Trenton
AIR QUALITY & HEALTH STUDY

The Delaware Valley Regional Planning Commission is the federally designated Metropolitan Planning Organization for the Greater Philadelphia region, established by an Interstate Compact between the Commonwealth of Pennsylvania and the State of New Jersey. Members include Bucks, Chester, Delaware, Montgomery, and Philadelphia counties, plus the City of Chester, in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties, plus the cities of Camden and Trenton, in New Jersey.

DVRPC serves strictly as an advisory agency. Any planning or design concepts as prepared by DVRPC are conceptual and may require engineering design and feasibility analysis. Actual authority for carrying out any planning proposals rest solely with the governing bodies of the states, local governments or authorities that have the primary responsibility to own, manage or maintain any transportation facility.

DVRPC's vision for the Greater Philadelphia Region is a prosperous, innovative, equitable, resilient, and sustainable region that increases mobility choices by investing in a safe and modern transportation system; that protects and preserves our natural resources while creating healthy communities; and that fosters greater opportunities for all.

DVRPC's mission is to achieve this vision by convening the widest array of partners to inform and facilitate data-driven decision-making. We are engaged across the region, and strive to be leaders and innovators, exploring new ideas and creating best practices.

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Introduction

Project Background

Air quality has a major effect on human health. Everyone breathes in air, giving any airborne pollutants a direct pathway to the lungs from which they can then enter the bloodstream and affect other parts of the body, such as the heart and kidneys.[1,2] Numerous scientific studies have linked ozone and particle pollution to chronic respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD), lung cancer, cardiovascular disease, kidney disease, premature birth, and even premature death.[3] Depending on the specific pollutant, air toxics can lead to increased risks of cancer; neurological; reproductive and immune system damage; respiratory irritation; and developmental problems.[4] Additionally, certain populations, including children, the elderly, and people who work outdoors, are particularly vulnerable to the effects of air pollution.[5]

On January 28, 2021, the City of Trenton Planning Board voted to adopt the *Trenton Community Health and Wellness Plan* (the Plan) as an element of the Trenton250 Master Plan. The Plan provides a policy framework and action agenda to improve community health and wellness across four goal areas: healthy foods and nutrition, physical activity, access to healthcare and health literacy, and healthy housing. The Plan addresses air quality issues indirectly in the healthy housing section by recommending actions

to improve the quality and safety of the city's housing stock. It also notes that future updates should include actions to address asthma and other respiratory illnesses.

The recommendation for future research prompted City of Trenton Planning Department staff to ask the Delaware Valley Regional Planning Commission (DVRPC) to help the city identify sources of air pollution that may negatively affect the respiratory health of Trenton residents and assist in the development of mitigation efforts to reduce these sources of pollutants. DVRPC staff worked with the city to convene a group of community, governmental, and academic stakeholders; analyzed existing health, air quality, and transportation data to quantify incidences of respiratory disease and identify sources of pollution that may be contributing to poor respiratory health outcomes; and recommended actions stakeholders could undertake to mitigate the negative health impacts of pollutants. Given the lack of neighborhood-level air quality data, DVRPC staff also worked with the city to convene an air monitoring subcommittee, recruit academic and community partners, identify monitoring locations, and develop a monitoring plan. The following memo details the study process and initial findings.

Planning Process

DVRPC staff worked with staff from the Trenton Planning Division to convene an advisory committee to help guide the development of the study. Approximately 20 individuals representing 12 different organizations—including local, county, and state government; community-based organizations; and higher-education institutions—participated. The advisory committee met twice in 2021 to kick off the project, identify data sources, and discuss existing conditions, which are detailed on page 3. DVRPC staff reconvened the advisory committee two times in 2022 to update the full group on the status of the air monitoring study and discuss further recommendations for mitigating the health impacts of poor air quality.

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[1] Kate Kelland, "How Air Pollution Gets Into the Bloodstream and Damages the Heart," Huffpost, April 26, 2017, www.huffpost.com/entry/how-air-pollution-gets-into-the-bloodstream-and-damages-the-heart_n_5900c845e4b0026db1dd7227.

[2] Nicholas Bakalar, "Air Pollution Tied to Kidney Disease," *New York Times*, September 21, 2017, www.nytimes.com/2017/09/21/well/live/air-pollution-tied-to-kidney-disease.html?mcubz=3.

[3] "State of the Air 2022: Health Impact of Air Pollution," American Lung Association, accessed May 2022, www.lung.org/research/sota/health-risks.

[4] "Health and Environmental Effects of hazardous Air Pollutants," U.S. Environmental Protection Agency, February 3, 2020, www.epa.gov/haps/health-and-environmental-effects-hazardous-air-pollutants.

[5] "State of the Air 2022."

Upon an initial review of available demographic, air quality, and health data, members of the advisory committee expressed a desire to form an air monitoring subcommittee to learn more about the New Jersey Department of Environmental Protection's (NJDEP's) air monitoring program and explore the possibility of implementing a short-term air monitoring project in Trenton.

The air monitoring subcommittee met six times between September 2021 and July 2022 to recruit academic partners; discuss the scope, timeline, and objectives for an air monitoring study; identify locations to deploy low-cost sensors; and finalize data monitoring and analysis roles. More details on the air monitoring study can be found on page 20.

Basin at Stacey Park, Trenton, New Jersey
Source: Shawn Megill Legendre, DVRPC

Existing Conditions

Demographics

Population

According to the 2020 American Community Survey (ACS), approximately 83,387 people live in the City of Trenton.[6] Once a booming manufacturing center, Trenton's population grew rapidly during the first half of the 20th century. At its peak in 1950, Trenton was home to about 129,781 residents. However, like many other American cities, Trenton experienced steep declines during the second half of the 20th century as people and jobs left the city for the surrounding suburbs and rural areas. Although the population decline has slowed, Trenton's current population is at its lowest in over a hundred years. According to the U.S. Census Bureau's Center for Economic Studies, 69,448 people work in Trenton, of whom only 5,985 also live in the city.[7]

Age

Trenton is a relatively young city, with a median age of 35 years. This is five years younger than the state's median age of 40 and almost four years younger than the county's median age of 38.8. Trenton's younger median age is related to the fact that a larger percentage of its residents are children: 26.4 percent of Trenton residents are under 18 compared to 22 percent and 21.3 percent of state and county residents, respectively. As shown in Figure 1, some Trenton

Figure 1: Median Age by Census Tract, 2020

neighborhoods have especially high rates of young residents. According to the 2020 ACS, 42.6 percent of North 25/Central West/Battle Monument residents and 38 percent of the Franklin Park/Chambersburg residents are under 18.[8]

Understanding where higher percentages of children and older adults live is important because of the connection between age, air quality, and health. For example, asthma, which is exacerbated by poor air quality, is the most common chronic disease in children. Of New Jersey children, 8.7 percent are estimated to currently have asthma.[9] Additionally, numerous studies have shown that long-term exposure to air pollution can pose a health hazard for elderly adults. A study from the Harvard T.H. Chan School of Public Health found that "long-term exposure to low pollution levels [fine particulate matter (PM$_{2.5}$), nitrogen dioxide, and ozone] was linked with increased risk for pneumonia, heart attack, stroke, and atrial fibrillation."[10]

Race

Approximately half (49 percent) of Trenton residents identify as Black or African American, which is much higher than the percentage of residents who identify as Black both statewide (13.4 percent) and countywide (20.5 percent). 35 percent of Trenton residents identify as White, compared to 65.5 percent

[8] U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP05: ACS Demographic and Housing Estimates," accessed March 17, 2022.

[9] "Mercer County Public Health Profile Report: Asthma Hospitalizations and Emergency Department Visits: Rate for 10,000 Residents, 2020," New Jersey State Health Assessment Data, February 10, 2022, www-doh.state.nj.us/doh-shad/community/highlight/profile/NJASTHMAHOSP.countyAAR/GeoCnty/11.html.

[10] "Even low levels of air pollution can harm hearts, lungs in elderly," Harvard T.H. Chan School of Public Health, accessed May 2022: www.hsph.harvard.edu/news/hsph-in-the-news/even-low-levels-of-air-pollution-can-harm-hearts-lungs-in-elderly.

Figure 2: Race and Ethnicity, 2020
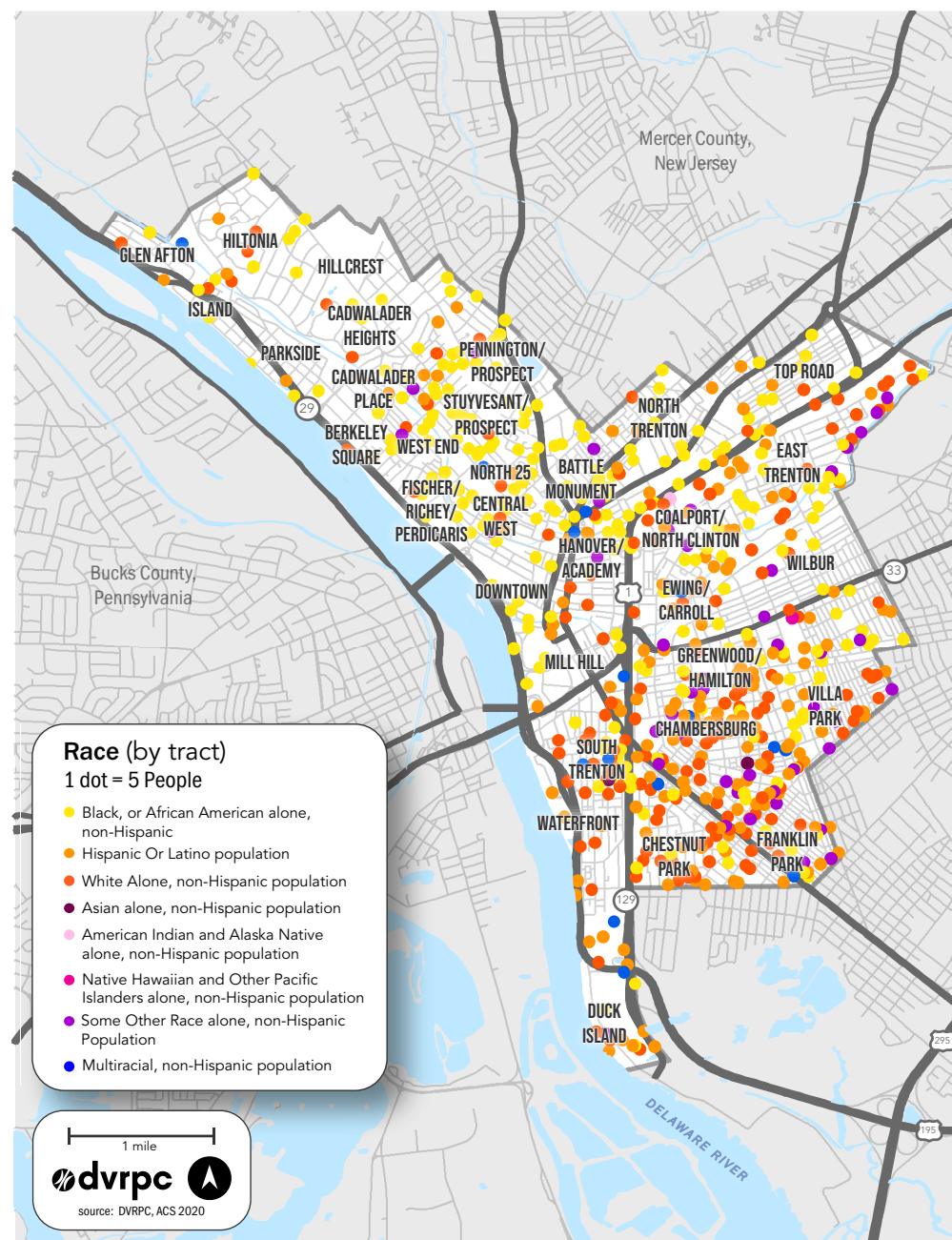
statewide and 59.7 percent countywide. Very few Trenton residents identify as Asian (1 percent), compared to 9.7 percent of state residents and 11.5 percent of county residents.[11] Additionally, the percentage of Trenton residents that identify as Hispanic or Latino (37.2 percent) is higher than both the state- and countywide rates of 20.4 percent and 17.9 percent, respectively.[12]

As shown in Figure 2, many residents who identify as Hispanic or Latino live in the southeastern part of the city, in the Chambersburg, Chestnut Park, Franklin Park, and Villa Park neighborhoods. The northern half of the city has predominantly Black or African American residents.

As with age, certain racial and ethnic groups are more vulnerable to poor health outcomes associated with poor air quality. The Asthma and Allergy Foundation of America's *Asthma Disparities in America* report found that "Black, Hispanic, and Indigenous populations in the United States...have

the highest asthma rates, deaths, and hospitalizations."[13] The report also notes that Black Americans are 1.5 times more likely to have asthma and three times more likely to die from asthma than White Americans.[14] The report states that social determinants (such as income, education, and the built environment) and structural inequities (such as systemic racism and segregation) are largely responsible for disparities in asthma rates.[15] Other studies have upheld this finding, including one by University of California, Berkeley, researchers that found that "historically redlined census tracts have significantly higher rates of emergency department visits due to asthma, suggesting that this discriminatory practice might be contributing to racial and ethnic asthma health disparities."[16]

Income and Poverty Rate

The median household income for the City of Trenton is $37,002, less than half as much as both the county and state median household incomes ($83,306 and $85,245 respectively). As shown in Figure 3 on page 6, the median household income is even lower in some Trenton neighborhoods, with Mill Hill ($14,409), Pennington/Prospect ($18,825), and North 25/Central West/Battle Monument ($23,547) having the lowest. Conversely, some Trenton neighborhoods have higher median household incomes that are about three-quarters that of the county and state. For example, the median household income in Chestnut Park is $67,485 and $67,188 in Hilltonia/Hillcrest.[17]

The poverty level is a function of both household income and family size. The federal weighted average poverty level for a family of four in 2020 was

[11] U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP05: ACS Demographic and Housing Estimates," accessed May 2022, data.census.gov/cedsci/table?q=Trenton,%20NJ&tid=ACSDP5Y2020.DP05&moe=false.
[12] Ibid.

Chambers Street and East State Street, Trenton, New Jersey
Source: Miles Owen, DVRPC

[13] Asthma and Allergy Foundation, *Asthma Disparities in America: A Roadmap to Reducing Burden on Racial and Ethnic Minorities*, (Asthma and Allergy Foundation of America, 2020), www.aafa.org/asthma-disparities-burden-on-minorities.aspx.
[14] Ibid.
[15] Ibid.
[16] Anthony Nardone et al., "Associations between historical residential redlining and current age-adjusted rates of emergency department visits due to asthma across eight cities in California: an ecological study." *The Lancet Planetary Health* 4, no 1 (2020): e24-e31. doi:10.1016/S2542-5196(19)30241-4.
[17] U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP03: Selected Economic Characteristics," accessed May 2022.

$26,2020. Approximately 27 percent of Trenton residents live below the poverty line, which is almost 2.5 times the county's poverty rate (11 percent). Additionally, almost 37 percent of Trenton youth under 18 live below the poverty line.[18]

As with certain racial and ethnic groups, low socioeconomic status is also associated with greater exposure to and harm from air pollution.[19] Scientists theorize that the disparities are, in part, related to the built environment and discriminatory practices. Sources of pollution, such as industrial facilities and highways, were often located near low-income communities and communities of color.

Health Insurance

Many New Jersey and Trenton residents were able to obtain health insurance in 2014 with the implementation of the Affordable Care Act and the expansion of Medicaid benefits to additional populations. However, despite the higher rates of insured residents, 15 percent of Trenton residents are uninsured—a rate two times greater than that of the state. Some Trenton neighborhoods have rates of uninsured individuals as high as 29.8 percent.[20] As shown in Figure 4, the tracts with the highest rates of uninsured residents tend to be in the southeastern portion of the city, where the rates of foreign-born individuals are also high.[21] Citywide, the percentage of uninsured, foreign-born residents is over 35 percent.

[18] Ibid.

[19] "Disparities in the Impact of Air Pollution," American Lung Association, April 20, 2020, www.lung.org/clean-air/outdoors/who-is-at-risk/disparities.

[20] U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP03: Selected Economic Characteristics," accessed May 2022.

[21] U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP02: Selected Social Characteristics in the United States," accessed May 2022.

Figure 3: Median Household Income by Census Tract, 2020

Median Household Income (by tract)
- $1 to 25,000
- $25,001 to 35,000
- $35,001 to 45,000
- $45,001 to 55,000
- $55,001 to 68,000

source: DVRPC, ACS 2020
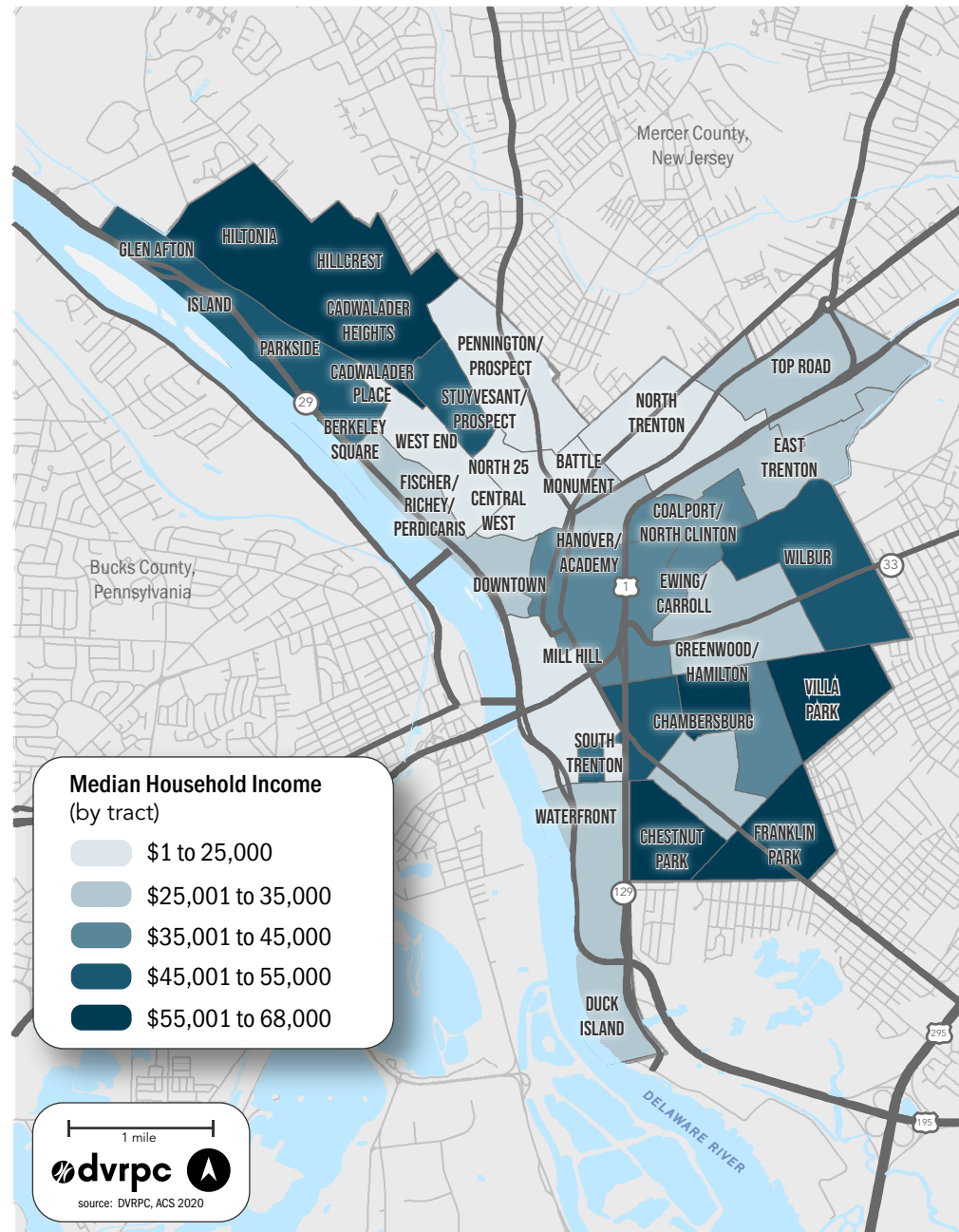
Figure 4: Percentage of Residents without Health Insurance by Census Tract, 2020

No Health Insurance (by tract)

- Less than 0.6%
- 0.6 to 2.33%
- 2.34 to 3.33%
- 3.34 to 5.91%
- More than 5.91%

1 mile

dvrpc

source: DVRPC, ACS 2020
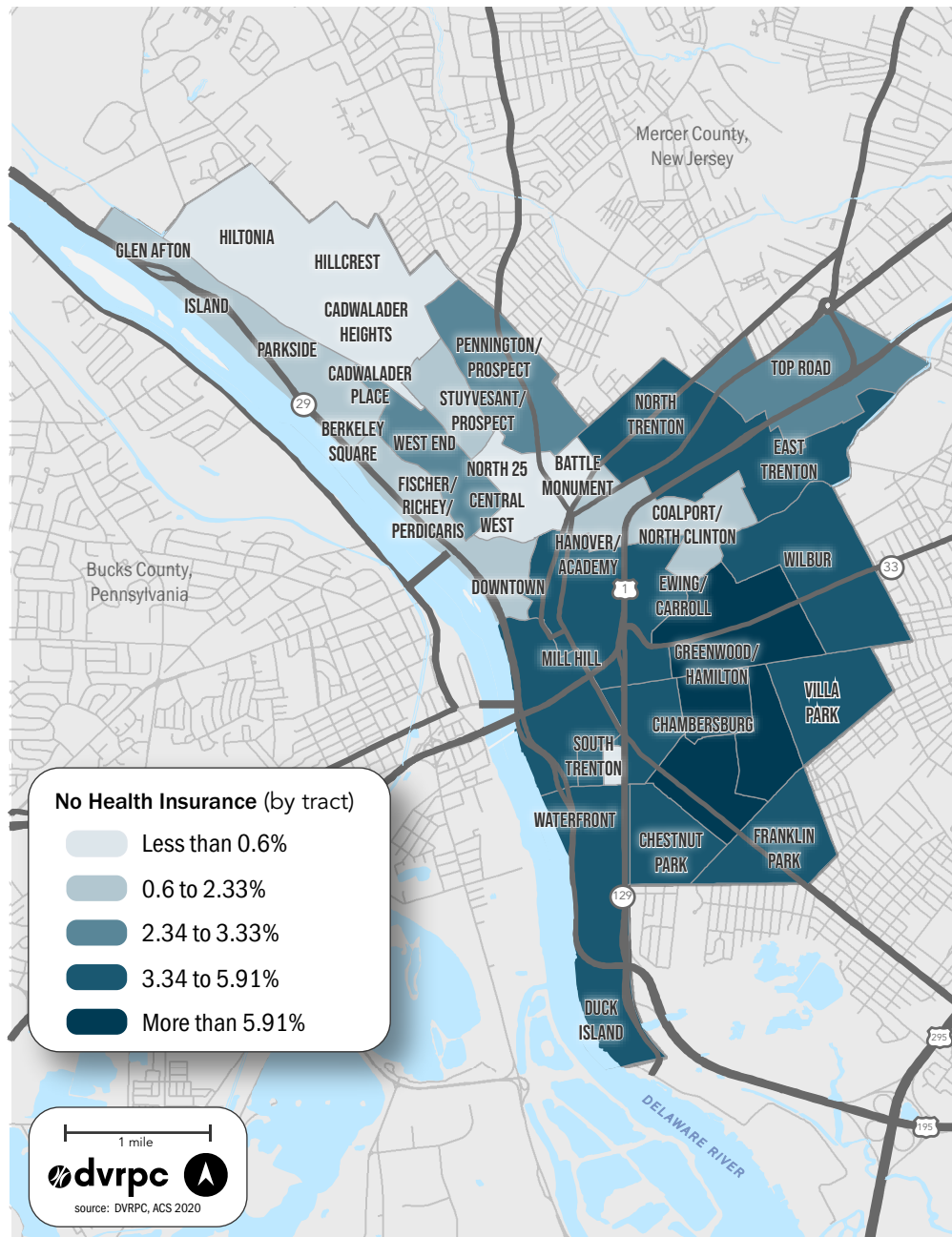
The percentage of uninsured individuals also tends to rise amongst 19 to 64 year-olds. Although this trend can be seen across most geographies, it is particularly stark in Trenton. As shown in Figure 5 on page 8, the percentage of uninsured Trenton residents ages 19 to 25 and 26 to 34 years is two and three times the rate of uninsured residents at the state and county levels. Governmental programs, including the Children's Health Insurance Program and Medicare, provide free or low-cost health insurance for children and older adults, respectively; however, there are fewer supplemental health insurance programs for able-bodied, working-age adults. Working-age adults tend to obtain health insurance through their employer, purchase it through a health insurance marketplace, or receive coverage through government programs like Medicaid (see callout for more information).

NEW JERSEY MEDICAID

To be eligible for New Jersey Medicaid, a person must be:

- a resident of the state of New Jersey;
- a U.S. national, citizen, permanent resident, or legal alien;
- in need of health insurance assistance; and
- have low income or very low income. For example, have an annual household income under $39,900 for a family of four.

They must also be:

- pregnant;
- responsible for a child 17 years or younger; or
- have a disability or a family member in their household with a disability.

Figure 5: Percentage of Residents without Health Insurance by Age, 2020

Legend:
- New Jersey
- Mercer County
- Trenton
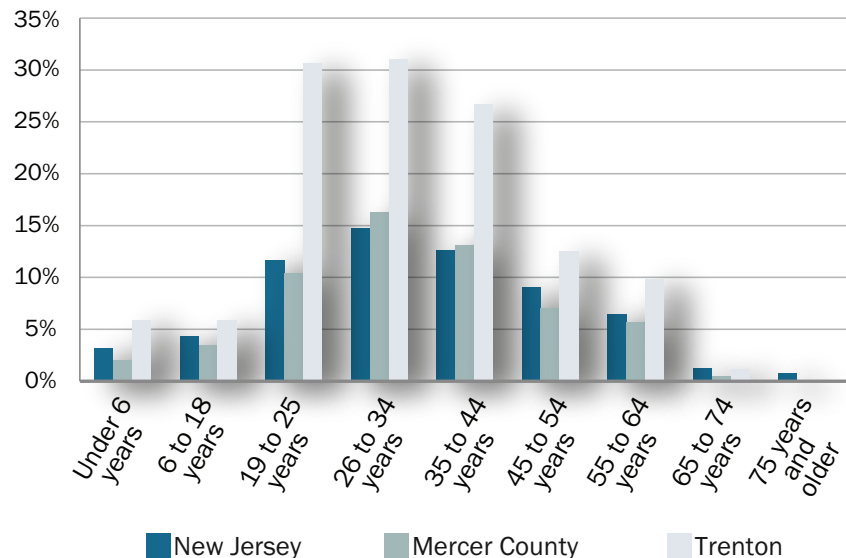
Source: U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates, "DP03: Selected Economic Characteristics."

Unlike other demographic factors, such as race and income, the percentage of uninsured residents has not been connected to poor air quality. However, studies have shown that having health insurance can have a huge positive effect on an individual's health since it allows them to not only receive and pay for acute care when they are ill but also to make use of preventative services like yearly check-ups and screenings to ensure that they stay healthy or catch diseases before they progress too far. In communities with high rates of asthma and other diseases related to poor air quality, having health insurance and access to healthcare are critical.

Trail and Wooded Area along the Assunpink Creek, Trenton, New Jersey
Source: Miles Owen, DVRPC

Built Environment

Location

The City of Trenton is the capital of New Jersey and the county seat of Mercer County. Located along the banks of the Delaware River, Trenton is bordered by Ewing, Lawrence, and Hamilton townships to the north, east, and south, respectively. To the west, across the Delaware River, are the Pennsylvania municipalities of Lower Makefield Township, Morrisville Borough, and Falls Township. The city encompasses an area of approximately 7.65 square miles.[22]

Prevailing Winds

The city's location and surrounding geographic features are important considerations when thinking about air quality. Air quality is not an isolated issue since air moves across the region, and even the country, potentially bringing pollutants with it. This was evident in the summer of 2021, when smoke from wildfires on the West Coast brought hazy skies and dangerous air quality to the East Coast. Although this is an extreme example, winds from surrounding communities regularly blow through the city, affecting the air that Trenton residents breathe. In Trenton, the prevailing winds, which describe the direction that the wind blows most often in a location, change by season. From November to March, the prevailing winds come from the northwest, potentially importing pollutants from Bucks County and the Lehigh Valley. Between April and October, the prevailing winds tend to come from the south and west, carrying pollutants up from the I-95 Corridor. Figure 6 is the Wind Rose from the Trenton Mercer Airport, which shows the historic prevailing winds approaching Trenton, New Jersey, and the percentage of days when the wind blows from that particular direction.

Figure 6: Prevailing Wind Direction at the Trenton Mercer Airport
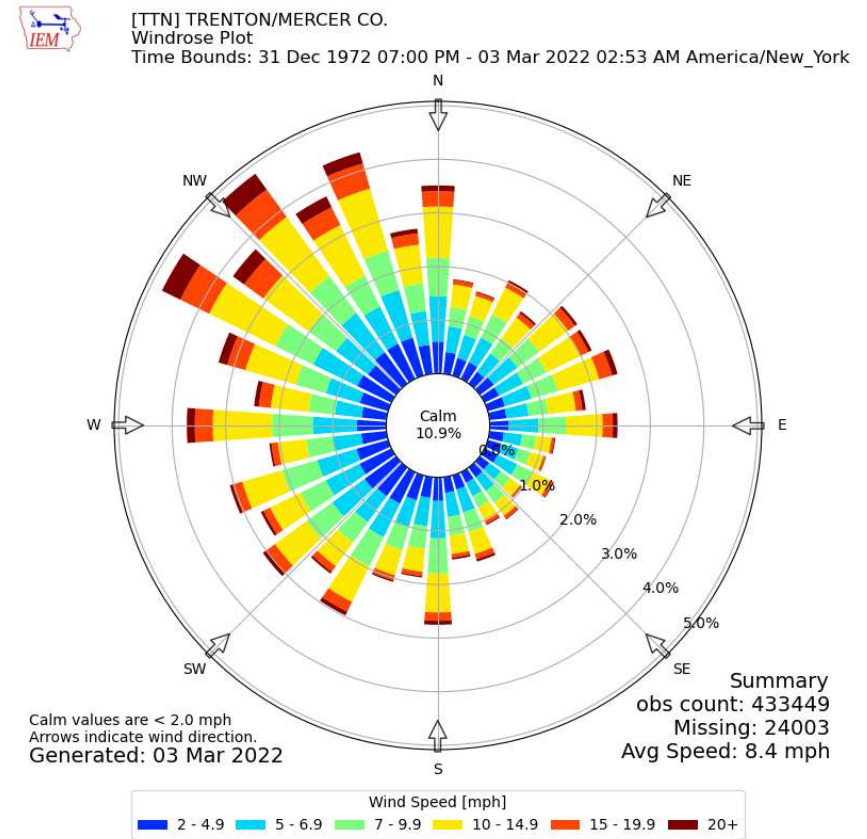
Source: Iowa Environmental Mesonet of Iowa State University, 2022

Transportation

As shown in Figure 7, several major transportation corridors pass through Trenton, including U.S. Route 1 (U.S. 1), State Route 129 (NJ 129), and State Route 29 (NJ 29). Trenton is also home to the Trenton Transportation Center, a major hub for bus and train services with connections to cities along Amtrak's Northeast Corridor and throughout New Jersey via NJ Transit. The Northeast Corridor also serves freight rail through and within the city.

Trenton's road network forms important connections for vehicles traveling between New Jersey and Pennsylvania, and for freight movement making connections between I-295, U.S. 1, and NJ 29, which are all designated as either a Primary Highway Freight System Roadway (I-295 and NJ 29) or an Important Urban Freight Corridor (U.S. 1).

Traffic Congestion

The Travel Time Index (TTI) is a measure of the ratio of the observed time it takes to travel a certain road segment during a congested period compared to a non-congested or free-flow traffic condition. Essentially, the TTI is an indicator of traffic congestion. TTI values greater than 1.5 indicate that the road segment is highly congested. Figure 8 on page 11 is a map of the TTI for roadways in the City of Trenton and identifies the highly congested roadway segments.

The location of major roadways, especially roadways with higher traffic volumes, traffic congestion, and truck counts, are important for better understanding air quality and health concerns in the city since pollutants emitted from cars and trucks are often found in higher concentrations near major roadways. The U.S. Environmental Protection Agency (EPA) notes that vehicles directly emit hundreds of chemicals into the air, including particulate matter (PM), carbon monoxide

Figure 7: Transportation Infrastructure in Trenton, 2021
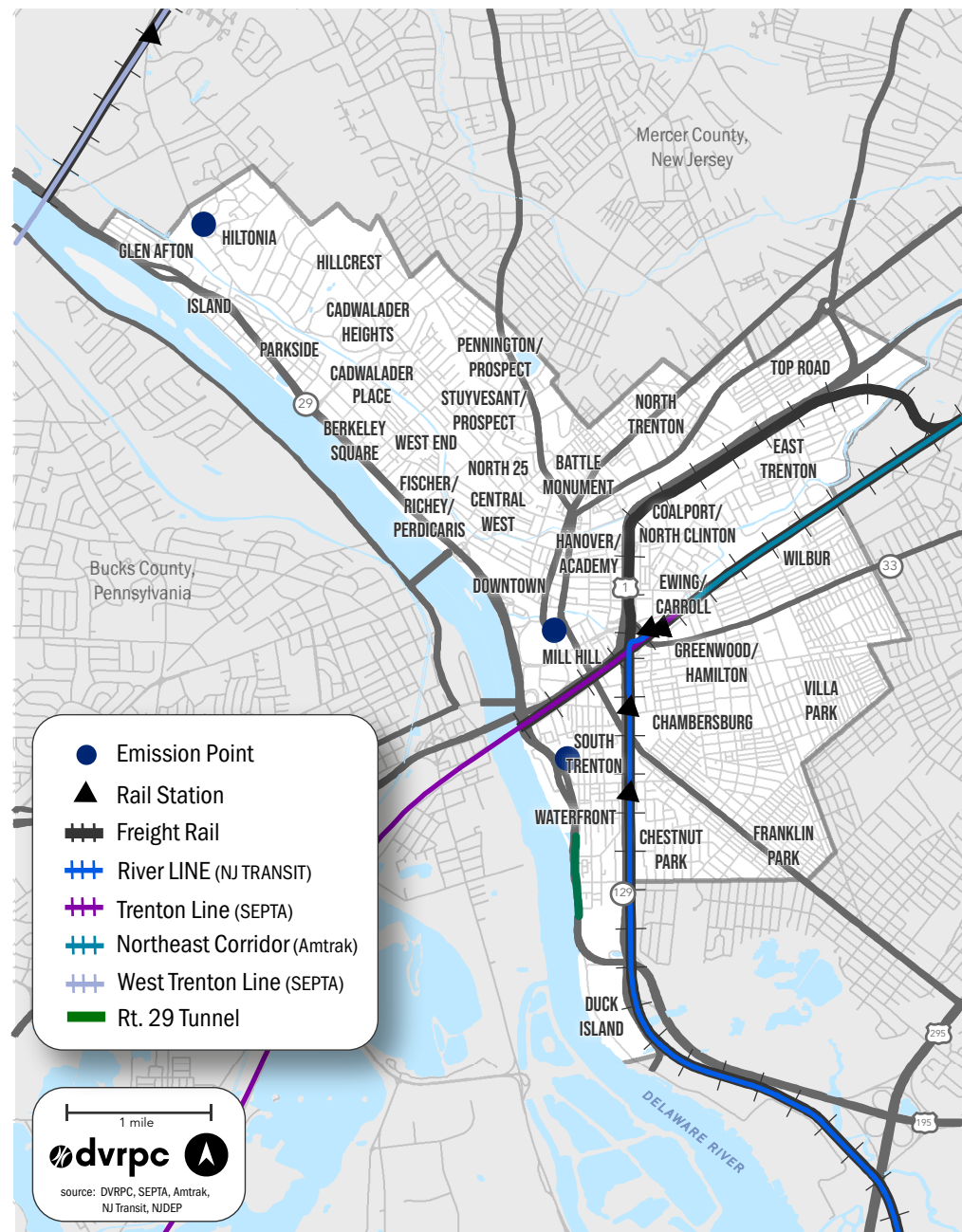
(CO), oxides of nitrogen (NOx), and benzene. Cars and trucks also emit compounds that form other dangerous pollutants like nitrogen dioxide (NO_2) and ozone (O_3).[23] Data from the 2017 National Emissions Inventory indicates that over 45 percent of ozone-forming NOx and almost 11 percent of $PM_{2.5}$ emissions in Mercer County are attributed to on-road mobile sources. These percentages are higher than both the state of New Jersey as a whole and the national values.[24] Medium- and heavy-duty trucks are known to emit higher levels of air pollution than passenger vehicles. As noted above, these pollutants are associated with many adverse health outcomes like higher rates of asthma, cardiovascular disease, preterm and low-birthweight infants, and premature death.[25]

Traffic Volumes

While Figure 8 is a map of the TTI, it gives a good indication of the roadways in the city with the highest vehicle volumes. Traffic counts conducted by DVRPC and NJDOT support this relationship and show that the roadways with the highest vehicle volumes in the city are U.S. 1 and NJ 29, with more than 20,000 to 30,000 vehicles per day (vpd), and NJ 129, with more than 15,000 vpd. Other streets with high vehicle volumes (greater than 10,000 vpd) include Market Street, Olden Avenue and Chambers Street. More information can be found on the DVRPC traffic count database: www.dvrpc.org/webmaps/TrafficCounts.

[23] Office of Transportation and Air Quality, "Near Roadway Air Pollution and Health: Frequently Asked Questions," U.S. Environmental Protection Agency, August 2014, www.epa.gov/sites/default/files/2015-11/documents/420f14044_0.pdf.

[24] "2017 National Emissions Inventory (NEI) Data," U.S. Environmental Protection Agency, last updated December 27, 2022, www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-data.

[25] Office of Transportation and Air Quality, "Near Roadway Air Pollution and Health."

Figure 8: Travel Time Index (TTI), 2017

Travel Time Index
(5:00 to 6:00 PM)

- Less than 1.0
- 1.0 to 1.2
- 1.3 to 1.5
- Greater than 1.5

1 mile

source: DVRPC, INRIX 2017
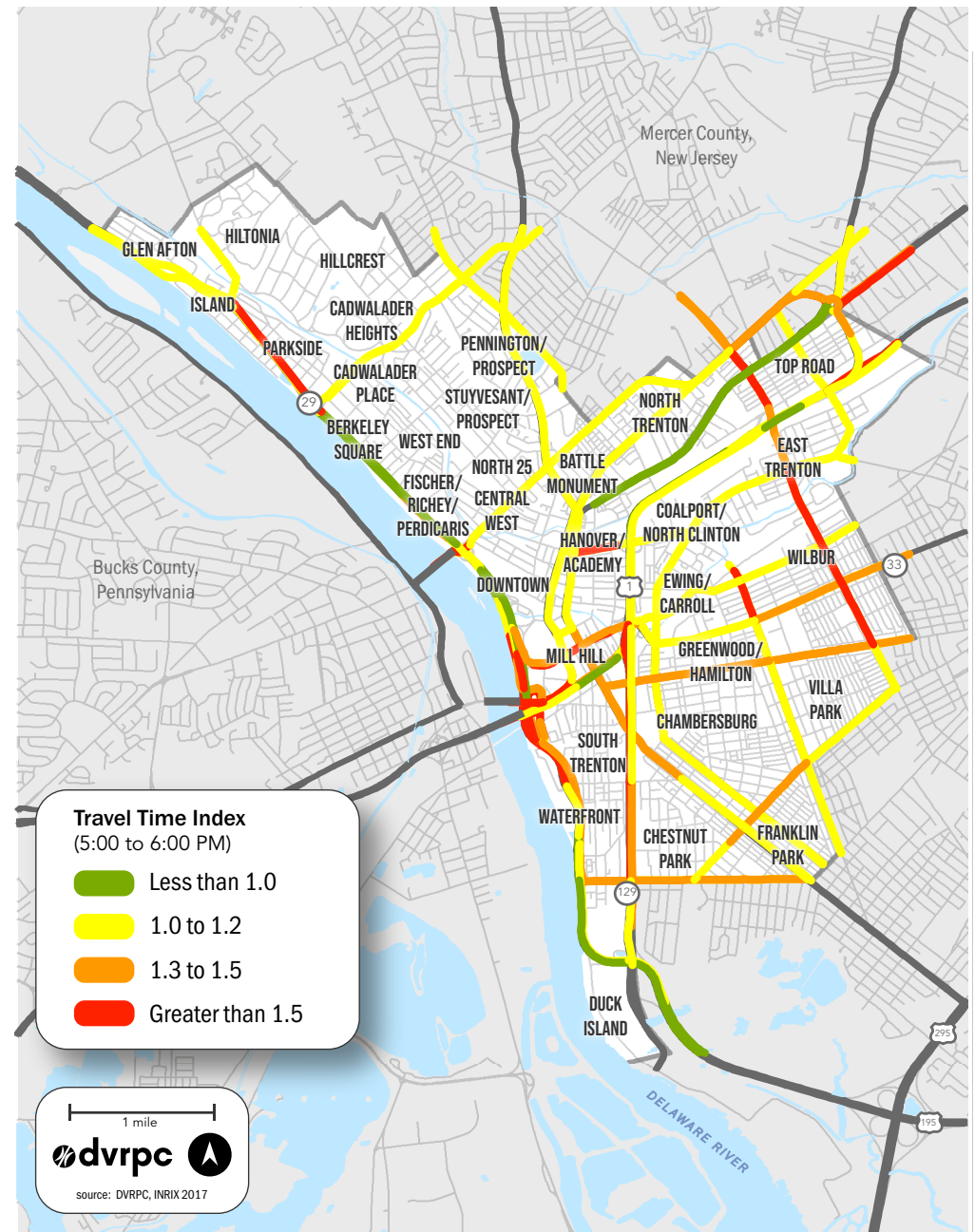
Figure 9: Average Daily Truck Counts, 2021

Daily Truck Counts

- Less than 200
- 201 to 300
- 301 to 400
- 401 to 500
- Greater than 500

1 mile

source: DVRPC 2021, NJDOT 2021
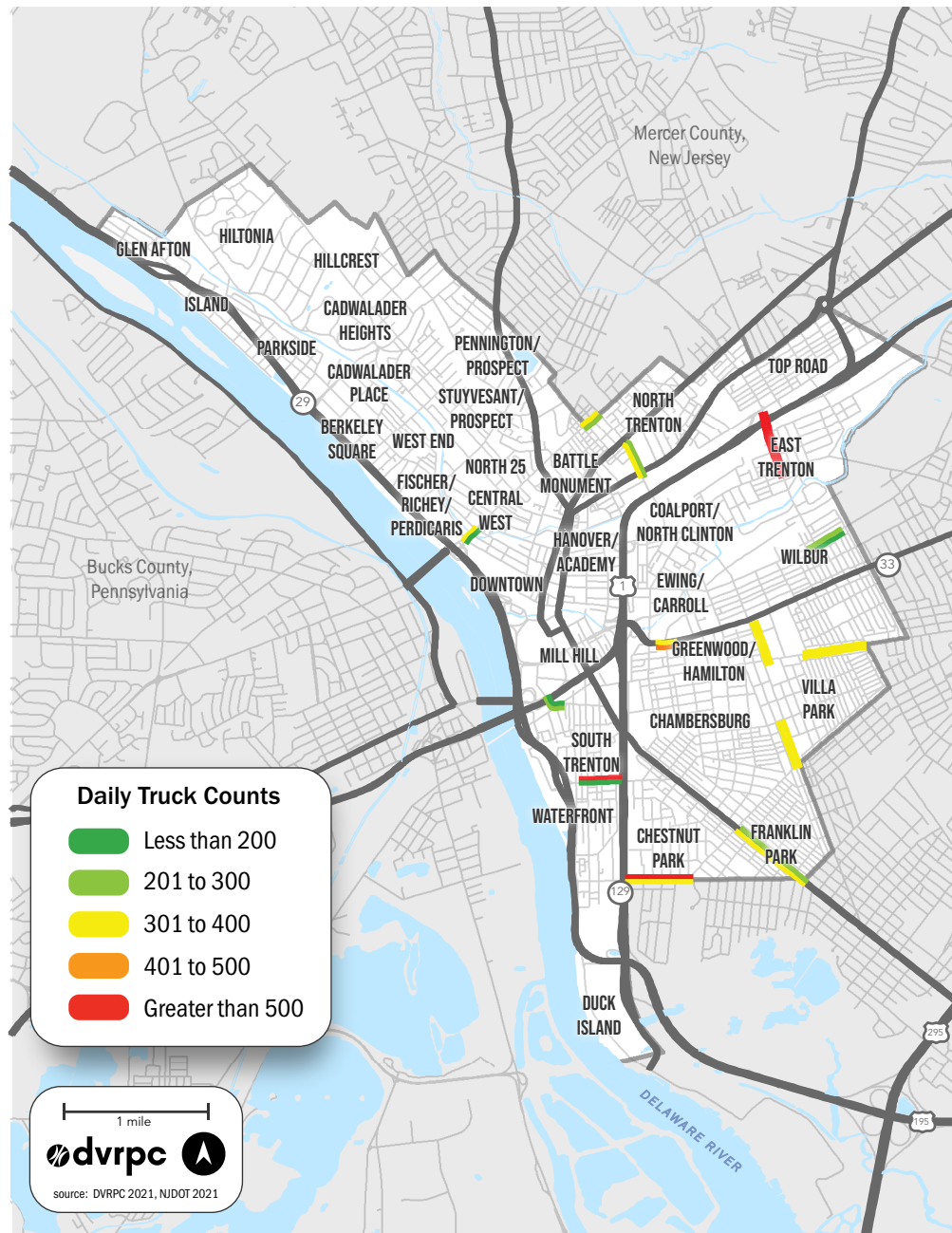
Truck Counts

A significant portion of the heavy-duty trucks in Trenton are traveling on local roads to make connections between the designated freight routes noted above. As shown in Figure 9, there is a high volume of truck traffic that passes through Trenton, often on smaller, local roads. High trucks counts are notable in the south and eastern portions of the city, with certain locations like Cass Street Westbound and Lalor Street Westbound seeing over 700 and 500 heavy-duty (Federal Highway Administration Class 5 or greater) trucks per day, respectively. Cass Street is a two-lane road with primarily residential uses and the New Jersey State Prison along it. Lalor Street transitions from a four-lane road to a two-lane road with residential and commercial uses.

Truck traffic is also very high on both the north- and southbound sides of North Olden Avenue, with over 500 trucks going in each direction per day. This section of North Olden is a two-lane road fronted by a mix of residential, industrial, and commercial uses. Cass and Lalor streets and Olden Avenue are all classified as minor arterials, and these levels of truck volumes are significant for roadways of that classification.

The higher truck counts on Cass and Lalor streets are likely due to the fact that vehicles over 13 tons are banned from NJ 29 between the NJ 129 interchange and just north of the Route 29 Tunnel. Any vehicles carrying hazardous materials or propane tanks are also prohibited from entering the tunnel. These restrictions force these vehicles onto local streets to avoid that section of NJ 29. Additionally, many trucks use Cass and Lalor streets to connect to NJ 129 and U.S. 206, which also provide connections to U.S. 1 and I-295.

Preliminary truck route analysis using data from the INRIX travel database shows that trucks are taking U.S. 1, NJ 29 and NJ 129, and to a lesser extent U.S. 206, through Trenton to access I-295 and the industrial facilities in southeastern Bucks County, Pennsylvania from points in New Jersey.[26]

The redevelopment of the former U.S. Steel Site, known as the Keystone Trade Center, will add a significant amount of new distribution and logistics space to the Lower Bucks and surrounding area. It will consist of multiple warehouse and distribution facilities totaling fifteen million square feet once all phases are complete. This new industrial and warehousing center is expected to increase heavy-duty truck travel on the roads in Trenton.

DVRPC published a detailed study of truck traffic and movements in June 2019, titled the *City of Trenton Truck Network* (DVRPC Publication Number TM18026). This publication identifies potential areas of conflict between trucks and other travelers on local roads and identifies recommended truck routes in the city. The publication can be downloaded at: www.dvrpc.org/Products/TM18026.

[26] INRIX is a data services company that collects and aggregates anonymous GPS probe data from commercial vehicle fleets and mobile apps as well as cameras and sensors on roadways to characterize travel patterns and conditions on the nation's roadway networks. In 2017, the Federal Highways Administration awarded INRIX a contract to provide state departments of transportation and metropolitan planning organizations across the country with travel time data to help establish highway performance targets and report on progress. Source: Theo Douglas, "Federal Highway Administration Partners With INRIX to Measure, Monitor and Report Health of Road Networks," *Government Technology*, June 7, 2017, www.govtech.com/transportation/federal-highway-administration-partners-with-inrix-to-measure-monitor-report-health-of-road-networks.html

Cass Street between NJ 29 and NJ 129, Trenton, New Jersey
Source: Google Street View, November 2022

Parks, Tree Coverage, and Preserved Open Space

As noted in the *City of Trenton Management Plan for Forests and Trees*, Trenton has 1,403 acres of tree canopy, which accounts for 27 percent of the city's total area (about 6,624 acres). This includes canopy cover over structures, roads, and other impervious surfaces. The city also has 464 acres of protected open space and 7.5 miles of existing trails.[27] As shown in Figure 10, much of the city's tree coverage is concentrated in the Cadwalader Heights, Parkside, and West End neighborhoods, with a few other pockets of wooded areas in parks and cemeteries, and along the Assunpink Creek. The neighborhoods with more tree coverage tend to correspond to the areas with higher median household incomes, higher median age, and lower rates of asthma and strokes.

Numerous studies have shown that parks, trees, and other green spaces can help to mitigate the effects of air pollution. Trees can improve air quality directly by removing pollutants—including NO_2, O_3, and $PM_{2.5}$—from the air. The National Park Service notes that, "Urban forests can remove multiple tons of ozone, gaseous air pollution, and particulate matter each year either through direct uptake of gases or temporarily intercepting airborne particles."[28] Trees also help to reduce the air temperature, which in turn, helps to decrease the amount of ozone pollution. Lowering the ambient air temperature also reduces the need for air conditioners, thereby lowering energy consumption in buildings and reducing pollutant-producing emissions from power sources.

[27] Delaware Valley Regional Planning Commission, *City of Trenton Management Plan for Forests and Trees*, July 2022, www.dvrpc.org/Products/19044.
[28] Urban Ecology Research Learning Alliance, "Eco-Values of the Urban Forest: I-Tree Analysis, Air Pollution Removal by Urban Forests," National Park Service, U.S. Department of the Interior, January 7, 2022, www.nps.gov/articles/000/uerla-trees-air-pollution.htm.

Figure 10: Tree Coverage, 2016

source: DVRPC, University of Vermont
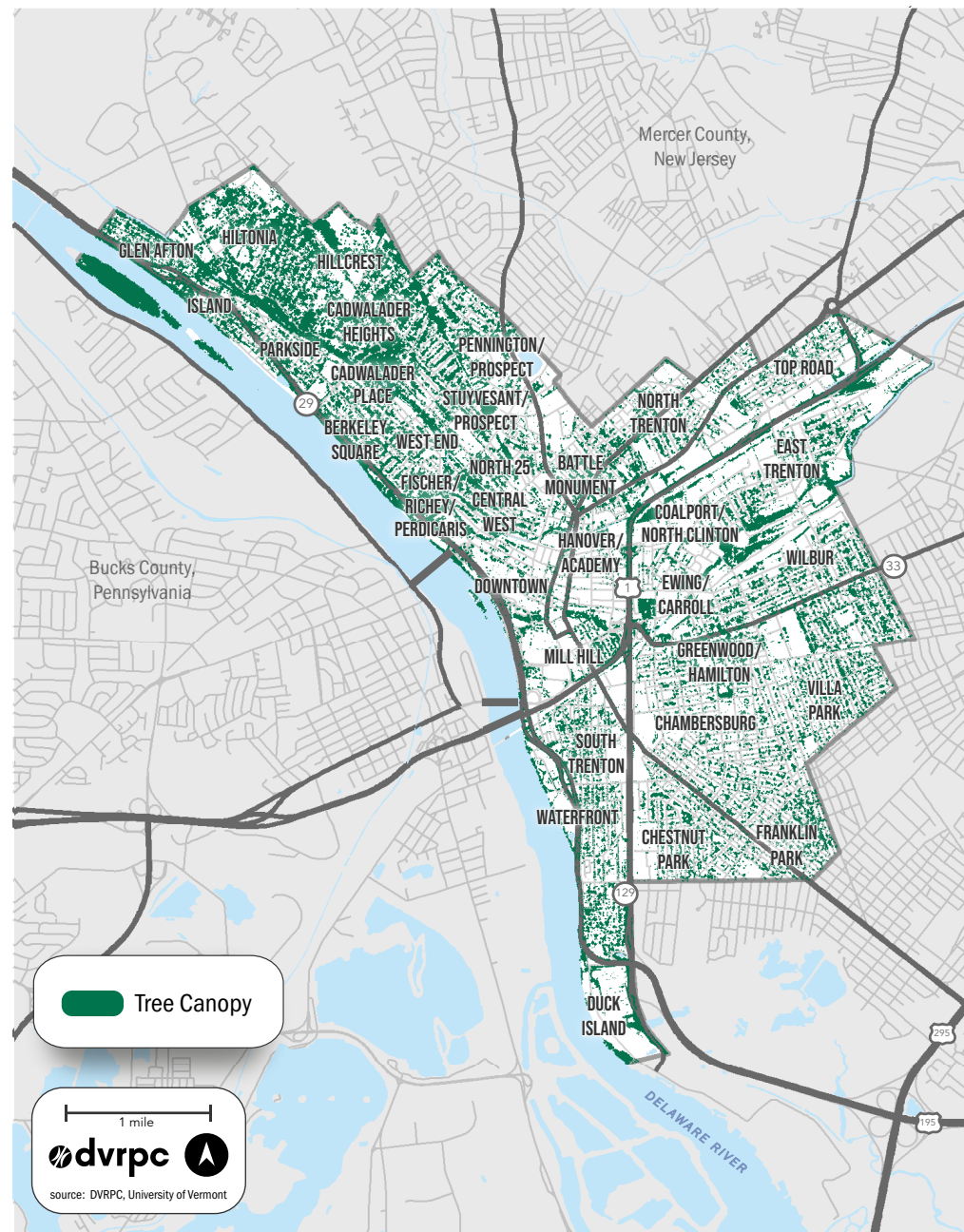
Air Quality

Although we know that poor air quality can be very detrimental to human health, it is one of the most difficult environmental resources to measure because its sources are diffuse and regional in nature. Common sources of air pollution include industry, cars, trucks, buses, fires, and dust. Locally produced sources of air pollution include daily roadway traffic—especially from high-volume roads like US 1 and NJ 29—and industrial facilities, which include local energy-generating plants.

Air quality is regulated by the federal Clean Air Act (CAA), which sets limits on certain air pollutants. Authority to enforce the CAA lies with the EPA, although this authority is delegated to state and local governments like the NJDEP.

The CAA established National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The EPA has set NAAQS for six criteria pollutants: O_3, PM, CO, NOX, sulfur dioxide (SO_2), and lead (Pb). Table 1 briefly describes the sources and human health effects of the six criteria pollutants.

The city of Trenton and Mercer County are part of the Philadelphia-Wilmington-Atlantic City Ozone Nonattainment Area and the New York–Northern New Jersey–Long Island $PM_{2.5}$ Maintenance Area. This means that the ambient or background outdoor air quality does not meet the NAAQS for ozone and that the area has previously not met the NAAQS for $PM_{2.5}$. Ozone levels are typically worse in the warmer months when sunlight and higher temperatures fuel the chemical reaction between NOx and volatile organic compounds (VOCs) to form ozone at ground -level where it impacts public health.

Table 1: Criteria Pollutants

Pollutant	Sources	Health Effect
Ozone (O_3)	Formed by chemical reaction of volatile organic compounds (VOCs) and NOx in the presence of sunlight	Decreases lung function and aggravates asthma and other lung diseases
Particulate Matter (PM)	Chemical reactions; fuel combustion, industrial processes	Aggravates or causes heart or lung diseases
Carbon Monoxide (CO)	Fuel combustion	Reduces the amount of oxygen reaching the body's organs and tissues; aggravates heart disease
Nitrogen Oxides (NOX)	Fuel combustion	Aggravates lung diseases and increases susceptibility to respiratory infection
Sulfur Dioxide (SO_2)	Fuel combustion, electric utilities and industrial processes, and natural sources	Aggravates asthma and increased respiratory symptoms
Lead (Pb)	Metal refineries and other metal industries, leaded gasoline, waste incinerators, and battery manufacturing	Damages the developing nervous system in children, cardiovascular and renal effects in adults

Source: *City of Trenton Natural Resource Inventory*, DVRPC 2015

Air Monitoring Network

NJDEP's Bureau of Air Monitoring maintains a network of 30 ambient air monitoring stations across the state. A filter-based air monitoring station is located at the Trenton Library at 120 Academy Street, Trenton, New Jersey, which measures $PM_{2.5}$. A continuous monitoring station at Rider University in neighboring Lawrenceville, New Jersey, also monitors for O_3 and meteorological parameters. NJDEP provides a daily air quality forecast to alert the public when ambient air conditions will be unhealthy for the public. Citizens can access the forecast or sign up for poor air quality text and email alerts at www.airnow.gov.

These monitors are helpful in understanding regional air quality; however, they are not able to provide finer detail on neighborhood-level differences in air quality. As a proxy for more precise air quality measures, the study team analyzed transportation data, including truck counts (described above), and the location of point source pollution. As shown in Figure 11, there are four regulated emission points within Trenton and an additional four just east of the city boundary. Within the city, two of the four sources are hospitals and one is a steam generation plant. There are also two freight centers on the city's eastern edge, including one heavy industrial center and one specializing in local manufacturing and distribution. The location of the freight centers is worth noting in part because these sites may emit pollutants directly, but also because they may generate higher volumes of truck traffic. As noted above, studies have shown that medium- and heavy-duty trucks emit higher levels of air pollution than passenger vehicles.

Figure 11: Emission Points and Freight Centers, 2021
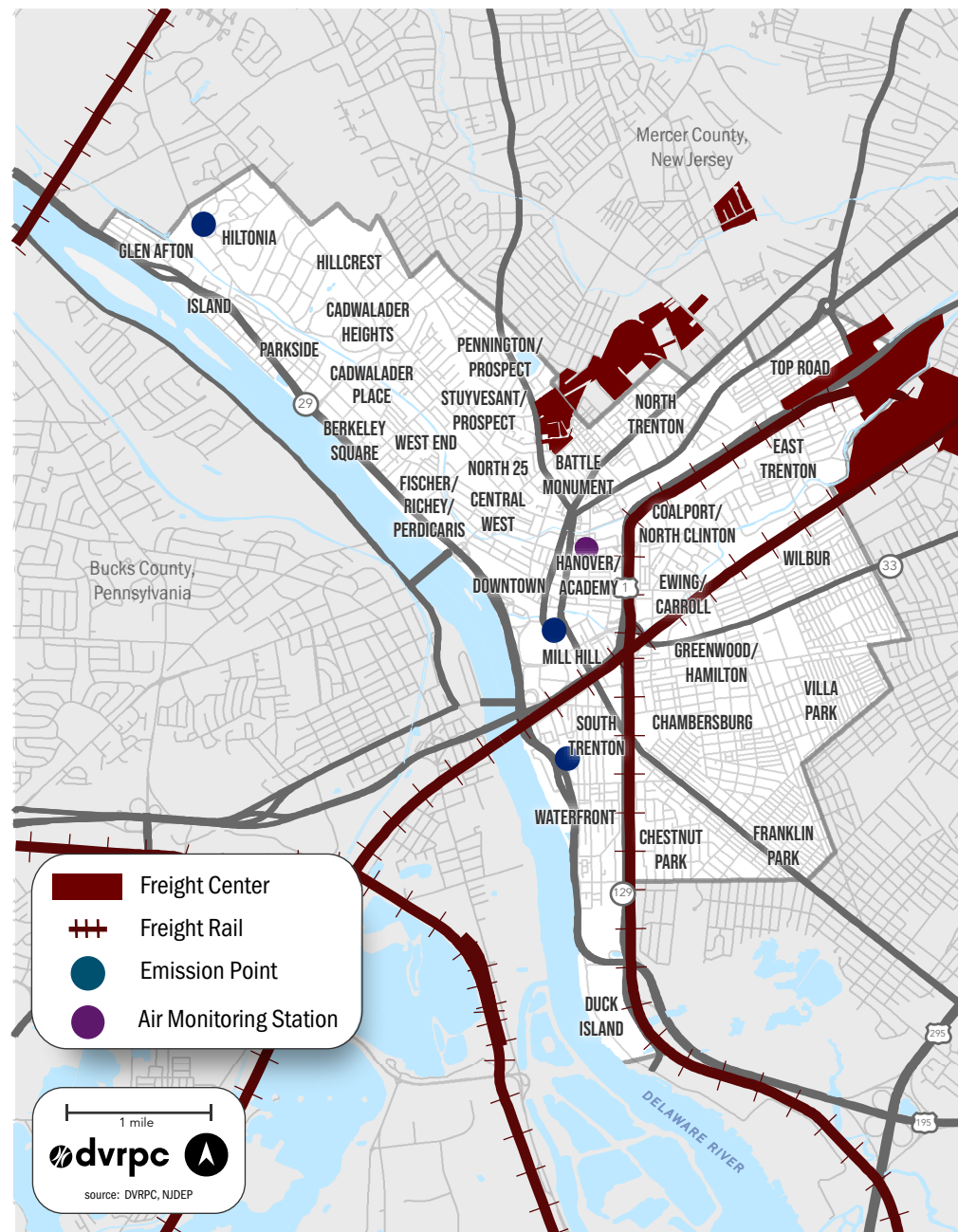
Health

As noted above, numerous studies have demonstrated that poor air quality can have significant effects on human health. More specifically, studies have linked ozone and particle pollution to higher incidences of chronic respiratory diseases like asthma and COPD, lung cancer, cardiovascular disease, kidney disease, premature birth, and even premature death.[29] Respiratory diseases like asthma and COPD are often connected to higher levels of air pollution since the pollutants are inhaled and affect the respiratory system first, before particles are absorbed into the bloodstream and travel to other organs in the body.

Asthma

Asthma is a chronic lung disease that inflames and narrows the airways in the lungs causing a number of breathing problems. Uncontrolled asthma can lead to hospitalization and even death. Although it cannot be cured, it can be controlled with proper medication and attention.[30] Although asthma can affect people of all ages, it often develops during childhood and is one of the leading causes of school absenteeism. As noted in the "Demographics" section above, low-income, minority, and young populations often experience more health complications due to asthma than the general population.[31]

According to the U.S. Centers for Disease Control and Prevention, 10.7 percent of Trenton adults have asthma. This is greater than both the county- and statewide rates of 7.8

[29] "State of the Air 2022."

[30] "Asthma Attack: Causes, Symptoms & Treatment," American College of Allergy, Asthma, and Immunology, accessed May 2022, acaai.org/asthma/symptoms/asthma-attack/.

[31] CDC Healthy Schools, "Asthma," U.S. Centers for Disease Control and Prevention, February 24, 2022, www.cdc.gov/healthyschools/asthma/.

Figure 12: Adult Asthma Rates by Census Tract, 2019

Asthma Rates (by tract)
- 9 to 9.6%
- 9.7 to 10.3%
- 10.4 to 11.3%
- 11.4 to 12.2%
- 12.3 to 13.3%

source: DVRPC, CDC 500 Cities 2019
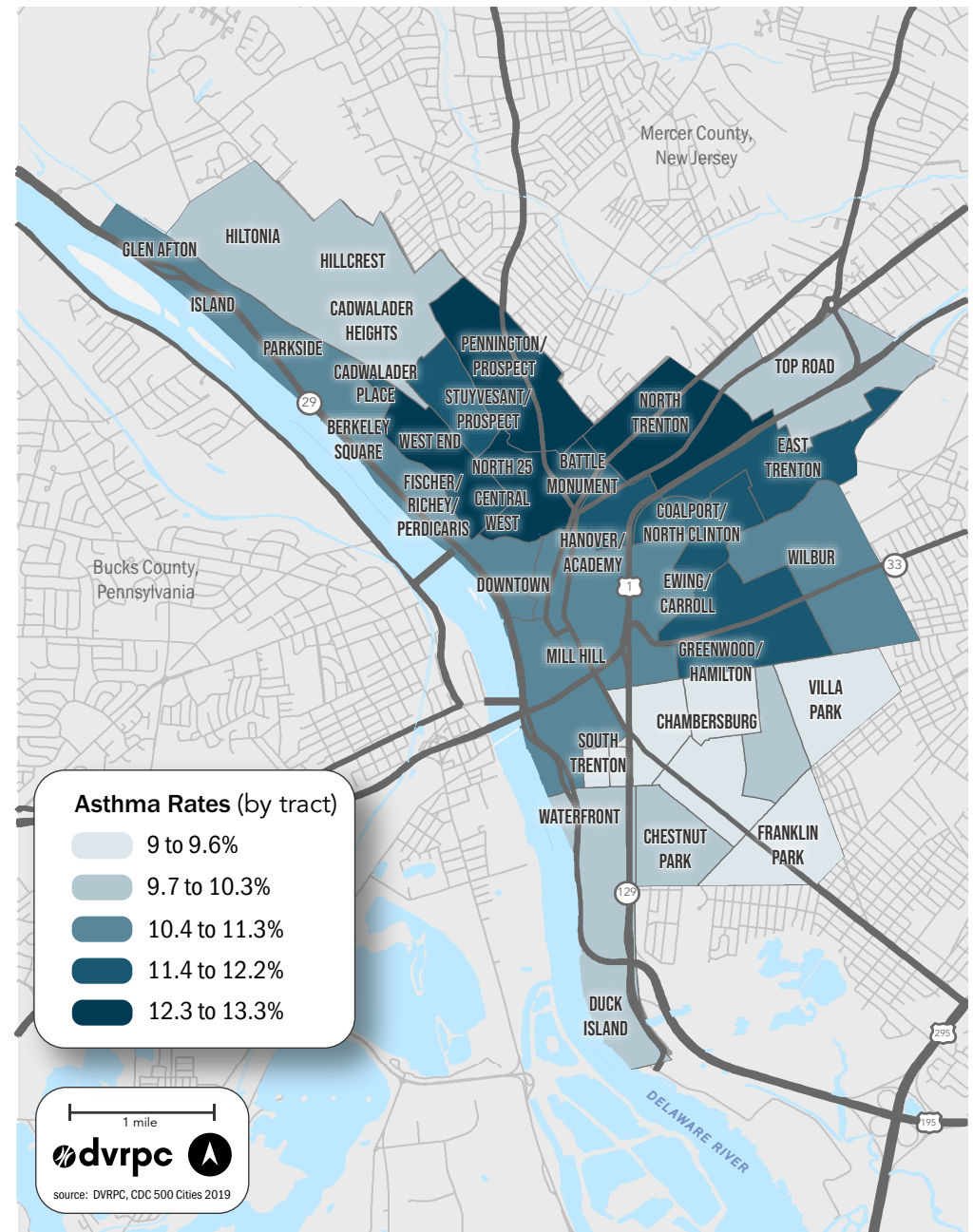
percent and 8.6 percent, respectively.[32] Neighborhoods such as Pennington/Prospect, Stuyvesant/Prospect, Battle Monument, North 25, and North Trenton have some of the highest rates of adult asthma in the city, with the lowest rates concentrated in the southern portion of the city. See Figure 12 for more information.

Other Chronic Diseases

As shown in Table 2, the communities that have higher rates of Adult Asthma also tend to have higher rates of other chronic diseases like

COPD and cardiovascular diseases. These communities also correspond to areas with higher rates of households living in poverty. For example, the Pennington/Prospect, North 25/Central West/Battle Monument, and Fisher/Richey/Perdicaris neighborhoods have some of the highest rates of adult asthma (approximately 13 percent) and some of the highest rates of COPD, heart disease, high blood pressure, and stoke in the city. They also have some of the highest poverty rates in the city, with 44.9 percent, 41.2 percent, and 45.2 percent of households living in poverty, respectively. Poverty is not the cause of the high rates of chronic disease but is closely connected to a person's ability to afford essential services like housing, food, utilities, and healthcare. On a more systemic level, low-income

[32] Centers for Disease Control and Prevention, *500 Cities: Local Data for Better Health, 2019 release* (2017 data), accessed May 2022: chronicdata.cdc.gov/500-Cities-Places/500-Cities-Local-Data-for-Better-Health-2019-relea/6vp6-wxuq/data.

Table 2: Chronic Disease Rates by Neighborhood

Neighborhood	Adult Asthma Rate	COPD	Coronary Heart Disease	High Cholesterol	High Blood Pressure	Stroke	Poverty Rate
Waterfront/Duck Island	10	9.2	8	36.5	37.1	4.5	23.5
Chestnut Park	10.3	7.5	5.8	31.1	32	3.5	23.9
Franklin Park	9.3	6.7	5.2	30.9	30.3	3	18.8
Franklin Park/ Chambersburg	9.4	6.3	4.5	28.2	27.6	2.7	27
Chambersburg	9.8	6.9	5	29.3	28.6	2.9	26.5
Villa Park	9.4	6	4.7	30	29.8	2.7	17.1
Chambersburg	9.2	6	4.7	28.8	27.7	2.7	19.5
Chambersburg/South Trenton	9.6	7.3	5.9	30.9	30.9	3.4	23.1
Hanover/Academy/Mill Hill/Downtown Trenton	10.8	8.5	6.8	34	39.4	4.5	42.7
Mill Hill	11.3	11.2	9.8	38.4	44.8	6.4	27.7
Downtown Trenton	11.3	8.9	7.7	36.5	46.7	5.5	26.1
Fischer/Richey/ Perdicaris	12.9	11.2	8.7	36.2	47.9	6.6	45.2

Table 2: Chronic Disease Rates by Neighborhood (Continued)

Neighborhood	Adult Asthma Rate	COPD	Coronary Heart Disease	High Cholesterol	High Blood Pressure	Stroke	Poverty Rate
Berkley Square/ Parkside/Island/Glen Afton	11	6.9	5.7	33.2	40.2	3.9	10.4
Hilltonia/Hillcrest/ Cadwalader Heights	9.9	6.1	5	31.6	36.6	3.2	10.9
Pennington/Prospect	13.3	11.1	8.6	36.2	48.1	6.7	44.9
Stuyvesant/Prospect	12.2	8.7	7	34.5	46	5.4	34.5
North 25/Central West/ Battle Monument	13.2	10.4	7.7	34.5	45.9	6.1	41.2
Battle Monument/ Hanover/Academy	12.1	8	6.3	33.1	42.6	4.7	28.7
North Trenton	12.7	9.2	6.7	33.3	43.2	5.2	35.2
Top Road	10.1	8.8	6.6	34.2	35.9	4	31
East Trenton	11.6	10.6	8.5	35.2	41.7	5.8	64.6
Coalport/North Clinton/ Ewing/Carroll	11.5	8.2	6.3	33.1	41.8	4.5	17.4
Greenwood/Hamilton	11.6	9.7	8	35.7	41.9	5.4	24.1
Wilbur	10.9	6.8	5.2	30.9	35.8	3.7	18.1
South Trenton	9	7.7	6	30.6	39.4	3.8	-
Trenton City	10.7	8.1	6.4	32.8	37.4	4.2	27.3

Sources: U.S. Centers for Disease Control and Prevention, 500 Cities data, 2019 release (2017 data); ACS 2012–2017 5-year estimates, S1701 Poverty Status in the Past 12 Months

communities often have fewer health-supporting amenities like parks and grocery stores and more health-harming places, such as industrial facilities and highways

The findings from the existing conditions analysis confirmed what many community members and stakeholders already knew: there are significant economic and health disparities between Trenton and the rest of the county and state. Transportation data also confirmed that there is a high volume of trucks traveling through residential neighborhoods in Trenton. However, the lack of neighborhood-level air quality data prevented the study team from drawing conclusions as to the cause of some of the health disparities in the city since many factors, including indoor air quality, can affect the prevalence of asthma and other chronic diseases.

Air Monitoring Study

To better understand if the high asthma rates in specific Trenton neighborhoods were related to poor outdoor air quality, the study team decided to pursue an air monitoring project. A subcommittee of the advisory committee initially met in September 2021 to learn about NJDEP's air monitoring program from Luis Lim, Chief of NJDEP's Bureau of Air Monitoring within the Division of Air Quality. Mr. Lim shared some preliminary resources that the Bureau of Air Monitoring had been working on, including a web page on community science air monitoring and Quality Assurance Project Plan templates for four types of community science projects.

In December 2021, NJDEP, representatives from The College of New Jersey (TCNJ), Rider University, Rutgers University, and the City of Trenton began meeting to discuss initiating a mobile monitoring network in the city. Staff from the city met with DVRPC and NJDEP to identify potential locations to place the sensors. Based on the existing conditions data—specifically the asthma rate, truck counts, and truck travel time data—and their knowledge of the city, the partners identified 14 sites that generally fell into five categories:

- near industrial sources;
- near highway sources with high truck counts;
- near a combination of high truck counts and industry;
- near sensitive populations; and
- reference and control sites.

NJDEP agreed to deploy a series of Purple Air monitors at select locations across the city, with some control sites outside of the city, in order to suggest whether the point sources and roadways are significantly contributing to $PM_{2.5}$ levels in the city. The monitors continuously collect $PM_{2.5}$ data and upload the data to the Purple Air website, where the data is available to the public. The subcommittee selected $PM_{2.5}$ as the pollutant

for monitoring because of the quality of low-cost PM sensors and the health impacts of this pollutant, as well as $PM_{2.5}$ being a reasonable proxy for pollution from industrial and transportation sources.

> **PURPLE AIR MONITORS**
> Purple Air monitors are low-cost sensors (approximately \$250–\$300 each) that use laser particle counters to measure airborne PM in real time and calculate the concentrations of $PM_{1.0}$, $PM_{2.5}$, and PM_{10}. Purple Air monitors need to be connected to a power source to operate. Additionally, they need to be connected to Wi-Fi to upload data to the web, but they can be equipped with SD cards for manual data downloads. The monitors should be mounted between six and 15 feet above the ground to capture pedestrian exposure to air pollution.

NJDEP began installing the monitors in May 2022, and the academic partners will be accessing the data for analysis over a one-year period. As of September 2022, NJDEP had installed seven Purple Air monitors in the city of Trenton that are uploading $PM_{2.5}$ air quality readings to the Purple Air website. An additional monitor is located near NJ 129 and Cass Street that does not have a Wi-Fi connection. NJDEP is downloading its data manually. There are additional Purple Air monitors on the Rider University Campus and on a private residence in Morrisville, Pennsylvania. Data from these monitors can be accessed at www2.purpleair.com. A map, list of the locations, and corresponding sensor numbers of the Purple Air monitors deployed for this effort can be found on page 21.

The goal of the monitoring effort is to determine if air quality varies across the city and whether there are identifiable sources of pollution that may be impacting specific neighborhoods. Data from the monitors will be collected for at least one year to account for seasonal variations in air quality. The data from this effort is available to the public and academic institutions for

Figure 13: Air Monitoring Sites, 2022
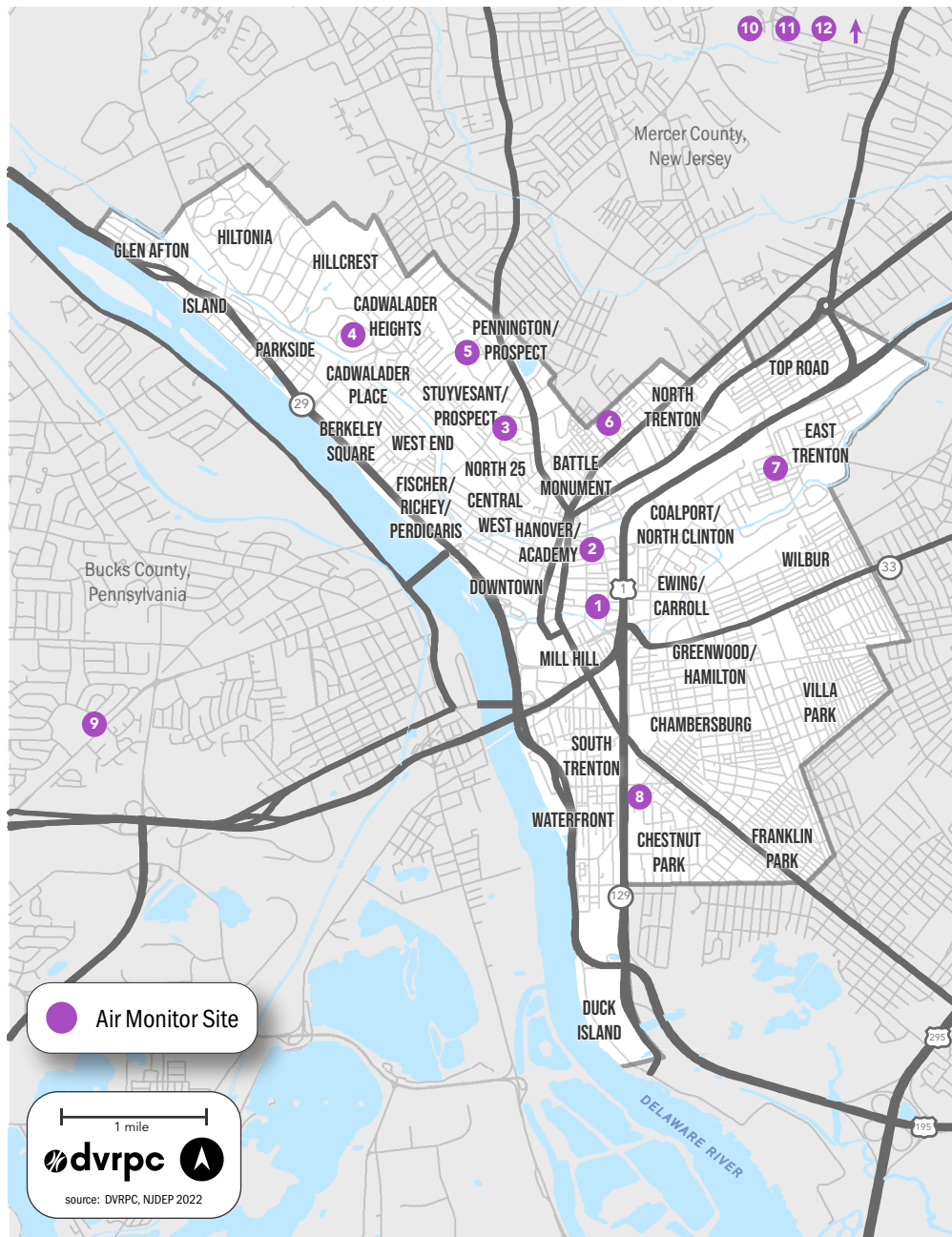
AIR MONITORING SITES (WITH SENSOR NUMBER)

1. **Artworks (NJ2348)**
   19 Everett Alley, Trenton, NJ

2. **Trenton Free Library (NJ5461)**
   120 Academy Street, Trenton, NJ

3. **Prospect Village (NJ1F53)**
   120 Prospect Village

4. **Ellarslie, Trenton City Museum (NJD551)**
   299 Parkside Avenue, Trenton, NJ

5. **Woodrow Wilson Homes (NJ52DD)**
   5 Eisenhower Avenue, Trenton, NJ

6. **Donnelly Homes (NJ5CD)**
   875 New Willow Street, Trenton NJ

7. **East Trenton Collaborative (NJF180)**
   601 N. Clinton Avenue, Trenton, NJ

8. **Home Rubber (no WiFi)**
   31 Woolverton Street, Trenton, NJ

9. **Private Residence (BAB2)**
   W. Trenton Avenue near Alden Avenue, Morrisville, PA

10. **Rider University West House (Rider U-10)**
    Rt. 206, Lawrence, NJ

11. **Rider University, Student Recreation Center (Rider U-07)**
    2083 Lawrenceville Road, Lawrence, NJ

12. **Rider University, Michael P. Brady Track (Rider U-01)**
    50 W. Long Drive, Lawrence, NJ

research purposes. As of January 2023, NJDEP had collected at least three months of data and was starting to process the preliminary data, in collaboration with the academic partners. The research team plans to provide the city with a summary of their findings after they have collected a full year of data.

Mitigation Strategies and Funding Sources

Although identifying and implementing the appropriate site-specific mitigation strategies will depend upon the results of the air monitoring study, there are many strategies that can be taken to improve ambient or background air quality while positively impacting the quality of life of Trenton's residents.

A few of the strategies, with potential funding sources, are listed below.

Strategies to Improve Air Quality in Trenton

- **Modernize the diesel truck fleet.** Newer diesel trucks (after Model Year 2010) emit up to 90 percent fewer $PM_{2.5}$ and NOx emissions than the earlier models. Encouraging fleet modernization, or even electrification, can help to reduce emissions from diesel vehicles traveling within and through the city.
- **Invest in truck route signage to direct trucks to preferred routes and facilities.** Directing trucks to travel on appropriate roadways that have the capacity for heavy-duty vehicles can improve safety and reduce emissions from congestion, as well as remove an emissions source from neighborhoods where populations that are sensitive to air pollution may live or work.
- **Work with state officials to remove the ban on trucks in the NJ 29 Tunnel.** This recommendation was cited as the "least costly alternative to reduce truck traffic in the City of Trenton," in the *City of Trenton Truck Network* memorandum published by DVRPC in 2019.
- **Electrify city fleet and school buses.** There are various state and federal funding programs available to fund the replacement of fleet vehicles and school buses with electric vehicles. Electric vehicles have zero tailpipe emissions and would help to improve local air quality in the city.

- **Continue to convene the air quality and health advisory committee,** led by a local organization, to continue to assist the city and NJDEP to address air quality and health-related issues.
- **Plant trees in accordance with the *City of Trenton Management Plan for Forests and Trees*** to reduce urban heat island effects, improve air quality, and beautify the city.
- **Continue to pursue opportunities for safe and convenient bicycle and pedestrian connections,** including regional trails and connections to transit. Providing more and safer options for walking and biking can help to shift mode choices from cars to active transportation options, which can help to improve air quality by reducing vehicle miles traveled and associated emissions.
- **Investigate and pursue opportunities to improve indoor air quality.** Although this project focused on outdoor air quality, team members acknowledged that poor indoor air quality may also contribute to the city's high asthma rates. Efforts to address indoor air quality are ongoing and include the Trenton Health Team's Healthy Housing Initiative and Goal 4: Promote Healthy Housing Conditions of the *Trenton Community Health and Wellness Plan*.

Rowhomes along Hamilton Avenue near Hudson Street, Trenton, NJ
Source: Getty Images

Funding Sources

Congestion Mitigation and Air Quality Improvement Program

DVRPC's Competitive Congestion Mitigation and Air Quality Improvement Program (CMAQ) seeks to fund transportation projects that will improve air quality and reduce traffic congestion in the DVRPC region. CMAQ-eligible projects will demonstrably reduce air pollution emissions and help the DVRPC region meet the federal health-based air quality standards. General eligible project categories include pedestrian and bicycle projects, transit improvement programs, congestion reduction and traffic flow improvements, and funding of transportation demand management programs, among others. More information can be found at the program website: www.dvrpc.org/cmaq.

Transportation Set-Aside Program

The Transportation Alternatives Set-Aside (TA Set-Aside) program provides federal funds for community based "non-traditional" surface transportation projects designed to strengthen the cultural, aesthetic, and environmental aspects of the nation's intermodal system. TA Set-Aside projects must relate to surface transportation.

The TA Set-Aside program is administered by the New Jersey Department of Transportation (NJDOT), in partnership DVRPC. Eligible projects types that could result in improved air quality include:

- Construction, planning, and design of on-road and off-road trail facilities for pedestrians, bicyclists, and other non-motorized forms of transportation, including sidewalks, bicycle infrastructure, pedestrian and bicycle signals, traffic-calming techniques, lighting and other safety-related infrastructure, and transportation projects to achieve compliance with the Americans with Disabilities Act.
- Any environmental mitigation activity, including pollution prevention and pollution abatement activities and mitigation to address stormwater management, control, and water pollution prevention or abatement related to highway construction or due to highway runoff.

Bike Lane on East State Street, Trenton, NJ
Source: Miles Owen, DVRPC

New Jersey Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a multistate, market-based program that establishes a regional cap on carbon dioxide (CO_2) emissions and requires fossil fuel power plants of a certain size to obtain an allowance for each ton of CO_2 emitted annually. Power plants can purchase allowances from quarterly auctions, other generators within RGGI, or through projects that offset CO_2 emissions. States use the proceeds from the CO_2 allowance auctions to invest in programs to help further reduce CO_2 and other greenhouse gas pollution, spur clean and renewable energy, and provide rate relief on energy bills.

In compliance with New Jersey's RGGI Strategic Funding Plan: Years 2020 through 2022, proceeds from the CO_2 allowance auction are split between three state agencies (60 percent to the New Jersey Economic Development Authority, 20 percent to the New Jersey Board of Public Utilities and 20 percent to NJDEP). Funds from 2020 through 2022 are devoted to programs and projects that fall within the scope of four initiatives:

1. Catalyzing Clean, Equitable Transportation;
2. Promoting Blue Carbon in Coastal Habitats;
3. Enhancing Forests and Urban Forests; and
4. Creating a New Jersey Green Bank.

Under Catalyzing Clean, Equitable Transportation, all three New Jersey agencies have committed a portion of their RGGI funds to advance electrified transportation across the state, with a focus on environmental justice communities. Funds will support the deployment of electric medium- and heavy-duty vehicles for commercial and industrial use. They will also help to expand the electrification of local government-owned vehicles, like garbage trucks and school buses. Efforts to electrify New Jersey's transportation sector will not only help to reduce greenhouse gas emissions, but will also significantly reduce criteria air pollutants and toxics.

EPA Clean School Bus Funding

With funding from the Bipartisan Infrastructure Law, EPA's new Clean School Bus Program provides $5 billion over five years (Fiscal Years 2022–2026) to replace existing school buses with zero-emission and low-emission models. More information can be found at the program website: www.epa.gov/cleanschoolbus.

Federal Transit Administration Low or No Emission Grant Program and Grants for Buses and Bus Facilities Funding

With funding from the Bipartisan Infrastructure Law, the FTA will award $7.5 billion over five years (Fiscal Years 2022–2026) through these two grant programs to support state and local efforts to modernize aging transit fleets with low- and no-emission buses, renovate and construct bus facilities, and support workforce development.

Kids Getting on a School Bus
Source: Getty Images

Acknowledgments

DVRPC is extremely grateful to our partners and supporters who participated in the advisory committee and air monitoring subcommittee meetings, recruited academic partners, helped to develop an air monitoring plan, identified monitoring locations, and secured and installed low-cost sensors. This plan and the ongoing air quality monitoring effort would not have been possible without their contributions.

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Trenton Air Quality and Health Study

Abstract:
Air quality—both indoors and outdoors—has a major effect on human health. Numerous scientific studies have linked ozone and particle pollution to chronic respiratory diseases like asthma and chronic obstructive pulmonary disease, lung cancer, cardiovascular disease, and even premature death. Although we know that poor air quality can be detrimental to human health, it is one of the most difficult environmental resources to measure because its sources are diffuse and regional in nature. This study analyzes existing health, air quality, and transportation data to quantify incidences of respiratory disease and identify sources of pollution that may be contributing to poor respiratory health outcomes. It details the process that DVRPC and the city undertook to convene an air monitoring subcommittee, recruit academic and community partners, identify monitoring locations, and deploy low-cost air quality sensors, with the goals of determining if air quality varies across the city and whether there are identifiable sources of pollution that may be impacting these neighborhoods.

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