HOUSTON, TEXAS

Urban Heat Island Mitigation

A ULI Virtual Technical Assistance Panel Report

May 25–27, 2021

Urban Land Institute

About the Urban Land Institute

THE URBAN LAND INSTITUTE is a global, member-driven organization comprising more than 45,000 real estate and urban development professionals dedicated to advancing the Institute's mission of shaping the future of the built environment for transformative impact in communities worldwide.

ULI's interdisciplinary membership represents all aspects of the industry, including developers, property owners, investors, architects, urban planners, public officials, real estate brokers, appraisers, attorneys, engineers, financiers, and academics. Established in 1936, the Institute has a presence in the Americas, Europe, and the Asia Pacific region, with members in 80 countries.

More information is available at uli.org. Follow ULI on Twitter, Facebook, LinkedIn, and Instagram.

About the ULI Urban Resilience Program

ULI's Urban Resilience program is focused on how buildings, cities, and communities can be more resilient to the impacts of climate change and other environmental vulnerabilities. The program works with ULI members to provide technical assistance, advance knowledge through research, and catalyze the adoption of transformative practices for real estate and land use policy.

About the Resilient Land Use Cohort

This virtual technical assistance panel is part of a larger series of resilience technical assistance and learning opportunities called the Resilient Land Use Cohort (RLUC). The RLUC is a network of ULI district councils, member experts, and community partners in eight cities working together to identify strategies to be more resilient in the face of climate change and other vulnerabilities, including floods, extreme storms, drought, wildfire, and extreme heat, as well as the related social, environmental, and economic impacts. RLUC provides on-the-ground technical assistance through ULI's flagship technical assistance models—Advisory Services panels and technical assistance panels. These panels leverage ULI member expertise to advise on complex real estate and land use challenges related to climate resilience, addressing planning, zoning, land use, development strategy, housing, and infrastructure. ULI's Urban Resilience program convenes the cohort regularly to learn from national best practices and discuss peer cities' next steps advancing resilience through land use policies and development strategies. Funding for this engagement and the cohort is provided by the ULI Foundation with support from JPMorgan Chase.

COVER PHOTO: Discovery Green, Houston, Texas.

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Acknowledgments

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Finally, the panel extends its thanks and appreciation to the more than 30 city staff members, nonprofit partners, community leaders, and experts who shared their perspectives, experiences, and insights with the panel as stakeholder interviewees.

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Executive Summary

Extreme heat kills more people annually than any other natural disaster, as pointed out in the CDC's publication *Climate Change and Extreme Heat Events*, and if left unaddressed, Houston can expect the following heat-related changes by 2050:

- The hottest day of summer will be 7°F warmer than today;
- Twenty-two more days will exceed 100°F;
- Fifty more nights will exceed 80°F; and
- Summers overall will be 55 days longer than today (see August 2020 *Climate Impact Assessment for the City of Houston*).

This type of extreme heat affects the entire United States, yet for southern states like Texas, the danger is more present, more pressing, and requires more aggressive and immediate interventions.

Added to the extreme heat brought on by climate change, Texas's cities are particularly hot. The urban heat island (UHI) effect, the difference in temperatures between rural and urban areas, is exacerbated by roads, parking lots, buildings, and limited vegetation, leaving cities 2 to 6°F warmer on average than their surroundings, as described in ULI's 2019 report *Scorched: Extreme Heat and Real Estate*. The UHI effect is currently driving temperatures in a manner that is more dangerous and pressing than climate change.

The city of Houston has certain measures in place that can help people manage in the extreme heat on a short-term basis, but the underground tunnels connecting downtown buildings and cooling centers for residents do not provide solutions for lowering the UHI effect. City leadership understands that changes need to be made across Houston and in the built environment to begin to reduce the UHI effect and make the city, its buildings, and Houston's residents more resilient to heat.

At the request of the city's chief resilience officer, ULI Houston participated in the ULI Resilient Land Use Cohort, a network of cities across the United States exploring resilient land use strategies and identifying measures and interventions for the built environment that can begin to mitigate the critical climate issues facing those cities. For Houston, one of the more pressing issues is extreme heat.

Resilience is important to Houston's city leadership, as demonstrated by its establishment and funding of the position of chief resilience officer (CRO). Under the CRO's leadership, the city has embarked on a number of resilience initiatives to identify and measure accelerating climate factors and begin to address how businesses and residents can respond and adapt. From recent reports such as *Living with Water Houston* and *Resilient Houston*, strategies are taking shape to protect Houston from future disasters. Heat mitigation and heat resilience—and the role the built environment plays in each—are now in focus.

In response, this technical assistance panel (TAP) was convened to address a series of questions from the city to identify heat resilience design and construction strategies that should be implemented more widely, the opportunities and challenges for demonstrating short-term mitigation feasibility, potential city policies that could encourage heat mitigation in the private sector, and a list of examples or best practices for guidance in efforts going forward.

Following in-depth briefings and interviews with city staff, real estate developers, heat experts, and other local stakeholders, the panel deliberated about the heat mitigation challenges and potential solutions that city departments and related organizations might use to reduce UHI effect and be more resilient to heat. The panel arrived at a series of recommendations that can be put in place today to set the foundation for resilience work citywide. It also identified work already underway that should be accelerated or leveraged more broadly. These recommendations for public- and private-sector decision-makers can set the pace regionally and encourage leadership in heat resilience work.

Community Education and Engagement. At the foundational level, education and engagement need to take place across a number of platforms and constituencies—individually, at the neighborhood level, within the business community, at the watershed or ecosystem level, at the city level, and across the region. A mapping initiative that identifies key characteristics, such as impervious area, tree canopy, ground vegetation, demographics, and more, should support this effort. This data will help the city identify the geographies where heat mitigation needs are urgent and areas that have programs in place worth accelerating.

Landscape and Building Design Strategies. Landscape and building design deploy a host of best practices that can assist the city of Houston and developers in pursuit of heat mitigation and UHI reduction. Nature-based solutions promote the use of green roofs, bioswales, native vegetation, and more to absorb heat, absorb excess water, and provide opportunities for carbon capture and shade. Advancements in building materials make features like cool roofs, cool walls, double-glazed windows, and transitional vestibules and entries more commonplace than ever before. The ready adoption of these practices in other heat-stressed cities and the data post-implementation can bolster the future-proofing argument for these measures with real returns on investment in the short and long terms for developers.

Building Policies and Codes. To further support the case for heat mitigation and resilience strategies in the built environment, the city can use additional or revised policies and building codes to support best practices in heat mitigation. Aligning policies among city departments and ensuring that existing codes can be expanded to include a robust mitigation strategy will be key to the adoption of these measures. When possible, streamlining the process and applications related to these new policies is also critically important.

Implementation Opportunities and Challenges. The opportunities and challenges of heat mitigation strategies,

Examples of nature-based solutions for reducing the heat island effect, including tree canopy preservation, native vegetation lining walkways, and use of permeable surfaces for walking paths.

policies, and funding mechanisms are closely linked. The lack of community awareness about the opportunities to reduce the heat island effect is also an opportunity for dialogue with and further education of the community. The current economic vehicles the city has in place, such as tax abatement or Tax Increment Reinvestment Zones (TIRZs), do not include heat resilience efforts, but could do so with some revisions. Similarly, the city has codes in place that address tree removal and replacement, which is a great start, but the codes do not yet take canopy into consideration.

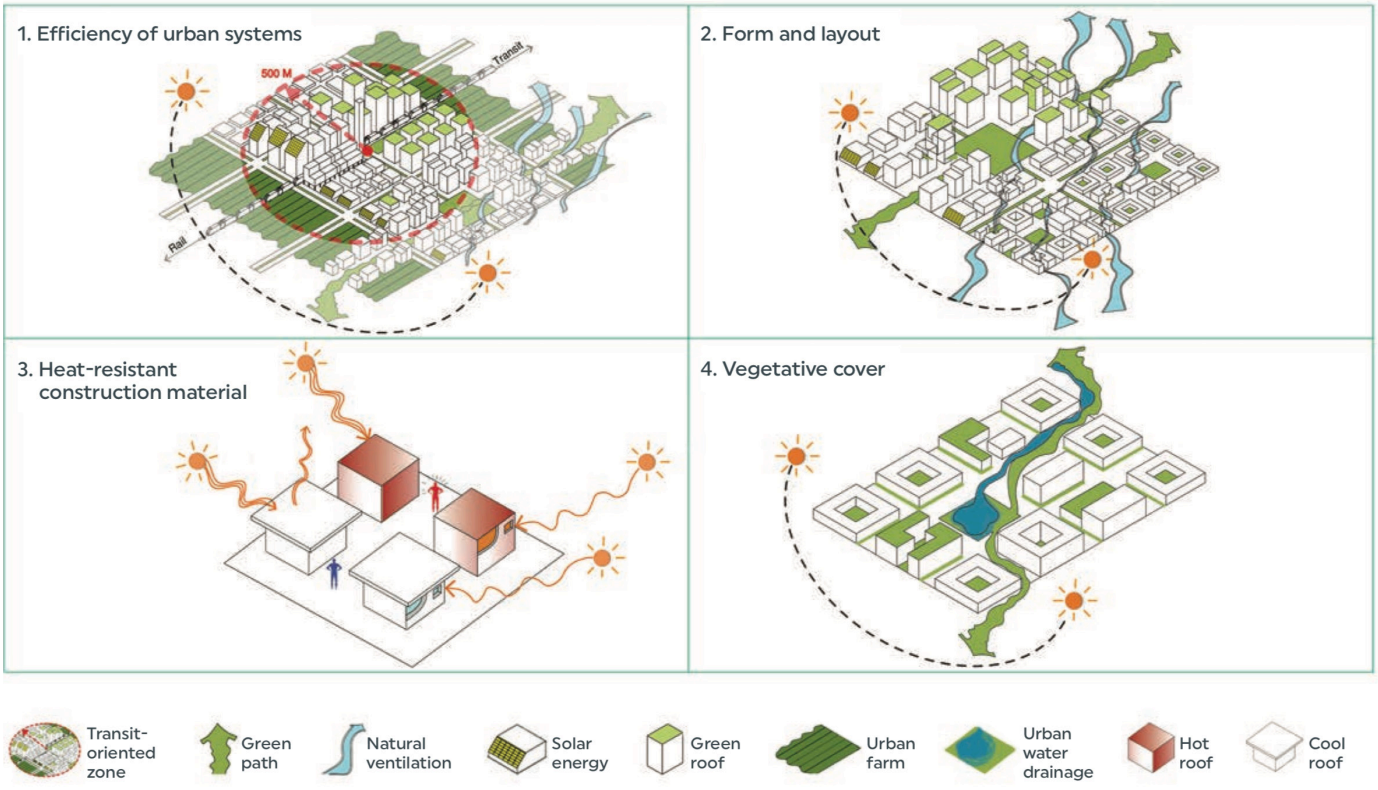
Developer Toolkit. The panel also recommends the city consider creating a toolkit for developers, which can assist in raising awareness of heat resilience strategies that have proven to be financially feasible. Areas of focus would include building design, building materials and engineering, light-colored and reflective surfaces, green infrastructure, operational changes, and urban development patterns. The toolkit could also highlight the emerging interest in comfort-based certifications like LEED and WELL, which are becoming increasingly important to commercial tenants.

Collaboration and Knowledge Sharing. Across the United States, a host of cities, private businesses, and institutions are collaborating to identify the various climate issues affecting their regions and together find the solutions that will provide a resilient path forward. Looking to these studies for relevant tools and resources will prove beneficial as Houston strengthens its resilience path.

Panel's goals for the city of Houston:

- Reduce the urban heat island effect
- Prepare people and the built environment for what is coming

As the city contemplates its heat mitigation goals and considers the means by which it will build on existing work to achieve those goals, the panel encourages it to strive for consensus among and collaboration with stakeholders to achieve collective desired outcomes. Detailing clear priorities across stakeholder groups will help focus the efforts of consultants, leaders, funders, and the development community. Finally, leveraging stakeholder consensus and agreed-upon priorities, the city can lead and support ongoing productive dialogue with public officials and private-sector partners who seek to make good use of the limited public resources.



Four factors—reduction of waste heat and greenhouse gas emissions, form and layout, heat-resistant building characteristics, and vegetative coverage—contribute to urban climate and are the backbone of holistic UHI mitigation efforts. A toolkit for developers could include diagrams such as this one from ULI's publication *Scorched* that depicts district-scale heat island mitigation strategies.

Panel Assignment

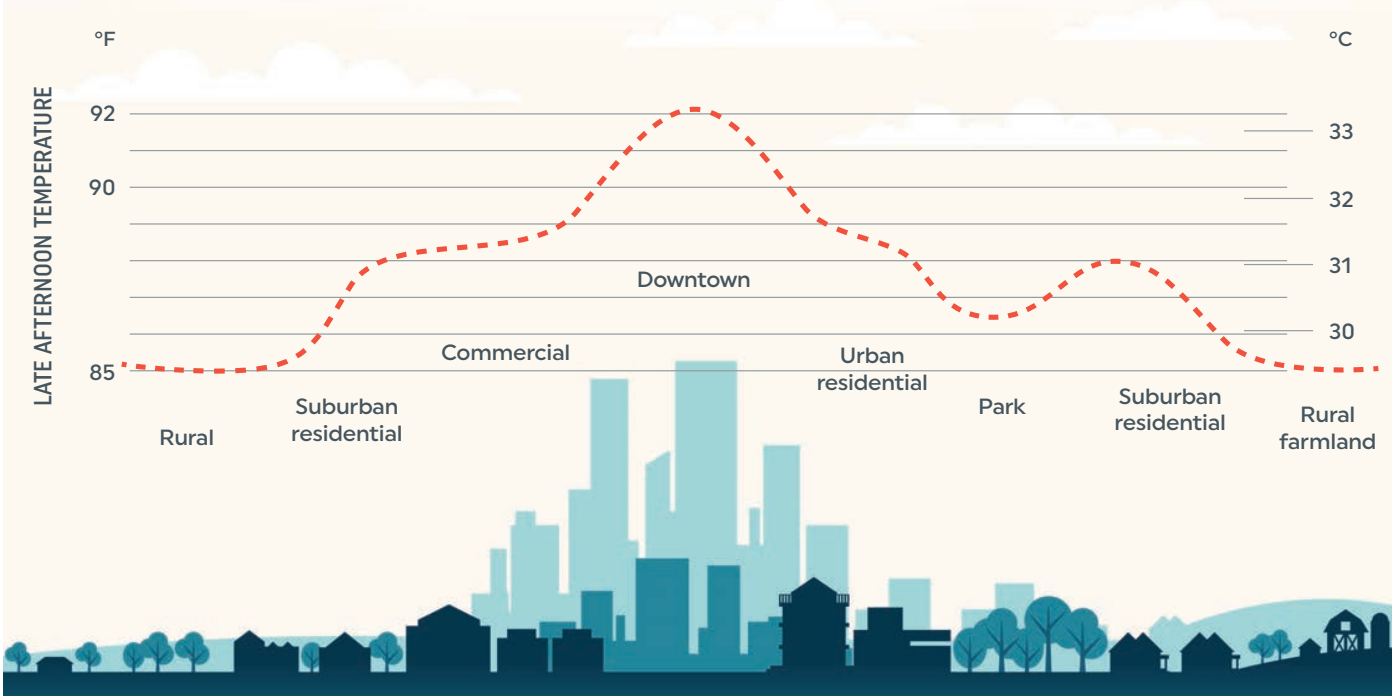
With temperatures on the rise across the globe and the anticipated rise in Houston expected to be between 2.8°F and 3.8°F by 2050, the number of days that Houston will spend in an extreme "heat event" state will increase substantially.

According to the Centers for Disease Control and Prevention, exposure to extreme heat can "increase discomfort and fatigue, cause heat cramps, and increase emergency room visits and hospitalizations." More critically, extreme heat is deadly and has contributed to nearly 8,000 deaths in the United States from 1999 to 2009. According to AccuWeather, Houston is one the 10 warmest cities in the United States, and Harris County leads Texas in the number of heat-related deaths.

The urban heat island effect is currently the source of a majority of the increased temperature risk in U.S. cities.

Much of the UHI effect can be traced to building and urban design, including land use change, waste heat, air pollution, and building geometry. Each of these combine and contribute to making cities warmer, increasing the danger for residents and putting more pressure on leaders—both public and private—to work to reduce this dangerous UHI effect in U.S. cities.

Lower-income residents and other vulnerable populations in Houston experience UHI issues to an even greater degree than the rest of the population. Households that cannot afford adequate air conditioning, cannot relocate to cooling centers, or live in neighborhoods with less green space and more impervious surfaces (frequently, low-income communities, and Black and other communities of color) are likewise particularly vulnerable to extreme heat, as are the elderly, the very young, and those with preexisting medical conditions.



The urban heat island profile, as depicted in *Scorched*.

To address the UHI effect for Houston, public leadership turned to ULI Houston for technical assistance in identifying methods best suited for the region's climate to reduce the UHI effect. Specifically, city leadership was interested in potential modifications to the built environment and best practices in new development design and construction.

Desired Outcomes

Through this work, the city sought to achieve greater consensus among stakeholders moving forward and to identify recommendations with clear priorities to help focus the efforts of consultants, leaders, funders, and other stakeholders. The city was also seeking a tool to inspire productive dialogue with public officials and potential private-sector partners who seek to make efficient use of limited public resources.

Panel Scope

To achieve the city's desired outcomes, it asked ULI Houston to convene a technical assistance panel to addressing the following four questions:

1. What are the various building and site-scale landscape design heat resilience strategies that are commonly used in Houston today and those that, if implemented more widely, have the potential to help the city achieve its extreme heat resilience goals? (Potential strategies include but are not limited to cool and green roofs, cool pavement, tree planting and preservation, prairie restoration, green stormwater infrastructure, and shade structures.)
2. What are opportunities and challenges for demonstrating short-term feasibility by referencing relevant regulations and potential financing mechanisms to help the city achieve its heat mitigation goals?
3. How could possible future city policy encourage local property owners and developers to mitigate extreme heat at their projects and open spaces?
4. Are there relevant examples or best practices (either regionally or nationally) that provide opportunities for guidance or lessons learned?

ULI Houston convened a small group of members, real estate professionals with expertise relevant to the questions at hand, to study the issue, interview city and private-sector stakeholders, and ultimately deliver a set of recommendations and actionable strategies that the city can put in place to begin to reduce the urban heat island effect for Houston and begin to prepare people and the built environment for the increased temperatures and extreme heat events to come.

Background

Challenges surrounding extreme heat in Houston are not new, as evidenced by the network of air-conditioned tunnels that employees and visitors use to move between buildings downtown. While measures such as these tunnels and hard-working HVAC units can ease the impact of extreme heat, the temperatures continue to rise, the number of extreme heat days is increasing, and the cascading effects and dangers precipitated by natural disasters multiply (e.g., hurricanes lead to power outages and power outages lead to loss of life due to extreme heat). Without more proactive measures to reduce the UHI effect, Houston residents will continue to suffer, and the number of those affected will only increase.

The city's definition of a heat event is based on National Weather Service (NWS) guidance: when NWS issues a Heat Advisory, the city of Houston may open cooling centers in the interest of public health. Related to this, the city's Heat Event plan is activated when the city experiences three or more consecutive days with temperatures 103°F or higher or the heat index is forecast to reach 108°F or higher for two consecutive days.

As noted during the briefing with city leadership, Houston has had seven declared disasters in the past six years. In 2016, the city hired a chief resilience officer to produce a comprehensive strategy to address flooding, hurricanes, and heat. In January 2020, Houston published its *Living with Water* report and followed in February with the release of *Resilient Houston*, a strategy to link existing efforts with new measures to "collectively protect Houston against future disasters." Although progress has been made on the public-sector side, including the Complete Communities neighborhood plans, widespread tree plantings, and instructive heat mapping through the H3AT initiative, significant work remains in addressing heat mitigation in the built environment, particularly as it relates to the work of the private sector.

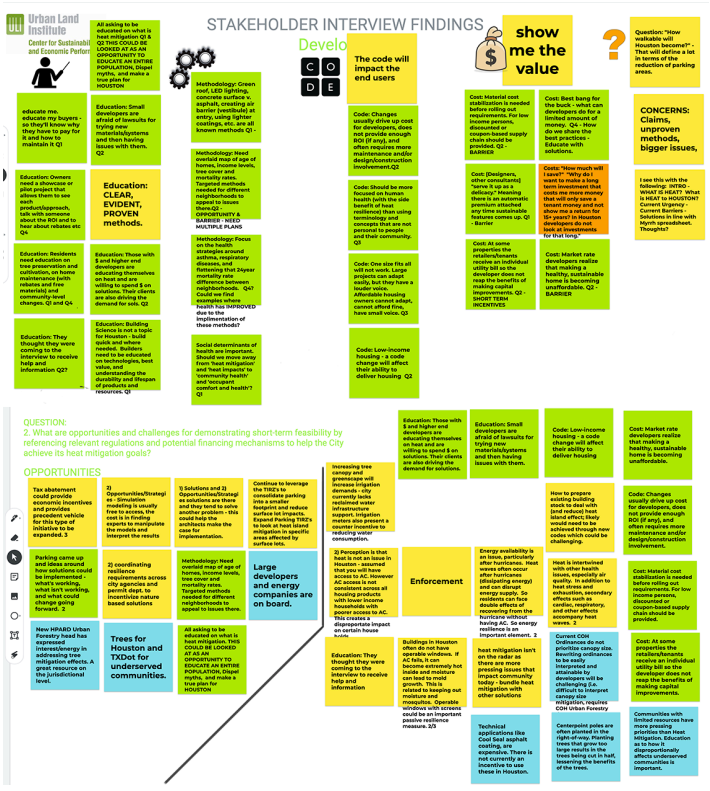
What We Heard

To better understand the nature of current and potential heat mitigation strategies in Houston and to gauge the level of understanding and potential acceptance of future strategies, the panel interviewed more than 30 stakeholders from around the region, including developers, experts on heat and its effects, city officials and staff, community leaders, and other real estate experts.

Developers

- **Education.** "Educate me and educate my buyers" about heat mitigation so they will know what it is, what it costs, and how to maintain the related equipment.

- **Pilot Project.** A demonstration project that can showcase a product or approach, potential rebates, and provide information about potential returns on investments.
- **Methodology.** Targeted information, aided by overlay maps of homes, income levels, tree cover, and the like could assist developers in implementing the right mitigation strategy for the right neighborhood; a focus on the social determinants of health is important and may necessitate a shift in strategy from "heat mitigation" to "community health."
- **Code.** Changes to the building codes will result in increased costs to developers, which will be passed along to residents and tenants; one-size-fits-all will not work for every building; focus on the human health impacts of the code measures and make it personal.
- **Value.** Material cost stabilization is needed; shift from a "delicacy" mentality by designers for these improvements (which come with a near-automatic premium); costs incurred by the developer only pay off in the very long term and may be past the point of the developer's involvement in a project.
- **Parking.** "How walkable will Houston become?" The direction the city wants to take regarding walkability will determine the future of new parking lots, structures, and other impervious surfaces.



The panel mapped out the feedback from the various stakeholder groups.

Heat Experts

- **Urban Heat Islands.** The UHI effect is driven by spatial conditions, including materiality, waste heat, lack of vegetation, buildings, and the urban design of cities (e.g., tall buildings create canyons of the street).
- **Incentivize through Co-benefits.** Urban heat recommendations should pair with other resilience and mitigation efforts to maximize the potential to incentivize action.
- **Performance-Based Incentives.** Use off-the-shelf performance-based approaches and tools that are available today; set broader performance targets to include multiple risks (e.g., stormwater and heat).
- **Low-Hanging Fruit.** From education efforts for developers, architects, and the public on the topic of heat islands to converting to double-glazed, operable windows, to reducing parking mandates, a number of immediate and lower-cost strategies can be effective today.
- **Transition Impacts.** There are stresses on the body caused by extreme temperature transitions and easing these transitions will positively affect human health (e.g., temperature transitions between a hot sidewalk and air-conditioned space might be facilitated by a shaded entryway).
- **Multilevel Mapping and Evaluation.** In addition to citywide approaches to heat mitigation, neighborhood-level studies and mapping are needed to identify the variations between neighborhoods and the correlating necessary interventions.
- **Houston's Unique Climate.** The high heat and high humidity of Houston may limit the nighttime re-radiation of heat from materials; increased emissions can lead to increased rainfall.

Community Leaders

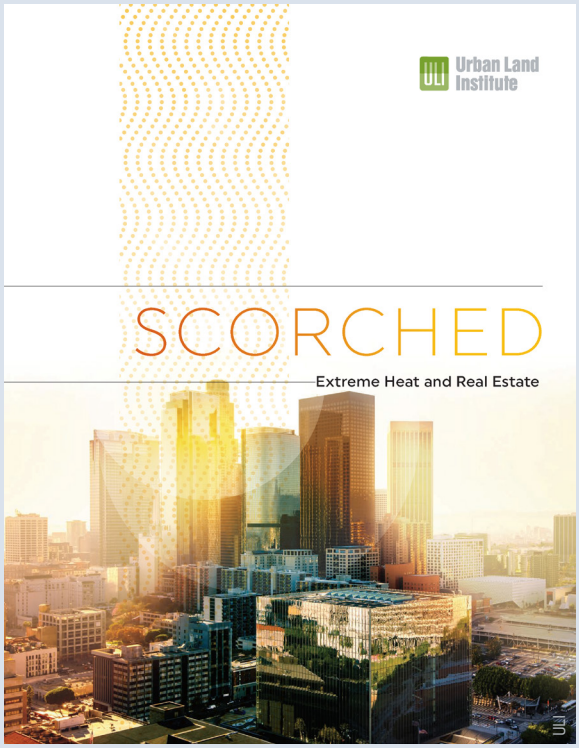
- **Other, More Pressing Concerns.** Heat mitigation to address future temperature increases is not top-of-mind for many in the community as they are facing more pressing concerns today such as access to running water following the record freezing temperatures in February 2021.

Scorched

ULI's Urban Resilience program published *Scorched: Extreme Heat and Real Estate* in 2019 to outline how extreme heat will affect the real estate and land use sectors and to highlight the leadership and the potential positive impact of the real estate sector in implementing "heat-resilient" building designs and land uses. The report provides an overview of extreme heat's connections to the built environment and an in-depth discussion of heat mitigation and adaptation strategies related to building design, building materials, green infrastructure, and public space design.

Overall, ULI found that extreme heat is an issue with increasing relevance to the real estate and land use sectors because of the intensifying impacts of climate change and the urban heat island effect, changes in amenity expectations and market demands in some regions, and the growing interest of regulators. In response, some developers, designers, and other land use professionals are addressing temperature-related risks through the life cycle of a building or development—from investment to construction to operations and maintenance.

Investing in heat-mitigation technology and approaches can lead to a host of benefits, such as improved tenant experience, reduced operating costs, improved likelihood of business continuity, enhanced branding, and additional foot traffic in pedestrian and retail environments.



- **Cooling Centers.** More strategically placed cooling centers are needed across the city.
- **Reforestation.** Increase urban forest canopy and increase access to information on native species; address the interference caused when locating trees and utility poles and lines in the same right-of-way (e.g., when the trees grow taller and interfere with the utility lines, they are trimmed dramatically, thus lessening their ability to absorb heat and provide shade).

Public-Sector Leaders

- **Program Alignments.** Aligning heat mitigation efforts with other city programs will increase the attention to and impact of each.
- **Tax Incentives.** The Green Infrastructure Tax Credit is in place and may need clarification around city expectations and revisions to make the application process easier; tax abatement could provide economic incentives needed to support heat mitigation efforts.
- **Energy Resilience.** In addition to heat resilience, energy resilience is important to address power losses following weather events, which lead to loss of air conditioning and exacerbate problems experienced by an already strained emergency response system.
- **Building Mechanics.** Many buildings in Houston do not have operable windows with screens, which eliminates any possibility for the simple passive resilience measure of opening a window if the air conditioning fails. Similarly, while air conditioning is required by code, many low-income housing buildings are equipped with substandard units that do not adequately cool the associated spaces.
- **Tree Cover.** Increasing tree cover can reduce the amount of stormwater in the system, increase the amount of available shade, and help reduce the heat island effect.
- **Water Use.** While Houston is not currently water constrained, supplies may be constrained by treatment capacity or threat of contamination. By using effluent to irrigate trees and other green infrastructure, the city could help protect against risks to its water supply.

Foundational Recommendations

When considering the landscape of heat mitigation strategies before it, the city is encouraged to start by addressing some foundational activities that will strengthen necessary implementation partnerships and provide all partners with the level-setting needed to support initiatives, mitigation strategies, and building and landscape improvements citywide.

Education and Engagement

Heat resilience and mitigation are key to a successful sustainability model. Because sustainability is built upon people, planet, and profit, when one of those factors is out of balance or not addressed, sustainability cannot be achieved. With its significant impact on people, increasing temperature is an ongoing and increasing threat to our planet's sustainability. People can choose to ignore or embrace the climate and heat challenges before them, but when Houston is faced with another summer marked by 22 days at temperatures above 100°F, everyone will quickly and personally feel the effects of heat. Everyone therefore should have a seat at the table and play an active role in helping the city create a solution that will work for the entire community in an equitable manner.

Throughout the city's work to better understand, forecast, and mitigate the effects of rising temperatures, care should be taken to address the impacts and opportunities at every level, from the individual to the neighborhood scale, the city basis, and regional level. Impacts can be felt citywide and, as such, every resident and every organization has a role to play. Helping residents understand the actions they can take individually to mitigate heat and protect their health will be critical to implementation success going forward. In addition, the business community has a key role to play, as the decisions its members make regarding office location, building amenities, and characteristics (e.g., LEED and WELL

building standards) greatly influence the UHI effect. The business community can also be a key ally in the distribution of information to employees regarding the role individuals can play in heat mitigation and resilience. Similarly, considering the city and regional watershed, organizations focusing on the natural ecosystem of the Houston area can be leveraged to help educate the community about the natural cooling benefits provided by parks, nature preserves, tree canopy, and bodies of water.

Multi-Level Mapping

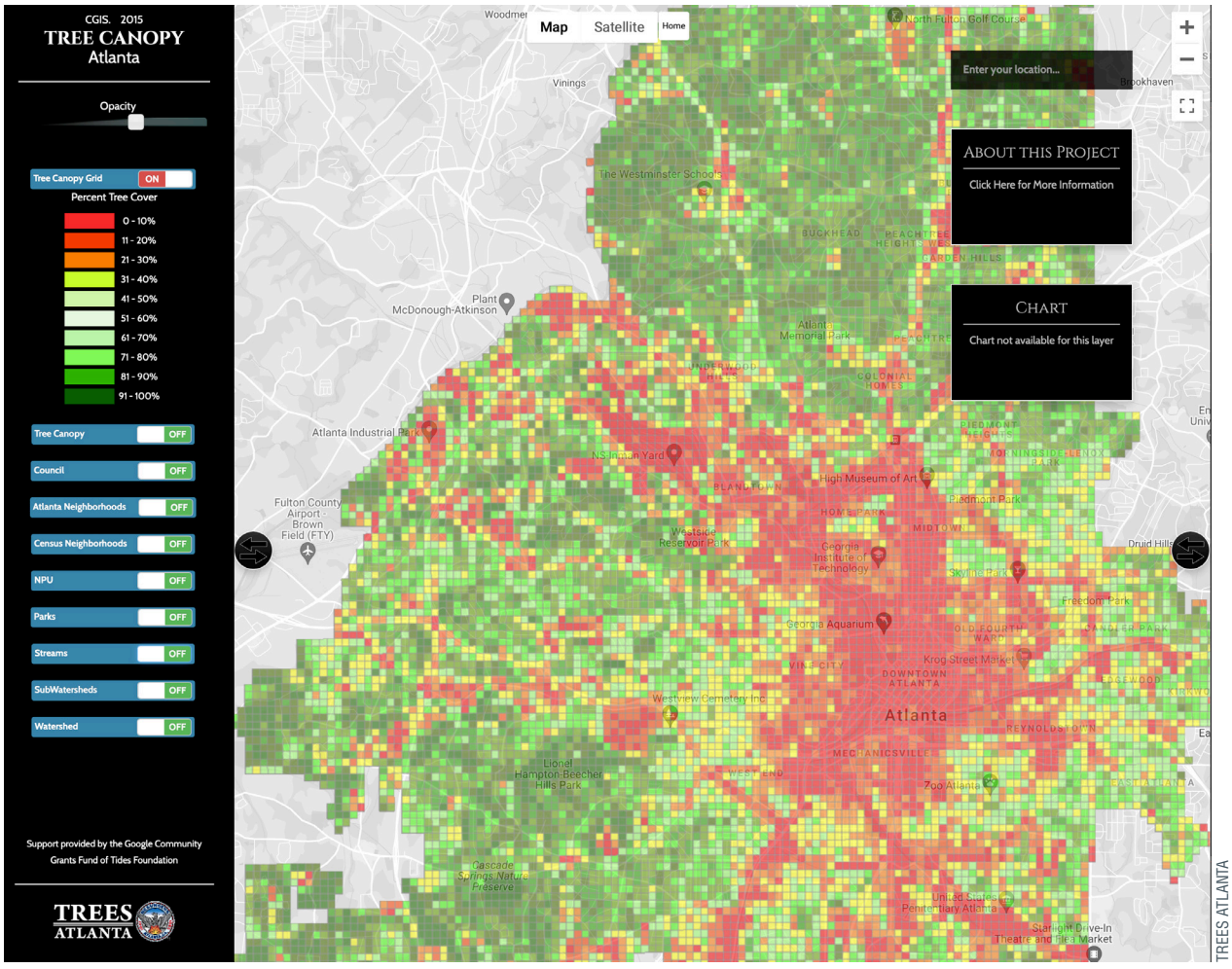
The city of Houston has taken important steps toward understanding the current heat environment. Building on that initial work and data collection, and by using tools like StoryMap, the city can visually tell the story of today's environmental conditions influencing heat conditions across Houston. Initial mapping layers to consider might include the following:

- Impervious area;
- Tree canopy;
- Ground vegetation;
- Surface reflectance/albedo;
- Air temperature and humidity; and
- Demographics (to help pinpoint areas of social vulnerability).

Mapping work of this nature is regularly conducted in the private sector and at the university level, both of which might be willing partners in an initiative of this nature.

Heat Map Assessment and Modeling

Through the layering of multiple geospatial information systems (GIS) data sets, the city can identify areas in need of urgent intervention. The data may also help identify geographies that are using heat mitigation methods worth accelerating or expanding across the region.

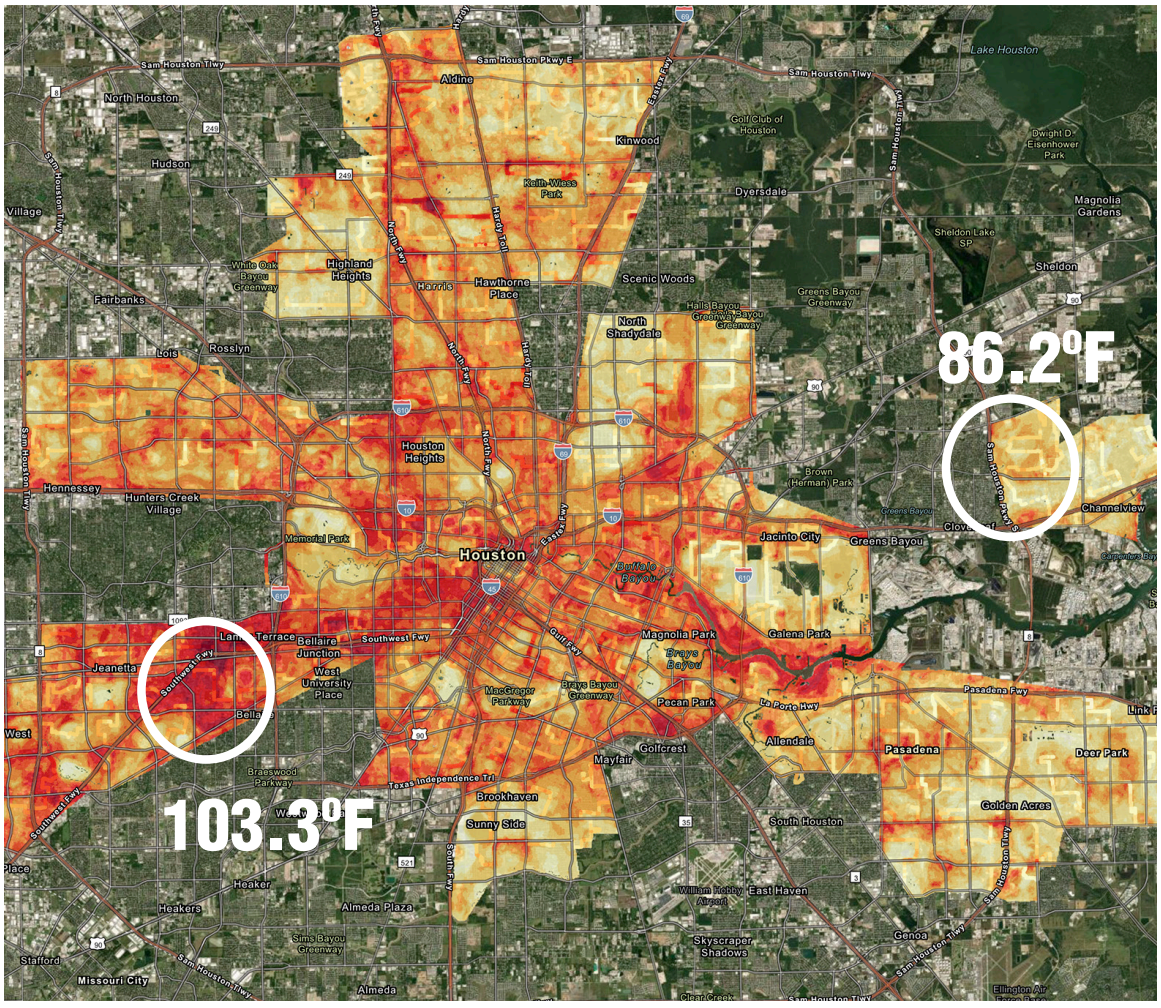


Atlanta's "Tree Canopy Atlanta" tool uses GIS technology to map its existing tree canopy in relation to a host of other data layers, http://geospatial.gatech.edu/TreesAtlanta/.

Through this mapping and modeling, the city can identify and quantify the impacts of heat on various socioeconomic and demographic sectors across the city. The identification of these relationships today can begin to inform and assist in the modeling of future impacts, including the potential scale of interventions needed, so steps can be taken and processes put in place to mitigate those future adverse events. By way of example, the layering of a heat map with a map of median income and tree canopy may help identify areas of the city that are experiencing excessive heat events that could be mitigated with the introduction of greater tree canopy. Identifying this need and mapping its intersection with lower-income neighborhoods could provide the basis for the city's pursuit of funding for a campaign to increase the tree canopy in those neighborhoods.

Not all neighborhoods have had equal access to investment and funding over the years. Today, given the protracted nature of these funding inequities, a number of neighborhoods have been simply left behind. An overlay and analysis of existing heat mapping could further identify the relationship between heat and specific neighborhoods across Houston. This type of analysis, and specifically a vulnerability assessment of the heat island impacts, will help the city identify in a very quantifiable manner the neighborhoods that have been disproportionately affected. Once known, intentional and targeted actions can be taken (e.g., add more cooling centers in those neighborhoods) and an equitable approach used to support those neighborhoods and protect the residents today and into the future.

Although the mapping initiatives are key to identifying the current heat and resource environment across the city, the maps and related data can also be used to develop models to test strategies that will work best in specific areas. The mapping trends over time can be extrapolated to help municipal leaders better understand future impacts. With steadily increasing temperatures, experts differ on the time horizon ahead, whether it is two years or 10, yet the trends in Houston can be quantified through these modeling efforts, adding much needed support for the actions, policies, and regulations of today that will help mitigate tomorrow's heat impacts.



CAPA Heat Watch for Houston and Harris County, www.h3at.org.

STOSS LANDSCAPE URBANISM

Boston's DISCOVER Moakley is an all-day community event hosted to raise awareness of and provide education on climate resilience and wellness.

Implementation Opportunities and Challenges

The TAP panel was charged with identifying opportunities and challenges for demonstrating short-term feasibility mechanisms for heat mitigation. In pursuit of answers, the panel found that many of the challenges the city faces are closely interlaced with interesting opportunities. While these issues may be hard to separate here in a report, the interconnected nature might assist in the more ready application of solutions to each of the challenges identified.

Raise Community Awareness and Seek Engagement

Throughout the stakeholder interviews, it became readily apparent that no clear or uniform understanding exists of what a heat event is or where one may typically occur. Moreover, while it is certain that hot and uncomfortable days lie ahead for residents across Houston, many residents do not currently view extreme heat as a pressing issue requiring individual or community action. The challenge of misunderstanding or a lack of full understanding presents the city with an opportunity to present and explain the issue to the entire Houston community in one unified voice. It is important to identify and define a "heat event" for the community such that community members can begin to understand what it is, identify the dangers to themselves and their neighbors, and see themselves as key actors in the solution. Partnerships with community development and other neighborhood or place-based organizations can help spread the message citywide.

In addition to general education of the community about extreme heat, it is also important to raise awareness of the heat island effect and its dangers across the city. At present, UHI effect is not perceived as a citywide challenge, and some stakeholders believe it only affects "neighborhoods on the other side of the city." Because of this misunderstanding, UHI effect does not garner the attention it should.

Business leaders and the private sector need to understand where heat events occur and how their business operations may be adding to the heat island effect. The real estate

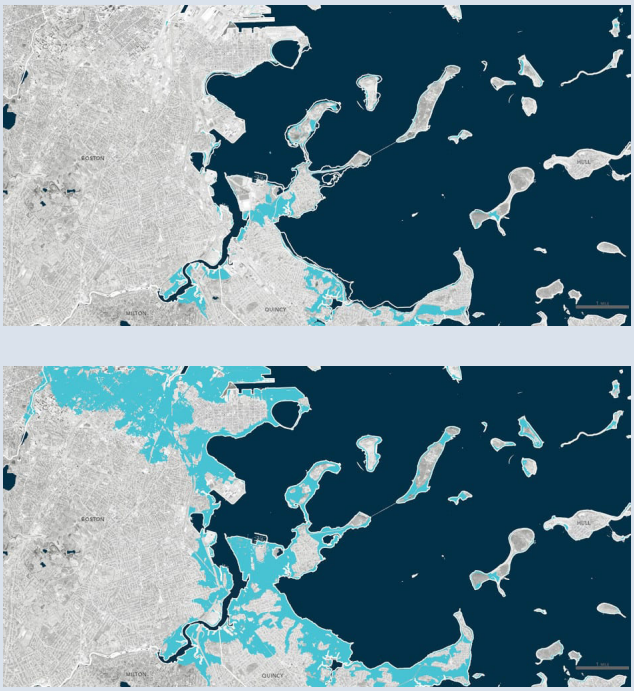
Boston Green Ribbon Commission

The Boston Green Ribbon Commission (GRC) is a group of business, institutional, and civic leaders in Boston working to develop shared strategies for fighting climate change in coordination with the city's Climate Action Plan. Its mission is to accelerate implementation of the city's Climate Action Plan by convening, organizing, and enabling leaders from Boston's key sectors.

The GRC works through a structured network of individual members; sector and working groups; and affiliated organizations and experts who form teams to work on initiatives and projects. GRC members and staff consult frequently with city leaders and staff.

As the GRC enters its second decade of aggressive and equitable climate action work, it has alignment at the city, state, and federal levels on climate targets—a major opportunity when it comes to climate action in Boston.

More recently, the GRC engaged in a strategic planning process to determine where to go from here and how the GRC network can add the most value in this next phase of city climate work. This strategic plan lays out its mission, vision, theory of change, values, key action areas, and priority projects for the next five years from 2021 through 2025.



GREEN RIBBON COMMISSION

Anticipated sea-level rise in Boston in 2050 (top) and 2100.
www.greenribboncommission.org.

community needs to be fully aware of the effects of the heat island effect and know how and where heat mitigation efforts may be deployed. By working with business associations to raise private-sector awareness of the dangers of extreme heat, Houston can establish a foundation of knowledge of the dangers and potential solutions for extreme heat throughout the business community.

By engaging neighborhoods and the business and real estate communities in identifying community-level problems, those same communities can work together to identify community and business/industry-wide solutions. This collective work and understanding leads to stronger buy-in and support for individual contributions to the solutions and can help reinforce any follow-on work needed to support the identified solutions.

Develop Clear and Accessible Economic Vehicles

At present, the city has several programs in place that can assist in funding future work relating to heat mitigation or offset the costs associated with such improvements. The existing tax abatement program for green infrastructure could be expanded to include heat island mitigation and management approaches. Separately, the TIRZ that is currently being piloted for condensing parking will help reduce heat island effects by consolidating parking and potentially reducing the number of surface lots, which are frequently characterized by impervious—and hot—black asphalt.

Should the city expand these programs or pursue new economic incentives for developers or property and building owners, it will be critical to reinforce equitable distribution and access to all new programs and policies. The city is encouraged to review any solutions through an equity lens to ensure that relief and funding will be clear, accessible, and used by the communities for which they are intended.

Stakeholders and real estate practitioners stressed the importance of clarity and accessibility of the requirements, particularly any new requirements, to prohibit use beyond the intended purpose. New code requirements can add cost pressures to projects across the board and have the potential to affect low-income housing developments in particular. These requirements will come with little short-term return on investment, so purpose, clarity, and a path toward compliance are keys to proper and timely adherence.

Enhance Energy Resilience

As mentioned previously, surviving extreme temperatures in Houston requires access to adequate air conditioning. Adequate air conditioning is not guaranteed for all city residents, and loss of air conditioning during storms and power outages can affect everyone. The connection between health and heat cannot be overstated, and that critical connection is likewise tied to energy security and resilience. Without energy, air conditioning cannot operate; without air conditioning, negative health impacts follow. Therefore, energy resilience becomes a critical factor in insuring residents have adequate access to cool spaces.

The city has suffered and will continue to be impacted by hurricanes, which frequently cause widespread power outages and are often accompanied by a heat wave. Reliable energy resources in the face of hurricanes and other weather events are key to the city's heat resilience.

Delivering Equitable Heat Mitigation Strategies

Low-income and underserved communities in Houston often face multiplying effects from the heat. Air conditioning may not be adequate, the heat island effect is stronger in areas of reduced tree canopy, and access to transportation to cooling centers during power outages may be a challenge. By using the mapping efforts mentioned earlier and partnering with local utilities, specific neighborhoods could be identified and prioritized for assistance and energy resilience efforts to help meet immediate cooling needs and to plan interventions and improvements for greater resilience in the future.

Competing Code Priorities

Throughout the city, a number of initiatives are underway that were designed to address environmental issues. At the same time, a closer look at the individual codes and requirements reveals some competing code requirements across multiple levels of jurisdictions. For example, the construction of detention basins to address stormwater removal is often achieved through removal of large forested areas without adequate canopy mitigation. In other instances, the current ordinances, while a good start, do not reach far enough. For example, the "City of Houston Landscape Regulations for Development: Tree and Shrub Ordinance" measures the caliper of the tree trunk but does not account for the size of tree canopy of the tree removed or its replacement.

Communication among departments and interagency communication between jurisdictional entities will reduce these competing interests and begin to have a greater positive effect on resilience efforts.

One simple energy resilience measure that could be rolled out across Houston is to encourage or incentivize the installation of operable windows in homes. Although each room is required by code to have at least one operable window, moving beyond the minimum and installing multiple operable windows in each room can provide residents with some relief from the heat during power outages that often occur after a storm.

It is also important to note that the costs related to property improvements required by these codes often result in increased costs to Houston residents and, more often than not, particularly affect renters in low-income housing developments. Care should be taken in the code revisions to mitigate adverse impacts.

The bright spot in the matter of competing code priorities is the mayor's clear focus on resilience efforts. This top-down leadership and clear prioritization of resilience can provide the necessary guidance to begin to resolve competing priorities at the city level.

Working with Property Owners

Individual homeowners and property owners can play an important role in the success of citywide heat mitigation efforts. By providing information about and motivating individuals to better understand how their actions on privately owned parcels can influence heat across the city, incremental progress can be made that can have widespread benefits. For example, homeowners may wish to remove a tree that presents a potential hazard during a hurricane. Are they aware that the same tree is helping mitigate heat on their property and in the surrounding neighborhood? Do they know that replacing a tree that provides only narrow shade with one that has a much wider canopy improves heat resilience? Nonprofit organizations could be called on to help educate residents about incentives for proactive mitigation behaviors that may support resilience efforts and deeper understanding about heat mitigation citywide.

JONNU SINGLETON, SWA GROUP

Buffalo Bayou Park transformed an under-maintained water corridor into one of the country's leading parks and acts as a national case study for the restoration of urban rivers around the United States.

Landscape and Building Design Strategies

Houston is taking a leadership role in promoting heat resilience measures across the city and can become an even stronger leader in this area across the region. The CRO, with the support of the mayor and an integrated approach across city departments, can further Houston's efforts to reduce the UHI effect and build Houstonians' knowledge and preparedness for the increased heat yet to come. The built environment plays an outsized role in adding to the heat island effect and, as such, can also play a significant role in reducing that same hazard. The following best practice measures can be deployed across Houston, implemented by the city in public spaces, and encouraged and incentivized for privately owned buildings and property.

Nature-Based Actions and Tactics

- **Increased Surface Reflectivity and Vegetated Areas.** Moving away from materials such as asphalt and dark-colored concrete and pavers that absorb and emit heat and moving toward plantings and vegetative areas or, if firm material is required, light-colored pavers that have a good solar reflectance index value can positively impact the amount of heat that is felt and absorbed by people moving through these spaces.
- **Green Roofs.** Rooftops that are covered or partially covered by vegetation can have tremendous heat absorption and air cooling properties and, at the same

time, provide an amenity for the building's occupants to view, walk among, or view from surrounding buildings.

- **Bioswales.** Small vegetated drainage channels, which may be planted with native species, can serve a number of resilience functions as they assist in stormwater drainage, filter groundwater, and assist in cooling air. With thoughtful design, bioswales can be viewed as an attractive property amenity or water feature.
- **Tree Canopy.** As mentioned earlier, trees are key players in absorbing heat, reducing carbon, and providing critical shade. Specifically, taking measures to protect existing tree canopies and prioritize canopy coverage for new trees will support the current tree ecosystem and assist in beneficial expansion.
- **The Role of Utility Companies.** In much the same way that certain codes may conflict with resilience efforts, the intersection of trees and utility poles and lines is often rife with conflicting priorities. In new developments, the city requires the planting of street trees, which are often placed in the right-of-way. As the trees grow larger and begin to interfere with utility lines, the utility companies trim the trees in a manner that cuts the canopy in half and reduces the trees' ability to provide shade and mitigate heat. The city is encouraged to work with the utility companies to increase pole height to allow space for taller tree canopies along rights-of-way. In other neighborhoods that frequently lose power, the city and utility companies are encouraged to partner on a pilot

Tactics in the Public Realm

A study conducted by Arizona State University analyzed heat in a city as a thermodynamic system, with the urban form and street network creating significant impact. Open spaces, streets, and underused lots can be resources for additional vegetation, shading, and cooling surfaces.

- Shading over walking paths—through tree canopy or built structures—can mitigate the urban heat island effects.
- Shaded and inviting transit stations can address safety, provide comfort, and improve residents' ability to cope with the heat.
- Vegetation along sidewalks can create a barrier from the heat emitted by cars and asphalt.
- Dual-function shade structures provide relief from heat and can include seating areas and opportunities to interact with water.
- Sprinklers or splash pads create fun, interactive spaces with direct cooling for those in the water and a cooling mist for others nearby.

This rendering depicts a host of heat mitigation tools implemented together to create an environment that is both inviting and cooler for city residents and visitors.

program to put utilities underground, which will eliminate the canopy/line conflict and increase energy resilience in the face of storms because buried lines are no longer subject to the effects of fallen limbs or trees.

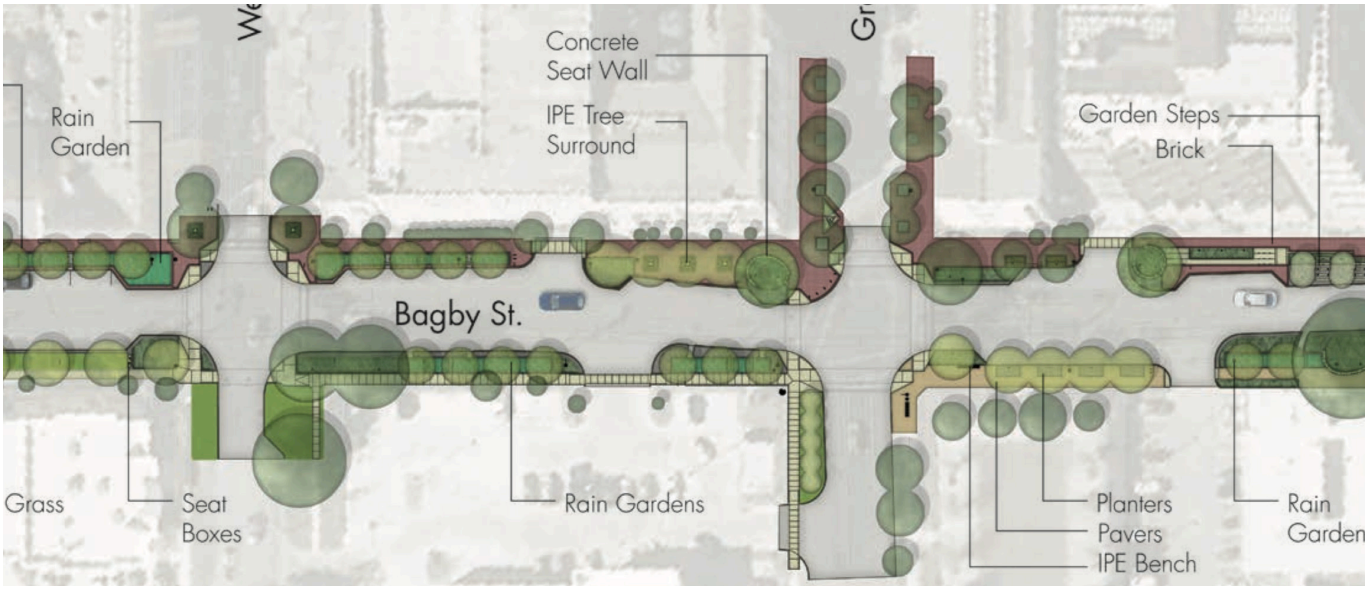
- **Planting and Care.** Existing resources across Houston can be tapped to help expand homeowners' knowledge of native plantings that dissipate heat as they thrive in Houston's climate. Nonprofit organizations can assist homeowners in selecting native trees and establishing a tree care program that works well in Houston's climate. The Houston Botanical Garden's Community Outreach program, Houston Wilderness, and Trees for Houston are great examples of existing resources to promote to homeowners and leverage for assistance in further solutions, recommendations, and guidance on plantings' care and maintenance.
- **Planting and Care on Public Land.** Organizations such as the Texas Department of Transportation and Houston Wilderness have established best practices for planting in public spaces and can be tapped by the city to likewise guide its tree and planting efforts.
- **Commingling Reforestation.** The city may also wish to consider partnering in flood remediation efforts in an effort to commingle reforestation activities with the establishment and maintenance of retention basins. The additional tree canopy will assist with heat resilience as well as provide additional water absorption mechanisms.
- **Community Input on Shade.** As noted, many low-income communities may not have the resources to privately plant additional trees to provide much needed shade. At the same time, it may not be wise for the city to simply plant new trees in a neighborhood without community input. By working with the community and gaining insights into where shade is needed most, identifying which walking paths are most used in which area, the city's efforts will have the greatest positive impact.

Tactics for the Built Environment

As the city contemplates heat mitigation strategies for the built environment, whether in the public or private realm, there are a number of strategies that can be used successfully in Houston's climate that will reduce the heat island effect in the city in both new construction and retrofits.

New Construction

- **Lighting.** LED lights are becoming standard in the built environment and emit less heat and require fewer replacements than their incandescent counterparts. This lower-light and lower-heat environment has positive benefits for the natural ecosystem surrounding buildings by causing less light interference with animals and habitats.
- **Air Conditioning Evaluation.** Regular maintenance or even upgrades to more efficient HVAC systems or air- (and ground-) source heat pumps should be included in a building's heat mitigation plan or strategy because



This image, included in the recent ULI publication *Scorched,* depicts Houston's Bagby Street with a range of heat mitigation measures in the public realm, from rain gardens to new shaded sitting areas and planters.

Case Study: Mitigation Practices for New Construction in Lockwood South, Buffalo Bayou Partnership

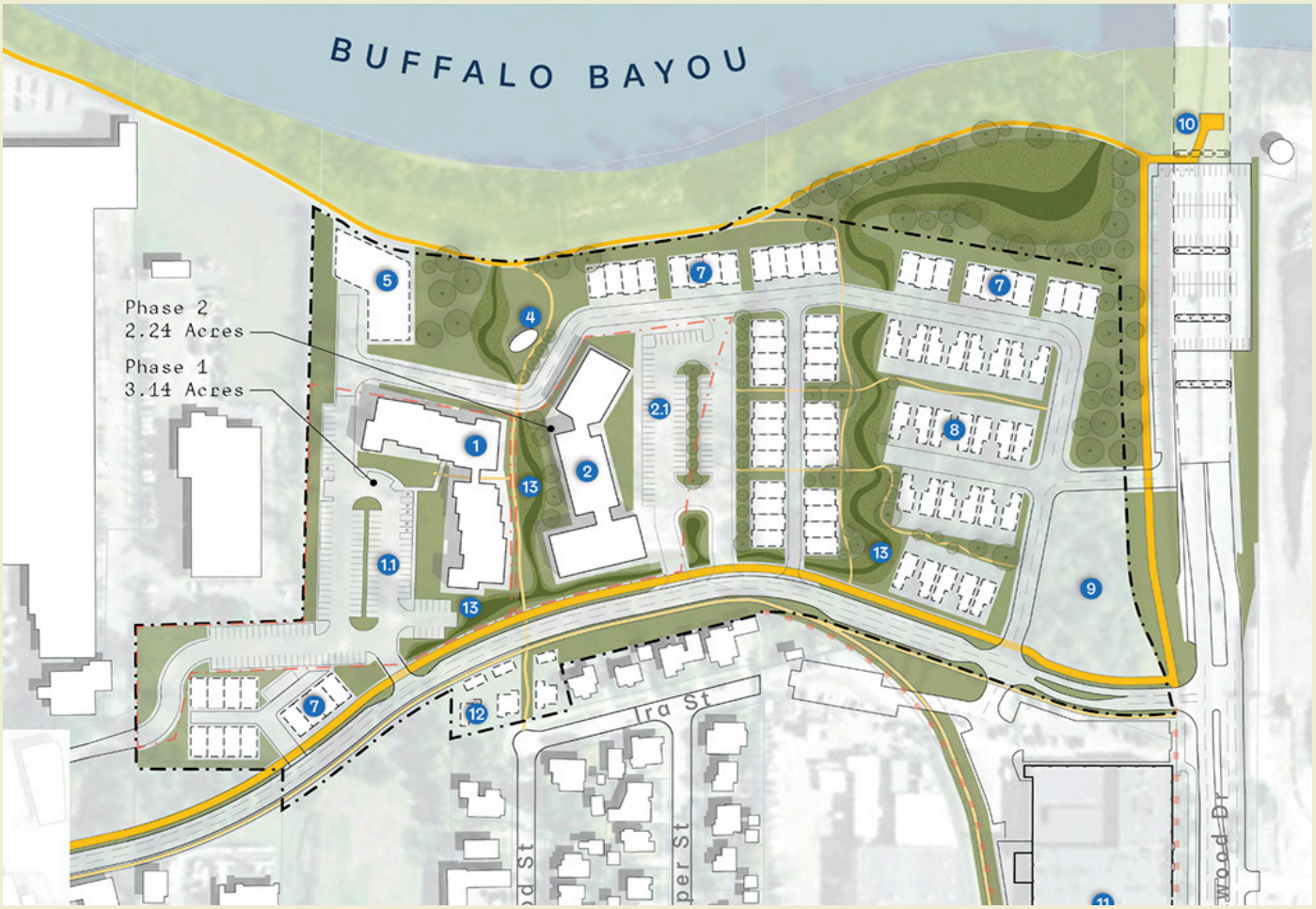
Houston's Buffalo Bayou Partnership (BBP), a nonprofit formed in 1986 to protect, enhance, and transform a 10-mile stretch of Buffalo Bayou, generously stepped forward with its plans for Lockwood South to serve as a case study for the panel's heat mitigation study. By referring to a specific site and analyzing BBP's proposed development plans, the panel expanded upon its recommendations and was able to pinpoint specific interventions that could enhance this particular development's heat resilience.

Lockwood South, the BBP case study at hand, sits along the southern edge of Buffalo Bayou and is bordered by Lockwood Drive to the east, a small neighborhood and commercial uses to the south, and an industrial facility to the west. The Buffalo Bayou Hike and Bike Trail runs along the northern edge of the property, wandering through open grassland and scrub forest.

BBP's designers and planners for Lockwood South have, to date, envisioned the site as an economically inclusive neighborhood that integrates with its natural surroundings, connects residents and neighbors to the waterfront, and generates activity and density without adding to the environmental challenges Houston already faces relating to stormwater runoff, urban heat island, and the like.

Because the site is clear of existing buildings, the focus of the planning efforts so far has been the integration of landscaping features and stormwater mitigation tools into the natural environment of the site, including features such as bioswales, public green spaces, and green "fingers" that extend vegetative spaces into areas between buildings, inviting nature close and providing more opportunities for water absorption and drainage. The planners have also carefully considered potential building orientation, watersheds and hydrology, the prairie and forest characteristics of the site, and access (water, bike, pedestrian, and vehicular).

Using this information, the panel made a series of recommendations that could be used specifically on the new buildings and surrounding infrastructure that constitute the phase two affordable housing portion of the project. While the developer presented two separate design proposals for the entire site, the panel's recommendations translate effectively to each proposal.



BUFFALO BAYOU PARTNERSHIP

The panel focused on the Lockwood South development site when formulating recommendations that can be applied to new construction projects led by the Buffalo Bayou Partnership. The 18-acre Lockwood South site will feature about 350 mixed-income multi- and single-family units.

Cool Roofs and Walls. In addition to the careful orientation of the buildings to maximize natural air flow and minimize solar intensity, buildings should incorporate roofing and wall materials that are highly insulated, reflective of sunlight, and/or absorb and use heat and water as in the case of green roofs.

Shade Opportunities. While the eastern half of the site is considered "forested," the trees are small and not of a species expected to grow much larger to provide useful shade or evapotranspiration. In light of this, and in addition to the tree plantings already proposed by the planning team, additional thought should be given to constructed shade structures. Whether by using awnings attached to buildings (front entry, back porch, or side yard) or large sail-type shade structures that could serve the public realm, additional shading mechanisms will be important for the health and comfort of both residents and park visitors.

Water Use/Reuse and Cooling. Splash pads and other interactive water features would be a welcome addition to the development plan. In addition to providing an opportunity for play by children living at Lockwood South, the sound of water and water movement are typically pleasurable for those living in or visiting the area. With benches placed nearby and breezes kicking up off the bayou, there is also the benefit of a light spray or mist coming from the fountain and cooling visitors.

LOONEY RICKS KISS ARCHITECTS/ULI

PLAZA COMPANIES

MITHUN/TIM GRIFFITH

MICHAEL VERGASON ARCHITECTS

Top left: Large awnings attached to entryways or other spaces outside a building can provide much-needed breaks from the sun and expand the living or commercial space beyond a building's walls. Top right: Large shade structures in the public realm can provide cooling as well as notable public gathering space. Bottom left: White walls reflect the intense sunlight and help keep interior spaces cool. Bottom right: Public water features provide cooling, play space, and visual and other sensory interest.

Case Study: Existing Building Adaptation in Turkey Bend, Buffalo Bayou Partnership

A second case study provided by the Buffalo Bayou Partnership centered on the redevelopment of the Turkey Bend industrial property located east of the Lockwood South development and at the site of the former Houston Barge Terminal at Turkey Bend.

BBP envisions the redevelopment of Turkey Bend's former waterfront industrial buildings into spaces that preserve the unique industrial character, reconnect the neighborhoods to the bayou, and celebrate community, art, and participation. Situated on an offshoot of Buffalo Bayou, the buildings at Turkey Bend are sturdy, full of character, and provide interesting opportunities to connect with the waterfront and nature, both visually and tactically.

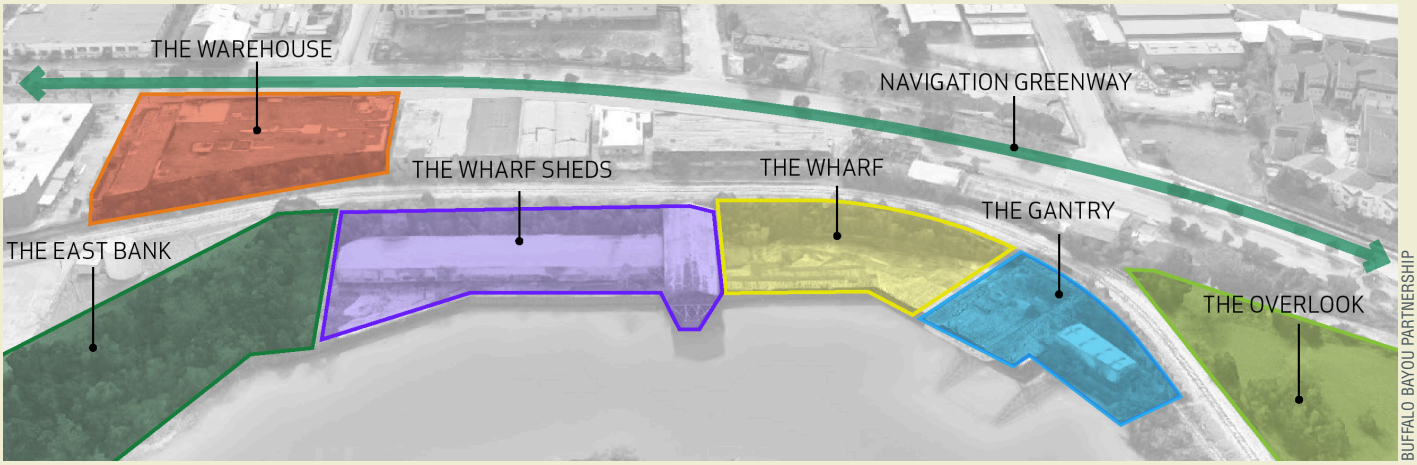
When considering the potential for heat mitigation and climate adaptation throughout the project, the panel focused on four key factors that will help mitigate extreme heat in this project and can be replicated in other adaptive use projects across Houston.

Transitional Spaces. Renovations to the warehouse will include the construction of a new entry into the building. Although the primary design purpose may be to visually connect visitors to the waterfront beyond, the shaded entry also provides a welcome space in which to transition gradually from the extreme heat outside, into the shaded outdoor space, and eventually to the artificially cooled spaces inside. This gradual transition helps visitors acclimate more gently and humanely between temperatures and lessens the shock of moving between cooled spaces and the heat beyond.

Multiuse Infrastructure. While it may be difficult to avoid paved areas entirely within a project of this size, choosing to leverage the paved spaces in a variety of ways will allow needed functionality and reduce the amount of additional impervious surfaces across the project. As envisioned, the paved entry into the Wharf will be used to launch watercraft and provide critical access for emergency vehicles. The space may also become a site for food truck parking on weekends or a site for smaller festivals or performances. This type of hardscape multifunctionality should be considered across the city, with an eye toward conversion of paved spaces into vegetated areas where feasible. Similarly, the building infrastructure could also be designed to serve multiple purposes. With backup power sources (solar and batteries), the buildings could provide sheltered space for people to gather and recharge mobile devices during power outages.

Preserve and Enhance Native Vegetation. The east bank of Turkey Bend is home to a variety of native plants and small trees. BBP recognizes the value of the native ecology and intends to restore the east bank into a space that celebrates the native vegetation and provides a welcome walking path for visitors. Embracing native species that can tolerate the heat, require little additional irrigation, and absorb additional rainfall in extreme weather events is a best practice that should be encouraged throughout Houston. In addition to the natural cooling of vegetated spaces (compared to paved or even turfed areas), the shade that larger native trees can provide will also provide welcome cooling to those choosing to walk, rest, or recreate along the paths of the east bank.

Shaded Outdoor Spaces. The industrial history of this waterfront site provided the developer with unique opportunities to reimagine spaces like the wharf gantry—formerly a shed for servicing and storing industrial watercraft and machinery. The open-air building provides the developer with an opportunity to create a new "front porch" to Turkey Bend that is open and accessible to all. With its high ceiling, the space is fully covered and shaded from the sun. The lack of walls allows breezes through the space and encourages people to wander into the space within. Given the placement of the stairs at the end of the structure, the developer has created a natural open-air amphitheater and performance space. Shaded outdoor venues like this can create opportunities for gathering and community building while still protecting people from the extreme heat and intensity of the sun.



Turkey Bend redevelopment site with future destinations identified.

BUFFALO BAYOU PARTNERSHIP

Native vegetation is maintained and encouraged, and walkways are interspersed along the east bank to provide visitors with cooler spaces in which to relax and enjoy recreation.

BUFFALO BAYOU PARTNERSHIP

The existing infrastructure of the Wharf is reconditioned into multiuse space for watercraft launch, food truck parking, emergency vehicle access, and more. The multifunctional nature of the one space reduces the need for additional paved, impervious surfaces in other sections of Turkey Bend.

BUFFALO BAYOU PARTNERSHIP

The Turkey Bend redevelopment site carries an industrial legacy as a formerly working waterfront.

BUFFALO BAYOU PARTNERSHIP

The new entrance to the renovated warehouse provides visual connections to the water and serves as an important space in which visitors can gradually escape from the heat outside into the shaded entrance, and eventually to the artificially cooled spaces inside the building.

BUFFALO BAYOU PARTNERSHIP

The wharf gantry, perhaps targeted for demolition by other developers, will instead be repurposed as a shaded outdoor gathering and multiuse space.

efficiently running equipment is key to sustainability and the system's ability to cool effectively over time. In addition, strategically placed and efficient ceiling fans can have a positive impact on the cooling of living spaces and can reduce the air-conditioning load.

- **Double- and Triple-Glazed Windows.** Although the International Energy Conservation Code requires double-glazed windows, some developers and building owners are moving to low-emissivity or triple-glazed windows to enhance a building's ability to maintain a constant interior temperature.
- **Transitional Spaces.** The addition of an air barrier or vestibule at the entry to a building can assist with maintaining a consistent temperature inside the building as well as assist visitors with temperature acclimation as they move from the hot air outside to the cooler air inside.
- **Building Orientation.** When possible, developers and architects should consider orienting new buildings in a manner that provides for maximum air flow around the buildings and, at the same time, minimizes the impact of the sun on windows and interior spaces.
- **Parking Solutions.** Given the amount of space new developments allocate to the automobile, improving the parking situation is important. Whether the city considers reducing the parking mandate on developments in certain situations or building developers and owners find new solutions for parking today's required spaces (e.g., structured parking solutions, automated garages that require fewer square feet per car, etc.), there is room for improvement generally in the manner by which parking is addressed in Houston and certainly through the lens of heat mitigation. Using cool pavement coatings and moving to light-colored surfaces in remaining parking environments can also positively affect heat mitigation by reducing the surface temperature.
- **Cooling Centers.** The panel recommends that the city partner with the real estate development community to help build or establish additional cooling centers to expand the city's network. The location of future cooling centers should be guided by data collected during heat mapping efforts.

Architects, engineers, and landscape designers are learning about best practices in heat mitigation from their peers around the country, and their expertise should be leveraged to improve Houston's built environment. Similarly, looking for solutions as a part of a larger thermodynamic system or by combining techniques across platforms (engineering, architecture, etc.) presents an opportunity to amplify one heat mitigation technique to achieve multiple benefits. This multiple-benefit approach is encouraged across all actions and initiatives.

Retrofits

In addition to the heat mitigation strategies listed here for new buildings, existing buildings are prime candidates for upgrades or retrofits that will help reduce the heat island effect in Houston and mitigate the impact of heat inside and outside the building.

- **Roofing Materials.** While a green roof may not always be feasible due to the additional weight of planting infrastructure on the roof deck, roofs may be resurfaced with a white or light-colored membrane.
- **Building Envelope.** Improvement in the cooling of an existing building's walls may also be achieved by resurfacing or painting with light-colored materials.

> "We did over 100,000 energy building simulations across the U.S. and found that the energy savings from cool walls are generally equal to or greater than that of cool roofs."
>
> —Ronnen Levinson, director, Heat Research Group of Lawrence Berkeley National Laboratory, in *Scorched*

- **Building Entry.** Additional canopies, vestibules, or shaded entryways can be added to an existing building to help cool the entrance and provide a welcome space for temperature transition between the extreme heat outside and cooled spaces inside.
- **Window Material and Operation.** It is possible to upgrade existing building windows with double- or triple-glazed options, and making them operable for residential

installations adds to the potential for natural cooling and ventilation when the weather permits. Installation and use of ceiling fans can also assist in cooling spaces when windows are open or amplify the cooling of a building's air conditioning system.

UHI Impact Analyses

As the city contemplates the manner in which it can promote, incentivize, or codify these best practices in heat mitigation and heat resilience for new construction and retrofits, the panel recommends the city establish a baseline heat island measurement for key geographies and a system by which regular measurements will be taken going forward. This type of baseline and ongoing measurement will help Houston leadership better understand the impact of public and private improvements throughout the process and identify areas where additional refinements to policies and practices may be needed based on the data gathered.

ULI HOUSTON

BUFFALO BAYOU PARTNERSHIP

ULI HOUSTON

Top left: A white roofing membrane is installed to create a cool roof. Top right: Large, industrial-sized fans can help circulate air and cool rooms and outdoor spaces. Bottom left: A transitional space in a building entry allows visitors to move from the extreme outdoor heat into a shaded and slightly cooler area before fully entering a much cooler air-conditioned space. Bottom right: Existing buildings can be retrofitted with heat mitigation measures such as this covered walkway that shades and protects building visitors.

ROBERT UMENHOFER

Exterior shading on the facade of Finch Cambridge, a 98-unit, mixed-income building, prevents solar heat gain in the summer months. Finch Cambridge employs passive building design strategies to provide a healthy living environment for its residents and is prepared for New England's cold winters and increasingly hot and humid summers.

Policy and City Initiatives

As many of the initiatives and tools discussed in this report rely on private-sector adoption, the city will need to plan and act strategically to encourage participation across the private sector.

Lead by Example (Public-Driven Initiatives)

One way to encourage private-sector adoption is to lead by example with actions and interventions in the public sector and public realm that are aligned with other municipal programs. Two examples could include:

- improving the shading along existing public pathways, routes, and public spaces in at-risk neighborhoods (e.g., Gulfton); and
- piloting and measuring the performance of mitigation strategies on public buildings. This pilot program could demonstrate the viability of select measures and showcase the associated options and benefits to local developers.

Heat mitigation strategies that include updates to the building code should focus on the broader human health benefits and note the associated benefits of heat resilience, rather than focus on and use terminology and concepts that are either too technical or impersonal.

- Code updates addressing heat strategies should be identified by neighborhood since conditions vary and no single approach would work for all neighborhoods equally.
- As mentioned previously, many buildings in Houston often do not have operable windows, which leaves buildings in dangerous conditions for inhabitants if the air conditioning fails. In many instances of power outages, interior heat and moisture buildup can lead to mold growth. Requiring operable windows with screens could be an important passive resilience measure.

As new codes are drafted and customized for neighborhoods, the city is encouraged to frame certain performance-based approaches based on readily available off-the-shelf tools.

- The Parks and Recreation Department's current landscape ordinances could be edited to better address dissipating heat energy and to also take into account tree canopy preservation (instead of the current tree caliper measure) when tree trimming or replacement is required.
- Performance-based incentives and design, comfort and health, and experiential benefits have value, some of which can be quantified by the city now and measured going forward.
- Other performance metrics could include measurements at the building level, such as the reduction in HVAC costs from cool roofs or walls, and citywide measurements, such as the number of emergency room visits for heat-related injuries.

The city may also consider using tax abatement as an incentive for deploying heat mitigation measures on private property. This type of economic incentive could provide a precedent for future expansion of initiatives of this nature.

Potential also exists to build heat resilience elements into new development agreements. As a city where development activity is strong, Houston is in the enviable position of being able to strengthen its heat resilience measures through initiatives and more pointed agreements with the private sector.

Finally, because the heat burden or heat stress on Houstonians is greater at the beginning of summer as residents begin to adjust to the hotter outside temperatures, the Recreation Department is encouraged to move more activities outdoors in shaded areas to allow people to experience and acclimate to the heat on a more natural and less stressful basis.

A potential heat resilience toolkit for developers might cover a range of building design, material, and urban planning aspects.

Create Stakeholder Awareness

To assist the city in raising the visibility and awareness of heat mitigation solutions that will work financially for the development community, the Planning and Development Department should consider commissioning a toolkit for developers, architects, and designers, featuring heat-resilient materials, strategies, and benefits. By establishing and communicating best practices, the city is encouraging and enabling the activities it seeks from the development community.

In addition to the materiality of the development process, the city is encouraged to leverage emerging interest in comfort base certifications (LEED IAQ, WELL, etc.) to highlight the importance of urban heat in the development and ownership of real estate. The interest in these certifications extends beyond the building owner/developer level and has become a key factor in some corporate tenants' building/leasing search.

In addition to the toolkit's guidance about heat mitigation through design and materiality (white roofs, lighter surfaces, green roofs, enhanced tree preservation and planting, etc.), it might also address tactics such as vestibule/air barrier installations and specific health-related measures such as air quality and comfort. If implemented more widely, the toolkit and its accompanying tactics have the potential to help the city meet the following goals:

- **Education.** This can be an opportunity to educate the entire population at all levels, dispel any climate and/or heat myths, and provide the vehicle needed for the delivery of a consistent message and plan.
- **Definition.** The toolkit could provide the city's definition of heat and then serve to communicate it broadly.
- **Multi-Tiered Educational/PR Campaign.** The information and resources in the toolkit could be customized based on intended market:
  - » Developer content would include the pilot program and a roadshow of solutions and value.
  - » Residents/tenants would receive information that focuses on an overview of health and economic benefits and requirements.
  - » In addition to information related to their campuses, for universities information included might also educate and encourage participation in the messaging and expansion of professionals' knowledge.

Better Align Policy and Guideline Opportunities

In much the same way the challenges and opportunities of addressing heat mitigation at the city level were intertwined, the same can be said for the opportunities around implementing new policies and guidelines.

Houston's building codes provide a challenge today in that they do not push hard enough toward resilience. The opportunity to address health impacts as they relate to heat resilience, for example, could now include a requirement that buildings have operable windows for ventilation and that roofing improvements use materials that radiate less heat.


NATIONAL CENTER OF EXCELLENCE/ASU

NATIONAL CENTER OF EXCELLENCE/ASU

The Chicago City Hall green roof measures almost 80°F cooler than the other sections of the roof that have not been improved with the green infrastructure.

Likewise, the city's landscape ordinances could stretch further to better facilitate heat energy release and tree canopy preservation and enhancement.

The city's Planning and Development Department may also wish to employ simulation tools to help evaluate potential designs as microclimates with the goal of testing, adjusting, and refining practices before large-scale rollout and implementation.

In view of the work before the city, and in light of the competing code priorities, it is important to acknowledge that further alignment is needed between city programs, incentives, and regulations to help foster innovative strategies for heat and resilience co-benefits. Finally, introducing metrics into the evaluation and permitting processes will help institutionalize the resilience focus and ensure that all players are aware of and working toward the same heat mitigation goals.

Explore Plans, Policies, and Collaborations in Other Cities

Throughout the study, the panel identified a number of other programs from around the country that may be worth exploring as the city further shapes its heat resilience strategies and works to formulate recommendations and policies for the built environment. The following list may provide a good starting point for some programs or a valid comparison for programs already underway in Houston.

Policies and Plans

- **Chicago Green Roof FAR Bonus.** This floor/area ratio (FAR) bonus, established following a deadly 1996 heat wave, has encouraged creation of about 500 green roofs across Chicago.
- **Stormwater Retention Credit Trading Program, Washington, D.C.** This program has not only assisted in reducing the amount of stormwater runoff in the city but has also had the spin-off effect of encouraging green roofs in the D.C. area.
- **Site Greening/Cooling Rating Systems.** Rating systems are often used in codes to set a minimum required score and may also provide bonus ratings for efforts above the minimum requirements. Improvements and tactics included in these ratings systems cover landscaping measures, cooling techniques, habitat considerations, and more.
  - » Seattle Green Factor
  - » Washington, D.C., Green Score
  - » Cambridge Cool Factor (in development)
- **Urban Forest Master Plans and Tree Ordinances.** Cities are using tree canopy mapping of public and private land to analyze the distribution of tree canopy and identify priorities relating to the establishment of new tree canopy, preservation of existing canopy, and management, maintenance, and any new ordinances that may be required going forward.
- **Urban Heat Plans.** In other instances, cities are mapping and modeling heat and heat islands across geographies and recommending specific strategies based on that modeling.
  - » Dallas Urban Heat Island Management Study
  - » Boston Heat Resilience Study (in development)
  - » Louisville Urban Heat Island Project
  - » Philadelphia–Hunting Park Community Heat Relief Plan

Collaborations

- **Los Angeles Urban Cooling.** This collaborative brings together research institutions, city and county government, and the private sector to identify the problem and together figure out how to reduce the urban heat island effect and impacts of extreme heat in Los Angeles.
- **Boston Green Ribbon Commission.** While convened by the city of Boston, this collaborative is run by large institutions, universities, and large employers to learn and collaborate around climate change challenges such as rising sea levels and rising temperatures.
- **Southeast Florida Regional Climate Change Compact.** Multiple jurisdictions in southeast Florida joined forces to study and plan for rising sea levels and have now also included a focus on extreme heat.
- **San Diego Regional Climate Collaborative.** Again, research institutions, universities, the nonprofit sector, and the business community formed a collaborative to study the impacts of climate change and together shape plans and strategies for regional adaptation and mitigation.

MICHAEL VERGASON LANDSCAPE ARCHITECTS

Sundance Square Plaza in downtown Fort Worth, Texas, is a gathering place that defines the city's character, provides a respite from hot summer temperatures, and accommodates large crowds for parades, festivals, concerts, and fitness classes.

Conclusion

Houston is well on its way to identifying key strategies and implementation tactics that will help reduce the heat island effect across the city and support its efforts to alert residents to the dangerous heat impacts ahead. While some may believe increased air conditioning is the solution, at least in the near term, addressing excessive heat not only reduces the effects of heat waves, but also reduces development costs in the long run as cooling infrastructure becomes more complex, expensive, and costly to operate. The built environment and the real estate industry have a key role to play in these efforts and, through diligent messaging, careful code revisions, and steady monitoring, the city may begin to level the anticipated trajectory temperatures are expected to take in Houston.

By using historic information, data, and mapping to inform its solutions and by partnering with organizations across the region to assist with the work, the city's path forward to meeting the demands of heat mitigation can begin to take shape. Establishing baselines today, against which future progress will be measured, will assist the city in accurately identifying today's foundational resilience conditions and tomorrow's anticipated improvements.

The city should be commended for its ordinance that supports tree preservation, yet the requirements should go a step further to quantify and protect the tree canopy and shade coverage. This ordinance may require additional revisions to incentivize further adoption and maximization by the development community.

For many, topics like heat mitigation and heat impacts sound remote, scientific, and impersonal. By moving to language that centers community health and occupant comfort and health, the public and development community may begin to see themselves and their tenants in these scenarios and the actions may resonate more quickly and deeply. These changes in language may seem minor, but the intentional focus on health is warranted and will add a needed sense of urgency to the work.

Many low-income communities in Houston spend an estimated 30 percent of their household income on energy bills and cannot afford basic repairs to their homes. To assist, the Houston Advanced Research Center and Department of Energy are partnering to create a program to provide grants for such repairs.

Houston's Progress toward Resilience

	FOUNDATIONAL Baseline efforts or step one; Led by city's Department of Planning and Department of Public Works	ACCELERATING Creates a level of change	LEADERSHIP Actions beyond all others, leading the pack, aspirational
Individuals	› Education › Health information › Energy cost relief for low-income residents › Access to free/low-cost supply chain	› Resources are easily found and used › Suggested data are used › Tools (e.g., rebates) are redeemed	› Individuals feel safer from heat and health concerns › Clear stories are shared in media, meetings, etc. › Individuals feel supported and part of mission
Neighborhood	› Education › Health information › Organized event(s)	› Regularly scheduled events on heat, environment, etc. › Clear awareness from and engagement with neighborhood groups	› Low-income neighborhoods are equal to others in terms of leading change › Represented at the 'table' › Tree counts maximized › Health issues reduced
Business community	› Education › Pilot/examples › City meetings › Process clarity and improvement	› Tax incentives/rebates catalyze change and identified as differentiators by business community	› Business owners and leaders are partners with city and other organizations › Leaders share their resilience measures in media and annual reports, etc.
Watershed (eco-level)	› Assess eco gaps › Overlay heat map	› Plan put into place to fill gaps › Tackle related barriers › All agencies and stakeholders engaged	› The watershed is a "reborn" heat sink that resolves issues through natural processes
City level	› Code modifications › Lead campaign (with focus on health) › Form key partnerships › Finish mapping neighborhoods/trees/health/income/water	› Providing rebates, education, and management that show a marked change in activity/practices › Mapping exercise results in custom approaches based on segmented needs	› City is recognized globally as an innovator that took its major issues with extreme heat and created a city with the same temperatures across neighborhoods, decreased mortality from heat, and adopted innovative practices and policies › Citizens are happy › No cascade effects of power loss after/during extreme heat
Regional level	› Lead campaign › Form partnerships › Complete vulnerability assessment	› Consistent rebates and messaging › Communications on the "why" of the initiatives	› Similar to city level, region is recognized globally as an innovator, though now with an added emphasis on collaboration with results › Multiple municipalities working together to benefit the entire region, including smaller communities with smaller budgets

It is not reasonable to assert that any one department in city government can or should be responsible for the implementation of all of the items noted in this table. Instead, the panel recommends that the city, and the Resilience Office specifically, convene department leads and relevant community nonprofit organizations to identify a division of responsibility across the region as well as a process for further mobilization, collaboration, and collective accountability.

Although the panel would like to believe that the private sector will naturally follow the lead of the city and begin ready adoption of heat mitigation measures, code revisions will be warranted to incentivize developers and property owners who may not be as ready to address the future fiscal and health impacts of business as usual. Aligning city department agendas across the code revisions will help insure uniform approaches and measures that have cumulative, rather than competing, impacts.

Finally, given the cascading impacts of weather events—a heat event, followed by a hurricane, causing power outages—a vulnerability assessment by the city and broader region would help pinpoint and prioritize the geographies and infrastructure most at risk. With this knowledge and understanding, plans can be put in place and resources directed to the areas most in need.

Houston is hot and humid, temperatures are rising, and this will not change. What can change, however, is how the public and private sectors prepare for, respond to, and manage efforts to mitigate heat and protect community health across the region. With these measures, taken at the foundational level (today's efforts, or step one), the point of acceleration (actions that create systems change), and the leadership level (Houston leads the way in creating best practices), the city can plan, prepare, and begin to see real impacts that protect the community and insure healthy and resilient residents, neighborhoods, and economies into the future.

About the Panel

Angela Cotie
Panel Co-Chair

Cotie has been involved with many high-profile projects during her 24 years in the construction industry and is currently leading a large airport project in Houston.

A Penn State graduate, she was an ENR Texas/Louisiana Top 20 under 40 in 2015 and a 2018 STEAM Role Model for the Houston Women's Chamber. She has worked with AGC Houston to start a local Women in Construction initiative and is the mom and stepmom to four.

Cotie is ACE Mentor Houston's chairman of the board, a board member for Houston Area Parkinson's Society, a board member of Construction Career Collaborative, a Galveston Career Connect leader, HISD chamber member, and a past board member for PSU's Architectural Engineering Program. She is also active with her sons' fledging cattle company and active with her children's school, FFA, and activities

Dalia Munenzon
Panel Co-Chair

Munenzon has a decade of professional experience in architecture and urbanism, focusing on adaptive strategies and resilience methods. She leverages experience in urban systems design, environmental planning, and architecture to work with local communities across scales toward resilient cities and urban environments.

She is currently the Houston associate and in the past served as the Boston associate for One Architecture & Urbanism, leading the firm's projects in the greater Boston area. Her work on resilience is focused on waterfront design and long-term strategic planning. She has led such high-profile, award-winning projects as Climate Ready Boston Downtown, East Boston, and Charlestown; Moakley Park Vision Plan; Peddocks Island Masterplan; Fourth Regional Plan, Triboro, Lower Manhattan Coastal Resiliency Project; and the East Side Coastal Resiliency Project.

Munenzon received a master's in architectural studies from MIT and a bachelor's in architecture and town planning from the Technion Israeli Institute of Technology. Her undergraduate thesis, which looked at the future of coastal cities, was awarded the Raiskin Award in 2012. She has been a guest critic at Harvard GSD, MIT, UC Berkeley, CCA, Northeastern, Boston Architectural College, University of Pennsylvania, RISD, Wentworth Institute, and The Cooper Union. She hopes to carry forward her knowledge and experience to promoting healthy, inclusive, and resilient cities in the 21st century

John Bolduc

Bolduc is an environmental planner with the city of Cambridge Community Development Department where he manages climate change initiatives. He manages the city's Climate Change Vulnerability Assessment and the Resilient Cambridge Plan, coordinates the Climate Protection Action Committee, an advisory group to the City Manager on local climate change policy and implementation, administers the Building Energy Use Disclosure Ordinance, and participates in a range of other municipal sustainability efforts. Bolduc has been with Cambridge since 1997 and has over 35 years of experience in local sustainability and environmental protection. He holds a BS in resource economics from the University of California at Davis and an MA from Tufts University in urban and environmental policy.

Myrrh Caplan

Caplan is senior sustainability director for Skanska in the United States. She is a leader of sustainability efforts across the United States and oversees a team that advises and manages projects seeking certification in LEED, WELL, Living Building Challenge, Net Zero, Envision, and others, as well as assisting clients with organizational strategy setting. She and her team manage Skanska's initiatives in the United States around carbon, community investment, and healthy buildings.

With over two decades in the construction and development industries, her résumé includes more than 225 projects, and accreditations in LEED, TRUE and Parksmart (USGBC), WELL (IWBI), FitWel (CAD), and Envision (ISI).

Caplan's most recent experience includes advising city clients and campus owners on the pursuit of net zero goals and on incorporating resilience measures into their master planning. She is also currently an engaged co-chair and committee member on several community-oriented and national committees.

Bungane Mehlomakulu

Mehlomakulu is an expert in sustainable building design with nearly 20 years of experience in the built environment developing low-energy, high-performance solutions for buildings focused on the health and well-being of the people who use them.

His career focuses on developing design solutions incorporating building needs, architectural intent, and building science and performance. He is actively engaged in the local and national discussions to create a more sustainable built environment.

Andrew Richards

Richards resides in Houston and manages his own company, AEME LLC. He is a real estate development and management professional with over 20 years of experience building single-family, multifamily, commercial, and hospitality projects. His fascination with urban development has led him from his hometown of New York City through Frankfurt, Los Angeles, Dubai, and now Houston. His small but determined company focuses on the purchase, development, and management of infill projects in Houston's core, taking advantage of the growth in the city and the southern United States overall. When he is not dreaming about skyscrapers, Richards pretends to be a golf player, a world-class downhill skier, and successful fisherman.

Rachel Claire Wilkins

Wilkins is a designer at SWA. She began her design career as a pre-med major at Loyola University, where she was far more entranced with the beauty of unicellular organisms under a microscope than her course material. As a designer she is object-specific and takes great pleasure in working geometry and materiality of spaces to best produce a desired experience. She graduated from the University of Houston with a master of architecture in 2012 and joined SWA at the beginning of 2020 after a seven-year tenure at OJB. Her past project experiences include public parks, high-end retail and mixed use, corporate campuses, and office towers.

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