LIVING WITH HEAT

Urban Land Institute
Boston/New England

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LIVING WITH HEAT

Urban Land Institute

Boston/New England

122 °F | 50 °C

Contents

104 °F | 40 °C

86 °F | 30 °C

68 °F | 20 °C

ABOVE Introductory comments from Arlen Stawasz to kick off the LWH Design Charrette in June 2019
Image credit: Steve Lipofsky

THANK YOU

We wish to thank the ULI Boston/New England Climate Resiliency Committee and the ULI Center for Sustainability and Economic Performance (CSEP) for its support in exploring climate resiliency solutions and for the generous support that enabled ULI Boston/New England to produce “Living with Heat (LWH)”.

Without The JPB Foundation’s financial support and the in-kind support of the ULI Boston/New England membership as well as member organizations Arrowstreet, Perkins and Will, and CBT Architects; the charrette and report would not have been possible.

A special thank you to Arrowstreet Graphic Design who donated their time and expertise to produce this report. We would also like to thank the 70+ ULI members, experts, staff, and community organizations who participated in the charrette and contributed to this report.

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We are beginning to feel the impacts of climate change. In addition to the wide range of political, social, and economic concerns that climate change is sparking in our communities, we are faced with the invisible threat of extreme heat on our society and the built environment. The ULI Boston/New England report that you are about to read focuses on the consequences of climate change in the Greater Boston area—specifically, extreme heat and its ancillary issues. The ideas contained here are representative of the opinions and thought leadership of 70+ industry experts, including engineers, architects, and real estate development professionals, in consultation with community stakeholders. These experts met for a day-long conversation to develop integrated solutions for a future with increased heat as a frequent and pervasive part of our daily lives.

This one-day event was followed by months of discussion, and this report is the result of our collective efforts. We accept that extreme heat will be more common, the weather is changing, and our communities are at risk; and we recognize that no solution can be all-encompassing. It is our hope that this report will spark conversation, shift our understanding of what is possible, and aid us in reframing challenges into opportunities as we move toward this new reality.

Sincerely,

Arlen Stawasz, Associate AIA,
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ABOVE Average Daily Land Surface Temperature and Tree Canopy in the Metropolitan Boston Area
Image credit: Trust for Public Land, Climate Smart Cities

Executive Summary

How can land use professionals help to mitigate the effects of urban heat islands (UHIs) on the built environment while simultaneously helping the most vulnerable segments of the population deal with public health issues created by extreme heat?

The purpose of the LWH report is to help local real estate developers, designers, and policymakers to acknowledge the consequences of extreme heat and to seek solutions to make buildings, neighborhoods, parks, and outdoor spaces more adaptable to environmental conditions and comfortable for occupants.

LIVING WITH HEAT

In response to this worsening problem, ULI Boston/New England convened a LWH charrette to develop strategies to deal with the immediate threats to communities during extreme heat events, as well as devise design solutions to mitigate the impact of the rising temperatures predicted by 2070.

The charrette focused on four separate UHIs in the Metro Boston region, each with its own distinct challenges and opportunities. The sites were located in the communities of East Boston, Lower Roxbury, Chelsea/Everett, and Somerville. In addition to being prototypical examples of the UHI effect in various settings, the four sites were also selected because each is undergoing significant commercial and/or residential development or redevelopment. As many projects are in the planning stages, this represents a prime opportunity for offering recommendations for forming strategies to combat extreme heat in the near and long term for each of these sites—and for the region as a whole.

The larger intent was for the solutions proposed to the issues raised to be replicable and have wider applicability beyond these designated sites. For each site, interdisciplinary teams of ULI members with expertise in development, urban planning, landscape architecture, and sustainability were assembled.

In order to gain insight into the focus sites, panelists conducted interviews with groups of stakeholders from each of the site locations in two one-hour sessions. Stakeholders included representatives from local government, nonprofits, community development corporations, state and quasi-public agencies, and public advocacy/activist groups.

The stakeholders from each site were presented with the following boilerplate questions to initiate the discussions:

- Who/what is at risk during extreme heat days?
- What is your vision for the site in the next 50 years (2070)?
- What has been done to mitigate heat islands in your neighborhood?
- What resources do you currently use during heat events?

Following the stakeholder meetings, panelists from each of the sites met for three hour brainstorming sessions, and presented their initial findings to the other teams and the ULI Boston/New England Climate Resiliency Committee. The teams then prepared assessments and recommendations for each of the sites.

Several common solutions emerged from the four sites, many of which are consistent with widely recognized UHI dynamic planning models for heat island mitigation. One such recommendation was to establish a network of cooling stations that would allow residents to move more comfortably through their neighborhoods during times of extreme heat. While all teams suggested upgrading bus stops and other places of respite (pocket parks, etc.) to include shade and misting devices, plans varied in scale from site to site, including suggestions to install solar panels and collect stormwater at bus stops.

Some of the recommendations were relatively modest in scale, such as the plan to create a festive summer heat pop-up mobile trailer in Lower Roxbury during times of extreme heat. The initiative would not only allow residents to cool off in a safe, community-building environment, but also to have access to medical treatment and educational materials regarding self-care during heat events. Another common theme was the redesign of streetscapes to increase vegetation and reduce auto use at the Somerville, Chelsea/Everett, and East Boston sites. Other recommendations were larger in scale, including creating a shaded overpass in Somerville by redeveloping the corridor underneath the elevated McGrath-O'Brien Highway, or daylighting submerged rivers in Somerville and Chelsea/Everett to create cooling mechanisms. Still others involved the wholesale redevelopment of grocery-anchored retail centers (Market Basket in Chelsea and Liberty Plaza in East Boston) to reduce the asphalt and impervious surface areas that absorb and retain heat, and in East Boston, that plan included a design to increase access to the cooling winds of Boston Harbor.

While there are numerous parallel initiatives on the strategic and policy fronts to mitigate the effects of UHIs, how these recommendations will be received by the public and private sectors remains to be seen, given the lack of awareness regarding the gravity and urgency of the problem. The ULI Boston/New England effort is unique locally in investigating the vision for a different future prepared for climate change and living with extreme heat. Property owners, developers, government entities, and policymakers will need to alter their thinking to make the types of choices and investments to address this issue. Careful planning will be required to maintain the continuity and quality of the urban experience, and new strategies for material selection, street design and open space planning will need to become geared towards mitigating the effects of heat.

While building a more resilient community will require investment over time, the cost of doing nothing could be profoundly disruptive and exponentially more expensive, particularly when figuring in the human cost. Actions to reduce damage from extreme heat events not only protects the health of the most vulnerable populations, but allows the outdoor workforce such as those in the construction industry to operate at full capacity.

The images and drawings included in this report are meant to provoke conversations among various stakeholders, continue the ongoing regional discussion, and become the jumping-off point for potential urban solutions. They should be used to spark discussions, identify risks and opportunities, and assist with understanding the issues and threats created by extreme heat on the individual sites. Integrating climate resilience measures in the regulatory and best practices processes will be complex and will require time, vision, and collaboration among decision-makers, stakeholders, and experts contributing to city building. It is hoped that the ULI LWH initiative provides a forum for integrating design and vision to the many ongoing discussions of extreme heat and its current and future impact on the built environment in the metropolitan Boston area.

ABOVE (LEFT) Dynamic Planning Diagram
Image credit: Perkins and Will

ABOVE (RIGHT) Stakeholder Ambar Johnson shares some ideas and feedback with the Somerville design team during the LWH charrette.

WORLD WIDE HEAT

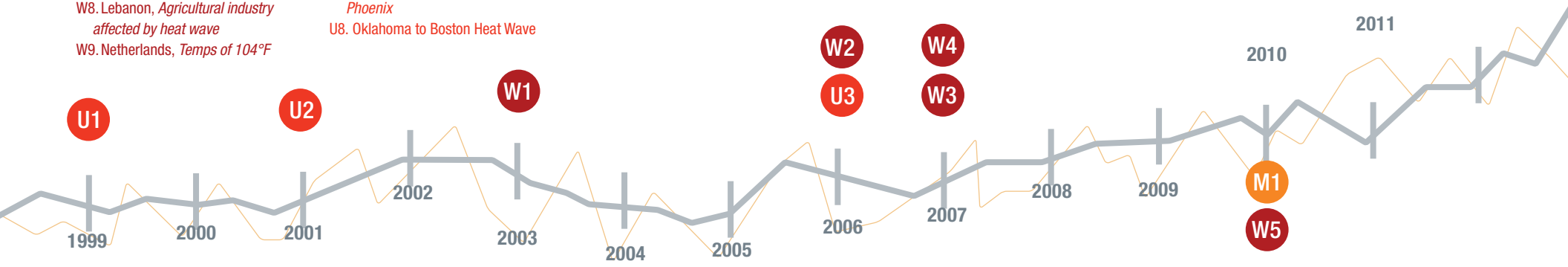
W1. European Heat Wave, *June–August*
W2. European Heat Wave, *July*
W3. Hungary & South Europe, *Record breaking temperatures*
W4. Asian Heat Wave, India, *Recorded temps of 114°F*
W5. Russia, *Estimated 55,000 deaths*
W6. Australia Heat Wave
W7. Pakistan, *Temps reached 111°F, At least 65 deaths*
W8. Lebanon, *Agricultural industry affected by heat wave*
W9. Netherlands, *Temps of 104°F*

UNITED STATES HEAT

U1. Chicago, *July, 600+ deaths*
U2. North American Heat Wave, *Record temps affected California*
U3. New Jersey, *Temps of 108°F*
U4. Maryland, Ohio, Virginia, & West Virginia, *Intense storms with high winds*
U5. Oregon, *Temps of 92°F*
U6. Carolina's, *Temps of 100°F± for consecutive days*
U7. Arizona, *Temps of 122°F in Phoenix*
U8. Oklahoma to Boston Heat Wave

METRO BOSTON HEAT

M1. July had several days over 90°
M2. Longest Heat Wave
M3. Warm Winter, *Warmest December of all time in Northeast*
M4. Driest Boston Summer, *3.92" for June–August*
M5. Events are canceled, *"A dangerous heat wave"*
M6. Deaths caused by heat, *Heat index of 105°F*
M7. Schools shut down
M8. Hottest July on Record
M9. Projected 40 days over 90°F
M10. Projected: Boston summers to be as hot as Washington, DC
M11. Projected 90 days over 90°F



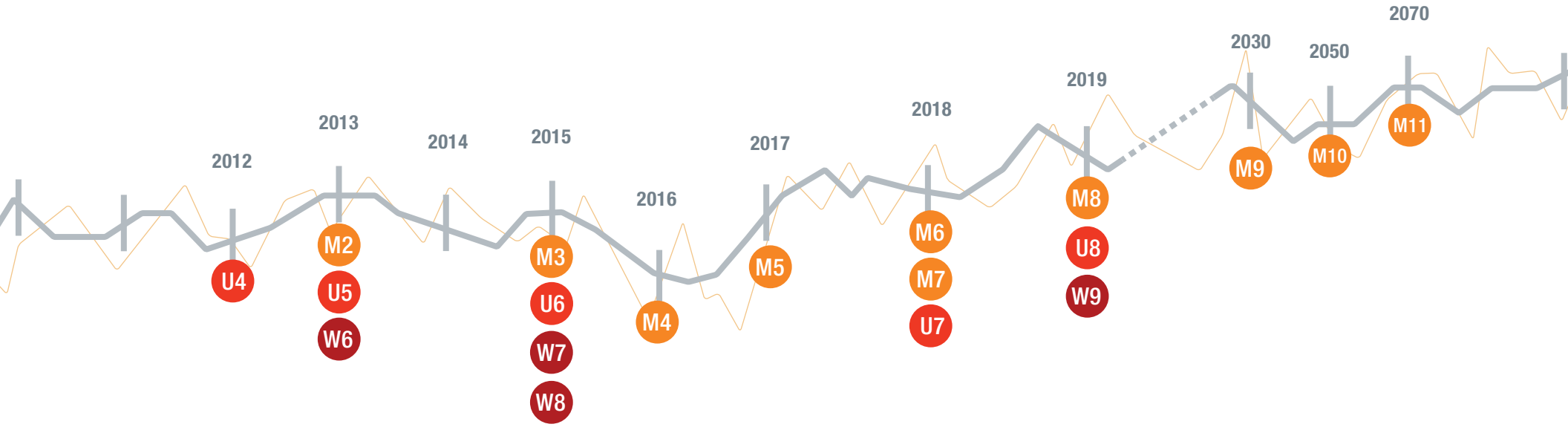
ABOVE Extreme Heat Examples 1999–2019
**For Additional Information, Refer to Appendix*
Image credit: Arrowstreet, Perkins and Will

Urban Implications

"Extreme heat is poised to rise steeply in frequency and severity over the coming decades, bringing unprecedented health risks for people and communities across the country [1]."

— Union of Concerned Scientists

In the five years following the 2014 publication of ULI Boston/New England's groundbreaking work, "The Urban Implications of Living with Water", the impacts of climate change, both nationally and within the Greater Boston market, have only become more pronounced.



According to the National Oceanic and Atmospheric Administration (NOAA), the average annual cost of climate disasters between 2014 to 2018 was $99 billion, more than double the average annual cost of $42 billion between 1980 and 2018 [2]. Locally, Massachusetts has experienced 10 federally-declared weather-related disasters since September of 2010, in the form of severe storms (including a pair of billion dollar Nor'easters in 2018), tornadoes, floods, tropical storms, and snow and ice storms [3].

But while storms and rising seas have garnered most of the media attention in terms of acknowledging the effects of climate change, there is another, more deadly threat—extreme heat. According to the Centers for Disease Control and Prevention (CDC), extreme heat now causes more deaths in U.S. cities than any other weather-related event [4]. In 2003, the summer heat wave that gripped Europe claimed the lives of an estimated 70,000 people [5]. In the U.S., the heat wave of 1995 was responsible for the deaths of over 700 [6], mostly low-income, elderly residents in Chicago. And heat-related deaths are typically underreported, because heat waves tend to be more widely dispersed and do not involve the devastation of property that come with tropical storms, tornadoes, and winter storms [7]. This lack of awareness has created an "invisible threat" to the built environment and public health, particularly for those in low-income communities.

EXTREME HEAT: A WORSENING PROBLEM

There is now a growing awareness and increasing sense of urgency around extreme heat, as nine of the 10 warmest years in history have occurred since 2005, with the last five years being the hottest on record [8]. July of 2019 was the hottest month in history, with the U.K., Germany, the Netherlands, and Belgium all registering all-time national temperature highs during the 2019 heat waves, and Paris also recording its hottest day ever [9]. In the U.S., heat waves (which FEMA defines as a period of 2–3 days or more of high heat and humidity with temperatures above 90°F) were widely reported across the nation in the summer of 2019.

Although there are some who dismiss the recent spike in extreme temperatures as merely cyclical, the graph above illustrates that there has been a steady uptick in global temperatures since 1980.

ABOVE (LEFT) Two members of the Lower Roxbury team review the site plan during the LWH charrette
Image credit: Steve Lipofsky

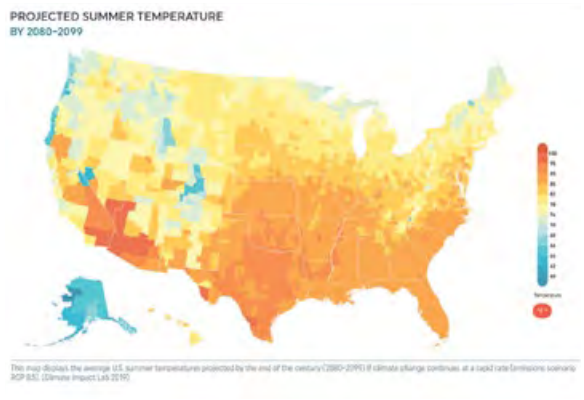
ABOVE (RIGHT) The East Boston team hard at work reviewing strategies and policy proposals during the LWH charrette
Image credit: Steve Lipofsky

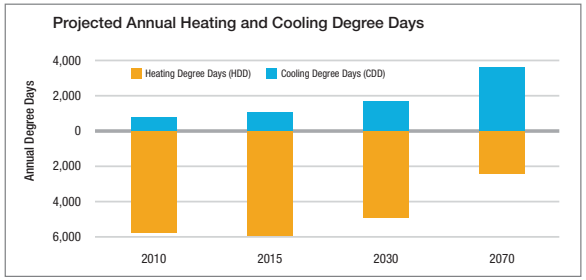
GREATER BOSTON

"Our cities have been constructed for the climate of the past, and aren't prepared for the climate that is already changing and will continue to change as we move in a warmer, wetter direction"

— John Bolduc, Environmental Planner
for the City of Cambridge, MA

New England has been increasingly subjected to severe weather events in recent years, including the four consecutive Nor'easters in March of 2018 that triggered historic flooding in Boston's Financial District. However, little attention has been paid to the potentially devastating effects of extreme heat in the region. Despite being thought of as a cold weather climate, Greater Boston is just as susceptible to the effects of extreme heat as other regions of the country. The population has also not assimilated behaviors to adapt to high temperatures, and is more vulnerable to the effects of extreme heat than regions where it is a more regular occurrence. Typically, Boston averages 10 days per year in excess of 90°F [10], but in 2018 that number rose to 23 [11], and 2019 saw 14 days in excess of 90°F. During the late summer heat wave of 2018, at least 20 school districts in Massachusetts issued early dismissals or class cancellations [12].





ABOVE (TOP) Projected Summer Temperature Map
Image credit: Climate Impact Lab 2019

ABOVE (BOTTOM) National Forecasted Heat Index
Image credit: NOAA/NWS

"The risk is higher when we see a more drastic change in temperature. Our body tends to be more susceptible and at a higher risk for disease when you have days jumping from 40°F to 80°F, (which happens more often in the Northeast than in other parts of the country)"

Dr. Francesca Dominici, Co-Director of Harvard's Data Science Initiative, WBUR interview, 5-7-2017 [13].

URBAN HEAT ISLANDS

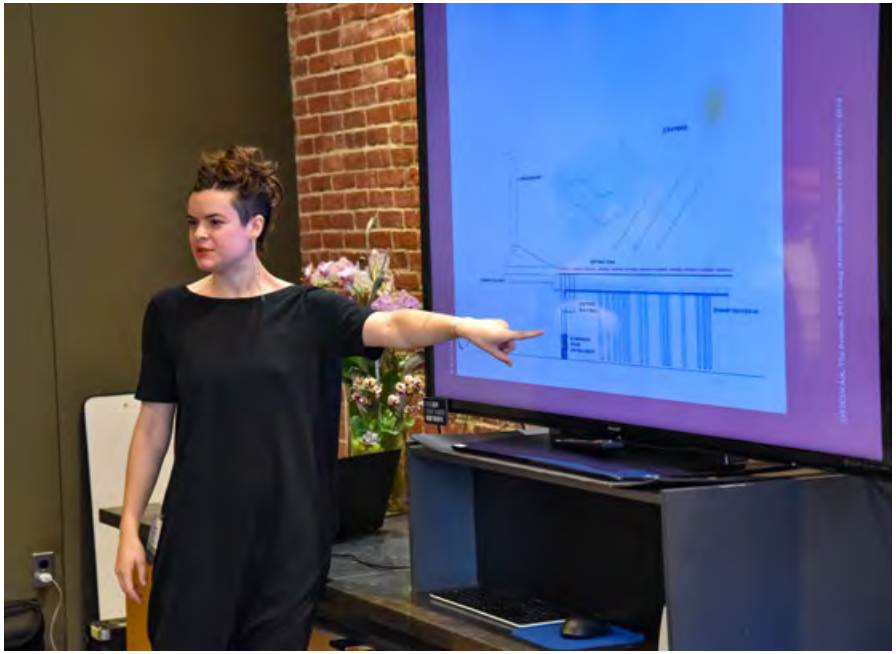
The problem of rising temperatures is further exacerbated in cities due to the urban heat island (UHI) effect. UHIs occur in developed areas with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. On hot days, roof and pavement surface temperatures in metropolitan areas can be 50–90°F (27–50°C) hotter than the air, while those of nearby shaded or moist surfaces remain close to air temperatures. According to the Environmental Protection Agency (EPA), the annual mean air temperature of a city (or metropolitan area such as Greater Boston) with one million or more people can be 1.8–5.4°F (1–3°C) warmer than surrounding rural zones. In the evening, the difference can be as high as 22°F (12°C) due to the slow release of heat from urban infrastructure. Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, water pollution, and heat-related illness and mortality [14].

HISTORIC BUILDING DESIGN INADEQUATE

Cities in New England have largely been built for the climate of the past and are not designed for future conditions—when extreme heat will become much more common. Historically, buildings in predominantly cold climates have been built using materials with a high thermal mass—like brick and concrete—which are specifically designed to retain heat.

In the past, those buildings were able to absorb and store heat during the day, and cool off at night—the desired effect during cold New England winters. But with the increased temperatures brought on by climate change, those buildings can no longer effectively shed the excess heat. Instead, it stays stored in the building, creating what Dr. Joseph Allen, the director of the Healthy Buildings Program at Harvard's T.H. Chan School of Public Health, refers to as "indoor heat waves", which present a myriad of public health challenges [15].

In 2016, the City of Boston launched an ongoing initiative, Climate Ready Boston, which is designed to help Boston plan for the impacts of climate change and to build a resilient future. The accompanying report, "Climate Ready Boston" states that while the average summer temperature in Boston from 1981 to 2010 was 69°F, summers are projected to be as high as 76°F by 2050 and 84°F by 2100. Compared to the period from 1971 to 2000, when there were 11 days per year over 90°F, the authors of the report predict there may be as many as 40 by 2030, and 90 by 2070. That means that by 2050, Boston's summers may be as hot as those of Washington, DC, and by the end of the century, may be hotter than those currently experienced in Birmingham, AL [16].



ABOVE (LEFT) The Chelsea/Everett team sketching proposals during the LWH charrette
Image credit: Steve Lipofsky

ABOVE (RIGHT) Larissa Belcic introduces the innovative microclimate design work of OFICINNA to kick off the LWH charrette
Image credit: Steve Lipofsky

THE HEAT INDEX

In addition to the true thermodynamic or "dry-bulb" temperature, there is the heat index (HI) to consider. The heat index takes into account both the temperature and the relative humidity level. When the relative humidity level is high, the temperature feels warmer to the human body, and the high humidity makes it more difficult for the body to cool itself down by sweating, because perspiration does not evaporate easily in moist air. According to the Union of Concerned Scientists, there have been seven days per year on average with a heat index above 90°F for the state of Massachusetts. By midcentury, this number would increase statewide to 33 days per year on average, and by the end of the century, an estimated 5.8 million people would be exposed to a heat index above 90°F for the equivalent of two months or more per year [17].

EFFECTS OF EXTREME HEAT ON HEALTH

The rise in temperature in metropolitan areas is leading to an increase in health-related problems, particularly for children, the elderly, and economically disadvantaged groups. During extremely hot and humid weather, the ability of the body to cool itself is greatly diminished. So when the body heats too rapidly to cool itself properly, or when too much fluid or salt is lost through dehydration or sweating, the body temperature rises, which can lead to fatigue, muscle cramps, heat exhaustion, fainting, and heat stroke (National Weather Service) [18]. Even small temperature increases above seasonal normal levels can result in illnesses and deaths. A series of consecutive days with warmer-than-average temperatures

often results in more hospital admissions for respiratory, cardiovascular, and kidney-related diseases, according to the CDC) [19].

On average, more than 65,000 people in the United States visit emergency rooms each summer for acute heat illness, according to the CDC and more than 600 die from heat-related causes each year [20]. However, there is widespread agreement that the number of heat-related deaths in the country is underestimated due to underreporting. Many deaths are not directly attributed to heatstroke, but drastic increases in temperatures can turn preexisting conditions such as heart problems or lung disease fatal. By 2050, there could be 3,000 to 5,000 annual heat-related deaths in the United States if the current level of greenhouse gas (GHG) emissions continues, according to the 2018 National Climate Assessment. In the Northeast, we can expect approximately 650 deaths per year by 2050 [21].

Disparate impacts – Like many other environmental health issues, the impacts of extreme heat are felt disproportionately across society. Unequally vulnerable communities include those who are challenged by poverty or homelessness, the elderly, young, socially isolated, and those who have preexisting medical conditions. African-American, Latino, and Asian communities are also considered higher risk groups, as are outdoor workers, including the construction industry [22].

Low-income communities in the United States are also often underserved by green spaces that can mitigate urban heat and by civic amenities such as cooling facilities, because of discriminatory land use policies, lack of investment in historically marginalized communities, and associated crime safety concerns by residents of the community. Low-income communities are also less likely to have access to air conditioning and cooler recreational facilities such as swimming pools or gyms [23]. It is important to note that the residential portions of three of the UHIs selected for this study, East Boston, Lower Roxbury, and Chelsea-Everett are predominately low-income neighborhoods, with significant African-American, Latino, and Asian populations.

EFFECTS OF EXTREME HEAT ON COGNITION

While much of the research regarding health issues triggered by extreme heat and heat waves focuses on the most vulnerable populations and/or catastrophic outcomes, there is also a significant impact on healthy adults and children in the form of impaired cognitive functioning, according to recent studies.

One study evaluated the differential impact on cognitive function during a 2016 heat wave using Greater Boston college students. Half of the residents were housed in buildings with air conditioning (AC), while the other half were not. The study found that students without AC had statistically significant (over 10 percent) longer reaction times on arithmetic and color-word tests, and had 10 percent more incorrect answers than students living in buildings with AC [24]. Another study, conducted by the National Bureau of Economic Research, analyzed 10 million students taking their PSATs over a 14 year span. Researchers found that in facilities without AC, in the years with a higher number of hotter school days prior to the test, the student's ability to learn was significantly reduced, with extreme heat being particularly damaging to low income and minority students [25].

> "We are all susceptible to the effects of heat stress and heat waves, even the young and healthy, and there are impacts beyond mortality, such as impaired cognitive functioning experienced as a result of indoor heat waves. This has implications for students as well as the business community."
>
> Dr. Joseph Allen, director of the Healthy Buildings Program at the Harvard T.H. Chan School of Public Health.

REGIONAL DEVELOPMENT TRENDS

The metropolitan Boston area has been undergoing an unprecedented level of commercial and residential development in recent years. In Boston alone, there were 109 real-estate development projects under construction at the close of 2018, totaling 28 million square feet and costing a combined $12.2 billion, according to the Boston Planning and Development Agency. And while there is substantial redevelopment taking place throughout Greater Boston, activity is more pronounced in Boston, Cambridge, and the inner suburbs connected to the cities by public transit. The four UHIs selected for this study are all currently undergoing or anticipating significant redevelopment.

Impacts on Productivity and Health in the Construction Industry – The construction sector will continue to be severely impacted by extreme heat, according to a new report from the International Labour Organization (ILO). The industry accounted for just six percent of global working hours lost to heat stress in 1995, but that number is expected to more than triple to 19 percent by 2030 [26]. In the Boston/New England markets, the rise in average temperatures may actually produce a net increase in productivity, enabling more construction activities to take place during winter months. However, the negative effects on the health of construction workers due to extreme heat is an increasing problem.

"A day of lost productivity on a $200 million construction project might cost an owner up to $250,000 in labor, leased equipment, and contractual penalties. With a 10 percent profit margin yielding just $20 million, that single day of lost productivity could significantly impact profit and loss."

Jeff Burns, partner at Construction Risk Partners, from NOAA report, 9/27/17 [27].

A study published in the International Journal of Environmental Research and Public Health found that the construction industry accounted for 36.8 percent of all occupational heat-related deaths in the U.S.[28]. In 2015, the American Journal of Industrial Medicine published a study that found that between 2000–2010, construction workers were 13 times more likely to die from heat-related deaths compared to workers in other industries [29]. The risk of heat-related illnesses is compounded by the fact that little to no regulations are present and/or enforced to protect these workers [28].

In addition, The Bureau of Labor Statistics reports that incidents of nonfatal, heat-related illnesses that required a construction or extraction worker to take time off to recover are on the rise since 2015. In 2017, there were 700 incidents reported in the U.S., up from 640 the year before and 280 in 2015 [30]. In response, Occupational Safety and Health Administration (OSHA) has issued helpful guidelines for those working outside in extreme heat.

"Heat stress affects physiological and physical performance, which can lead to injuries and even fatalities. Extreme climate conditions are definitely impacting the way we think and plan for worker safety and wellbeing."

Cindy DePrater, Senior Vice President and Chief Environmental Health & Safety Officer, Turner Construction Company.

BUSINESS CONTINUITY

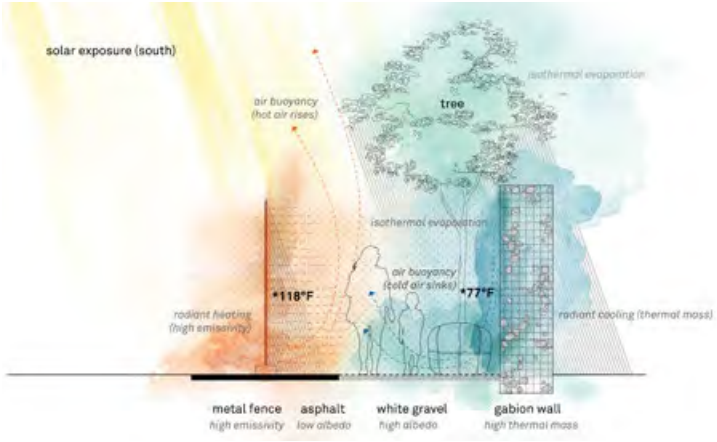
Extreme heat can contribute to other adverse events such as electrical grid failures, transportation interruptions, wildfires, and water shortages, all of which can cause human harm, business disruptions, and economic losses. Buildings and developments designed to be more prepared for these events have the potential to be more attractive to tenants, particularly in Class A office space, and may also eventually be eligible for preferable insurance rates. These types of weather-related continuity events also present risks because of potential property losses, tenant defaults, or both [23].

MITIGATING RISKS

"Sustainable development supports, and often enables, the fundamental societal and systems transitions and transformations that help limit global warming to 1.5°C. Such changes facilitate the pursuit of climate-resilient development pathways that achieve ambitious mitigation and adaptation in conjunction with poverty eradication and efforts to reduce inequalities (high confidence)"

— "Special Report on Global Warming of 1.5°C", 2018, Intergovernmental Panel on Climate Change (IPCC) [31].

As temperatures increase and heat waves become more prevalent and longer in duration in Greater Boston, land use professionals, in conjunction with city, state, and regional agencies, can play a major role in mitigating these effects. But as is often the case with proactive measures—as was seen following the publication of "Living With Water"—one of the first questions typically asked is, "What is this going to cost?" Investments in resilience have clear financial benefits, in addition to the human and social gains described elsewhere in this report. However, it's not always easy to put a price on the benefits, and not every potential investment will make perceptible business sense. Civic leaders, commercial real estate investors, and homeowners need to think about the avoided costs of heat-related incidents, about the likelihood of those incidents happening with or without an investment in heat mitigation, and finally, about the costs of the up-front work as compared to the benefits.



For example, a city with public schools and public housing will end up spending less money if it can mitigate heat impacts than would be spent on ambulances, hospital stays, and sick days if heat impacts are not addressed. Similarly, the lower cost, mostly non-mechanical, interventions in this report can make economic sense for commercial landlords worried about losing rent or being exposed to liability. When the business case is supportable, the money is there for investments in greater resilience measures.

LIVING WITH HEAT SOLUTIONS

Many of the municipalities in the Boston metropolitan region have already begun initiatives to prepare for climate change. While much of the programming does not specifically address the effects of UHIs or the increase in extreme temperatures, many of the programs being instituted—such as increasing open space and vegetation, encouraging white/green roofs, etc.—serve to mitigate the effects of UHIs.

In addition to Climate Ready Boston, the City of Boston adopted Article 37 Green Building and Resiliency Policy Guidelines in 2017, which requires all projects to consider present and future climate conditions in assessing project environmental impacts, including carbon emissions, extreme precipitation, extreme heat, and sea level rise [32]. In 2015, the City of Cambridge conducted a rigorous Climate Change Vulnerability Assessment (CCVA) focusing on the risks from increasing temperatures, precipitation, and sea level [33]. The assessment sought to identify Cambridge's key physical and social vulnerabilities, and the City will release its Climate Change Preparedness & Resilience (CCPR) Plan at the end of 2019. In 2017, the City of Somerville also conducted a CCVA, and in 2018, released Somerville Climate Forward, a comprehensive climate change plan that details a set of implementable actions designed to reduce Somerville's contribution to climate change and prepare the City for its unavoidable impacts [34, 35].

There are a number of solutions to mitigate the effects of UHIs, including increasing tree and vegetation cover, the use of green/cool roofs, minimizing the use of asphalt and increasing the amount of pervious surfaces, etc [14]. But it is important to note that there is no 'one size fits all' approach to managing extreme heat. The solutions offered in this report are geared toward the specific UHIs, using a "parfait" of mitigation strategies, but it is hoped that other metropolitan areas will find these strategies helpful in mitigating the effects of extreme heat in their communities.

"Climate mitigation strategy does not really work like a menu, where you pick and choose what strategies you want to use. So the question becomes, 'How do we actually apply thermally sensitive thinking – this climatic parfait – to different scales, sites and contexts?'"

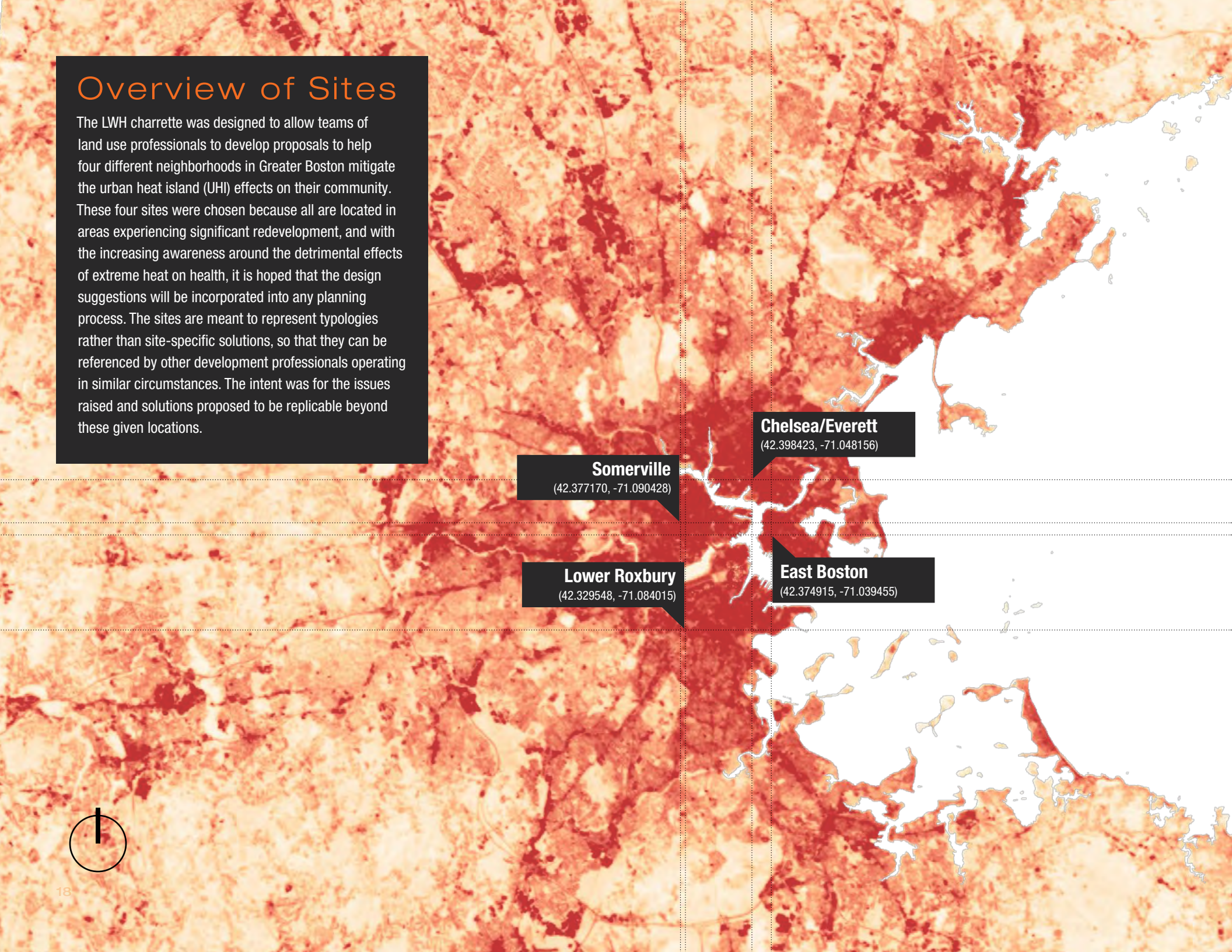
— Larissa Belcic, project manager, OFICINAA

ABOVE Diagram of the "Climatic Parfait"
Image credit: OFICINAA

OPPOSITE PAGE Section of the bioclimatic chamber that utilizes the Climatic Parfait.
Image credit: OFICINAA

Overview of Sites

The LWH charrette was designed to allow teams of land use professionals to develop proposals to help four different neighborhoods in Greater Boston mitigate the urban heat island (UHI) effects on their community. These four sites were chosen because all are located in areas experiencing significant redevelopment, and with the increasing awareness around the detrimental effects of extreme heat on health, it is hoped that the design suggestions will be incorporated into any planning process. The sites are meant to represent typologies rather than site-specific solutions, so that they can be referenced by other development professionals operating in similar circumstances. The intent was for the issues raised and solutions proposed to be replicable beyond these given locations.



LEFT New England Land Surface Temperature Map
Image credit: Boston Area Research Initiative (BARI)

EAST BOSTON

The East Boston focus area includes residential, convenience retail, community amenities, and the neighborhood's only large grocery-anchored shopping center Liberty Plaza in Central Square. The plaza is positioned in a way that blocks the natural cooling winds from the harbor. There is an overlap at this location of extreme heat vulnerability and coastal flooding. Commercial/industrial properties comprise over a third of the site, and over a quarter of the area is residential use. The neighborhood is currently under review as part of the BPDA planning process and residents are engaged in the future of their neighborhood.

LOWER ROXBURY

Much of the Lower Roxbury site is an urban heat island, a mix of commercial, residential, and educational buildings, with a high percentage of impervious surfaces, primarily asphalt. There is a significant amount of development currently underway in the area as well as future projects being planned. Roxbury is well-served by public transportation, is in close proximity to the area's world class medical institutions, and is increasingly attractive to investors. It is also a historically black, low to moderate income community with the highest concentration of affordable housing in the City of Boston presenting a greater risk for heat related illness and mortality.

SOMERVILLE

The Somerville site is characterized by a large commercial parking lot and retail buildings, as well as some smaller businesses along major streets. In addition, a residential neighborhood constitutes nearly a third of the area, so rising temperatures will present significant public health risks if residents are not able to access opportunities for cooling. Rising temperatures will be magnified in our focus area due to a lack of tree canopy and open space, as well as the high percentage of impervious surfaces. There are two significant developments underway that impact the study area, the Green Line Extension (GLX), which will support the development currently underway in Union Square as well as open up additional development opportunities, and the redevelopment of Union Square, a master-planned, 15 acre site that will deliver 2.4 million square feet of office/lab space along with housing, green space, and retail.

CHELSEA/EVERETT

The Second Street corridor, connecting the communities of Chelsea and Everett, features a number of dynamic commercial retail uses, anchored by an active shopping center, a future hotel and significant industrial users with regional impact. The cumulative impact of these users is significant impervious cover and the production of significant waste heat from idling trucks and HVAC equipment. Situated in close proximity to Logan International Airport, the site is a critical corridor for utility and transit infrastructure, with the potential future expansion of the MBTA Silver Line route and a proposed new MBTA commuter rail stop, which will significantly affect future traffic patterns for all modes of transit.

EAST BOSTON

The boundaries of the East Boston study area were drawn to intentionally capture mixed-use typologies indicative of the entire neighborhood. The study area includes residential, convenience retail, community amenities, and a recently renovated park as well as the neighborhood's only large grocery-anchored shopping center, Liberty Plaza in Central Square. The plaza is a typical big box retail center, with a large asphalt parking lot devoid of trees or grass cover, which borders the neighborhood on one side. The rear of the plaza faces Boston Harbor, and while the site has impressive views of the water, it experiences frequent coastal flooding. Heat mapping confirms the severity of the heat island effect in this area, which is exacerbated by the lack of access to cooling ocean breezes in some sections. Building types constructed with the same materials in other areas of the neighborhood are less hot, due to better access to breezes and the massing of waterfront buildings and typography. Other contributing factors to the UHI effect include additional large areas of asphalt, limited tree canopy and green space, dark roof materials, and congested vehicular traffic.

There are some amenities provided by the City during extreme heat events, but additional programing is needed to provide adequate relief for residents during those times.

RIGHT East Boston Context and Site Plan
Image credit: Arrowstreet


Charlestown
Boston Logan International Airport
Mario Umana Academy
Proposed Ferry Routes
Liberty Plaza
East Boston Greenway
Airport Station
Route 1A
EBNHC
I-90
Boston Harbor
Maverick Station
500 ft


Site Boundary
Harbor Swim
Liberty Plaza
White Roofs
Charlestown Ferry
Long Wharf Ferry

EAST BOSTON DEMOGRAPHICS

East Boston has a population of 46,665 and grew by 17 percent from 2000–2015. The data indicates that East Boston is 58 percent Hispanic, 34 percent white, four percent Asian, and two percent Black/African-American. Over half of East Boston's population is foreign-born—the highest percentage of all Boston's neighborhoods—with over half of the foreign-born population from either Colombia or El Salvador.

The median home value in East Boston is $480,200. Just 29 percent of the housing stock is owner-occupied, so the neighborhood has a very high percentage of renters. The average rent in East Boston is $2,584, up from $2,163 in the same time period in 2014. The median household income for East Boston was $52,154 in 2017 with a poverty rate of 20 percent.

SHORT TERM SOLUTIONS

It is vitally important to integrate any heat island mitigation strategies into the existing fabric of the neighborhood infrastructure. Also, when devising cooling solutions such as adding additional air conditioning units for residents, factors such as energy use and waste heat from the units that contribute to the heat island effect should be considered.

Promote the Use of Cool Roofs – While newer commercial buildings have been installing white roofs in accordance with the City of Boston's Article 37 requirements, most individual residences and older commercial structures have dark roof materials. Encouraging property owners to select a white or light roof material when it needs replacing will diminish the heat island effect for the property and the surrounding area. For roofs that don't require replacement, paints can be applied that would achieve the same results. Boston should consider adopting a measure similar to the City of Philadelphia's Cool-Roof Law, which requires all new construction to use highly reflective roofing materials that meet or exceed Energy Star cool roof standards, and also provides capital for energy efficiency improvements to both homeowners and businesses [36].

Create Residential Home Cooling Programs – Many residents do not have air conditioning. Taking advantage of programs such as the HomeWorks program [37], offered by the City of Boston, or MassSave [38] , for interest free home improvement loans, would allow residents to add air conditioning in a cost-effective manner. Increasing awareness of how this will positively impact residents is the first step to ensure people will pursue the most energy efficient route when improving systems in their home or business.

Education, Outreach and Access to Cooling Centers – Neighborhood community centers currently serve as cooling centers during times of extreme heat. However, it is often difficult for residents to determine the appropriate temperature threshold during heat events at which they need to make the move from their home to the cooling center. Outreach programs should be designed to encourage at-risk residents, particularly seniors, to utilize these centers year-round so it is a welcoming place for them in an extreme heat event. Additional cooling centers should also be identified so that all residents without cars can have easy access to a center. Transit should also be provided for elderly or others who need assistance getting to these centers.

Install Cool Bus Stops – Bus stops should be redesigned to provide relief from the heat, incorporating shade cover, cooling misters and water bottle filling stations.

Engage MBTA – To ensure that public transit plays a role in decreasing the heat island effect, the MBTA is a required partner. Trains often experience delays due to extreme heat as they were not designed for the increased temperatures now being recorded in Boston, so the MBTA needs to consider the effects of increased temperatures when upgrading infrastructure for trains and buses. Improvement in public transit for Metro Boston is also imperative for the success of long-term strategies.

LEFT Aerial image of proposed design solution for East Boston
Image credit: Arrowstreet

LAND USE

The East Boston site is predominately made up of commercial and residential uses with some additional land for Mixed Use, Industrial, and Federal, State, or Municipal uses. The waterfront is currently occupied by big-box retail including the neighborhood's only grocery store. The residential neighborhood is positioned to the northeast with little to no access to the harbor.

IMPERVIOUS GROUND COVERAGE

One major contributor to urban heat island is the dark, impervious ground cover that retains and slowly releases heat, offering little opportunity for cooling.

In East Boston, a majority of the neighborhood can be classified as impervious. Typical residential buildings have no front or side yards. Many homes have a small yard with limited pervious surface.

TREE CANOPY AND SHADING

East Boston has the lowest tree canopy of any neighborhood in the City of Boston. The Neighborhood of Affordable Housing currently has a tree planting program for new trees on public property.

While there is some existing tree coverage on the East Boston site, some of the trees are located on private property, in the rear yard of residences, or are generally in-accessible.

Moreover, trees located in the public right-of-way appear to be younger trees that currently offer limited canopy compared to old-growth canopies.

ABOVE Site Diagrams
Image credit: Arrowstreet
Data source: Trust for Public Land, Climate Smart Cities

Collaboration with Massport – East Boston and Massport have long been deeply entwined. While the airport and its runways are major contributors to the UHI in the area, the greenspace and parks Massport owns and operates in East Boston help mitigate those effects. Piers Park II is currently under construction and includes design measures which anticipate consequences of climate change, both coastal flooding and extreme heat. East Boston and Massport should continue to work together on future development and greenspace projects to ensure actions are taken to reduce UHI effect. Additional greenspace in the neighborhood could offset the impact of the airport, by having a cooling effect and improving air quality.

LONG TERM SOLUTIONS

Zoning Changes to Transform Liberty Plaza – Identify areas of the neighborhood that would benefit from a zoning change to incentivize redevelopment that mitigates the heat island effect. A zoning trade-off could be offered to the property owner of Liberty Plaza to encourage redevelopment. For instance, in exchange for additional building height and a mixed-use zoning designation, residential and office programs would be mandated on upper floors. The grocery store and other retail could remain in place for residents but the building configurations would be reimagined as towers around increased open space, and allow access to the water for the neighborhood.

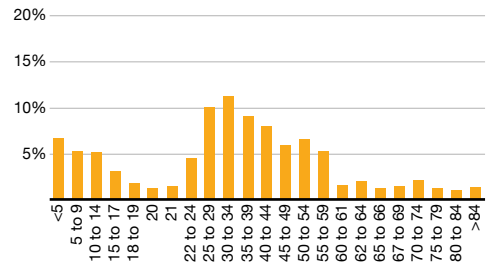
Leverage Harbor as Natural Cooling Resource – The redesign of Liberty Plaza would also include keeping the existing corridors of the neighborhood clear of buildings that block ocean breezes from the harbor. Currently, the natural wind patterns are interrupted by Liberty Plaza. Opening these cooling corridors will allow natural breezes into the neighborhood.

Additional Benefits of Plaza Redesign – In addition to decreasing the heat island effect, the redevelopment of Liberty Plaza would also control the impact of coastal flooding, as the site regularly floods during storms or King Tides. Greenspace and pervious ground materials will also absorb more water, reducing the impact of flooding on buildings, streets, and residents surrounding the site. Careful redesign should be done to use these strategies to improve both of these challenges faced by the current site.

Create New Street Typologies – Changes to typologies will also require improvements in public transit, including additional routes and frequency. Mindful urban design and planning initiatives will ensure successful implementation, including limiting the distance residents have to walk to access public transit or car sharing programs, improving the safety for pedestrians, and ensuring emergency and maintenance vehicles and snow plows have direct access to all properties. These improvements in transit will allow the city to limit personal car usage.

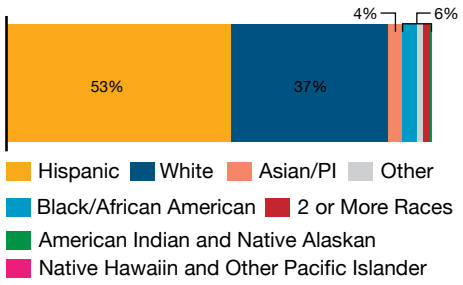
COMMUNITY-WIDE STATISTICS

Age



U.S. Census Bureau,
2013-2017 American Community Survey 5-Year Estimates
Data are for Census Block Group Approximations
of the East Boston Neighborhood

Race and Ethnicity



U.S. Census Bureau, 2010 Census
Data are for Census Block Group Approximations
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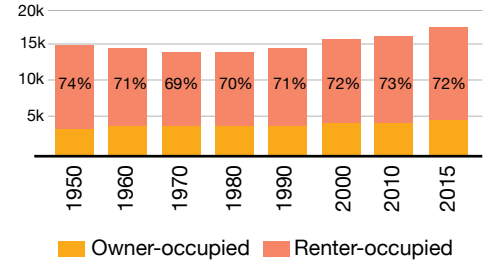
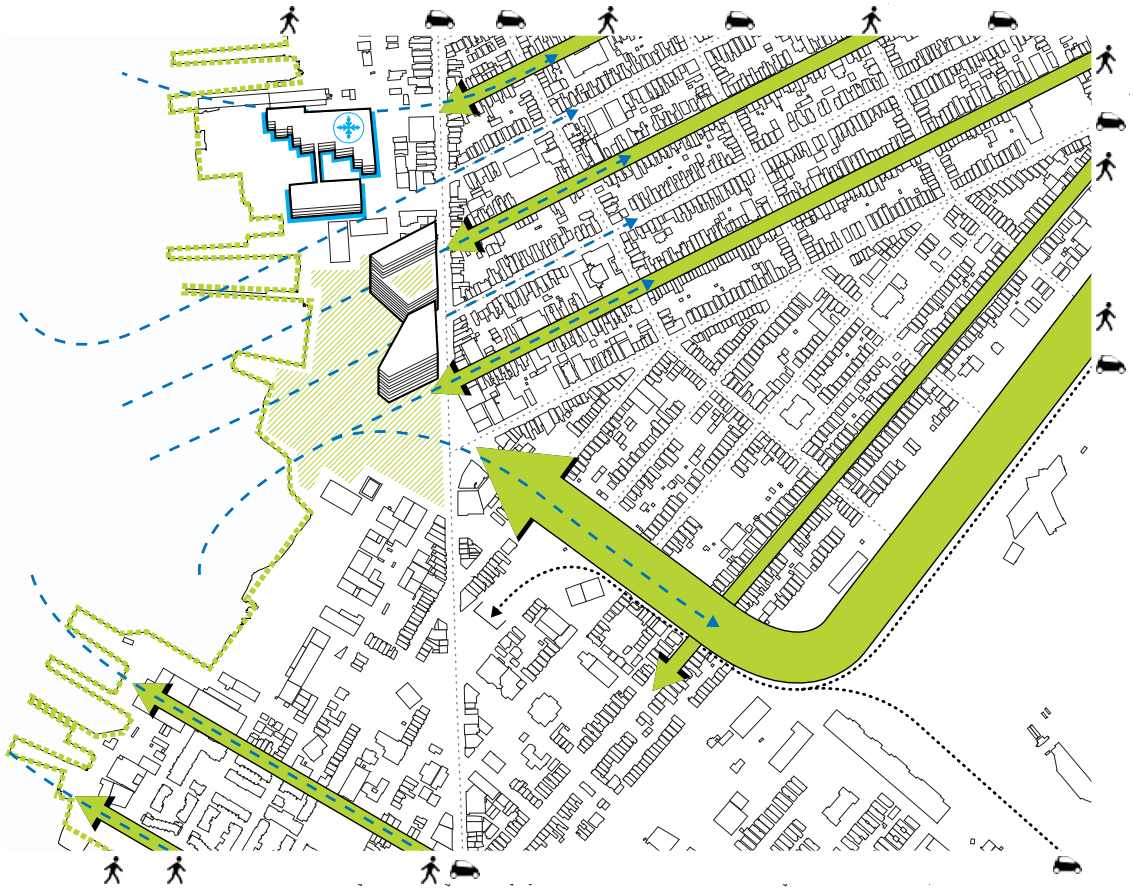
Housing Tenure



Boston Planning & Development Agency - Neighborhood
Profiles, August 2017



LEFT Concept diagram for the East Boston design proposal. Alternating green/pedestrian and vehicular corridors connect to the porous waterfront, opening opportunities for development and community resources. Green corridors double as cooling corridors, drawing cool air from the harbor through the neighborhood.
Image Credit: Arrowstreet

BELOW Street view of existing conditions on Saratoga Street in East Boston
Image Credit: Google Maps

1) Identify main routes for bus and other vehicle transportation so that the entire neighborhood has better access to multiple transportation modes. Imposing limits on personal vehicle use will mean that fewer streets are required to handle traffic loads. Sidewalks can be widened to include tree canopy and misters for hot days.

2) Eliminate parking lanes on one or both sides of many streets so that green space and tree canopy can be increased.

3) Create pedestrian and bike only streets. Select streets will have asphalt removed and concrete sidewalks redesigned through a network of low maintenance green space and trees. Handicap accessibility will be maintained but surrounded by greenspace, reducing hot temperatures and making the pedestrian experience more manageable to a public transit route nearby.

ABOVE Street view of proposed green/cooling corridor on Saratoga Street in East Boston that connects the neighborhood to the waterfront
Image Credit: Halvorson Design Partnership

Ground Materials – Encourage and eventually mandate pervious paving mixed with green space and tree canopy. Careful planning measures would ensure all residents have a safe and short route to transit, and emergency vehicles would still have access to all properties.

Promote Walkability – Improved public transit would help reduce the dependence on cars. Paired together, all these solutions would also make short walks more enjoyable with shade, greenspace, and misters to combat the effects of extreme temperatures.

LOWER ROXBURY

Lower Roxbury is a diverse, historically black community with the highest concentration of affordable housing in the City of Boston [39]. There are many longstanding active community groups and community development organizations that help to advocate for and provide much of that affordable housing. The focus area is comprised of a mix of commercial, residential, civic, and educational buildings.

The area has a high percentage of impervious surfaces, primarily asphalt, a modest tree canopy, and many dark rooftops. The area is also home to Dudley Station, the busiest bus terminal in New England, connecting 17 MBTA routes, which constantly cycles diesel engine buses through the center of the commercial area. All of this contributes to its status as an urban heat island.

A significant percentage of households live below the poverty level, so the population is more vulnerable to heat-related illness and mortality than the general population. In considering solutions, concerns about the safety and security of parks, high transit use, and limited mobility among the elderly population are important considerations for this area. At the same time, Lower Roxbury has several assets that can and do contribute to its resilience. It is a dynamic neighborhood with diverse land uses, diverse populations, areas poised for change, an extensive institutional and civic presence, and many engaged community organizations.

RIGHT Lower Roxbury Context and Site Plan.
Image credit: Arrowstreet


Brookline
Dorchester
Ruggles Station
Tremont St
Ruggles St
Whittier Street Health Center
Washington St
DeWitt Center
Melina Cass Blvd
Madison Park
Technical Vocation HS
Malcolm X Blvd
Roxbury Crossing
Station
Boston Public
Schools Admin
Dudley Station
Orchard Gardens
Housing
Boston Public Library
500 ft

There is a substantial amount of development currently underway in the area, including a 7.5 acre (P3) city-owned site. Future projects are also in the planning stages, and displacement through gentrification is a major concern for the neighborhood. However, the need for a mix of incomes in Lower Roxbury is seen as a key to spurring the economic revitalization of Dudley Square, which has been a priority for the City of Boston. Lower Roxbury is well-served by public transportation, is adjacent
to Northeastern—a top tier university—is in close proximity to world class medical institutions, and for the first time in many decades, has begun to attract high levels of capital. In this environment of change and opportunity, it is even more important that any new development consider how to support the existing community while mitigating the effects of extreme heat events.

To that end, there has also been significant community-focused investment in the area by local CDC's, including the Dewitt Community Center and the redevelopment of the Whittier Choice Neighborhood with over 700 units of affordable, moderate-income, and market-rate housing being developed in partnership and currently under construction. The BPDA has engaged local residents and organizations in a robust public process to update community goals and incorporate them into requests for proposals for publicly owned vacant land in Dudley Square. These eight parcels, related to the city's history of urban renewal, are meant to respond to the needs of the community. There are also multiple open space projects under construction in the neighborhood. "Plan: Dudley Square", a report which summarizes the community's recommendations, is written in support of Boston's climate goals, specifically stating that new developments should minimize heat island impacts through various measures [40]. As many development projects are in the planning stages, this is a prime opportunity to recommend and illustrate not only strategies but also a vision for combating extreme heat and mitigating the heat island effects in the near and long term.

LEFT Street view of proposed design solution for Dudley Station in Lower Roxbury.
Image credit: Arrowstreet

The team focused on the physical and programmatic designs that would support current residents of Lower Roxbury in living more comfortably and safely during increasingly hot summers.

ROXBURY DEMOGRAPHICS

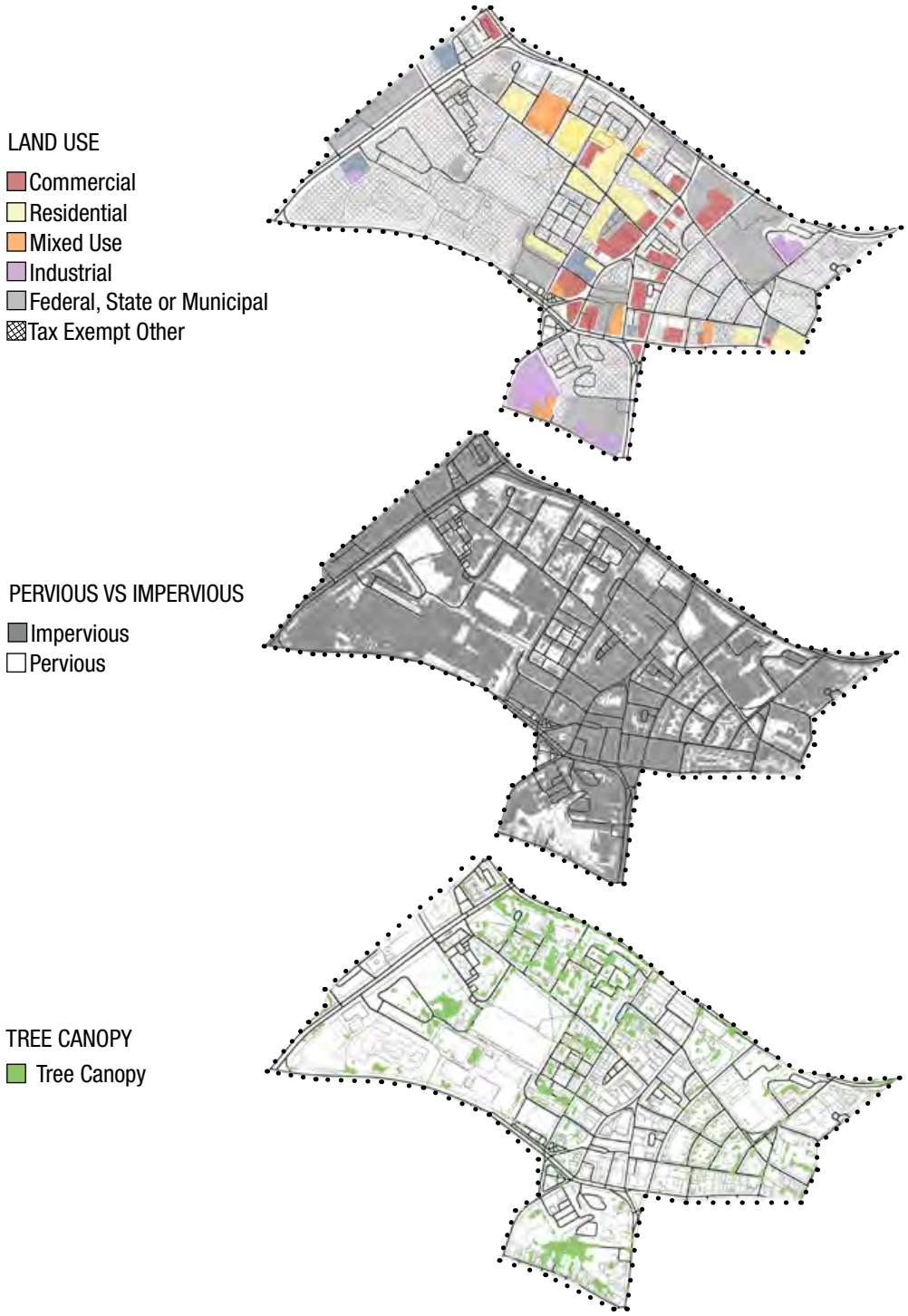
Roxbury has a population of 59,206 and grew by 20 percent between 2000 and 2015. The most recent US Census data indicates that the Roxbury is 51.5 percent Black/African-American, 30 percent Hispanic, 10.5 percent white, and four percent Asian. Thirty-five percent of Roxbury's population is foreign-born.

The median home value in Roxbury is $408,900. Just 20.5 percent of the housing stock is owner-occupied, so the neighborhood has a very high percentage of renters. The average rent in Roxbury is $2,842 up from $2,393 in the same time period in 2014. The median income for Roxbury is $27,721 with a poverty rate of 31 percent.

SHORT TERM SOLUTIONS

Stakeholder input revealed a few interesting challenges: 1) There remains a lack of awareness concerning the health effects of extreme heat for much of the population. 2) It can be challenging to get people out of hot home environments, particularly for those with mobility challenges. 3) Investments should improve life for current residents concerned about displacement. For these reasons, participants considered a low-investment, high-impact, near-term and adaptable solutions.

Summer Heat Pop-up Park (SHPP) – The concept for the SHPP was inspired by Boston Water & Sewer Commission's H2Go Water Trailers, which provide free water at area public events as part of the Commission's ongoing "We Are All Connected" campaign. This festive summer heat pop-up mobile trailer would serve two primary goals: 1) provide attractive cooling relief in close proximity to vulnerable populations, and 2) raise awareness of the health risks associated with rising heat and what individuals can do about it.



LAND USE

Nearly half of the Lower Roxbury project site is dedicated to Tax-Exempt land uses. This means that the land is dedicated open space, transportation, State or City facilities including schools, higher education, and the Boston Housing Authority. The remainder of the site is residential and commercial with few industrial uses. Tax-Exempt property is dedicated to providing a mix of services to residents, visitors, and workers in the neighborhood and its surroundings, making accessibility an important focus.

IMPERVIOUS GROUND COVERAGE

One major contributor to urban heat island is the dark, impervious ground cover that retains and slowly releases heat, offering little opportunity for cooling. The existing conditions in Lower Roxbury offer many opportunities to address this as a majority of the site is impervious ground coverage.

TREE CANOPY AND SHADING

Canopy coverage in Lower Roxbury is mainly concentrated in or at the boundary of residential areas. The main commercial and transit center of Dudley Square lacks any significant tree coverage and could prove an opportunity connecting the pockets of tree canopy.

LEFT Site Diagrams
Image credit: Arrowstreet
Data source: Trust for Public Land, Climate Smart Cities

The SHPP would provide immediate cooling in a festival atmosphere. It would also provide pop-up canopy cover, flexible water cooling features such as cold misters, and any variety of other give-away cooling features for the home or individuals. Where there are appropriately located indoor community spaces, the programmatic elements of the pop-up can be incorporated. For people already experiencing heat stress, public health resources such as Boston Emergency Medical Services could be made available on site.

To draw people in, the SHPPs need to be not-only well located, but also appealing. SHPPs would emanate a carnival or fair atmosphere, with creative pop up design solutions with a heat mitigation focus. It can also be viewed as a community building experience. A public safety "heat-crew" can be on the scene, connecting with the community and addressing any safety concerns that arise during heat waves. Once people are drawn to the site, and safely cool, there is a critical window for communication and education around rising heat, health resources, and resources for retrofits. Summer Heat Pop-Up success, coupled with EMS data about where heat related illness calls were made, can help guide the next deployment.

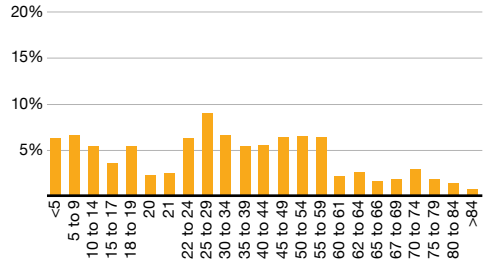
Build a Network of Indoor Cooling Places – Incorporate DeWitt Center, Northeastern, Whittier Street Health Center and the Reggie Lewis Center into a network of cooling centers for hot days, and devise strategies for transporting the elderly, children, and those with mobility issues to those centers.

Gather EMS Data – The City should reach out to Boston EMS to obtain data on the number of heat-related incidents that were responded to over the last few years. From there, drill down on the data to find out what types of heat-related incidents they responded to and determine what proactive measures could be implemented in the community to mitigate future incidents. This would also allow for assignment of a dollar figure to such incidents relative to taking proactive actions to determine the cost effectiveness of solutions.

Resiliency Checklist Alignment – The City of Boston should ensure its Article 80 Resiliency Checklist is thoroughly reviewed by developers pursuing new developments or redeveloping existing properties. It may also be helpful for the City of Boston to provide developers with heat mapping along with explanations of how the projects on the development parcels can be designed to mitigate the effects of extreme heat.

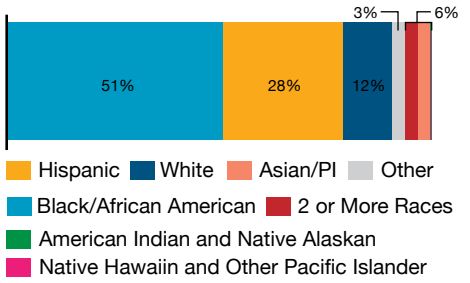
COMMUNITY-WIDE STATISTICS

Age



U.S. Census Bureau,
2013-2017 American Community Survey 5-Year Estimates
Data are for Census Block Group Approximations
of the Roxbury Neighborhood

Race and Ethnicity



U.S. Census Bureau, 2010 Census
Data are for Census Block Group Approximations
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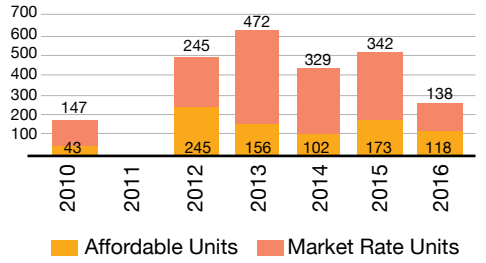
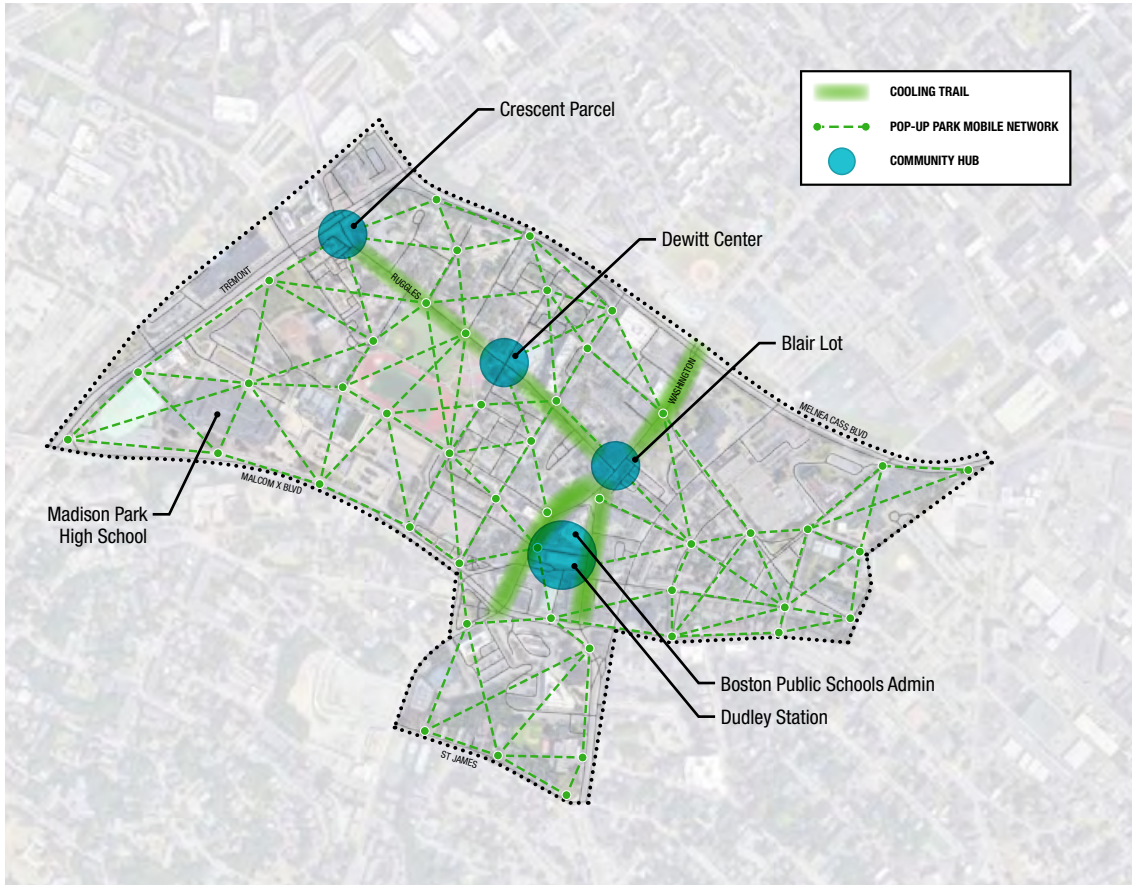
BPDA Approved Housing



Boston Planning & Development Agency - Neighborhood Profiles, August 2017



LEFT Concept diagram for the Lower Roxbury site showing the proposed network of cooling trails, pop-up parks and community hubs
Image credit: Arrowstreet

BELOW Street view of existing conditions on Ruggles Street in Lower Roxbury
Image Credit: Google Maps

LONG TERM SOLUTIONS

Apply the Palette of Resiliency Tools to Focus Area – There are a number of parcels in the development stage (with more being put out to bid) as well as existing infrastructure that offers opportunities to build up heat resilience. Immediate design considerations would be the implementation of cool roofs, designing vegetated terraces at different levels in new construction projects, urban gardens, and leveraging development to create effective streetscape cooling strategies.

Create a Cooling Corridor – The Lower Roxbury study area has two main nodes of public transportation that residents use to commute: Dudley Square (bus service) and Ruggles Station (MBTA Orange Line and Commuter Rail). Creating a heat-mitigating pedestrian connection would improve the connectivity of residents with the rest of Greater Boston. Ruggles Street is the ideal pathway for this cooling trail due to its pedestrian scale, proximity to homes, and connection to schools, transit, and commercial and public spaces. The Dudley-Ruggles cooling trail, with over a half-mile of green infrastructure, improved paving materials, seating, and interspersed water features, would invite residents to share the space and create additional opportunities for community-building spaces. The publicly owned parcels that will be disposed

ABOVE Street view of proposed cooling infrastructure on Ruggles Street in Lower Roxbury
Image Credit: Arrowstreet

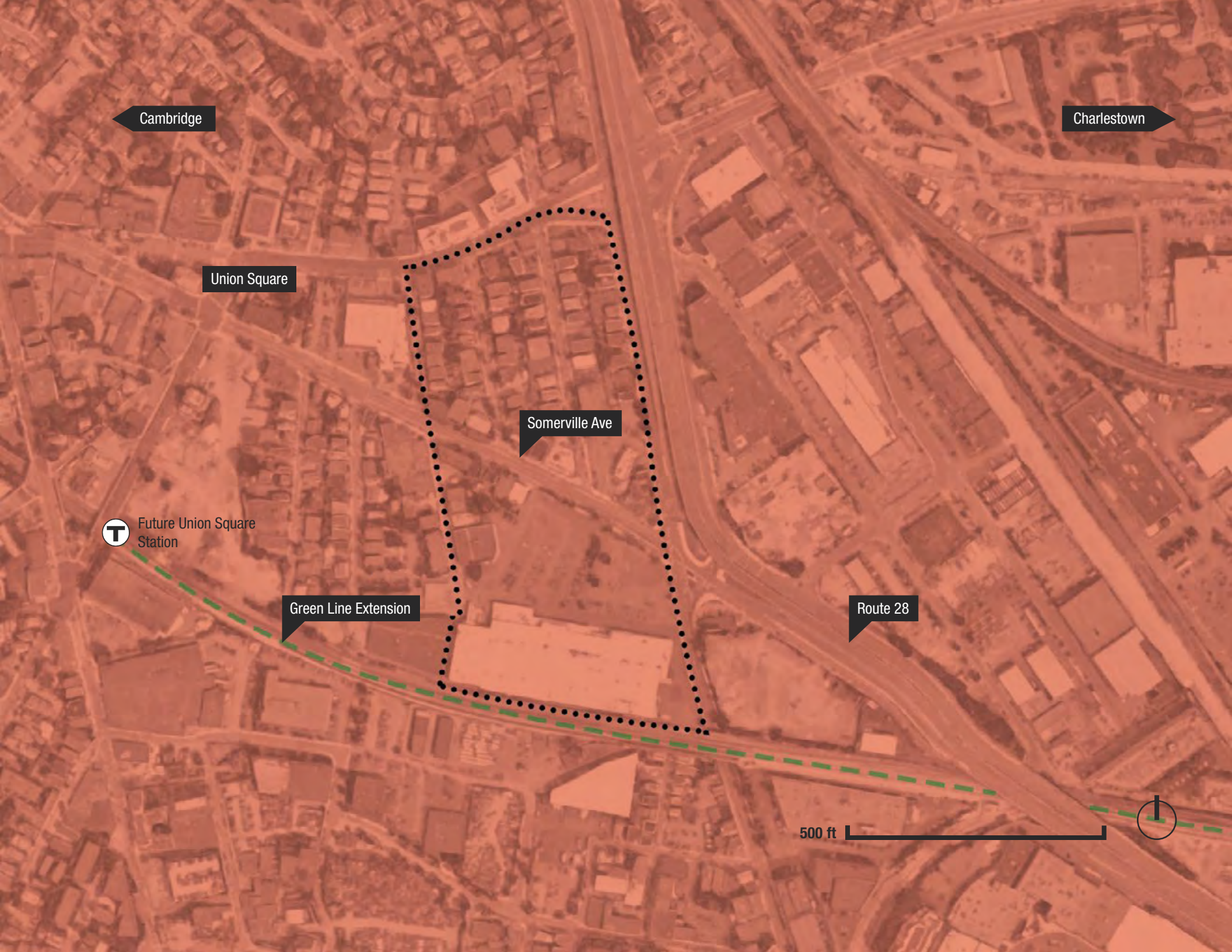
along the route, carry with them the expectation of delivering public benefit. As such, future developments on these sites could be compelled to incorporate dynamic cooling design solutions at a larger scale, creating engaging public spaces that highlight the cooling corridor while benefiting the overall development. With the anticipation of an increasingly hotter environment, there will be a tendency for individuals to seek refuge inside their homes, increasing isolation in vulnerable populations. For the Lower Roxbury area, the Dudley/Ruggles corridor is well positioned to become a cooling trail for people traveling from home to work to transportation hubs.

SOMERVILLE

The City of Somerville is currently experiencing a period of rapid growth, characterized by the need to balance economic and job growth while maintaining housing affordability and preserving the city's strong residential and mixed-use neighborhoods. The future Green Line Extension (GLX) will provide access to public transit service in historically underserved areas of Somerville, including the study area in question. Compared to nearby cities such as Boston and Cambridge, Somerville has a built environment that is particularly susceptible to urban heat island impacts. As average annual temperatures continue to rise and more frequent and longer periods of extreme heat occur, heat impacts are likely to be exacerbated, due primarily to the high percentage of impervious surfaces and lack of tree canopy and access to open space. With the increasing influx of development interests in the study area, largely as a result of GLX, there is a unique opportunity to think holistically about how to minimize the effects of extreme heat and reduce urban heat island impacts to the residential neighborhoods and commercial and mixed-use corridors throughout the study area.

Rising temperatures will present significant public health risks for residents of Somerville, as a result of increased urban heat island impacts and a lack of access to indoor and outdoor cooling. These risks demonstrate the need to adapt the urban form for a warmer climate in order to maintain a quality of life for residents that supports outdoor activity, including commuting and exercising. The major challenges for this site will include identifying opportunities to reduce urban heat island impacts on densely populated residential streets with very old infrastructure and belowground utilities, overhead power lines, and narrow sidewalk widths. Additional challenges include developing solutions to ensure indoor cooling for residents in triple-deckers, developing designs that foster social resilience, and looking for opportunities to reduce impervious surface and to integrate green infrastructure wherever possible.

RIGHT Somerville Context and Site Plan
Image credit: Arrowstreet


Cambridge
Charlestown
Union Square
Somerville Ave
Future Union Square Station
Green Line Extension
Route 28
500 ft

The overall study area is characterized by a large commercial parking lot and retail building, small businesses and mixed-use developments along major streets, and a large elevated highway that runs along the boundary of the study area. Most significantly, a residential neighborhood constitutes nearly a third of the area, and is comprised of a high concentration of triple-decker rental properties, many of which were built in the early 1900's, are poorly insulated and rely on window air conditioning units.

Ninety-seven percent of the study area is impervious surface and the largest commercial area is a retail plaza anchored by a Target department store and an auto parts store. Much of the asphalt parking lot is underutilized, representing a major heat trap for the neighborhood. Four of the fourteen commercial buildings currently have white roofs, and only one uses solar panels.

There are two significant developments underway that will have a substantial impact on the study area.

Green Line Extension (GLX) –The aforementioned project will significantly reduce vehicle trips and related air emissions while increasing access to public transit service in historically underserved areas. GLX is expected to support increased ridership of more than 50,000 passenger trips per day once completed in 2021.

Union Square Redevelopment – This redevelopment plan outlines a 20-year vision for the future development of Union Square, which seeks to bring jobs, 3.5 acres of open space, and affordable and market rate housing to the neighborhood while also increasing the commercial tax base. Phase one of the 15.3 acre buildout known as US2 is a 175,000-square-foot LEED Gold lab building which includes a blue roof for environmentally friendly water retention. It is expected to be completed in 2021.

LEFT Perspective view of proposed design solution in Somerville
Image credit: Perkins and Will

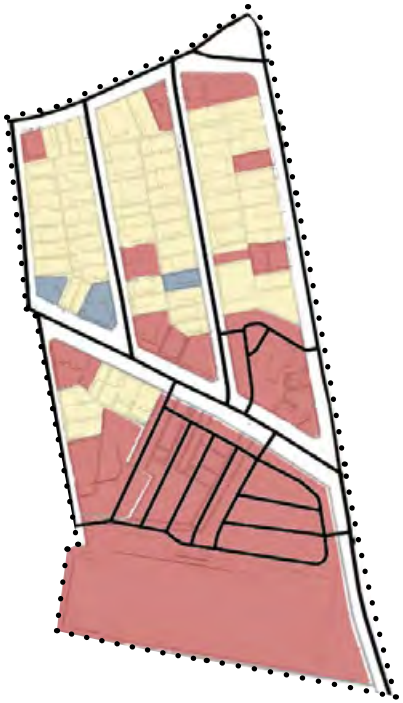
DEMOGRAPHICS

Somerville, the most densely populated city in Massachusetts (18,000+ per square mile), was once a working class industrial city. The population of 81,000 has grown by approximately eight percent since 2010, and the most recent census data indicates that the city is 70.6 percent white. Asian and Hispanic residents make up approximately 10 percent each of the population, with Black/African-Americans representing an additional 6.6 percent. 24.4 percent of Somerville's residents are foreign-born, and nearly 30 percent of all households speak a language other than English at home. The median home value in Somerville is $713,500; 34.4 percent of the housing stock is owner-occupied; the city has a transient rental population—60 percent of which turns over every 3 years.
The median household income for Somerville was $81,562 in 2017 with a poverty rate of 12.4 percent.

SHORT TERM SOLUTIONS

Network of Public Cooling Options – Create a comfortable corridor of publicly accessible cooled spaces designed for both short-term and longer stays, using a combination of outdoor spaces designed for cooling comfort and indoor spaces that are air-conditioned and can provide greater respite from extreme heat. The cooling network should be a mix of shaded outdoor spaces, including walking corridors, parks, misters, water features, plazas, and open space, and indoor spaces that encourage people to stay for longer periods of time, such as indoor markets, pop-up shops, and other activated indoor spaces. Design considerations for outdoor spaces should include materials that don't retain heat and greater investment in shaded bus and transit stops.

Develop Connections to the Community Path – Behind the existing commercial plaza is the rail corridor that will be part of the GLX to Union Square; the new transit stop will be within a short walk for the existing commercial plaza. The railway can become less of a divider by implementing connections to the Community Path and extending the Path to provide a shaded corridor for bikers and pedestrians.

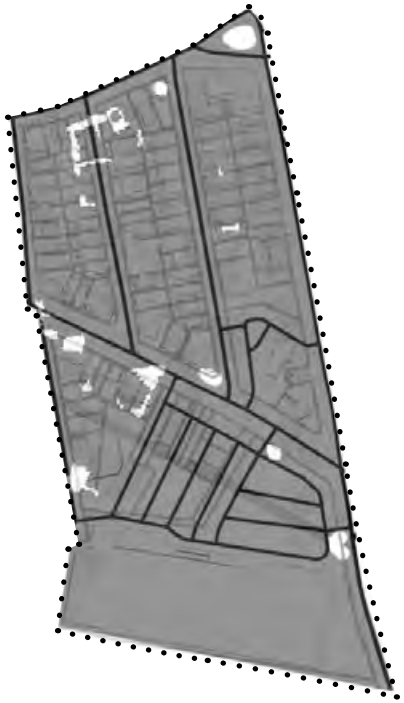


LAND USE

- Commercial
- Residential
- Mixed Use
- Industrial
- Federal, State or Municipal
- Tax Exempt Other

LAND USE

Located directly adjacent to Route 28, the Somerville site is over 50 percent commercial with the majority of the remaining land dedicated to residential uses.



PERVIOUS VS IMPERVIOUS

- Impervious
- Pervious

IMPERVIOUS GROUND COVERAGE

Nearly the entire Somerville site is classified as impervious. With about 25 percent dedicated to large surface parking lots paved in dark asphalt, there are little to no pockets of relief from extreme heat conditions.

TREE CANOPY

- Tree Canopy

TREE CANOPY AND SHADING

In the residential areas of the site, most of the tree canopy is located in the rear yards of private properties. On the south side of the main road, Somerville Avenue, there is a fairly consistent line of canopies made of larger trees.

ABOVE Site Diagrams
Image credit: Arrowstreet
Data source: Trust for Public Land, Climate Smart Cities

Implement Green Initiatives Throughout New Development Projects – New developments, including US2, should incorporate heat island mitigation elements such as green balconies, vegetated facades, rooftop gardens, improved energy efficiency measures, publicly-accessible green and open spaces, shaded structures along main street corridors, and other heat reduction measures.

Rethink Existing and Future Street Design – Future trends suggest a shift to electric vehicles, ride shares, and automated vehicles. This shift is likely to lead to a reduced demand for on-street parking and a need to re-think infrastructure along residential and commercial corridors. Any redevelopment of existing streets should incorporate trees, benches, shade structures, and other opportunities for cooling and protection from the elements. These strategies should be combined with green infrastructure improvements to integrate stormwater management with heat mitigation strategies.

Develop Heat Mitigation Regulations and Guidance for Built Environment – The City should encourage new development to consider heat mitigation strategies through incentives or changes to zoning requirements. In new construction, this will likely include the incorporation of more Passive House design elements as well as developing a menu of shade structures, heat mitigation strategies, and green infrastructure solutions to assist developers, residents, and business owners in understanding the types of interventions available. Solutions may include creative public art installations, trellises, layered tree canopies, awnings, solar parking canopies, reflective surfaces and materials that don't trap heat, green or cool roofs, natural ventilation, and urban design strategies that foster cooler environments.

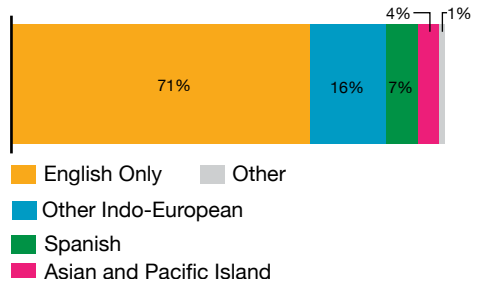
LONG TERM SOLUTIONS

The long-term solutions for this study area focused on repurposing existing development and infrastructure patterns as assets to mitigate heat impacts.

Shaded Overpass – The corridor underneath the elevated McGrath-O'Brien Highway is currently underutilized and often acts as a barrier for moving between neighborhoods in Somerville. The elevated highway can be repurposed as a shaded corridor to improve the pedestrian experience and activate the underutilized space. The underpass could be developed to serve as a cool and protected corridor for walking, cycling and programming community events. The design would include layered tree plantings along the edge of the highway, which would retain the cooler air that naturally emanates from the concrete structure, shield the neighborhood from vehicle emissions, and beautify the corridor.

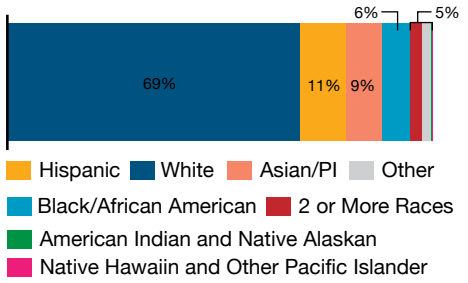
COMMUNITY-WIDE STATISTICS

Language Spoken at Home



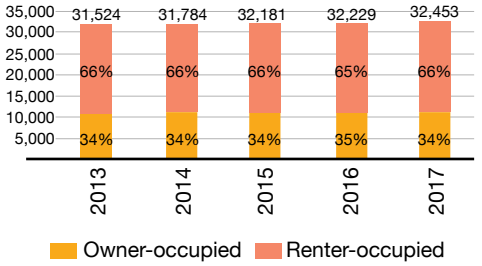
U.S. Census Bureau,
2013-2017 American Community Survey 5-Year Estimates
Data are for Census Block Group Approximations
of Somerville

Race and Ethnicity



U.S. Census Bureau, 2010 Census
Data are for Census Block Group Approximations
of Somerville

Housing Tenure



U.S. Census Bureau,
2013-2017 American Community Survey 5-Year Estimates
Data are for Census Block Group Approximations of
Somerville

LEFT Street view of proposed design solution in Somerville
Image credit: Perkins and Will

BELOW *Street view of existing conditions in Somerville*
Image Credit: Google Maps

RIGHT Aerial view of proposed design solution for Somerville.
Image Credit: Arrowstreet

The underpass could be activated by bringing in vendors and pop-up markets or installing more active uses, such as a skate park. Portions of the area under the overpass could also provide a protected cycling area; snow storage during the winter months; and, a connection between the study area, the forthcoming GLX corridor, and an extension of the Community Path.

Redevelopment of Commercial Plaza and Daylighting of Historic River – According to historic maps of the focus area, Millers River has been buried beneath a portion of the site for approximately 100 years. Daylighting the river, which refers to the uncovering of buried waterways, could create a cooling mass at the southern portion of the site that can be carried throughout the site with a thoughtful design that utilizes the prevailing winds for cooling. Combining this daylighting with a thoughtful redevelopment of the commercial plaza that reduces the amount of parking and encourages a mixed use redevelopment that supports small businesses, affordable housing, open spaces, and activated retail, such as a beer garden or outdoor market, will provide a great benefit to the community, both economically and culturally.


Millers River
Complete Street
Page 38
Community Center
I-93 Section
Page 42

CHELSEA / EVERETT

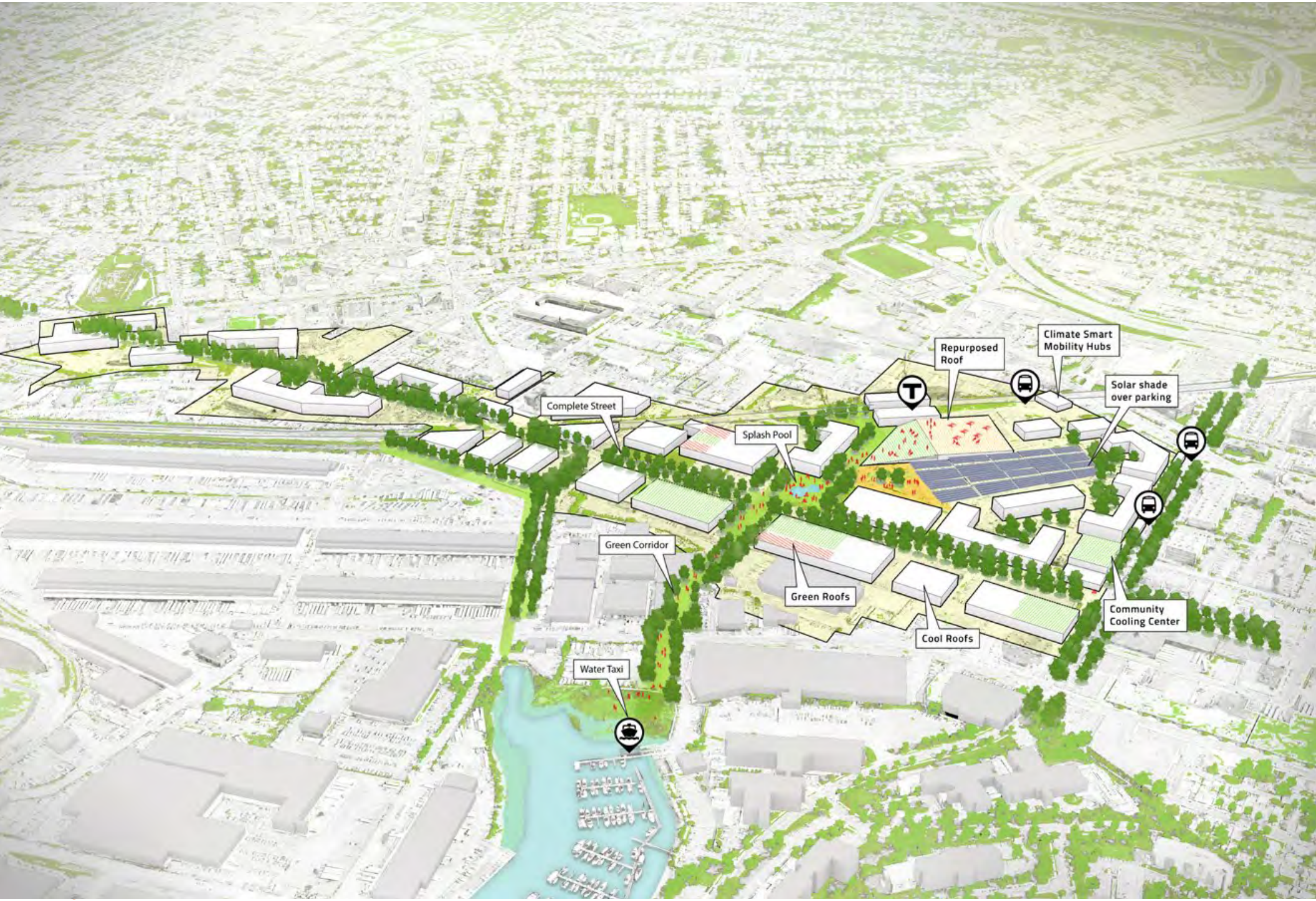
The Second Street corridor that connects the communities of Chelsea and Everett features a number of dynamic commercial and retail uses, including a multi-tenanted shopping center anchored by Market Basket, a regional grocery chain. The focus area is also home to significant industrial users with regional impact, including food distributors, as well as manufacturers, and several metal scrap yards. There is also a substantial amount of housing in the neighborhood as well as a hotel that is under construction on a former industrial site.

The cumulative heat island impact of these users is significant, as 88 percent of the study area is comprised of black tar/asphalt roofing and asphalt paving. There is also significant production of waste heat from idling trucks and HVAC equipment from the distribution centers. None of the commercial buildings have white roofs, and only one building uses solar panels.

At the same time, this is a critical corridor for utility and transit infrastructure. The site encompasses the City of Chelsea's Carter Street stormwater pump station and MBTA commuter rail tracks, and there is potential future expansion of the MBTA Silver Line route and a proposed new MBTA commuter rail stop, which will significantly affect future traffic patterns for all modes of transit. Climate change presents numerous challenges to this area, including a growing flood risk and increasing temperatures that will magnify the urban heat island effect. In addition, heavy development is expected to continue in both cities along the corridor.

RIGHT Chelsea / Everett Context and Site Plan
Image credit: Arrowstreet


Medford
Winthrop
Revere Beach Pkwy
Route 1
New England Produce Center
Boston Flower Exchange
Market Basket
Chelsea Station
Island End River
500 ft


Repurposed Roof
Climate Smart Mobility Hubs
Solar shade over parking
Complete Street
Splash Pool
Green Corridor
Green Roofs
Cool Roofs
Community Cooling Center
Water Taxi

DEMOGRAPHICS

Chelsea Demographics – Chelsea is the second most densely populated city in Massachusetts and one of the most ethnically diverse in the state. The population of 40,160 has grown by 14.2 percent since 2010, and the most recent census data (2017) indicates that the city is 65.9 percent Hispanic, 21.9 percent White, 7.1 percent Black/African-American, and 3.6 percent Asian. Over 45 percent of Chelsea's population is foreign-born, and over 70 percent of all households speak a language other than English at home. Alerting all residents to the dangers of heat and poor air quality is difficult because there are at least 35 different languages spoken in the city according to a WBUR report [13].

The median home value in Chelsea is $371,900. Just 25.7 percent of the housing stock is owner-occupied, so the city has a very high percentage of renters. The average rent in Chelsea is $2,498 up from $1,976 in the same time period in 2014. The median income for Chelsea was $51,839 in 2017 with a poverty rate of 19.5 percent.

Everett Demographics – Everett has a population of 46,880 and has grown by 12.6 percent since 2010. The most recent census data indicates that the city is 45.9 percent white, 22.9 percent Hispanic, 19.8 percent Black/African-American, and 6.5 percent Asian. Forty-one percent of Everett's population is foreign-born, and 56.1 percent of all households speak a language other than English at home.

The median home value in Everett is $427,200. Just 39.7 percent of the housing stock is owner-occupied, so the city has a high percentage of renters. The average rent in Everett is $2,415 up from $1,809 in the same time period in 2014. The median income for Everett was $57,524 in 2017 with a poverty rate of 13.9 percent.

LEFT Aerial view of proposed design solution for Chelsea / Everett
Image credit: CBT Architects, One Architecture & Urbanism

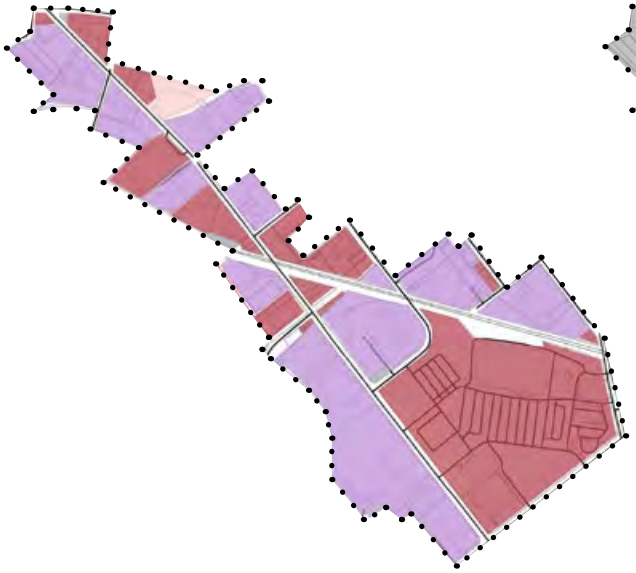
SHORT TERM SOLUTIONS

Improve Outdoor Pedestrian/Bus Environment – Residents and employees who walk to Market Basket and cannot afford cars—or for some, even buses—need a comfortable environment to make the trip. The bus stop infrastructure needs to be improved, as a sign on a pole often constitutes a bus stop. Bus stops along the Silver Line (Buses #4 and #5) could be designed with solar roofs and/or also be used to collect storm water. For pedestrians, refuges could be created in the middle of the long walkway along Second Street that provide shade, misters, etc. Working water fountains should also be installed so that people can fill up water bottles on their journey. Any improvements should be piggybacked on transportation infrastructure that already exists.

Engage Existing Businesses to Implement Green Practices – Along Second Street in Chelsea there are multiple businesses with large lots, which presents a great opportunity to engage existing businesses. Business owners should be encouraged to use blue/green roofs for their properties, with a larger idea of creating a series of business-themed green roofs. For example, installing a bamboo roof on the J.B. Sash & Window building, planting flowers on the roof of the New England Flower Exchange, or growing hops on the roof of local breweries. Engaging business owners with creative ways to cool these spaces can also serve as a source of civic pride and unity for the Chelsea business community. Business owners should also be encouraged to provide green solutions for outdoor gathering spaces for employees.

Create a New Central Spine – Second Street is a major corridor connecting the cities of Chelsea and Everett; however, it has seen under-investment in compared to other major thoroughfares in these cities. A new central spine in this neighborhood would seek to upgrade utilities, incorporate multi-modal transportation options, and create a sense of place. Ideally, a future Second Street will incorporate bicycle lanes, dedicated Silver Line transit lanes, and provide safe and comfortable passage for pedestrians.

To prepare for the future of the Second Street corridor, the Cities of Chelsea and Everett need to invest in utility infrastructure, well-planned streetscape amenities, and community art to bring attention to this area under rapid redevelopment. The new central spine should incorporate green infrastructure to manage stormwater on a street that lacks traditional drainage throughout the

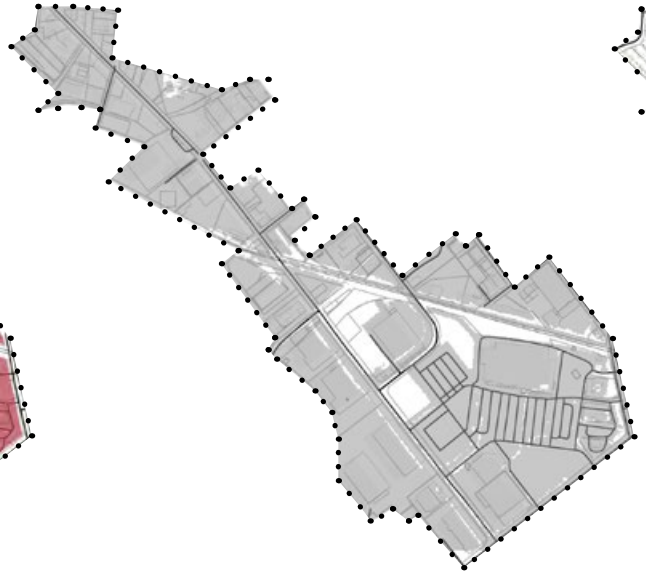


LAND USE

- Commercial
- Industrial
- Residential
- Federal, State or Municipal
- Mixed Use
- Tax Exempt Other

LAND USE

The Chelsea / Everett project site is predominantly characterized by its commercial and industrial land uses. The southeastern edge of the site in Chelsea includes a large parking-centric shopping plaza anchored by Market Basket and smaller commercial retail users. Industrial uses like the Boston Flower Exchange, State Garden, metal scrap yards, and auto body shops make up the central portion of site. The project site extends into Everett to the northwest at Route 16/Revere Beach Parkway where commercial retail users line that state roadway.

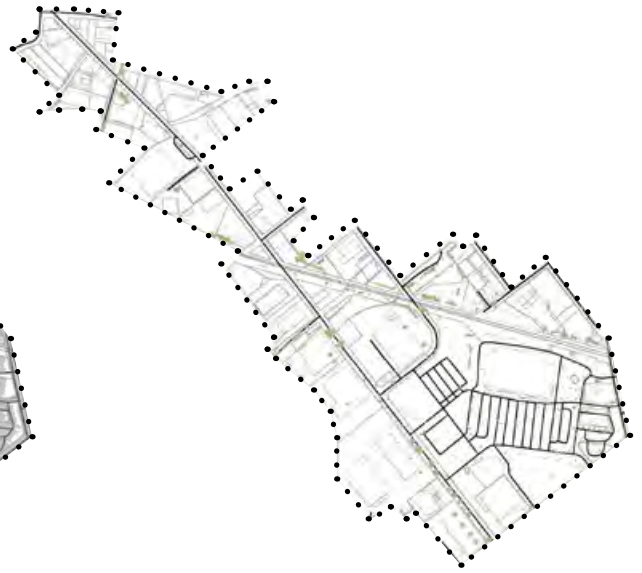


PERVIOUS VS IMPERVIOUS

- Impervious
- Pervious

IMPERVIOUS GROUND COVERAGE

To support the industrial and commercial uses, large asphalt parking lots and aging low-rise asphalt roofing materials cover large areas of the site. The limited pervious / open space in the project site near Market Basket site is anticipated to be redeveloped in the future to support transit-oriented development program desired in this area.



TREE CANOPY

- Tree Canopy

TREE CANOPY AND SHADING

There is little to no effective tree canopy on the project site. Limited tree vegetation cannot thrive in this urban heat island. Pedestrian infrastructure that does exist has long stretches of unshaded surface, providing limited relief from extreme heat.

ABOVE Site Diagrams
Image credit: Arrowstreet
Data source: Trust for Public Land, Climate Smart Cities

corridor. It should also include streetscape improvements—benches, street trees, and signage—as well as placemaking elements such as community murals and metal art to celebrate the history of this district—produce & metal scrap yards. It is worth noting that the City of Everett is currently working with utility companies to underground the overhead utilities in this corridor.

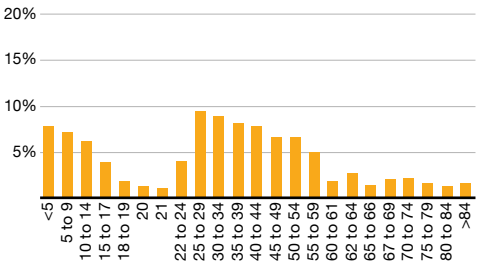
LONG TERM SOLUTIONS

Redevelop/Expand Market Basket – Much of what is already in place in the focus area is there to stay. However, Market Basket owns approximately 40 undeveloped acres, and the site is served by the new Silver Line MBTA stop. In close proximity to that stop is the proposed site of the new commuter rail stop. This transportation nexus could unlock opportunities for the neighborhood to be a focal point of the region rather than an "edge" location as stated in the 2014 Connect Chelsea: Three Visions for a Gateway City Report. Market Basket, in conjunction with the City of Chelsea, had been considering redeveloping the site while retaining the grocery store as a mixed-use (residential/hotel/commercial) development over a decade ago until the family-owned business underwent a major restructuring in 2014, derailing the plans. There is now renewed interest on the part of the City and Market Basket to move forward with redevelopment on the northern edge of the site. The panelists favor four-story residential above ground floor commercial uses, which would also reduce the area of the impervious parking lot. It is worth noting that permitting is already in place on the northern portion of the site to allow for hundreds of apartments in close proximity to the new Silver Line Station.

Affordable Housing and Elevated Pedestrian Platform Over Second Street – The Everett side of Second Street has a very narrow right of way and would seem to be a logical location to do affordable housing by developing a wider right-of-way through land acquisition/easements of up to 60 feet. An elevated, vegetated and shaded pedestrian/bicycle corridor could be developed over Second Street that would allow for heavy trucking and passenger vehicles and future dedicated lanes for the MBTA Silver Line below. Significant street tree plantings on the ground plane would buffer elevated decks from properties and mitigate the urban heat island effect. An arbor could potentially be installed to grow vine cover in this industrial produce district. The elevated deck would provide heat refuge for pedestrians with PV-solar shade cover and misting stations.

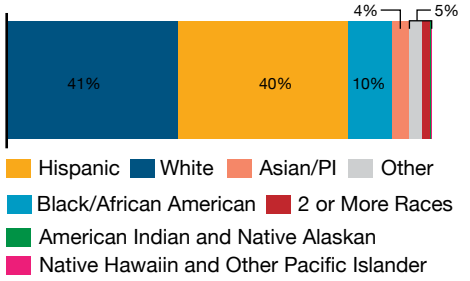
COMMUNITY-WIDE STATISTICS

Age



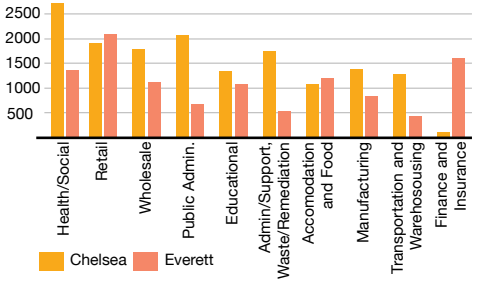
U.S. Census Bureau,
2013-2017 American Community Survey 5-Year Estimates
Data are for Census Block Group Approximations
of Chelsea and Everett

Race and Ethnicity

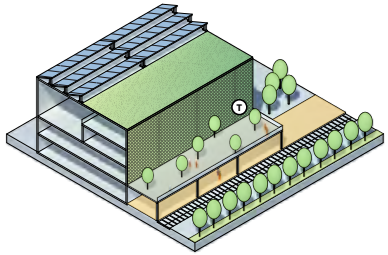


U.S. Census Bureau, 2010 Census
Data are for Census Block Group Approximations
of Chelsea and Everett

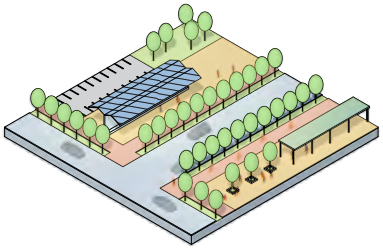
Commercial Industry



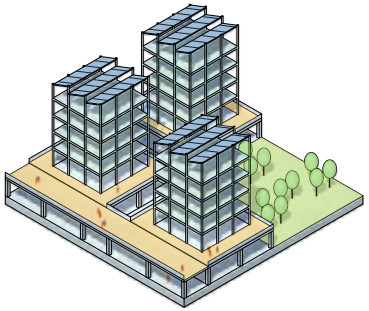
U.S. Census Bureau,
Longitudinal Employer-Household Dynamics (LEHD), 2017



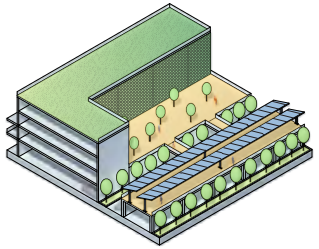
NEW ENGLAND PRODUCE CENTER
URBAN FOOD MARKET WITH ACCESS TO
THE SILVER LINE AND MBTA



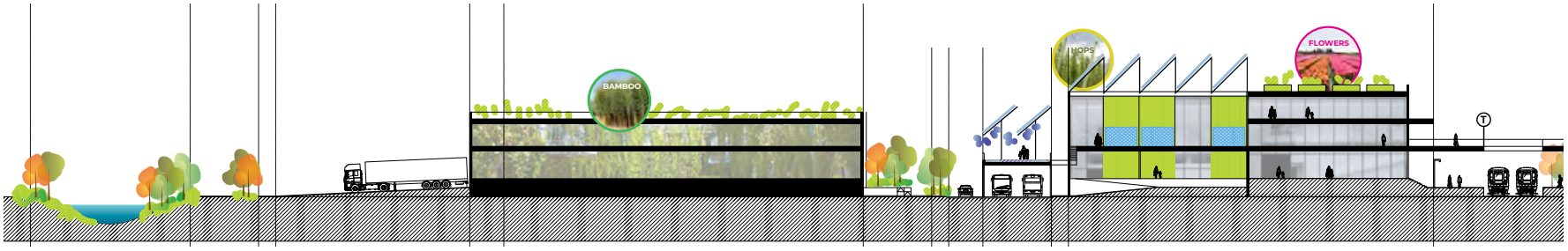
SMART HUB – COOLING STATIONS FOR
PICKUP & TRANSIT COMBINES WITH
COMPLETE STREETS AND
GREEN INFRASTRUCTURE



VERTICAL FARMS AND LOGISTIC STORAGE TO
EXPAND PRODUCTION AND STORAGE CAPACITY



NEW MIXED USE RESIDENTIAL WITH GREEN/
BLUE ROOFS. ELEVATED PATHWAY ABOVE
SECOND STREET.



DAYLIGHTED
ISLAND END RIVER

LOGISTICS FACILITY
WITH GREEN ROOF

2NS STREET SILVER LINE
AND ELEVATED
PEDESTRIAN WALKWAY

NEW ENGLAND PRODUCE
CENTER FOOD HALL

OPPOSITE PAGE Site section and concept axonometric diagrams.
Image credit: CBT Architects, One Architecture & Urbanism

ABOVE Perspective image showing proposed design solution adjacent to the Market Basket Grocery Store.
Image Credit: CBT Architects, One Architecture & Urbanism

LEFT Street view of existing conditions adjacent to Market Basket Grocery Store.
Image Credit: Google Maps

Where do we go from here?

"The climate crisis we face is more significant than just what is happening to our coastlines. Heat is, in fact, the most fatal of the climate impacts that we will confront in the Boston area. Making our communities more resilient to heat will require residents, businesses, land use professionals, and governments to work together to design and implement equitable solutions for combating the effects of climate impact."

— Kalila Barnett, Climate Resilience Program Officer, Barr Foundation.

As we were reminded all too often during the summer of 2019, extreme heat events are becoming an increasingly common occurrence in Greater Boston The region experienced 14 days exceeding 90°F this year and 23 in 2018, and conditions will only worsen. Massachusetts will go from its previous average of seven days per year with a heat index above 90°F, to 33 days per year on average by midcentury, and 62 by the end of the century.

Exacerbating the problem is that extreme heat remains an "invisible" threat, despite causing more deaths in U.S. cities than any other severe weather event. Extreme heat is particularly deceptive in cooler climates like Greater Boston, where the population is less well acclimated to the sudden changes in temperature. The effects of rising temperatures are being magnified by urban heat islands such as the four LWH study areas, and from a health perspective, are particularly damaging for the predominately low and middle income populations living there.

Since the release of "Living with Water", the cities of Boston, Cambridge, and Somerville have conducted vulnerability assessments focused on the effects of climate change in their communities and have adopted appropriate resiliency measures—which also serve to directly or indirectly address the threat posed by extreme heat.

The Boston Green Ribbon Commission emphasized the importance of tackling extreme heat in its Climate Ready Boston report, calling for green infrastructure development in public land and rights of way, while updating its heat emergency action plan. However, to effect real change, there needs to be a commitment on the part of the stewards of much of Greater Boston's built environment, meaning the region's public and private sectors need to develop mitigation and adaptation strategies for rising temperatures.

The LWH charrette, drawing on the membership of ULI Boston/New England under the guidance of the Climate Resiliency Committee, brought together some of the region's leading climate change experts to devise innovative design and policy initiatives to mitigate the effects of UHIs in the region. Based on their work, the Committee understands the fierce urgency of now and has delivered a road map for the land use community.

It is hoped that the recommendations put forth in this report will not only help to address the issues within the specific sites, but to become a valuable tool for those planning their own developments with an eye towards resiliency. The sites are therefore meant to represent typologies rather than site-specific solutions, so that they can be referenced by other land use professionals.

Our challenge as stewards of the built environment is to apply new approaches to climate resiliency. Due to the complexity of issues that extreme heat and rising temperatures bring to land use, it will require bold thinking and action to strike a balance between economic and social well-being. We all need to work together to develop the robust public/private partnerships, public policy changes, and strong governmental leadership that will ultimately result in more resilient communities within the region.

IMPLEMENTATION MAP

The four project site teams developed site specific strategies. Many of these strategies overlapped between sites and are organized by low & high difficulty and short & long term. Many of the proposals require broader coordination for successful implementation, such as zoning changes or funding sources and a future of more electric public transportation and fewer personal cars. These may seem like obstacles, but the benefits of these strategies extend beyond reducing heat island effect. These strategies also consider existing typologies of neighborhoods and infrastructure, improve public health, reduce emissions contributing to climate change, absorb coastal flood water and rain water, leverage resources across jurisdictional boundaries, and create programs for stronger neighborhood engagement, among others.

Image credit: Jordan Zimmermann

Legend

- *Somerville*
- *East Boston*
- *Chelsea / Everett*
- *Lower Roxbury*

Money
Built Environment
Transportation + Infrastructure
Policy

APPENDIX

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Extreme Heat Events

Expanded details from pages 10 and 11

WORLD WIDE HEAT EVENTS

W1. 2003, European heat wave: European heat wave of 2003, record high temperatures across Europe in 2003 that resulted in at least 30,000 deaths (more than 14,000 in France alone). https://www.britannica.com/event/European-heat-wave-of-2003

W2. 2006, European heat wave: Due to the extreme heat in July 2006, the ocean water reached a temperature normally reached in September. This increase in water temperature led to faster evaporation of ocean waters, making August one of the cloudiest and wettest months in recorded history in various western European countries. https://www.britannica.com/event/European-heat-wave-of-2003

W3. 2007, Hungary and South Europe: Southern Europe sizzled in record-breaking temperatures yesterday with the heatwave being blamed for deaths in Hungary and Romania, power cuts in Macedonia and forest fires from Serbia to Greece. Up to 500 people have died in Hungary because of the heatwave with deaths attributed to heatstroke, cardiovascular problems and other illnesses aggravated by high temperatures which reached a record high of 41.9C (107F) in the southern city of Kiskunhalas. https://www.theguardian.com/world/2007/jul/25/weather.travelnews

W4. 2007, Asian heat wave, India: The death toll from India's annual heat wave has increased to 31, with meteorologists saying temperatures may start to ease within the next week. All of the official deaths reported so far this year have occurred in the eastern state of Orissa, where on Sunday (May 10) the meteorological department recorded temperatures as high as 114.1°F (45.6°C) in the western town of Sambalpur, the Indo-Asian News Service (IANS) reported. https://reliefweb.int/report/india/least-31-dead-amid-indian-heat-wave

W5. 2010, Russia: The torrid weather that choked western Russia in the summer of 2010, killing an estimated 55,000 people, was by far the worst such event of the past 33 years, according to a climate index that scientists have devised to gauge the magnitude of heatwaves. The index, which takes into account the severity of temperature extremes as well as the duration of the heatwave, could become a benchmark for evaluating the impacts of future climate change. https://www.nature.com/news/russian-summer-tops-universal-heatwave-index-1.16250

W6. 2013, Australia: Australia has been sweating through a major heat wave to start the year. Heat records fell across a large part of the country in the first week of the New Year. The warm weather is currently centered over sparsely populated Western Australia, but it could hit major population centers along the east coast by late next week. https://www.climatecentral.org/news/australia-2014-heat-wave-picks-up-where-2013-left-off-16938

W7. 2015, Pakistan: Hotter than average temperatures have killed at least 65 people in just three days in Karachi, Pakistan. Temperatures reached a high of 44°C (111°F) on Monday, according to the Pakistan Meteorological Department, way above the average daily high for May of 35°C (95°F). https://www.nytimes.com/2015/06/26/world/asia/karachi-pakistan-heat-wave-deaths.html

W8. 2015, Lebanon: The heat wave currently hitting the Middle East is taking its toll on Lebanon with the agricultural industry, mainly farmlands and crops, poultry and livestock now under threat. Rising temperatures have already led to the death of thousands of chickens at several farms in the regions of Hasbaya and Marjeyoun. https://www.lbcgroup.tv/news/news-bulletin-reports/225105/report-extreme-heat-wave-threatens-lebanons-agricu/en

W9. 2019, Netherlands: Almost 400 people more died in the Netherlands during Europe's recent record-breaking heatwave than in a regular summer week, Dutch national statistics agency CBS said on Friday. In total, 2964 people died in the Netherlands during the week that started on July 22, the CBS said, which was around 15 percent more than during an average week in the summertime. Temperature records tumbled across Europe during late July's heatwave, and for the first time since records began topped 40°C (104°F) in the Netherlands on July 25. https://www.reuters.com/article/us-weather-netherlands/heatwave-caused-nearly-400-more-deaths-in-netherlands-stats-agency-idUSKCN1UZ0GA

UNITED STATES HEAT EVENTS

U1. 1999, Chicago: During the latter few days of July 1999 an unusually intense heat episode occurred over northern Illinois including the Chicago metropolitan area. It was the most intense heat to affect the region since the tragic episode of July 13th, 1995 when over 600 persons died due to heat related factors. https://www.weather.gov/lot/1999Jul29

U2. 2001, New Jersey: As the Blister of '11 entered its sixth day in New Jersey, it didn't just break records, it stomped them to pieces. Newark baked at 108°F at 3 p.m. — the hottest day ever in the state's largest city, according to the National Weather Service, which has kept records since the 1930s. It was seven degrees hotter than the next closest temperature on a July 22. Until yesterday, the temperature in Newark had never reached above 105. https://www.nj.com/news/2011/07/nj_heat_wave_breaks_records_te.html

U3. 2006 North American heat wave- California hit especially: A record-breaking heat wave affected much of the state of California during the period from Sunday, July 16 through Wednesday, July 26, 2006. Although numerous daily maximum temperature records were set, the aspect that made this event unique was the elevated overnight minimum temperatures that easily surpassed previous daily, or even all-time, high minimum temperatures at several reporting stations. This was especially true in the southern Sacramento Valley and much of the San Joaquin Valley. Along with the intensity of this heat wave, the duration of abnormally high maximum and minimum temperatures was particularly noteworthy. This event impacted California's economy, energy supply and health. http://adsabs.harvard.edu/abs/2006AGUFM.A13D0971E

U4. 2012, Maryland, Ohio, Virginia, and West Virginia: On June 29, 2012, a rapidly moving line of intense thunderstorms with high winds swept across the midwestern and eastern United States, causing widespread damage and power outages. Afterward, the area experienced extreme heat, with maximum temperatures exceeding 100°F (37.8°C). This report describes 32 heat-related deaths in Maryland, Ohio, Virginia, and West Virginia that occurred during the 2 weeks following the storms and power outages. Median age of the decedents was 65 years, and most of the excessive heat exposures occurred within homes. During 1999-2009, an annual average of 658 heat-related deaths occurred in the United States. Heat-related deaths are preventable, and heat response plans should be in place before an extreme heat event (EHE). Interventions should focus on identifying and limiting heat exposure among vulnerable populations. https://www.ncbi.nlm.nih.gov/pubmed/23739336

U5. 2013, Oregon: The heat takes a brief holiday Saturday, with temperatures in Northwest Oregon and Southwest Washington rising into the mid- to upper-80s thanks to occasional cloud cover. Friday was hotter than anticipated, including Portland where the high topped out at 92°F. Eugene also came in at 92°F. Salem and Troutdale recorded highs of 91°F, and McMinnville, Vancouver and Hillsboro reaching 90°F. https://www.oregonlive.com/weather/2013/06/heatwave_oregon_bakes_while_th.html

U6. 2015, Carolina's: High temperature in Charlotte, NC reached 100°F on three consecutive days (June 22nd through June 24th), and in Florence, SC temperatures reached 101 on four consecutive days (June 15th through June 18th). Temperatures in Lumberton, NC peaked at 104°F, 102°F in Fayetteville, NC, and 100°F in Wilmington, NC. https://www.weather.gov/ilm/heatwaves

U7. 2018, Arizona: The temperature in Phoenix has almost reached a record-breaking 122°F (50°C) recorded on June 26, 1990, and it's becoming harder and harder to escape the insane heat. The flights are being canceled, and things are literally melting. Today it's up to 116°F (47°C), and 168°F (76°C) on the concrete. To illustrate just how bad the situation is we have collected some shocking images of things melting in Arizona. https://www.boredpanda.com/hot-arizona-phoenix-heatwave-high-temperature-melting/?utm_source=google&utm_medium=organic&utm_campaign=organic

U8. 2019, Oklahoma to Boston: Two-thirds of the continental United States is expected to fry under an intense heat wave over the weekend in a phenomenon caused by a large dome of high pressure lingering over the affected areas. The unusual heat wave has already begun in some areas such as St. Louis. The National Weather Service (NWS) said the areas to be struck by temperatures ranging from 90°F (32°C) to more than 100°F (38°C) stretched from Texas to much of the Plains. NWS is warning the Plains of a "major heat wave" starting Wednesday and into the weekend. Parts of Kansas, Nebraska, Iowa, Missouri, Oklahoma and Illinois are now under an excessive heat warning. Highs each afternoon in these states are expected to be in the mid- to upper-90s and with a heat index as high as 113°F (45°C). https://www.nytimes.com/2019/07/17/us/weather-heat-wave.html

METRO BOSTON HEAT EVENTS

M1. 2010, July over 90°F: By mid-century in Boston, the sweltering heat of July 2010 may be thought of as cooler-than-average conditions, as more days above 90°F routinely occur. The 2010 dates on this "postcard from the future" for Boston are actual; 2050 dates are representative of average projections. Postcards are also available from the cities of New York, Philadelphia and Washington, DC. https://www.climatecentral.org/gallery/graphics/boston_july_days_over_90_degrees

M2. 2013, longest heat wave: The summer of 2013 has been one of the warmest in Boston history, with well over ten 90 degree days. But what will it take to break records? https://www.wcvb.com/article/longest-heat-waves-in-boston-history/8118001

M3. 2015-2016, Warm Winter: The 2015 - 2016 winter up to this point in the season has been anything but normal. After a record warm start including the warmest December of all-time for the Northeast, it took many in New England until December 29th to see the first measurable wintry event which included a mixed bag of snow, sleet and freezing rain. Not only did it rank among the top 5 latest first measurable events, but it was the latest since 1953 and 1954 for Hartford, CT and Boston, MA, respectively. https://www.bostonglobe.com/metro/2016/02/25/this-winter-track-one-warmest-ever-boston/h9zeQwaoVEnuiHM6LyeoiL/story.html

M4. 2016, Driest Boston Summer: The summer of 2016 will go down as the driest ever recorded in Boston. The National Weather Service says 3.92 inches of rain fell on the city in June, July and August — the meteorological summer. That breaks the previous record of 3.97 inches, set in 1957. The dry weather was accompanied by record-breaking heat, as last month was Boston's warmest August in recorded history, according to the weather service. The average temperature was 76.5°F, one full degree higher than the previous record, which was set in 1988. https://www.wbur.org/news/2016/09/01/driest-boston-summer

M5. 2017, heat wave cancels events: Americans from Texas to Maine sweated out a steamy Saturday as a heat wave canceled events from festivals to horse races and pushed New York City to order steps to avoid straining the electrical system. The National Weather Service said "a dangerous heat wave" sent temperatures into the 90s, with high humidity that made it feel considerably hotter. It was expected to stay warm at night, in the upper 70s to low 80s, with more heat on the way Sunday for the East Coast. https://www.boston.com/news/local-news/2019/07/20/its-brutal-heat-wave-across-half-the-us-cancels-events

M6. 2018, deaths: Hundreds of people in Boston sat under the hot sun through temperatures that reached the mid-90's to watch a preholiday concert. The heat index made it feel closer to 105, so fans took precautions. https://boston.cbslocal.com/2018/07/04/heat-wave-northeast-deaths-weather/

M7. 2018, school shutdown: Massachusetts schools are preparing to feel the heat on Monday, and some are deciding to avoid it completely by canceling classes. The trend began on Saturday when it was announced Lowell Public Schools were debating closing because of the heat. In a letter sent out Saturday, the schools confirmed the possibility, citing predicted temperatures of 94°F for Monday. https://www.boston25news.com/news/extreme-heat-causing-some-schools-to-close-down-monday/771735642

M8. 2019, hottest July on record: Tuesday brought more 90-degree weather to Boston, for the second official heat wave this summer — with warm temps on the way again Wednesday. Many cities and towns in New England have had more 90-degree days than Boston. For instance: Windsor Locks, in Connecticut, has had 18 such days this month, the most there in any month on record. Most climate sites are experiencing one of — if not the — warmest Julys on record. It doesn't matter which climate site you review, this is a top 10 warm month pretty much everywhere in the Northeast. https://www.wbur.org/news/2019/07/30/boston-heat-july-forecast-rec

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Urban Land Institute Boston/New England

The mission of the Urban Land Institute is to provide leadership in the responsible use of land and in creating and sustaining thriving communities worldwide.

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- Fostering collaboration within and beyond ULI's membership through mentoring, dialogue, and problem solving
- Exploring issues of urbanization, conservation, regeneration, land use, capital formation, and sustainable development
- Advancing land use policies and design practices that respect the uniqueness of both the built and natural environments
- Sharing knowledge through education, applied research, publishing, and electronic media
- Sustaining a diverse global network of local practice and advisory efforts that address current and future challenges

Established in 1936, the Institute today has more than 45,000 members worldwide, representing the entire spectrum of the land use and development disciplines. ULI relies heavily on the experience of its members. It is through member involvement and information resources that ULI has been able to set standards of excellence in development practice. The Institute has long been recognized as one of the world's most respected and widely quoted sources of objective information on urban planning, growth, and development.

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