Oklahoma City
Summary of Assessments & Services

March 2024

Prepared for the City of Oklahoma City by CAPA Strategies

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Background

In 2023 and 2024, the climate adaptation consultancy CAPA Strategies (CAPA) conducted multiple heat and air quality assessments in Oklahoma City (OKC). The purpose of these activities was to capture a variety of perspectives on two pressing environmental stressors in the region – urban heat and air pollution – including spatial, social, quantitative, and qualitative information. Each of the five assessments and services addressed different topics, from heat intensity and pollutant concentration, to human perceptions of heat risk and feasible intervention strategies for heat mitigation. Taken together, the outputs of these activities offer a holistic view of heat and air pollution exposure in OKC, ground environmental data in social context, and build a strong foundation of knowledge for future discussions, outreach, plans, fundraising, and decision making.

This report provides a summary of all activities performed including methods, participants, findings, and conclusions. It offers insight into multiple campaigns and initiatives, though the details reported here are not exhaustive. Each of the five activities has a dedicated report or deliverable, including complete accounts of processes and outcomes, which can be referenced for more information.

Activities were funded collaboratively by the City of OKC and regional partners. Funders included the City of OKC's Office of Sustainability, the Association of Central Arizona Governments (ACOG), the Oklahoma City Community Foundation (OCCF), and the Oklahoma Department of Environmental Quality (DEQ).

Assessment / Service	Description	Funder(s)
Heat Watch Mapping Campaign	The Heat Watch program convened local volunteers to drive pre-planned routes around the city, at three times of day, to collect ambient air temperature data. The results were used to create heat distribution maps, revealing which areas of the city are hottest and most prone to the urban heat island (UHI) effect. **Final product:** *Oklahoma City Heat Watch Report*	City of OKC DEQ
Air Quality Monitoring	During the Heat Watch campaign, volunteer drivers attached air quality monitors to their vehicles and collected air quality data (PM2.5) around the city. Stationary sensors were installed on fire stations for a period of three weeks after the campaign. **Final product:** *Oklahoma City Air Quality Monitoring Report*	ACOG DEQ
Jurisdictional Scan	The jurisdictional scan involved a review of heat-relevant plans, reports, and codes. It provided an overview of the potential "UHI mitigation and adaptation levers" that the City could use to advance heat resilience. The scan set context and realistic directions for heat mitigation; highlighted potential barriers in existing codes, plan goals, and policy language; and identified notable stakeholders. **Final product:** *Oklahoma City Jurisdictional Scan Report*	ACOG OCCF
Social Survey	The 'OKC Summer Heat Survey' explored where residents were most exposed to summer heat and air pollution; how residents perceived summer conditions and heat risk in OKC; residents' attitudes about trees, green space, and other heat mitigation or adaptation measures; and residents' knowledge of the UHI effect. The survey received 2,009 complete responses; 250 of which were analyzed in depth. Those 250 consisted of both High and Low Heat Vulnerability (HVI and LVI) ZIP codes. **Final product:** *Oklahoma City Summer Heat Survey Report*	OCCF
Intervention Guidebook	This resource includes a variety of heat mitigation and adaptation strategies that can be applied citywide and/or in individual residences. The interventions are based in heat-related research and best practices; are suitable for the humid subtropical climate of OKC; and are in alignment with existing codes, plan goals, and policies. Content includes tips for implementing different interventions, special considerations, and case study examples. Proposed interventions were informed by the Social Survey and Jurisdictional Scan. **Final product:** *Heat Mitigation & Adaptation Guidebook – Strategies for Oklahoma City*	OCCF

Heat Watch

Oklahoma City Heat Watch Training Session

Overview & Methods

Heat Watch is CAPA's urban heat island mapping program that engages local stakeholders in an on-the-ground data collection process to better understand the distribution of ambient heat (i.e. near-surface air temperature) across a region. Project leaders at the City of OKC Sustainability Office engaged with over 110 local community members to cover 350 square miles of urban and rural area in a mobile mapping exercise on August 12th, 2023. Together, this group co-designed the study with CAPA to sample heat across the diverse land uses and geographical features of the OKC region on a typical hot day. A heat-focused partnership emerged between local stakeholders including Sustainability Office staff, residents, emergency officials, and researchers. Throughout the process, participants learned about the Urban Heat Island (UHI) effect in their area and raised awareness of the issue through training, discussions, and media coverage. Together, the group achieved two main objectives:

1. Developed high resolution descriptions of the distribution of ambient (air) temperature and humidity (heat index) across your region; and

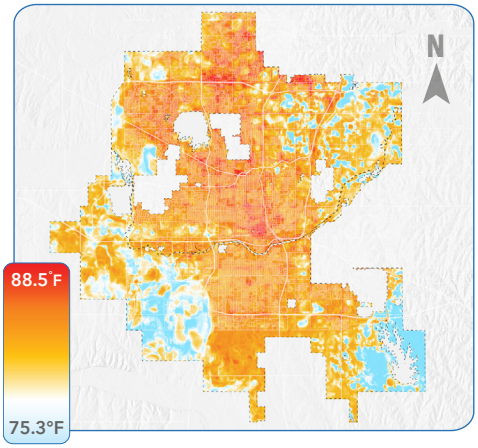
2. Engaged local communities to create partnerships to better understand and address the inequitable risks posed by extreme heat.

The results provide a snapshot in time of how urban heat varies across neighborhoods and how local landscape features affect temperature and humidity. In the report we present the process, mapping outputs, media coverage and photographs from Heat Watch, as well as next steps for how to build on the results.

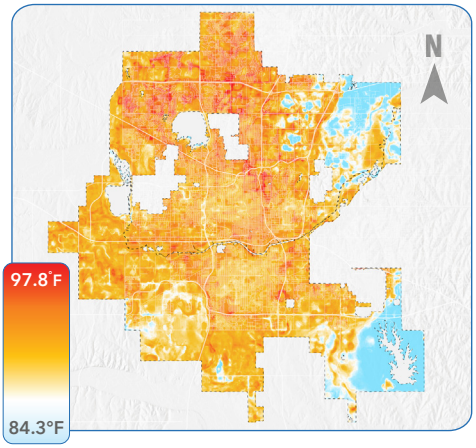
Results

Heat Watch outputs include the temperature and relative humidity measurements collected by participants at morning, afternoon and evening, as well as modeled outputs of temperature and heat index distribution across the entire study area. CAPA developed the models using multi-band spectral imagery from the Sentinel-2 satellite constellation. The processed bands of the imagery describe at high resolution (10-meter) patterns in the land cover below. CAPA used the bands in a machine-learning process to generate a model trained by the traverse point measurements. The outputs were mapped to show heat distribution within each time period.

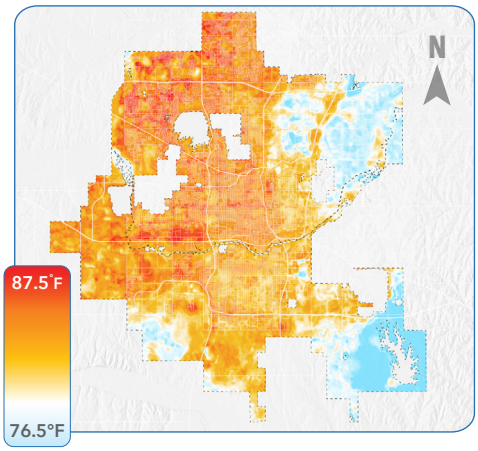
Morning Area-Wide Predictions (6 - 7 am)



Afternoon Area-Wide Predictions (3 - 4 pm)



Evening Area-Wide Predictions (7 - 8 pm)

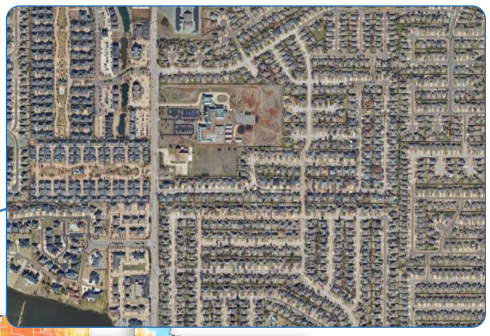


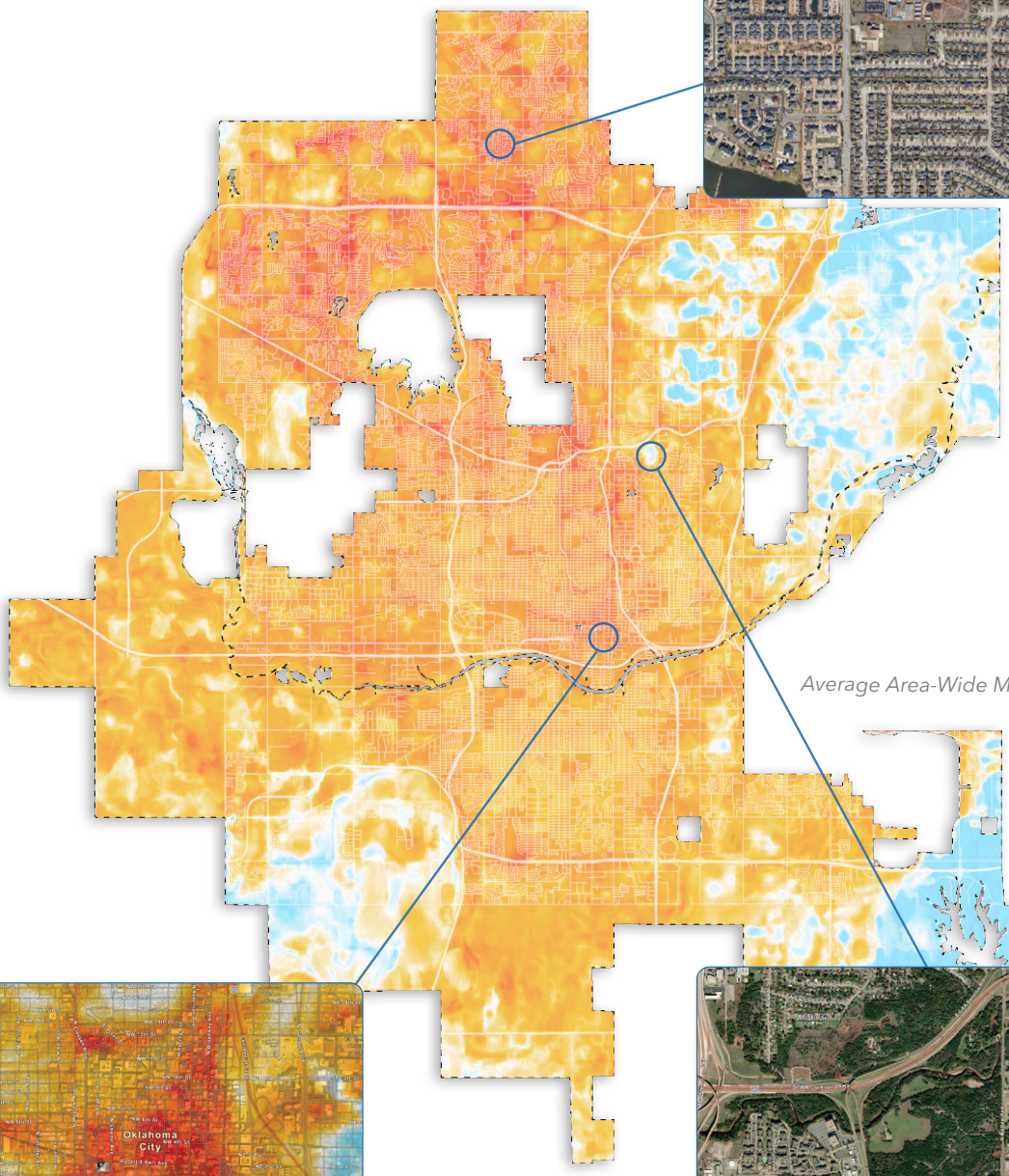
A maximum measurement of 98.1°F was recorded on the day of the campaign (August 12th, 2023), among over 223,000 measurements. The maximum difference among measurements in a single time period occurred in the morning, with a 14.7°F differential (note this statistic refers to the measurements, not the models). This indicated that temperatures can vary widely across OKC at the same time of day, creating disproportionate exposure to urban heat depending on one's location in the city.

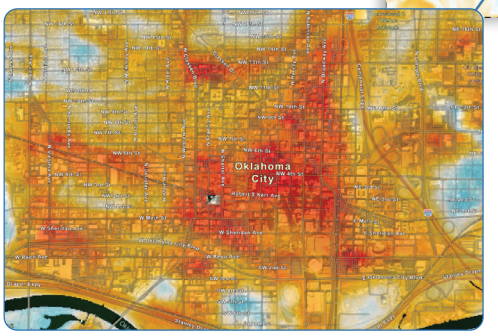
CAPA noted differing concentrations of heat based on land cover patterns, such as homogeneous suburban neighborhoods in the northwestern portion of the region, indicating higher temperatures likely due in part to high proportions of impervious surfaces and limited natural space. Dense building material in the downtown also appeared as a heat island relative to surrounding areas. On the contrary, areas with wide open space and preserved natural forest seemed to provide cooling to surrounding areas. Datasets are available for download on the Open Sciences Framework here: link and the maps are visualized on ArcGIS Online here: link.

See map on following page.

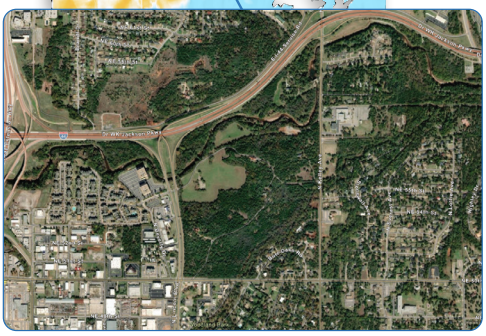
Heat concentrates in these homogeneous suburban neighborhoods with high amounts of impervious surfaces and little natural space.







With such a large region, the GIS tool "Dynamic Range Adjustment" helps to see heat variation at smaller scales.



Open space and natural forested areas provide cool refuge to surrounding developed areas.

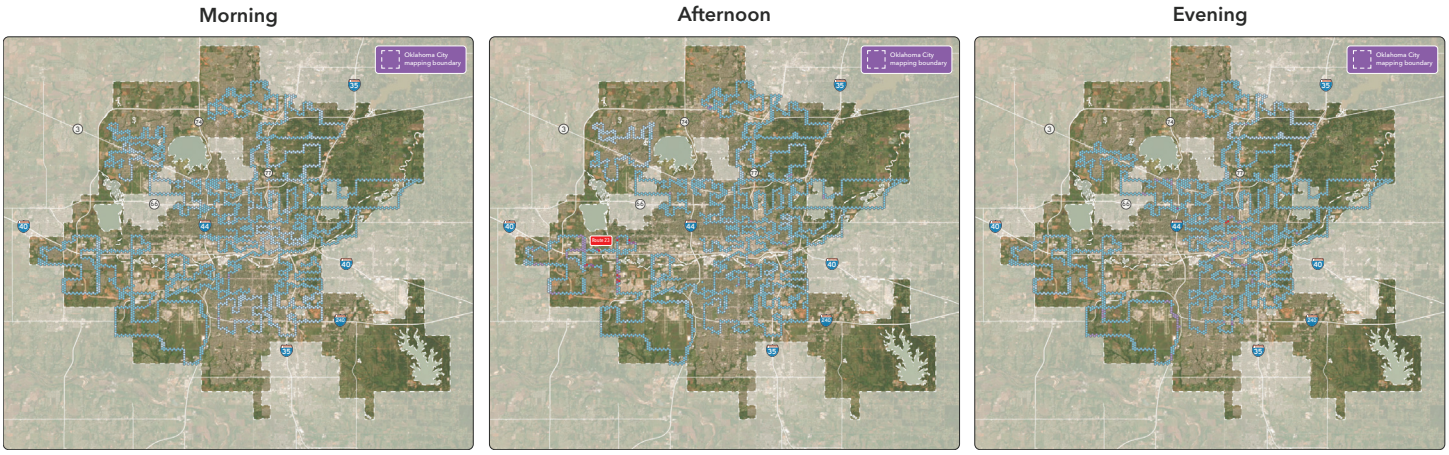
Air Quality Monitoring

Overview & Methods

In tandem with the Heat Watch campaign, project members in OKC aimed to better understand the distribution of air pollution across the city. Air quality monitoring was conducted both as a mobile campaign, offer a spatially-rich snapshot, and as a stationary campaign, allowing partners to observe temporal patterns.

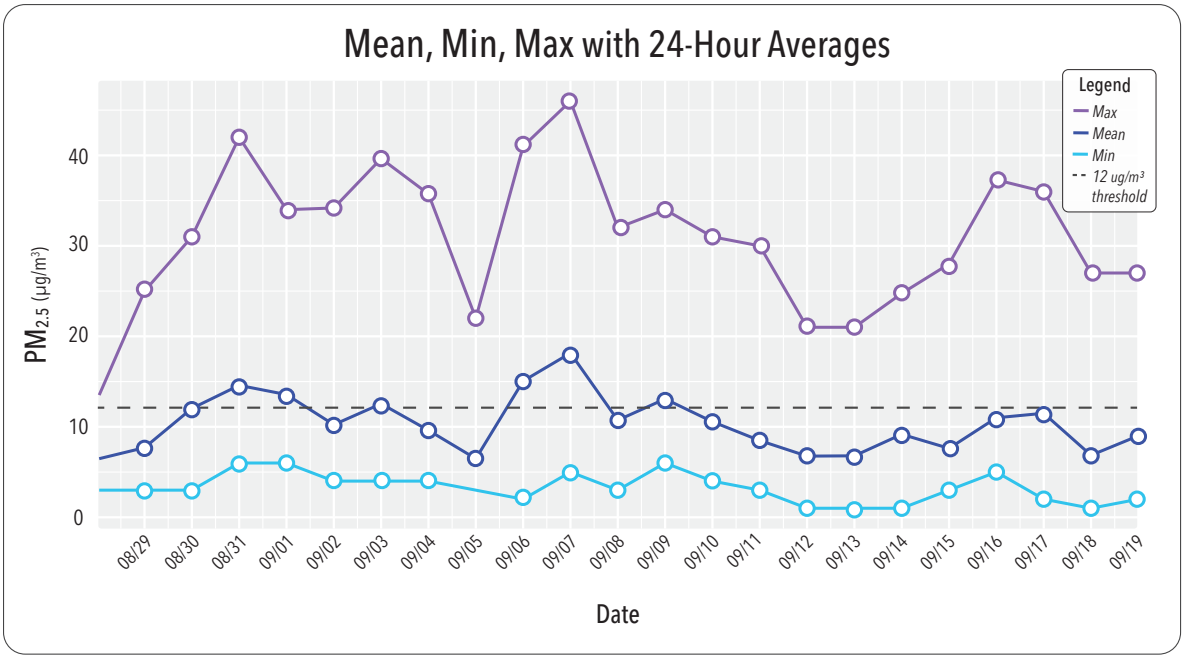
During the Heat Watch campaign, each volunteer attached an AirBeam sensor alongside the CAPA heat sensor to collect mobile readings of a harmful pollutant class known as Particulate Matter (PM2.5). The same traverses were used to collect mobile air quality data as were driven for the Heat Watch campaign, as the two efforts occurred simultaneously. The sensors were then installed for a three-week stationary phase outdoors at fire stations and public buildings spanning the region. The stationary mapping campaign generated a geographically diverse picture of PM2.5 distribution during the period from August 31st to September 19th, 2023. For this phase, AirBeam sensors were installed primarily behind local fire departments, which provided geographic spread, a secure public location, and a steady power source. Sensors were also installed at several Department of Environmental Quality (DEQ) regulatory monitoring sites for measurement validation. Data trends were analyzed for each sensor, revealing which locations reached elevated pollution levels (i.e. average PM2.5 of >12 ug/m3 over a 24 hour period).

Results

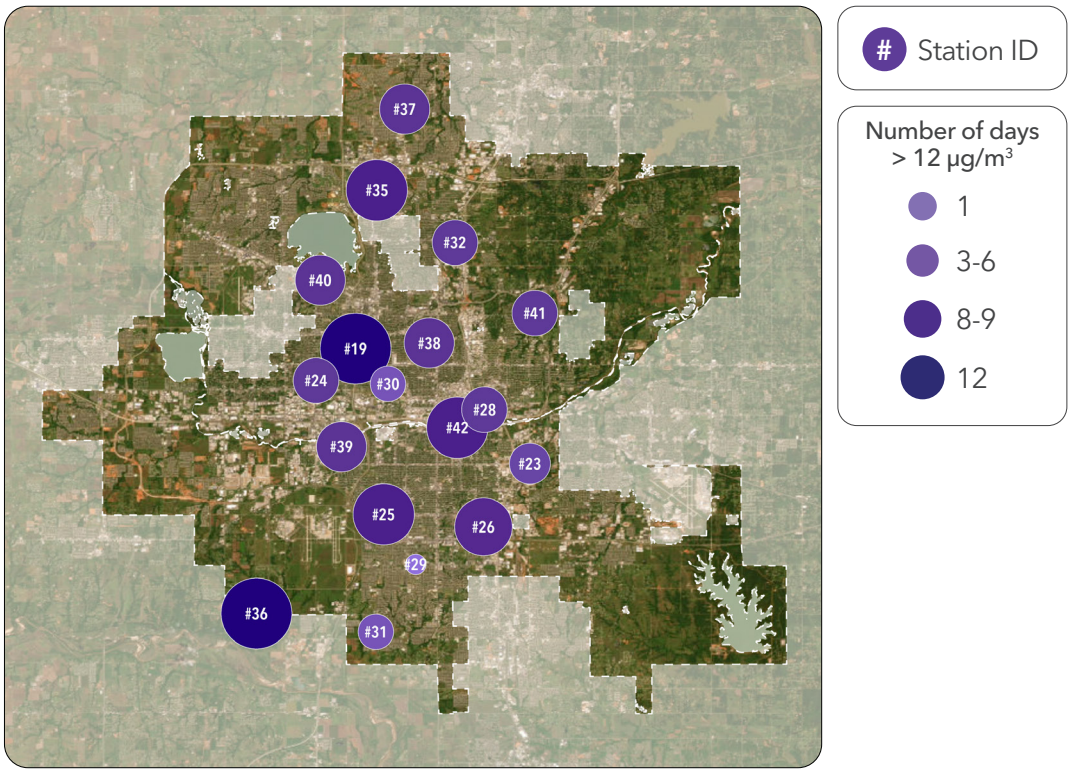


Morning: Particulate matter levels were relatively low across the Oklahoma City area during the mobile campaign, which may have been due in part to rainfall prior to and during the campaign day (2.33mm over previous 24hr period at WRWA station.[1] In the morning, PM2.5 levels were the lowest with an average of 4 ug/m3. In areas with more dense vegetation to the northeast and south we see levels near 0 ug/m3. **Afternoon:** In the afternoon, PM2.5 levels rose slightly across the area, with several "hazardous" level measurements in the industrial zone to the west of downtown (Route 23). It is important to note here that extreme values, which may be related to roadway vehicles or point-source emissions, are not excluded from the mobile datasets, as they are considered accurate measurements and reflect real conditions observed along the traverses. **Evening:** In the evening time, particulate matter levels were at their highest of the three time periods, with near-zero concentrations in densely vegetated areas to the northeast and "unhealthy" levels measured in several locations in the central city and along roadways near the airport.

During the stationary campaign, average measurements were the highest on September 6th, while maximum levels peaked on September 7th. The lowest average measurements were collected on September 18th. Measuring the highest in PM2.5 concentration over the two week period was AirBeam 26, installed at Fire Station #16 at McCracken Park in the Cloverleaf neighborhood, with an average PM2.5 reading of 13.2 µg/m3. Following closely was AirBeam 19, installed at the DEQ West regulatory site in Will Rogers Garden, located by the interchange between interstate I-44 and Highway 66, with an average PM2.5 reading of 13.1 µg/m3. The lowest measuring sensor was AirBeam 31, at Fire Station #35 located in the Rivendell neighborhood, with an average reading of 9.0 µg/m3.



Mean, Min, Max with 24-Hour Averages



Days over 12 PM2.5 By Sensor

Conclusions

According to the EPA, when PM2.5 measurements reach a 24-hour average between 12-35 µg/m3, sensitive individuals should avoid outdoor activity as they may experience respiratory symptoms. CAPA tabulated the number of days that each sensor measured 24-hour means of over 12 µg/m3. AirBeams 19 and 26 both measured 12 days out of 21 with an average concentration over that threshold. This is significant for sensitive individuals that reside or spend the majority of their time in the areas surrounding those monitoring locations.

As evidenced by the mobile traverses, on relatively low air pollution days (mean < 8 ug/m3) concentrations of particulate matter do vary across the area by location and time of day. On-road mobile monitoring reached locations outside of established DEQ reference station areas, highlighting areas experiencing elevated concentrations of particulate matter that may not have otherwise been detected (e.g., along the industrial area near Route 23 in the afternoon).

1. Certain locations consistently saw elevated levels of air pollution more often than others, contributing to disparate levels of exposure by location;

2. The co-located AirBeam and DEQ West regulatory station tracked closely in $PM_{2.5}$ measurements (correlation coefficient of 0.67); and,

3. Given the evidence of spatial variability in $PM_{2.5}$ concentrations across the area, significant gaps persist in the long-term air quality monitoring network across Oklahoma City, hindering the ability of planners to sufficiently strategize long-term adaptation actions as well as short-term response activities during poor air quality events.

Given these findings, CAPA recommended increasing the presence of long-term stationary monitoring networks across OKC. Specifically, monitoring could be done in areas that indicated higher levels of PM2.5 concentrations in the mobile study, as well as the peak-day and 24-hour mean exposure maps from the stationary study. Collaborative studies that span governance structures are a key building block for raising public awareness, co-creating mitigation and adaptation strategies, and guiding further research. Air quality monitoring results should be integrated with complementary local research for a robust understanding of the distribution and effects of PM2.5 in OKC. Datasets are available for download on the Open Sciences Framework here: link

Jurisdictional Scan

Overview & Methods

A jurisdictional scan is a context-setting exercise. The process involves a systematic review of existing codes, plans, and policy language to identify opportunities and limitations related to urban heat mitigation or adaptation. In OKC, documents were reviewed for "UHI mitigation and adaptation levers;" in other words, pathways for addressing the urban heat island effect. Documents were also reviewed for references to relevant stakeholders who might play a role in heat-related work. The scan captured important details such as municipal code requirements governing tree canopy, energy efficiency and development; goal and policy language used in City-adopted plans; and heat-related challenges or needs identified in local communities.

The jurisdictional scan began with document selection. Several suggestions were provided by the City of OKC Office of Sustainability and others were identified by CAPA through supplemental research. Multiple documents were reviewed which did not have any apparent connection to urban heat and were ultimately excluded from the scan. In total, CAPA reviewed nine plans and guidance documents, five municipal ordinances and codes, and two project reports.

Plans & Guidance Documents
Oklahoma City Metropolitan Area Tree Canopy Assessment (2019)
Oklahoma County Hazard Mitigation Plan (2019 Update)
City of Oklahoma City, *Hazard Mitigation Plan* (Update 2022)
City of Oklahoma City, *Emergency Operations Plan* (2023)
Ozone Alert Days (2022)
*plan**okc*** (2020)
*green**okc*** (2020)
*adapt**okc*** (2020)
So8th: A Community Vision (2023)
Municipal Ordinances and Codes
International Building Code (2018)
International Energy Conservation Code (2009)
OKC Municipal Code, Chapter 38: Parks Recreation, Cultural Affairs, Etc.
OKC Municipal Code, Chapter 59: Zoning and Planning Code Article VI: Zoning and Base Districts
OKC Municipal Code, Chapter 59: Zoning and Planning Code Article XI: Landscaping and Screening Regulations
Other assessments and summary reports
Lynn Lifestyle Summary – Northeast Oklahoma City (2016)
Cost of Nonattainment Study for the Oklahoma City Area

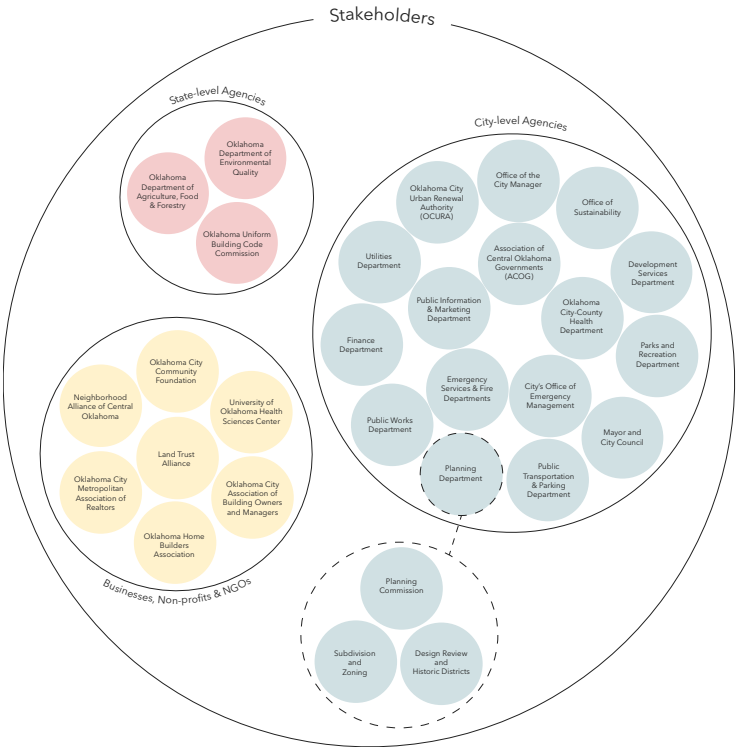
Findings

The current landscape of plans, codes, and policies in OKC showcases considerable support for heat resiliency measures. This is especially true for measures concerning trees/greening and emissions reductions. Strategies such as changes in building configuration and density, tree canopy expansion, and energy efficiency standards may be particularly implementable given existing plans and code language.

Measures that promote short-term heat risk (e.g., emergency preparedness) and individual resilience are less prominent in existing documents. For example, the *Oklahoma County Hazard Mitigation Plan* identifies heat as a threat and proposes general solutions like prevention and education/awareness; however, the plan does not detail actionable steps or protocols that could be followed to achieve stated goals. Given the potential for extreme heat events in OKC, perhaps combined with air pollution, there is a notable opportunity for the City and partners to shore up emergency response plans for that specific hazard. The City might also consider opportunities to expand upon bottled water and fan giveaways, and build resilience in the off season with supports like home weatherization and education.

Like many cities, OKC's ability to implement the goals and policies may be limited by two factors. First, while plan language signals a general awareness and acceptance of issues pertaining to urban heat, sustainability, and greening, many of the desired outcomes are not legally enforceable. Codes like the IBC and IECC are not extensive or creative when it comes to mandated heat-mitigation solutions. Furthermore, the City will be limited in its ability to strengthen the municipal code if mandates conflict with state-level guidance, per the Dillon Rule. A possible solution is to incentivize, rather than mandate, specific behaviors and development standards. Secondly, many of the stated goals and policies are not accompanied by clear guidance for how to implement them. In the future, there will be a need to clarify the steps that must be taken to reach desired outcomes. Establishing milestones and success metrics is a useful strategy in plotting out and tracking progress toward goals.

The following stakeholders entities were identified through the jurisdictional scan:



Conclusions

In the future, the City of OKC might consider developing a heat-specific action plan, resilience plan, and/or emergency response protocol. Additionally, the City could create detailed guidelines to facilitate implementation of the many goals and policies identified in this scan, or aim to have unenforceable goals codified in new legislation. In the meantime, there are numerous actions the City might take to address UHI that align with stated goals in existing plans, policies, and codes. Potential directions include:

1. Develop an urban forestry plan outlining goals, strategies, and actions for managing, preserving, and expanding the urban tree canopy in alignment with numerous tree-related goals and policies identified during the scan.

2. Create clear policies to protect and care for existing trees. Tree protection ordinances can be introduced to regulate removal, pruning, and preservation of trees on both public and private property. For private property, consider incentives such as tax breaks, grants, or fee waivers to encourage tree planting and preservation.

3. Enforce emissions controls on vehicles, including regular inspections for compliance with emission standards and incentivizing low-emission or electric vehicles to reduce sources of nitrogen oxides (NOX) and volatile organic compounds (VOCs). In addition, continued investment in public transportation improvements offers opportunities to reduce ozone and its health-related impacts.

4. Continue to pursue opportunities for renewable energy, such as solar microgrids, wind, and geothermal to create energy redundancies and address increasing energy consumption.

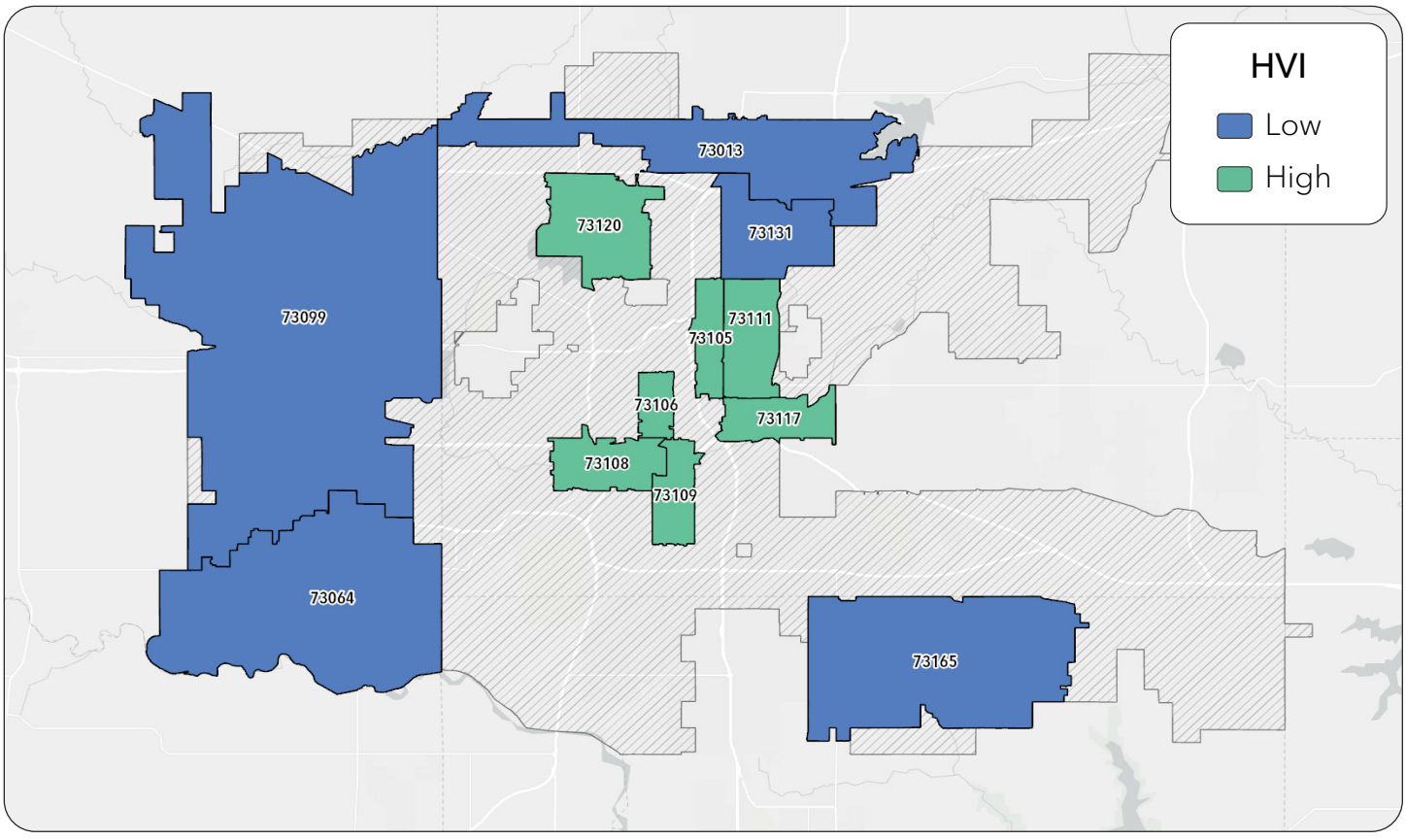
5. OKC uses the International Energy Conservation Code (IECC) 2009 to promote energy efficiency in its buildings. The City might consider updating its building and energy codes to newer iterations, such as the 2015 IECC or later versions, to reflect advancements in energy-efficient technologies and practices. There is also an opportunity to rigorously enforce these existing or updated codes, ensuring compliance across all construction projects.

Social Survey

Overview & Methods

Social information gives additional meaning and depth to environmental data, such as that collected via Heat Watch and air quality monitoring. While those assessments showed where heat exposure might be occurring, a subsequent survey explained what that exposure means for the people who experience it, and what the City could do to help. CAPA and the OKC Office of Sustainability co-developed a 20-question 'Summer Heat Survey' which was disseminated online, citywide. The survey was offered by City staff at in-person events and was also distributed via the City's and OKC Zoo's email networks. Questions were framed around four thematic sections: demographic information, risk perception, exposure, and preparedness. Over 2,000 complete survey responses were collected and the full dataset was provided to the OKC Office of Sustainability for future use. A selection of 250 responses were analyzed in detail for the *Oklahoma City Summer Heat Survey Report*.

The 250 responses were identified using a mix of intentional and random selection. First, the OKC Sustainability Office identified 12 priority ZIP codes that were of greatest interest. These included five ZIP codes that had scored low (Low HVI), and seven ZIP codes that had scored high (High HVI), on a heat vulnerability developed by the University of Oklahoma in partnership with the City of OKC. Theoretically, residents in the Low HVI areas would be less exposed to and/or more able to cope with summer heat than those in High HVI areas. For the final analysis, CAPA included all 96 survey responses that came from High HVI ZIP codes, and took a random sample of 154 from the 357 received from Low HVI areas (total n=250).



Results

Detailed survey results are available in the Oklahoma City Summer Heat Survey Report, and excerpts and a summary of key findings are included below.

Demographics

The vast majority of survey participants were homeowners (84.8%); and 100% had access to some form of mechanical cooling at home, whether a portable or central air conditioner (AC) or a heat pump. Among all participants, the average amount of time spent working indoors was 93%, compared to 7% of working time spent outdoors. The vast majority commuted by car (88.4%), and received information about extreme heat events from weather channels, websites and apps (84.8%) or local news (62.4%).

Risk Perception

Most survey participants agreed with the statement "Heatwaves in OKC last longer than they used to," including 60.4% from the High HVI group and 49.9% from the Low HVI group. Results indicate that those from High HVI areas were more likely to perceive longer heatwaves, which may be informed by the intensity of their exposure to such events.

Majorities of both HVI groups also agreed with the statement "I am able to keep my home cool enough in the summer," though agreement was notably higher in the Low HVI group (72.7% compared to 60.4%). Renters were overrepresented in the 'Disagree' cohort compared to their share of the total survey sample. All of those who disagreed with this statement had some form of mechanical cooling at home, whether a portable or center air conditioner (AC) or heat pump. The significant presence of mechanical cooling among those who disagreed suggests that ACs and heat pumps were not being used to full effect, possibly due to restrictive energy costs or non/semi-operational equipment.

Participants from both groups were most likely to agree with the statement "Summer heat in OKC is harder to deal with than it used to be," including 46.8% from the Low HVI group and 55.2% from the High HVI group. This result suggests that those in High HVI areas are potentially more exposed to, and struggling more to cope with, summer heat.

Survey takers from both HVI groups decisively agreed with the statement "We need more trees and greenspace in OKC" (over 90% in each group), revealing a common appreciation for trees and green space. However, only about two-thirds of participants agreed with "We need more trees and green space in my neighborhood." Disagreement with this statement was similar for High HVI and Low HVI areas, although High HVI areas typically have low tree canopy coverage. Some residents may have reservations about the cost of upkeep and watering, maintenance responsibilities, or property damage and mess from fallen limbs and leaves.

Approximately one third of respondents agreed with the statement "I have experienced health impacts as a result of heat in OKC," with slightly more agreement coming from the High HVI group. Nearly one fifth selected either 'Neutral' or 'I don't know,' both of which may indicate uncertainty about heat-related health impacts. Some may have experienced heat-related health impacts without making the association between the symptoms and heat exposure.

Participants were asked about their current level of knowledge on four topics: Signs and symptoms of heat-related illness, Who is most likely to get sick from heat, How trees and green space can keep the city

cool, and How trees and green space can improve air quality. In all cases, around 50% of respondents selected the middle option, "I know something about this." Among the remaining 50%, it was much more common for participants to select "I know a lot about this" rather than "I know nothing about this."

Finally, participants were asked about their interest in various heat mitigation or adaptation strategies. Over 90% from both HVI groups said they would support "Planting more trees on public property" and "Improving maintenance of trees and green space on public property." Fewer respondents – closer to three quarters – said they would support "Assisting homeowners with tree planting and/or maintenance on private property." Taken together, the results give the impression that survey respondents are open to trees in general, especially on public property, but may be less interested in private, residential trees. However, a relatively high percentage of respondents also selected 'Neutral' or 'I don't know / Need more information' when asked about homeowner assistance for trees. This means that support for the strategy could increase with outreach and more information given to residents. Around 80% of respondents also said that they would support "Creating or enforcing rules for new buildings and developments that require more canopy, greenspace, and/or energy efficiency" and "Opening public cooling centers during heatwaves."

Exposure

Participants were asked where they typically felt negatively impacted by heat and air pollution. The most common response for both stressors was "During outdoor recreation." Since outdoor recreation is typically optional, some exposure can be avoided through personal decision making. Exposure in the home or at work cannot be easily avoided, especially when individuals experience financial barriers or a lack of agency to make changes to their environment (e.g., running AC at home or weatherizing a workspace). Residents of High HVI areas were approximately 14% more likely to experience heat at home during the day, and 10% more likely at night, compared to the Low HVI group. Respondents from both the HVI and Low HVI groups were much more likely to say "I am not negatively affected by air pollution" than "I am not negatively affected by heat. This suggests that heat may be a more widespread stressor while air pollution is limited to specific parts of the city, likely affected by the concentrations of roadways, industrial activity, or other pollution sources.

Participants were asked whether heat ever disrupts their daily lives, and how so. A majority of all participants (68.6%) responded 'Yes' to this question, with a stronger affirmative response from the High HVI group (78.1% compared to 63%). Nearly 90% of write-in explanations referred to disruptions in scheduling and reductions in outdoor activities. For example, many people limit time outdoors for exercise and recreation, cancel outdoor events, walk dogs less often, or rearrange schedules so that they run errands or spend time outside during the morning and evening. Several responses referred specially to young children or babies and their low tolerance for heat, meaning that outdoor family playtime is limited in summer. Approximately 11% of respondents, representing both High and Low HVI groups, referred to health impacts of heat which concerned them, such as heat stroke, headache, lethargy, difficulty breathing, fatigue and headaches.

Preparedness

Most survey takers expressed at least moderate confidence in their preparedness for summer heat. Those in High HVI areas were about 13% more likely to feel 'somewhat prepared' while those in Low HVI areas were equally more likely to feel 'fully prepared.' Feelings of preparedness may be due, in part, to the widespread availability of AC among the survey population.

Participants were asked whether they ever have to cut back on necessities, such as food or gas in the car,

to pay energy bills for cooling. The issue appears to affect those in the High HVI group more, at about 25%, compared to those in the Low HVI group, at about 20%. Of those who answered 'Yes,' 35 individuals provided additional information about the necessities they cut back on. Twenty-four (68.5%) of those who provided a write-in response referred to cutting back on food and/or groceries; three of those referred to "eating out." Others reported that they cut back on gas for the car (14.3%), or cut back on all expenses (17.1%). While not "essentials," some reported cutting back on extra curricular activities, fun activities and outings, streaming services, and retirement savings to pay electric bills. Cutbacks on essentials like food and gas appear to affect those in both High and Low HVI groups.

Survey takers made several requests for assistance and support, which are summarized in the following themes: Energy bill or home cooling assistance, Home insulation or weatherization, Trees and green space, Information and education, and Cool and/or indoor places to recreate, especially for families.

Conclusions

It appears that OKC residents are exposed to heat regardless of residence in a High HVI or Low HVI area. The most common exposure pathways are during outdoor recreation and while commuting (most often by car). While all participants had access to in-home AC, those from High HVI groups were slightly more likely to experience heat exposure in the home and were less able to keep their homes "cool enough" in summer suggesting possible challenges with energy bills and the cost of AC use. Participants from the High HVI group were also slightly more likely to have experienced heat-related health impacts, to perceive longer heatwaves in OKC, and to cut back on necessities to pay for energy bills. These findings were consistent with expectations. Surprisingly, multiple respondents from the Low HVI group also reported cutting back on necessities to pay for energy bills, suggesting that cooling-related energy burdens may be more widespread than anticipated.

The City has numerous options for addressing urban heat that are likely to have public backing. Participants were largely supportive of measures including public tree planting, public tree and green space maintenance, supporting trees on private property, and opening cooling centers. Interest in public trees and green space was higher than interest in private trees. The City may need to do outreach and education about tree care and benefits to advance private property planting. There is also an opportunity to advance education about the UHI effect, air pollution, and how trees and green space can help. Health-related messaging and education, including signs and symptoms of heat illness, may help residents better understand, recognize, or avoid impacts on their personal health.

Intervention Guidebook

Overview & Methods

The City of OKC has identified urban heat as a concern in multiple plans and policies. Although there are a wide range of mitigation and adaptation strategies available, not all are well-suited to the humid subtropical climate and governance landscape of OKC. For example, the City has limited power to enact regulations that conflict with State requirements due to the Dillon Rule. It can be challenging for cities to sort through all of the options, identify those that are most relevant and practical, and hone in on best implementation practices. The intervention guidebook provides a tailored set of heat intervention strategies appropriate for OKC, taking into account local characteristics and needs. It is a resource for municipal staff, partners, and community members, and can help initiate and inform conversations about heat mitigation and adaptation in the city.

The content was informed by the jurisdictional scan and social survey which CAPA conducted in OKC; literature review for relevant case studies and implementation best practices, both generally and for humid subtropical climates specifically; and feedback from City staff and partners. This ensured the offerings were rooted in local needs and possibilities, as well as best available knowledge and practice in the field of urban heat resilience.

Foundations

This section offers an overview of the climate and environmental challenges faced by OKC, and includes a chapter on the benefits and challenges associated with a tree-based approach to heat mitigation. Trees are typically considered the best defense against urban heat, though they are not ideal in all situations. Subsequent sections emphasize non-tree based strategies.

City Scale Strategies

This section covers high-level heat mitigation and adaptation strategies which are available to municipal managers and planners, non-profit or community based groups, academic institutions, commercial property owners, business owners, developers, utility companies, and other non-residential entities, as well as multi-family property owners or landlords. These are characterized as built environment and infrastructure; funding, policy and legislation; and social support strategies. The strategies in this section are relatively more expensive and time consuming than those offered as 'Household Scale' strategies, make an impact at a larger scale, and pertain to heat mitigation as well as adaptation.

Household Scale Strategies

This section covers household-level strategies for responding to heat and building resilience. These strategies, which are available to all individual residents and homeowners, are relatively inexpensive, can be implemented on a short timeline, and pertain to heat adaptation rather than broad mitigation. Tips and existing resources for OKC residents are linked at the end of this section.

Summary of Recommendations

Type	Heat Mitigation or Adaptation Strategy	Details
City scale	Trees	Planting, maintenance, and preservation
	Green roofs	Vegetated systems
	Reflective and/or light colored materials	High albedo (reflective) roofs; Light colored walls, roofs, and pavements
	Open/green space	Native vegetation; Community gardens; Urban agriculture; Preservation
	Blue-green infrastructure	Bioswales; Permeable pavements; Cool pavement
	Pedestrian and active transportation infrastructure	"Complete Streets;" Bike lanes; Pedestrian safety improvements
	Shading	Non-vegetative shade structures
	Energy efficiency updates	Weatherization; Retrofits (applies to all building types)
	Alternative energy systems	Solar; Geothermal; District cooling; Microgrids
	Legislation and policy changes	Funding; Tree maintenance; Public health
	Financial and technical assistance	Subsidies and rebates; Tree planting and maintenance help
	Community education	Value of trees; Heat safety and risk
	Job training and volunteer corps	Activating community stewards; Building wealth in underserved communities
	Emergency response and resource giveaways	Heat emergency response plan; Cooling resources
	Indoor recreational opportunities	Low cost programs; Subsidies to existing facilities
Household scale	Small-scale applications of City Scale strategies	Residential tree planting; Green/vegetated, light colored, and/or reflective residential roofs and building materials; Home weatherization; Energy efficiency upgrades and alternative home energy sources
	Maximizing air flow	Strategic use of fans and windows
	Air conditioning and dehumidification	
	Insulation and venting	
	Shades, overhangs and window films	
	Self cooling and rest	Individual, health-based strategies

Intersections & Conclusions

All of the assessments and services described in this report built on the others. Heat Watch and air quality monitoring gave the City of OKC and partners an initial understanding of where to focus attention and resources; in other words, where heat and air pollution were most concentrated and potentially most problematic. The jurisdictional scan and social survey combined to inform strategies in the intervention guidebook. The latter three activities addressed questions opened by environmental assessments: *How do OKC residents experience the heat and air pollution shown on a map? What needs and challenges exist? What can the City and its partners do to address those challenges?*

Taking these five activities and their respective products into consideration, a number of cross-cutting recommendations emerge:

Assist residents with energy needs: There is a need for energy assistance across the city, not only in High HVI areas. Per the survey, those in middle-income ZIP codes are also affected by high energy bills and may struggle to keep their homes cool enough in summer. Per the intervention guidebook, existing support programs like the Low Income Home Energy Assistance Program (LIHEAP) have insufficient funds even to meet the needs of low-income households. The City and partners might consider opportunities to assist homeowners in low to middle income brackets with home weatherization, insulation, and/or efficiency updates. This will ensure that cooling systems can run efficiently and at a lower cost. While the City might subsidize updates to low-income households, education and weatherization tips could be shared with higher-income residents.

Balance indoor and outdoor heat mitigation: Heat maps of OKC reveal high concentrations of urban heat in the central and north/northeast parts of the city. It can be expected that outdoor heat exposure will be particularly high in these areas and, per the survey, most residents experience heat exposure outdoors during recreation or while commuting. There is a clear need for the City to prioritize efforts that mitigate the UHI effect and cool the outdoor environment. However, heat exposure also occurs at home, indoors, especially for lower-income households, those living in High HVI areas, and those who cannot afford to run AC. This means that the City must also consider strategies to improve indoor conditions, perhaps prioritizing households in those hottest areas on the map for outreach and support.

Integrate heat mitigation and air quality initiatives: There is some overlap between areas displaying relatively high heat and air pollution, especially near the north-central part of the city. High temperatures can exacerbate the severity and health impacts of ozone and air pollution. According to the survey, most residents are exposed to both heat and air pollution, whether outdoors, at home, at work, or while commuting. Some intervention strategies that mitigate urban heat – such as increasing tree cover, reducing personal vehicle traffic, and increasing opportunities for active and public transportation – will also have a positive effect on air quality. These two stressors are closely related, and addressing them simultaneously may increase potential for funding, collaborative partnerships, public interest, and overall environmental impact.

Address heat with proactive measures and emergency preparedness: There are numerous opportunities for upstream, proactive resilience building that the City and partners could pursue. For example, making changes to the built environment – depaving surfaces, increasing the amount of shade (from trees or manmade structures), installing cool pavements – or preparing homeowners with safety information, in-home cooling resources, and helpful tips. Still, much of OKC experiences high temperatures in the

summer, and emergency situations are likely to occur as broad resilience initiatives are underway. Outdoor workers, those in precarious living situations (unhoused or in mobile homes, for example), those without functional AC, and sensitive individuals with pre-existing health conditions may need emergency support even in light of cooling measures implemented across the city. The City can balance long-term or permanent solutions with a robust emergency response protocol for those who will remain at risk in an urban heat island. This includes options like emergency wellness checks to the hottest areas on the map, and deployment of resources to those same locations (for example, mobile misting stations, bottled water giveaways, cooling centers). Heat and air pollution data point to geographic areas that might be prioritized both for proactive, long-term interventions as well as emergency response protocols.