TULSA URBAN DATA PIONEERS

AIR QUALITY SENSOR PLACEMENT PROJECT

Report of the Project Team

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by

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1.00--EXECUTIVE SUMMARY

1.10--Project Mission

The Tulsa Urban Data Pioneers' Air Quality Sensor Placement Project (Project) mission was to determine for each of Tulsa's nine (9) Council Districts (CDs) the optimum areas for placing two (2) $PM_{2.5}$ Air Quality Sensors, with one area being in close proximity to at least one significant source of $PM_{2.5}$ pollution and the other being remote from significant $PM_{2.5}$ pollution sources.

1.20--Project Results

After analyzing data about $PM_{2.5}$ pollution sources and Census Tracts (CTs) located in Tulsa, the Project Team determined that the following eighteen (18) CTs were optimum areas for placing $PM_{2.5}$ Air Quality Sensors (two per CD, with one CT in close proximity to at least one significant source of $PM_{2.5}$ pollution and the other being remote from significant $PM_{2.5}$ pollution sources).

Distance from PM Source	CD 1	CD 2	CD 3	CD 4	CD 5	CD 6	CD 7	CD 8	CD 9
Close	**5.00**	**46.00**	**16.00**	**45.00**	**85.01**	**90.04**	**76.17**	**76.29**	**50.01**
Remote	**79.00**	**76.12**	**3.00**	**37.00**	**38.00**	**73.12**	**69.03**	**76.37**	**41.01**

The Project Team also determined that the 18 $PM_{2.5}$ Air Quality Sensors should be acquired from PurpleAir, LLC (https://www2.purpleair.com).

2.00--Discussion

2.10--Project's Ultimate Purpose

The Project's ultimate purpose is to determine whether there are significant differences in residential exposure to $PM_{2.5}$ pollution

- among Tulsa's nine (9) City Council Districts (CD) and, within each CD,
- between locations in close proximity to at least one significant source of $PM_{2.5}$ pollution and locations remote from significant $PM_{2.5}$ pollution sources.

2.20--Project Rationale

"PM2.5 [particle pollution] is fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller." EPA, ***Particulate Matter (PM) Basics***, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics (last accessed 5-28-2020). People exposed to $PM_{2.5}$ pollution are at significant risk of suffering health problems (including cardiovascular disease, cerebrovascular disease, chronic kidney disease, chronic obstructive pulmonary disease, dementia, type 2 diabetes, hypertension, lung cancer, pneumonia) and premature death. Benjamin Bowe, MPH; Yan Xie, MPH; Yan Yan, MD, PhD; Ziyad Al-Aly, MD, ***Burden of Cause-Specific Mortality Associated With $PM_{2.5}$ Air Pollution in the United States*** 1, in JAMA Nework-Open, available at https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2755672 (2019, last accessed 5-28-2020) [***Burden***]. Recent studies have revealed that the health risks associated with exposure to $PM_{2.5}$ pollution are significant even at concentration levels below current regulatory standards. See ***Burden***, at p. 1; Elizabeth Ridlington, Gideon Weissman, Morgan Folger, ***Trouble in the Air: Millions of Americans Breathed Polluted Air in 2018*** 11-12, available at https://environmentamerica.org/feature/ame/trouble-air (Environment America Research & Policy Center, U.S. PIRG Education Fund, Frontier Group Winter 2020, last accessed 5-28-2020) [***Trouble***]

Although $PM_{2.5}$ pollution concentrations in Tulsa are below U.S. regulatory standards [Currently, the EPA has primary and secondary standards for PM2.5 (annual average standards with levels of 12.0 $\mu g/m^3$ and 15.0 $\mu g/m^3$, respectively,; 24-hour standards with 98th percentile forms and levels of 35 $\mu g/m^3$), U.S. E.P.A., ***National Ambient Air Quality Standards (NAAQS) for PM***, at https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm, last accessed 5-28-2020], Tulsa has reason to be concerned about the health effects $PM_{2.5}$ pollution has on its residents. Tulsa's $PM_{2.5}$ pollution levels are above the levels recommended by U.S. E.P.A. Scientists. [In 2016, Tulsa had an annual average PM2.5 concentration of 9.5, compared to an average of 8.5 across the Dashboard cities, City Health Dashboard, Tulsa Metric Detail for Air Pollution - Particulate Matter in 2016, at https://www.cityhealthdashboard.com/ok/tulsa/metric-detail?metric=21, last accessed 5-28-2020 (***Tulsa PM Metric***). U.S. E.P.A. Scientists and others have recommended that the standard be set as low as 8 $\mu g/m^3$, see Sean Reilly, ***EPA scientists said U.S. should tighten key air pollution limit. The agency's head just said no***, in SCIENCE MAGAZINE, Apr. 14, 2020, 1:55 PM, at https://www.sciencemag.org/news/2020/04/epa-scientists-said-us-should-tighten-key-air-pollution-limit-agency-s-head-just-said, last accessed 5-28-2020). Tulsa's annual average $PM_{2.5}$ pollution level is above the annual average $PM_{2.5}$ pollution level across 500 U.S. Cities. See ***Tulsa PM Metric***. In 2018, Tulsa was among 26 large and small urban areas with more than 100 days of elevated $PM_{2.5}$ pollution levels. See ***Trouble***, Table 5: Ten most populated metropolitan areas with more than 100 days of elevated particulate pollution in 2018, at p. 23.

Children, older adults, and people suffering from heart or lung disease are more vulnerable than other people to health problems associated with exposure to $PM_{2.5}$ pollution. See U.S. E.P.A Particle Pollution and Your Health, at https://www3.epa.gov/airnow/particle/pm-color.pdf, last accessed 5-28-2020. In addition, studies have shown that people of color and socioeconomically disadvantaged communities are disproportionately afflicted with $PM_{2.5}$ pollution related health problems. See ***Burden at 1.*** Low-income neighborhoods and neighborhoods with significant people of color populations are more likely than others to be closer to significant sources of $PM_{2.5}$ pollution. See ***Burden at 1.***

There are demographic differences among Tulsa's CDs and within each CD that could signify that there are significant differences in residential exposure to $PM_{2.5}$ pollution among Tulsa's CDs and within CDs between locations in close proximity to at least one significant source of $PM_{2.5}$ pollution and locations remote from significant $PM_{2.5}$ pollution sources. At the present time, only two (2) air quality monitors capable of measuring $PM_{2.5}$ pollution levels are located in or near Tulsa (one in far North Tulsa and one South of Tulsa near Glenpool), so without the deployment of more $PM_{2.5}$ Air Quality Sensors it is not presently possible to get more granular measurements of $PM_{2.5}$ pollution levels in various parts of Tulsa.

2.30--CT Selection Rationale

The Project Team used CTs as the basis of determining the optimal $PM_{2.5}$ Air Quality Sensor placement areas CT locations can be mapped in relation to $PM_{2.5}$ pollution sources, and various databases provide useful information about people and things located within them. CTs with low population densities were eliminated from consideration so the Project Team could focus on CTs where the presence or absence of high $PM_{2.5}$ pollution levels would have the greatest impact.

2.40--CT Selection Methodology

Most particulate matter forms from power plant, industrial, truck, and automobile emissions. Accordingly, the Project Team used information from the Oklahoma Department of Environmental Quality's Air Quality Division to identify the seven (7) point sources of $PM_{2.5}$ pollution located in Tulsa that have acquired operating permits and emit at least five (5) tons of $PM_{2.5}$ pollution annually. These point sources were ranked by the amount of their $PM_{2.5}$ pollution emissions.

CD	PM2.5 Pollution Emitters	T/yr	Address
2	Holly Frontier Tulsa Refining	67.10	3333 Southwest Blvd.
2	Hollyfrontier Tulsa Refining	44.74	1700 S. Yukon
1	Universal Sandblasting & Coating	44.00	1800 S. 49th W. Ave
2	PSO-AEP Power Plant	14.21	3600 S. Elwood Ave.
3	Waste Management of Oklahoma	9.56	13720 E. 46th St. N.
3	Valmont Newmark	7.54	801 N. Xanthus Ave.
2	Covanta Tulsa Renewable Energy	5.00	2122 S. Yukon Ave.

The Project Team also used Tulsa traffic maps to locate 14 transport routes heavily travelled by cars and trucks.

Major Routes	Crosstown Expressway	Skelly Drive	Creek Turnpike	BA Expressway
Interstate Highways	I244	I44	Hidden I444	
US Highways	US64	US75	US169	US412
Oklahoma Highways	OK11	OK51	OK364	
Expressway / Parkway	Gilcrease	LL Tisdale		
Tulsa Streets	Riverside Drive	Memorial Drive	71st St	

GIS mapping and Google Earth was used to determine CTs within each CD that are close and remote to these 21 significant sources of $PM_{2.5}$ pollution.

CTs deemed to be close to at least 1 significant source of $PM_{2.5}$ pollution were evaluated on the bases of the following criteria about the $PM_{2.5}$ pollution sources to which they are close:

- Distance,
- The number of $PM_{2.5}$ pollution sources, and
- Amount of $PM_{2.5}$ pollution emissions.

Based on the above criteria, the Project Team made judgments about which are the CTs where residents are likely to be the most affected by $PM_{2.5}$ pollution. Wind Data for 2019 showed on that on average wind blew from a southerly direction most of the year. As a consequence, CTs located in northerly directions from $PM_{2.5}$ pollution sources were preferred. Given uncertainties inherent in the Project Team's judgment (see **2.50** below), two (2) CT finalists per CD were selected from among CTs close to $PM_{2.5}$ pollution sources.

At this point in the process, health, socio-economic, and environmental information related to identifying communities most vulnerable to $PM_{2.5}$ pollution was gathered for each CT finalist.

Project Team members then used this information to cast their votes for the CTs close to $PM_{2.5}$ pollution sources they believed would be the optimum places to host a $PM_{2.5}$ Air Quality Sensor. CTs receiving a majority of the votes were selected. The tables below show the locations of the "winning" CTs and their health and socio-economic characteristics.

CD	CT	N	S	W	E
1	5.00	Apache	Pine	Peoria	US75
2	46.00	US75/ Ark. R.	W 25th/ W 23rd	US75	Jackson Ave/ ArkR
3	16.00	Pine	Admiral Blvd	Yale Avenue	Sheridan Road
4	45.00	21st St	31st St	Riverside Dr	Peoria Ave
5	85.01	21st St	31st St	Memorial Dr	Mingo Road
6	90.04	31st St	41st St	US169	Garnett Road
7	76.17	61st St	71st St	Memorial Dr	Mingo Road
8	76.29	91st St	101st St	Sheridan Road	Memorial Dr
9	50.01	41st St	I44	Arkansas River	Peoria

CD	CT	Hi Blood Pressure	Life Expectancy	Children in Poverty	Income Inequality	Race/Ethnic Diversity	> Housing Cost
1	5.00	50.80%	67.5	71.5%	-61.2	52.1	42.8%
2	46.00	35.60%	74.1	74.2%	-53.6	85.7	36.8%
3	16.00	39.70%	70.4	50.7%	-39.0	77.9	44.5%
4	45.00	34.40%	81.2	18.8%	30.1	23.1	22.5%
5	85.01	39.20%	72.5	42.4%	-21.1	76.3	26.7%
6	90.04	33.00%	74.7	43.7%	-29.9	77.7	41.3%
7	76.17	33.90%	78.9	30.7%	-27.0	82.1	47.0%
8	76.29	29.10%	80.8	14.6%	5.0	62.3	26.2%
9	50.01	32.60%	73.8	40.9%	-15.3	46.8	26.7%

Income Inequality = [(HH in top 20% - HH in bottom 20%)/Total HH] x 100 (higher score is better)

Racial/Ethnic Diversity: 0 means all persons are in a racial/ethnic group, 100 means all racial groups are equally represented. The Higher the score, the greater the diversity. Majority/Minorities are not identified.

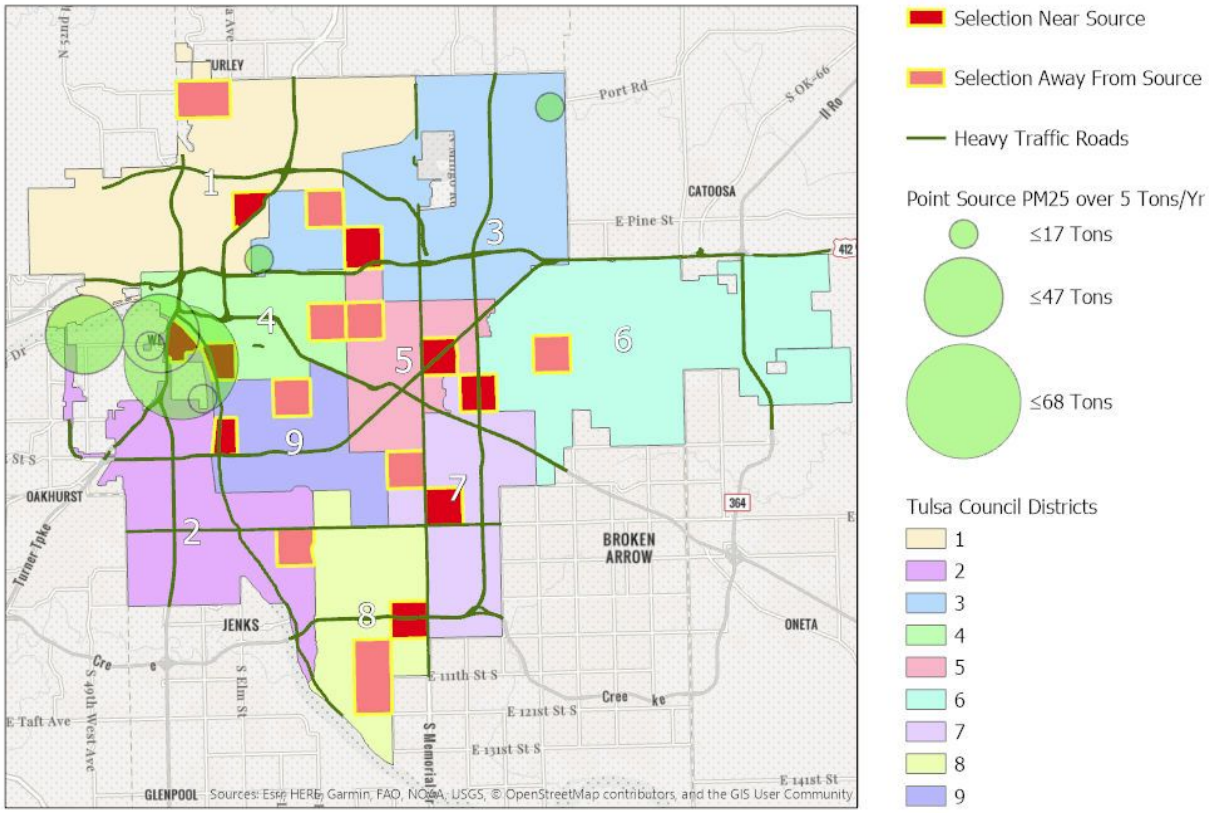
Housing Cost, Excessive: % of households where housing costs is 30% or > than income (less is better)

The CTs remote to $PM_{2.5}$ pollution sources were selected to host $PM_{2.5}$ Air Quality Sensor on the basis of 3 factors: Population density, distance from nearest $PM_{2.5}$ pollution source, and, all other things being equal, being located in a southerly direction from $PM_{2.5}$ pollution sources. After these selections were made, health, socio-economic, and environmental information related to identifying communities most vulnerable to $PM_{2.5}$ pollution was gathered about the "winners." This information can be used to make some preliminary assessments of whether the health, socio-economic and environmental circumstances of communities residing in CTs close to $PM_{2.5}$ pollution sources are substantially different than those of communities residing in CTs remote to $PM_{2.5}$ pollution sources. The tables below show the locations of the "winning" CTs and their health and socio-economic characteristics.

CD	CT	N	S	W	E
1	79.00	56th St N	46th St N	Osage Drive	Peoria
2	76.12	71st St	81st St	Lewis Avenue	Harvard Avenue
3	3.00	Xyler St	Pine St/ Ute	Harvard Avenue	Oswego/ Pittsburg
4	37.00	11th St	21st St	Harvard Avenue	Yale Avenue
5	38.00	11th St	21st St	Yale Avenue	Sheridan Road
6	73.12	21st St	31st St	129th E Avenue	145th E Avenue
7	69.03	51st St	61st St	Sheridan Road	Memorial Drive
8	76.37	101st St	121st St	Yale Avenue	Sheridan Road
9	41.01	31st St	41st St	Lewis Avenue	Harvard Avenue

CD	CT	Hi Blood Pressure	Life Expectancy	Children in Poverty	Income Inequality	Race/Ethnic Diversity	> Housing Cost
1	79.00	51.0%	67.0	42.0%	-41.2	53.5	35.3%
2	76.12	23.4%	79.5	8.2%	29.1	68.5	23.2%
3	3.00	42.3%	71.5	57.1%	-43.0	84.0	35.8%
4	37.00	29.2%	75.6	7.8%	-6.3	40.6	22.0%
5	38.00	34.5%	74.3	1.2%	-8.9	48.5	24.9%
6	73.12	33.2%	78.1	38.8%	-17.3	86.8	33.2%
7	69.03	40.0%	81.2	9.6%	-6.6	58.6	28.6%
8	76.37	32.9%	82.9	3.9%	58.5	43.4	21.0%
9	41.01	35.7%	81.6	0.0%	39.0	29.3	25.1%
Tulsa Score		35.9%	75.8	30.4%	-13.6	77.0	31.6%
Dashboard Score		29.6%	79.0	20.4%	-1.1	62.0	35.8%

Below is the GIS map showing the locations of all the selected CTs relative to each other and Tulsa's significant sources of $PM_{2.5}$ pollution



2.50--Caveat re Selecting Sites Close to PM2.5 Pollution Sources

Accurate information about the pathways of $PM_{2.5}$ pollution from the seven (7) significant permitted point source emitters located in Tulsa could not be acquired because emission pathways can be determined only through expensive modeling techniques or by accessing the results of such modeling acquired by Air Quality regulators and made available to the public. Only point sources that emit at least 100 Tons of $PM_{2.5}$ pollution annually have been required to provide regulators with detailed information about the pathways of their emissions. None of Tulsa's permitted point source emitters meet the 100 Tons threshold. In absence of this information, the Project Team had to use the intuitive judgment that residents of CTs closer to point sources of $PM_{2.5}$ pollution are more likely to be affected by their emissions than residents of CTs more remote from those point sources.

2.60--Air Quality Sensor Selection Rationale

For the following reasons, the Project Team recommends that the City of Tulsa, with help from private sources if necessary, purchase and deploy 18 PurpleAir PA-II Air Quality Sensors (https://www2.purpleair.com/products/purpleair-pa-ii):

- Reasonable Price--$229.00
- High Accuracy relative to competitors (see http://www.aqmd.gov/aq-spec/evaluations/summary-pm)
- Real-time $PM_{2.5}$ concentrations measurement capability
- Built in WiFi enabling the storage and retrieval of $PM_{2.5}$ concentration data and its transmission to any smart device and PurpleAir's 24/7 Sensor Map (https://www.purpleair.com/map?opt=1/mAQI/a10/cC0#1/4/-30)

3.00--Next Steps

Fulfill the ultimate purpose of the Project (see ***1.31*** above), the City of Tulsa, with help from willing Project Team members and others, take the following actions:

- Acquire 18 PurpleAir PA-II Air Quality Sensors
- Select appropriate installation sites (residences, libraries, businesses, etc.), which must
    - Be secure
    - Provide electricity 24/7
    - Provide WiFi interconnection 24/7
- Install Sensors
- Monitor Sensors' performances
- Operate Sensors and collect their data for at least one year
- Compare $PM_{2.5}$ pollution data from the sensors
- Determine the significance of the comparative data for future policy development and actions