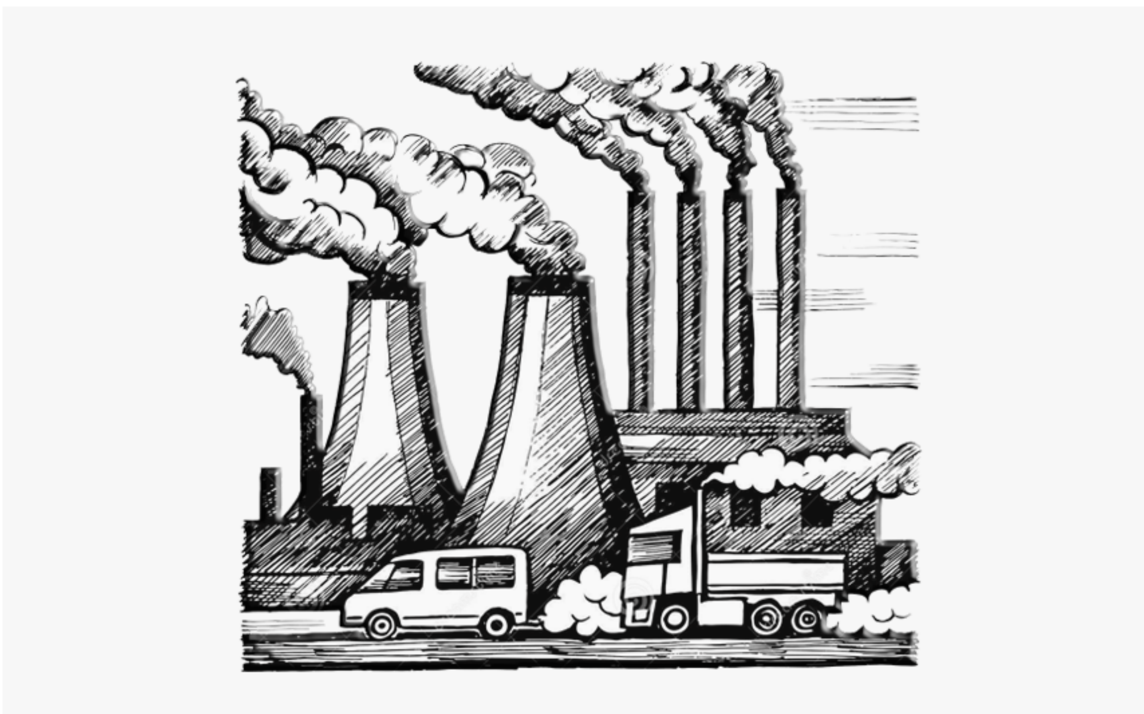
Air Pollution in Southeast Colorado Springs

Colorado College Environmental Program in Collaboration with
Solid Rock Community Development Corporation



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I. EXECUTIVE SUMMARY

This report aims to ameliorate the gap in knowledge around air quality in an effort to assist Solid Rock Community Development Corporation in combating air pollution in Southeast Colorado Springs. To address this issue, we set up a two week scientific study of air quality in Southeast, visualized the collected data with maps, explored how to expand air quality monitoring, and researched policies that could help regulate the harmful impacts of air pollution.

To assess the status of air quality in Southeast Colorado Springs, we set up two temporary air filter sites, one at Solid Rock and one at Colorado College, and found that most pollutants did not differ statistically between the sites for the two days of data collected. The three pollutants that did differ (sodium ion, magnesium ion, and chloride) had higher values at Colorado College than at Solid Rock. Although modeled pollutant concentrations and the subsequent asthma risks indicate that air quality is a city-wide issue, the greater percentage of residents below poverty and higher population density in Southeast indicate the region's increased vulnerability to air pollution.

A lack of long-term accurate air quality data and inequitable distribution of air monitoring sites demonstrates a pressing need for the establishment of air monitoring stations in Southeast. The second section of this report proposes actions that can be taken to learn more about air quality on city and community scales. A station certified by the Environmental Protection Agency (EPA) is the most reliable way to gather long term, accurate air pollution data, but there is no telling how long it would take to achieve, and existing evidence of air pollution disparities would likely need to be presented to justify funding for its implementation. In lieu of an EPA monitoring station in Southeast, we suggest a variety of smaller-scale monitoring methods, such as air monitoring mobile trailers or Vehicle-Based Air Quality Monitoring Units. On a community level, we have identified citizen science programs that provide models for communities to reliably collect air quality data and foster awareness.

In addition to expanding air quality monitoring in Southeast Colorado Springs, we also suggest community and city level actions to mitigate the health consequences of air pollution. First, we suggest the establishment of cooling and cleaner air centers in Southeast Colorado Springs so that residents can access clean air during dangerous high heat and high pollution events. Second, we provide several city level policy recommendations to reduce the impact of air pollution. These policy recommendations include implementing a vehicle emission testing program for cars registered in Colorado Springs, increasing charging stations for electric vehicles, regulating point source polluters with shutdown programs on high wind days, and creating a local air quality commission to devote increased attention to air quality.

Good air quality is critical to everyone's health, but is a deeply understudied issue in Southeast Colorado Springs. We hope to provide a baseline study of air quality in Southeast Colorado Springs and accompanying policies in support of a future, longer-term study.

II. Introduction

In 2020, Colorado Springs had some of the worst air quality in Colorado, with 104 days of elevated ozone.[1] For nearly one-third of the year, residents were forced to live under the strain of poor air quality. This data is supplemented by a report from the American Lung Association, which states that Colorado Springs is barely passing the Environmental Protection Agency (EPA) air quality standards for ozone.[2] Extensive research has proven that air pollution has negative effects on health, and these impacts are exacerbated in underserved populations.[3] Although Colorado Springs ranks highly for clean air (in 2019, the American Lung Association ranked Colorado Springs within the top 20 cities for clean air) any concentration of a pollutant signifies a risk to health.[4]

It is becoming increasingly well known that environmental issues have disproportionate impacts on underserved and underfunded communities.[5] This report will focus on air pollution, its impacts on Southeast Colorado Springs, and potential solutions. In Colorado Springs, Southeast has long been underserved, leading us to believe that the community may be experiencing harm from air pollution more strongly than in other areas of the city.[6] In our research, we set out to discover if this hypothesis is correct, and if it is, what steps should be taken to address it. As the Urban Land Institute illustrated in their 2018 report on Southeast Colorado Springs, the community has many strengths in its cultural diversity, multigenerational community, leadership and advocacy, excelling schools, and existing business infrastructure.[7] Our hope is to provide information and action plans to the Solid Rock Community Development Corporation to help the Southeast community flourish by improving one major aspect: its air quality.

To study and address the status of air quality in Southeast, we have divided this report into three major questions:

A. **How much do we know about air pollution in Southeast Colorado Springs?**
B. **How can we know more about air pollution in Southeast Colorado Springs?**
C. **Given what we know, what actions can be taken to reduce the impact of air pollution?**

[1] Huxley-Reicher, Bryn, Morgan Folger, and Matt Casale. "Trouble in the Air." Environment Colorado, 2021.
[2] "State of the Air Colorado: El Paso." American Lung Association, 2022.
[3] Fowlie, Meredith, Reed Walker, and David Wooley. Rep. *Climate Policy, Environmental Justice, and Local Air Pollution*, Brookings Economic Studies, 2020.
[4] "Colorado Springs Air Quality Index (AQI) and Colorado Air Pollution." IQAir, 2022.
[5] Fowlie, Meredith, Reed Walker, and David Wooley. Rep. *Climate Policy, Environmental Justice, and Local Air Pollution*, Brookings Economic Studies, 2020.
[6] Mulligan, James A, ed. Rep. *Southeast Colorado Springs, Colorado*. Washington, DC: Urban Land Institute, 2018.
[7] Ibid.

III. Question One: How Much Do We Know About Air Pollution in Southeast Colorado Springs?

We took several different data-driven approaches to study the air quality in Colorado Springs. First, we looked at long term data from existing monitoring systems to understand the temporal variation of pollution concentrations. Second, we transitioned into mapping modeled pollutant concentrations and social determinants of health to understand the spatial variability of pollutants in congruence with vulnerabilities that Southeast may face. Third, we carried out a two day temporary study where we collected particulate matter and compared its chemical composition between Colorado College and Solid Rock Christian Center. To understand how wind transports pollution to Solid Rock, we performed a two week study to analyze particulate matter and ground-level ozone concentrations, wind speed, and wind direction. Finally, we analyzed point source pollution to identify polluting facilities and to propose new locations for monitoring.

A. Pollutants

Six air pollutants are regulated by the Environmental Protection Agency (EPA): ground-level ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide.[8] In discussing the air quality in Colorado Springs, especially the Southeast neighborhood, we focus on particulate matter, ozone, and sulfur dioxide. Public health concerns in the Colorado Front Range region mainly focus on these pollutants given the region's oil and gas operations, urban development, and intensifying western wildfires.[9,10]

Particulate matter (PM) is a mixture of solid particles and liquid droplets in the air. They appear in varying sizes, with larger particles like dirt and smoke and smaller particles that cannot be seen by the naked eye. The EPA defines two types of PM: PM_{10},which is inhalable particles with a diameter of 10 micrometers and smaller, and $PM_{2.5}$, which is fine inhalable particles with a diameter of 2.5 micrometers and smaller.[11] PM can be emitted directly from a number of anthropogenic and natural sources, including construction sites, fields, and fires. A portion of PM in the atmosphere is formed through chemical reactions from emissions from power plants, industries, and automobiles. In terms of health impacts, $PM_{2.5}$ is a more serious threat to health than PM_{10} because the small particles can enter a person's lungs and bloodstream. This can be fatal for people with pre-existing heart or lung conditions. PM is also damaging to the environment, disrupting pH in water bodies, depleting nutrients in soils, damaging crops, and impacting diversity in ecosystems.[8]

Ground level ozone (O_3), a secondary air pollutant, is formed through chemical reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOC). These chemicals react in the presence of sunlight and are emitted by sources such as cars, power plants, and industries.[12] Unhealthy levels of O_3 frequently occur on hot and sunny days in urban environments due to temperature facilitating the reaction between NO_x and VOCs. Thus, while nitrogen dioxide (NO_2) is not a primary air pollutant in Colorado Springs, we

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[8] "Criteria Air Pollutants ." EPA. Environmental Protection Agency, 2022.
[9] Brasch, Sam. "Why Colorado's Record Ozone Pollution Is More about Cars than Wildfire Smoke." Colorado Public Radio. Colorado Public Radio, September 15, 2021.
[10] "Air Quality Impacts from Oil and Gas." Boulder County, October 14, 2020.
[11] "Particulate Matter (PM) Basics." EPA. Environmental Protection Agency, 2022.
[12] "Ground-level Ozone Basics." EPA. Environmental Protection Agency, 2022.

monitored it in this study as an O_3 precursor in order to investigate the seasonality of the O_3 formation. Like the other pollutants, O_3 can be transported by the wind, meaning unhealthy concentrations are not limited to urban areas. Studies have shown that O_3 contributes to airway inflammation and increases health risks for people with asthma.[13]

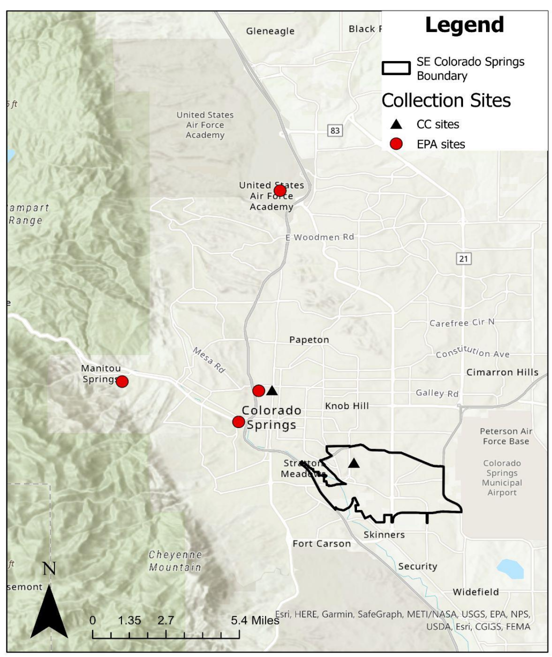
Sulfur dioxide (SO_2) is one of the most harmful pollutants among all sulfur oxides (SO_x) regulated by the EPA.[14] Sources of SO_2 are primarily the burning of fossil fuels by power plants and industries. It also results from smaller-scale industrial processes such as metal extraction and vehicle exhaust. SO_2 can also harm the respiratory system, and other sulfur oxides can react to form and contribute to PM concentrations. Environmentally, gaseous SO_x harms trees and plants at high concentrations.[11]

B. *Air quality in Colorado Springs*

1. *Temporal variation: analysis of long-term EPA data*

In Colorado Springs, the EPA only operates four permanent air monitoring sites. These sites are near I-24, I-25, the Air Force Academy, and Manitou Springs. Currently, there is no EPA-certified monitoring site in Southeast (Map 1). In order to provide a general overview of air quality in Colorado Springs we looked at long-term data trends measured at these stations, specifically the yearly and seasonal variation of $PM_{2.5}$, PM_{10}, SO_2, and O_3.

General Site Map (temporary sites vs EPA sites)



Map 1. Permanent EPA monitoring sites (in red dots) and temporary study sites (in black triangles). The border of Southeast Colorado Springs is outlined in black. There are no EPA sites in the boundaries of SE.

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[13] Olivieri, D., and E. J. E. R. R. Scoditti. "Impact of environmental factors on lung defenses." *European Respiratory Review* 14, no. 95 (2005): 51-56.

[14] "Sulfur Dioxide Basics." EPA. Environmental Protection Agency, 2022.

Over the past decade, ozone measured at Air Force Academy displays an increasing trend in yearly average, while $PM_{2.5}$ and PM_{10} do not show an increasing or decreasing trend. (Appendix 1, Figures 1, 2, and 7). This is consistent with the growing concern of ozone pollution in the Colorado Front Range.[15] $PM_{2.5}$, PM_{10}, and O_3 all show seasonal fluctuations, with higher concentrations occurring during the warmer months from June to September (Appendix 1, Figures 3, 4, 12 and 13). Upon closer examination, we find the summertime $PM_{2.5}$, PM_{10}, and O_3 concentrations to increase over the years, in August and September in particular (Appendix 1, Figures 5, 6, 14 and 15). The greater ozone chemical formation rate during summer is the main contributor to higher summertime ozone concentrations. Wildfires during hotter months also contribute to elevated PM and ozone concentration as smoke travels from the west or from within Colorado state.[16]

In terms of the trends of SO_2 concentrations, over the course of 2013 to 2021, data from the EPA station off of Highway 24 shows a noticeable decrease in SO_2 starting in 2016 (Appendix 1, Figure 16). Throughout 2016 and 2017, SO_2 scrubber systems were installed at the Martin Drake Powerplant to adhere to stricter federal emission standards. This has dramatically decreased SO_2 emissions from the facility.[17] Our data displays that the policies and controls for sources of pollution, i.e. installation of the SO_2 scrubbers, can lead to a significant impact. At the time of testing, these scrubbers captured over 97% of SO_2 emitted from each unit.

Though SO_2 seasonal trends show a relative peak in March, summer also tends to be when higher SO_2 concentrations occur (Appendix 1, Figure 17). Similar to PM and O_3, SO_2 concentrations during hotter months, especially June and July, also show an increasing trend over the years (Appendix 1, Figure 18), which combines to support that summertime is a more risky period for all pollutants. Prior studies have shown that higher temperatures increase pollution concentration, especially during extended periods of heat in summer.[18] Under the trend of global climate change, hotter summers and new weather patterns create suitable conditions for fires in summer and fall.[19] During the summer months, people generally spend more time outside, especially schoolchildren. Given the more dangerous air quality conditions during the summer, in-depth studies and regulatory actions should mainly focus on this period of the year. We will elaborate in *Section V. A* on how cooling and cleaner air centers as an example that addresses the hazards from both heat and air pollution.

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[15] Brasch, Sam. "The EPA Moves to Declare the Front Range a 'Severe' Air Quality Violator. Here's Why That Matters." *CPR News,* April 12, 2022.

[16] Flynn, Margot T., Erick J. Mattson, Daniel A. Jaffe, and Lynne E. Gratz. "Spatial Patterns in Summertime Surface Ozone in the Southern Front Range of the U.S. Rocky Mountains." *Elementa: Science of the Anthropocene* 9, no. 1 (2021).

[17] Anleu, Billie Stanton. "Colorado Springs Utilities Takes Charge of Drake Scrubbers." *The Gazette*, September 26, 2016.

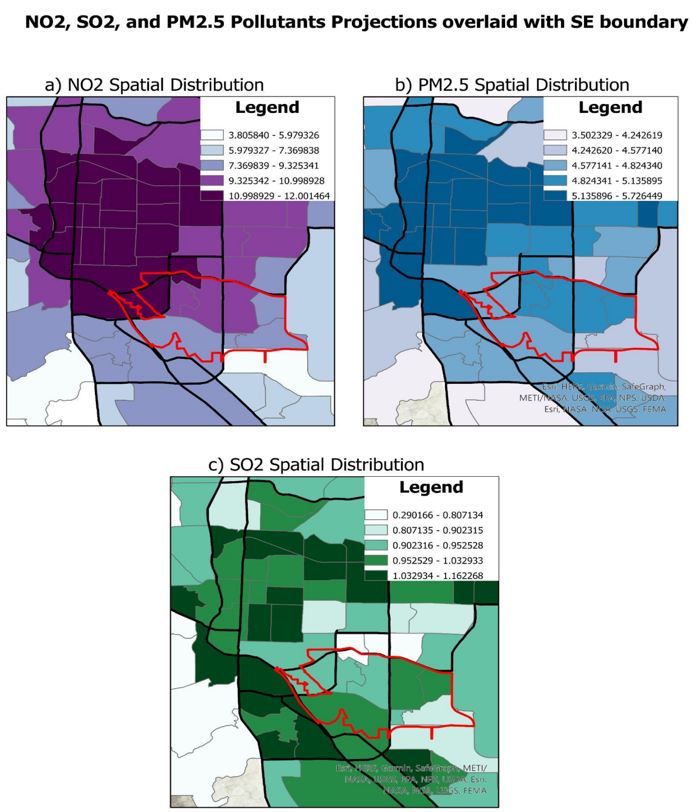
[18] Kalisa, Egide, Sulaiman Fadlallah, Mabano Amani, Lamek Nahayo, and Gabriel Habiyaremye. "Temperature and Air Pollution Relationship during Heatwaves in Birmingham, UK." *Sustainable Cities and Society* 43 (2018): 111–20.

[19] Zou, Yufei, Philip J. Rasch, Hailong Wang, Zuowei Xie, and Rudong Zhang. "Increasing Large Wildfires over the Western United States Linked to Diminishing Sea Ice in the Arctic." *Nature Communications* 12, no. 1 (2021).

2. *Spatial variation of pollutants*

For the next part of our research, we examined the spatial distribution of air pollutants in Colorado Springs. From the modeled pollution maps of $PM_{2.5}$, SO_2, and NO_2, we did not find a stark difference between air pollution concentrations in Southeast and the rest of the city (Map 2). This means that Southeast does not receive comparatively greater air pollution, and thus air quality should be addressed as a city-wide challenge.

Looking closely at the Southeast community on the modeled pollution maps, we see a trend of higher concentrations of SO_2 and NO_2 inside the Northwest boundary of Southeast. Though NO_2 is not one of our key pollutants in this study, NO_2 is a precursor for ground-level ozone, meaning that its emission directly contributes to the formation of ozone. For $PM_{2.5}$, there appears to be a higher concentration in the most densely populated space in the Southeast (Map 2.C). From these maps, we see three pollution corridors, one in the northwest, one in the north (seemingly along East Platte ave.), and one along the western side of I-25. It is important to note that the data on Map 2 is modeled, which means it is projected instead of measured in real-time. With stronger long-term monitoring campaigns that consist of more sites and a more comprehensive representation of communities, one would be able to create a more accurate view of air pollution in Southeast Colorado Springs.



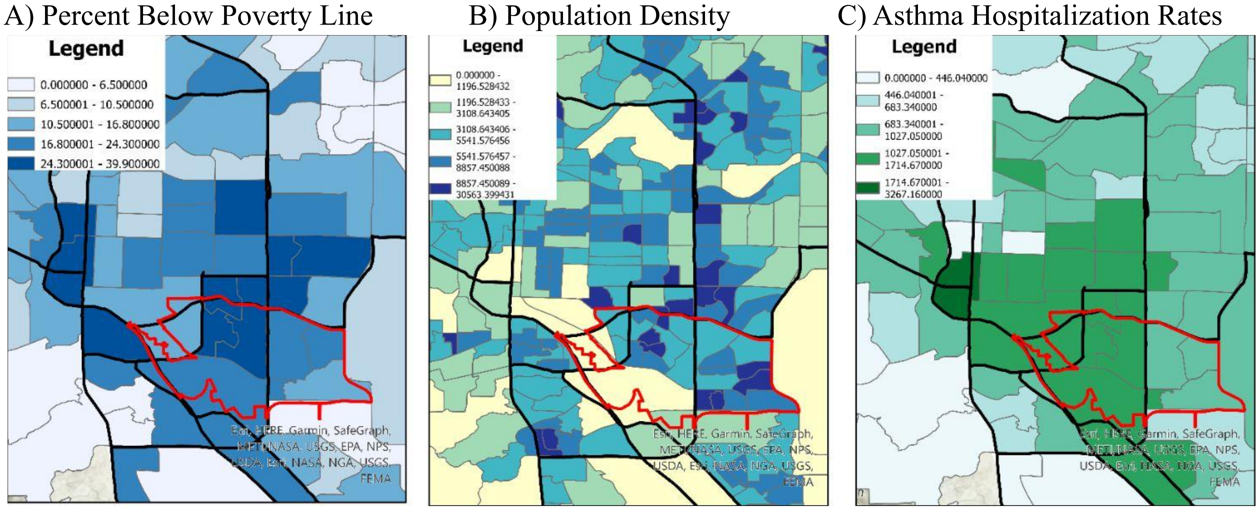
Map 2. Modeled air pollution concentrations of NO_2, $PM_{2.5}$, and SO_2. The border of Southeast Colorado Springs is marked with the red line. As seen, there is not necessarily higher concentrations of modeled pollution in SE.

3. *Social Determinants of Health*

We also looked at the spatial variation of social determinants of health in the Southeast. According to the Department of Health and Human Services, "social determinants of health are the conditions in the environments where people are born, live, learn, work, play, worship, and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks."[20] We have analyzed three major social determinants: percent below the poverty line, population density, and asthma hospitalization rates. Although we do not observe higher pollutant concentrations in Southeast compared to the rest of Colorado Springs, it is important to note that the higher proportion of residents under the poverty line, the greater population density, and the relatively higher rates of asthma hospitalization in Southeast make the community more vulnerable to air pollution compared to the other areas of the city (Map 3A, 3B, 3C). Typically, people living below the poverty line have less means to protect themselves from the effects of air pollution, such as access to cooling and clean air systems and affordable healthcare (see Cooling and Cleaner Air Centers, p. 21). Additionally, with higher concentrations of people in the Southeast, coupled with relatively higher asthma hospitalization rates, the Southeast is more susceptible to the health impacts of air pollution. Though the projection models of $PM_{2.5}$, SO_2, and NO_2 do not show higher air pollution in the Southeast, social aspects reveal the increased sensitivity of this community to unhealthy air quality.

Social, Population, and Health Disparities in Southeast, Colorado Springs

A) Percent Below Poverty Line B) Population Density C) Asthma Hospitalization Rates

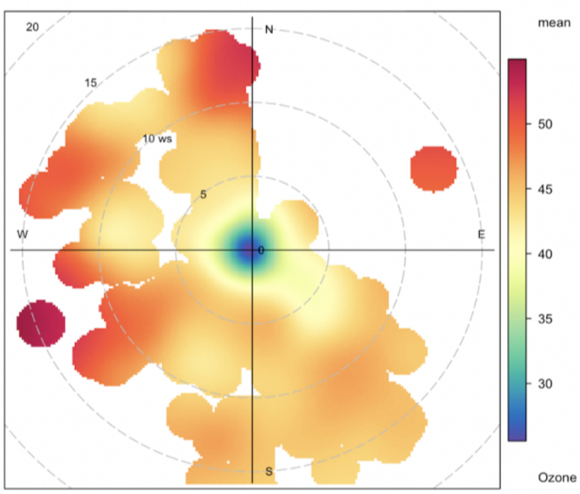


Map 3. Social determinants of health, which consists of percent below poverty line, population density, and asthma hospitalization rates. The border of Southeast Colorado Springs is marked with the black line.

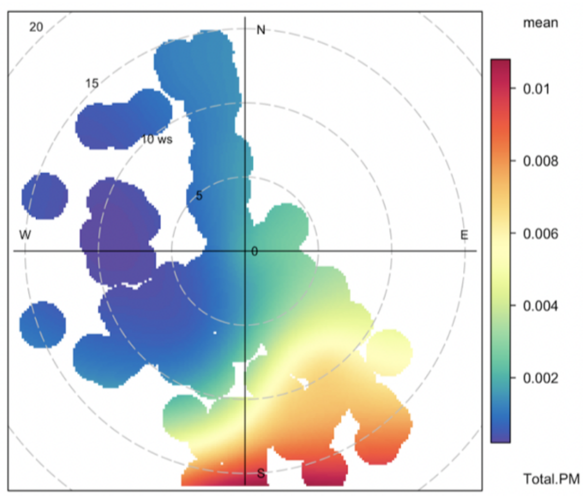
[20] "Social Determinants of Health." Social Determinants of Health - Healthy People 2030. Accessed April 19, 2022. https://health.gov/healthypeople/priority-areas/social-determinants-health.

4. *Temporary comparative studies (Apr 2022)*

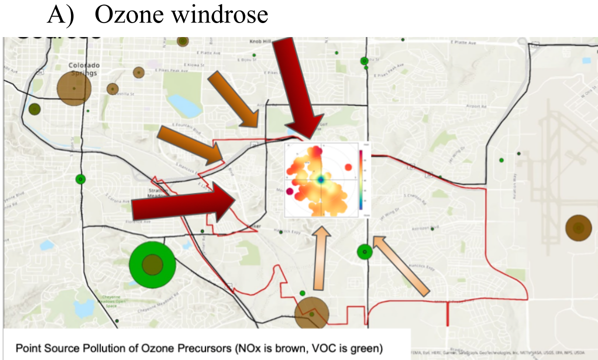
Given the lack of an EPA air monitoring station in Southeast, we established our own two-week study to analyze air pollution at Solid Rock, where we measured O_3 concentrations, PM concentrations, wind speed, and wind direction (Map 1). We found limited production of O_3 within Southeast, but observed that higher concentrations of O_3 are transported by wind coming from the North and the West (Map 4.A). This indicates that the point sources of pollution, those that emit ozone precursors VOCs and NO_x, from the North and the West are the main contributors to the ozone pollution at Solid Rock. One potential pollution site is a technology factory to the west of Solid Rock that produces microcontrollers and various types of integrated circuits (Map 4.C). Additionally, downtown and businesses/industrial areas on Platte Avenue are emitting pollution from the northwest. These are represented by the string of dots along Platte. Smaller concentrations of pollution come from point sources like gas stations, as well. For more information about the specific point source pollution see [Appendix 1.](#) The land use/zoning map also displays some industrial zones that did not show up on EPA point source reports (Map 5).



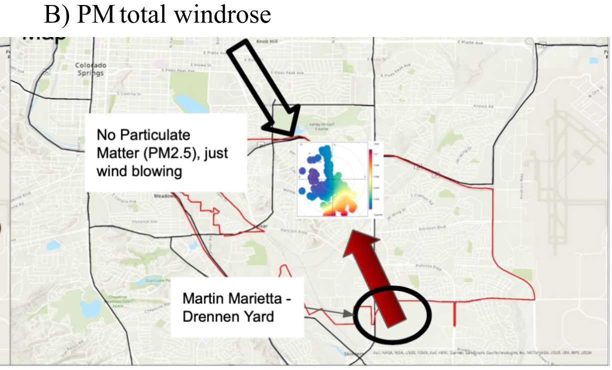
A) Ozone windrose



B) PM total windrose



C) Ozone windrose overlaid with point sources of ozone precursors (NO_x and VOCs) on map

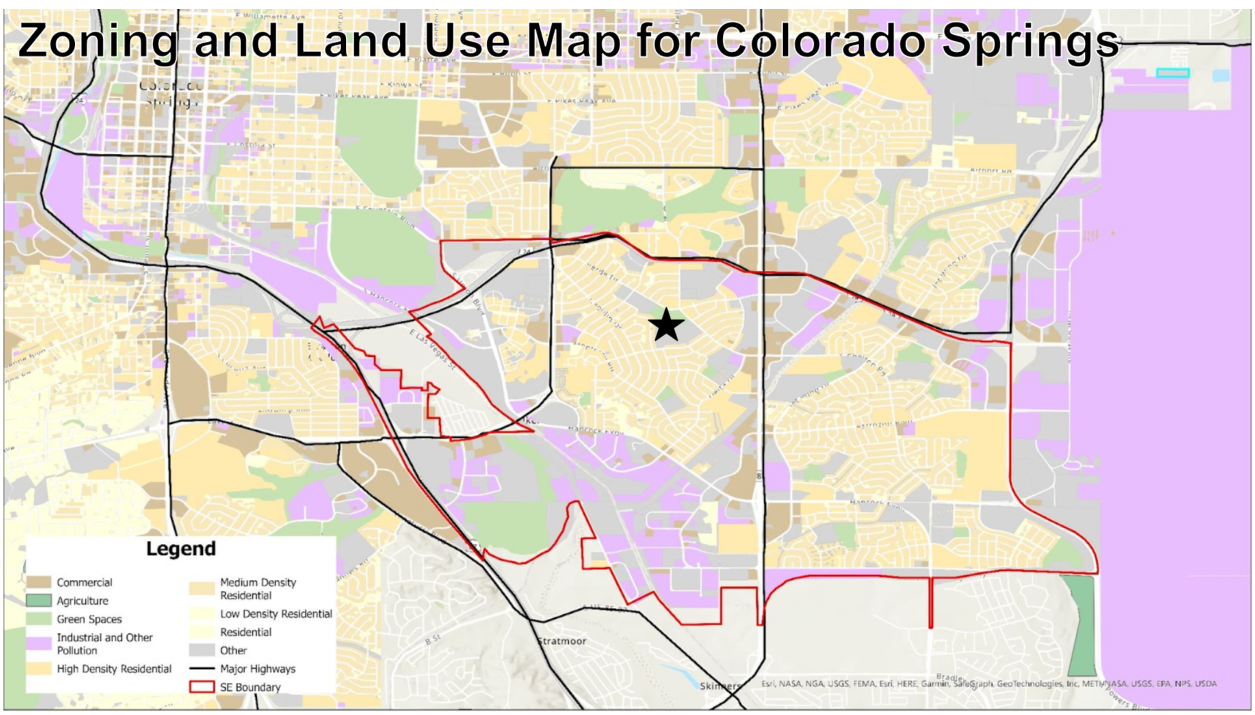


D) PM total windrose on map.

Map 4. A and B: Ozone and PM total windrose based on two-week measurement at Solid Rock. The scale bar for ozone windrose is in the unit of ppb, and the scale bar for PM is in the unit of mg/m^3. Wind direction refers to where the wind is coming from as measured from Solid Rock. C and D: Wind directions that contribute most to high ozone and PM levels.

We also performed a two-day study where we placed air filters at both sites for chemical composition analysis. The air filters that collected particulate matter did not show statistically different chemical compositions between Solid Rock and Colorado College for the two days of data collected. The three pollutants that had statistically significant differences (sodium ion, magnesium ion, and chloride) had higher concentrations at Colorado College than at Solid Rock, which can be found in Table 2 of Appendix 3. This further supports our claim that air quality is a city-wide issue. The PM windrose demonstrates that higher $PM_{2.5}$ concentrations occur with high southerly winds (Map 4. B). The point source of the open-pit gravel mine (called the Martin Marietta Drennen Yard) in southern Colorado Springs is likely the main emitter from this direction (Map 4. D).

Though we could not visualize and easily interpret the on-road emission data available in EPA database, motor vehicle emissions have been found to be another major source of ozone, and likely other pollutants, in the Colorado Front Range.[21,22] The main highways and roads that we believe are impacting the Southeast are Highway 24, I-25, and Academy Boulevard. To continue to understand air pollution in Southeast Colorado Springs, it is crucial to implement long-term monitoring along roads and, more importantly, compare that data to point sources' contribution to high pollution periods.



Map 5. Zoning and land use in Colorado Springs. The purple areas are dominated by industrial spaces and other pollution sources.

[21] Staff. "Scientists Pinpoint Sources of Front Range Ozone." *NCAR & UCAR News*, October 30, 2017.
[22] Flynn, Margot T., Erick J. Mattson, Daniel A. Jaffe, and Lynne E. Gratz. "Spatial Patterns in Summertime Surface Ozone in the Southern Front Range of the U.S. Rocky Mountains." *Elementa: Science of the Anthropocene* 9, no. 1 (2021).

C. *Site Selection for Expanded Air Monitoring*

Once we established an overview of the air quality challenges in Southeast, we turned to focus on detailed methods to increase monitoring, including suggested permanent sites. As winds from the north and west tend to bring in high concentrations of ozone, we believe it would be effective to set up a monitoring site in the northwest corner of the Southeast Colorado Springs region (Map 4. A and C). This suggestion is also supported by the high vulnerability of this northwest residential community, given the higher asthma hospitalization rates, population density, and percentage of residents below the poverty line (Map 3). Solid Rock, located in the Northwest corner, can be an ideal new monitoring site. We suggest continuing to run the monitoring instruments (particulate analyzer, ozone analyzer and filter pump) we have set up for this study for another several months.

Additionally, a site on the southern side of the Southeast region would prove helpful in monitoring PM because of the winds coming from the south (Map 4. B and D). We encourage the Environmental Program at Colorado College to continue its relationship with Solid Rock in regards to air quality monitoring in the Southeast. As the current dataset and modeled data are only based on two weeks of study, they are not statistically sound enough to yield significant conclusions. A longer-term dataset from an ongoing study would provide us with the stronger evidence needed to conclude if the air pollution levels in Southeast differ from the rest of the city.

Based on the land use purposes, we also propose several other air monitoring sites at various locations, including community centers, places of worship, schools, and potentially a health center. The sites are Solid Rock Community Development Corporation, Deerfield Hills Community Center, Harrison High School, Sierra High School, Pikes Peak Park Baptist Church, True Spirit Baptist Church, James Irwin Charter Elementary School, Giberson Elementary School, Victory World Outreach, Peak Vista Community Health Center, Solid Rock Youth Center.

In considering locations of future monitoring sites, it would be beneficial to set up equipment in areas that meet the criteria of an EPA-certified monitoring station. If residents of Southeast, Solid Rock, or any other organization eventually come together to advocate for new EPA-certified stations in this region, presenting pre-recorded data that was measured in accordance with EPA standards would greatly increase the chance of a site approval by the state government (See Appendix 4 for EPA criteria for site selection). Additionally, as we selected potential sites at community gathering spaces, active social interactions in these areas can result in great potential for community outreach at Solid Rock.

IV. Question Two: How To Learn More About Air Pollution In Southeast Colorado Springs

While our data on pollution in Southeast did not yield evidence of any significant difference in pollution concentration compared to Colorado Springs as a whole, it is important to note that the data we collected was only over the course of one week, which is not nearly enough time to provide a complete image of air pollution in Southeast. To be able to advocate for future change, more air pollution monitoring must take place in the region. Since there are only four EPA-certified air monitoring stations in Colorado Springs, with none near Southeast, action must be taken to increase air pollution monitoring in this part of the city. There is much to be learned from monitoring pollution across Southeast, particularly because the closest EPA sensor, which is several miles away from the community, is likely to misrepresent the actual air quality status in Southeast due to its distance.[23] More air monitoring in general means more data, which is crucial for holding polluting entities accountable so communities can defend themselves and create change.

Air monitoring is an important practice because it has the ability to save lives and, more generally, improve community health. About 90% of the world's population will breathe polluted air at some point in their lives.[24] This often goes undetected because pollutants are not always visible. Air pollution monitoring will help inform community members of the amounts, and kind, of air pollutants in an area. This information can then be used to bring awareness and further advocate for community-level or government action to combat the health effects of increased pollution and decrease the pollution itself. However, air pollution monitoring is not available for every community in the United States. This is particularly true for lower-income communities which tend to be at higher risk for respiratory illnesses that are caused or worsened by high concentrations of air pollutants. The lack of air monitoring in Southeast is alarming because of the danger residents face as a result of their social vulnerability.[25]

City government actions can be taken to expand air monitoring in Southeast, as actions at the city level have proven successful in other cities across the country and the world. Communities across the country have also come together to take part in air monitoring projects, which allow citizens to be informed about their air quality and to take further action. In our research, we looked at several methods and technologies that would introduce air monitoring to the Southeast across varying scales of implementation. We also discuss how Solid Rock can be involved in implementing each of these strategies, whether it is by taking control of a community project or supporting a larger scale project as a partner or advocate.

A. *EPA-Certified Stations*

Applying for the establishment of an EPA-certified monitoring station that would be implemented within the existing statewide ambient air monitoring network would be the most reliable, accurate, and best case scenario solution for expanding our knowledge about air pollution in southeast Colorado Springs. The current state-implemented and controlled air ambient monitoring network consists of 44 stations across 8 different multi-county regions "that are generally based on topography and have similar airshed characteristics."[26] The Colorado Air Pollution Control Division, which operates under the State Department of Public Health and Environment, states that in the past, new stations

[23] Hurdle, Jon. "More Eyes on Polluters: The Growth of Citizen Monitoring." *Yale Environment* 360, November 3, 2021.
[24] Chandler, Mark. "Air Quality: Community Engagement Helps Make the Invisible Visible." Earthwatch.
[25] Hijazi, Jennifer. "Community Air Monitoring Is an 'Inevitable' Issue for Industry." *Bloomberg Law*, December 8, 2021.
[26] "2021 Ambient Air Monitoring Network Plan". Colorado Department of Health and Environment. Air Pollution Control Division. 2021.

have been added to the network due to public health concerns from communities and due to special research studies.[27]

One of these stations would be the most reliable way to gather consistent data, and it would be beneficial to the community as there would be designated staff and experts that would run, maintain, and repair the station. However, there is almost no telling how long the process of attempting to establish a new monitoring station within the state's network would take. Furthermore, simply demonstrating that a community is concerned about air pollution will not be considered enough to warrant a new station. Evidence of a connection between public health and air pollution, and/or a notable difference between the quality of air in the Southeast region of the city compared to where the current stations are located, would need to be shown as justification for the state to add an additional station to their expansive network.[28] In other words, if a new EPA station is the end goal, the request needs to be backed up by clear and reliable evidence of a Southeast-specific air pollution problem.

B. *City Level Air Monitoring*

Because there is no time frame for how long the process of getting an EPA-certified air monitoring station in Southeast will be, and there is a need for long-term data to justify the addition of a new certified station, we reviewed several city-level air monitoring techniques. These have been implemented at the municipal government level across different cities in the United States and the world. These potential air monitoring methods would require lobbying to the city or state government, but they can provide substantial air pollution data that could fill the void left by the absence of an air monitoring station in Southeast Colorado Springs.

1. *Mobile Trailer Equipped with Air Monitoring Equipment*

In New Mexico, Albuquerque's Air Quality Program recently set up a mobile air pollution monitoring trailer. It is installed with equipment that measures the EPA's six criteria pollutants along with "organic black, brown, and total carbon; as well as 75 hazardous air pollutants (or HAPs) including volatile organic compounds (or VOCs)."[29] An investment of $750,000 from the city made the trailer possible. Its purpose is to target specific communities that may potentially be impacted by different levels of air pollution relative to the rest of the city as a result of their proximity to increased amounts of commercial or industrial pollution. In Fall 2021 it was parked in its first location, the San Jose neighborhood, which is a historically underserved part of the city similar to Southeast Colorado Springs. The trailer is parked in one location for a full year in order to collect a reliable data set for observation and analysis. Once this yearly cycle is complete, the Air Quality Program will then decide whether the trailer needs to stay in its current location for a more complete study that will account for variables and seasonality changes, which would take around three years in total. However, if the results after one year show no clear discrepancies between

[27] Ibid.
[28] Ibid.
[29] "City Launches New Mobile Air Quality Monitoring Trailer." City of Albuquerque, 2021.

the San Jose neighborhood's air quality and the rest of the city, it will more than likely be moved to a different location.

The Albuquerque mobile air monitoring trailer

A similar project in Southeast would require funding from either Colorado Springs or the Colorado State government, and there would likely need to be evidence of health problems that are directly linked to pollution in a specific part of the city. Additionally, these trailers require professionally trained, dedicated staff to maintain them throughout their entire use.

Advocating for a similar monitoring trailer program in Southeast would be an alternative method to measure air quality in a reliable, accessible, and versatile way. It is a long-term investment that would give residents an accurate look at what their air quality is really like. It would be a great asset for one of the fastest growing large cities in the country that has an urgent hole to fill in terms of identifying to what extent air pollutants are impacting the health of its residents.

2. *Vehicle Based Air Quality Monitoring Units*

Vehicle-based air quality monitoring units, which are attached to cars and driven around, are manufactured by several companies and have been implemented in several cities in the US already. The primary draw of vehicle mounted air quality monitoring solutions is that they cover large areas at a relatively low cost. Instead of placing many stationary sensors across a city, just a handful of sensors attached to vehicles can cover the same amount of ground for much less cost. The units can be attached to transit vehicles such as buses or be placed on dedicated air monitoring vehicles.

Vehicle-based air quality monitoring is not without drawbacks. By the nature of being mounted to a vehicle, they are only capable of measuring air quality on roads. This gives useful data about pollution on and near roads, but misses areas without roads. It is also difficult to get long-term and detailed data about a specific area because a parked vehicle would be vulnerable to the hyperlocal pollution of whatever road it was parked on.[30] For specific vehicle-based air quality monitoring solutions, see *Appendix 5*.

Toronto Urban Scanner Project

3. *Non-EPA Permanent Air Quality Monitoring Stations*

Permanent air quality monitoring stations have historically been the standard approach to city level air quality monitoring. These stations typically consist of a metal box attached to a building or other structure, and are upkept by a city contracted professional. The biggest advantage of a permanent station is that they provide long-term and detailed data about the air quality of the location where they are placed. This type of data is important when proving a discrepancy in air quality because mobile station data is not always suitable for publication. The other major advantage of permanent stations is that they can be placed away from roads; this allows them to be placed in residential areas and other important areas that are not near streets. The disadvantage of permanent stations is that they cover only one location, and many are needed to cover a large area. This leads to higher up-front costs and upkeep expenses.[31] Specifics of permanent stations can be found in Appendix 6.

An example of an AQMS

[30] "Urban Scanner US20: Scentroid: Mobile Air Quality Smart City Monitor." Scentroid, December 16, 2021.
[31] The World Air Quality Index project. "Chất Lượng Không Khí Trên Toàn Thế Giới: Airnet Sensor Network."

C. *Community-Based Air Monitoring*

In addition to EPA-certified stations and city level air monitoring, community-based air monitoring provides an opportunity for citizens to become involved in data collection, creating awareness and educating communities on their localized air quality. We suggest four air monitoring projects to Solid Rock; BouldAir, The Village Green Air Monitoring Station, PurpleAir sensors, and a continued partnership with Colorado College as ways to involve Southeast residents in air quality monitoring moving forward.

1. *BouldAir*

Boulder Air Innovation Research (BouldAir) is a nonprofit that investigates air quality for a variety of communities in Northern Colorado and the Denver Metro Area. Their model is based on combining existing air quality with EPA certified or research-grade equipment to target point sources, especially those in the oil and gas industry.[32] While oil and gas may not be the primary air quality concern for Southeast, BouldAir provides a flexible framework that could be implemented in Southeast or in Colorado Springs as a whole, with efforts targeted at improving the resolution of air quality data for at-risk communities. If measurements find notable point sources, BouldAir could help to hold them accountable for health ramifications. BouldAir's services are cheaper ($80,000-300,000) than many monitoring solutions, and make data available within days (rather than months to years for EPA data).[33] Costs could be reduced by continuing to partner with Colorado College for maintenance and data work. Work with BouldAir would lower the barrier to air quality data while reporting accurate results to authorities. It is a decidedly more efficient system than citizen-based monitoring or EPA sensing, with the drawback of operating mostly at the municipal level.

While the majority of BouldAir's contracts exist at the municipal level, they have several contracts with nonprofits as well. Solid Rock could contract with BouldAir directly or lobby the city to form a contract, and both would undoubtedly lead to some positive change for Southeast. However, the municipal level could fail to represent the interests of Southeast as it would implement monitoring for the city as a whole. It would be possible for other communities to vie for monitoring capabilities over Southeast, limiting the efficacy of monitoring for Southeast. Despite this, given that the consultation would include site visits, it is likely that researchers would consider the environmental justice impacts of the roads and industrial areas near Southeast as significant sources of pollution. Working at the municipal level, if done carefully, could help secure necessary funding and speed up the process at the cost of oversight of the project. If the air in Colorado Springs as a whole is cleaner, then the health impacts of pollution in Southeast could improve, but maintaining community agency is a priority of this report.

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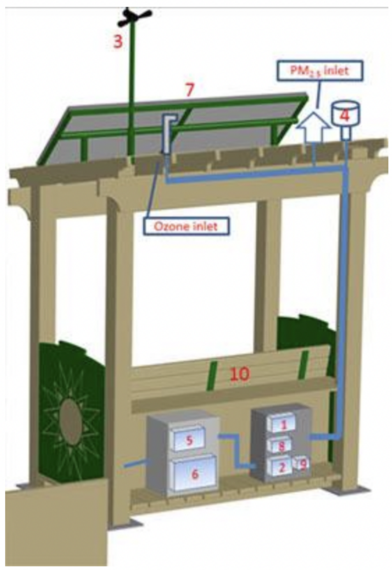
[32] Boulder Air Innovation Research. "About"

[33] Dr. Detlev Helmig interview by Ryan Freedman

2. *Village Green Monitoring Station*

A second potential type of air monitoring system is the Village Green Air Monitoring Station. It was developed by the EPA to encourage community-based work and show the potential for locals to learn about the air quality in their community.[34] The name "village green" refers to the station's placement; as it is meant to be in an outdoor accessible area where people congregate, like a park, to allow for greater participation and interaction with this technology.[35] The system is built into a park bench, as shown in the image below, and has solar panels that provide enough energy to power the station.



Village Green station schematic

List of Components - No. Component (model)

1. Particulate monitor (pDR-1500)
2. Ozone monitor (OEM-106)
3. Wind sensor (09101)
4. Humidity and Temperature sensor (HMP60)
5. Power controller (SunSaver SS-10L-12V)
6. Absorbed glass mat (AGM) battery (WKDC12-80P, 12 volt, 80 Ah)
7. Solar panel (SLP085-12MKCT 85 Watt, 12 VDC)
8. Microprocessor (Arduino Mega 2560)
9. Cellular router (AirLink Raven XE)
10. Bench Structure

Village Green Air Monitoring Station

The data is transmitted in real-time and is accurate enough to estimate the Air Quality Index (AQI), which is the EPA's index for reporting air quality; the higher the AQI value, the greater the level of air pollution and health concerns.[36] The Village Green station gets this information by measuring ozone, $PM_{2.5}$, wind speed, wind direction, humidity, and temperature.[37] These measurements do not meet official EPA air quality standards, but rather they are intended to help a community study how air pollution patterns vary with time and weather on a long-term timescale.

The first implementation of the Village Green Air Monitoring Station was in Durham, North Carolina at the Durham County South Regional Library in 2013.[38] This station is still operating today and is managed by the community where locals oversee its maintenance and continued operation. This station has

[34] "A DIY Dream: Build Your Own Village Green Air Monitoring Station." EPA. Environmental Protection Agency, March 26, 2018.
[35] Kimbrough, Sue, R. Williams, R. Duvall, T. McArthur, and C. Williams. *Village Green Design, Operations, and Maintenance Document.* U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-18/037, 2018.
[36] Ibid.
[37] Ibid.
[38] "Village Green Project." EPA. Environmental Protection Agency, April 19, 2021.

been used for educational outreach activities with nearby schools, library programs for children, and other patrons.[39] Due to the Village Green Station's success in Durham, seven other stations were set up across the US to improve the model's effectiveness for data collection in varying weather conditions. The project as a whole "exceeded its goal in bringing EPA's air quality science and technology to communities interested in air quality."[40] The EPA has released the seven other stations to the communities, where some of them continue to collect data. Continuing this work and implementing a station in the Southeast would require a few months of preparation. See Appendix 7 for the detailed plans for the implementation of a Village Green station. Knowing that the EPA started this project to engage a community in understanding and learning about their local air quality over time, this project provides Solid Rock with an opportunity to bring Southeast residents together over an issue that concerns the long-term health of the community.

There are funding options available through the EPA to get a Village Green Monitoring Station installed in the Southeast. For example, there is an EPA grant called Enhancing Air Quality Monitoring for Communities that awards money to support a community's effort to monitor their air quality and to promote awareness through outreach within surrounding communities.[41] This grant is found among many others on the EPA's Air Grants and Funding page, which is constantly being updated with new funding opportunities.

3. *PurpleAir Sensors*

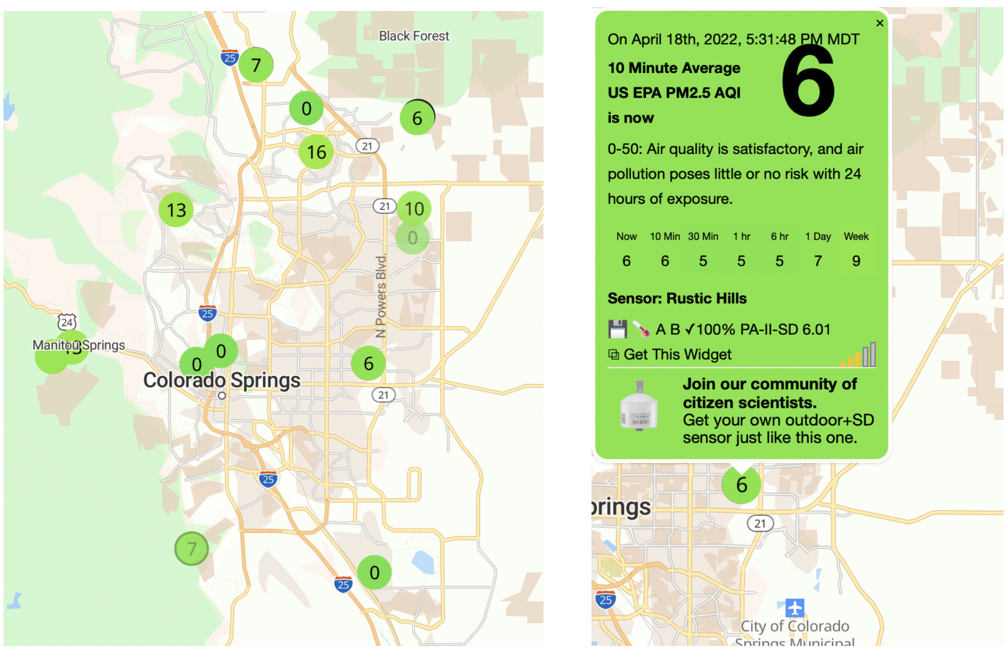
Another type of air monitoring we looked into is by the company PurpleAir, operating out of Draper, Utah, which has sparked a community science movement for air quality monitoring in the US and internationally. This company has created inexpensive air quality sensors that collect hyper-local, real-time air quality data.[42] This data is accessible to people everywhere through their website and app, contributing to our global knowledge of air quality because over 10,000 sensors have been installed worldwide. The expansiveness of PurpleAir sensors help to provide air pollution data with greater spatial representation.[43]

PurpleAir has three sensors for outdoor air monitoring. The PurpleAir PA-II for $249 and the PurpleAir PA-II-SD for $279 both measure real-time $PM_{2.5}$ concentrations, but the PA-II-SD has an SD card allowing the sensor to record and store data for locations where wifi is not available. The last model is the PurpleAir PA-II-FLEX for $299 that also measures $PM_{2.5}$ and has both wifi capabilities, an SD card, and a LED sensor that glows the color of the current air quality (green, yellow, orange, red, maroon)[44]. All three sensors need to be connected to a power source and wifi so they can transmit data to the PurpleAir website and app. The sensors require little maintenance, though it is advised to

[39] Ibid.
[40] "Village Green Project Air Monitoring Stations A Success." EPA. Environmental Protection Agency, May 7, 2019.
[41] "Air Grants and Funding." EPA. Environmental Protection Agency. Accessed April 19, 2022.
[42] "PurpleAir: Real-Time Air Quality Monitoring." PurpleAir, Inc. Accessed April 19, 2022.
[43] Brissette, Perry. "Breathing Easy — Scientists Praise a Grassroots Movement as Air Quality Sensors Arrive At Our Doorstep." Web log. *Medium* (blog), December 17, 2020.
[44] "Air Quality Sensors." PurpleAir, Inc. Accessed April 20, 2022.

check that the sensor is connected and upload data. Further details about all of the sensors can be found on the PurpleAir website.[45]

There are already active PurpleAir sensors in residential areas in Colorado Springs, as seen in the image below from PurpleAir's Real-Time Map. However, there are none in the Southeast. Each green circle in the image is a sensor and the number represents an estimated AQI value. When a user clicks on a sensor, information emerges, which includes AQI measurements and health conscious recommendations based on the AQI. Placing a few sensors in Southeast would provide an excellent opportunity to understand more about air quality in the area, especially because we can already see there is variability in air quality across Colorado Springs from the existing sensors.



PurpleAir Sensors in Colorado Springs

It is a relatively simple process to purchase and mount a PurpleAir sensor, so attaining air quality data with these devices is highly accessible. Due to their accessibility these sensors have gained recognition in the scientific community, where "scientists and air quality experts are praising this movement as a success, citing how these sensors help build a more complete picture of air quality as they reach into under-served locations like schools, tribal land, recreation areas, and parks."[46] Knowing that location-specific data is sparse in Colorado Springs, installing more sensors in the Southeast in particular would provide a more accurate picture of air quality there, helping to address concerns about spatial distribution of air monitoring. While PurpleAir sensors use different technology than regulatory grade devices, bringing awareness through the sensor data gives

[45] "PurpleAir: Real-Time Air Quality Monitoring." PurpleAir, Inc. Accessed April 19, 2022.
[46] Brissette, Perry. "Breathing Easy — Scientists Praise a Grassroots Movement as Air Quality Sensors Arrive At Our Doorstep." Web log. *Medium* (blog), December 17, 2020.

agency to locals and can empower youth through programs which could involve Southeast schools.

4. *PurpleAir and Air Pollution Education*

One proven way to engage citizens on the issue of air pollution is to connect with the younger members of the community through environmental education programs. As citizen-science monitoring stations such as PurpleAir are easy to use, the implementation of such a system could open the doors to greater community outreach to students. Environmentally-focused after-school clubs, such as Harrison High School's Adventure Club, could work with an onsite PurpleAir sensor at Solid Rock, providing an anchor for a relationship between Solid Rock and local students.[47]

If Solid Rock pursues the implementation of a PurpleAir sensor, it would be beneficial to recruit the help of after-school clubs for the maintenance of the system. Students would be the ones responsible for the collection of data, and the information that they gather would bring awareness to the status of Southeast air quality.

To accompany students' involvement in air quality monitoring, Solid Rock could also offer on-site air pollution education workshops. While at Solid Rock, students would learn from other members of the community, such as students from CC, UCCS, or PPCC. College students could volunteer to teach K-12 students about air quality and ways to protect themselves and their families. The after-school club initiative would foster a mutually beneficial relationship between local K-12 students, college students, and Solid Rock.

Resources for air pollution classes already exist. In Salt Lake City, Utah, the environmental advocacy group "Breathe Utah" has partnered with the Utah State Board of Education to create air pollution lessons plans (SEEd Lesson Plans).[48] The West Atlanta Watershed Alliance also has a curriculum for environmental education.[49] These resources could easily be co-opted by Solid Rock to host after-school club events for Southeast students.

Another example of environmental education on a larger scale is the Global Learning and Observations to Benefit the Environment (GLOBE) Program.[50] Since its inception nearly 30 years ago, GLOBE has provided hands-on meteorological experiments for school children all over the world. GLOBE has developed equipment that they send to science classes so that students can gather data and then share it on a global database. The "Surface Ozone Protocol" is an easily implementable lesson plan for an air pollution workshop as it asks students to measure ground ozone concentrations.[51] Although GLOBE's programs mainly center around meteorological studies, with less emphasis on air pollution, the protocols developed would provide inspiration for lesson plans that could be used by the after-school club initiative at Solid Rock. All of GLOBE's resources are also available in Spanish.

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47 "Clubs / Adventure Club." Harrison High School.
48 Monson, Dawn. "SEEd Lesson Plans." Breathe Utah, November 17, 2021.
49 "Environmental Education." West Atlanta Watershed Alliance, February 2, 2022.
50 "About GLOBE." The GLOBE Program.
51 "Surface Ozone Protocol." The GLOBE Program. The GLOBE Program, 2014.

Within the CC community, there are several groups who could become volunteers for this programming. The Teaching and Research in Environmental Education (TREE) program is a semester program where college students develop experience teaching K-12 students about the environment.[52] These undergraduates have the skills and passion to become environmental educators, and already have lesson plans from TREE semester that could be applied to a Solid Rock after-school program.

5. *Continued Partnership with Colorado College*

Finally, Solid Rock could seek a way to continue its relationship and collaboration with Colorado College and its Environmental Program. Future Colorado College students and faculty can create a program that takes part in collecting and analyzing air pollution data in Southeast, and give access of this data to Solid Rock and potentially other community organizations to communicate it with the residents. These environmental students could expand on the short two week study that we conducted at Solid Rock and eventually provide a more complete, well rounded study on the air quality in the Southeast. Many Colorado College students express their desire to give back to the community and city that they call home, and it would be safe to assume that many students studying environmental issues would not shy away from continuing a project such as this. The data collection would not necessarily have to stay at Solid Rock, as this kind of project would be somewhat flexible in terms of where data would be collected, but Solid Rock and the general area it is located in continues to be an ideal location to continue this research. Solid Rock's involvement could be as little as letting Colorado College take the reins and simply going to them for data, and as much as being directly involved with data gathering collection and analysis, there would just need to be a clear plan and goal of a partnership such as this.

See Appendix 8 for a table reviewing all the potential air monitoring methods listed above.

[52] "Teaching and Research in Environmental Education." Education. Colorado College.

V. Question Three: What Actions Can be Taken to Reduce the Impact of Air Pollution In Colorado Springs?

This section of our report is dedicated to discovering what direct actions can be taken to improve quality of life for citizens of Southeast Colorado Springs. Although our studies did not conclusively confirm that air pollution is worse in Southeast, it is still clear that the community's social determinants of health result in increased vulnerability to air pollution. Because of this increased vulnerability, we make suggestions to alleviate the impact that air pollution has on Southeast residents.

We have split up our action recommendations into two sections, each covering a different sector in which Solid Rock can enact change. First, we have collaborated with the Urban Heat Island researchers to study the possible implementation of a joint Cooling and Cleaner Air Center. This Center would protect citizens during high heat and high pollution events. Next, we offer a set of policy and regulation recommendations that Solid Rock could make to the City Council of Colorado Springs. These include increasing vehicle emission testing programs, incentivizing the purchase of electric vehicles, implementing shutdown protocols, and the institution of a local authority on air pollution.

Overall, we have discovered that there are a vast variety of ways in which Solid Rock could increase the protection and education of Southeast citizens. The result will be a healthier, more engaged community, where citizens can breathe clean air.

A. Cooling and Cleaner Air Centers

1. Why cooling and cleaner air centers?

Cooling and cleaner air centers are public facilities, like schools, religious centers, and recreation centers, that provide cooler and cleaner air during emergency heat and air pollution days. These centers provide cleaner air through either upgraded ventilation systems, adequate portable air cleaners, or air filters. We propose conjoining cooling and cleaner air centers because they have a similar structure (accessible public facilities), provide similar services (respite from extreme environmental elements), and because the highest air pollution days overlap with the most severe heat during the summer in Colorado Springs. These centers would be especially beneficial in areas such as Southeast that have more vulnerable populations but less resources to protect residents from dangerous air pollution exposure. For a more detailed explanation of what a cooling and cleaner air center can look like, see Section 1.3 of the Urban Heat Island report.

2. Where and how have cleaner air centers been implemented?

Cleaner air centers are a relatively new phenomenon, with evidence of only a few cleaner air centers that have been implemented in the Bay Area in California over the past two years. However, wildfire and air pollution response plans provide insight on how cleaner air centers can be implemented and the guidelines that they should follow. In 2019, the California government passed Bill 836 which helps fund cleaner air centers for vulnerable communities, and the state has allocated $5 million dollars to this program so far.[53] While passing this type of bill is not necessarily within Solid Rock's responsibilities, it serves as a precedent

[53] "Wildfire Response: Clean Air Centers for Vulnerable Population Grant Program (AB 836)," Bay Area Air Quality Management District.

for a bill that the state of Colorado or the city of Colorado Springs could adopt to ensure the implementation of cleaner air centers.

Cities that have applied for grants through AB836 also provide insight into standards that need to be met in order to establish a cleaner air center. The bill establishes three different project types for centers: funding for facility ventilation retrofits and high efficiency air filtration systems (MERV 13 or greater), funding for the purchase of state-certified portable air cleaners equipped with HEPA filter, and funding for HEPA or MERV 13 or greater air filter replacements.[54] According to AB836, facilities must be located in schools in or near historically underserved communities, be close to and provide easy access for vulnerable populations, have a reasonable capacity to meet the possible clear air center needs of vulnerable populations, and be ready for ventilation and filtration installation, upgrades, or retrofits.[55] These guidelines could inform Solid Rock and partners in selecting appropriate facilities for a cleaner air center.

3. *How are cooling and cleaner air centers funded?*

The cost of establishing a cleaner air center varies depending on facility and project type. Portable air cleaners cost around $300 and are best suited for rooms that already have a central air cleaner.[56] Central air cleaners are installed into the duct network of a facility and can cost between $250 to $3000, with an additional installation cost ranging from $700-$2000, depending on the size and efficiency of the device.[57]

There are a few approaches to accessing funding for cooling and cleaner air centers. As of 2021, the EPA has piloted a program to provide funding for technical assistance for the development of neighborhood cleaner air and cooling centers in public school facilities in vulnerable communities.[58] Through the program, the EPA hosts workshops with local partners to create an action plan to retrofit public facilities in cities selected for grant assistance.[59] The Bay Area Air Quality Management District in California, Kittitas County in Washington, Multnomah County in Oregon, and Pima County in Arizona are the first locations to receive assistance from this program.[60]

Another route to funding cooling and cleaner air centers in Southeast Colorado Springs is to expand the Pikes Peak Region Office of Emergency Management's (PPROEM) Emergency Operations Plan to account for high pollution and heat days.[61] As previously mentioned in this report and the Urban Heat Island Report, extreme heat and air pollution can result in serious health impacts. Although severe air pollution and heat exposure pose immediate threats to the safety and health of Colorado Springs residents, they are not adequately accounted for in the PPROEM's Emergency Operations Plan.

[54] Ibid.
[55] Ibid.
[56] "First-Steps Toward Achieving Healthful Indoor Air Quality," California Air Resources Board.
[57] Ibid.
[58] "Schools as Community Cleaner Air and Cooling Centers," Environmental Protection Agency.
[59] Ibid.
[60] Ibid.
[61] "Emergency Operations Plan 2021," Pikes Peak Regional Emergency Management, 2021.

Given the potentiality of high mortality rates linked to severe heat and air pollution, especially among vulnerable populations, it is reasonable to view these events as emergencies. Reframing high air pollution and heat days as emergencies is imperative to adequately preventing dangerous health issues. There are a number of agencies listed in PPROEM's 2021 Emergency Operations Plan that seem fit to assist in establishing cooling and cleaner air centers based on their stated roles and responsibilities. The agencies range from PPROEM divisions to city level partners that could aid in distributing resources, allocating funding, and emergency preparedness workshops for community partners. For a more detailed analysis of the agencies and their possible role in establishing cooling and cleaner air centers, see Appendix 10.

B. *Policy and Regulation*

Aside from Cooling and Cleaner Air Centers, which help to protect residents on particularly poor air quality days, there are other long term actions that can be taken to reduce air pollution in the Southeast and across Colorado Springs. We have outlined three specific areas that Solid Rock could bring to City Council: creating regulations around vehicle emissions and incentivizing electric vehicles, implementing shutdowns of point sources during high pollution days or high wind days, and creating a local authority on air pollution.

1. *Vehicles*

Emission Testing Program

Vehicle emission testing programs require cars to be regularly inspected for the levels of emissions they release. If implemented in Colorado Springs, this program would ensure that cars are not overemitting. Cars are checked for required components (which vary by car) including catalytic converters, air injection systems, and oxygen sensors. The gas cap is checked to ensure there is no leakage and vehicles are checked for any visible smoke.[62] Required vehicle emission testing already exists in several counties in Colorado, including Boulder, Broomfield, Denver, Douglas, Jefferson, Portions of Adams, portions of Arapahoe, portions of Larimer, and portions of Weld.[63] Seeing that this program has already been implemented across many counties in Colorado means that it could reasonably be adopted in Colorado Springs. See Appendix 9 for what cars require tests in Colorado. This regulation would need to be in partnership with the Colorado Department of Motor Vehicles (DMV), which would enforce the program via car registration. The DMV has available guidelines set out for emission testing, as the program has already been implemented in other counties across the state. Currently, there are six places in Colorado Springs that test car emissions.

Incentivize Electric Vehicles

Increasing electric vehicle use can also aid in reducing air pollution. As mentioned above, vehicle emissions are one of the largest producers of ozone.

[62] "How It Works." AirCare Colorado, 2018.
[63] "Gas Vehicles." Colorado Department of Revenue - Motor Vehicle, 2022.

Additionally, gas stations emit VOCs, so limiting our dependency on gas to power cars would significantly decrease pollutants. Colorado has incentivized electric vehicle ownership primarily through tax breaks and incentivizing charging stations to boost the amount of electric vehicles on the road.

Denver has already created an Electric Vehicle Action Plan with the goal to have 15% of cars registered in Denver be electric by 2020, 30% by 2030, and 100% by 2050. These are lofty goals that may not be transferable to Colorado Springs, but there are many aspects of Denver's plan that could be utilized to promote the use of electric vehicles here.[64] In terms of action items that Solid Rock could take to the city of Colorado Springs, it would likely be better to focus on some of the smaller goals of the overall Denver report, such as investing in charging stations.

The Gazette published an article on April 11, 2022 highlighting the importance of charging stations in Colorado Springs.[65] An electric vehicle readiness plan, which was presented to City Council, stated that 30,000 to 60,000 charging stations are needed to meet the demand for electric vehicles in the coming decades. Currently, there are only 39 charging stations in all of Colorado Springs, and ultimately people will not invest in an electric vehicle if it is not convenient.[66] Implementing more charging stations is essential to increasing electric vehicle ownership, even if there are not a significant amount of electric vehicle owners in Colorado Springs right now.

In order to increase charging infrastructure availability, Colorado Springs could build partnerships with businesses and organizations to accelerate the deployment of charging infrastructure at key locations (homes, multi-family residential buildings, retail centers, mobility hubs, and airports). City council members also serve on the board of the Colorado Springs Utilities, which could be another major stakeholder in the journey towards expanding charging stations.

As it stands, the burden of adopting electric vehicles does fall on the consumer, and this fact should not be ignored. Electric vehicles are expensive and there are fairly limited model options to meet the needs of every consumer in an equitable manner. While boosting the use of public transportation is also an effective way to lower pollutants from vehicles, the way Colorado Springs urban planning already exists makes it an extremely car dependent city. It should be noted that the Southeast community experiences a lot of traffic from people commuting across Colorado Springs in order to reach commercial areas, the airport, and other major locations. Hopefully, the availability of electric vehicles will increase in the coming years, lessening traffic pollution and allowing for more equity in ownership. While car manufacturers work to catch up to the demand for electric cars, Colorado Springs can take action to improve charging station infrastructure to incentivize more electric cars and invest in the future.

[64] "Denver Electric Vehicle (EV) Action Plan." City and County of Denver, April 2020.

[65] Shinn, Mary. "Colorado Springs Electric Vehicle Plan Shows the City Will Need Tens of Thousands of Chargers." *The Gazette*, April 12, 2022.

[66] ibid

2. *Implementing Shutdown Protocol Program*

One way to improve air quality on a short term scale is to shut down sources of particulate matter on days when air quality is particularly poor in the Southeast due to higher winds. The city of Albuquerque, which continues to have a good model for managing air quality issues, implements shutdowns of particulate matter sources on windy days per an existing ordinance. Shutting down particulate sources helps to improve air quality for residents. Shutdowns are implemented on days of high wind, meaning 30 miles per hour or more.[67] Colorado Springs experiences a handful of high wind days (wind 40 mph over the span of an hour and/or gusts of 58 mph for any duration) a year. Because there have only been 96 high wind days since 2005, shutting down point sources of particulate matter on highwind days could increase air quality but happen infrequently enough that temporary shutdowns of operations would not cause significant losses for companies.[68] It is apparent from our windroses and maps that the pollutants in Southeast are being blown in on particularly windy days, so implementing shutdowns could lessen impacts in Southeast especially. See Appendix 9 for the full Albuquerque ordinance on "fugitive dust," which is a broad term for particulate matter. This ordinance could be easily transferable to Colorado Springs and improve air quality on the days when wind speed is high.

Shutdowns could also be implemented for point sources of ozone and precursors to ozone like NOX and VOCs. As seen on *Map 4 (c)* there are many ozone point sources surrounding the Southeast that have greater pollutive impact on days that are exceptionally windy. Although there is no precedent for this type of shutdown, a Colorado Springs version could follow a similar protocol to the fugitive dust program in Albuquerque.

3. *Creating Local Authority on Air Quality*

Many cities have local authorities on air quality that implement and enforce air quality regulation. Having a centralized authority on air quality could be extremely beneficial for Colorado Springs, helping formalize efforts to improve air quality and expediting regulation to protect the health and safety of the city's residents. This committee could fall under the city's environmental or health departments. These departments could oversee the initiatives we detailed above as well as play an important role in monitoring point sources and ensuring that their emissions are in line with the Clean Air Act. Owners and operators of point sources may need more accountability in ensuring that they are in line with the Clean Air Act's standards and other federal and state level legislation. A local authority on air quality is the best way to create and centralize accountability, as air quality would be their sole responsibility and there would be more time and resources dedicated to locating, regulating, and checking on point sources.

[67] "Shutdown Notice and Health Alert Information." City of Albuquerque, 2022.

[68] O'Brien, Alex. "Colorado Springs Sees the Most High Wind Days in Late Fall and Early Spring." KOAA. *KOAA News5*, March 23, 2022.

VI. Conclusion

The results from our data collection at the Solid Rock Community Development Corporation suggest that the air in Southeast is not significantly worse than the air quality in Colorado Springs as a whole. However, this was simply a preliminary study, and the results should not be used to make any conclusions about the air quality in Southeast. With seasonal, daily, and spatial variation in pollution, two weeks of data from a single point cannot be relied upon to make any larger conclusions.

In order to get the data needed to conclusively show results for the purpose of lobbying or advocacy, a longer study will be needed and an increase in air monitoring and monitor density will be essential. There are many options for long term air quality studies, and we have outlined several that would be applicable in Colorado Springs as a whole and Southeast specifically. Regardless of which option is potentially implemented, each would allow for more effective advocacy and lobbying for air quality improvements, as well as raising community support and awareness.

Even without conclusive data on the impact of air pollution in Southeast, it is still worth considering how to improve air quality and thus quality of life for residents of Southeast. Our suggested policy and grassroots actions could be implemented in Colorado Springs, with the cooling and cleaner air centers being a more immediate solution to keeping residents safe. We believe that our recommendations should be used to create partnerships with organizations across the city. Social determinants of health may make Southeast more vulnerable to air pollution, but it should not be the sole responsibility of this community to solve this problem on its own.

Appendices

Appendix 1. EPA Historical Data

Historical data from the EPA's monitoring stations in Colorado Springs was used to analyze four pollutants: $PM_{2.5}$, PM_{10}, SO_2, and O_3. Daily mean data for $PM_{2.5}$ concentration in $\mu g/m^3$ at the Colorado College monitoring station was used to create multiple plots. The first plot was a yearly average of PM_{10} concentration plotted by year from 2008 to 2021. The daily mean data was averaged by year to create this plot. The second plot average PM_{10} concentration plotted by month for 2008-2021. The daily mean data was averaged by month for each year and then averaged by month for all of the years from 2008 to 2021. After observing a trend of higher concentration during the summer months, which were defined as June to September, the last four plots were made. The daily mean data was averaged by month for each year. The four plots show each summer month's averaged concentration over the 13 year (2008-2021) period. This process was repeated for daily mean data for PM_{10} concentration in $\mu g/m^3$ at the Colorado College monitoring station.

A similar process was performed for SO_2. Daily max 1-hour SO_2 concentration data in ppb at the EPA's Colorado Springs Highway 24 monitoring station was used. The same plots and processes as the $PM_{2.5}$ and PM_{10} data were created and used for a time period of 2013 to 2021 for the yearly average concentrations and the monthly average concentrations. The four summer months plots span from 2017 to 2021 when SO_2 concentration decreased between 2016 and 2017 as a result of Martin Drake implementing scrubbers in September of 2016 to adhere to a change in national policy for SO_2 concentration emissions which was implemented in December of 2017.

For O_3, data from the EPA's monitoring stations located at the Air Force Academy (AFA) and Manitou Springs (MS) were used. Plots were created with similar approaches as mentioned above, with an extended data collection period from 2001 to 2021 for the AFA site and a period from 2005 to 2021 for the MS site. For the sake of comparison, June, July, August, and September are considered months that show seasonalities for O_3 concentrations and were highlighted in the average O_3 concentration by month plot. Due to a 3-month period of missing data in 2019 of the AFA site, the year has been cut out from the site's statistics and was complemented by the data from the MS site.

PM2.5 and PM10 Temporal Data for Colorado Springs

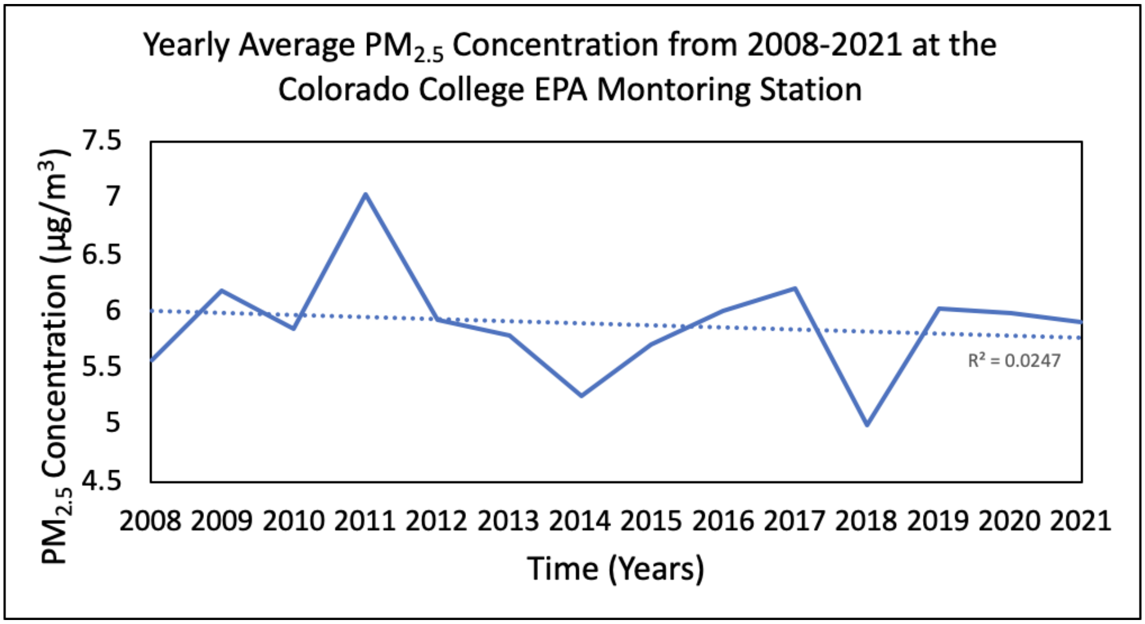

Figure 1. Averaged yearly $PM_{2.5}$ concentration (µg/m^3) from 2008-2021 averaged from daily mean $PM_{2.5}$ concentration data from the EPA's monitoring station at Colorado College.

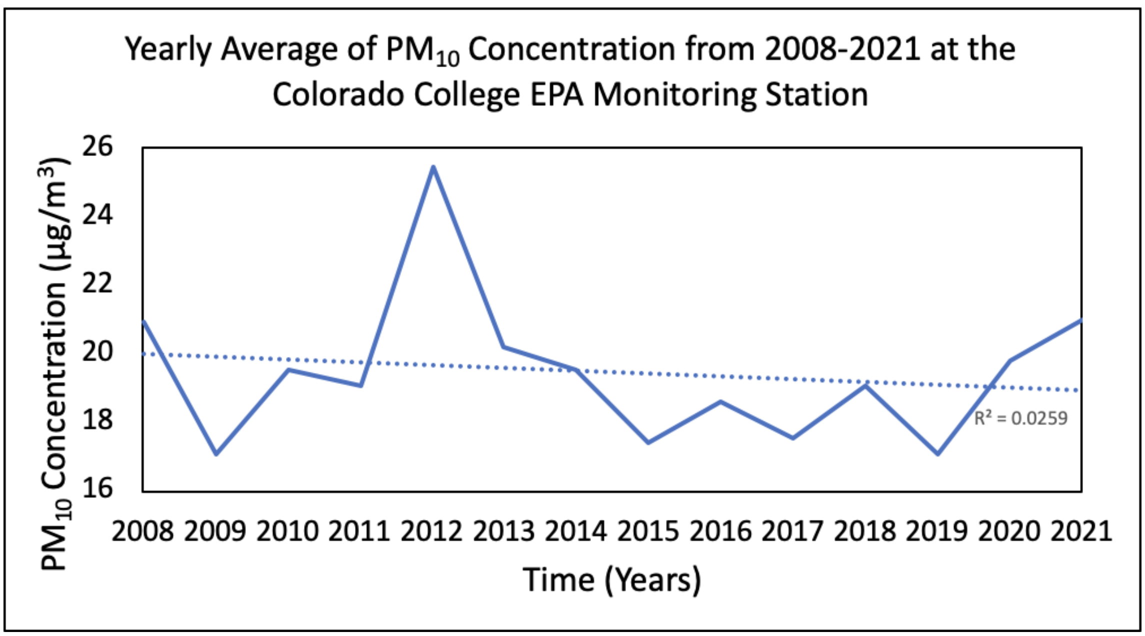

Figure 2. Averaged yearly PM_{10} Concentration (µg/m^3) from 2008-2021 from daily mean PM_{10} concentration data from the EPA's monitoring station at Colorado College.

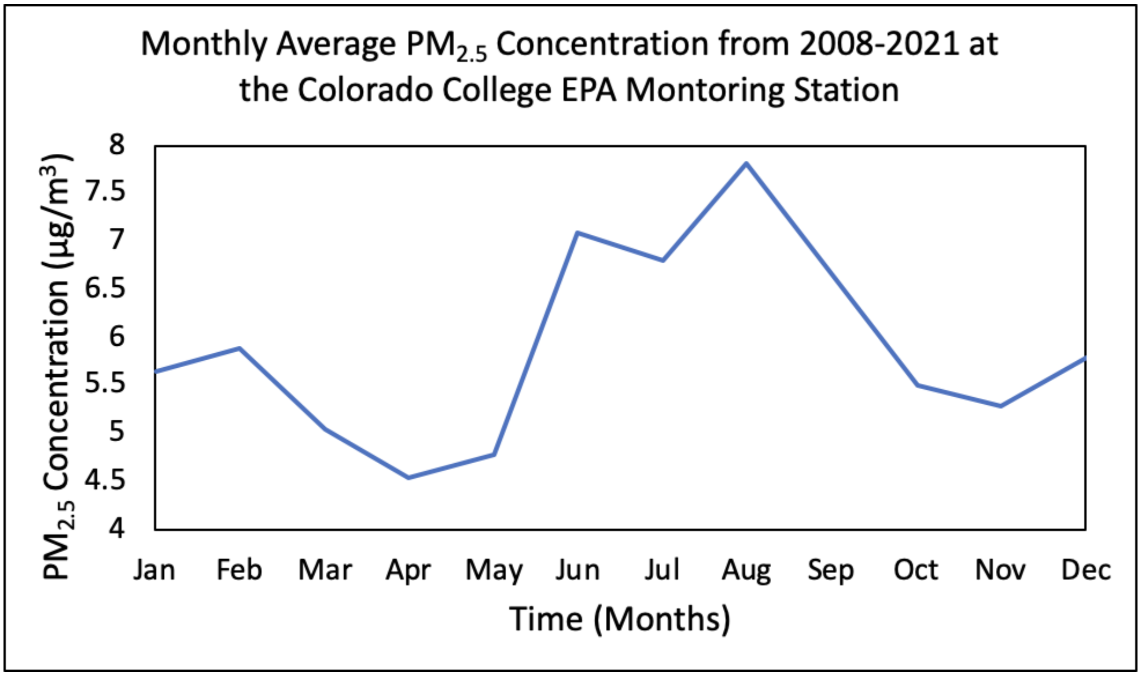

Figure 3. Averaged monthly $PM_{2.5}$ Concentration ($\mu g/m^3$) from 2008-2021 from daily mean $PM_{2.5}$ concentration data from the EPA's monitoring station at Colorado College.

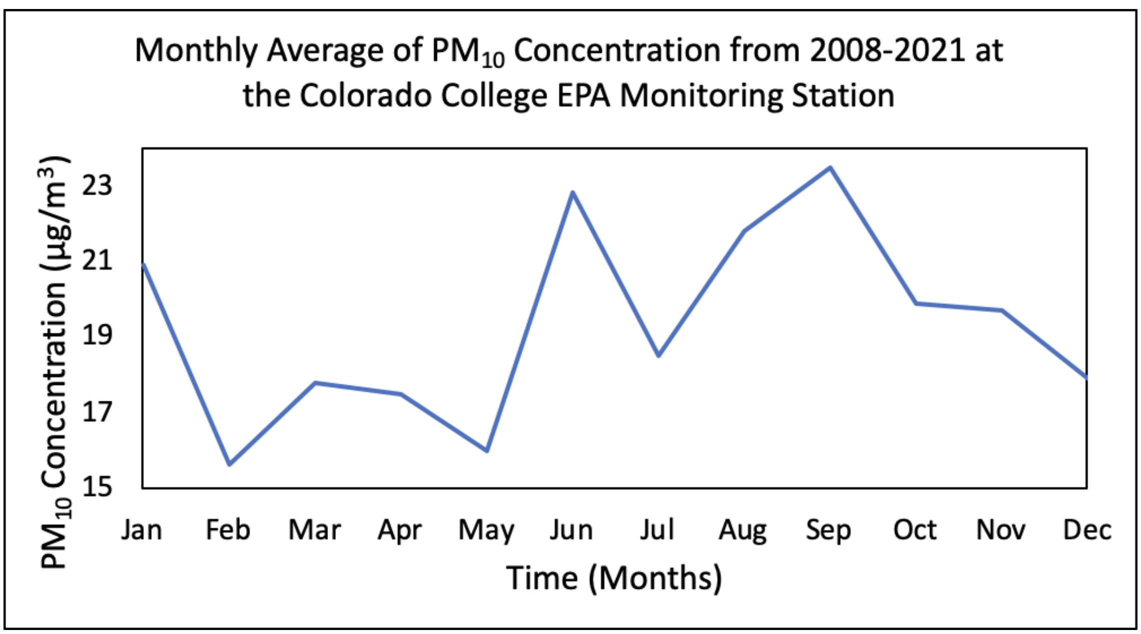

Figure 4. Averaged monthly PM_{10} Concentration ($\mu g/m^3$) from 2008-2021 from daily mean PM_{10} concentration data from the EPA's monitoring station at Colorado College.

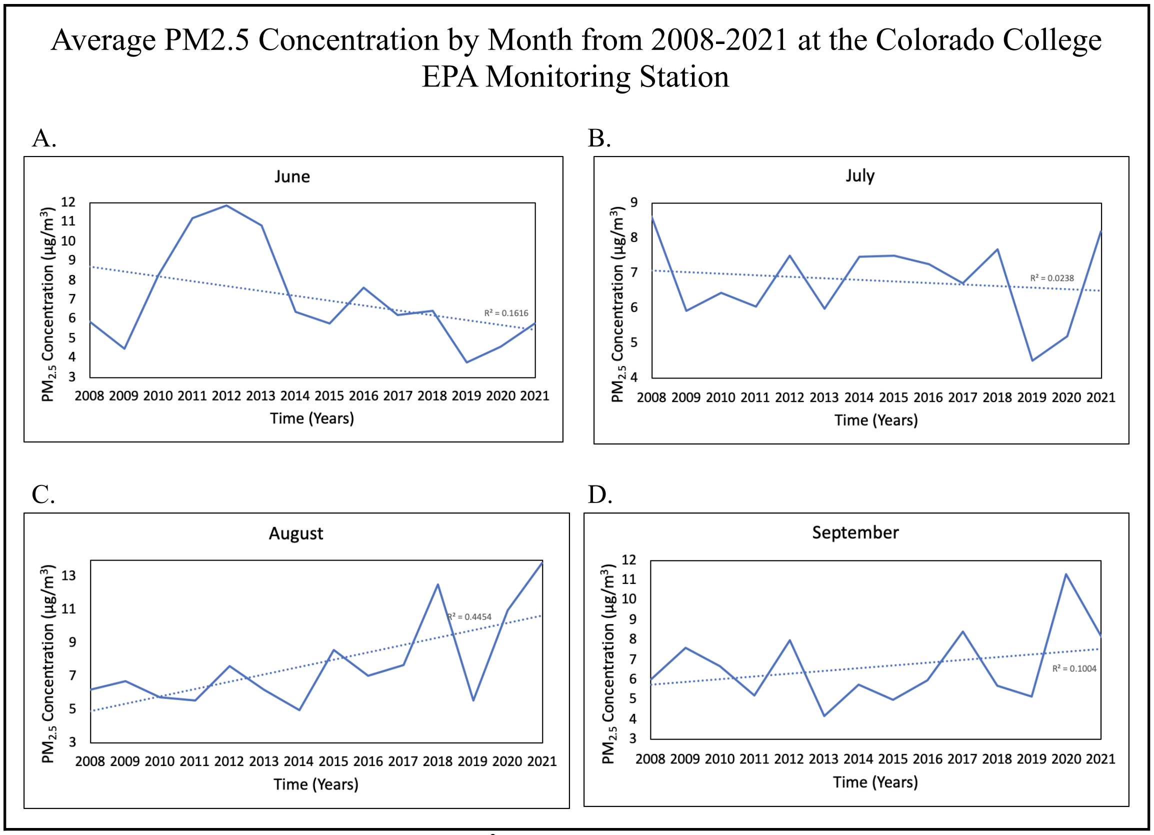

Figure 5. Averaged $PM_{2.5}$ concentration (µg/m^3) by summer months (A. June, B. July, C. August, D. September) from 2008-2021 from daily mean $PM_{2.5}$ concentration data from the EPA's monitoring station at Colorado College. $PM_{2.5}$ concentration for June and July show slightly decreasing trends with R^2 values of 0.16 and 0.0238 respectively. $PM_{2.5}$ concentration for August and September has an increasing trend from 2008 to 2021 with R^2 values of 0.44 and 0.10 respectively.

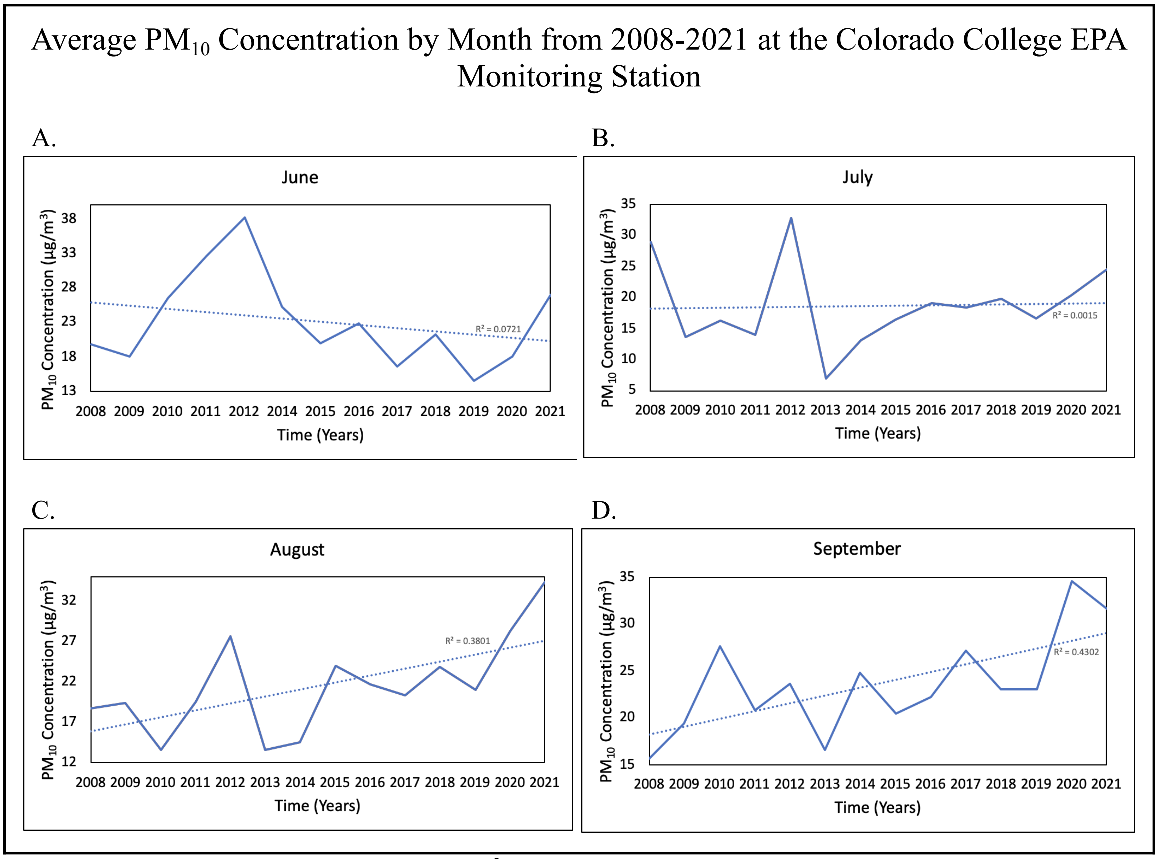

Figure 6. Averaged PM_{10} concentration (µg/m³) by summer months (A. June, B. July, C. August, D. September) from 2008-2021 from daily mean PM_{10} concentration data from the EPA's monitoring station at Colorado College. PM_{10} concentration for June and July does not show strong trends with R values close to zero (0.072 and 0.0015 respectively). PM_{10} concentration for August and September has an increasing trend from 2008 to 2021 with R^2 values of 0.38 and 0.43 respectively.

Ozone Temporal Data for Colorado Springs

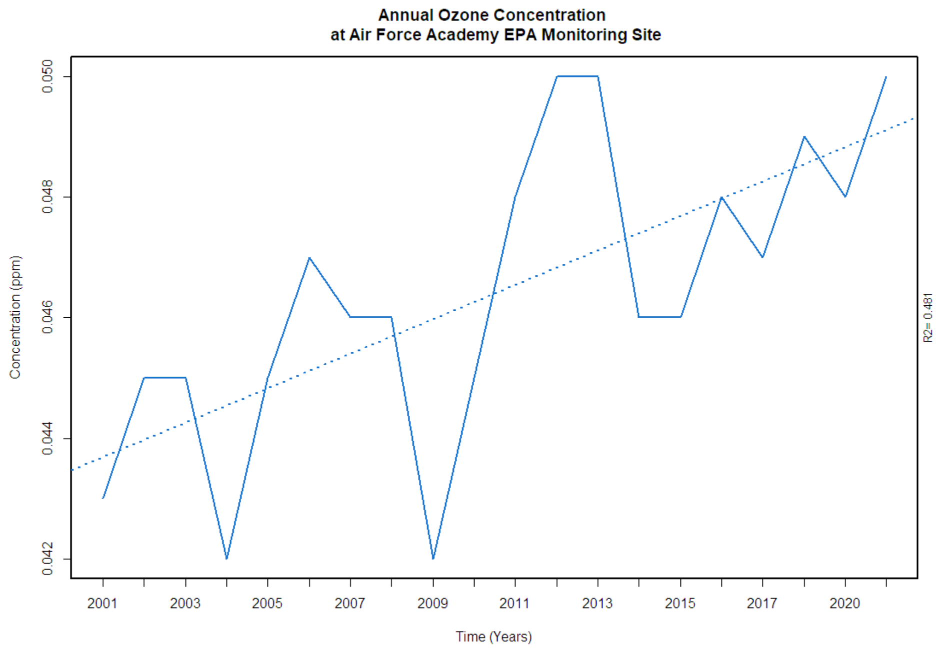

Figure 7. Yearly variation of ozone concentration (ppm) from 2001-2021, averaged from daily mean ozone concentration data from the EPA's monitoring station at the Air Force Academy. O_3 concentration has an increasing trend with an R^2 value of 0.481.

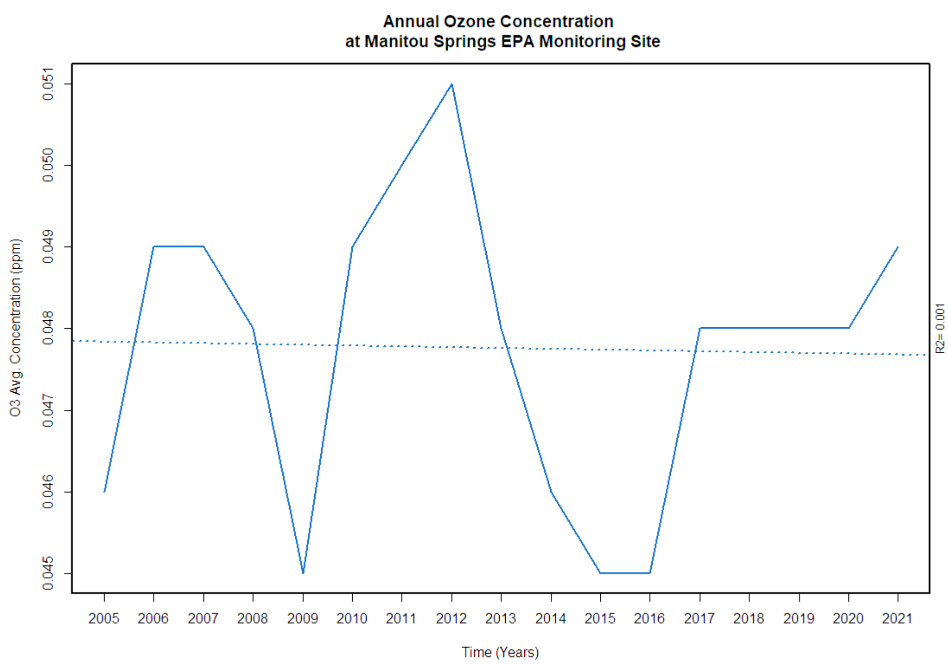

Figure 8.. Yearly variation of ozone concentration (ppm) from 2005-2021, averaged from daily mean ozone concentration data from the EPA's monitoring station at Manitou Springs. Ozone concentration has no significant trend with an R^2 value of 0.001.

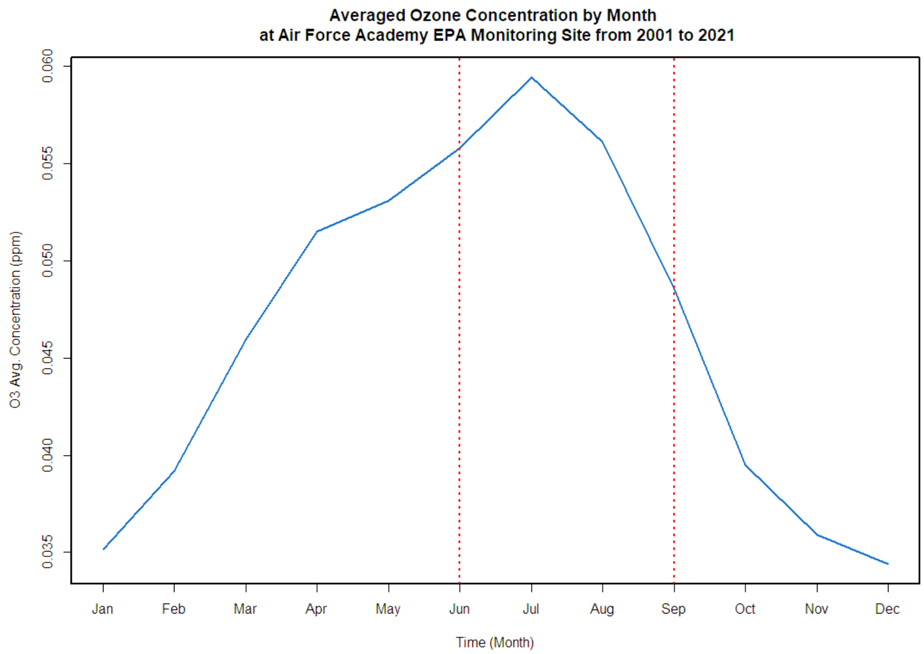

Figure 12. Averaged monthly O_3 concentration (ppm) from 2001-2021, based on daily mean SO_2 concentration data from the EPA's monitoring station at the Air Force Academy (AFA). The red lines highlight the summer months.

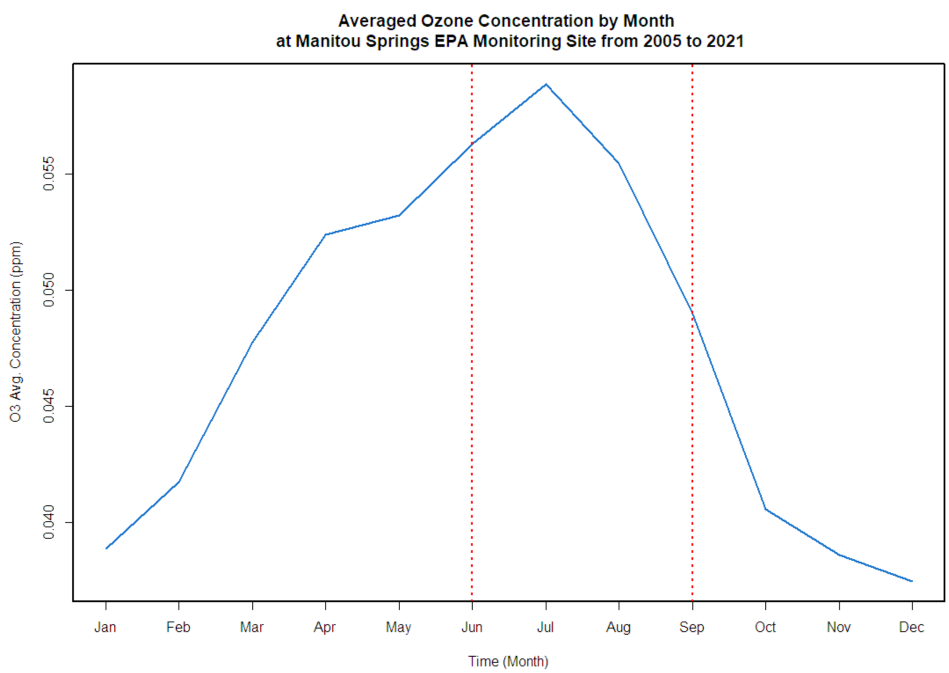

Figure 13. Averaged monthly ozone concentration (ppm) from 2005-2021, based on daily mean SO_2 concentration data from the EPA's monitoring station at Manitou Springs (MS). The red lines highlight the summer months.

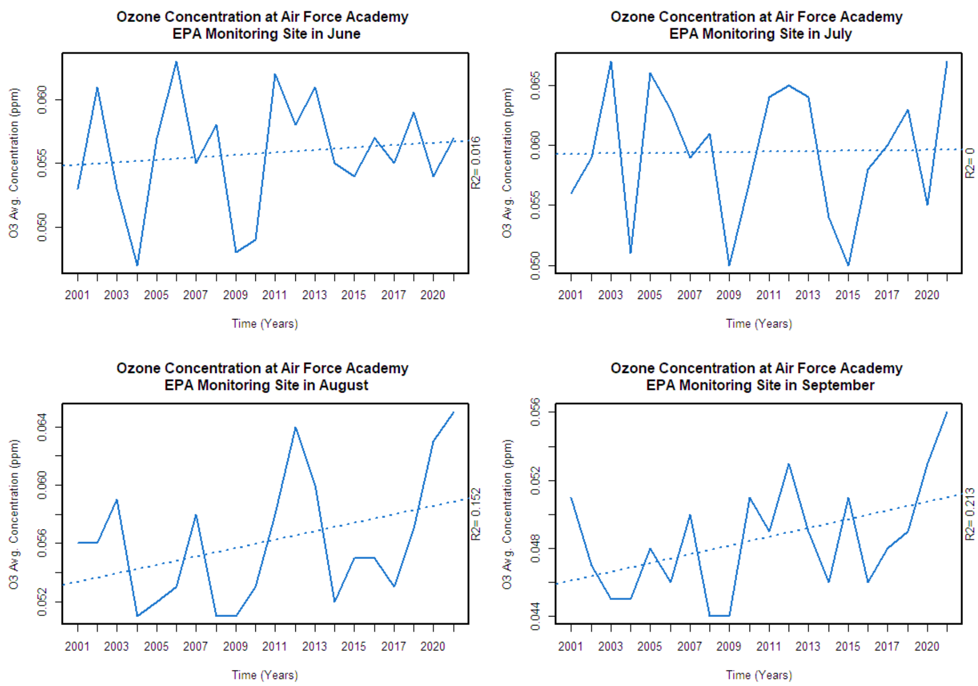

Figure 14. Averaged O_3 concentration (ppm) by summer months (from left to right, top to bottom: June, July, August, September) from 2001-2021. Data based on the daily mean ozone concentration from the EPA's monitoring station at the Air Force Academy. June and July have nearly no trend in concentration levels, while August and September have shown slight increasing trends (R^2 values of 0.152 and 0.213).

Figure 15. Averaged O_3 concentration (ppm) by summer months (from left to right, top to bottom: June, July, August, September) from 2005-2021. Data based on the daily mean ozone concentration from the EPA's monitoring station at Manitou Springs. June and July have a mild decreasing trend in concentration levels with R^2 value of 0.166 and 0.119, while August has shown a slight increasing trend (R^2 value of 0.138) and September shows no trend (R^2 value of 0.066).

SO_2 Temporal Data for Colorado Springs

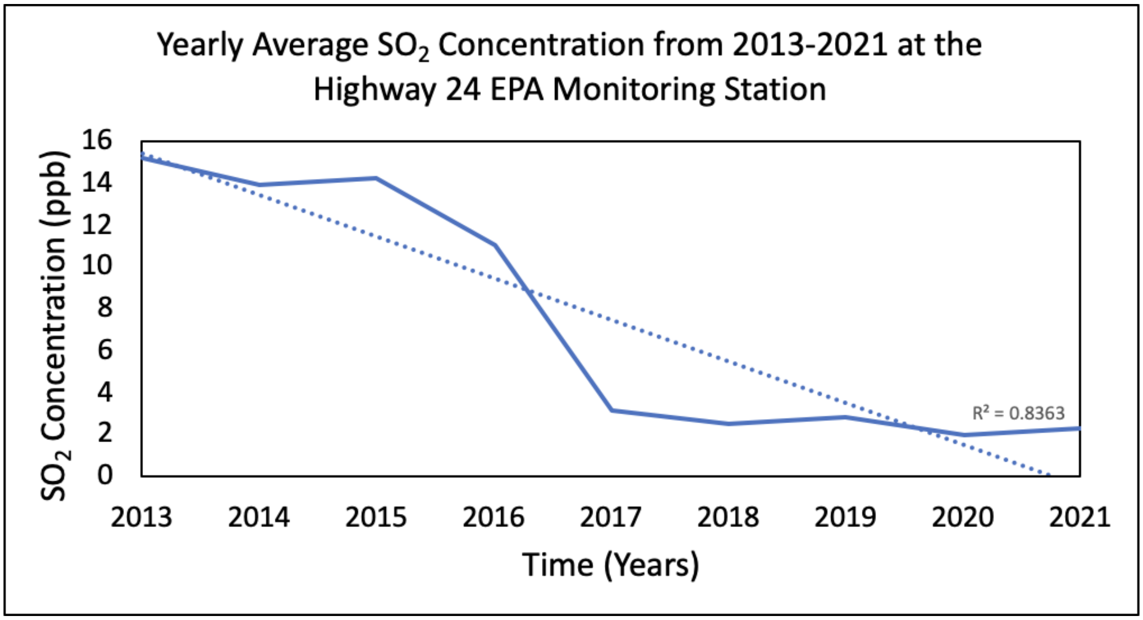

Figure 16. Averaged yearly SO_2 concentration (ppb) from 2013-2021 averaged from daily mean SO_2 concentration data from the EPA's monitoring station at Highway 24. SO_2 concentration has a decreasing trend as shown by the R^2 value of 0.84, and with a decrease from 11.04 ppb (2016) to 3.20 ppb (2017).

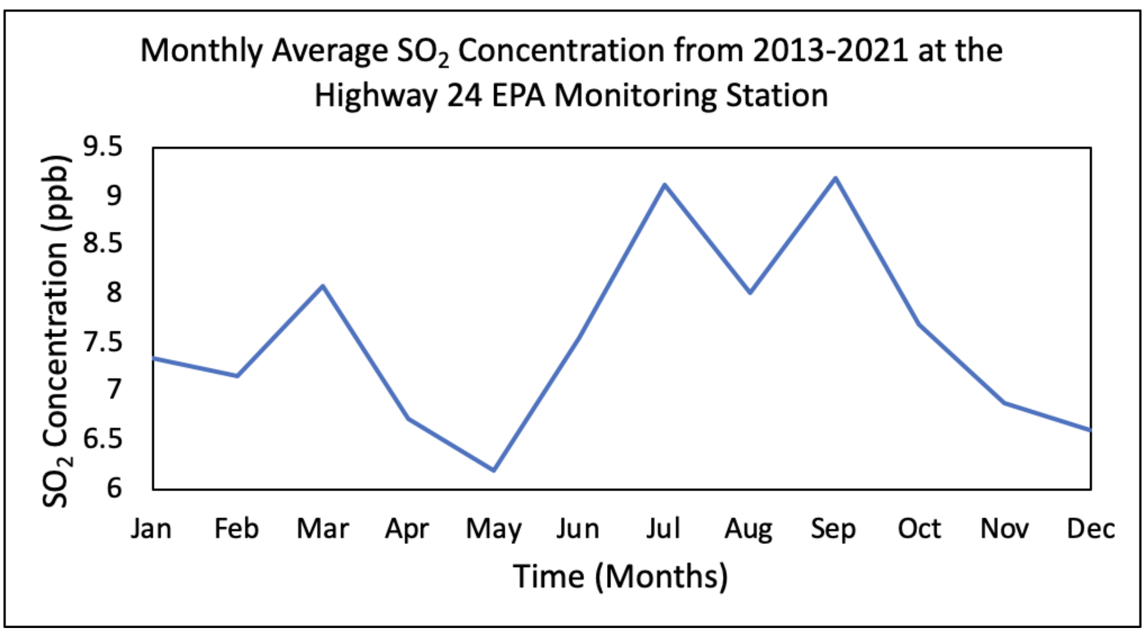

Figure 17. Averaged monthly SO_2 Concentration (ppb) from 2013-2021 from daily mean SO_2 concentration data from the EPA's monitoring station at Highway 24.

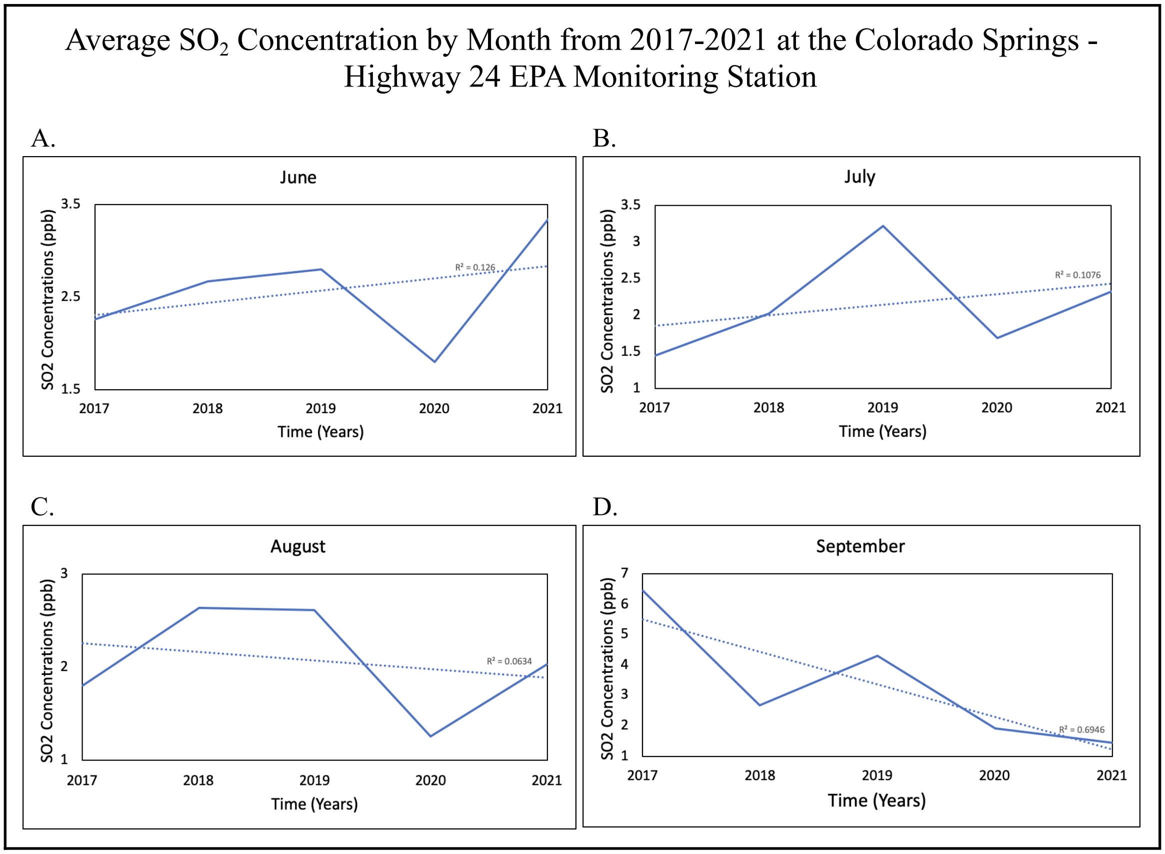

Figure 18. Averaged SO_2 concentration (ppb) by summer months (A. June, B. July, C. August, D. September) from 2017-2021 (after the implementation of scrubbers at Martin Drake Power Station) from daily mean SO_2 concentration data from the EPA's monitoring station at Highway 24. June and July have slight increasing trends (R^2 values of 0.126 and 0.1076 respectively) and September has a decreasing trend in concentration levels.

Point Source Locations (NO_x and VOCs)

Table 1. Emission type, location, and name of point sources in and around the Southeast of Colorado Springs. The coordinates for each emission site were converted to a Colorado Springs address, allowing for the determination of the type of industry/business that is causing the emissions in each location.

#	Brown (Nox) or Green (VOC)	Coordinates	Address	Name
1	Green	104.7948210°W 38.7966720°N	2880 S Circle Dr, Colorado Springs, CO 80906	7/11 and/or Phillips 66 (Gas Station)
2	Green	104.7769160°W 38.7964570°N	2350 Hancock Expy, Colorado Springs, CO 80910	7/11 and/or Conoco (Gas Station)
3	Green	104.7719870°W 38.7826040°N	3527 Wabash St, Colorado Springs, CO 80906	Kiewet Western Co.
4	Green	104.7577750°W 38.7919940°N	2780 S Academy Blvd, Colorado Springs, CO 80916	This location doesn't have a specific building or company associated with it
5	Green	104.7423630°W 38.7971820°N	2505 S Chelton Rd, Colorado Springs, CO 80916	Loaf 'N Jug (Gas Station and Grocery Store)
6	Green	104.7405670°W 38.8090210°N	1685 Jet Wing Dr, Colorado Springs, CO 80916	7/11 Gas Station
7	Green and Brown	104.7090000°W 38.7974000°N	7770 Milton E Proby Pkwy, Colorado Springs, CO 80916	Colorado Springs Airport
8	Green and Brown	104.7698780°W 38.7778240°N	1) 3895 Wabash St, Colorado Springs, CO 80906 2) 3965 US-85 #87, Colorado Springs, CO 80911	SRM Concrete and Martin Marietta "HWY 85/87 - Asphalt Plant
9	Green and Brown	104.8061970°W 38.7890510°N	2 Quail Lake Pl, Colorado Springs, CO 80906	Microchip Technology Co.

Appendix 2. Two Week Comparative Study Set-up

There are currently no EPA monitoring stations in Southeast Colorado Springs, so a temporary station was set up at Solid Rock to provide two weeks of data. A 2B Technologies Model 202 Ozone Monitor and a TSI DUSTTRAK DRX Desktop 853 Aerosol Monitor was used to provide O_3 and PM_{total} data and wind speed and direction data from the Solid Rock site. This data was then used to create wind roses to understand the concentration and direction that pollutants were coming into the Southeast from.

Appendix 3. Air Filter Study

Two temporary filter stations were set up at Colorado College and Solid Rock for three 24-hour periods of pollution collection. One station was set up on the rooftop of Olin Hall at Colorado College as a comparative site to the other station set up on the rooftop of Solid Rock Christian Center in southeast Colorado Springs. The same methodology was applied at both sites. A filter for each site was weighed for the initial mass. The filter was then placed at the site where a pump sucked in air through the filter, gathering any pollutants. The initial time was recorded from when the pump was turned on. Initial wind speed was also recorded. When the filter was changed, the final time and wind speed were recorded (immediately before and after the pump was turned off). The filters were weighed a second time (final mass) to measure the amount of pollutants gathered in the time period that they were on the roof.

Once the filters were collected, the final mass was recorded. The filters were cut to the size of the extraction area of the stations and then cut into 12 equal sized pieces where six of them were used for random sampling. The six pieces for each of the six filters (36 pieces in total) were weighed individually. Each sample was rolled and inserted into a 15 mL Falcon tube which was then filled with ten mL of Milli-Q water using a volumetric pipette. The samples were vortexed for 15 seconds and then put in a sonicator for ten minutes, and then vortexed for another 15 seconds. Each sample was then filtered using a 0.2 micron filter attached to a syringe. Three samples from each filter were used for XRF and three were used for ion chromatography. The samples used for XRF were transferred into a new 15 mL Falcon tube after being filtered. Each sample used for ion chromatography was split between two sample containers, one to test for cations and one to test for anions. The samples were then run through the XRF machine for ion chromatography and the Dionex IC machine for the ICP metal analysis. For each of the analyses Levene's independent sample t-test was run between the two sites for data from April 5, 2022 and April 6, 2022.

Table 2. Statistically significant differences in chemical composition between the Solid Rock and the Colorado College air filter monitoring stations. The Colorado College site has higher concentrations for all three differences.

Chemical Composition	Site	Mean (mg/L)	t	df	p
Sodium Ion (Na^+)	Solid Rock	2.588 ± 0.111	3.939	10	0.003
	Colorado College	3.368 ± 0.164			
Magnesium Ion (Mg^{2+})	Solid Rock	0.1167 ± 0.00843	3.627	10	0.005
	Colorado College	0.1500 ± 3.627			
Chloride (Cl^-)	Solid Rock	1.875 ± 0.1085	2.721	10	0.022
	Colorado College	2.382 ± 0.1513			

Appendix 4. EPA Regulations for Air Monitoring Siting

(from the US Code of Federal Regulations Title 40, Chapter I, Subchapter C, Part 58)

- Particulate Matter (PM) specific regulations
  - Horizontal and Vertical Placement
    - Neighborhood or larger spatial scale: probe or at least 80 percent of the monitoring path must be between 2-15 meters above ground level
    - Middle Scale: sampler inlets between 2-7 meters above ground
    - Microscale: sampler inlets between 2-7 meters above ground
    - microscale sites of any air pollutant, no trees or shrubs should be located between the probe and the source under investigation, such as a roadway or a stationary source.
- Ozone (O_3) specific regulations
  - Horizontal and vertical placement
    - probe or at least 80 percent of the monitoring path must be located between 2 and 15 meters above ground level
  - Spacing from Obstructions
    - 90 percent of the monitoring path must have unrestricted airflow and be located away from obstacles.
    - The distance from the obstacle to the probe, inlet, or monitoring path must be at least twice the height that the obstacle protrudes above the probe
      - exception can be made for measurements taken in street canyons or at source-oriented sites where structures are unavoidable
    - probe along wall is undesirable
      - must have airflow in an arc of 180 degrees
    - A monitoring path must be clear of all trees, brush, buildings, plumes, dust, or other optical obstructions, including potential obstructions that may move due to wind, human activity, growth of vegetation, etc.
  - Spacing from trees
    - probe, inlet, or at least 90 percent of the monitoring path must be at least 10 meters or further from the drip line of trees.
  - Distance from roadways (average vehicles per day on roadway: distance from roadway required in meters)
    - ≤1,000: 10
    - 10,000: 10
    - 15,000: 20
    - 20,000: 30
    - 40,000: 50
    - 70,000: 100
    - ≥110,000: 250
- SO_2 specific regulations
  - Horizontal and vertical placement
    - Neighborhood or larger spatial scale: probe or at least 80 percent of the monitoring path must be between 2-15 meters above ground level
    - Microscale, near-roads: sampler inlets between 2-7 meters above ground

- Spacing from Obstructions
    - 90 percent of the monitoring path must have unrestricted airflow and be located away from obstacles.
    - The distance from the obstacle to the probe, inlet, or monitoring path must be at least twice the height that the obstacle protrudes above the probe
        - exception can be made for measurements taken in street canyons or at source-oriented sites where structures are unavoidable
    - probe along wall is undesirable
        - must have airflow in an arc of 180 degrees
    - A monitoring path must be clear of all trees, brush, buildings, plumes, dust, or other optical obstructions, including potential obstructions that may move due to wind, human activity, growth of vegetation, etc.
- Spacing from trees
    - probe, inlet, or at least 90 percent of the monitoring path must be at least 10 meters or further from the drip line of trees.

- NO_2 specific regulations
    - Horizontal and vertical placement
        - Neighborhood or larger spatial scale: probe or at least 80 percent of the monitoring path must be between 2-15 meters above ground level
        - Microscale, near-roads: sampler inlets between 2-7 meters above ground
    - Spacing from Obstructions
        - 90 percent of the monitoring path must have unrestricted airflow and be located away from obstacles.
        - The distance from the obstacle to the probe, inlet, or monitoring path must be at least twice the height that the obstacle protrudes above the probe
            - exception can be made for measurements taken in street canyons or at source-oriented sites where structures are unavoidable
        - probe along wall is undesirable
            - must have airflow in an arc of 180 degrees
        - A monitoring path must be clear of all trees, brush, buildings, plumes, dust, or other optical obstructions, including potential obstructions that may move due to wind, human activity, growth of vegetation, etc.
        - near-road NO_2 monitoring stations, the monitor probe shall have an unobstructed air flow, where no obstacles exist at or above the height of the monitor probe, between the monitor probe and the outside nearest edge of the traffic lanes of the target road segment.
    - Spacing from trees
        - probe, inlet, or at least 90 percent of the monitoring path must be at least 10 meters or further from the drip line of trees.
        - microscale sites of any air pollutant, no trees or shrubs should be located between the probe and the source under investigation, such as a roadway or a stationary source.
    - Distance from roadways (average vehicles per day on roadway: distance from roadway required in meters)

- ≤1,000: 10
- 10,000: 20
- 15,000: 30
- 20,000: 40
- 40,000: 60
- 70,000: 100
- ≥110,000: 250

Appendix 5. Vehicle Based Air Quality Monitoring

There are several manufacturers of vehicle mounted air quality monitors. Some of the major manufacturers include Scentroid and IoT. The pollutants monitored can vary depending on the manufacturer and the model of monitor but humidity, GPS, particulate matter, and gas sensors are standard on most monitors. The monitor is attached to the vehicle by a rack and linked to a cloud server; no equipment or modifications to the vehicle are needed. Once functioning, the monitor takes data points every second and uploads them to the cloud. Over the course of weeks and months this data is slowly amalgamated into air quality trends. The GPS data from each data point allows it to be overlaid onto a map of the study area. Depending on the frequency and length of drives of the vehicle, a monitor will typically produce anywhere from 100,000-1,000,000 data points in a month.

There are several large drawbacks to the vehicle mounted air quality monitoring unit. The first major drawback is the accuracy of the data. By operating exclusively on roadways and parking lots, these monitors are susceptible to the emissions local only to that roadway such as the contaminants from vehicle exhaust. They also cannot give long-term and detailed data about the air quality of a region. This is because they are vulnerable to local pollutants as mentioned above and they also cannot get routine data from one location over a long period of time. The second primary drawback of these monitors is the price. Usually costing more than $10,000, these sensors are more expensive than most other solutions. Even though only a few are needed to cover a large area, they are still an expensive option.

Appendix 6. Non-EPA Permanent Air Quality Monitors

Permanent air quality monitors are manufactured by any number of different companies, some of which contract for state and local governments. Being the most commonly used method of air quality monitoring means that the data from permanent stations is the most trusted and previously relied upon by scientists, lobbyists, and policy makers. The process of getting a permanent air quality monitor installed in a location is hard to predict because it has not been done in Colorado Springs before. Also, if a monitor were to be installed it would need professional upkeep. This would have to be a new position because Colorado Springs does not currently employ someone for air monitor upkeep. The cost to the city in addition to the new position would be $5,000-$7,500 to purchase the monitors on a per monitor basis. To realistically cover the Southeast neighborhood, at least two monitors would be needed. If the city wants to do city wide monitoring that number would increase to at least 8-10. While they might be the most ideal in terms of data provided, permanent air stations may be difficult to lobby the city to implement.

Appendix 7. Village Green

Village Green Air Monitoring Station construction and implementation information provided by the EPA: Air Quality Monitoring – Village Green Project Summary, Technical Drawings, Arduinocode Code Libraries, Parts List, Circuit Board Design Files, and Village Green Durham Set-Up Photos.

Appendix 8. Air Quality Monitoring Methods Pros and Cons

Type of Air Monitoring	*Pros*	*Cons*	*Price and Sources of Funding*
EPA-Certified Station	-Most reliable data -Professionally trained staff -Real-time data that can be tracked online	-No telling how long it would take to successfully implement -State and federal project -Stationary (likely one would be placed in southeast) -Requires community health concerns and likely previous evidence of link between pollution and health effects in area -Requires longest time frame for lobbying/advocacy	-Funded by state gotvernment or grants ~$75,000 to set up ozone, $10,000 for yearly maintenance ~$30,000 to set up NO^2 (and other pollutans), $8,000 yearly maintenance -Every 5 years, $30,000 cost for maintenance -Variable rent/lease cost for land
Mobile Air Monitoring Trailer	-Very accurate and reliable data -Measures criteria pollutants, 75 other "hazardous air pollutants" -Professionally trained staff	-Expensive -Albuquerque version does not provide real time data -Must be parked in same place for a full year -Requires longer time frame for lobbying/advocacy	~$750,000 -Funded by city or state government
Vehicle Based Air Quality Monitoring Units	-Covers large geographic area -Only a couple units needed	-Can only operate on roads -Does not get comparable data from one location over extended time -Expensive individual units -Vulnerable to hyperlocal pollution on roadways	~$10,000 per unit but must be mounted on a vehicle
Permanent Air Quality Monitoring Stations	-Accurate and reliable data -Comparable data over a long period of time -Proven by frequent use historically -Real time data updates	-Only collects data from one location -Several would be needed to cover Southeast effectively -Typically needs professional upkeep	~$5,000-7,500 per unit
BouldAir	-Professional input translates complex science for community understanding -Flexible project scale	-Could fail to represent Southeast if implemented at municipal level -May be difficult to fund if implemented at community	~$100,000 but could grow or shrink in scale depending on the work

	-Consultation to determine monitoring scheme -Can implement in conjunction with existing sensors	level	
Village Green	-Community-based -Accessible real-time data -Assess long-term trends in air pollution and weather	-Need sunlight to power the station (solar panels) -Possible interruptions to wireless communication -Would need maintenance staff	~2,500 -EPA funding
PurpleAir	-Inexpensive air monitoring tool for measuring real-time particulate matter -Ideal for school programs and creating awareness around air quality in the Southeast -Accessible date through PurpleAir website and app	-The sensor is not regulatory-grade	~$250–$300 -City funding if necessary
CC Monitoring in Southeast	-Continue partnership with CC -Flexible in terms of level of involvement (from Solid Rock's side) -Equipment would be accessible, both for gathering and analyzing data -Students would learn while helping out the community	-Temporary solution to collecting air quality data in the Southeast -Environmental Program at CC would have to work out logistics	-Potentially funded by CC Environmental Program

Appendix 9. Policy and Regulation, Vehicle Emission Testing requirements

2022 Gas Emissions Requirements			
Model Year	**Gas or Hybrid**	**Frequency of Test**	**Testing Fee**
2022	Exempt	n/a	n/a
2021	Exempt	n/a	n/a
2020	Exempt	n/a	n/a
2019	Exempt	n/a	n/a
2018	Exempt	n/a	n/a
2017	Exempt	n/a	n/a
2016	Renewals are Exempt	n/a	n/a
	Need test if transfer of ownership	Every two years	$25.00
1991-2015	Need test	Every two years	$25.00
1976-1990 with Collector Plates	Need test	Every five years	1976 - 1981 = $15.00 1982 - 1987 = $25.00
1976-1990 Without Collector Plates	Need test	1976 - 1981 = Annually	1976 - 1981 = $15.00
		1982 - 1990 = Every two years	1982 - 1990 = $25.00
1976 or newer Grandfathered*	Exempt	n/a	n/a
1975 and older with Collector Plates	Exempt	n/a	n/a
1975 and older without Collector Plates	Need test	Annually	$15.00
Horseless Carriage / Kit Cars / All-Electric Vehicles and Street Rods	No test needed	n/a	n/a
*Vehicles model year 1976 or newer that have been registered as a "collector's item" prior to September 1, 2009, and the registration has never lapsed or expired or had a change of ownership.			

Full Albuquerque ordinance on Fugitive dust:
https://www.srca.nm.gov/parts/title20/20.011.0020.html

Appendix 10. Emergency Management in Connection to Cooling and Cleaner Air Centers

Agencies that appear most fit to take on severe heat/air pollution response based on their stated responsibilities in the PPROEM Emergency Operations Plan

1. Emergency Coordination Center (ECC) Role

   The ECC is a central coordination point for all emergency functions, communication and public information in the case of a disaster. Its stated responsibilities include collecting and communicating accurate information to the city, the El Paso County emergency response policy group, incident command, and regional partners. The ECC is also responsible for determining and prioritizing required actions, providing resource support, and incident accountability. Because the ECC is one of the core resources for emergency response, their support for severe heat/air pollution response, especially in areas that experience the Urban Heat Island effect, is critical.
2. Community Emergency Response Team (CERT)

   The CERT provides emergency preparedness education and training on a community/neighborhood level for volunteers. Their support could potentially be key to community response to severe heat and air pollution in Southeast Colorado Springs.
3. Board of County Commissioners (BoCC)

   The BoCC provides policy level guidance to county government departments and personnel involved with disaster response. The BoCC determines and authorizes the level of commitment of county resources and funds to disaster response. They also announce disaster declarations when a disaster has occurred or if a threat is imminent. The BoCC could play an important role in allocating funds and resources for emergency heat and air pollution situations.
4. Human Services Division of PPROEM

   Human Services assists coordination with Disaster Assistance Center, non medical mass care services, and coordinating the bulk distribution of emergency relief items. These responsibilities could directly translate to assisting a cooling center (non medical mass care service) and with coordinating the distribution of emergency relief items that may be needed in a severe heat and/or air pollution event.
5. Public Health Division of PPROEM

   Public Health coordinates with a range of agencies and groups to provide, implement, and inspect public health services. Because they provide public health information and risk communication with other counties and agencies, their increased recognition of severe heat issues in Colorado Springs is critical to the management of heat emergencies. The division also coordinates medical support for shelters. This role could be expanded to coordinating medical support for cooling and cleaner air centers.
6. Public Information and Communications Office of Colorado Springs

   The Public Information and Communications Office is tasked with disseminating details to the public on evacuations, closures, and process throughout an emergency. They also are responsible for spreading information on non-emergency safety and preparedness to the Colorado Springs community. Communication with the public about the risks and mitigation tactics of a heat emergency is of utmost importance to keeping people safe. Increasing the level of messaging around heat and air pollution emergencies may require collaboration with this Office.

7. Colorado Springs Public Works and Transportation Office

   Among other tasks, the Colorado Springs Public Works and Transportation Office is responsible for the establishment of emergency traffic routes in case of an emergency. Perhaps this Office can assist in making cooling and cleaner air centers as well as hospitals more accessible through the expansion of public transportation services during extreme heat days.

8. Schools (K-12) and Colleges/Universities

   Schools (K-12) and Colleges/Universities are responsible for providing use of facilities for disaster response. Schools (K-12) are also responsible for providing public transportation assistance through their bus fleets. These two stakeholder groups could assist in establishing facilities that could be utilized as cooling and cleaner air centers.