

Modeling Heat Island Impacts and its Mitigation: City of Cambridge as Case Study

City of Cambridge
September 7, 2017

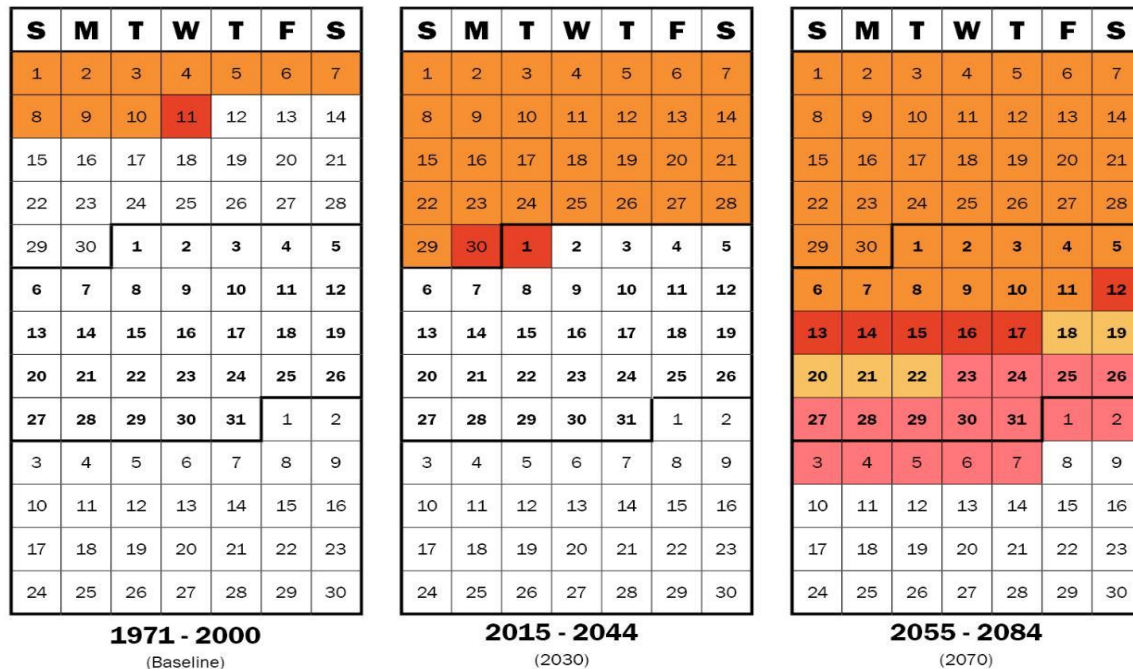
EPA Heat Island Webcast on Understanding Your City's Heat Island



Overview of Heat Vulnerability in Cambridge

Increasing Temperatures – Increasing Heat Vulnerability

By 2030, the number of days above 90°F could triple



■ Above 90°F - Low Scenario
 ■ Above 90°F - High Scenario
 ■ Above 100°F - Low Scenario
 ■ High 100°F - High Scenario

*Summer is considered to be the 91 days of June through August



Boston Marathon, April 16, 2012 (above 80F)

- More frequent & longer heat waves
- Temperatures exacerbated by urban heat island affect
- Average temps will be warmer

How Can Municipalities Plan for Greater Resiliency to High Temperatures?

Objectives:

1. Identify vulnerabilities to increasing heat if no changes made
2. Understand better how Cambridge's urban form influences temperatures and how it could be modified

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

1971 - 2000
(Baseline)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

2015 - 2044
(2030)

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	1	2	3	4	5
6	7	8	9	10	11	12
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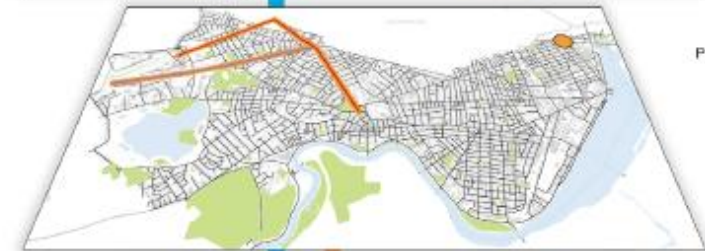
2055 - 2084
(2070)

Water



Stormwater

Roadway



Transit

- Porter-Harvard Rail Line
- Lechmere-Science Park Rail Line
- Alewife-Davis-Porter Rail Line
- Fitchburg Commuter Rail Line

Critical Services

Cambridge Water Department building (the City's Emergency Operations Center)



Critical Services

- Public Health Department building on Windsor Street
- Police Headquarters
- Professional Ambulance Services office
- Fire Department headquarters

Energy

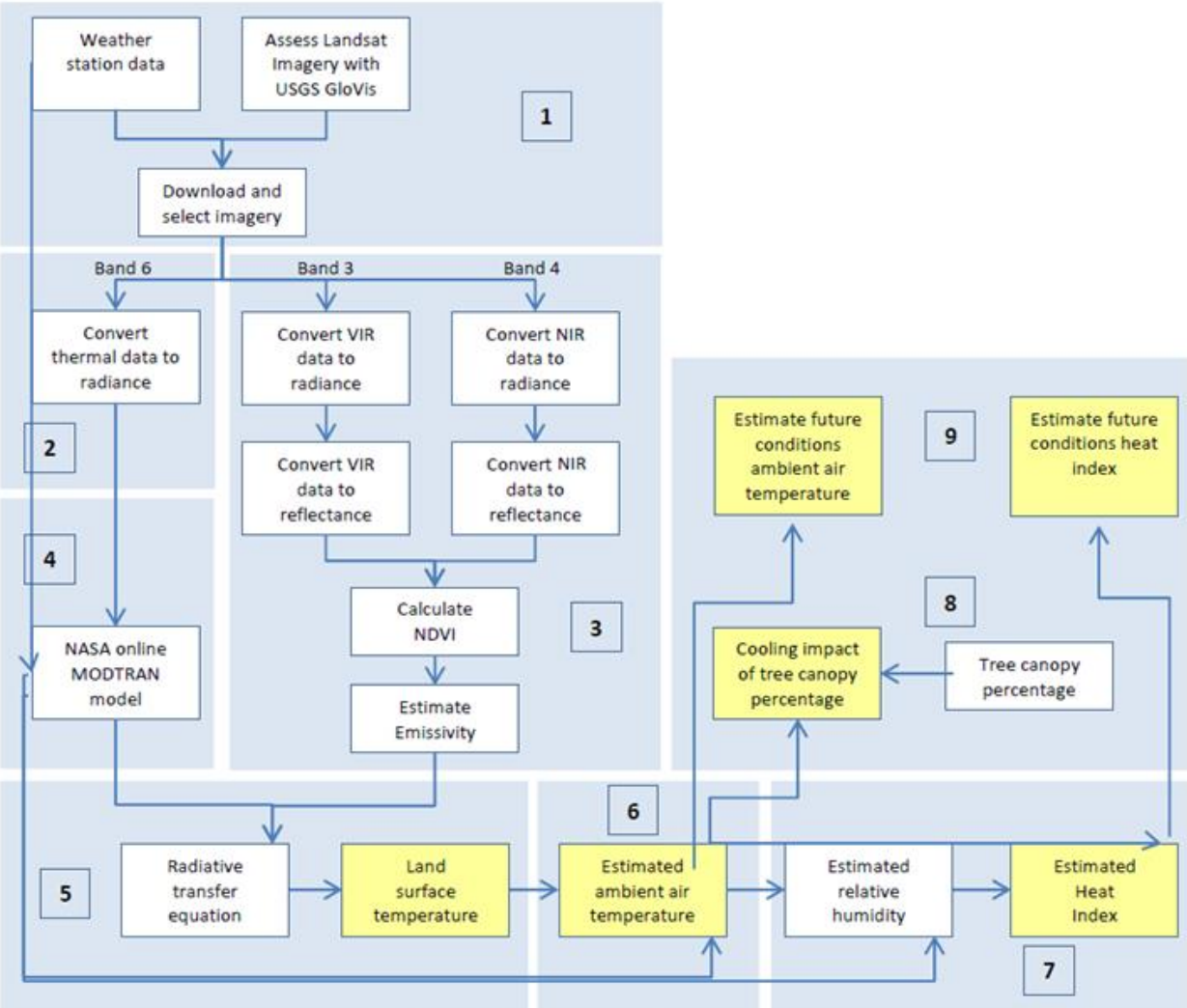
Third Street Regulator Station



Telecom

City Emergency Communications Center (Police HQ)

Translating Existing Land Surface Temperature to Future Ambient Air and Heat Index



Process for mapping heat index

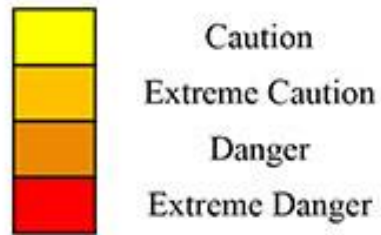
Source: Appendix D Urban Heat Island Protocol for mapping Temperature Projections, Kleinfelder for the City of Cambridge, November 2015

Translating Heat Index to Human Health Impacts

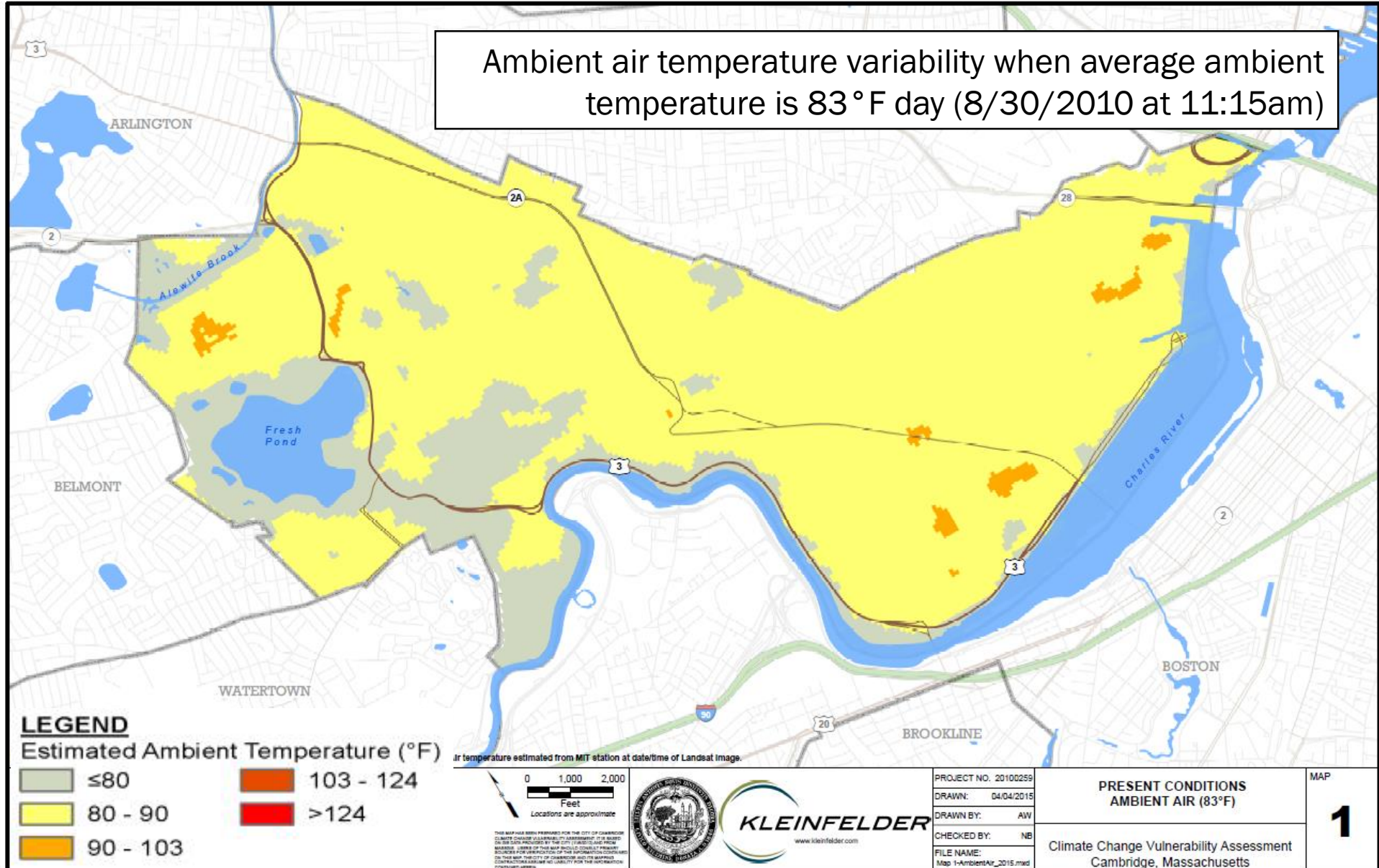
NOAA National Weather Service: Heat Index

TEMPERATURE (°F)

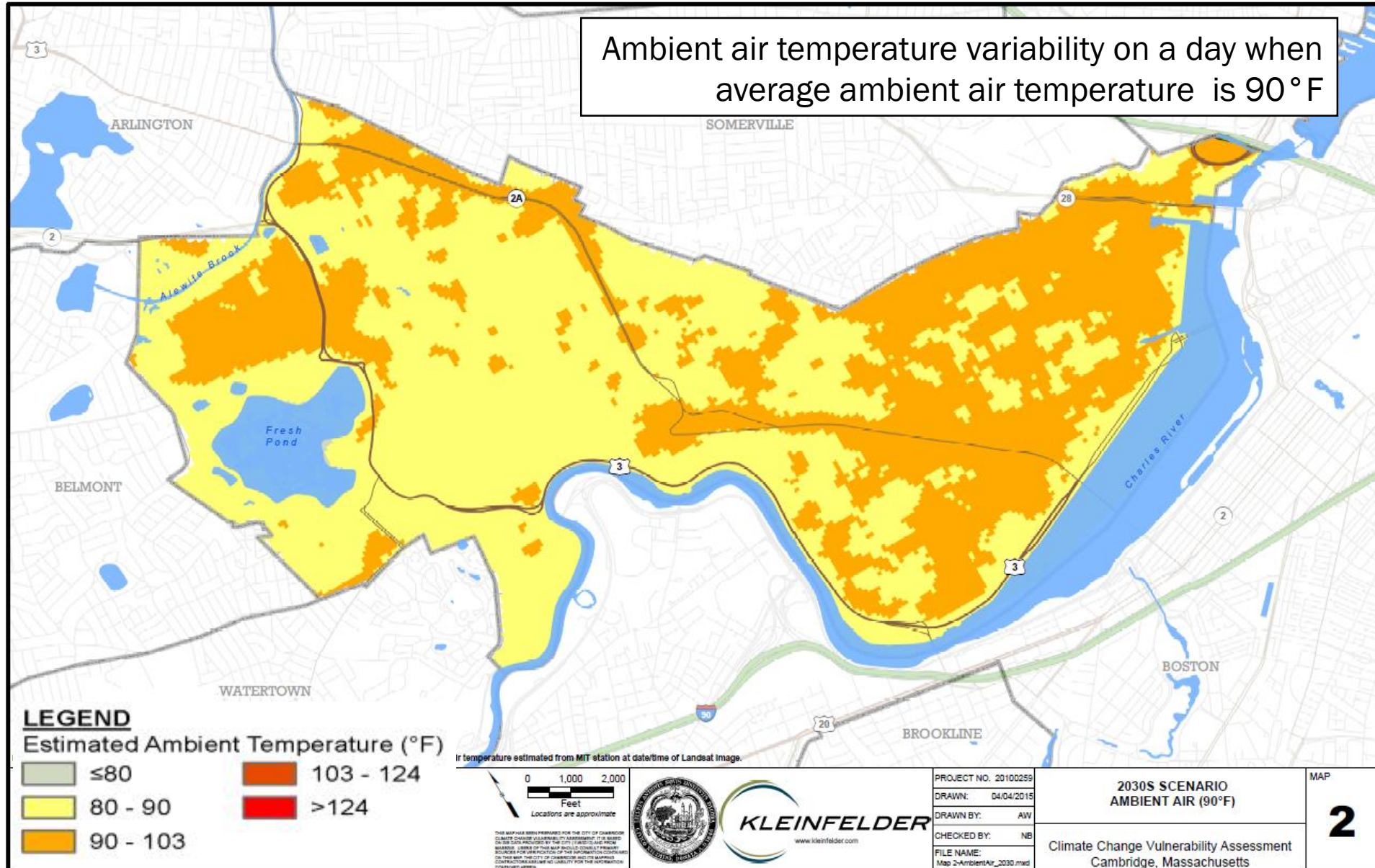
	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										



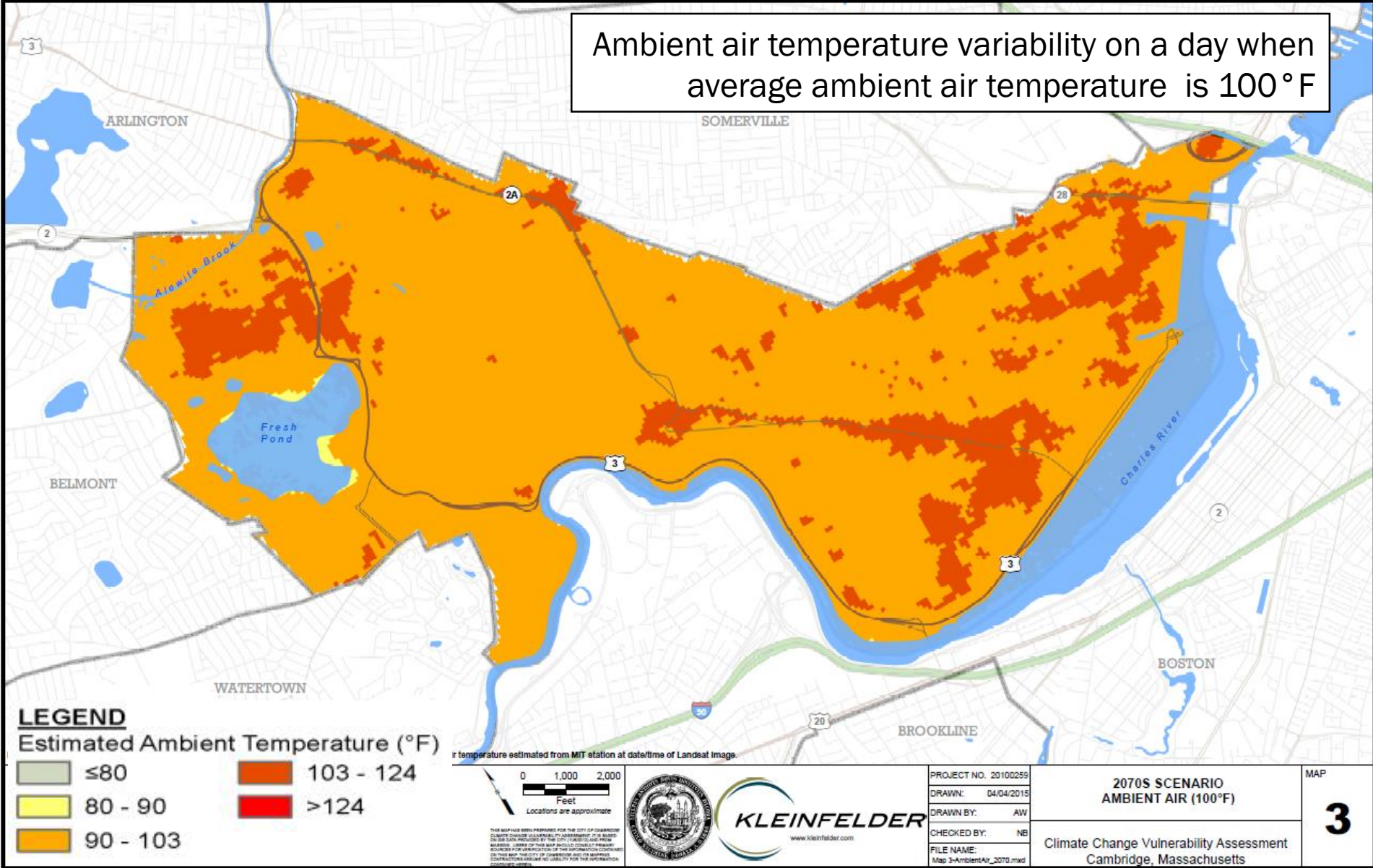
Heat Island Impacts with Ambient Air – Present Day, Existing Conditions



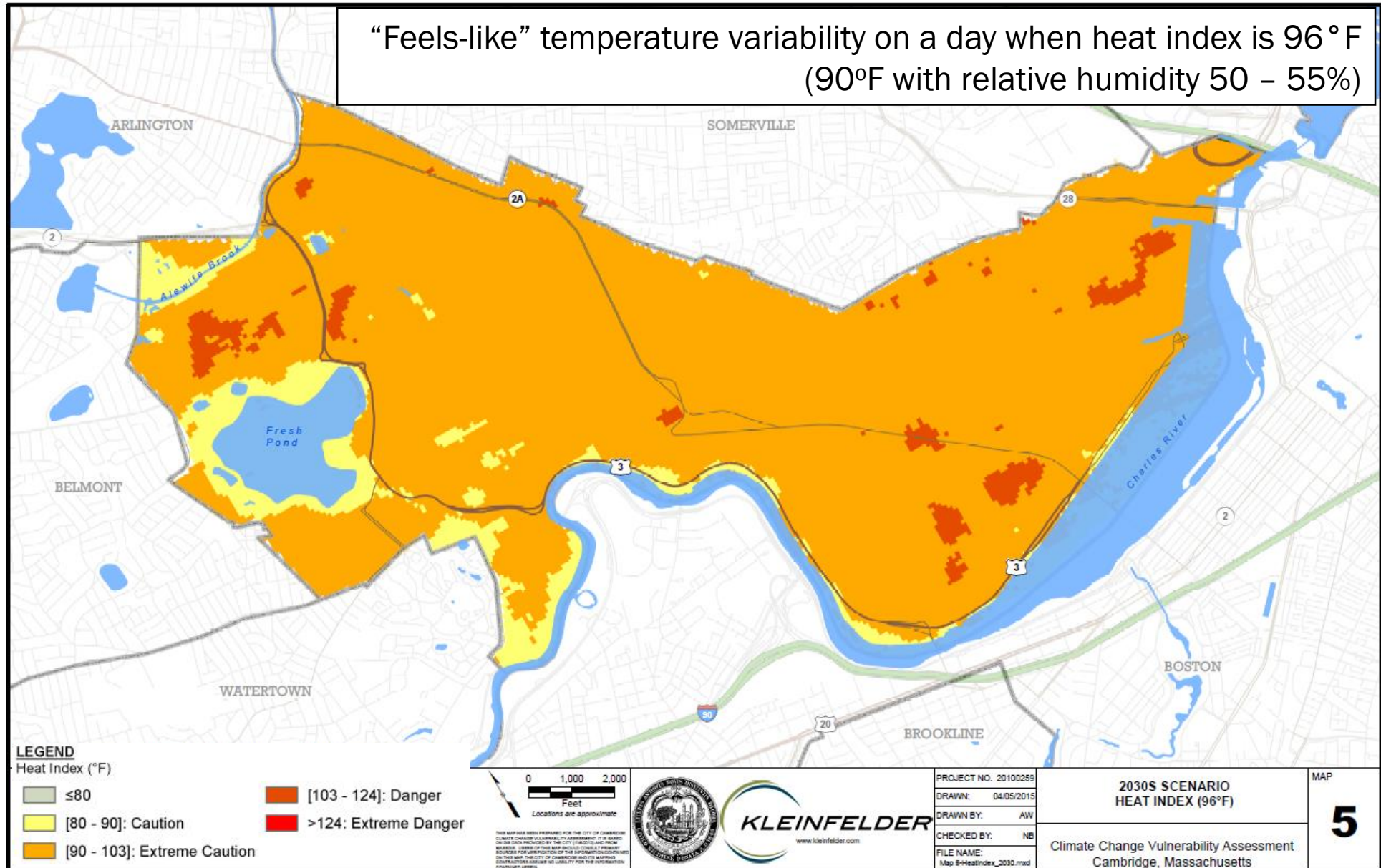
Heat Island Impacts with Ambient Air – 2030, Existing Conditions



Heat Island Impacts with Ambient Air – 2070, Existing Conditions



Heat Island Impacts with Heat Index – 2030, Existing Conditions

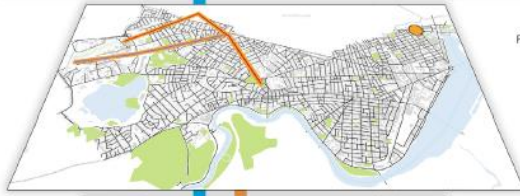


How UHI Maps were Used to Assess Heat Vulnerability

Water



Roadway



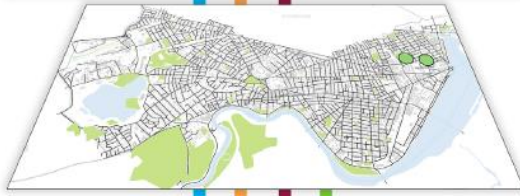
Critical Services

Cambridge Water Department building (the City's Emergency Operations Center)



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Third Street Regulator Station



Stormwater

Transit

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Critical Services

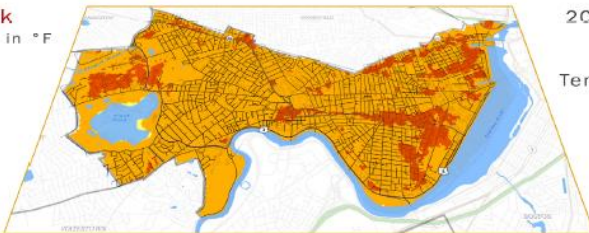
Public Health Department building on Windsor Street
Police Headquarters
Professional Ambulance Services office
Fire Department headquarters

Telecom

City Emergency Communications Center (Police HQ)

Heat Risk

Temperature in °F
 <80
 80-90
 90-103
 103-124
 >125



2070 Scenario
Estimated Ambient
Temperature of
100°F Day



Resilience Strategies

- A A Prepared Community:** Strategies to strengthen community, social, and economic resilience.
- B Adapted Buildings:** Strategies to protect buildings against projected climate change impacts.
- C Resilient Infrastructure:** Strategies to ensure continued service or a speedy recovery from community-wide infrastructure systems.
- D Resilient ecosystems:** An enhanced living environment integrating air quality, waterways, green infrastructure, and the urban forest as a system resilient to climate impacts.

*Cooling
impact of:*

Converting
impervious
surfaces to
vegetation



White roofs

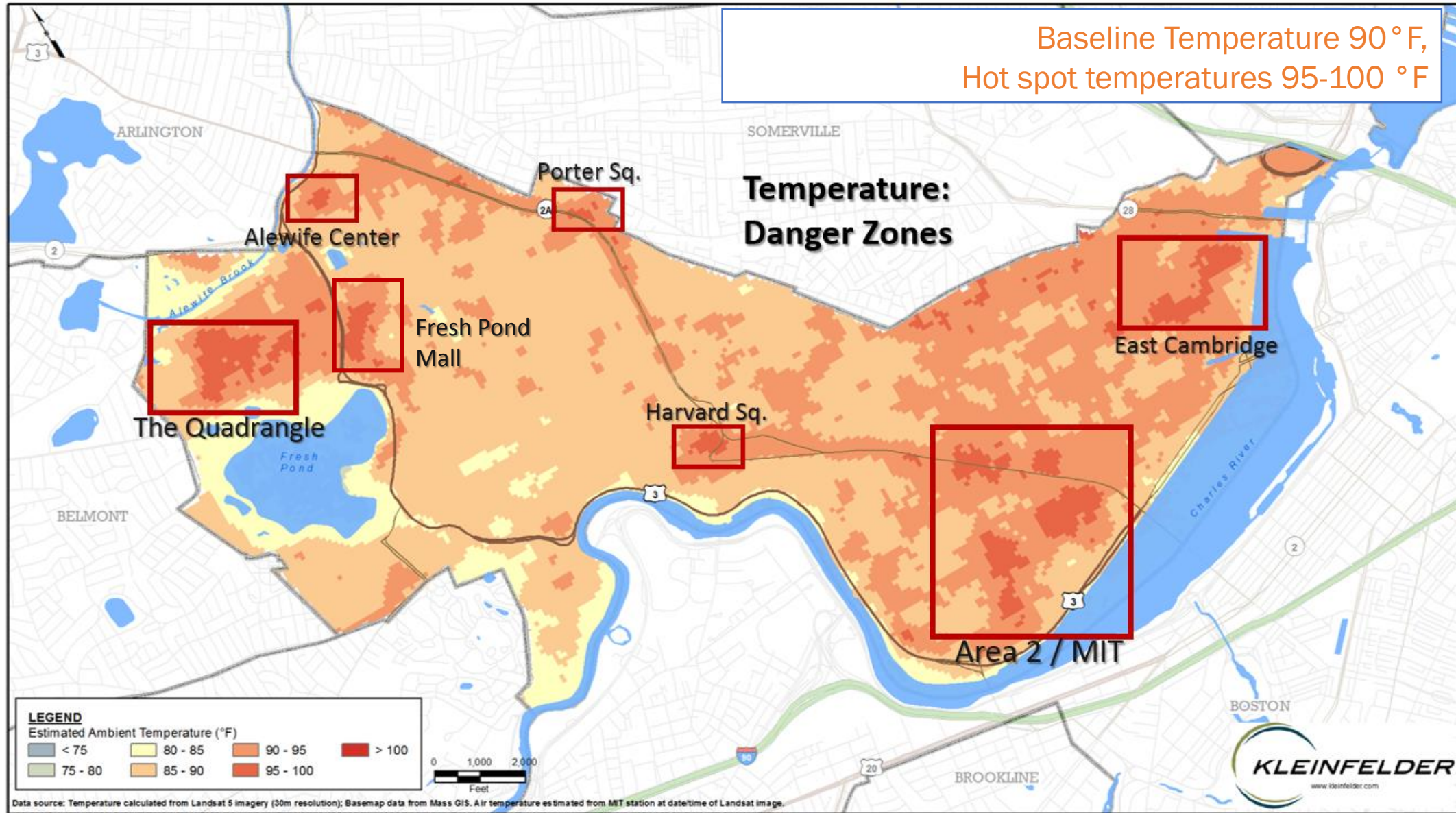


Expanding
urban forest
canopy

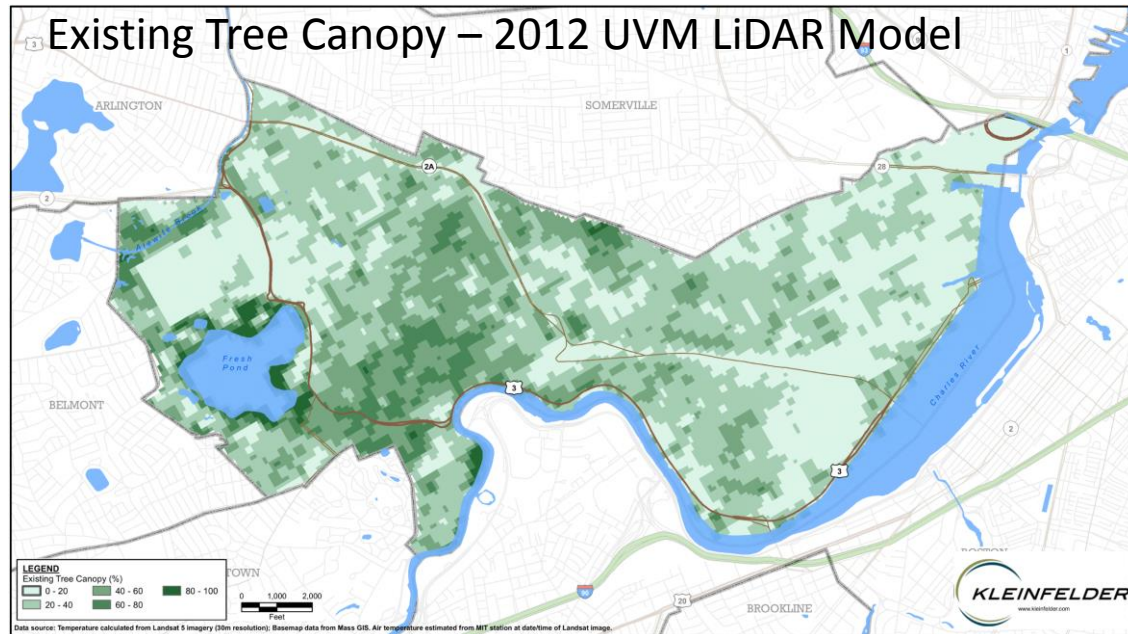


Resiliency Planning Objectives for Heat

Preparing for and Adapting to Increasing Heat Vulnerability

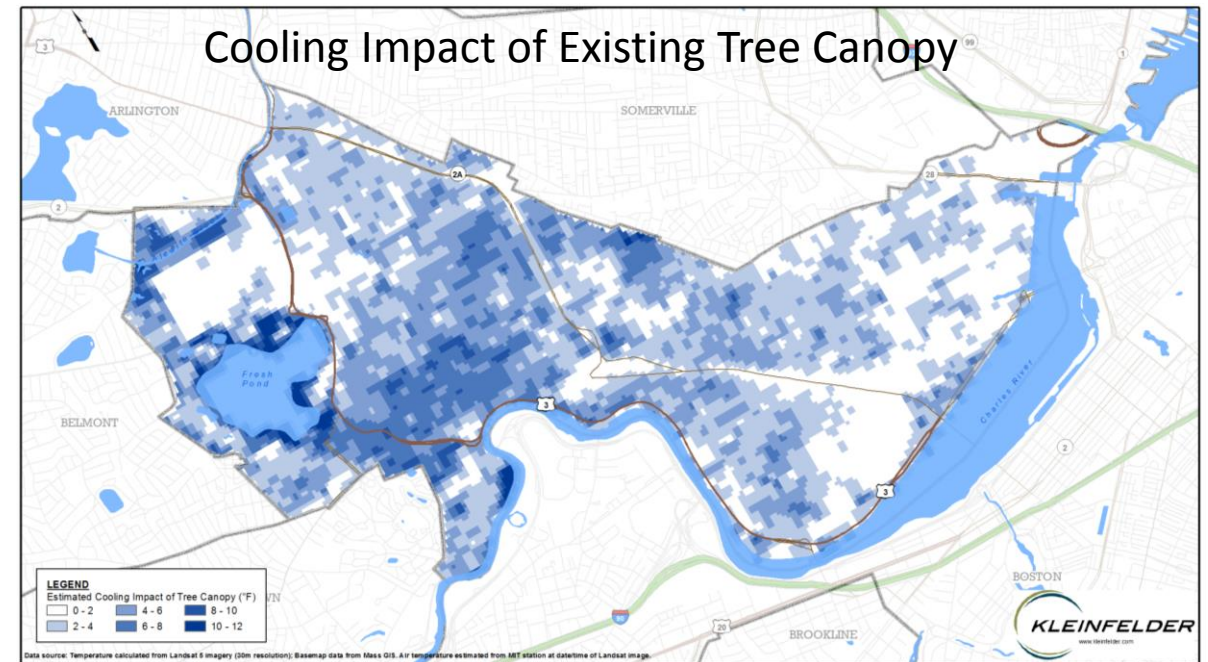


Estimating Cooling Impact of Existing Urban Forest Canopy

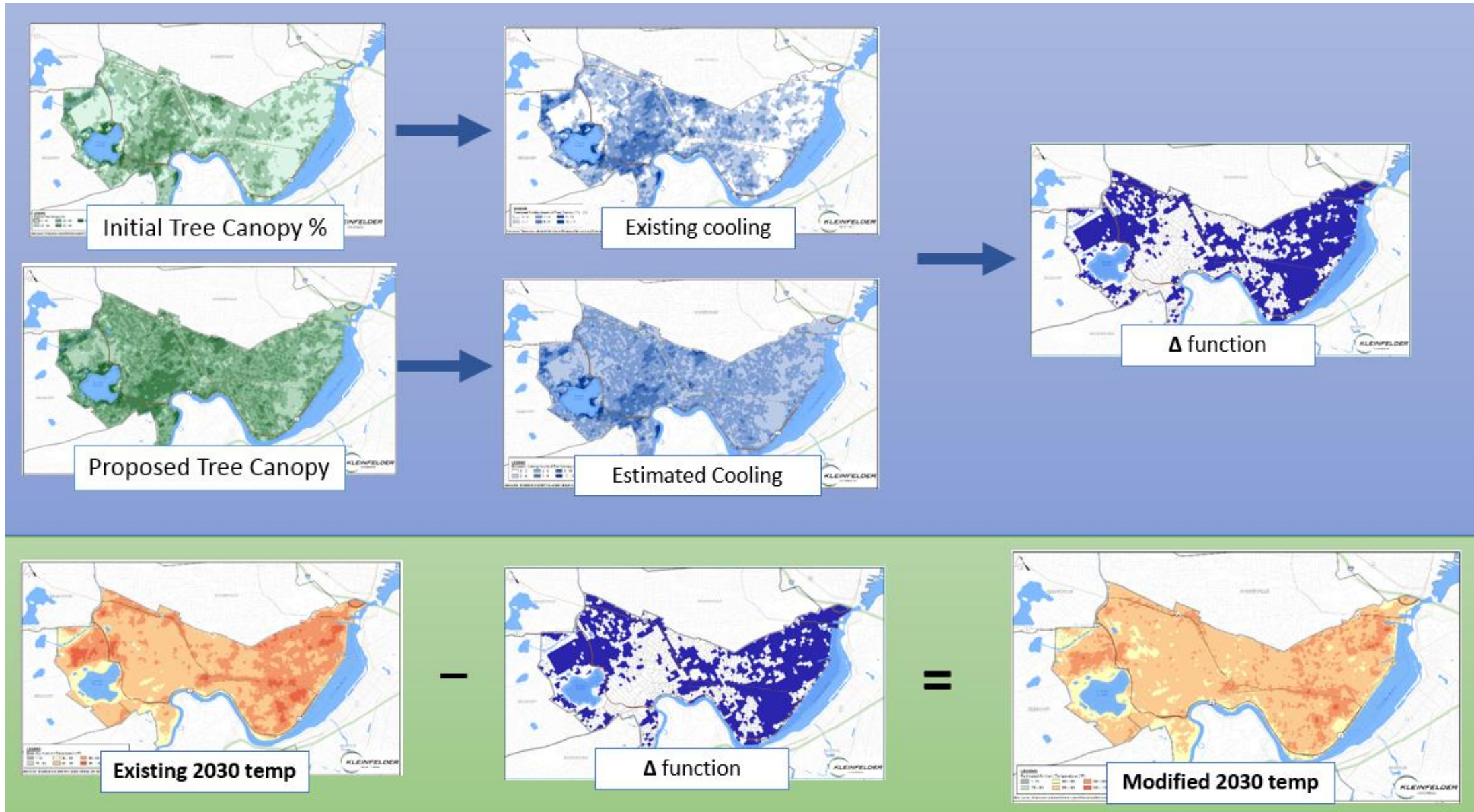


Cell Resolution: 30 meters x 30 meters (100' ft x 100' ft)

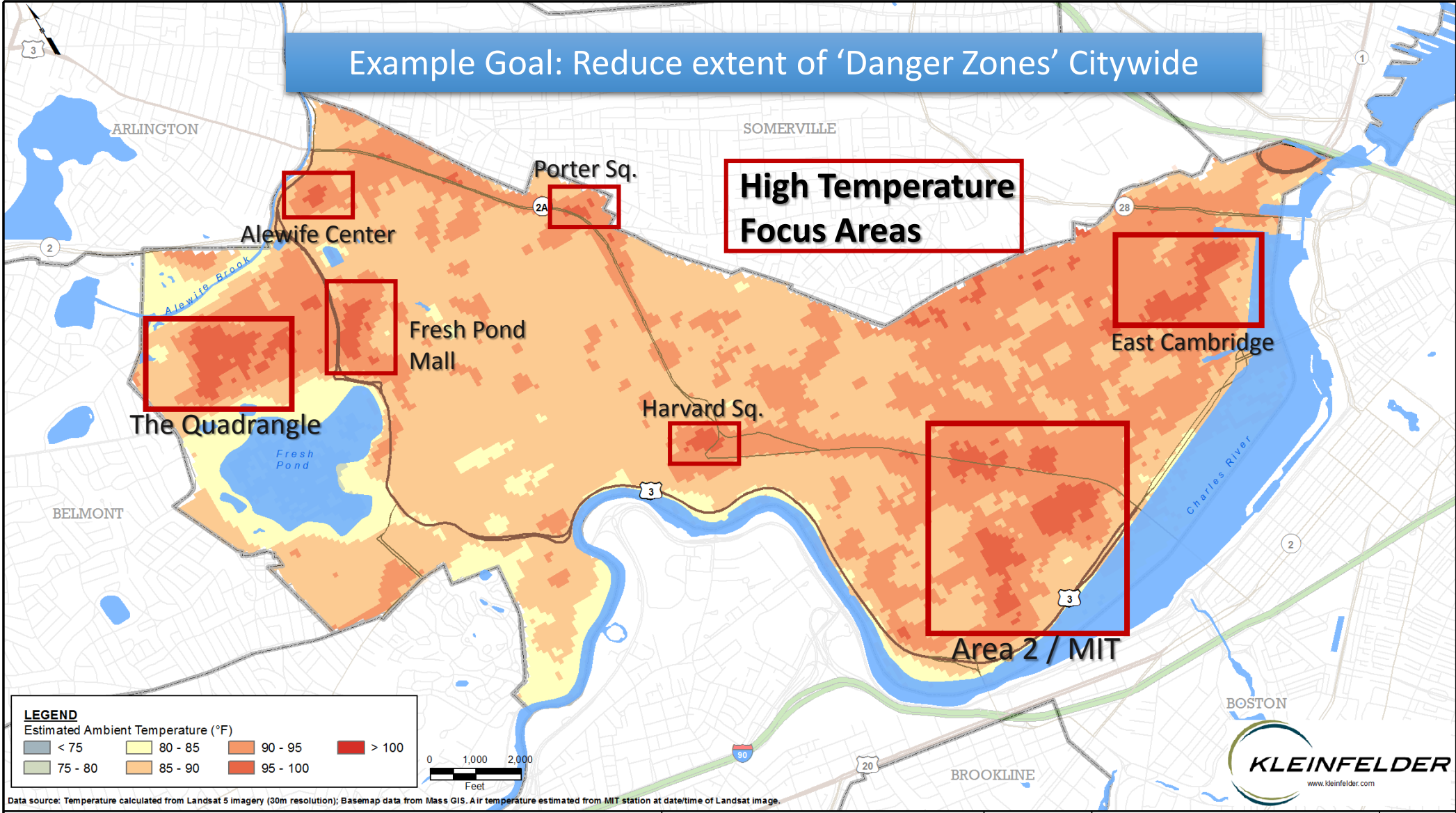
Calculated Cooling Impact:
+1% tree canopy increase relates to 0.12° F of cooling



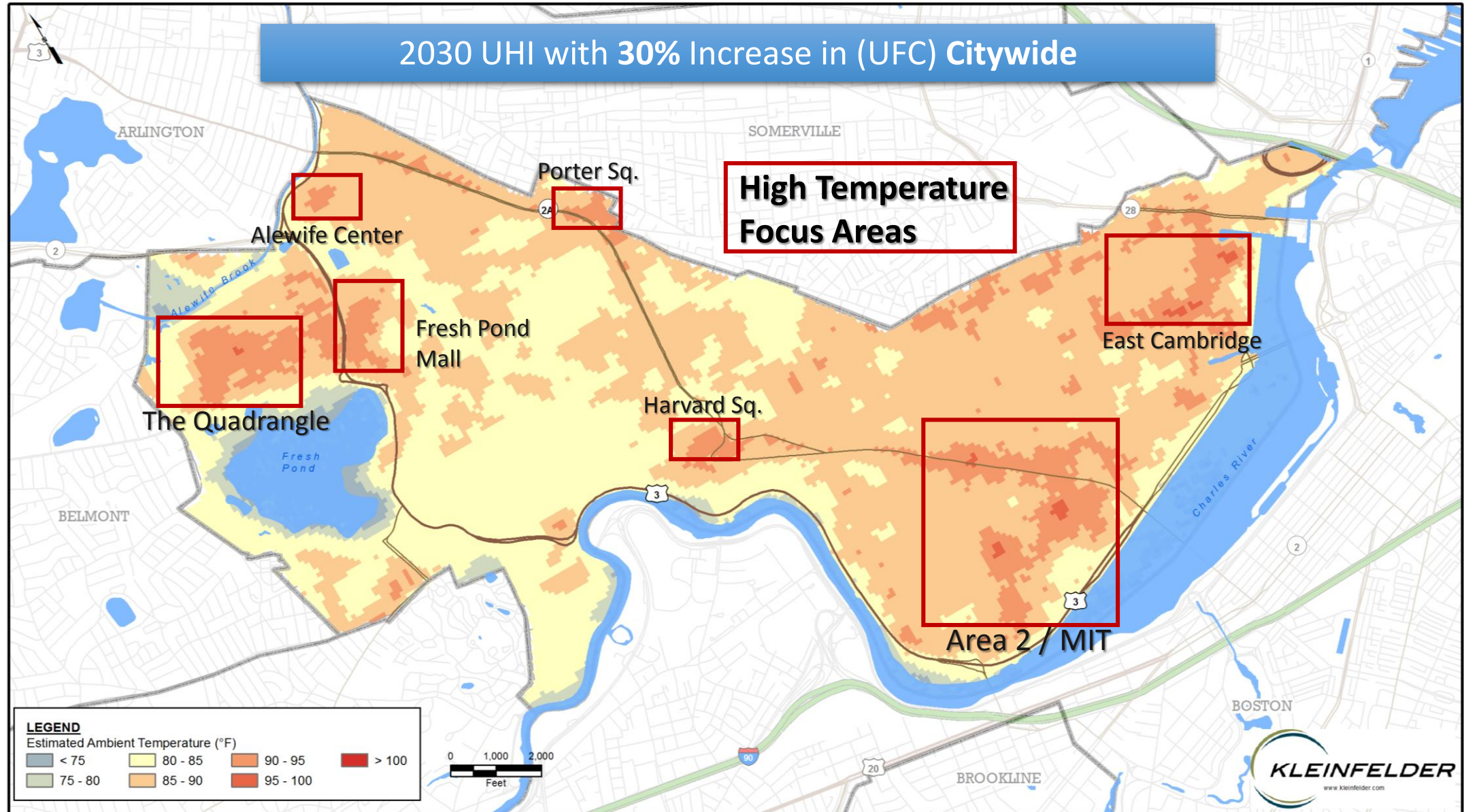
Impact of Expanding Urban Forest Canopy



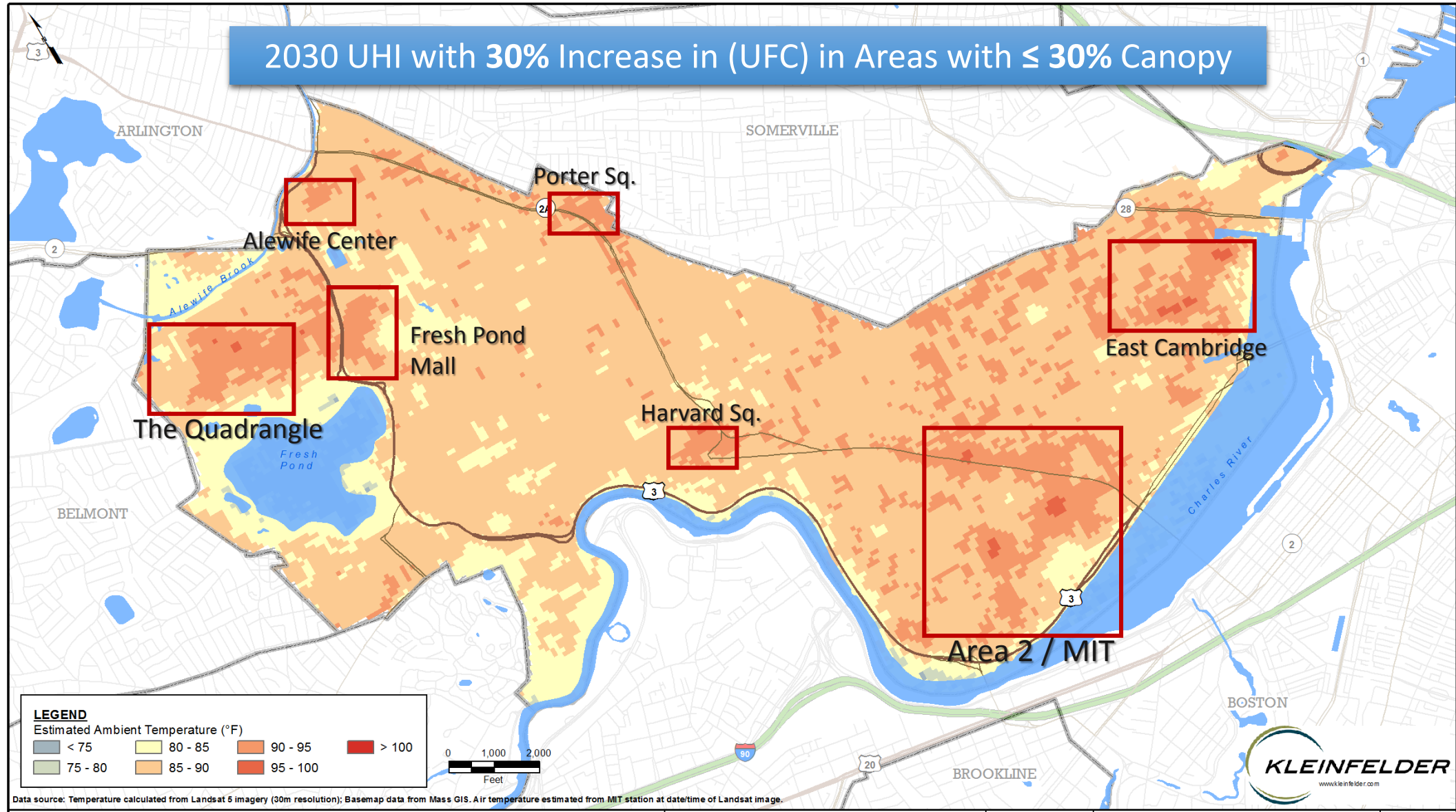
Baseline – 2030 UHI with Existing Urban Forest Canopy (UFC)



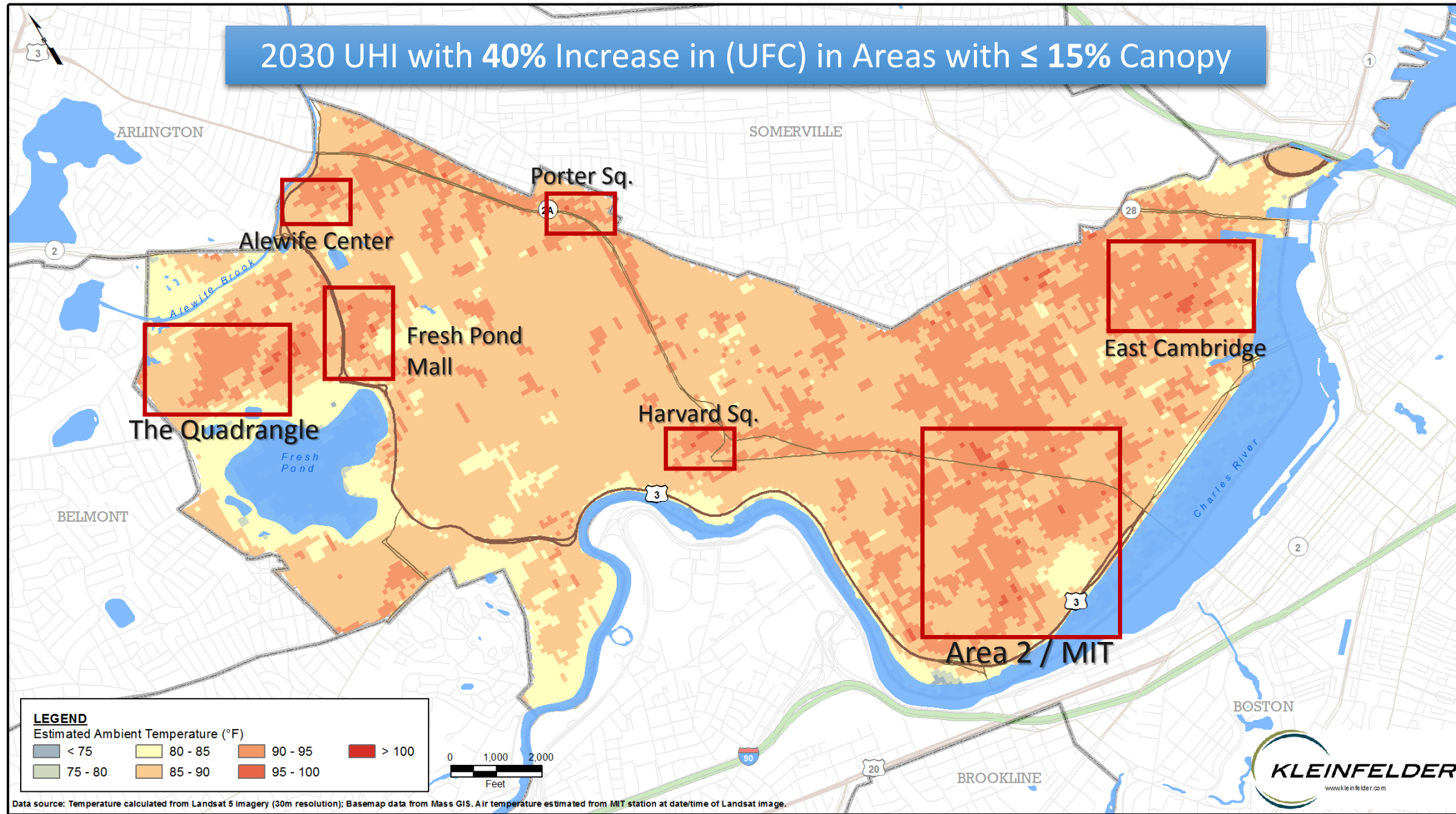
Impact of Expanding the Urban Forest Canopy



Impact of Expanding the Urban Forest Canopy



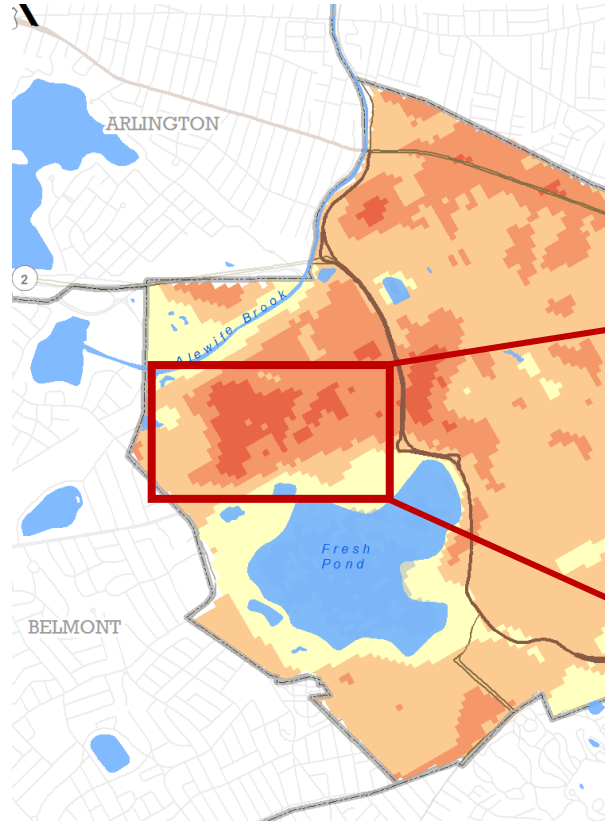
Impact of Expanding the Urban Forest Canopy



Cooling Impact Relative to Streetscape



Other Factors Contributing to UHI Effects

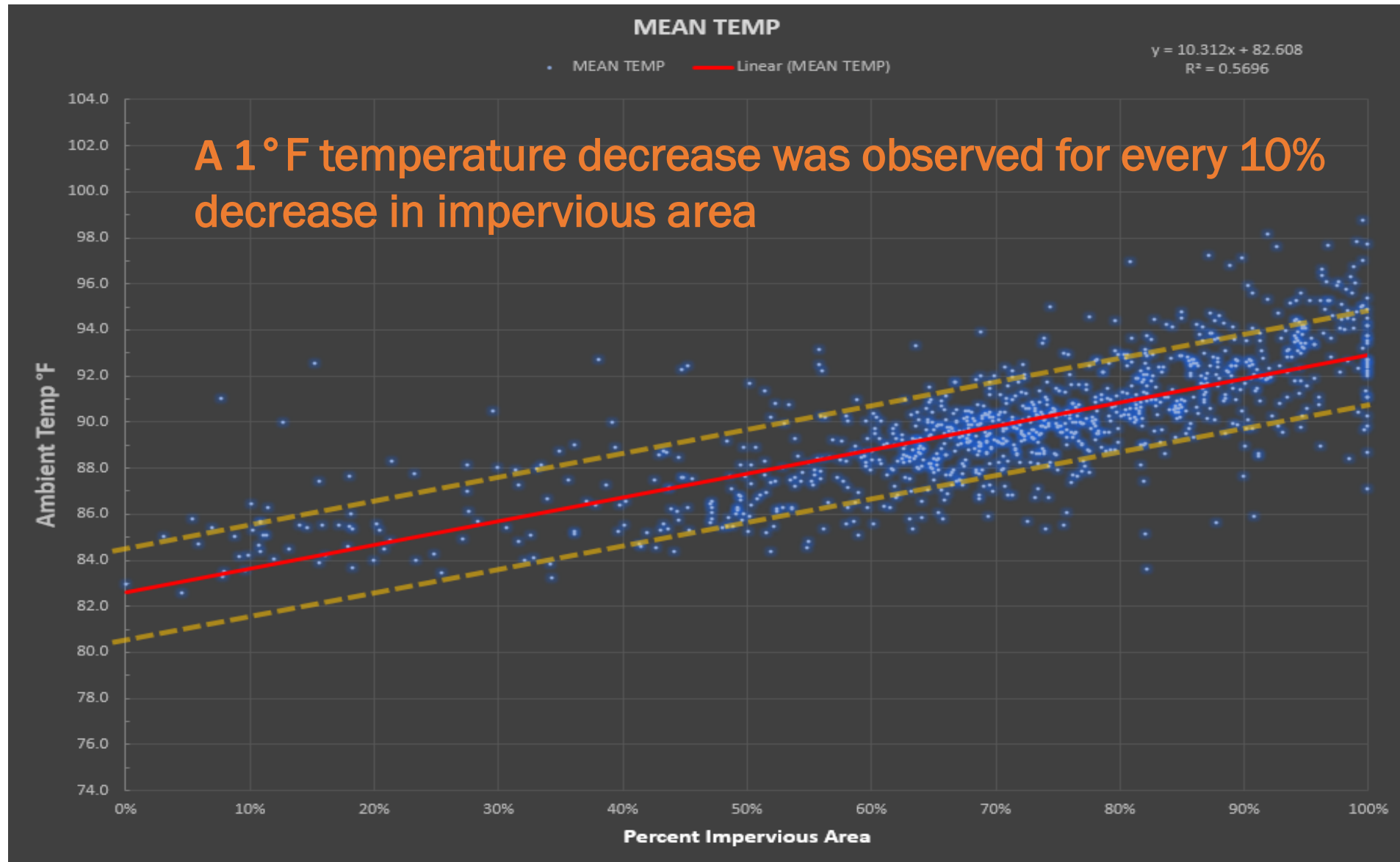


Urban Heat Island:

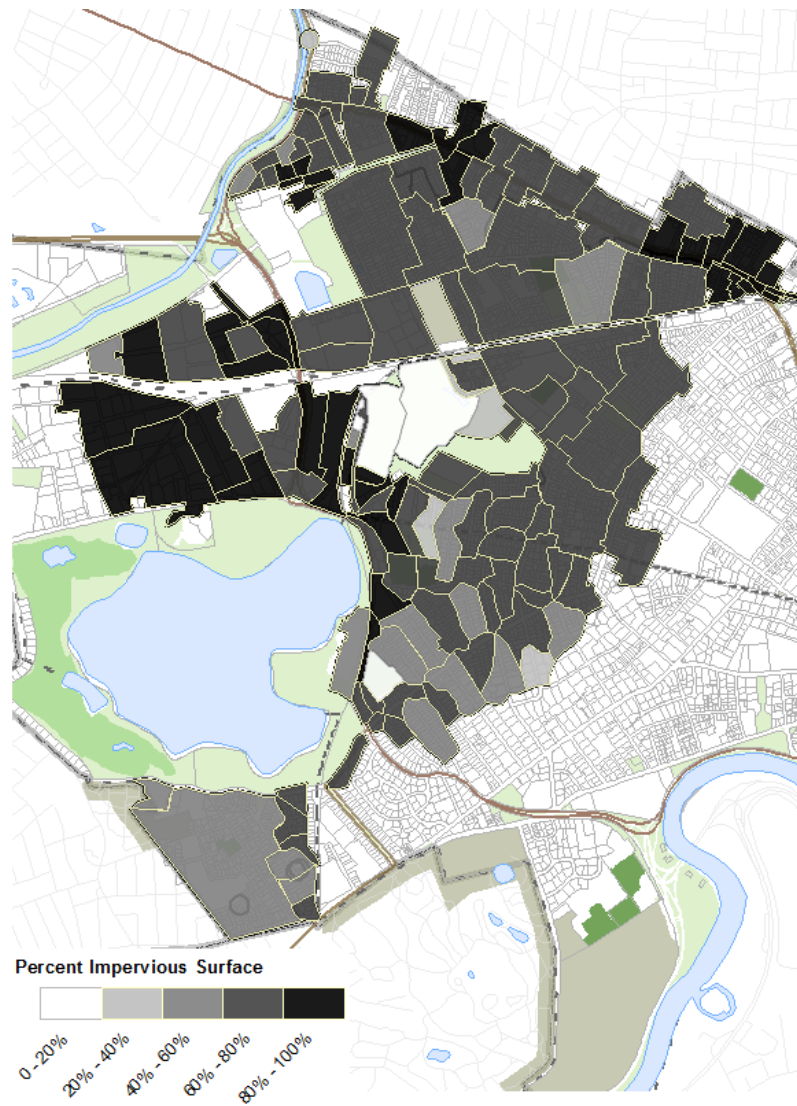
- Low Tree Canopy %
- High % Impervious Surface
- Large Square footage of roofs
- Dark roofing surfaces (Low SRI)

The Quadrangle

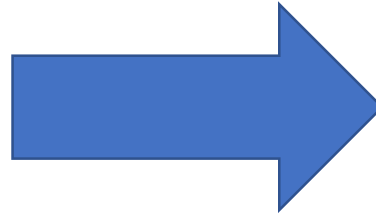
Relating Ambient Temperature and Percent Impervious Area



Green Infrastructure Effectively Reduces Impervious Area

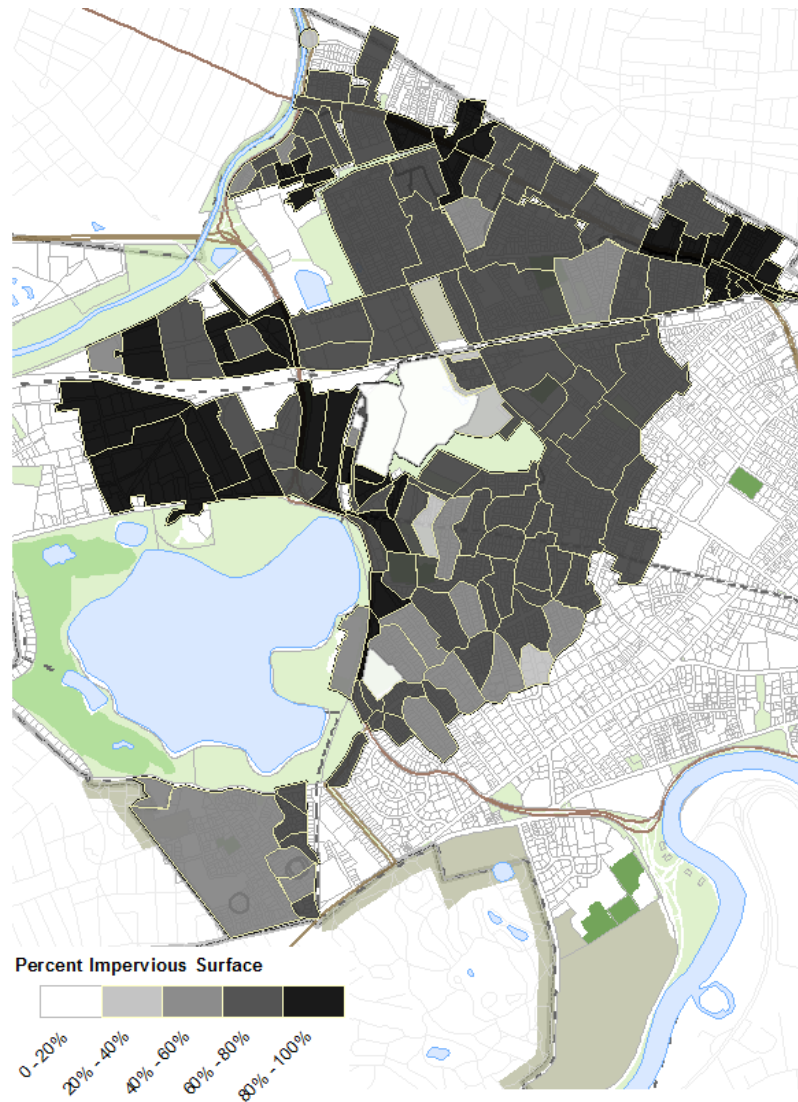


Existing Impervious Surface by Catchment

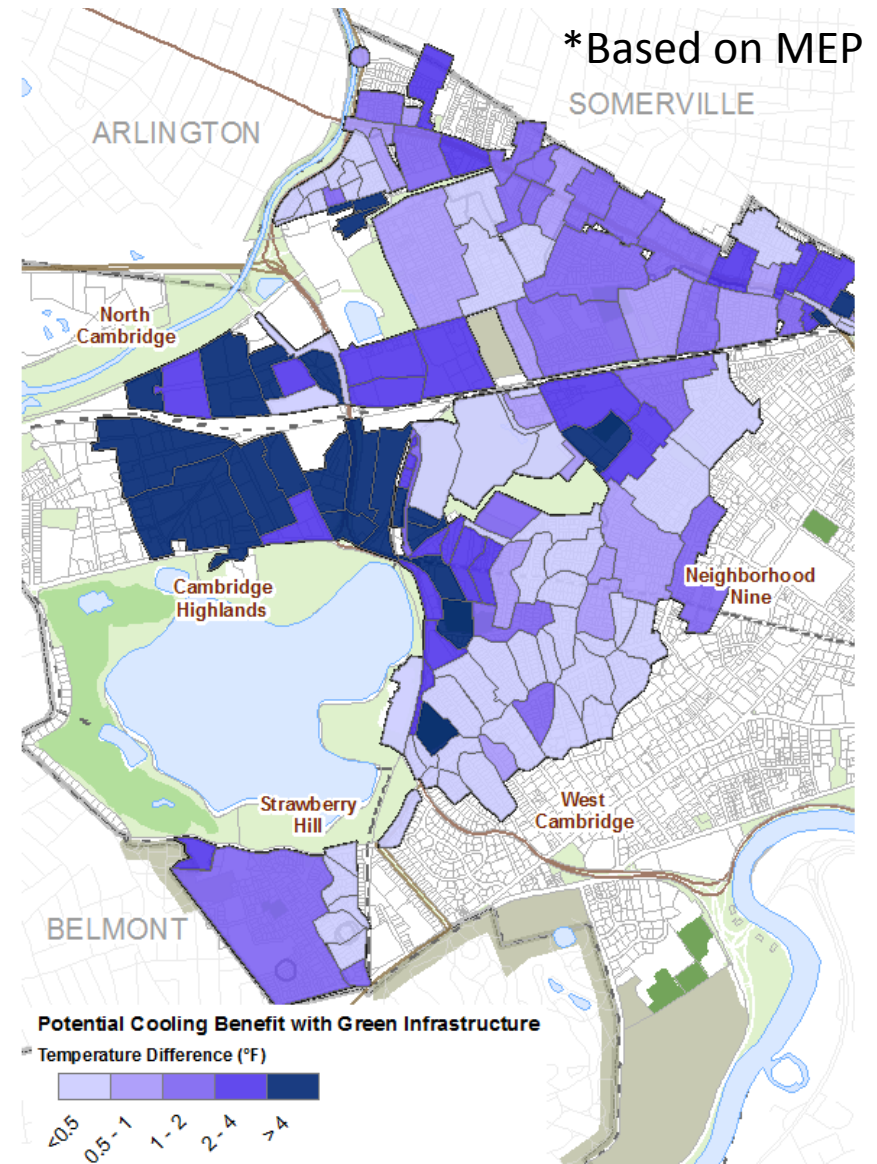


Proposed Impervious Surface with Green Infrastructure at MEP

Cooling Benefits of Green Infrastructure

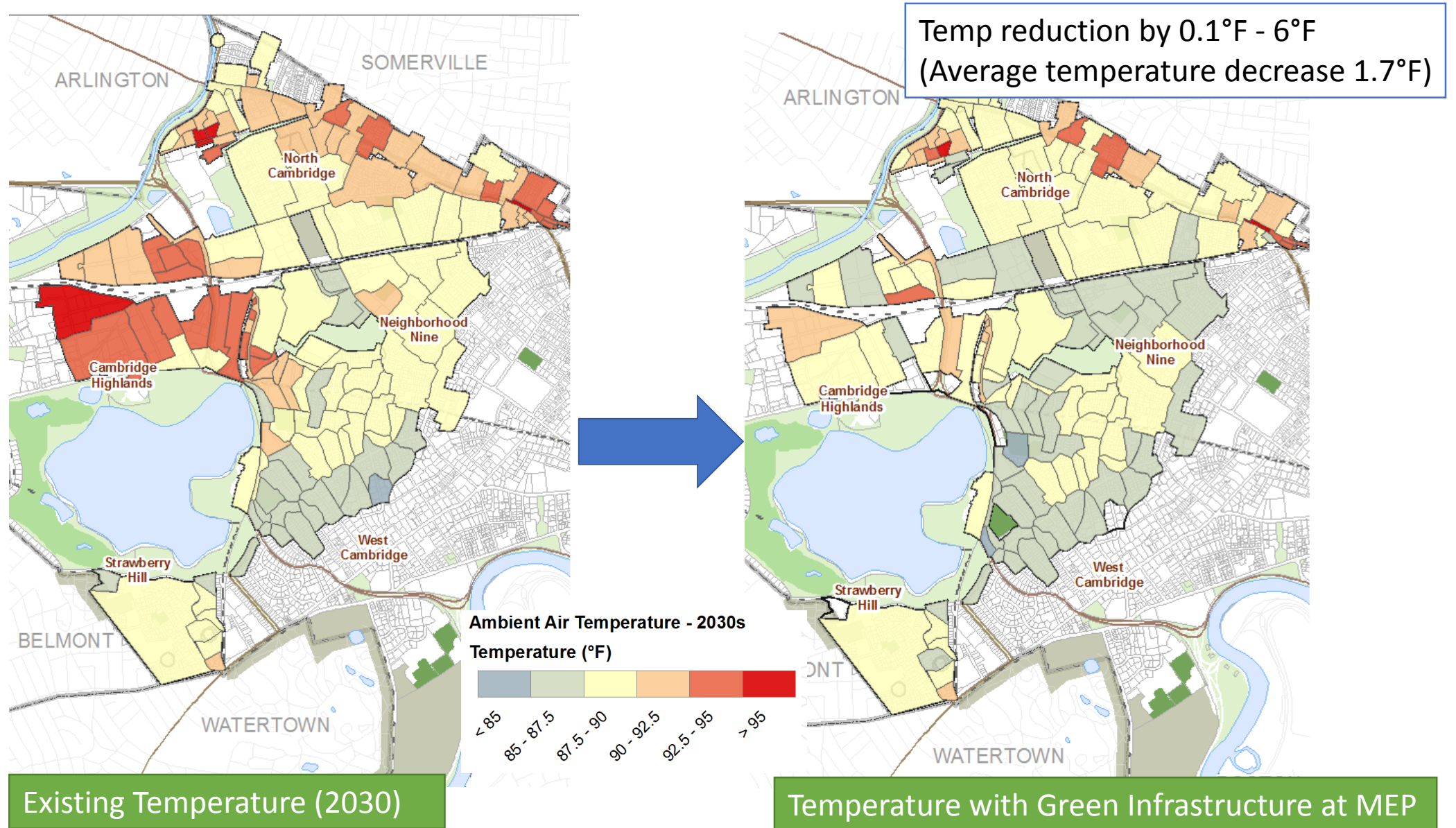


Existing Impervious Surface by Catchment

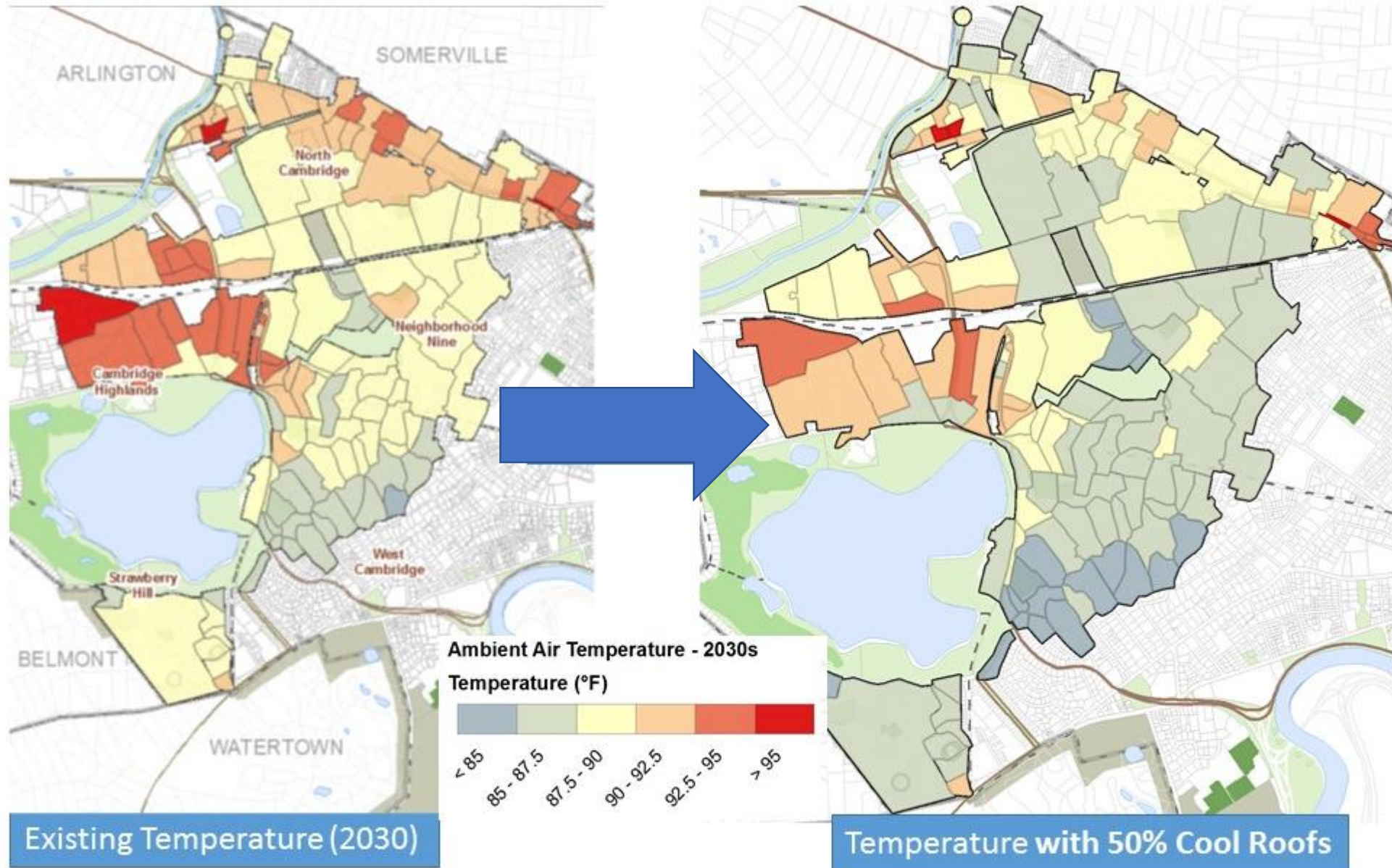


Cooling Benefit is determined by the *difference* in impervious area %

Impact of Green Infrastructure on UHI



Impact of White Roofs on UHI



What are Some Preliminary Findings?

- **A 1% tree canopy increase relates to 0.12 °F of cooling.** For street trees, approximately an average of 1°F cooling is achieved per tree per 100 ft, with a range between 0.15-6.2°F.
- **Green Infrastructure may reduce ambient temperature by 0.1°F - 6°F,** as a function of reduction of impervious areas, with an average temperature decrease of 1.7°F (area-weighted average across all catchments).
- **White roofs yielded a 2.4°F cooling benefit** with a 50% level of implementation across existing buildings (area weighted average)
- White roofs are more effective in cooling, but do not have the additional benefits of **water quality improvement and flood reduction** for smaller storms.

What is the combined effect of urban forest canopy and green infrastructure strategies?

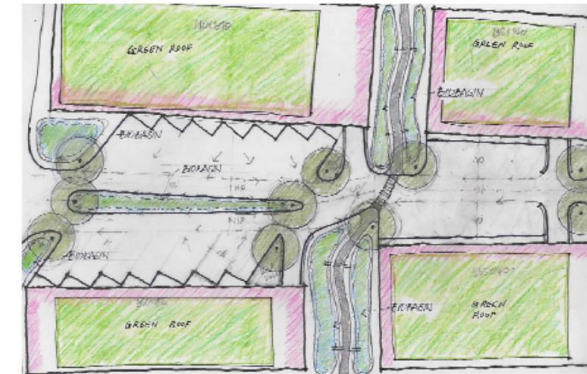


Figure 22: GI Concept for Light Industrial Parcel

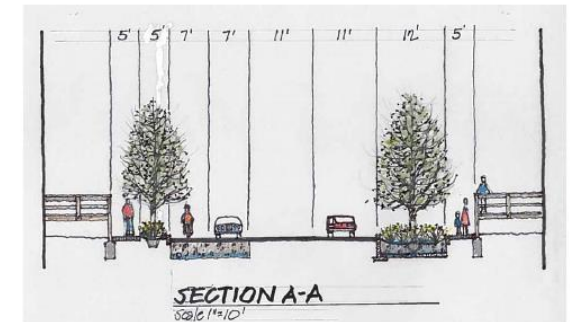


Figure 18: Section A-A for GI Concept for Public ROW Parcel

Next steps

- Combine the analysis to see the effect of mixed tactics
- Conclusion: modeling indicates City should target its efforts at neighborhood scale rather than set citywide goals
- Need to understand night temperatures
- Need to understand if there are regional effects and opportunities; Metro Mayors getting new data mapping UFC across 14 communities
- Ground mounted temperature and humidity sensors would provide more refined analysis, including night temperatures and seasonal differences and allow monitoring of trends due to climate change and implementation of actions

Contact Info

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Link to Project Website:

<http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilienceandadaptation.aspx>

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