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Poisoned for Oil: Spatial Consequence Analysis of Ethylene Oxide Emissions from a Petrochemical Facility in Port Allen, Louisiana-USA

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Abstract

The Gulf Coast region of Louisiana hosts one of the highest concentrations of petrochemical industries in the United States, contributing substantially to national economic output while simultaneously posing severe environmental and public health risks. Among the hazardous pollutants released from these facilities is ethylene oxide (EtO), a highly toxic and carcinogenic gas associated with elevated risks of leukemia, lymphoma, and respiratory disorders. Communities surrounding industrial corridors, commonly referred to as “Cancer Alley”, experience disproportionate exposure due to historical land-use patterns and environmental injustice. This study evaluates the spatial extent and severity of health risks associated with a hypothetical worst-case release of ethylene oxide from the ExxonMobil Port Allen Lube Plant in West Baton Rouge Parish, Louisiana. The Areal Locations of Hazardous Atmospheres (ALOHA) dispersion model was employed to simulate atmospheric transport under defined meteorological conditions using Gaussian plume theory. Acute Exposure Guideline Levels (AEGL-1, AEGL-2, and AEGL-3) were applied to delineate threat zones representing mild, serious, and potentially lethal exposure thresholds. Results indicate that outdoor EtO concentrations exceeding 200 ppm (AEGL-3) extend up to approximately 1,750 yards from the release source, posing immediate life-threatening risks. Indoor concentrations reaching 45 ppm (AEGL-2) affect areas up to 2.3 miles from the facility, exposing sensitive populations to long-term carcinogenic risks. Several critical facilities, including residential areas, logistics centers, and public institutions, fall within these impact zones. The findings highlight the urgent need for stricter emission control, continuous monitoring, emergency preparedness, and environmental justice-driven policy interventions to protect vulnerable communities in Louisiana’s industrial corridor.

1. Introduction

1.1 Industrialization and Environmental Health Risks in Louisiana

The Gulf Coast region of the United States represents one of the most heavily industrialized zones in North America, with Louisiana serving as a central hub for petrochemical production, refining, and chemical manufacturing. The state’s strategic location along the Mississippi River has facilitated decades of industrial expansion, provided economic benefits, and simultaneously contributed to extensive environmental degradation. Numerous petrochemical facilities, refineries, and storage terminals are concentrated along the river corridor between Baton Rouge and New Orleans, an area widely known as Cancer Alley due to persistently elevated cancer risks observed among nearby populations (Xue & Jia, 2019).

Long-term industrial activity in this corridor has resulted in continuous emissions of hazardous air pollutants, including volatile organic compounds, particulate matter, and toxic industrial chemicals. Communities located near these facilities are frequently exposed to both routine operational emissions and accidental releases, increasing the probability of acute and chronic health impacts (Banzhaf et al., 2019). Several studies have demonstrated that residents in these areas experience higher rates of respiratory illness, cardiovascular disease, and cancer compared to state and national averages (Ali & Kamraju, 2023; Mohai et al., 2009). These conditions highlight the intersection of industrial development, environmental exposure, and public health vulnerability in Louisiana.

1.2 Ethylene Oxide as a Hazardous Air Pollutant

Among the hazardous chemicals released from petrochemical operations, ethylene oxide (EtO) has emerged as one of the most critical air toxics of concern. Ethylene oxide is widely used in industrial processes, including lubricant production, antifreeze manufacturing, and chemical synthesis. Despite its economic importance, EtO poses severe health risks due to its high reactivity and ability to penetrate biological tissues (ATSDR, 2022).

Ethylene oxide has been classified as a Group 1 carcinogen by the International Agency for Research on Cancer and as a known human carcinogen by the U.S. Environmental Protection Agency (IARC, 2012; Council, 2012). Epidemiological investigations have established strong associations between chronic EtO exposure and increased incidences of leukemia, lymphoma, breast cancer, and other hematological malignancies (Kirchhoff et al., 2004). Even at low atmospheric concentrations, long-term exposure has been linked to DNA damage, mutagenic effects, and elevated lifetime cancer risk (ATSDR, 2022).

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In addition to chronic health effects, acute exposure to high concentrations of ethylene oxide can result in severe respiratory irritation, neurological impairment, pulmonary edema, and potentially fatal organ failure (Banzhaf et al., 2019). These characteristics make EtO particularly dangerous during accidental release events, where exposure durations may be short but concentrations extremely high.

1.3 Environmental Justice and Community Vulnerability

The spatial distribution of petrochemical facilities in Louisiana reflects long-standing inequalities in land-use planning and environmental governance. Numerous studies have shown that low-income communities and communities of colour are disproportionately located near industrial zones, resulting in unequal exposure to hazardous air pollutants (Ali & Kamraju, 2023; Mohai et al., 2009). In Cancer Alley, residential neighbourhoods, schools, correctional facilities, and small businesses are often situated within proximity to emission sources, increasing cumulative exposure risk.

Environmental justice research emphasizes that vulnerability extends beyond proximity alone, encompassing limited access to healthcare, reduced political representation, and inadequate emergency preparedness (Banzhaf et al., 2019). These conditions magnify the consequences of chemical accidents, as residents may lack timely information, evacuation resources, or medical support. Consequently, accidental releases of ethylene oxide pose not only a chemical hazard but also a social and ethical challenge related to equitable risk distribution.

Understanding the spatial extent of toxic exposure is therefore essential for protecting vulnerable populations and informing policy interventions aimed at reducing environmental health disparities.

1.4 Atmospheric Dispersion Modelling for Chemical Risk Assessment

Atmospheric dispersion modelling provides a scientific basis for evaluating the movement and concentration of hazardous chemicals released into the atmosphere. Such models estimate how pollutants spread as a function of wind speed, atmospheric stability, terrain, and chemical properties (Turner, 2020). Dispersion analysis is widely used in emergency response planning, industrial safety assessment, and regulatory decision-making.

The Areal Locations of Hazardous Atmospheres (ALOHA) model, developed by the National Oceanic and Atmospheric Administration and the U.S. Environmental Protection Agency, is one of the most applied tools for consequence analysis of chemical releases (Manjanatha et al., 2017). ALOHA employs Gaussian plume dispersion principles to simulate transport and generate spatial threat zones representing varying levels of health impact.

Health consequences are typically interpreted using Acute Exposure Guideline Levels (AEGLs), which define concentration thresholds associated with mild, serious, and life-threatening effects (Manjanatha et al., 2017). AEGL-based zoning allows emergency planners to identify at-risk populations, designate evacuation areas, and prioritize response actions.

Despite the extensive use of dispersion modelling globally, limited site-specific assessments have been conducted for ethylene oxide emissions from petrochemical facilities in Louisiana. Addressing this gap is essential for improving chemical safety planning in regions characterized by dense industrial activity and vulnerable populations.

Accordingly, this study applies the ALOHA dispersion modelling framework to evaluate the potential consequences of a worst-case ethylene oxide release from the ExxonMobil Port Allen Lube Plant in West Baton Rouge Parish, Louisiana. The research aims to delineate AEGL-based threat zones, identify impacted facilities and communities, and provide scientific evidence to support environmental health protection and environmental justice initiatives.

2. Materials and Methods

2.1 Study Area

The study area (Figure 1) is centered on the ExxonMobil Port Allen Lube Plant located in Port Allen, West Baton Rouge Parish, Louisiana, USA. The facility lies along the western bank of the Mississippi River, directly opposite Baton Rouge, within the highly industrialized lower Mississippi River corridor. This region has historically attracted petrochemical industries due to its strategic river access, transportation infrastructure, and proximity to major markets. As a result, numerous refineries, chemical processing plants, storage terminals, and logistics facilities are concentrated within a relatively small geographic area, creating complex interactions between industrial operations and surrounding human settlements.

The land-use pattern surrounding the Port Allen Lube Plant consists of a mixture of industrial, commercial, transportation, and residential zones. Residential neighbourhoods, commercial businesses, and public institutions are located within short distances from the facility, reflecting historical zoning practices that allowed industrial development to occur in proximity to populated areas. This spatial configuration increases the potential for human exposure during accidental chemical releases, particularly for vulnerable populations such as children, the elderly, and individuals with pre-existing health conditions. Several critical facilities, including logistics centers, correctional institutions, and service establishments, are also situated within the vicinity, further heightening exposure risks.

The study area experiences a humid subtropical climate characterized by high temperatures, elevated humidity, and frequent precipitation throughout the year. Atmospheric conditions in southern Louisiana are often marked by low wind speeds and periods of stable air, especially during nighttime hours, which can significantly limit pollutant dispersion and result in higher downwind concentrations of hazardous gases (Turner, 2020). The relatively flat terrain of the Mississippi River floodplain further facilitates horizontal plume transport, allowing toxic emissions to travel considerable distances without topographic obstruction.

Port Allen forms part of Louisiana's industrial corridor, commonly referred to as Cancer Alley, a region widely recognized for disproportionately high environmental and public health burdens. Communities within this corridor are exposed to cumulative emissions from multiple industrial sources, including volatile organic compounds and known carcinogens such as ethylene oxide (U.S. EPA, 2022). Numerous studies have linked long-term exposure in this region to elevated risks of respiratory diseases, neurological disorders, and cancer, raising serious environmental justice concerns (Mohai et al., 2009). The selection of the Port Allen Lube Plant as the study area is

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therefore critical for evaluating the spatial consequences of ethylene oxide emissions and for supporting improved chemical risk assessment, emergency preparedness, and public health protection in Louisiana's petrochemical corridor.

Figure 1. The Port Allen Lube Plant is situated in Port Allen, LA, USA

2.2 Materials and Data Sources

This study utilized the Areal Locations of Hazardous Atmospheres (ALOHA) modelling system to assess the potential consequences of ethylene oxide (EtO) emissions from the ExxonMobil Port Allen Lube Plant in West Baton Rouge Parish, Louisiana. ALOHA is a widely applied atmospheric dispersion model developed jointly by the National Oceanic and Atmospheric Administration (NOAA) and the United States Environmental Protection Agency (EPA) for chemical emergency preparedness and hazard assessment (U.S. EPA, 2022).

The primary input materials included chemical properties of ethylene oxide, source characteristics of the petrochemical facility, and meteorological parameters governing atmospheric dispersion. Chemical data such as molecular weight, vapor density, boiling point, and toxicity thresholds were obtained from the ALOHA chemical library. Source information included the geographic coordinates of the Port Allen Lube Plant and assumed release characteristics representing a conservative worst-case scenario, consistent with standard industrial risk assessment practices (Hille, 2002; Mount et al., 2002).

Meteorological data used in the model consisted of wind speed, wind direction, ambient temperature, cloud cover, and relative humidity. These variables are essential for defining atmospheric stability and controlling plume transport behaviour. Terrain was assumed to be flat, reflecting the low-relief topography of the Mississippi River floodplain, which is appropriate for near-field dispersion modelling using ALOHA (Turner, 2020).

Material / Data	Description	Source	Purpose in Study
Ethylene Oxide (EtO) chemical properties	Molecular weight, vapor density, boiling point, toxicity thresholds (AEGL values)	ALOHA chemical library; U.S. EPA	Definition of chemical behavior and health impact thresholds
Petrochemical plant location	Geographic coordinates of ExxonMobil Port Allen Lube Plant	Facility location records; Google Earth	Identification of emission source and spatial reference
Emission source parameters	Release type, release height, emission rate (worst-case assumption)	Scenario-based assumption	Simulation of accidental EtO release
Meteorological data	Wind speed, wind direction, air temperature, cloud cover, humidity	NOAA meteorological standards	Determination of atmospheric stability and plume dispersion
Atmospheric stability classification	Pasquill Gifford stability classes (A-F)	ALOHA model	Estimation of dispersion coefficients (σy, σz)
ALOHA dispersion model	Gaussian plume-based atmospheric dispersion modeling software	NOAA and U.S. EPA	Simulation of toxic gas transport and concentration
Acute Exposure Guideline Levels (AEGLs)	AEGL-1, AEGL-2, AEGL-3 concentration thresholds	U.S. EPA	Health-based classification of exposure risk
Base maps	Satellite imagery and spatial context	Google Earth	Visualization of plume extent and impacted facilities
Impacted receptor data	Residential, commercial, and institutional facilities	Field interpretation: Google Earth	Identification of vulnerable populations and infrastructure

Table 1. Materials and data used with their sources

2.3 Atmospheric Dispersion Modelling Framework

The atmospheric dispersion of ethylene oxide (EtO) was simulated using the Areal Locations of Hazardous Atmospheres (ALOHA) model, developed by the National Oceanic and Atmospheric Administration (NOAA) in collaboration with the United States Environmental Protection Agency (EPA). ALOHA is widely applied for chemical emergency response and consequence assessment due to its ability to rapidly estimate downwind toxic concentrations following accidental releases (U.S. EPA, 2022; Hille, 2002).

ALOHA is fundamentally based on Gaussian plume dispersion theory, which assumes that contaminants released into the atmosphere are transported downwind and dispersed laterally and vertically due to atmospheric turbulence (Turner, 2020). The model is particularly suitable for near-field dispersion assessment under flat terrain conditions, making it appropriate for the Mississippi River floodplain.

2.4 Gaussian Plume Dispersion Equation

The concentration of a pollutant at any point downwind from the emission source is estimated using the Gaussian plume equation (Equation (1)).

$$C(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z u}\exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H)^2}{2\sigma_z^2}\right)+\exp\left(-\frac{(z+H)^2}{2\sigma_z^2}\right)\right] \quad (1)$$

where:

i. $C(x,y,z)$= pollutant concentration at point (mg m⁻³)
ii. Q = emission rate (mg s⁻¹)
iii. u = mean wind speed at release height (m s⁻¹)

iv. σ_y, σ_z = horizontal and vertical dispersion coefficients (m)
v. x = downwind distance (m)
vi. y = crosswind distance (m)
vii. z = vertical height above ground (m)
viii. H = effective release height (m)

The exponential terms represent lateral and vertical spreading of the plume, while the second exponential term accounts for ground reflection, ensuring mass conservation (Turner, 2020; Ohba et al., 2004).
Dispersion coefficients σ_y and σ_z are functions of atmospheric stability class and downwind distance, commonly defined using Pasquill-Gifford stability categories (A-F), where stable atmospheric conditions (E-F) typically result in higher ground-level concentrations due to limited vertical mixing (Turner, 2020).

2.5 Determination of Atmospheric Stability

Atmospheric stability plays a critical role in plume behavior and was determined using meteorological parameters, including wind speed, cloud cover, and solar radiation. Pasquill-Gifford stability classification defines atmospheric turbulence as:

Class A-B: very unstable

Class C-D: neutral

Class E-F: stable

Stable atmospheric conditions are particularly hazardous during toxic gas releases, as reduced turbulence limits dilution and extends plume travel distance (Zellner, 2000). ALOHA internally applies this classification to calculate dispersion coefficients and plume geometry.

2.6 Source Term and Release Assumptions

The source term Qrepresents the mass release rate of ethylene oxide and is defined using Equation (2).

$$Q = \frac{M}{t} \tag{2}$$

where:
i. M= total mass released (kg)
ii. t= release duration (s)

A worst-case release scenario was adopted to evaluate maximum potential exposure, consistent with standard industrial risk assessment practice (Shariff and Leong, 2009). The release was assumed to occur at or near ground level, representing leakage or rupture from processing equipment.

Ethylene oxide is lighter than air (vapor density ≈ 0.98 relative to air), allowing it to behave as a neutrally buoyant gas under many atmospheric conditions. Consequently, Gaussian dispersion remains appropriate for modeling its atmospheric transport (ATSDR, 2022).

2.7 Health Risk Classification Using AEGL Thresholds

To evaluate potential health impacts, predicted concentrations were compared with Acute Exposure Guideline Levels (AEGLs) established by the U.S. EPA. AEGLs represent airborne concentration thresholds above which adverse health effects may occur following short-term exposure (U.S. EPA, 2018).
The three AEGL levels are defined as Equation (4)-(5):

- AEGL-1:
$$C \geq C_{AEGL1} \tag{3}$$

Mild, transient, and reversible health effects.

- AEGL-2:
$$C \geq C_{AEGL2} \tag{4}$$

Irreversible or serious long-lasting health effects or impaired ability to escape.

- AEGL-3:
$$C \geq C_{AEGL3} \tag{5}$$

Life-threatening or fatal effects.
For ethylene oxide, representative AEGL concentration thresholds used in emergency planning include approximately:
i. AEGL-1 ≈ 10 ppm
ii. AEGL-2 ≈ 45 ppm
iii. AEGL-3 ≥ 200 ppm (U.S. EPA, 2022).
These thresholds were used by ALOHA to delineate spatial threat zones corresponding to yellow, orange, and red impact regions.

2.8 Spatial Delineation of Threat Zones

ALOHA computes downwind distances at which predicted concentrations fall below AEGL thresholds by solving the Gaussian plume equation iteratively across increasing distances x. The maximum downwind distance D for each AEGL zone is determined (Equation (6)) where:

$$C(x) = C_{AEGL} \tag{6}$$

Threat zones are then mapped as concentric plume footprints extending from the source in the prevailing wind direction. These zones represent areas where populations may experience varying degrees of health impact depending on exposure duration and location (Hille, 2002; Ohba et al., 2004). Both outdoor and indoor exposure were evaluated, as ethylene oxide can infiltrate enclosed spaces and prolong exposure duration, increasing long-term carcinogenic risk (ATSDR, 2022).

2.9 Methodological Reliability and Limitations

The Gaussian dispersion approach provides reliable estimates for short-range chemical releases under homogeneous terrain and steady meteorological conditions. However, it does not explicitly account for complex building geometry, terrain variability, or time-varying meteorology. Despite these limitations, Gaussian-based models remain standard tools for emergency response and regulatory screening due to their transparency, reproducibility, and conservative risk estimation (Hille, 2002; Ohba et al., 2004). The conceptual framework of the study is shown in Figure 2.

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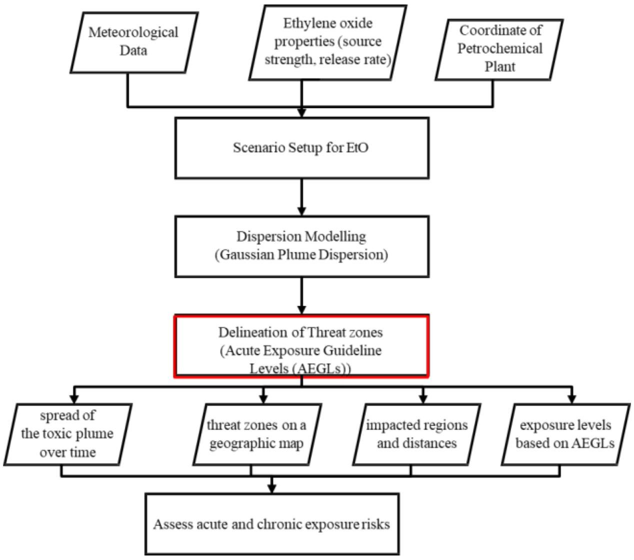

Figure 2. Conceptual Framework used to analyse the Spatial Consequence Analysis of Ethylene Oxide Emissions from a Petrochemical Facility in Port Allen

3. Results and Discussion

The atmospheric dispersion modelling results provide critical insight into the spatial extent and severity of ethylene oxide (EtO) exposure risks associated with a hypothetical worst-case release from the ExxonMobil Port Allen Lube Plant. Using the ALOHA model, AEGL-based threat zones were delineated to evaluate potential acute and chronic health impacts under conservative meteorological conditions.

3.1 Spatial Distribution of Ethylene Oxide Plume

Model simulations indicate that ethylene oxide exhibits substantial downwind transport due to its gaseous nature and low molecular weight (Figure 3). Under stable atmospheric conditions, the toxic plume extended several kilometres from the emission source, forming elongated dispersion patterns aligned with prevailing wind direction (Figure 4). Similar plume behaviour has been reported in previous dispersion modelling studies of light industrial gases, where limited vertical mixing leads to elevated ground-level concentrations over extended distances (Ohba et al., 2004).

The flat topography of the Mississippi River floodplain further facilitated horizontal plume propagation, allowing ethylene oxide concentrations to remain above health-based thresholds far from the source. This finding reinforces the vulnerability of low-relief industrial corridors, where terrain does not significantly impede contaminant transport.

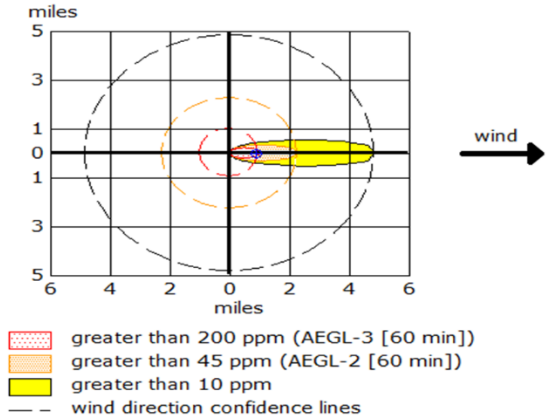

Figure 3. Spatial distribution of ethylene oxide (EtO) dispersion and AEGL-based threat zones from the Port Allen Lube Plant under a 60-minute release scenario. The red zone represents concentrations greater than 200 ppm (AEGL-3), the orange zone indicates concentrations greater than 45 ppm (AEGL-2), and the yellow zone shows concentrations greater than 10 ppm (AEGL-1). Dashed lines indicate wind-direction confidence limits.

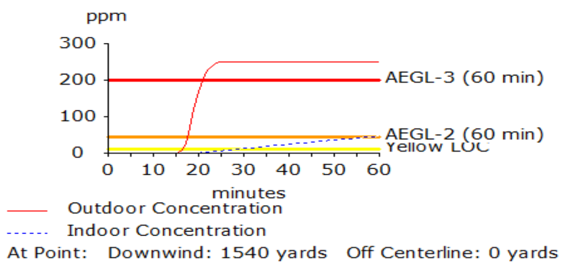

Figure 4. Time concentration profile of ethylene oxide (EtO) at a receptor located 1,540 yards downwind of the release source. The solid red line represents outdoor concentration, while the dashed blue line indicates indoor concentration. Horizontal lines denote AEGL-3 (200 ppm), AEGL-2 (45 ppm), and AEGL-1 (10 ppm) thresholds for a 60-minute exposure duration.

3.2 AEGL-3 Zone: Potentially Lethal Exposure

The red threat zone, corresponding to AEGL-3 exposure levels, represents concentrations capable of causing life-threatening or fatal health effects following short-term exposure. Model outputs indicate outdoor ethylene oxide concentrations exceeding 200 ppm extended approximately 1,750 yards (about 1.6 km) downwind from the release point.

Exposure within this zone poses immediate health risks, including respiratory failure, severe lung injury, neurological impairment, and damage to vital organs. Acute EtO inhalation at such concentrations has been documented to cause pulmonary edema and central nervous system depression, with potentially fatal outcomes if exposure persists (ATSDR, 2022; U.S. EPA, 2022).

The presence of commercial and industrial facilities within this zone significantly increases occupational exposure risk, particularly for outdoor workers and emergency responders. These findings align with previous industrial accident assessments demonstrating that AEGL-3 zones often overlap with areas of high human activity, underscoring the importance of rapid evacuation and emergency response protocols (Hille, 2002). Figure 5 presents the spatial overlay of ALOHA-modelled ethylene oxide threat zones on high-resolution satellite imagery. The AEGL-3 zone is concentrated around the Port Allen Lube Plant, indicating areas exposed to potentially lethal concentrations. The AEGL-2 zone extends across adjacent industrial and commercial facilities, while the AEGL-1 zone covers a substantially larger geographic area, intersecting transportation corridors and nearby communities. The plume alignment reflects prevailing wind direction, demonstrating the potential for cross-river transport of toxic emissions toward populated areas in Baton Rouge.

Figure 5. Georeferenced ALOHA dispersion output showing AEGL-based ethylene oxide threat zones overlaid on Google Earth imagery for the Port Allen Lube Plant. The red (AEGL-3), orange (AEGL-2), and yellow (AEGL-1) zones illustrate decreasing exposure severity with increasing distance from the emission source. The spatial overlay highlights the proximity of residential neighbourhoods, transportation corridors, and industrial facilities located within predicted impact zones.

3.3 AEGL-2 Zone: Serious and Long-Term Health Effects

The orange threat zone, defined by AEGL-2 concentrations, extended up to approximately 2.3 miles (3.7 km) from the emission source, with modelled indoor concentrations reaching 45 ppm (Figure 5). Exposure at this level is associated with irreversible or serious long-lasting health effects and impaired ability to escape (U.S. EPA, 2022).

Health implications within this zone include neurological damage, respiratory distress, and significantly elevated lifetime cancer risk. Epidemiological studies have established strong links between chronic ethylene oxide exposure and increased incidences of leukaemia and lymphoma, even at relatively low concentrations (Steenland et al., 2004; ATSDR, 2022). Indoor exposure is particularly concerning, as EtO can infiltrate enclosed environments and persist longer than outdoor plumes, thereby increasing exposure duration.

Several critical facilities, including logistics centres, commercial establishments, and public institutions, were identified within this zone (Figure 6). The spatial overlap between AEGL-2 exposure areas and populated environments highlights a major public health concern, especially for individuals with limited mobility or pre-existing medical conditions.

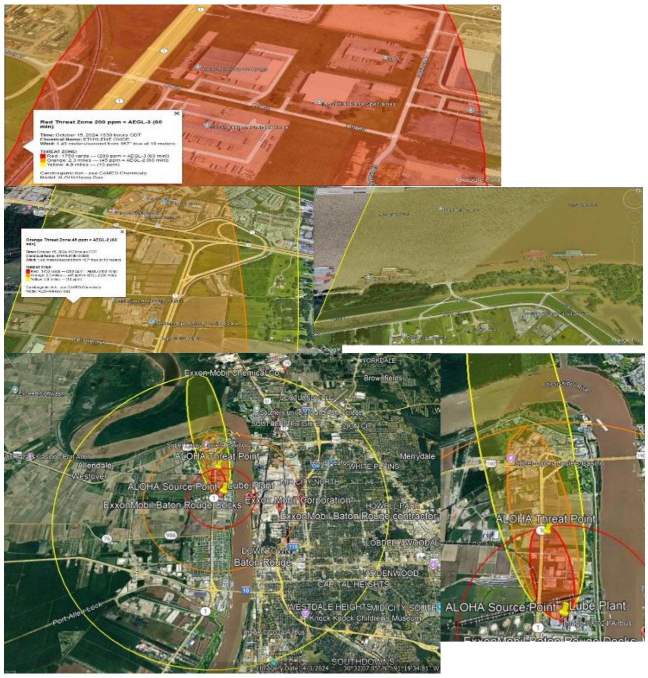

Figure 6. High-resolution spatial representation of ALOHA-modelled ethylene oxide threat zones intersecting specific receptor locations near the Port Allen Lube Plant. Insets illustrate localized exposure conditions within AEGL-3 and AEGL-2 zones, demonstrating the proximity of built infrastructure and operational facilities to areas of elevated toxic concentration.

3.4 AEGL-1 Zone: Mild and Transient Health Effects

The yellow threat zone, corresponding to AEGL-1 exposure, extended nearly 4.8 miles (7.7 km) from the facility, with concentrations around 10 ppm (Figure 6). Although classified as mild, exposure at this level may result in eye irritation, throat discomfort, coughing, headaches, and dizziness (EPA, 2022). While these effects are generally reversible, repeated or prolonged exposure, particularly in environmentally burdened communities, can contribute to cumulative health stress. Studies have shown that even low-level chemical exposures can exacerbate respiratory conditions and reduce overall community health resilience (Hille, 2002). The extensive spatial coverage of the AEGL-1 zone suggests that large portions of Port Allen and surrounding communities could be affected during a significant release, emphasizing the importance of community-wide warning systems and public education.

3.5 Environmental Justice and Public Health Implications

The results reveal pronounced environmental justice concerns, as communities surrounding the Port Allen Lube Plant already experience cumulative exposure from multiple industrial emission sources. Residents within Louisiana's Cancer Alley are disproportionately exposed to carcinogenic air pollutants due to historical zoning practices and limited regulatory enforcement (Mohai et al., 2009). The modeled plume overlaps with residential neighborhoods and essential infrastructure, illustrating how accidental chemical releases compound existing health disparities. Vulnerable populations, including children, elderly individuals, and incarcerated people, face heightened exposure risk with limited capacity to respond effectively during emergencies. Similar findings have been reported in prior

environmental justice studies emphasizing the unequal distribution of industrial risk (Xue et al., 2019).
These outcomes reinforce the need to integrate dispersion modeling into environmental permitting, land-use planning, and public health policy to reduce disproportionate risk exposure.

3.6 Implications for Emergency Planning and Risk Management

The spatial delineation of AEGL-based threat zones provides critical guidance for emergency response planning. Identifying plume extents and exposure distances supports the development of evacuation strategies, shelter-in-place decisions, and allocation of emergency resources. The findings demonstrate the importance of continuous air monitoring systems, real-time meteorological tracking, and coordinated communication between industry operators and emergency management agencies. ALOHA modeling has proven effective as a screening-level risk assessment tool, offering rapid and scientifically grounded insights that can inform both short-term emergency response and long-term regulatory strategies (Ohba et al., 2004; Zellner et al., 2000).

4. Conclusion

This study assessed the potential consequences of a worst-case ethylene oxide release from the ExxonMobil Port Allen Lube Plant in West Baton Rouge Parish, Louisiana, using the ALOHA atmospheric dispersion model. The results indicate that ethylene oxide poses significant acute and chronic health risks, with potentially lethal concentrations extending up to approximately 1.6 km from the emission source and serious long-term exposure risks affecting areas more than 3.7 km downwind. The extensive reach of AEGL-based threat zones demonstrates that accidental EtO releases could impact large segments of surrounding communities, including residential neighborhoods and critical infrastructure. Indoor exposure risks are particularly concerning due to the carcinogenic nature of ethylene oxide and its ability to persist within enclosed environments. The findings highlight urgent needs for stricter emission control measures, enhanced air quality monitoring, and strengthened emergency preparedness strategies in Louisiana's petrochemical corridor. Incorporating dispersion modeling into industrial safety planning and environmental justice assessments can significantly improve public health protection and risk communication. Ultimately, this research underscores the importance of proactive chemical risk management to safeguard vulnerable populations and promote sustainable industrial development.

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