Dominici Lab

December 19, 2025
Prepared for SELC

Michael Cork, MPH, PhD candidate, Harvard T.H. Chan School of Public Health (Lead author)
Dr. Gianluca Guidi, PhD Harvard T.H. Chan School of Public Health (Co-author)
Dr. Francesca Dominici, Clarence James Gamble Professor of Biostatistics, Population, and Data Science (Senior Scientific Advisor)
Dominici Lab, Harvard T.H. Chan School of Public Health
https://hsph.harvard.edu/research/dominici-lab/

Primary point of contact: Michael Cork (Author), mcork@g.harvard.edu

Report: $PM_{2.5}$ Air Pollution Impact of Proposed Expedition Generating Station

Executive Summary

- This report analyzes the potential health impacts and healthcare related costs associated with increased exposure to fine particulate matter ($PM_{2.5}$) that would result from the proposed Expedition Generating Station, a 1,540-megawatt natural gas–fired power plant in Fluvanna County, Virginia.
- $PM_{2.5}$ is one of the most harmful forms of air pollution. Public health experts agree that no level of $PM_{2.5}$ exposure is safe; even small long-term increases—well below the National Ambient Air Quality Standards—raise the risk of heart attack, pneumonia, cardiovascular disease, stroke, asthma attacks, and premature death.
- Using emission rates from a comparable Virginia power plant, the proposed Expedition facility is estimated to emit 153 tons of primary $PM_{2.5}$, 153 tons of NO_x, 19 tons of SO_2, 80 tons of VOCs, and 88 tons of NH_3 each year.
- Fluvanna County—the site of the plant—would experience the highest modeled $PM_{2.5}$ increase (0.07 µg/m³) and receive 5.4% of the overall health burden. Chesterfield County would receive the largest share of the total population-weighted exposure (14.08%).In total, 93.7% of the regional health burden occurs within Virginia.
- Dispersion modeling of these emissions reveals that more than 4 million people would experience increased $PM_{2.5}$ exposure (≥ 0.001 µg/m³), primarily in Virginia. Residents of towns closest to the plant, Palmyra (0.093 µg/m³) and Lake Monticello (0.075 µg/m³), would experience the largest modeled increases.
- According to the EPA COBRA model, the Expedition Generating Station is estimated to impose $27–50 million in health-related damages each year. Over a typical 30-year operating life, these annual damages correspond to roughly $500 million–1.0 billion in cumulative public-health costs in present-value terms.
- Census tracts experiencing $PM_{2.5}$ increases above 0.01 µg/m³ have a higher percentage of Black residents (26.6%) than Virginia (18.9%) or the United States overall (12.5%).

Introduction

This report was led by Dr. Michael Cork under the supervision of Dr. Francesca Dominici, Director of the Harvard Data Science Initiative and Professor at the Harvard T.H. Chan School of Public Health. The analysis focuses on the impact of the proposed Expedition Generating Station, a new 1,540-megawatt combined-cycle natural gas power plant in Fluvanna County, Virginia.[1] If built, the facility would add a large new source of combustion-related emissions in a region already hosting significant energy infrastructure. As explained below, the proposed Expedition plant would increase the concentration of air pollution in communities in Fluvanna County and downwind areas of Virginia and neighboring states. To date, these changes to air quality, and the economic costs of the resulting health impacts, have not been quantified. We quantify some of those impacts with this report. This report addresses that gap by estimating the health damages attributable to increased fine particulate matter ($PM_{2.5}$) and ozone exposure. These estimates represent only a subset of the plant's potential impacts: we do not quantify other important environmental and community effects such as water use, wastewater discharges, methane leakage, climate damages, noise, light pollution, or land-use impacts. Accordingly, the health-related costs reported here should be understood as conservative and incomplete, capturing only part of the total burden the facility would impose.

Built on peer-reviewed research

The Dominici Lab's work builds on decades of robust research on the public health impacts of air pollution.[2] The research team applies approaches for causal inference to data on emissions to model the movement through the air (dispersion) of particulate matter emitted by power generation to quantify changes in air quality and to identify the communities that would be most impacted by those changes. For the purposes of this report, the analysis focuses on a specific type of pollution, fine particulate matter ($PM_{2.5}$). We then estimate the economic impact of increased health burdens due to power plant air pollution based on data reported by the EPA.[3]

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[1] Tenaska Inc., "Expedition Generating Station," Expedition Generating Station, accessed November 25, 2025, https://expeditiongeneratingstation.com/.

[2] X. Wu et al., "Evaluating the Impact of Long-Term Exposure to Fine Particulate Matter on Mortality among the Elderly," *Science Advances* 6, no. 29 (2020): eaba5692, https://doi.org/10.1126/sciadv.aba5692; Yaguang Wei et al., "Short Term Exposure to Fine Particulate Matter and Hospital Admission Risks and Costs in the Medicare Population: Time Stratified, Case Crossover Study," Research, *BMJ* 367 (November 2019): l6258, https://doi.org/10.1136/bmj.l6258; Qian Di et al., "Air Pollution and Mortality in the Medicare Population," *New England Journal of Medicine* 376, no. 26 (2017): 2513–22, https://doi.org/10.1056/NEJMoa1702747; Qian Di et al., "Association of Short-Term Exposure to Air Pollution With Mortality in Older Adults," *JAMA* 318, no. 24 (2017): 2446–56, https://doi.org/10.1001/jama.2017.17923; Michael Cork et al., "Methods for Estimating the Exposure-Response Curve to Inform the New Safety Standards for Fine Particulate Matter," *Journal of the Royal Statistical Society Series A: Statistics in Society*, January 16, 2025, qnaf004, https://doi.org/10.1093/jrsssa/qnaf004.

[3] US Environmental Protection Agency, "CO-Benefits Risk Assessment (COBRA) Web Edition," Data and Tools, accessed November 25, 2025, https://cobra.epa.gov/.

What is $PM_{2.5}$ and why does it matter?

Fine particulate matter smaller than 2.5 micrometers in diameter—known as $PM_{2.5}$—is one of the most harmful forms of air pollution.[4] Because of its microscopic size (roughly 30 times smaller than the width of a human hair), $PM_{2.5}$ can penetrate deep into the lungs and enter the bloodstream, triggering inflammation throughout the body.[5]

Exposure to $PM_{2.5}$ is associated with a wide range of adverse health outcomes, including asthma attacks, respiratory and cardiovascular disease, heart attack, stroke, and premature death.[6] According to major public-health assessments, $PM_{2.5}$ accounts for the majority of the roughly eight million global deaths each year attributed to air pollution, making it a leading environmental risk factor worldwide.[7]

$PM_{2.5}$ originates from two main sources. Primary $PM_{2.5}$ is emitted directly into the air from combustion processes such as power generation, vehicle exhaust, and industrial activity. Secondary $PM_{2.5}$ forms in the atmosphere when gases like sulfur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs) react chemically to produce sulfates, nitrates, and organic aerosols. Both forms contribute to total $PM_{2.5}$ concentrations that affect air quality and public health.

There is no known safe level of exposure to $PM_{2.5}$.[8] Even at concentrations well below current regulatory standards, studies have shown measurable increases in hospitalizations, disease burden, and mortality risk.[9] While emission-control technologies such as scrubbers and filters can reduce particulate emissions, they cannot fully eliminate them.

Purpose of this analysis

This report quantifies potential increases in $PM_{2.5}$ concentrations and associated health burdens that would result from operation of the proposed Expedition Generating Station with emission-control technologies installed. We use state-of-the-art dispersion modeling and demographic analysis to estimate who would be most affected and how those impacts are distributed. In addition to direct $PM_{2.5}$ emissions, the analysis includes precursor gases—NO_x, SO_2, VOCs, and NH_3—that contribute to secondary $PM_{2.5}$ formation, providing a fuller picture of the plant's expected air-pollution footprint.

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[4] American Lung Association, "Particle Pollution," accessed November 25, 2025, https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution.
[5] US Environmental Protection Agency, "Particulate Matter (PM) Basics," Overviews and Factsheets, May 30, 2025, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics.
[6] US Environmental Protection Agency, "Particulate Matter (PM) Basics."
[7] Health Effects Institute and IHME, "State of Global Air Report 2025," accessed November 25, 2025, https://www.stateofglobalair.org/resources/report/state-global-air-report-2025.
[8] American Lung Association, "Particle Pollution."
[9] Wu et al., "Evaluating the Impact of Long-Term Exposure to Fine Particulate Matter on Mortality among the Elderly."

The analysis presented in this report models both primary emissions and secondary particulate formation using emissions estimated from plant-level data. Specifically, we apply empirically derived emission factors from a closely comparable facility to the proposed Expedition facility's capacity and expected utilization. We limit the scope of the assessment to air-quality impacts and resulting health effects. This report does not evaluate other environmental or operational impacts such as water use, noise, construction emissions, or land-use changes. Emissions from any temporary construction activities or backup generators are also not included in this screening-level assessment.

In this report we use the Greensville County Power Station as a reference facility for deriving emission factors because it employs turbine technology, fuel type, and emissions-control systems similar to those proposed for the Expedition Generating Station, and it represents a modern combined-cycle natural gas plant operating in Virginia.

Analytical Approach and Methodology

To estimate the Expedition facility's potential air-quality and health impacts, we conducted a multi-step analysis combining emissions estimation, atmospheric dispersion modeling, demographic assessment, and health-impact valuation.

Project information and data sources

We began with publicly available information about the proposed Expedition Generating Station, including its geographic location (Fluvanna County, VA), the planned nameplate capacity of 1,540 MW, and the intention to operate as a combined-cycle gas–fired power plant.[10] These parameters—location, size, and technology type—form the basis for estimating the volume and composition of emissions that the proposed Expedition Generating Station would contribute to regional air pollution.

Because the plant does not yet exist, no operational data are available. To translate the project's characteristics into quantitative emissions estimates, we relied on the best available empirical evidence from comparable gas plants operating under similar conditions.

Reference plant and derivation of emission factors

We selected the Greensville County Power Station, a modern Dominion Energy combined-cycle natural gas plant in Virginia, as the reference facility for deriving emission factors.[11] Greensville uses turbine technology, fuel type, and emissions-control systems—including selective catalytic reduction (SCR) and oxidation catalysts—similar to those proposed for the Expedition

[10] Tenaska Inc., "Expedition Generating Station."
[11] Dominion Energy, "Power Stations," accessed November 25, 2025, http://www.dominionenergy.com/en/About/Making-Energy/Power-Stations.

Generating Station. These similarities make it the most appropriate analog for estimating expected emissions.

To quantify expected emissions, we used pollutant-specific emission factors derived from the U.S. Environmental Protection Agency's Emissions & Generation Resource Integrated Database (eGRID), which provides standardized information on electricity generation and associated air emissions from U.S. power plants.[12] Where available, eGRID reports emissions at the individual facility level; for certain pollutants, however, emissions are estimated and reported only at broader geographic scales due to limitations in national monitoring and reporting requirements. For this analysis, we used the most geographically precise and most recent eGRID data available for each pollutant and converted all emission intensities to kg/MWh.

For primary $PM_{2.5}$, we used a three-year average of facility-level data from 2019–2021 to derive an emission factor of 0.01499 kg/MWh, reflecting year-to-year variability in reported particulate emissions. For ammonia (NH_3), we used the 2021 facility-level emission factor of 0.00864 kg/MWh. For NO_x and SO_2, which are continuously monitored and consistently reported at the plant level, more recent facility-specific data were available; we therefore used 2023 emission factors from the Greensville plant of 0.01497 kg/MWh and 0.00181 kg/MWh, respectively.

For volatile organic compounds (VOCs), eGRID does not provide facility-level emission factors for individual power plants, as VOC emissions are not directly monitored at electric generating units and are instead estimated within EPA's National Emissions Inventory framework.[13] As a result, VOC emission factors in eGRID are reported only at the state level. Consistent with EPA guidance and best practice, we therefore used the Virginia-specific VOC emission factor for 2021, equal to 0.00781 kg/MWh, which represents the most geographically specific and internally consistent estimate available for a combined-cycle gas facility operating in Virginia.

Taken together, these emission factors represent the best available, EPA-consistent estimates of pollutant intensities for a modern combined-cycle natural gas power plant in Virginia. The use of facility-level data where available, supplemented by state-level estimates where required by data limitations, ensures that emissions inputs are both geographically appropriate and methodologically transparent. The combination of multi-year averaging for $PM_{2.5}$ and mixed-year data for gaseous precursors provides a conservative, data-driven basis for assessing both primary and secondary particulate emissions.

Estimation of annual emissions

Annual emissions depend on the plant's nameplate capacity, an assumed utilization rate (capacity factor), and the emission factor for each pollutant. We adopted a Greensville-based

[12] United States Environmental Protection Agency, "Emissions & Generation Resource Integrated Database (eGRID)," Collections and Lists, July 27, 2020, https://www.epa.gov/egrid.
[13] United States Environmental Protection Agency, "Emissions & Generation Resource Integrated Database (eGRID)."

capacity factor computed from 2019–2021 operations (CF ≈ 0.688), which reflects data-informed utilization for a similar Virginia combined-cycle plant.

Annual emissions for each pollutant were calculated using:

Emissions (tons/year) = 1540 MW × EF (kg/MWh) × CF × 8760 hours/year ÷ 907.185 kg/ton

Table 1. *Estimated annual emissions from the proposed Expedition Generating Station*

Pollutant	Annual emissions (kg/yr)	Tons/yr
Primary $PM_{2.5}$	139,090	**153.3**
NO_x	138,871	**153.1**
SO_2	16,833	**18.6**
VOCs	72,454	**79.9**
NH_3	80,138	**88.3**

These totals represent the primary $PM_{2.5}$ emitted and precursor gases that contribute to secondary $PM_{2.5}$ formation downwind.

Dispersion Modeling of Pollution

Next, we used the InMAP (Intervention Model for Air Pollution) dispersion model to estimate how emissions from the plant would travel through the atmosphere and contribute to downwind $PM_{2.5}$ concentrations.[14] InMAP incorporates wind patterns, temperature, terrain, and atmospheric chemistry to simulate how pollutants move, react, and eventually settle at ground level.

Because the permit does not provide detailed information on operating conditions, we applied standard assumptions used in air-quality modeling, including a 65-meter stack height consistent with EPA Good Engineering Practice.[15]

[14] Christopher W. Tessum et al., “InMAP: A Model for Air Pollution Interventions,” *PLOS ONE* 12, no. 4 (2017): e0176131, https://doi.org/10.1371/journal.pone.0176131.
[15] US Environmental Protection Agency, “Guideline for Determination of Good Engineering Practice Stack Height,” June 1, 1985, https://www.wbdg.org/epa/criteria/epa-450-4-80-023; see also Zoning Text Amendment, Fluvanna County Planning Commission (Sep. 9, 2025) (requesting a waiver from the

The model generated a gridded surface showing the additional annual average $PM_{2.5}$ that would be added across the region if the plant were built. This analysis focuses solely on additional pollution from the plant and does not include existing ambient $PM_{2.5}$ levels from other sources such as Tenaska's directly adjacent 1,011 MW gas facility,[16] traffic, industry, or regional background pollution. The analysis also does not incorporate potential additional emissions associated with increased traffic, construction activity, or other indirect impacts of the project.

Estimating Community Exposure

To determine how many people would be affected, and by how much, we overlaid the modeled pollution surface onto U.S. Census tract boundaries. Using population counts from the 2022 American Community Survey (ACS), we determined the number of residents living within each tract.[17]

For each census tract and county, we calculated population-weighted average exposure, which accounts for both the modeled concentration in each portion of the tract, and the number of people living in that portion. This approach gives a more accurate picture of how individuals residing in those communities would be affected. All spatial analysis was conducted in R, a programming language, using publicly available geospatial tools.

Demographic and Socioeconomic Assessment

To understand which communities would bear the greatest burden, we conducted a demographic and socioeconomic assessment using ACS[18] and Centers for Disease Control and Prevention (CDC) data.[19] For tracts with increased $PM_{2.5}$ exposure ($PM_{2.5}$ exposure as explained below), population-weighted averages were calculated for indicators such as race and ethnicity, poverty rate, median household income, median property value, age distribution, social vulnerability indicators, and adult asthma prevalence.

These values were then compared with state and national averages to identify potential environmental justice concerns, such as disproportionate impacts on lower-income or historically marginalized communities. In addition, we calculated each county and state's share of the total population-level $PM_{2.5}$ exposure attributable to the plant. This reveals not just where

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County's 145 foot limit for stack height), https://www.fluvannacounty.org/sites/default/files/fileattachments/planning_amp_zoning/page/23796/section_11.pdf.

[16] Sketch Plan and Maps, Fluvanna County Planning Commission (Aug. 28, 2025), https://www.fluvannacounty.org/sites/default/files/fileattachments/planning_amp_zoning/page/23796/section_4.pdf.

[17] American Community Survey, updated December 12, 2024. "5-Year Data (2009 - 2023)." 2022 estimates. Accessed October 13, 2025.

[18] US Census Bureau, "American Community Survey 5-Year Data (2009-2023)," Census.Gov, accessed November 25, 2025, https://www.census.gov/data/developers/data-sets/acs-5year.html.

[19] CDC, "Health Outcomes," PLACES: Local Data for Better Health, January 6, 2025, https://www.cdc.gov/places/measure-definitions/health-outcomes.html.

pollution concentrations are highest, but where the overall health burden is greatest due to population size.

Health and Economic Impact Estimation

Finally, we utilized the EPA COBRA (Co-Benefits Risk Assessment)[20] tool to estimate the health effects and associated economic costs from the plant's added $PM_{2.5}$ emissions. COBRA applies epidemiological evidence linking $PM_{2.5}$ exposure to outcomes such as premature death, hospitalizations, heart attacks, asthma attacks, and missed workdays. Results represent annual health-related costs to communities in Virginia and neighboring states.

Threshold for detection

For visualization and summary purposes, the report uses two practical thresholds to help interpret the modeled changes in $PM_{2.5}$. The maps display areas with increases of 0.005 μg/m³ or more, which allows readers to see the complete spatial footprint of the plant's pollution, including smaller but still detectable downwind impacts. For the demographic and socioeconomic analysis, we used a slightly higher threshold of 0.01 μg/m³ to focus on communities experiencing the most elevated exposure.

Neither threshold represents a health-based cutoff—there is no safe level of $PM_{2.5}$—but rather a way to clearly present modeled changes from the Expedition Generating Station. Based on modeled EPA and CDC data compiled in the NIH HDPulse portal, baseline annual $PM_{2.5}$ concentrations are about 6.9 μg/m³ in the surrounding region.[21] Large epidemiological studies show that even small long-term increases at these baseline levels—below current regulatory standards—are associated with measurable health risks.[22] We used these visualization thresholds to highlight the areas receiving the greatest relative increases in exposure from the plant's emissions.

Results: Estimated Air Pollution from the Proposed Expedition Generating Station

Regional $PM_{2.5}$ Increases (Figure 1)

Figure 1 shows the modeled increase in annual average $PM_{2.5}$ concentrations attributable to emissions from the proposed Expedition Generating Station expansion in Fluvanna County. The highest incremental concentrations occur in Fluvanna County itself, particularly in the census tracts immediately surrounding the proposed plant site. Elevated concentrations extend

[20] US Environmental Protection Agency, "CO-Benefits Risk Assessment (COBRA) Web Edition."
[21] National Institute on Minority Health and Health Disparities, "HDPulse - Health Disparities and Minority Health Resources (NIMHD)," accessed November 25, 2025, https://hdpulse.nimhd.nih.gov/.
[22] Wu et al., "Evaluating the Impact of Long-Term Exposure to Fine Particulate Matter on Mortality among the Elderly"; Cork et al., "Methods for Estimating the Exposure-Response Curve to Inform the New Safety Standards for Fine Particulate Matter."

eastward into Louisa, Goochland, Cumberland, Powhatan, and Buckingham Counties, reflecting prevailing wind patterns and typical atmospheric dispersion of fine particulate matter in central Virginia.

Even small, long-term increments in $PM_{2.5}$—especially when experienced by large populations—are associated with measurable increases in cardiopulmonary disease, hospitalizations, and premature mortality. This is relevant because several counties downwind, including Henrico, Chesterfield, and the Richmond metropolitan area, have substantially larger populations than the immediate vicinity of the plant, resulting in a meaningful cumulative exposure burden.

High-Exposure Census Tracts (Figure 2)

Figure 2 provides a closer view of the Census tracts experiencing the most elevated modeled concentrations (≥ 0.01 μg/m³). These higher-exposure tracts form a band extending from central Fluvanna County into Louisa, Goochland, and Cumberland Counties. The spatial pattern is consistent with expectations for a tall-stack point source: concentrations are highest near the plant, tapering outward with distance but remaining elevated along the primary downwind corridor.

Notably, while Fluvanna County contains the largest concentration increments, several neighboring counties also show clear pockets of elevated exposure, demonstrating that the plant's air-quality impacts would not be confined to the immediate community.

Town-Level Impacts (Figure 3)

Figure 3 illustrates modeled population-weighted $PM_{2.5}$ increments for towns and Census-designated places. The highest exposure levels occur in Palmyra and Lake Monticello, both located in Fluvanna County and in close proximity to the proposed facility. These communities experience the largest projected increments (0.07–0.09 μg/m³), reflecting their location in the core impact zone.

Other nearby towns—including Columbia, Rivanna, Scottsville, Keswick, Goochland, Powhatan, Cumberland, and Louisa—experience additional $PM_{2.5}$ exposure ranging from approximately 0.02 to 0.06 μg/m³. Many of these towns are small to mid-sized population centers situated directly along the eastward dispersion path.

Because several of these communities have moderate to large populations relative to rural tracts closer to the plant, they contribute substantially to the overall regional exposure burden despite experiencing lower increments than the peak areas.

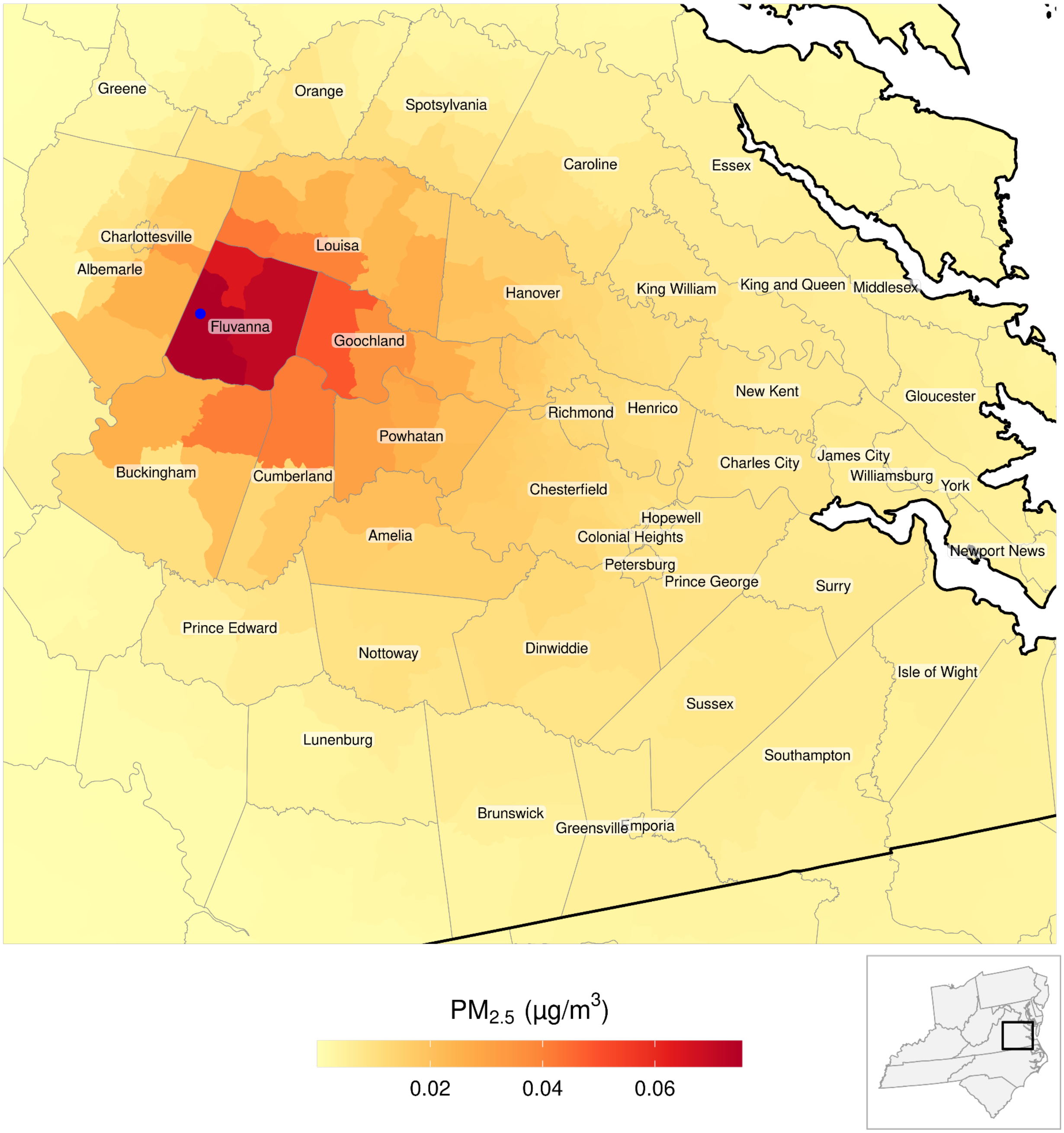

***Figure 1: Estimated census tract-level increase in annual** $PM_{2.5}$ **directly attributable to the proposed Expedition plant.** Colors show the modeled increase in average annual $PM_{2.5}$ (µg/m³), summarized as the population-weighted mean within each Census tract. The blue dot marks the plant site in Fluvanna County, Virginia. County names are shown only where at least one tract has an increment ≥ 0.005 µg/m³; county boundaries are overlaid for reference. The inset at lower right locates the map within the eastern United States and outlines the zoomed extent.*

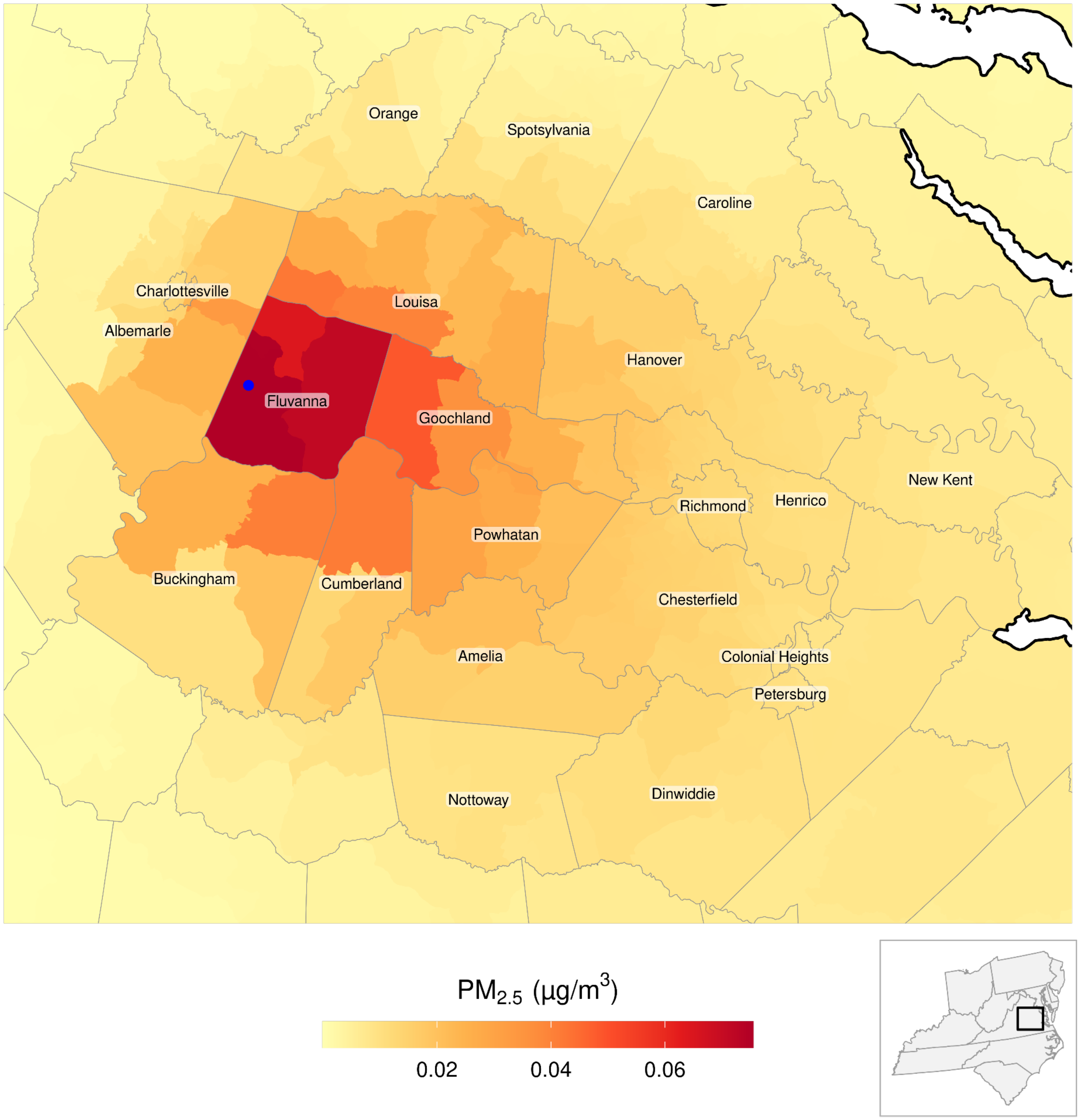

Figure 2: ***Zoomed-In View of High Exposure Census Tracts.*** *Colors show the modeled change in average annual $PM_{2.5}$ (µg/m³), summarized as the population-weighted mean within each Census tract. The blue dot marks the plant site in Fluvanna County, Virginia. County names are shown only where at least one tract has an increment ≥ 0.01 µg/m³; county boundaries are overlaid for reference. The inset at lower right locates the map within the eastern United States and outlines the zoomed extent.*

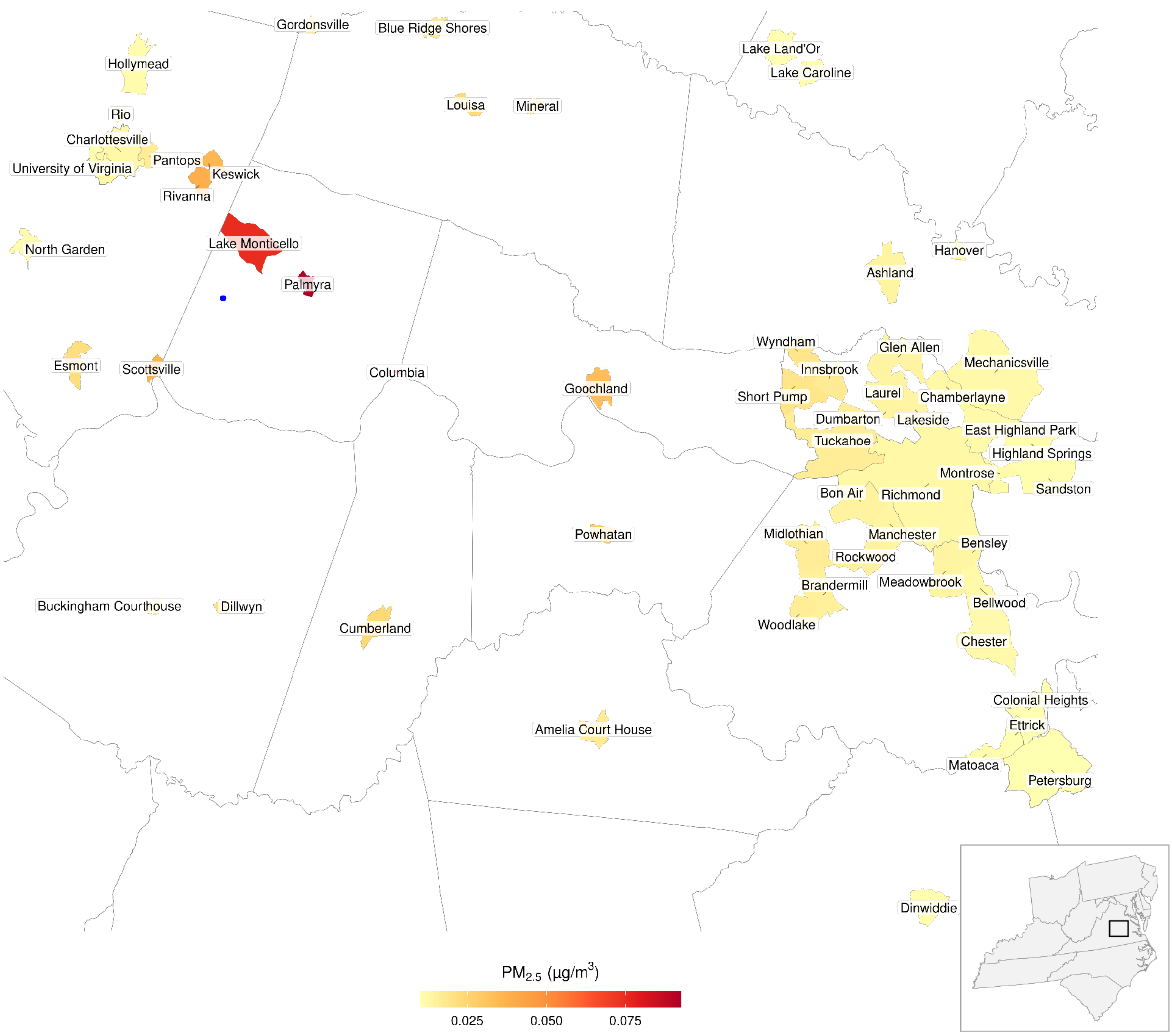

Figure 3: ***Estimated town-level*** **$PM_{2.5}$** ***concentrations from the proposed Expedition facility***. *Map shows modeled increases in average annual $PM_{2.5}$ (µg/m³) for towns identified in the American Community Survey (ACS) as Census-designated places. Values represent the average $PM_{2.5}$ concentration experienced by residents of each town, weighted by population across overlapping model grid cells. Only towns with modeled population-weighted exposure ≥ 0.01 µg/m³ are displayed and labeled. The blue dot marks the location of the proposed Expedition plant in Fluvanna County, Virginia. The inset at lower right shows the regional context within the eastern United States.*

County-level $PM_{2.5}$ concentration and exposure burden

Table 2 ranks counties by the highest average plant-attributable $PM_{2.5}$ concentration. Fluvanna County shows the largest increment (0.071 μg/m³), followed by surrounding rural counties including Louisa, Goochland, Powhatan, Cumberland, Buckingham, and Amelia. These counties are geographically closest to the proposed plant and encompass the central plume corridor identified in Figures 1 and 2.

Table 3 ranks counties by their share of the total exposure burden, defined here as the population-integrated $PM_{2.5}$ exposure (i.e., the product of the modeled concentration increment in each census tract and the number of residents in that tract, summed to the county level). This metric reflects where the largest absolute population exposure to plant-attributable $PM_{2.5}$ occurs across the region, rather than where concentrations are highest. The highest modeled concentration increments occur in smaller rural counties, and the largest share of regional exposure burden is borne by more populous areas, including Chesterfield County (14%), Henrico County (13%), and the City of Richmond (7%). These counties lie downwind of the core impact area and contain several hundred thousand residents, resulting in a substantial cumulative health burden.

Table 2. *Population-weighted average $PM_{2.5}$ concentrations attributable to the proposed Expedition Generating Station, with 2022 American Community Survey population estimates.*[23] *Values represent the modeled increase in annual average $PM_{2.5}$ experienced by residents in each county (μg/m³). Counties are sorted in descending order of exposure.*

County	State	Population	Average plant-attributable $PM_{2.5}$ exposure (μg/m³)
Fluvanna	Virginia	27400	0.07131
Louisa	Virginia	38100	0.02645
Goochland	Virginia	24900	0.02633
Powhatan	Virginia	30500	0.02507
Cumberland	Virginia	9700	0.02339
Buckingham	Virginia	16900	0.02260
Amelia	Virginia	13300	0.01739
Henrico	Virginia	333100	0.01439
Chesterfield	Virginia	366000	0.01429
Hanover	Virginia	110500	0.01403

[23] US Census Bureau, "American Community Survey 5-Year Data (2009-2023)."

Table 3. *County share of the total $PM_{2.5}$ exposure burden attributable to the proposed Expedition Generating Station. Exposure burden is defined as the population-integrated annual-average $PM_{2.5}$ increment (sum over census tracts of tract-average increment × tract population). Average plant-attributable $PM_{2.5}$ exposure reports the county population-weighted mean increment (μg/m³). Values are sorted in descending order of share of total exposure burden across all modeled counties.*

County	State	Population	Share of plant-attributable $PM_{2.5}$ exposure (%)	Average plant-attributable $PM_{2.5}$ exposure (μg/m^3)
Chesterfield	Virginia	366000	14.08	0.01429
Henrico	Virginia	333100	13.15	0.01439
Richmond City	Virginia	227200	7.14	0.01273
Fluvanna	Virginia	27400	5.44	0.07131
Albemarle	Virginia	112500	5.27	0.01346
Hanover	Virginia	110500	4.78	0.01403
Virginia Beach City	Virginia	457900	3.58	0.00308
Goochland	Virginia	24900	2.95	0.02633
Louisa	Virginia	38100	2.66	0.02645

Note: Population estimates are from the 2022 American Community Survey (ACS). $PM_{2.5}$ exposure values reflect modeled annual-average increments.

Town-Level Exposure

Table 4 identifies the towns experiencing the highest modeled increases in population-weighted $PM_{2.5}$ attributable to the proposed Expedition plant. The greatest impacts occur in communities located closest to the facility and along the primary downwind corridor in central Virginia. Palmyra shows the highest modeled increment at 0.092 μg/m³, followed by Lake Monticello at 0.075 μg/m³ and Columbia at 0.062 μg/m³. These towns lie within Fluvanna County, positioning them at the center of the modeled plume.

Additional towns—including Rivanna, Scottsville, Keswick, Goochland, Powhatan, Cumberland, and Louisa—show annual-average $PM_{2.5}$ increases ranging from approximately 0.02 to 0.04 μg/m³. Although these increments are lower than the peak values observed in the towns nearest to the plant site, they still represent non-trivial increases in long-term particulate exposure for thousands of residents. Because several of these communities have moderate population sizes and fall directly within the predominant downwind pathway, they contribute meaningfully to the overall regional exposure burden. These results highlight that while the highest concentration increases occur in the immediate vicinity of the proposed facility, multiple towns across central Virginia would experience clear and measurable increases in $PM_{2.5}$ due to the plant's emissions.

Table 4. *Top towns in the modeled region with the highest population-weighted increases in annual $PM_{2.5}$ attributable to the proposed Expedition plant. Values represent the modeled increment experienced by residents of each town (μg/m³).*

Town	State	Population	$PM_{2.5}$ (μg/m³)
Palmyra	VA	125	0.0925
Lake Monticello	VA	10,834	0.0751
Columbia	VA	40	0.0621
Rivanna	VA	2,088	0.0390
Scottsville	VA	571	0.0370
Keswick	VA	336	0.0354
Goochland	VA	953	0.0334
Powhatan	VA	473	0.0268
Cumberland	VA	334	0.0237
Louisa	VA	2,173	0.0235

Note: Population estimates are from the 2022 American Community Survey (ACS)

Socio-economic impact analysis findings

Table 5 summarizes demographic and socioeconomic characteristics of residents living in census tracts exposed to modeled increases in $PM_{2.5}$. An estimated 4.07 million people live in tracts with increments above 0.001 μg/m³, and about 1.4 million live in tracts where the modeled increase exceeds 0.01 μg/m³. Across these exposure groups, Black residents make up 26.6–27.4% of the population, compared with 18.9% in Virginia and 12.5% nationally. The percentage of Hispanic and Asian residents in the exposed tracts is lower than the national average, and the percentage of White residents is slightly below the national average but similar to the statewide value.

Unless otherwise noted, demographic and socioeconomic indicators are derived from the 2022 American Community Survey (ACS) at the census-tract level.[24] Median household income in the exposed tracts ($87,100–$90,500) is lower than the Virginia average ($100,600) but higher than the national average. Median property values in the exposed areas ($316,200–$328,000), based on ACS estimates of owner-occupied housing values, fall below the Virginia average ($389,000) and above the U.S. average ($281,900). Because ACS values reflect survey-based estimates rather than contemporaneous market sale prices, they tend to lag recent housing appreciation and are appropriately interpreted as longer-run indicators of neighborhood wealth rather than current listing values.

Social Vulnerability Index (SVI) values are drawn from the CDC/ATSDR SVI dataset, with exposed tracts showing values (39–42) comparable to the statewide average (39.9).[25] Adult asthma prevalence estimates are obtained from CDC sources, with prevalence in the exposed areas (10.5–10.6%) similar to both statewide and national values (10.1% and 10.5%, respectively).[26]

[24] US Census Bureau, "American Community Survey 5-Year Data (2009-2023)."
[25] CDC, "Social Vulnerability Index," Place and Health - Geospatial Research, Analysis, and Services Program (GRASP), October 22, 2024, https://www.atsdr.cdc.gov/place-health/php/svi/index.html.
[26] CDC, "Health Outcomes."

Table 5. *Demographic and socioeconomic indicators for populations exposed to additional plant-attributable $PM_{2.5}$ by exposure threshold. Thresholds denote modeled annual-average $PM_{2.5}$ increments (in μg/m³). Values reflect population-weighted tract averages.*

Metric	>0.001 μg/m³	>0.01 μg/m³	Virginia	National
Total Population Affected	4,067,300	1,400,600	8,624,500	331,097,600
Poverty Rate (%)	10.7	10.3	10.2	12.5
White (%)	59.4	60.6	63.5	65.9
Black (%)	27.4	26.6	18.9	12.5
Hispanic (%)	7.4	6.7	10.0	18.7
Asian (%)	3.7	4.3	6.9	5.8
Age 65+ (%)	16.2	16.6	16.0	16.5
Median Household Income ($)	$87,100	$90,500	100,600	$75,100
Median Property Value ($)	$316,200	$328,000	389,000	$281,900
SVI* (0-100)	41.9	39.2	39.9	*
Adult Asthma Prevalence (%)	10.6	10.5	10.1	10.5

**SVI (Social Vulnerability Index) is a CDC/ATSDR metric ranging from 0–100 that reflects community vulnerability based on socioeconomic conditions, household characteristics, minority status, and housing and transportation factors.*[27]

Health related economic impacts from proposed gas plant

To estimate the health costs associated with increased pollution from the proposed Expedition facility, we used the U.S. EPA's Co-Benefits Risk Assessment (COBRA) model.[28] COBRA is a nationally recognized public-health assessment tool that links changes in air pollution to health outcomes using peer-reviewed, epidemiologically derived concentration–response functions.

[27] CDC, "Social Vulnerability Index."
[28] US Environmental Protection Agency, "CO-Benefits Risk Assessment (COBRA) Web Edition."

The model takes user-specified emissions for the source county and applies its own dispersion modeling and health-impact calculations to estimate resulting cases of illness, premature mortality, and associated monetary damages.

We ran COBRA using annual emissions consistent with the data-driven estimates derived for the proposed gas generating unit in Fluvanna County, Virginia. Based on the plant's expected operation and the emission factors drawn from the Greensville reference facility, the Expedition facility is estimated to emit approximately 153.3 tons of primary $PM_{2.5}$, 153.1 tons of nitrogen oxides (NO_x), 18.6 tons of sulfur dioxide (SO_2), and 79.9 tons of volatile organic compounds (VOCs) per year. Ammonia emissions are also expected to be substantial—about 88.3 tons annually—but because COBRA does not accept ammonia as an input pollutant, these emissions are not directly included. Their contribution to secondary $PM_{2.5}$ formation is instead represented implicitly through COBRA's internal atmospheric chemistry.

Using these emissions inputs, the COBRA model projects $27–50 million in additional health-related damages per year, with the range reflecting alternative assumptions about the strength of the relationship between long-term $PM_{2.5}$ exposure and premature mortality. These damages reflect the monetized value of increased premature mortality, illness, hospitalizations, emergency-room visits, asthma attacks, restricted activity days, and lost workdays attributable to the plant's emissions. The "low" estimate corresponds to a more conservative mortality concentration–response function, while the "high" estimate reflects a stronger estimated mortality response supported by the epidemiological literature. All reported values represent annual impacts and are expressed in 2023 dollars, consistent with COBRA's valuation framework.

COBRA estimates 1.7 to 3.3 additional premature deaths per year, which account for most of the total damages. Monetized mortality impacts range from $25 million to $48 million annually, depending on the concentration–response function used. Additional $PM_{2.5}$-related health outcomes—including nonfatal heart attacks, respiratory and cardiovascular hospital admissions, asthma symptoms, stroke, and minor restricted activity days—contribute another $2–5 million per year.

COBRA also estimates damages associated with ozone (O_3) formation from NO_x emissions, including asthma-related emergency-room visits, school-loss days, and additional mortality. These ozone-related impacts total approximately $6.5 million per year and are already incorporated into the overall $27–50 million estimate. COBRA's pollutant-specific breakdown indicates that $PM_{2.5}$ accounts for $20–43 million of total damages, with the remainder driven by O_3 exposures.

These annual estimates provide the basis for evaluating longer-term cumulative impacts. Consistent with EPA regulatory practice, we report annual health damages as the primary outcome and provide cumulative and discounted lifetime estimates for context. Assuming a 30-year operating life consistent with EPA analyses for combined-cycle gas facilities, annual damages of $27–50 million correspond to an undiscounted cumulative total of approximately

$800 million–1.5 billion, or a discounted present value of roughly $500 million–1.0 billion using a 3% social discount rate.

Conclusions

This analysis provides an initial, data-driven estimate of the health and economic impacts associated with increased fine particulate pollution from the proposed Expedition Generating Station in Fluvanna County, Virginia. $PM_{2.55}$ is among the most harmful air pollutants, associated with elevated risks of heart disease, stroke, asthma, respiratory illness, hospital admissions, lost productivity, and premature death. These health burdens impose substantial and measurable economic costs in affected communities.

Modeling results indicate that emissions from the proposed plant would measurably increase $PM_{2.5}$ concentrations across Fluvanna, Louisa, Goochland, Buckingham, Powhatan, and surrounding counties, with the highest concentration increments in the census tracts nearest the facility. Because these downwind areas include both rural communities and larger population centers near Richmond, the overall population exposure extends well beyond the immediate vicinity of the site.

Using EPA-standard methods, the COBRA model estimates that the plant's emissions could impose $27–50 million in annual health-related damages, driven primarily by increased mortality risk but also including additional asthma attacks, hospital visits, emergency-room encounters, and lost work and school days. Sustained over a typical 30-year operating life, these annual impacts correspond to roughly $500 million–1.0 billion in cumulative public-health costs in present-value terms, underscoring the long-term health implications of the proposed facility.

Importantly, this analysis relies on data driven assumptions regarding plant operation, emissions controls, and atmospheric dispersion. Limited public information about the plant's final design, fuel use patterns, and expected annual utilization introduces uncertainty. If the facility operates at higher-than-assumed output, or if emissions controls perform below expectations, the resulting health burden could be substantially greater.

Given these uncertainties—and given that the modeled impacts already reflect tens of millions of dollars in annual health damages—the findings presented here should be interpreted as a lower bound on the potential burden the proposed Expedition plant may place on surrounding Virginia communities.

Appendix

Appendix 1. EPA COBRA Health Impact Results for the Proposed Expedition Gas Plant

These results reflect the EPA COBRA model applied to the proposed Expedition natural-gas electricity-generating unit in Fluvanna County, Virginia. The analysis incorporates annual emissions estimated from data-driven emission factors: 153.3 tons of primary $PM_{2.5}$, 153.1 tons of nitrogen oxides (NO_x), 18.6 tons of sulfur dioxide (SO_2), and 79.9 tons of volatile organic compounds (VOCs).

Note:

- *Negative values for change in incidence and monetary costs indicate added mortality, illness, and economic damages resulting from the plant's emissions (i.e., negative "health benefits").*
- *"High" and "Low" values reflect differences in underlying epidemiological concentration–response functions used in COBRA. For example, mortality impacts vary depending on which peer-reviewed study is applied.*
- *All monetary values are converted to 2023 dollars and rounded to two significant figures, consistent with COBRA output.*

Health Endpoint	Pollutant	Change in Incidence (annual cases)	Monetary Value (annual dollars)
Mortality (All Cause)	$PM_{2.5}$ | O_3	–1.70 to –3.30	–$25,000,000 to –$48,000,000
Nonfatal Heart Attacks	$PM_{2.5}$	–0.92	–$77,000
Infant Mortality	$PM_{2.5}$	–0.011	–$180,000
Hospital Admissions, All Respiratory	$PM_{2.5}$ | O_3	–0.18	–$4,700
Emergency Room Visits, Respiratory	$PM_{2.5}$ | O_3	–2.30	–$3,800
Asthma Onset	$PM_{2.5}$ | O_3	–6.30	–$480,000
Asthma Symptoms	$PM_{2.5}$ | O_3	–1,100	–$160,000

Emergency Room Visits, Asthma	O_3	–0.007	–$5.8
Lung Cancer Incidence	$PM_{2.5}$	–0.10	–$4,500
Hospital Admissions, Cardio-/Cerebrovascular Disease	$PM_{2.5}$	–0.19	–$5,600
Hospital Admissions, Alzheimer's	$PM_{2.5}$	–0.53	–$12,000
Hospital Admissions, Parkinson's	$PM_{2.5}$	–0.089	–$2,100
Stroke Incidence	$PM_{2.5}$	–0.085	–$5,400
Hay Fever/Rhinitis Incidence	$PM_{2.5}$ | O_3	–41	–$45,000
Cardiac Arrest, Out of Hospital	$PM_{2.5}$	–0.021	–$1,300
Emergency Room Visits, All Cardiac	$PM_{2.5}$	–0.47	–$1,000
Minor Restricted Activity Days	$PM_{2.5}$	–1,100	–$140,000
School Loss Days	O_3	–260	–$450,000
Work Loss Days	$PM_{2.5}$	–190	–$59,000
Total Health Effects from $PM_{2.5}$	—	—	**-$20,000,000 to -$43,000,000**
Total Health Effects from O_3	—	—	**-$6,500,000**
Total Combined Health Effects	—	—	**-$27,000,000 to -$50,000,000**

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