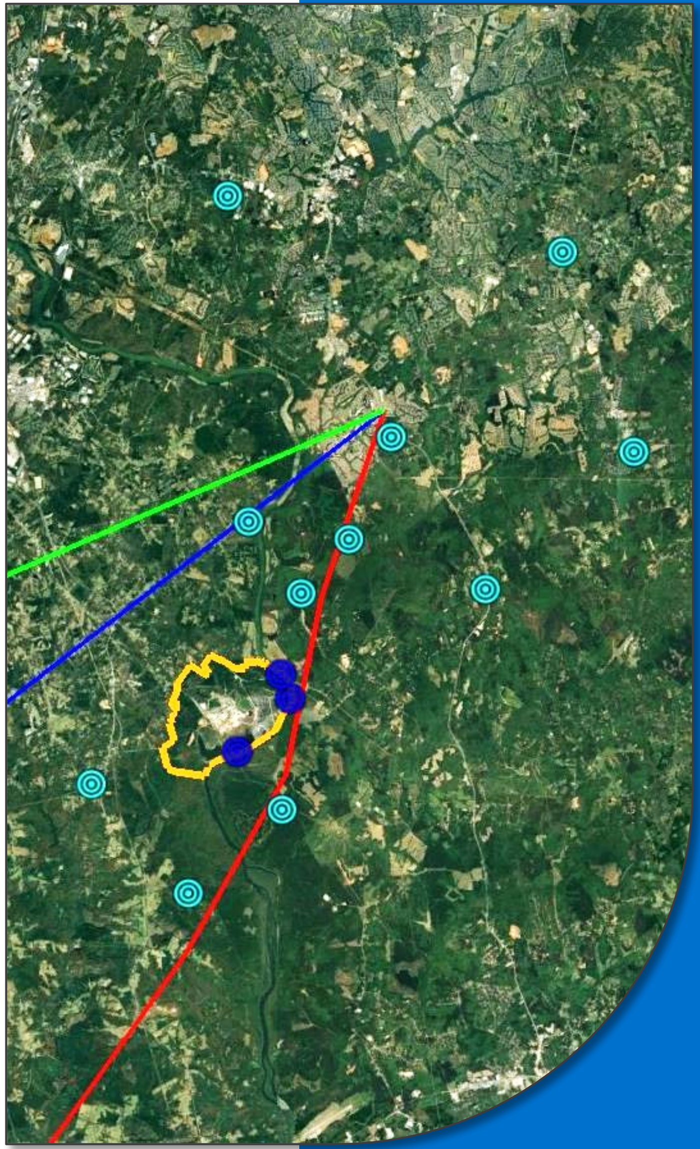
High-Resolution Rapid Refresh (HRRR) sub-hourly, 3-kilometer spacing dataset

Culpability Evaluation Criteria

Each model result was categorized into one of three classifications of reports: Full Path, Partial Path, Minimal Path, or No Path. These classifications represent the model's determination whether an air parcel was transported over the source.

Source Representation

To improve model accuracy and account for meteorological variability and parcel meander. The facility was characterized as the property boundary plus a ½ mile buffer zone from the source centroid.



Full Path

All three elevation paths passed over the property boundary or buffer zone

Partial Path

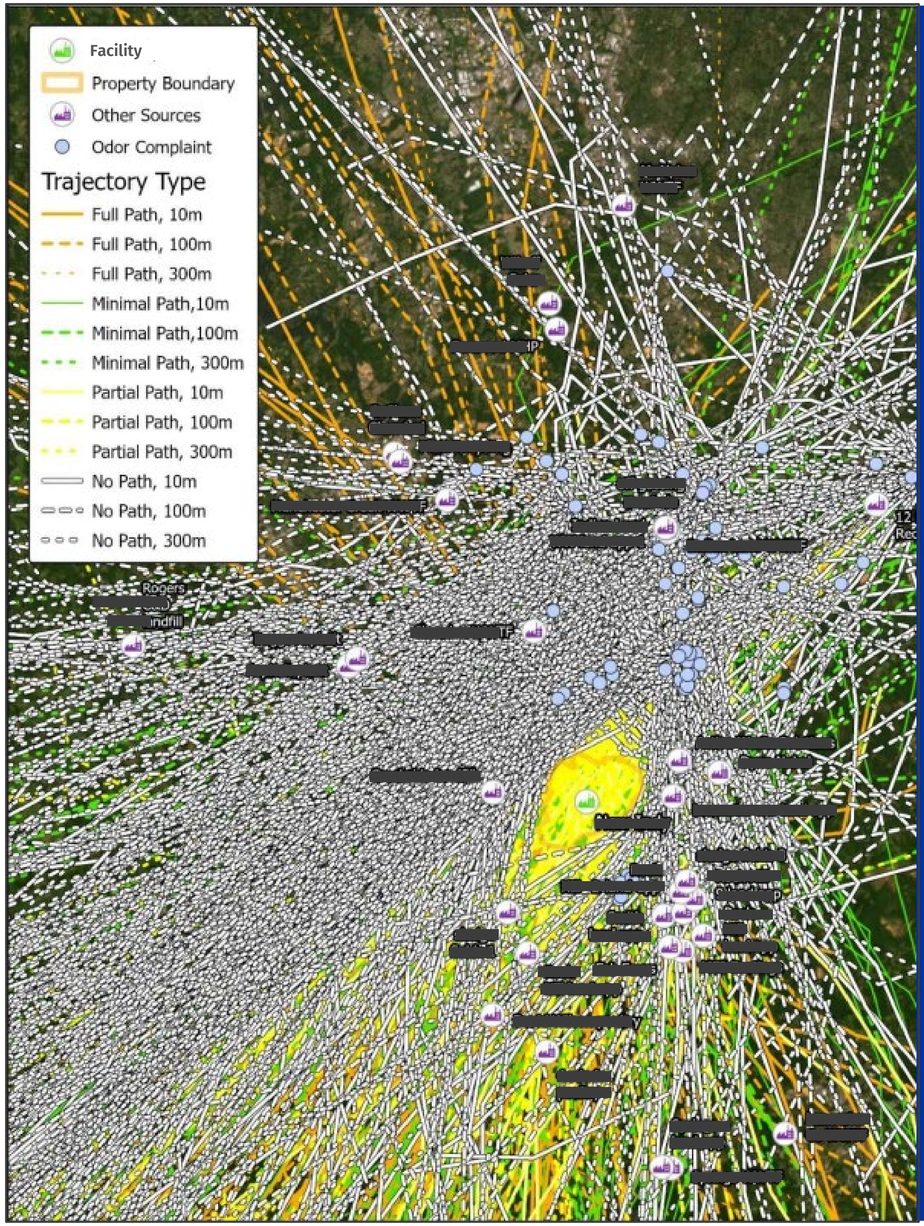
Two elevation paths passed within the property boundary or buffer zone

Minimal Path

One elevation path passed within the property boundary or buffer zone

No Path

none of the elevation paths passed within the property boundary or buffer zone



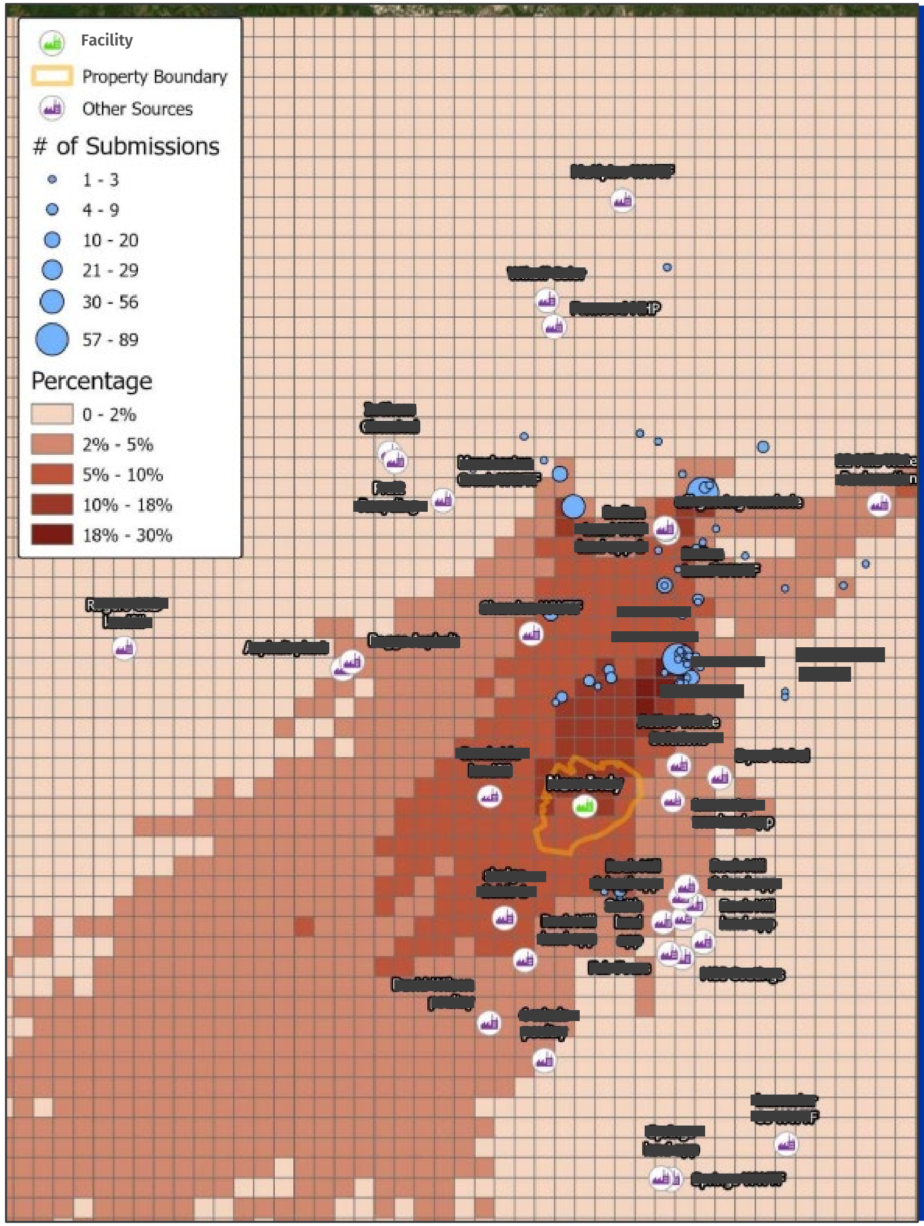
Human-Reported Model Results

Backward Trajectory Results

Modeled Events:

- Community Odor Reports
  - 586 events ⇨ 1,758 trajectories

Classification	% of Reports
Full Path	22%
Partial Path	12%
Minimal Path	20%
No Path	46%



Human-Reported Model Results

Backward Trajectory Results

Observations

- Highest percentage of back trajectories collect near clusters of high frequency odor reports
- Many of the highest percentage grid cells do not occur within the Facility property
- The highest percentage occurred in the vicinity of other sources of H_2S (Wastewater Treatment Plants)

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Monitor Based Concentration Results

Additional refinement of results was conducted to account for monitored concentrations. Backward trajectory evaluations were made for near, distant, and upwind monitor locations

Basic Heat Map

Trajectories are treated the same whether concentrations were at cutoff point of 5 ppb or well above the cutoff point

Concentration Field Analysis (CFA)

Determines air pollutant source locations by combining concentration measurements with back trajectories. Grid cells with larger CFA value implies the higher contribution of pollutant to the receptor site.

Concentration Weighted Trajectory (CWT)

The CWT model is a modification of CFA using a linear calculation, which is more robust to low pollutant measurements.

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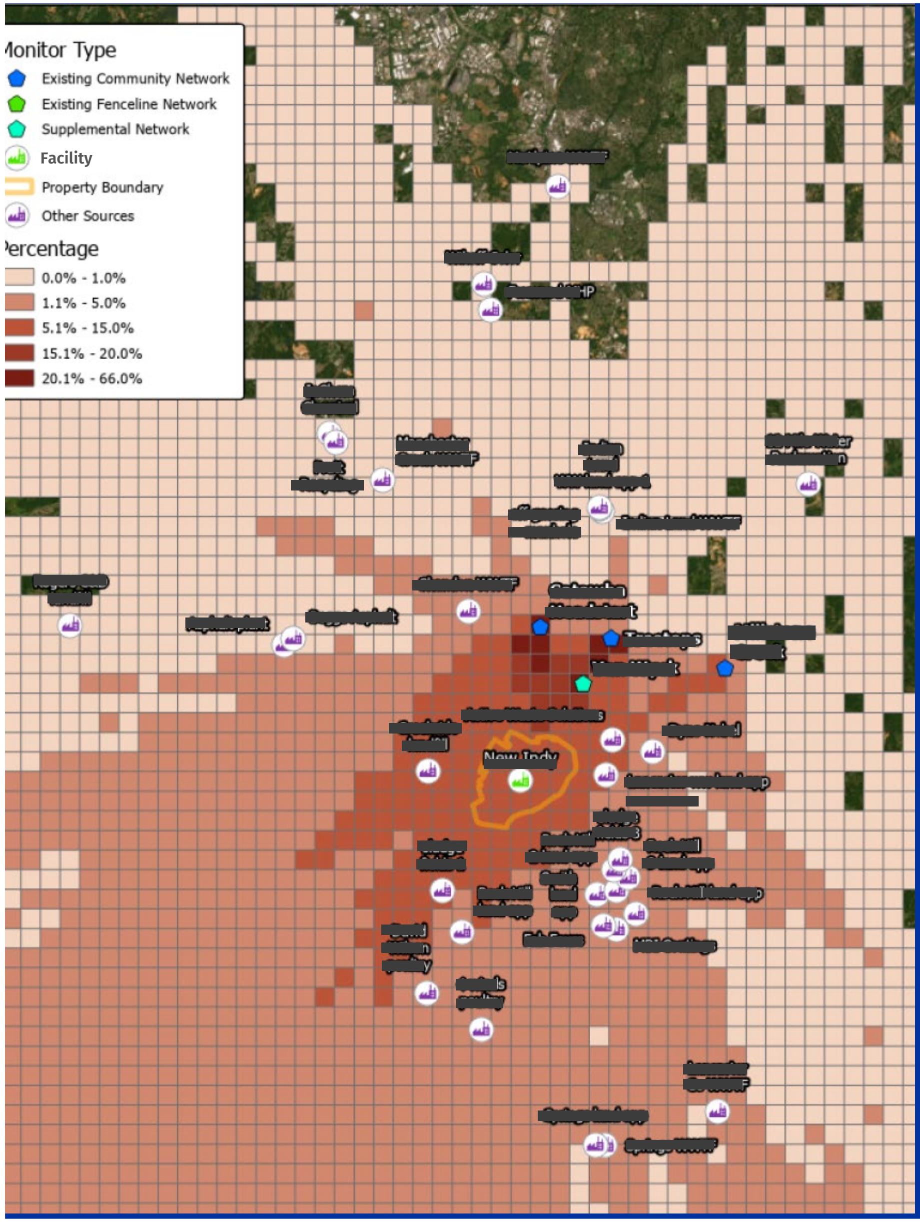

Monitor-Based Model Results

Backward Trajectory Results

Modeled Events:

- Monitored Concentration Reports (H_2S > 5 ppb)
  - 3,211 events ⇨ 9,633 trajectories
- Near Facility monitors displayed on left

Classification	% of Reports
Full Path	6%
Partial Path	5%
Minimal Path	9%
No Path	80%

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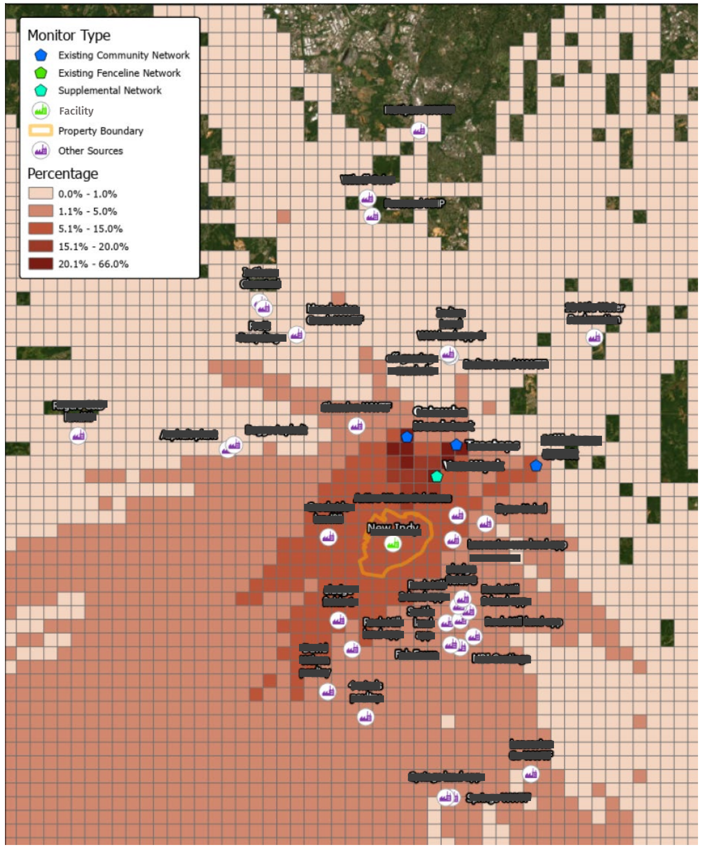
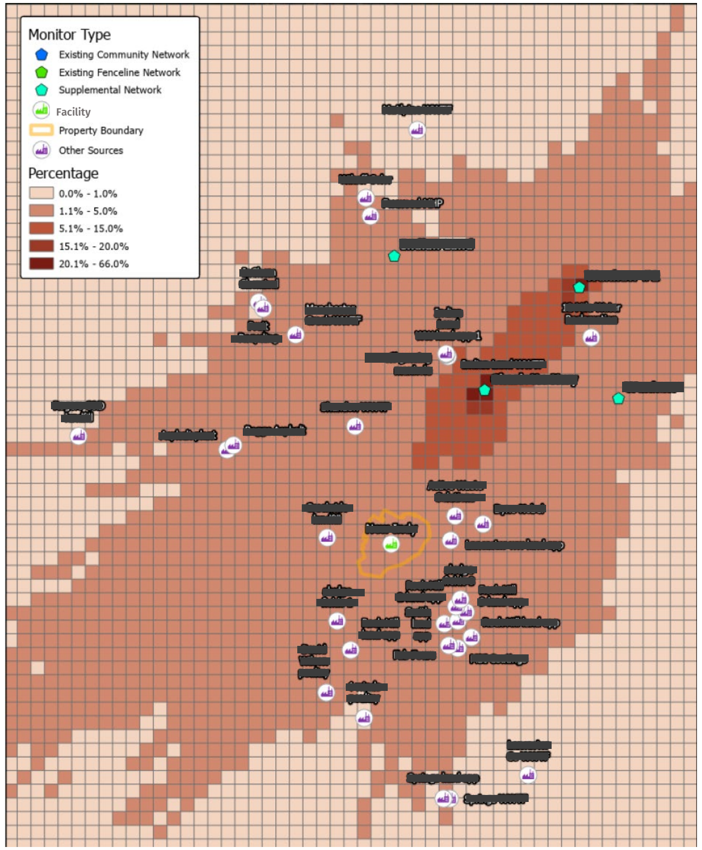
Monitor Back Trajectory Heat Maps

Basic Heat Maps

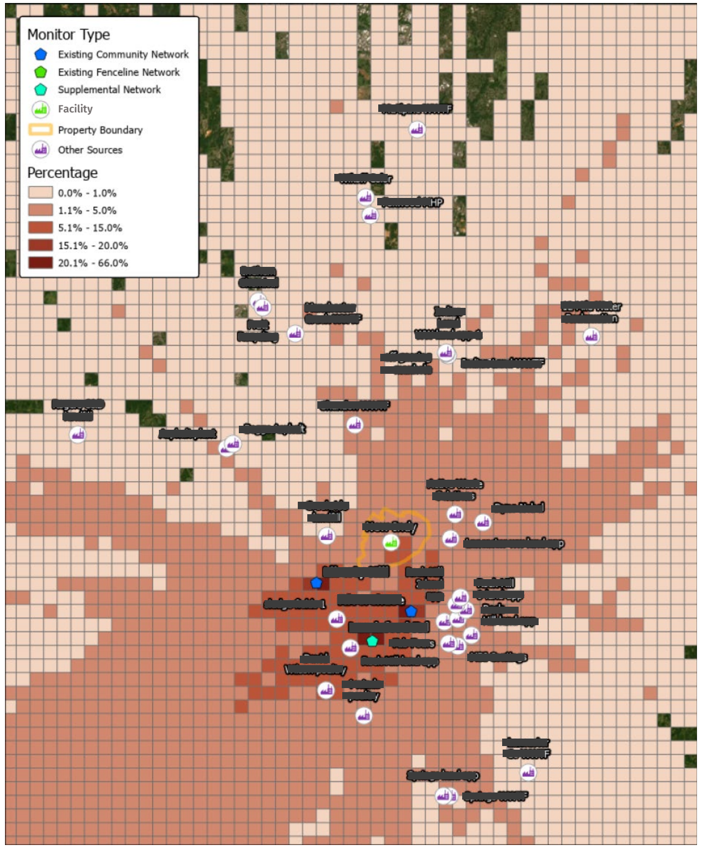
Near Facility Monitors



Distant Monitors



Upwind Monitors



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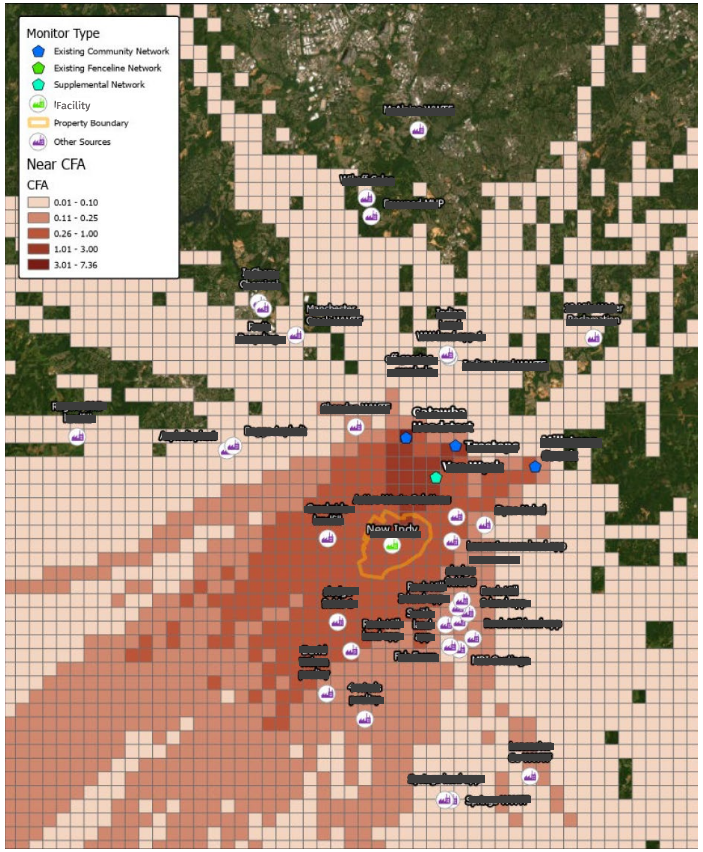
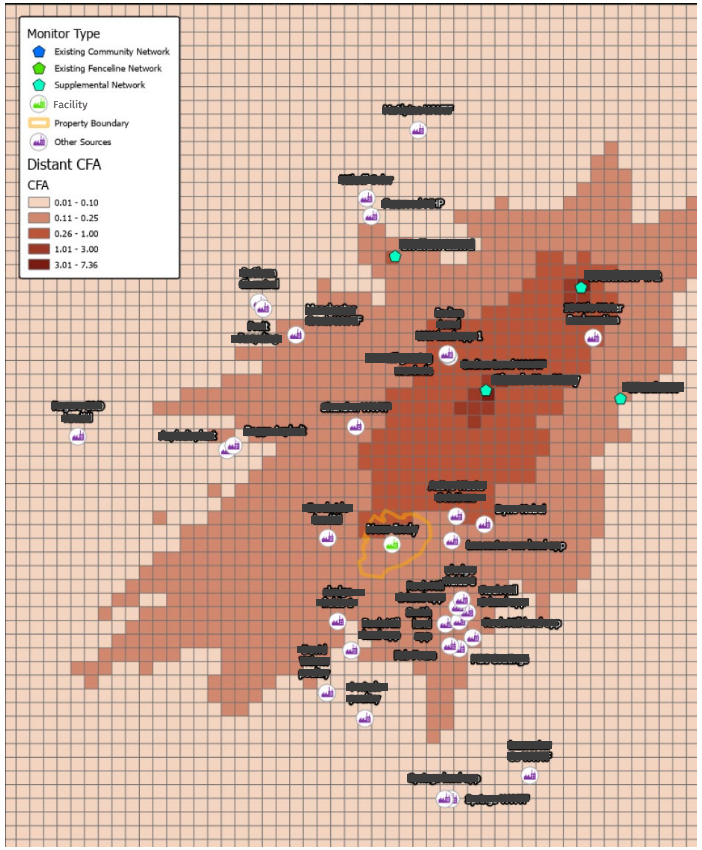
Monitor Back Trajectory Heat Maps

CFA Heat Maps

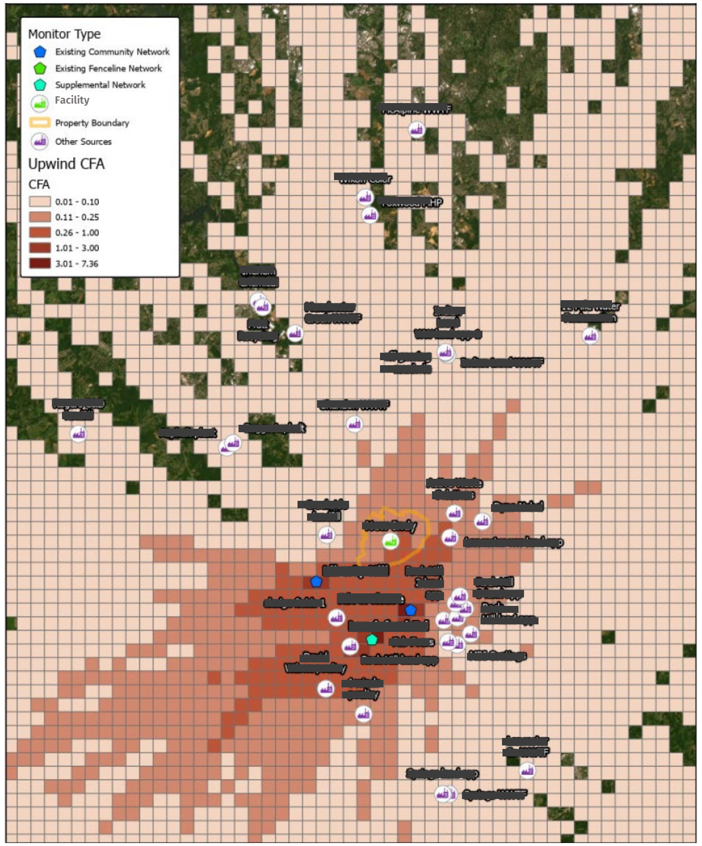
Near Facility Monitors



Distant Monitors



Upwind Monitors



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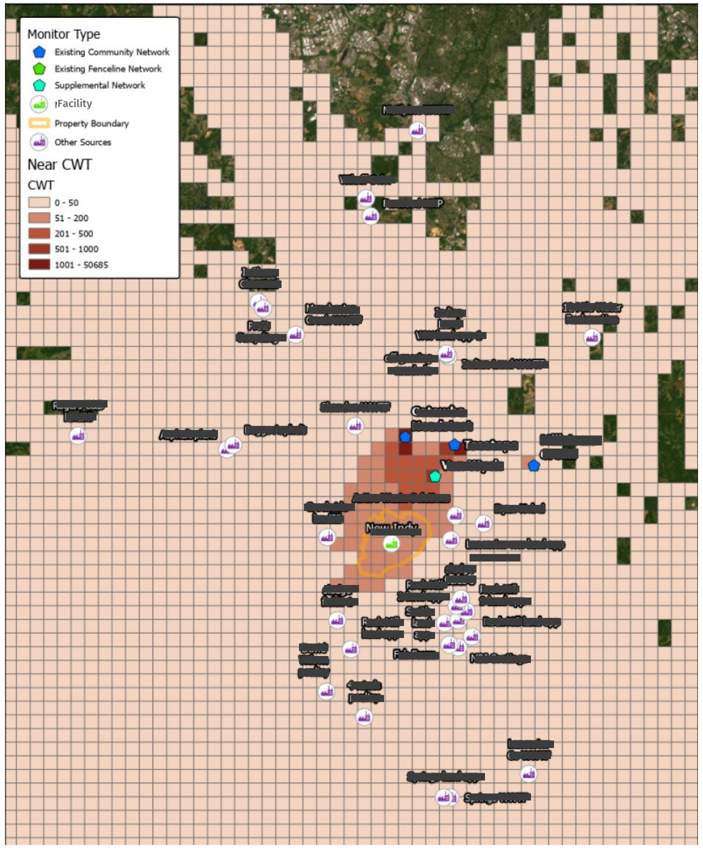
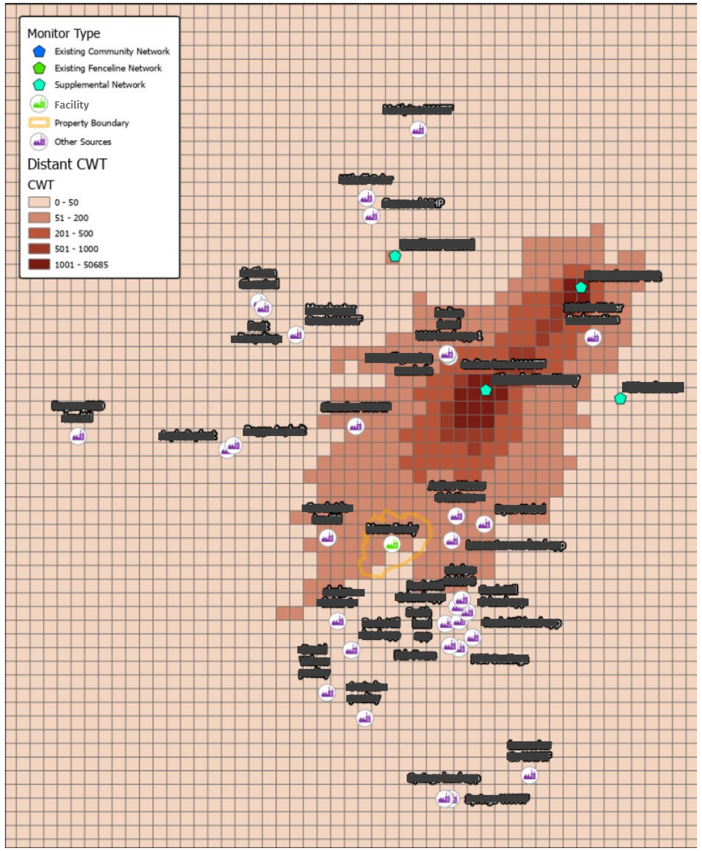
Monitor Back Trajectory Heat Maps

CWT Heat Maps

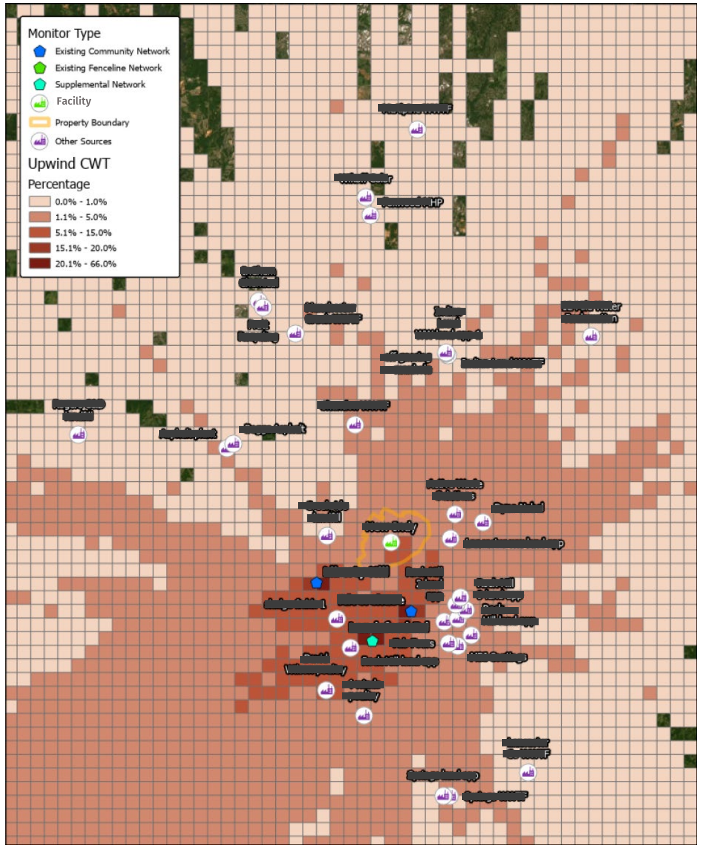
Near Facility Monitors



Distant Monitors



Upwind Monitors



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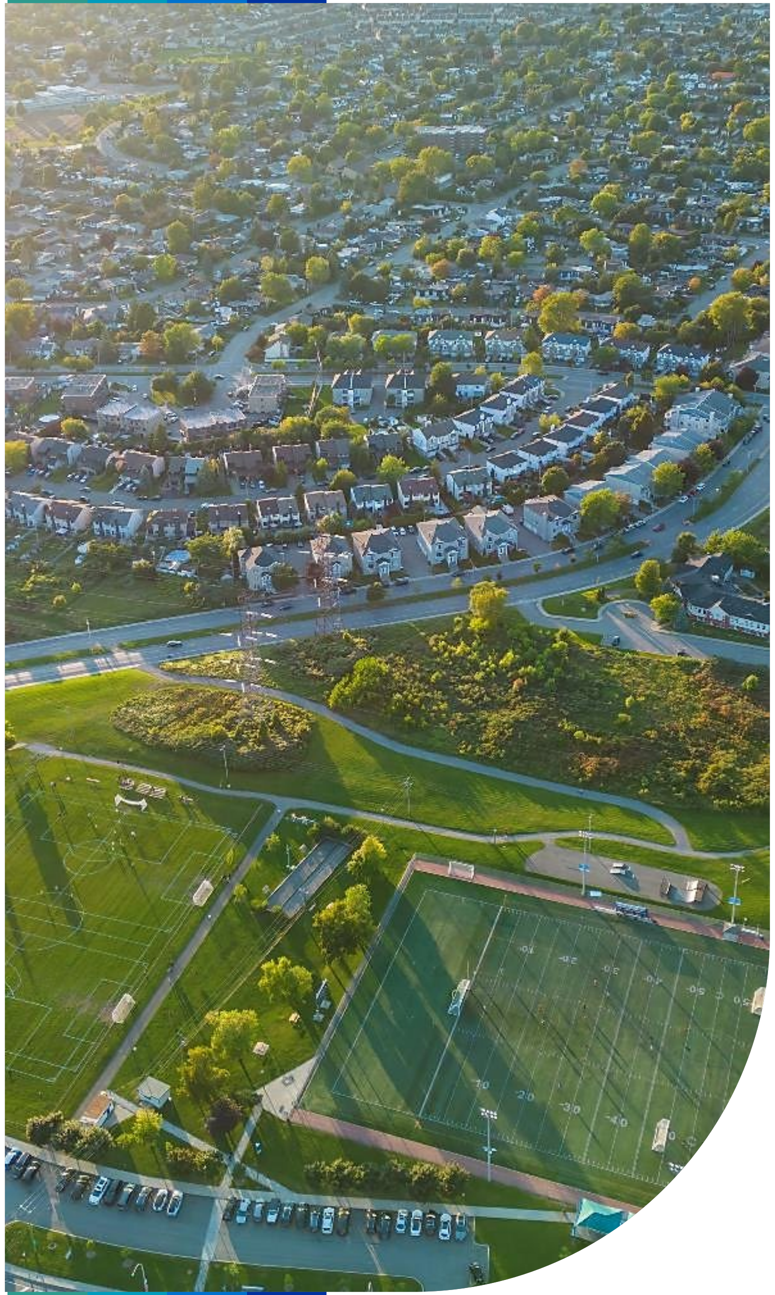
Conclusions

Combining community-based monitor readings, human reports, and back trajectory modeling provided understanding to air quality challenges and informed culpability of odor within a community.



Reducing Bias	Odor detection is highly subjective. Using multiple tools such as modelling, monitoring, and human reports reduces the bias and informs interpretation.
Informed Culpability	Although the facility did contribute to community odor issues. The analysis showed a much lower contribution than hypothesized with 46-80% culpability from other sources in community.
Future Use	Community monitoring combined with modeling provides insight as to where pollutants originate and can be used for source apportionment.

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Thank you

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