Brightline Air Quality Data Report: January 2023

Data Report Overview

- The Brightline Air Quality Monitoring Program has installed NO_2 calibrated devices expanding our network's ability to understand pollutant sources.
- Heat domes and temperature inversions were frequent occurrences negatively affecting San Francisco's air quality between September and December 2022.
- Compared to the previous two years, our network recorded low air quality readings during the fall due to the lowered intensity and duration of wildfires.
- Brightline's continued work with community leaders is providing strong qualitative insights through community interviews.

INTRODUCTION

Since March 2020, Brightline Defense ("Brightline") has developed a community-driven air quality monitoring program with Central City SRO Collaborative (CCSROC) and Community Youth Center (CYC) of San Francisco. The 19 sensor network covers neighborhoods such as the Tenderloin, SoMa, Chinatown, and has more recently expanded into the Bayview-Hunters Point.

This report will cover air quality data trends and findings from August 2022 to December 2022. With seven of Brightline's sensors now calibrated to detect NO_2 pollutants, Brightline is able to better understand regional and local air quality trends. This analysis will also share details on how weather, temperature, and meteorology has exacerbated air quality issues in the bay. Lastly, the report will debrief community interviews around sustainability, civic engagement, and environmental decision making spaces.

I. **Brightline Air Quality Monitoring Network Updates**

Since July 2022, Brightline has relocated six air quality monitoring sensors to new locations in Bayview-Hunters Point. These sensors were relocated in order to create a more equitable distribution of air quality monitoring data across Eastern San Francisco. Additionally, they were

strategically placed to monitor high vehicle congestion activity and community spaces. For instance, three sensors were relocated at the intersection of Industrial and Bayshore, at Cesar Chavez and Bryant, and Cesar Chavez and Hampshire to monitor vehicular traffic from highways. Another monitor was relocated to the Florence Fang Community Garden to understand the community's day-to-day air quality levels and their exposure to the nearby Caltrain route. One monitor was placed at the Wu Yee Children's Center on the intersection of Kirkwood Ave and Earl Street to monitor community air pollutant exposure from nearby bus routes and construction sites. Lastly, one sensor was moved to The Box Shop to monitor the industrial zoning and traffic near local neighborhoods.
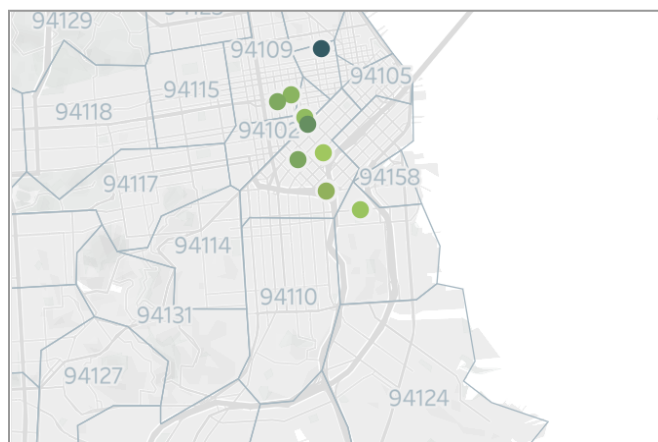
Brightline's AQ Map in May 2022
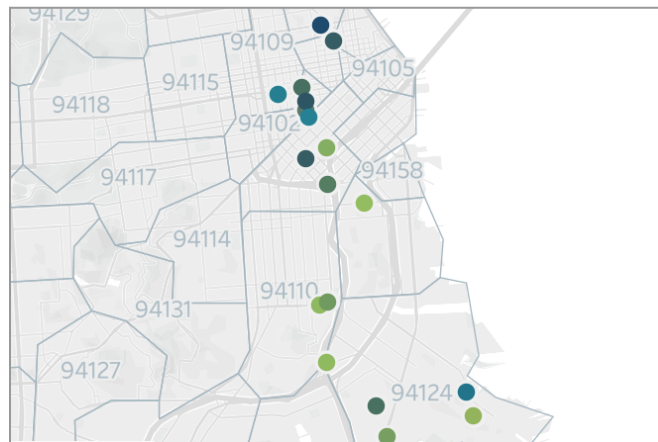
Brightline's AQ Map in December 2022

II.   Recent Data Collection and Analysis Work

a. NO$_2$ Overview

NO$_2$ is an air pollutant that is primarily emitted from burning fuel or combustion, and functions from cars, trucks, buses, and power plants. Over short periods, exposure to NO$_2$ can exacerbate respiratory diseases, such as asthma, leading to coughing, wheezing, and difficulty of breathing. Over longer periods of time, exposure can lead to an increase of vulnerability to developments of asthma and respiratory infections. NO$_2$ levels vary with direct emission levels, changing atmospheric conditions, other oxides of nitrogen, and other traffic-related pollutants, such as particulate matter.[1]

From June through September 2022, Brightline began implementing a calibrated NO$_2$ mass concentration functionality on seven devices located in SoMa, Chinatown, the Tenderloin, and Bayview Hunters Point. So far, these devices have been able to capture more accurate NO$_2$ readings for the summer through fall 2022 period, providing Brightline with data that could

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[1] https://www.epa.gov/no2-pollution/basic-information-about-no2

potentially inform associations among temperature, relative humidity, region, time of day (morning, afternoon, evening, night), and $PM_{2.5}$ with NO_2.

Since the first calibrated NO_2 readings in June, levels have remained well below national hourly average standards (188 μg/m^3). Boeddeker Park (the Tenderloin), Bessie Carmichael Elementary (SoMa), and Stockton and Broadway (Chinatown) lead with the highest average NO_2 readings, while BAAQMD Co-Location (Potrero Hill) and Macaulay Park (the Tenderloin) produce lower average NO_2 readings.

Ambient Air Quality Standards for NO_2[2]

	1-Hour Average	Annual Average
National Ambient Air Quality Standard	100 ppb (188 μg/m^3)	53 ppb (99.6 μg/m^3)
California Ambient Air Quality Standard	180 ppb (338.4 μg/m^3)	30 ppb (56.4 μg/m^3)

Brightline's Sensors - NO_2 Hourly Average

Device Name	Avg	St Dev	n
BAAQMD Co-Location	6	7	1,319
Bessie Carmichael Elementary	15	5	894
Boeddeker Park	18	7	1,246
BVHP Foundation	11	6	1,624
Howard & 9th	11	6	1,350
Macaulay Park	9	5	1,173
Stockton and Broadway	13	4	903

Across all sites, there appears to be more patterns in NO_2 fluctuations during the day time, with higher readings occurring in the afternoon, and lower readings occurring at night (afternoon > evening > morning > night). Throughout the day, NO_2 readings toggle across a wider range relative to $PM_{2.5}$. NO_2 levels peaked at the BAAQMD co-location on September 6, 2022 at 1pm

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[2] https://ww2.arb.ca.gov/resources/nitrogen-dioxide-and-health

and also at Boeddeker Park on October 19, 2022 at 3pm, both reaching about 60 μg/m^3. When we see unusual increases in NO$_2$, it is more likely that pollution sources are local compared to PM2.5 which sources pollution more regionally as PM2.5 can be transferred larger distances. We hope to see annual trends emerge that are in line with expected values and regional monitoring by BAAQMD reference sites.
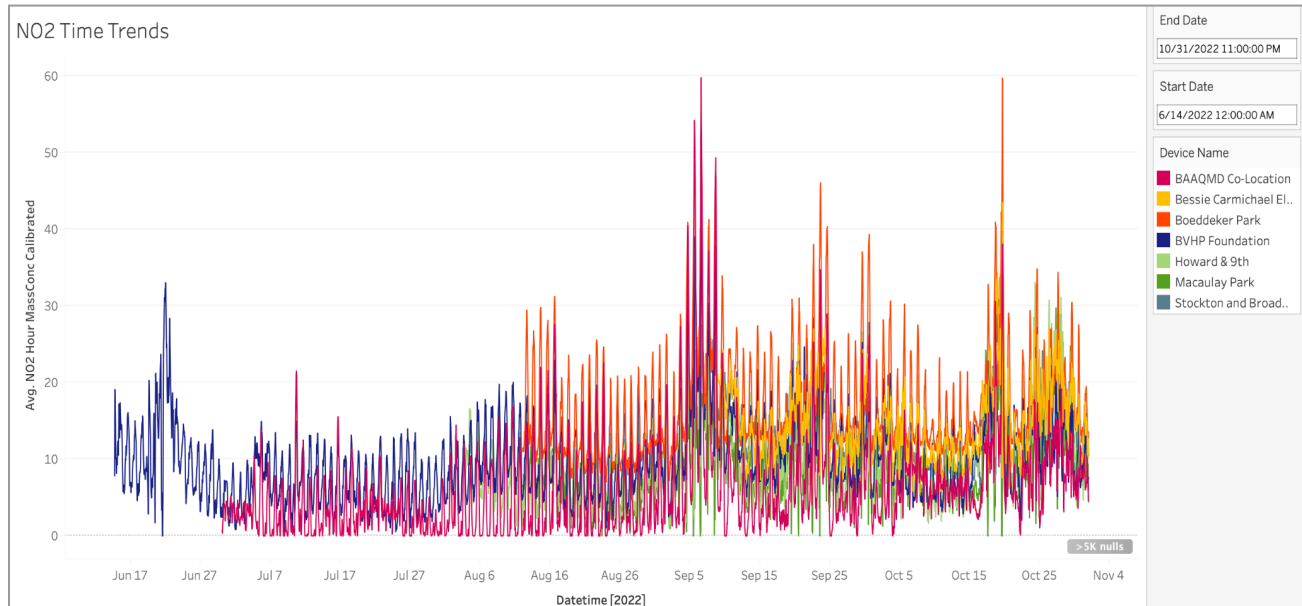
Graph depicting trends reported from each of Brightline's NO2 calibrated monitors over a period of six months
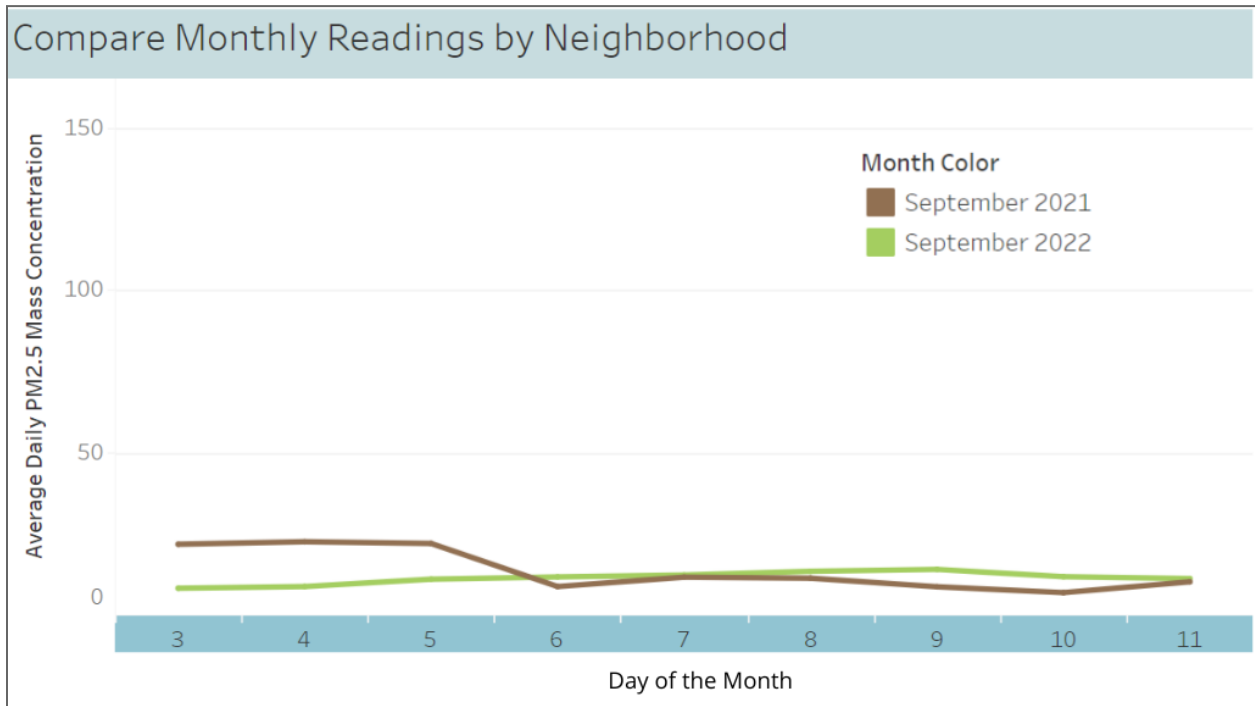
b. NO$_2$ Correlations

In general, we observe positive correlations between NO$_2$ and PM$_{2.5}$ and between NO$_2$ and temperature at all 7 sites. We also observe negative correlation between NO$_2$ and relative humidity at all 7 sites, using all data since the first NO$_2$ readings at each site. None of these correlations, quantified by the correlation coefficient r, are particularly strong. However, if we control for the time of day readings were collected, we observe more discernible correlations at certain sites between NO$_2$ and temperature and also humidity, but not necessarily with PM2.5. These findings align with our understanding of NO$_2$ and expect to see further trends emerge over the course of our monitoring.

III. Weather Trends affecting Air Quality in the Bay

San Francisco faced a range of extreme weather from August to December of this year. From the heat wave experienced in September to the weather inversions seen in December, these changes in meteorology and temperature have had negative impacts on San Francisco's air quality.

a. Heat Domes

In early September, the Bay Area saw a record breaking heat wave. Some areas of the bay reached temperatures as high as 116 degrees fahrenheit.[3] Not only did this wave highlight heat-related health concerns, but it also affected the bay's air quality. Heat domes are caused by high pressure in the atmosphere which compresses air down and heats it up, while also creating clear skies, intensifying the impact of sun rays.[4] On top of this, heat domes prohibit air from circulating, causing a build up of air particles and thus a rise in air pollutants. As a reaction to this, the Bay Area Air Quality Management District released Air Quality Advisories from September 3 through September 11 due to smog buildup, ozone pollution, and haze caused by active wildfires in California, Oregon, and Washington at the time[5]. Despite these advisories, air quality pollution levels did not exceed the national 24-hour standard. The average $PM_{2.5}$ mass concentration of this time period in 2022 started lower than previously recorded in the previous year, however it would slightly increase and exceed September 2021's $PM_{2.5}$ concentration readings by September 6th through the 11th.

Compare Monthly Readings by Neighborhood

Month Color
■ September 2021
■ September 2022

(Y-axis: Average Daily PM2.5 Mass Concentration — values 0, 50, 100, 150)
(X-axis: Day of the Month — values 3, 4, 5, 6, 7, 8, 9, 10, 11)

The heat wave posed a significant threat to San Francisco residents due to the lack of air conditioning infrastructure that exists within buildings. Many residents had to choose between opening their windows to cool off or closing them to protect themselves from poor air quality. As climate change increases the frequency of these natural phenomenons, San Francisco must start looking into solutions for lower income buildings to upgrade their HVAC infrastructure. To

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https://www.sfchronicle.com/weather/article/California-s-very-warm-September-broke-records-17505155.php#:~:text=September%202022%20was%20a%20month,recorded%20in%20Fairfield%20and%20Livermore.

4 https://www.mercurynews.com/2022/09/02/a-heat-dome-is-spiking-temperatures-in-the-bay-area-but-just-why-is-it-so-hot/
5https://www.baaqmd.gov/~/media/files/communications-and-outreach/publications/news-releases/2022/aqadvisory_220910_2022_063-pdf.pdf?la=en&rev=825f50fffacb492695abda48819d59ed

address these issues of heat related health concerns, Brightline teamed up with the National Oceanic and Atmospheric Association (NOAA), NICOS Chinese Health Coalition, and multiple city government agencies on the Urban Heat Watch initiative, a project collecting data on how heat is distributed across neighborhoods in San Francisco[6]. Through this partnership, Brightline hopes to learn more about the relationship between air quality and heat, as well as how to best serve the most vulnerable communities.

b. Weather Inversions

In late December 2022, the Bay Area was once again met with a series of days with high PM2.5 readings caused by weather inversion. A weather inversion occurs when the temperature of air increases as height increases. A front of cold air then traps the warm air underneath it, therefore decreasing winds and allowing air pollutants and particles to build up underneath this cap.[7] This type of weather phenomenon is especially harmful during the winter season because air pollution in San Francisco worsens due to an increase in heating and wood burning.[8]

Sutro Tower in San Francisco during a poor day of air quality during a temperature inversion. Taken in December 2022.

[6] https://sf.gov/news/san-francisco-activates-heat-mapping-effort-city-prepares-heat
[7] https://www.sfchronicle.com/weather/article/Why-is-the-Bay-Area-experiencing-unhealthy-air-17674584.php
[8] https://www.iqair.com/us/usa/california/san-francisco

Consequently, BAAQMD released Spare the Air alerts from December 19th through December 20th due to build up of wood fire pollution.[9] Another Spare the Air alert was put into place from December 22nd through the 25th to prohibit wood fire pollution.[10]
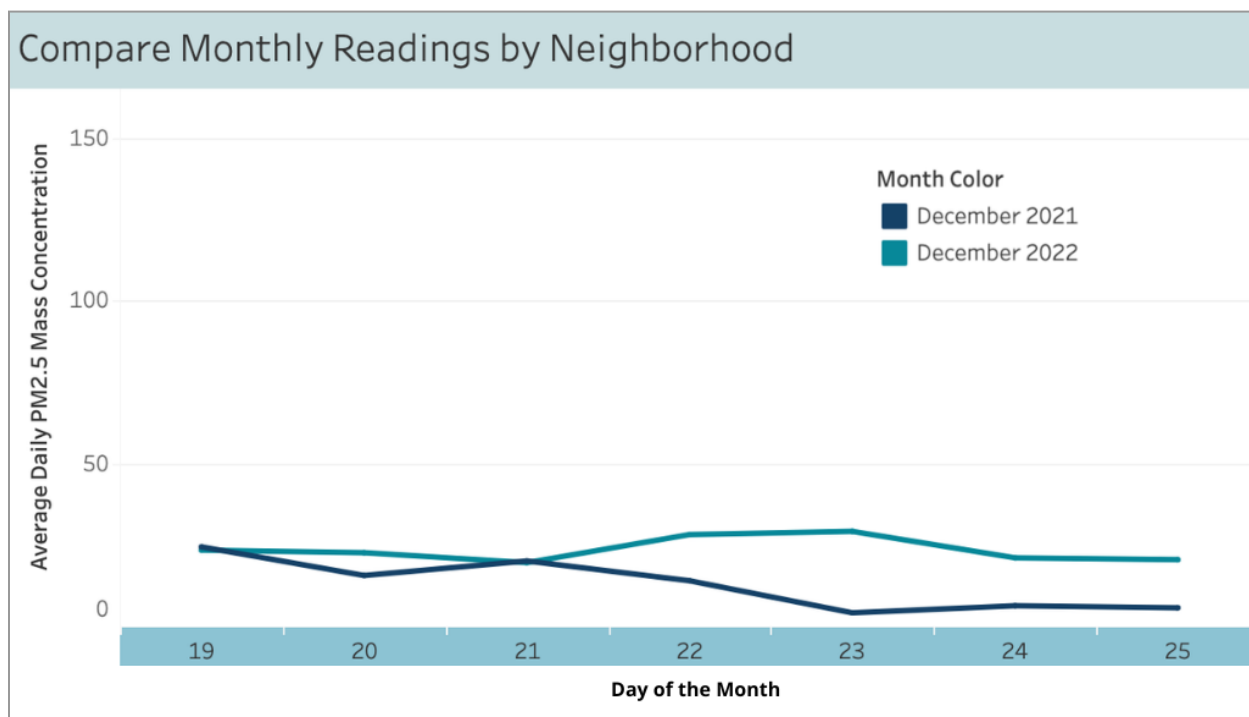
Our air quality monitoring network observed higher levels of PM2.5 during this time period of December in comparison to the previous year. Although we observed higher levels of PM2.5 this year compared to the previous year, our sensors still reported healthy levels of air quality overall.

IV.   2022 Wildfire Events affecting Bay Area Air Quality

Peak wildfire season in California typically occurs in the late summer/fall and comes to an end during periods of significant precipitation. In 2022, California experienced fewer destructive fires, while the number of California wildfires fell slightly below the 5 year average. Furthermore, unlike in previous years, the Air District Board also released fewer air quality advisories due to wildfire smoke.

However, starting July 11 through September 11, the Air District issued air quality advisories for wildfire smoke from various wildfire events primarily occurring in northern California and also

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[9]https://www.baaqmd.gov/~/media/files/communications-and-outreach/publications/news-releases/2022/2022_080_staalert_121922-pdf.pdf?la=en&rev=a52a00caf3dc474c8ab826d0e1bb3d45
[10]https://www.baaqmd.gov/~/media/files/communications-and-outreach/publications/news-releases/2022/2022_082_staalert_122222-pdf.pdf?la=en&rev=382cded5a6a247e487aa17b4e4b98c0a

in southwest Oregon. Air quality press releases can be found on the [BAAQMD site](#). Despite these air quality advisories, the average PM2.5 readings for all sensors still read healthy levels.

To further understand how wildfires affect Single Room Occupancy (SRO) communities, Brightline conducted an indoor wildfire air quality monitoring study with the Implementation Science (ImS) Training Program and the Partnerships for Research in Implementation Science for Equity (PRISE) Center of UCSF. This project involved deploying 20 sensors across 3 different SRO buildings located in SoMa and the Tenderloin from August to November. Findings from this study plan to be released in May 2023.

    a. Wildfire Smoke Exposure Vulnerabilities in San Francisco

Wildfire events can have regional effects yet, their impacts are shaped by a population's susceptibility and adaptive capacity. Thus, communities facing greater economic barriers than the general population, such as low-income families, housing-vulnerable communities, and frontline workers, are more vulnerable to wildfire smoke exposure.[11] A study in 2022 outlined key takeaways of how wildfire smoke can inequitably disrupt several economic sectors[12]:
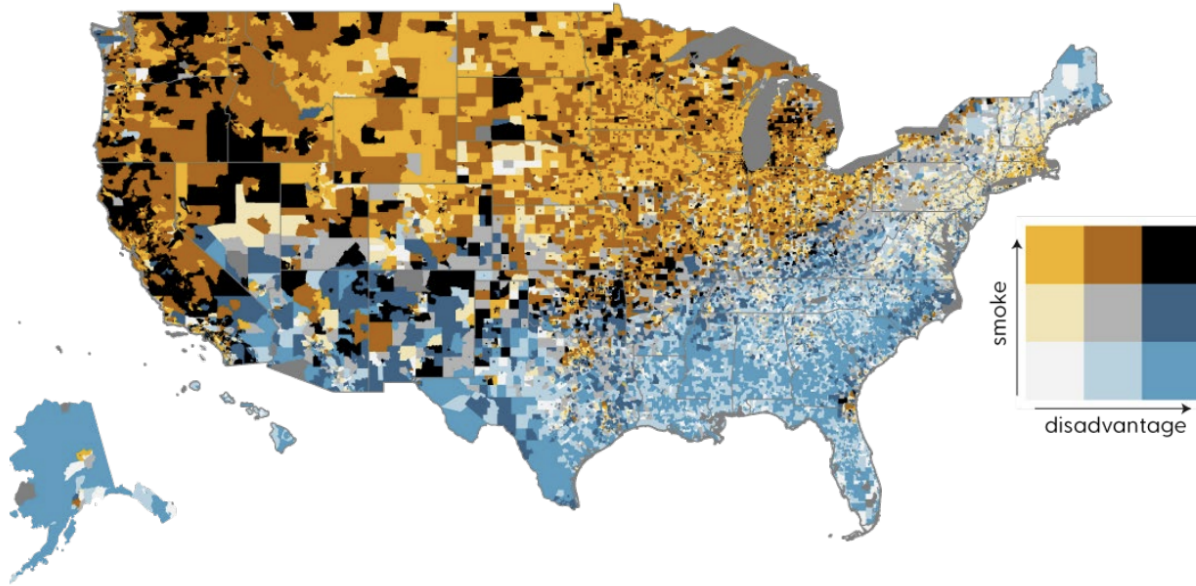
- Learning in young children and students in poverty from heavy smoke exposure can result in poor academic outcomes and increased food insecurity.
- Wildfires can pressure the housing sector by increasing housing costs and disproportionately impacting housing for vulnerable communities who live in less resilient housing types (older units, rental units, etc.) without access to protective adaptations.
- Increased occupational risk from smoke exposure decreases productivity, increases production costs, and disrupts industries that rely on frontline workers.

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[11] https://www.frbsf.org/community-development/wp-content/uploads/sites/3/disruptions-from-wildfire-smoke-cdrb06.pdf
[12] https://www.frbsf.org/community-development/wp-content/uploads/sites/3/disruptions-from-wildfire-smoke-cdrb06.pdf
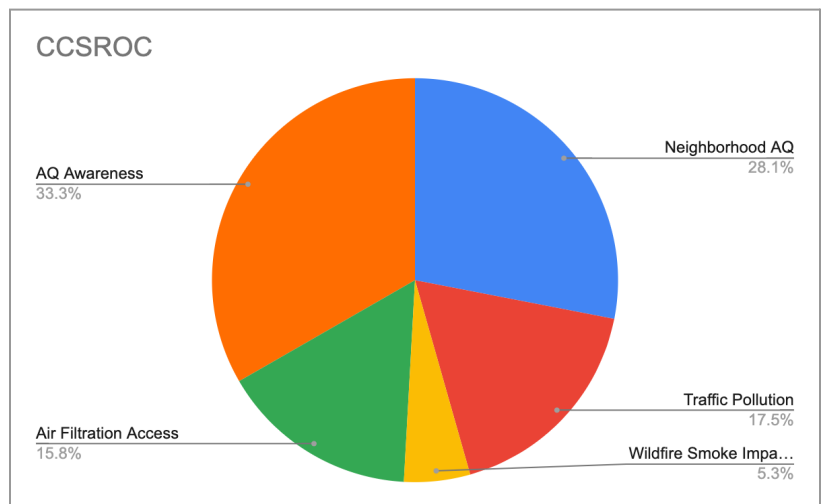
A need-based map using NOAA heavy smoke exposure data and CDC Social Vulnerability Index (SVI) estimates demonstrate that the highest assistance and mitigation need occurs where smoke exposures and social vulnerabilities coincide—in the Western regions of the US.[13]

Given that the priority populations Brightline serves in the Bay Area are more likely to experience smoke disruptions, it is key that these communities are prioritized in climate resilience planning and policy to more effectively prepare for the destabilizing effects of wildfire smoke.[14]

V. James Cary Smith Interview Findings

Brightline's James Cary Smith Program, in collaboration with Central City SRO Collaborative (CCSRO), La Voz, and Community Youth Center (CYC), began in March of 2022. The program, which is funded by a grant through BAAQMD, aims to cultivate authentic participation and community involvement in environmental decision making spaces, familiarize community members with BAAQMD staff and policies, and inform community members through exposure reduction workshops.

CCSROC

- AQ Awareness 33.3%
- Neighborhood AQ 28.1%
- Traffic Pollution 17.5%
- Air Filtration Access 15.8%
- Wildfire Smoke Impa… 5.3%

[13] https://www.frbsf.org/community-development/wp-content/uploads/sites/3/disruptions-from-wildfire-smoke-cdrb06.pdf
[14] https://www.frbsf.org/community-development/wp-content/uploads/sites/3/disruptions-from-wildfire-smoke-cdrb06.pdf

To gain deeper insight of community needs, Brightline and its community partners conducted interviews with community members in English, Spanish, and Cantonese. These interviews asked questions about sustainability, civic engagement, and air quality concerns. Overall, Brightline and Alliance Partners conducted 66 community interviews and found that only 36.4% of participants have attended a public meeting and 63.6% have not. Participants who stated they understand the public comment process is less than half at 45.5%. The majority of participants (78.8%) have also not submitted a public comment. The five core themes gathered from the 66 interviews are interests in neighborhood air quality, traffic pollution, impacts of wildfire smoke, access to air filtration, and air quality education and awareness. The following graphs depict the breakdown of interview themes by partnering organizations.
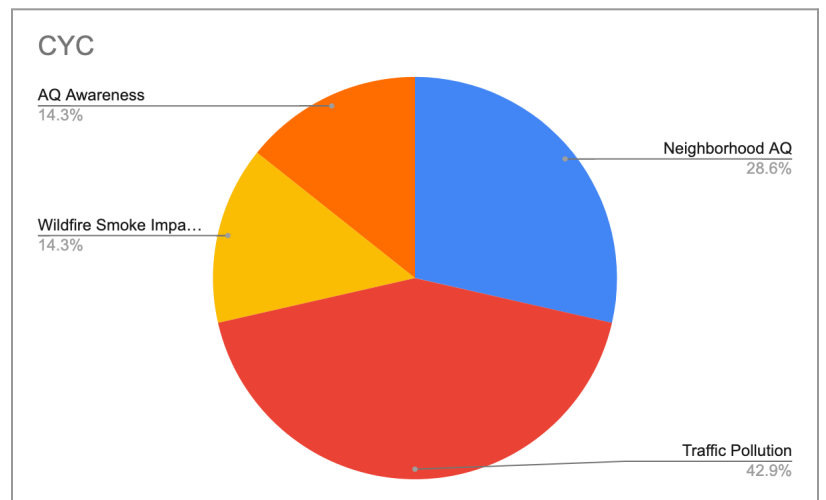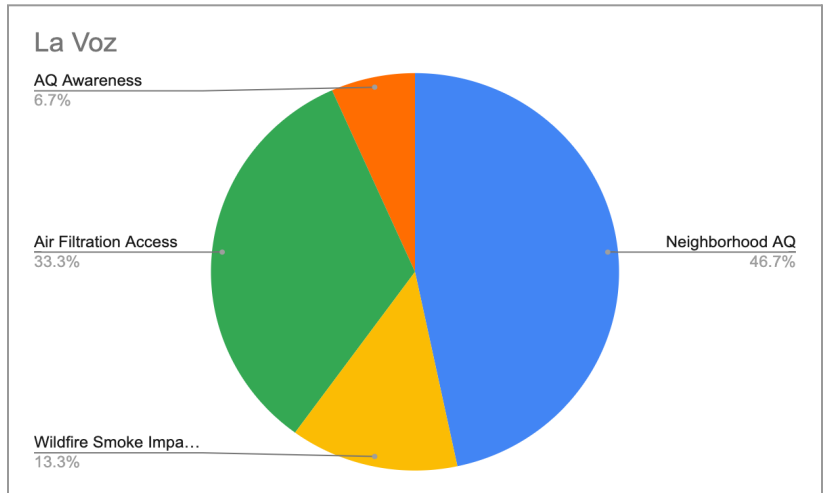
These interview findings will be used to inform Brightline and community partners on how to address community concerns through engagement with air quality monitoring agencies like BAAQMD, or through educational workshops in Year 2 of the James Cary Smith Program.

La Voz

AQ Awareness 6.7%

Air Filtration Access 33.3%

Wildfire Smoke Impa… 13.3%

Neighborhood AQ 46.7%

CYC

AQ Awareness 14.3%

Wildfire Smoke Impa… 14.3%

Neighborhood AQ 28.6%

Traffic Pollution 42.9%

Appendix I: Air Quality Impacts on Public Health

High levels of air pollution can cause a multitude of health effects, including premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased respiratory symptoms, such as irritation of the airways, coughing, or difficulty breathing. Studies show that those with preexisting respiratory illnesses,

children, and older populations are more susceptible to these health concerns. These health issues vary by vicinity to a freeway, exposure time, air circulation, and numerous other factors.

Particulate matter can come from many different sources but high concentrations of particulate matter in the Bay Area is often tied to vehicle emissions, stationary sources of pollution like gas generators, and wildfire pollutants. PM2.5 particles are incredibly small, less than 1/30th the size of a human air.
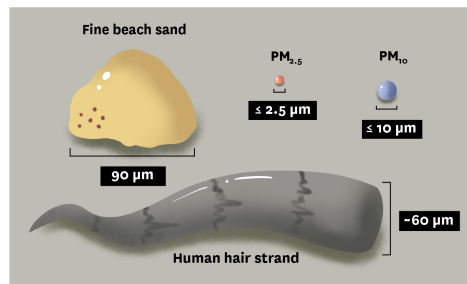
Image comparing the size of PM1.5 to fine sand and human hair by the San Francisco Chronicle[15]

[15] Zhu, Stephanie. "What is PM$_{2.5}$ and why is it so bad for you?" *San Francisco Chronicle.*
https://www.sfchronicle.com/projects/2021/air-pollution-pm25/