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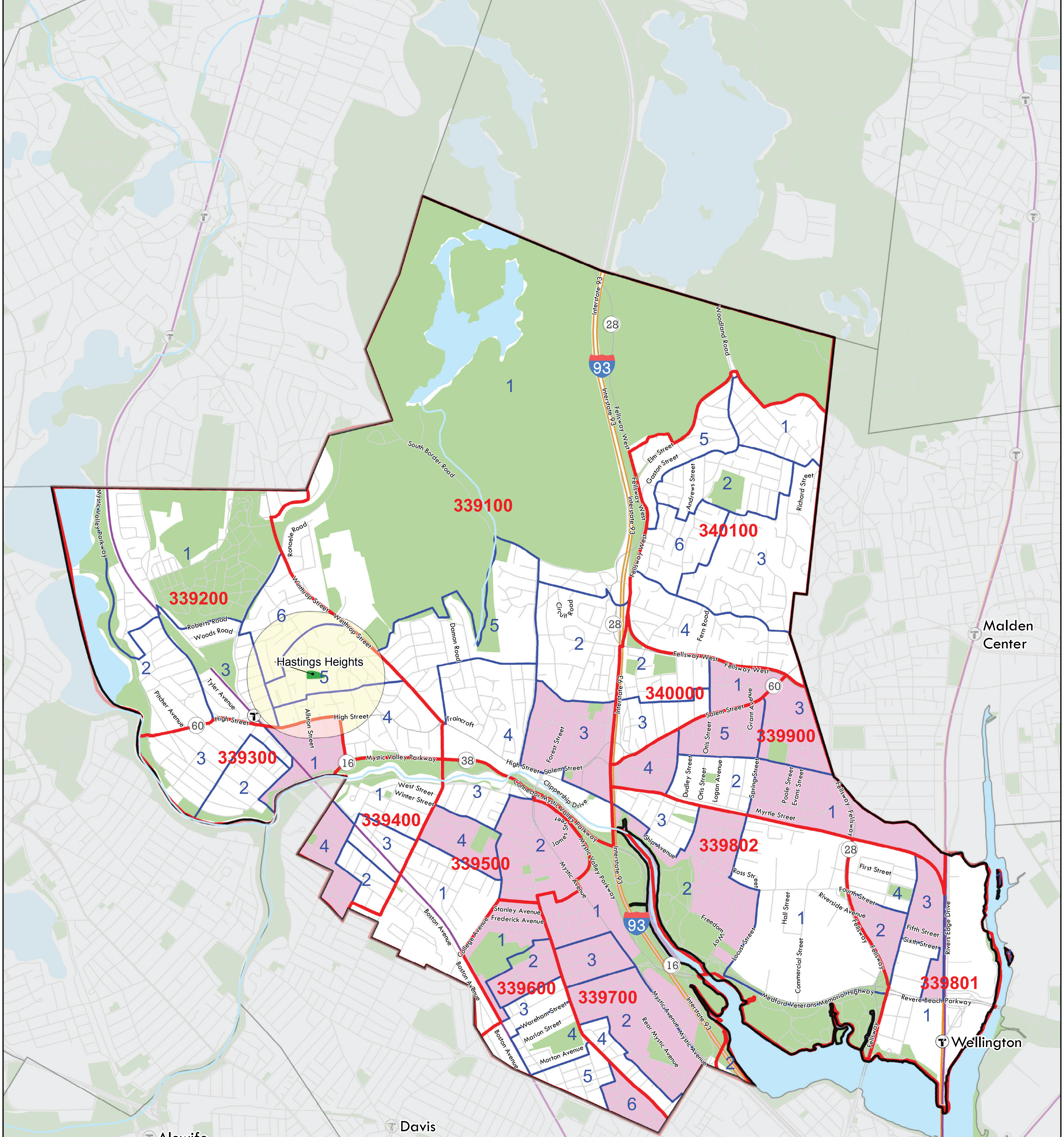

Census Tract Boundary

Block Group Boundary

Low/Moderate Income Population 51% or higher

Featured Park

1/4 Mile Buffer

Open Space

T Stations

Orange Line

Commuter Rail Line

NOTE: Low- and Moderate-Income Summary Data based on 2011-2015 American Community Survey estimates. Effective date for use of data: April 1, 2019.

0 0.25 0.5 1 Miles

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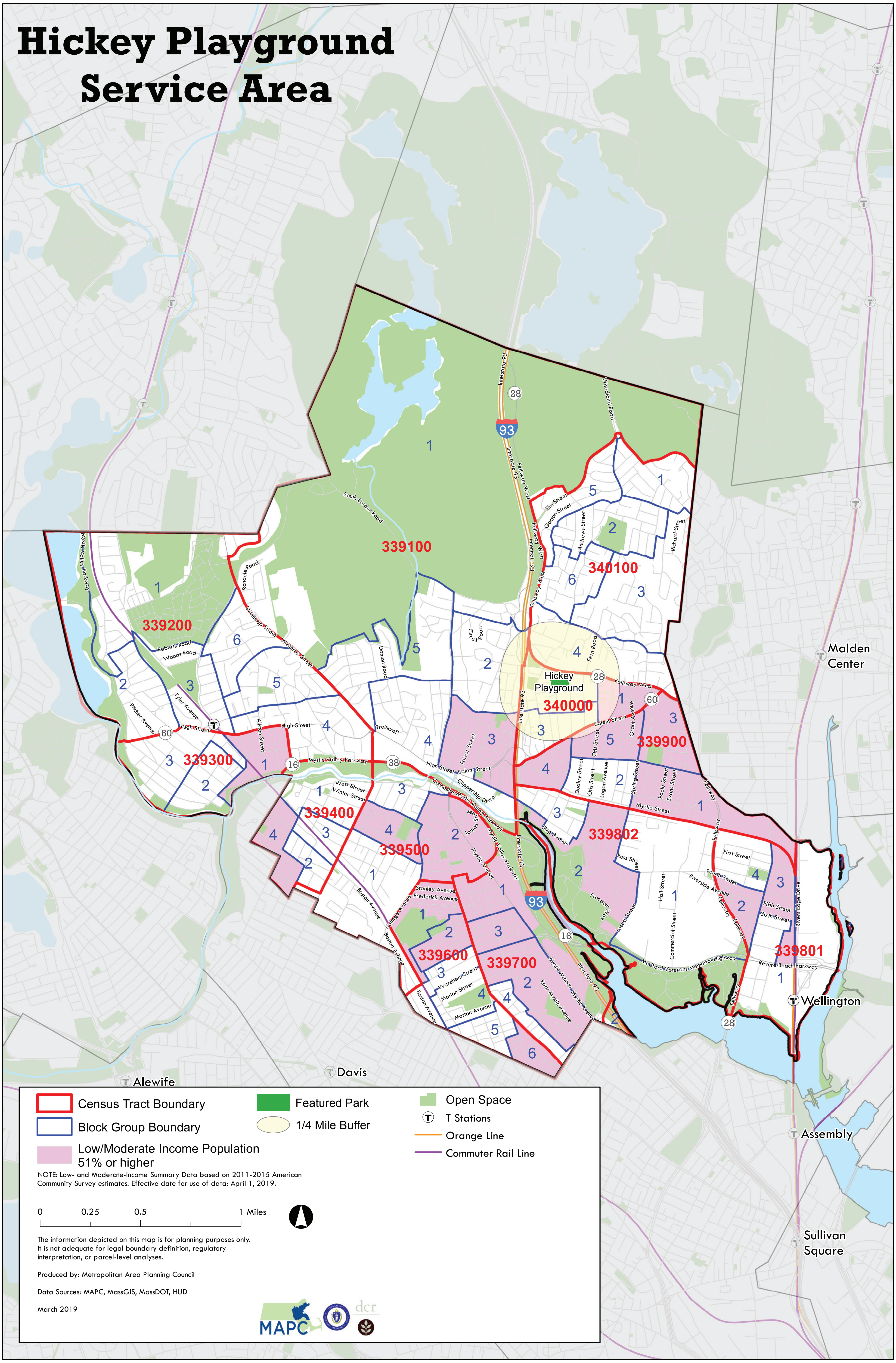
Produced by: Metropolitan Area Planning Council

Data Sources: MAPC, MassGIS, MassDOT, HUD

March 2019

MAPC dcr

Hickey Playground Service Area



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MAPC dcr

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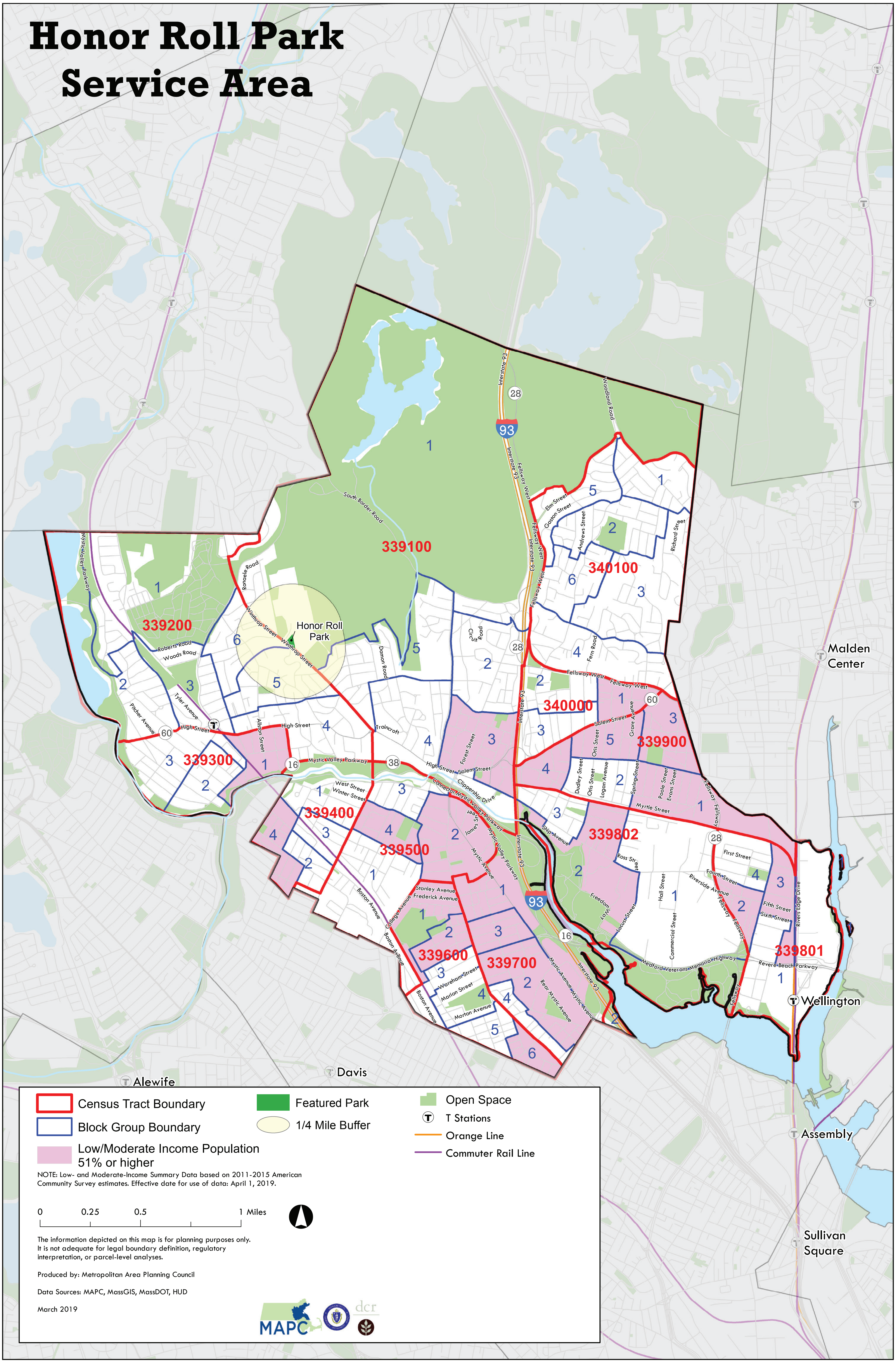

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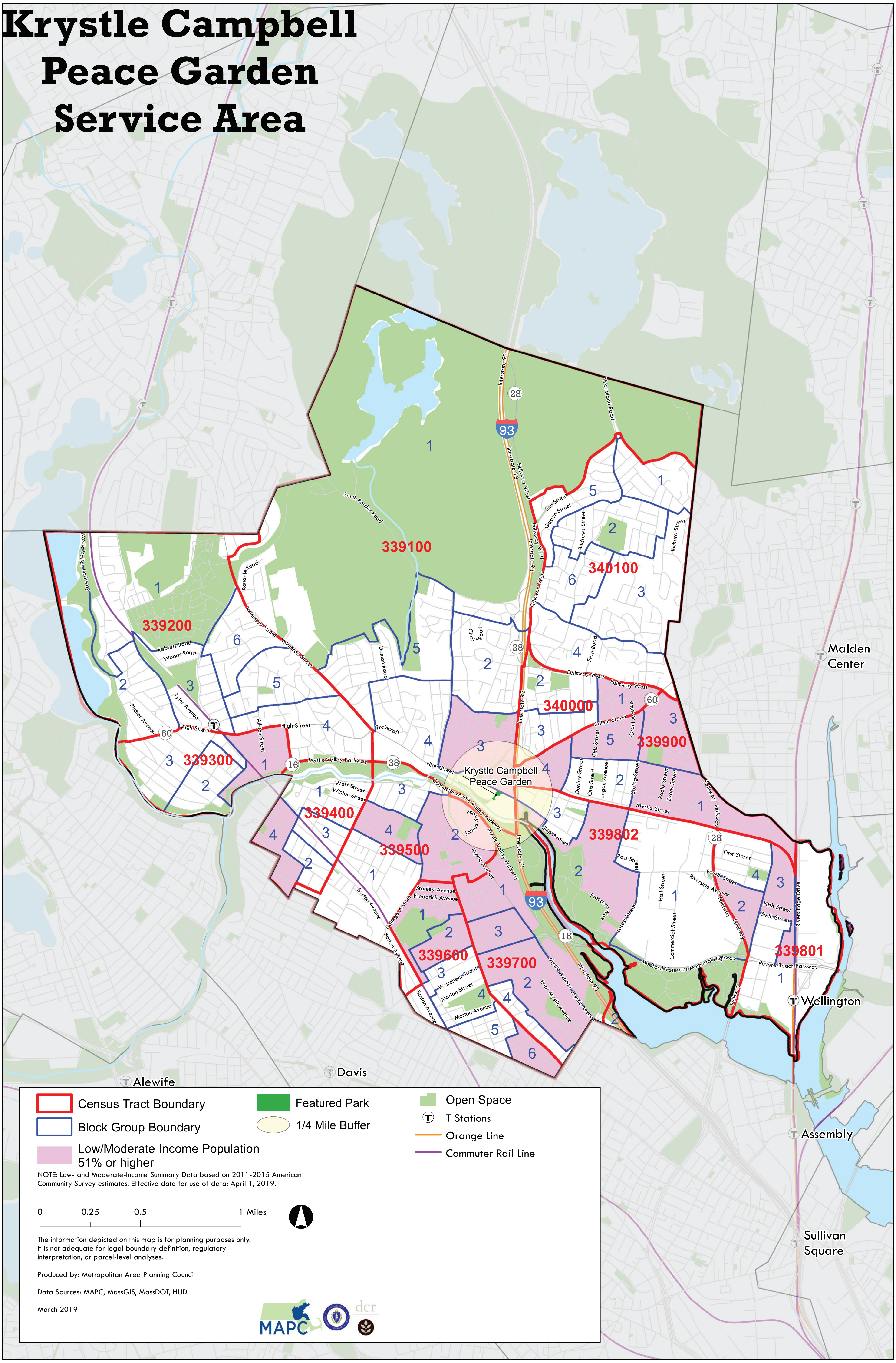

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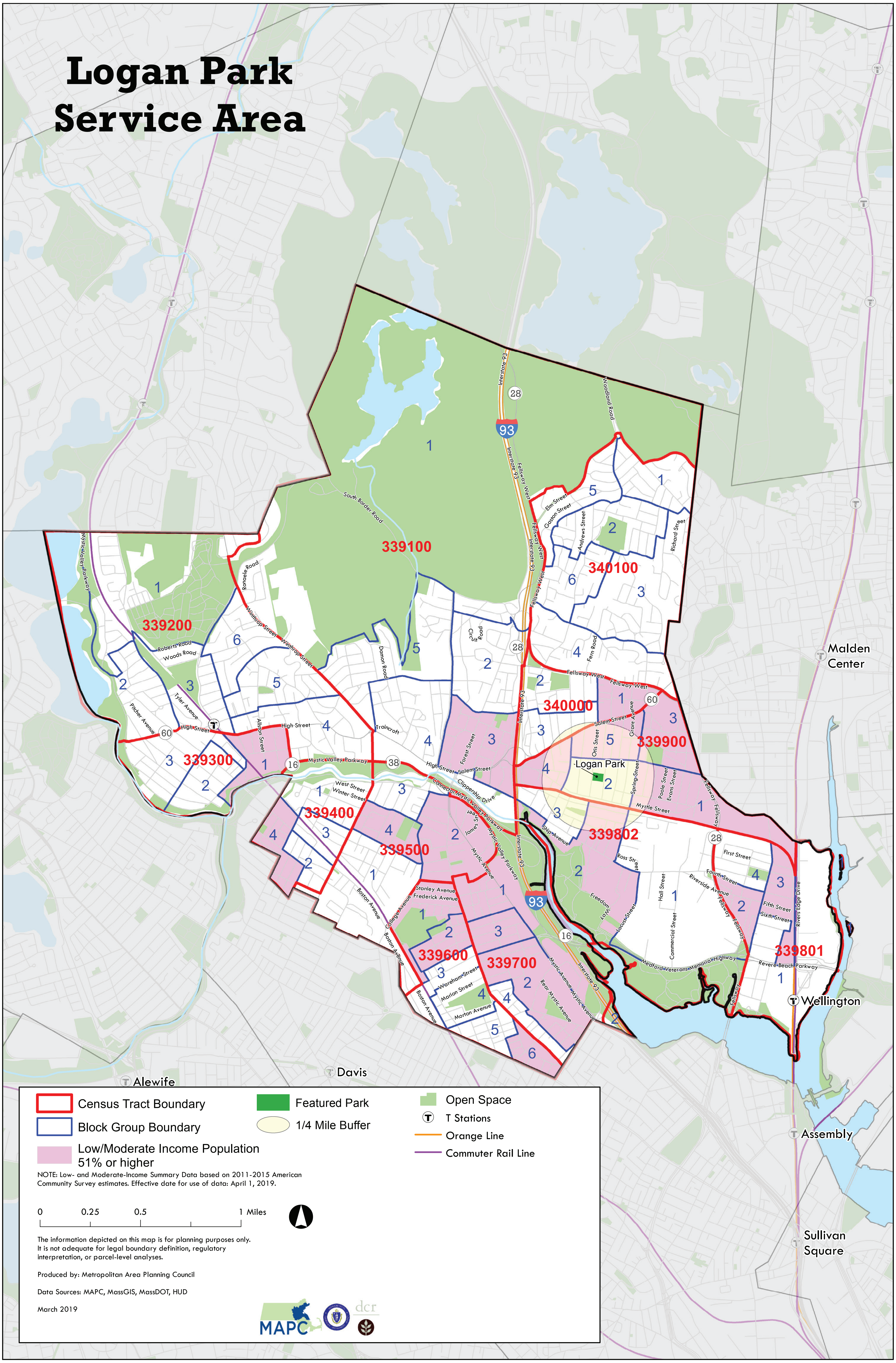

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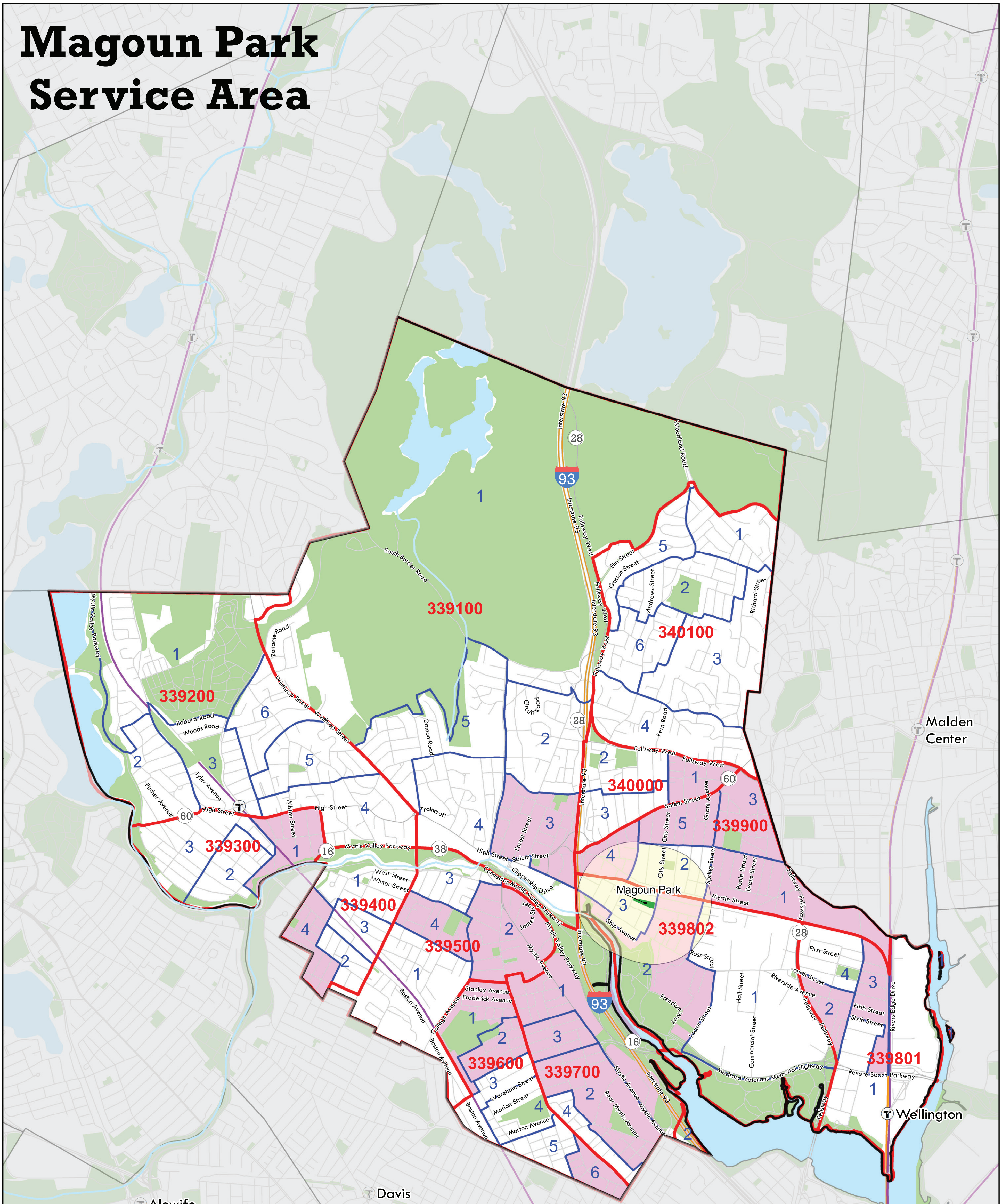

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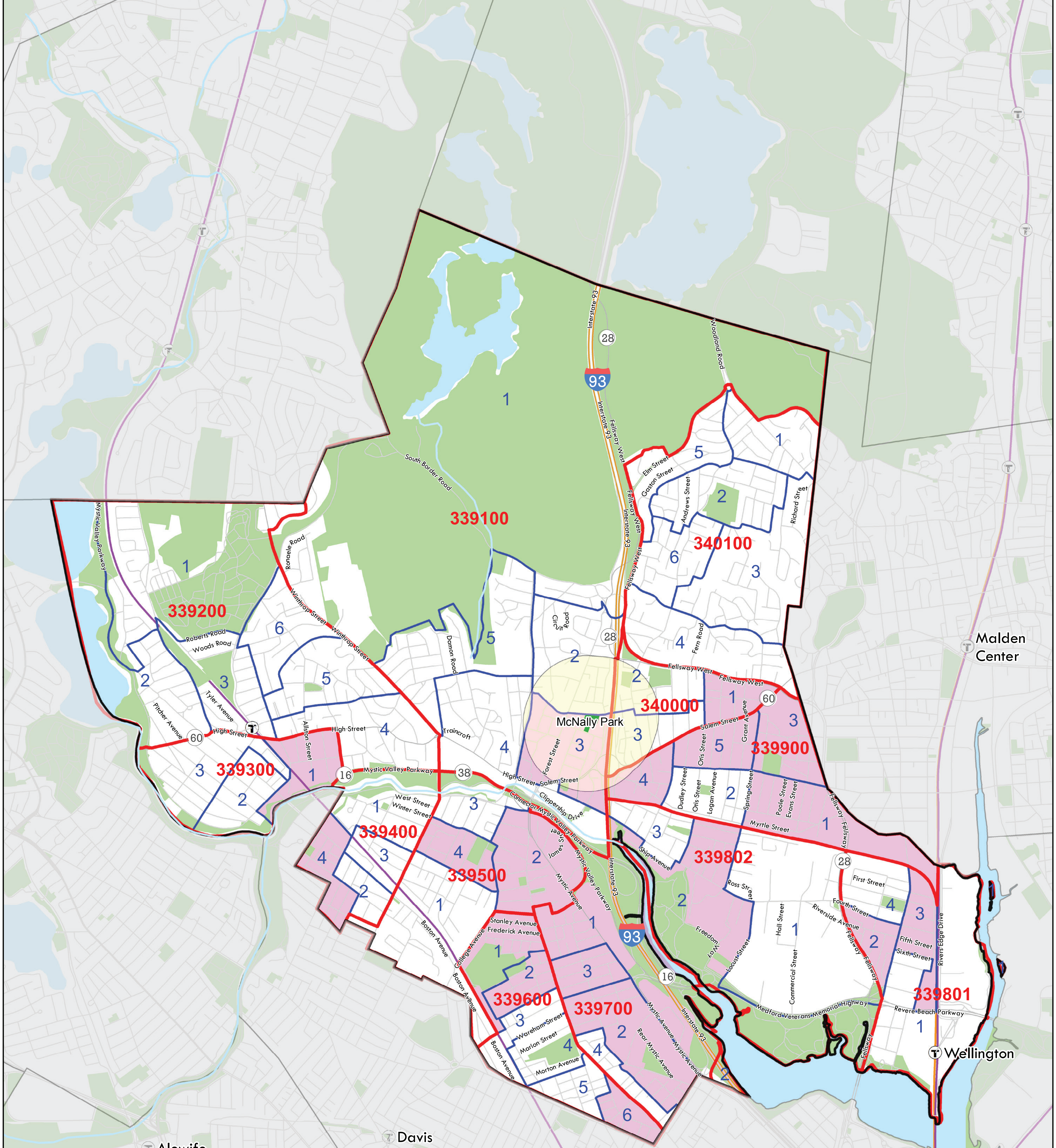

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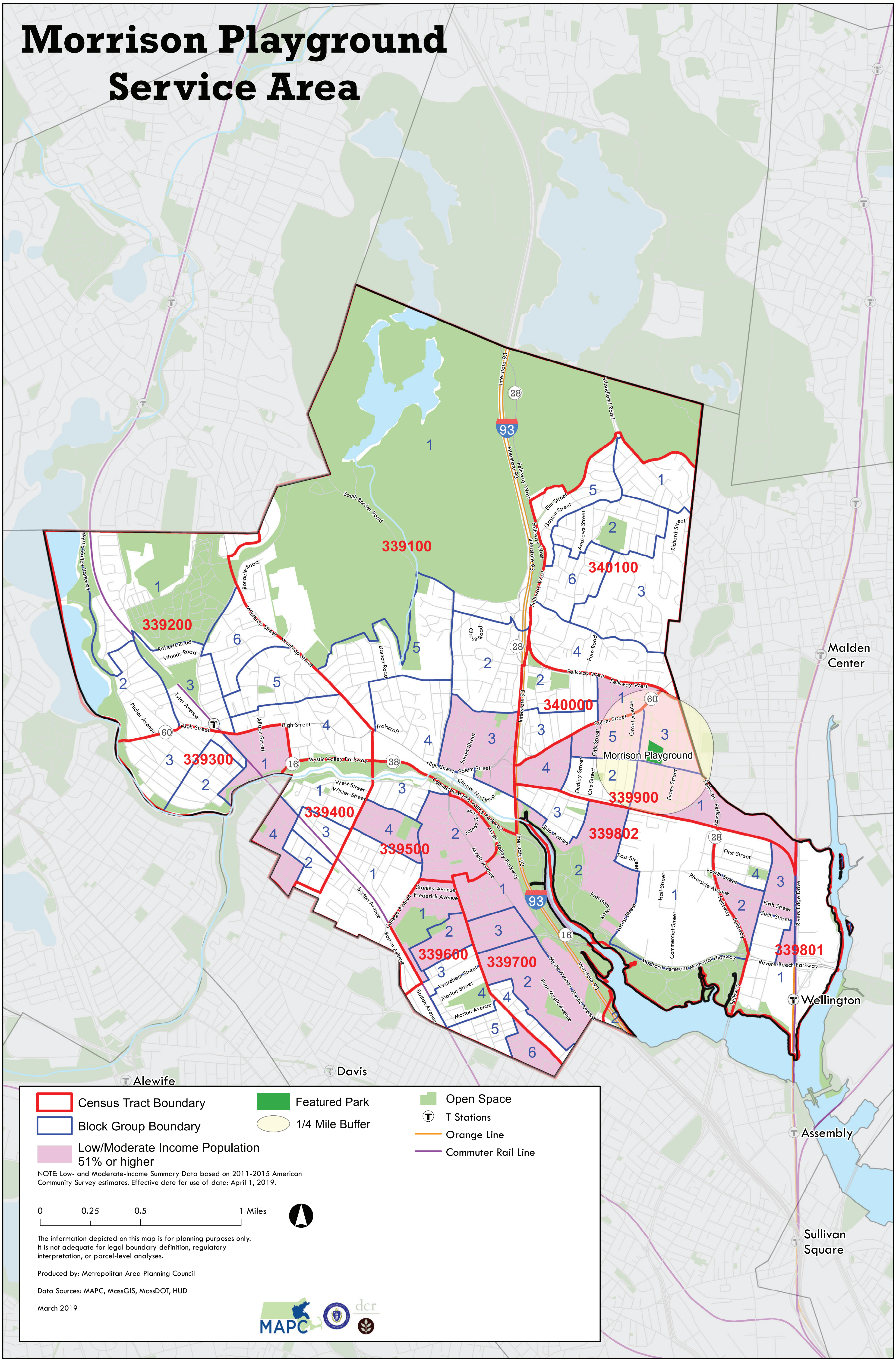

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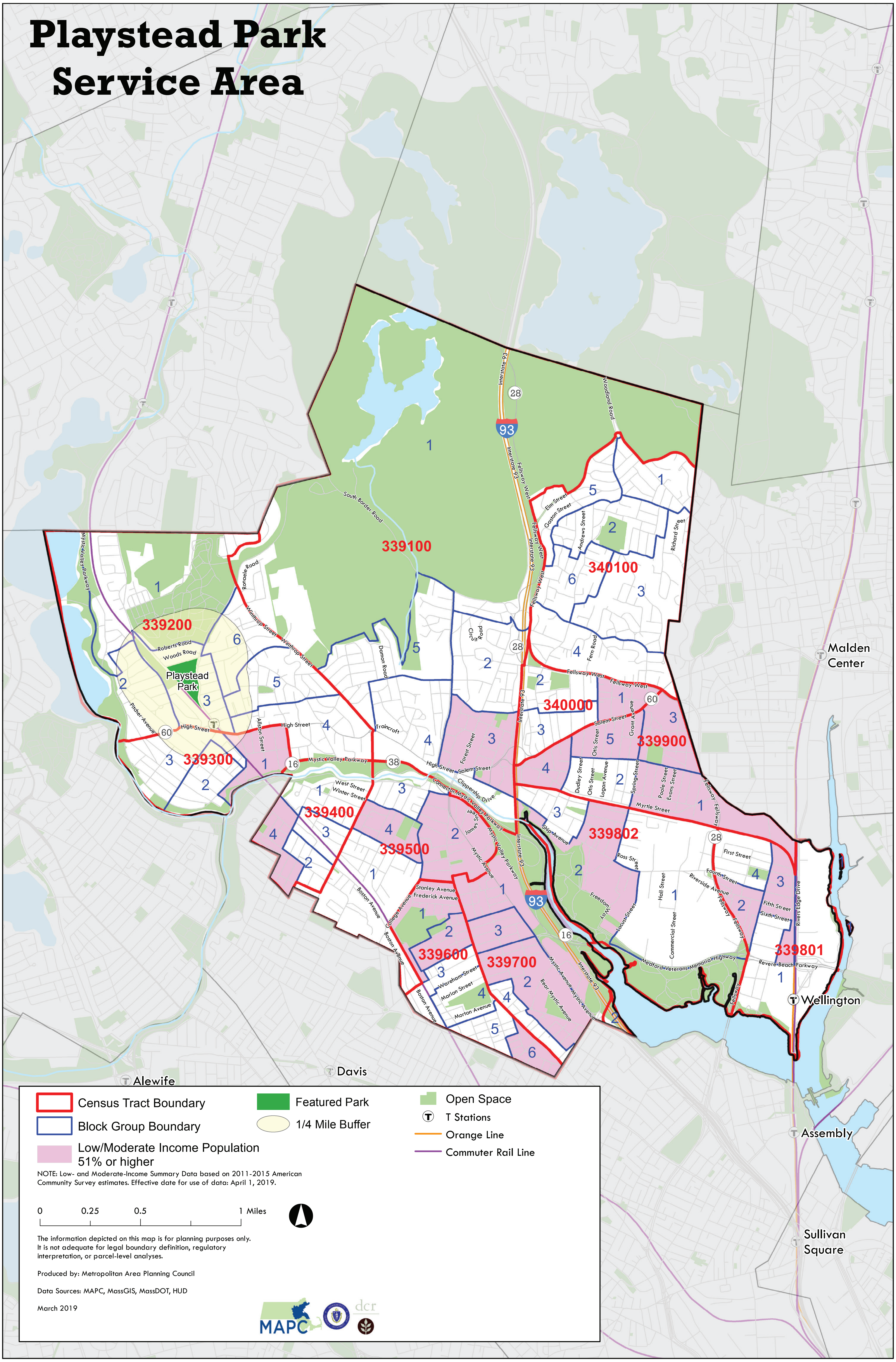

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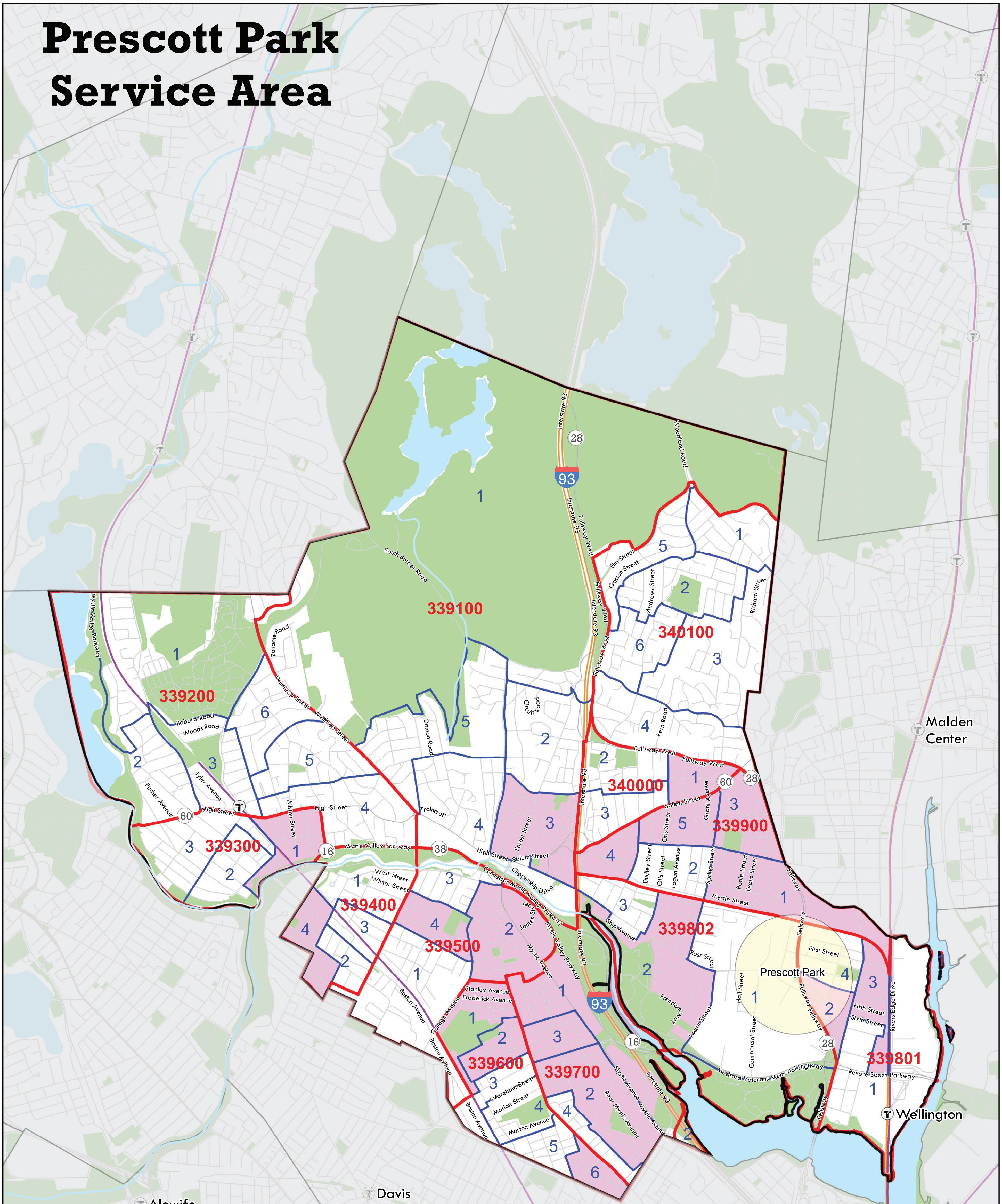

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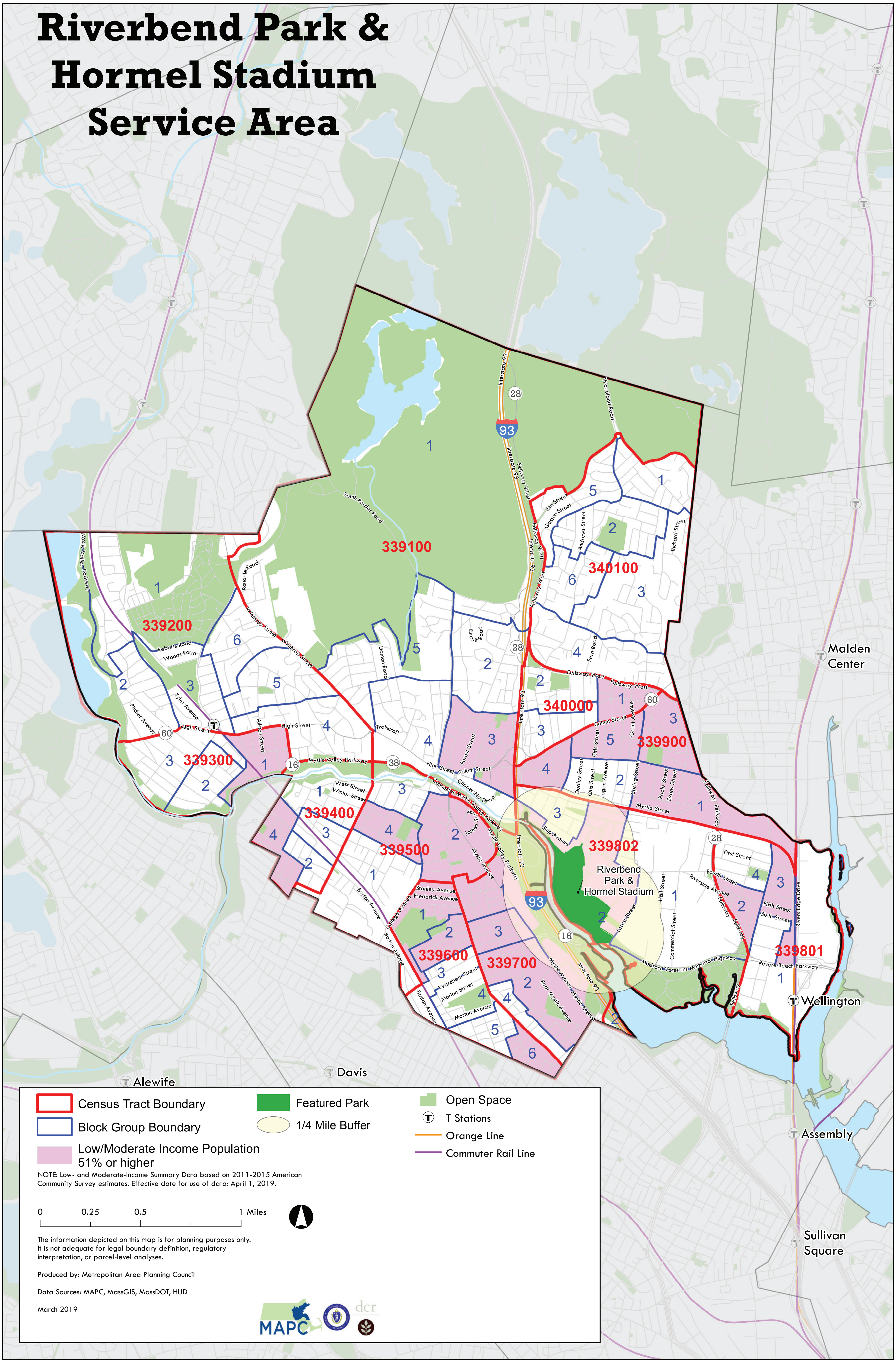

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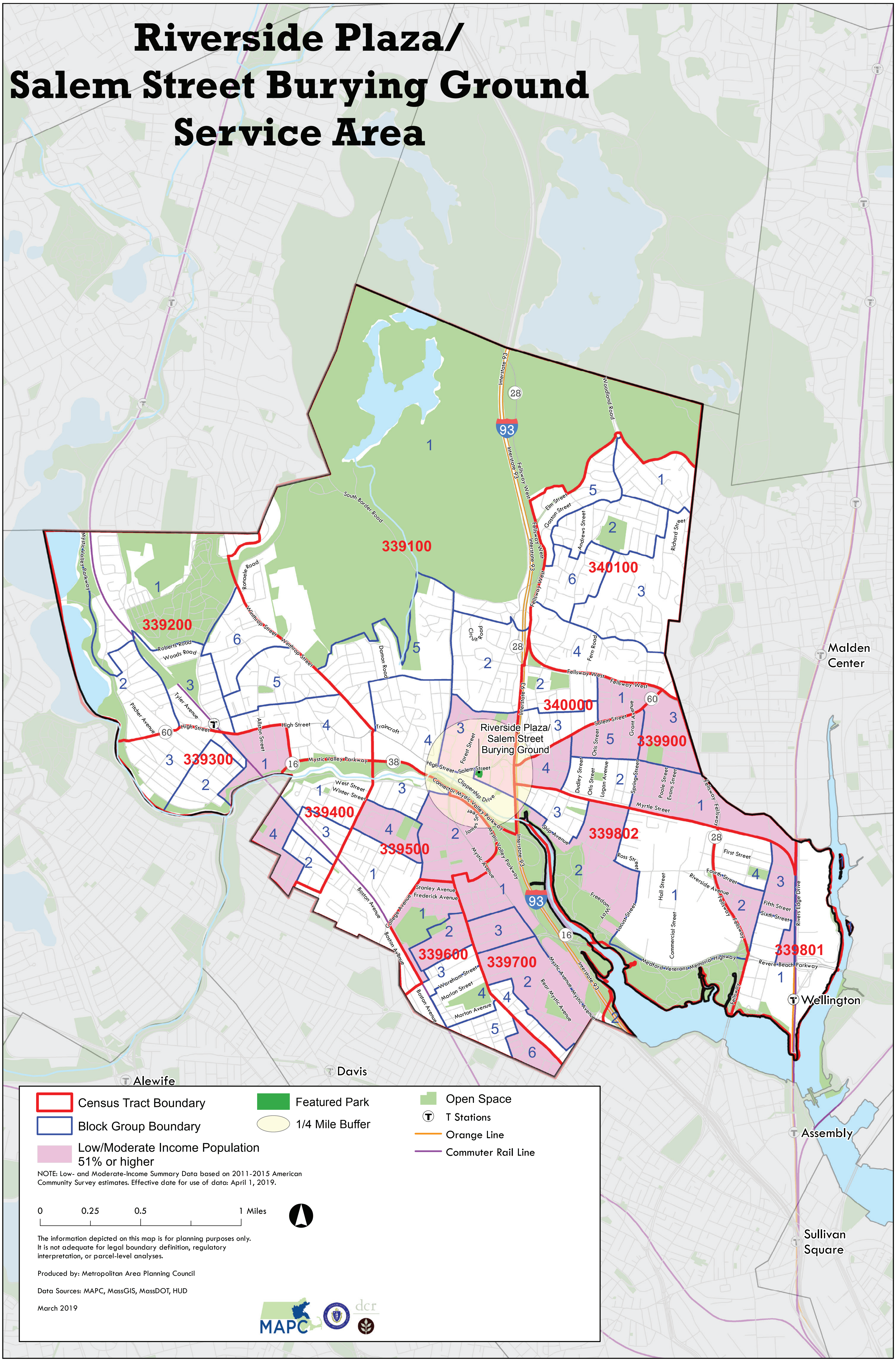

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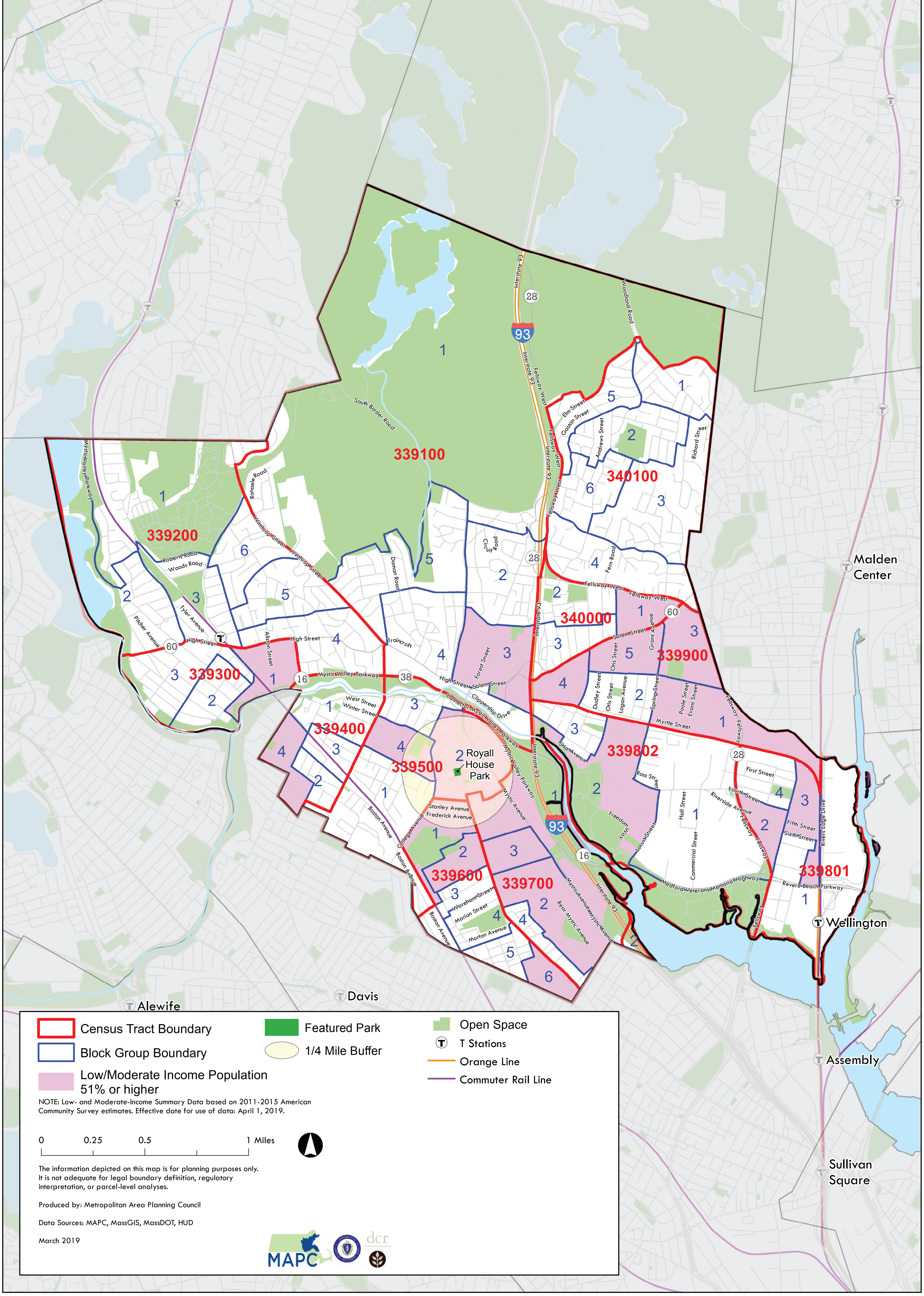

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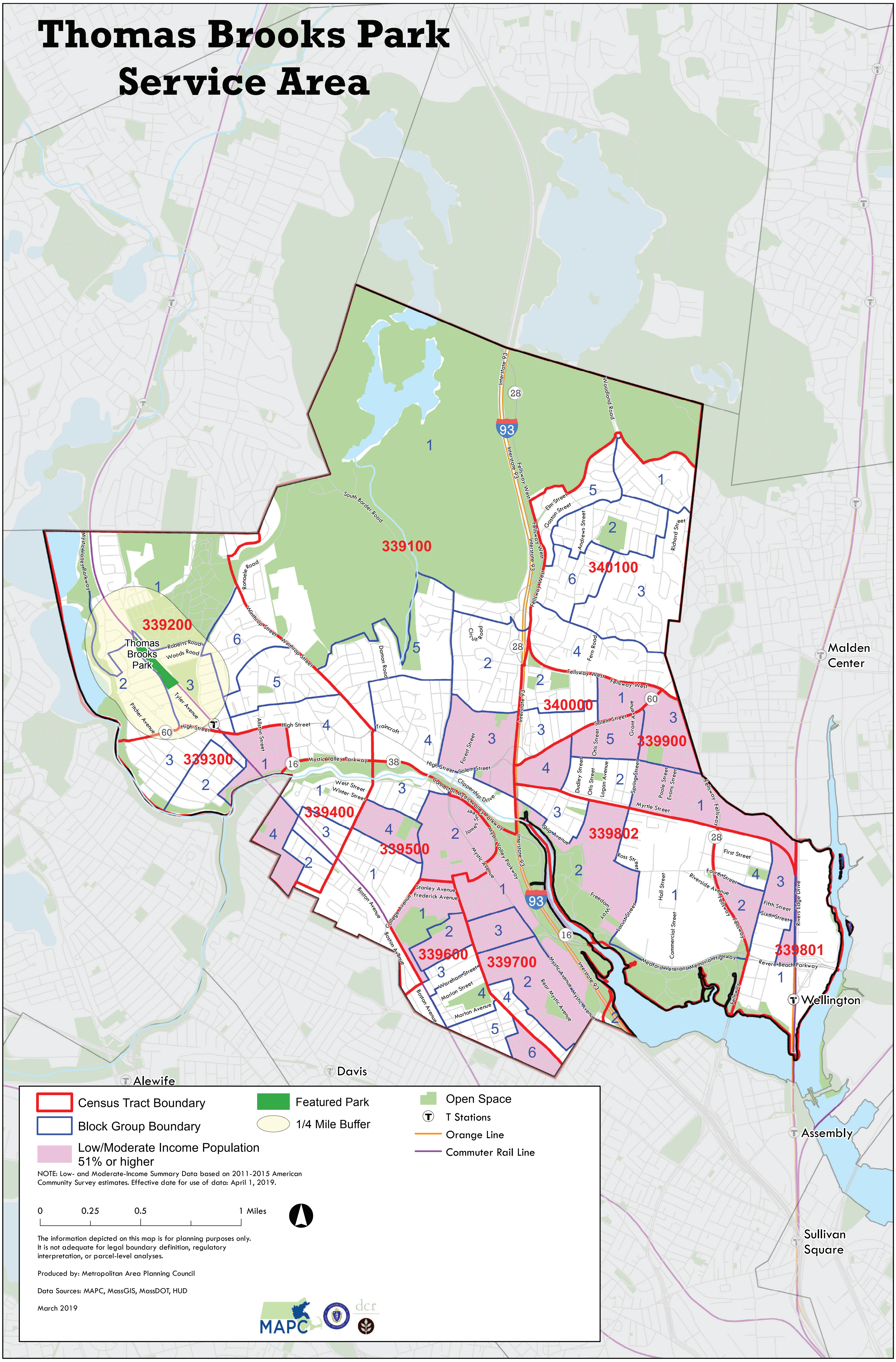

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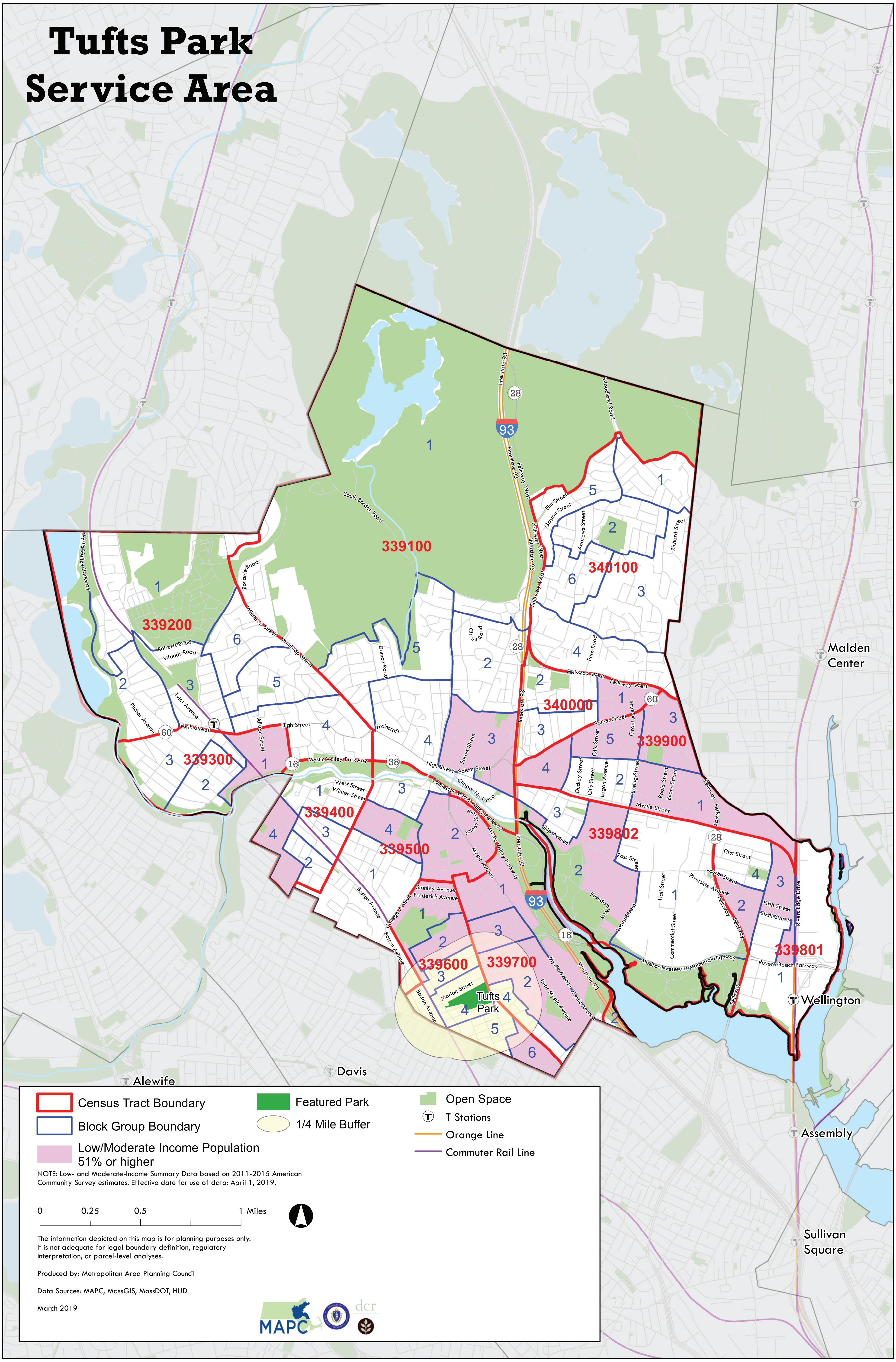

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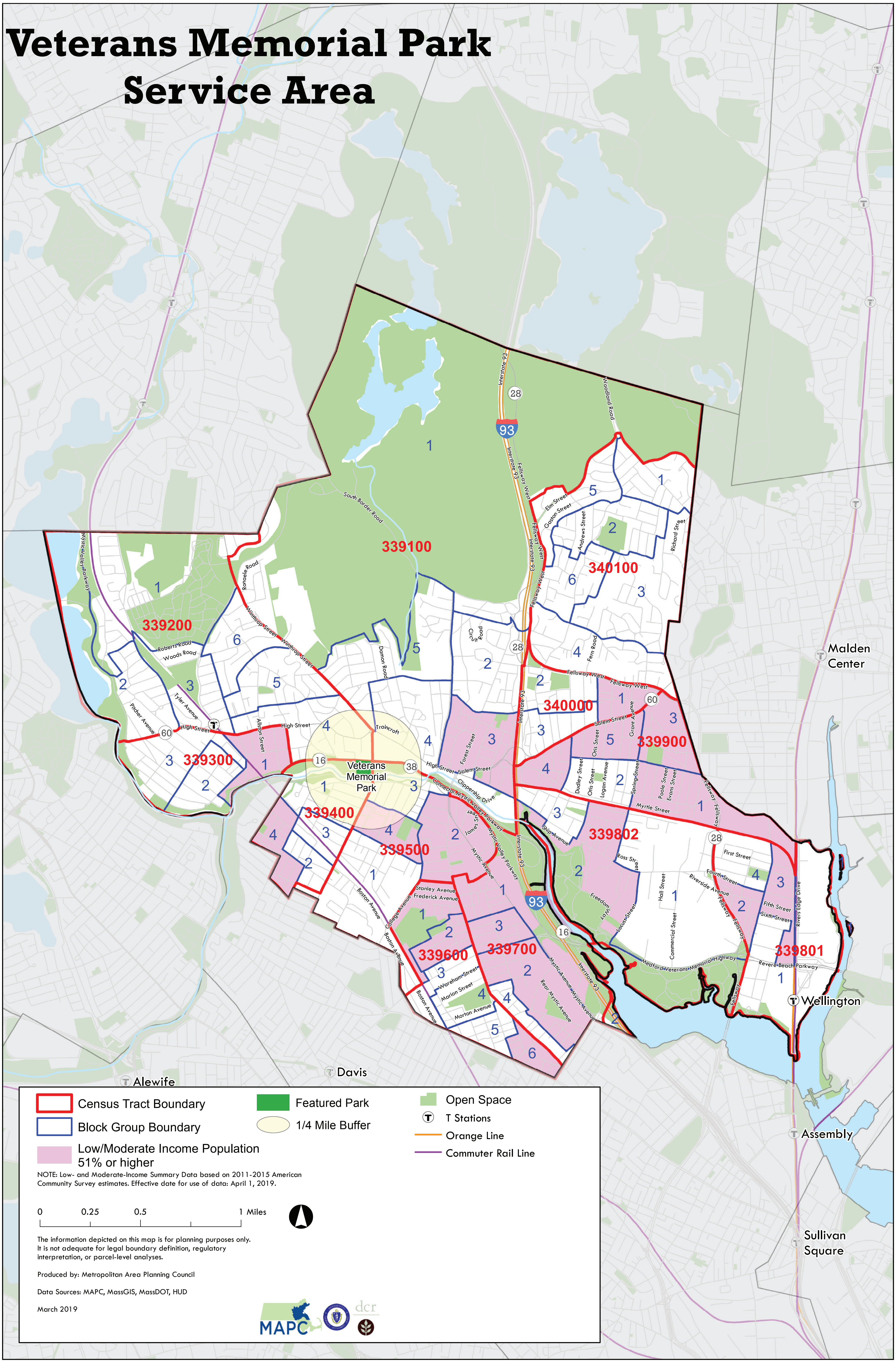

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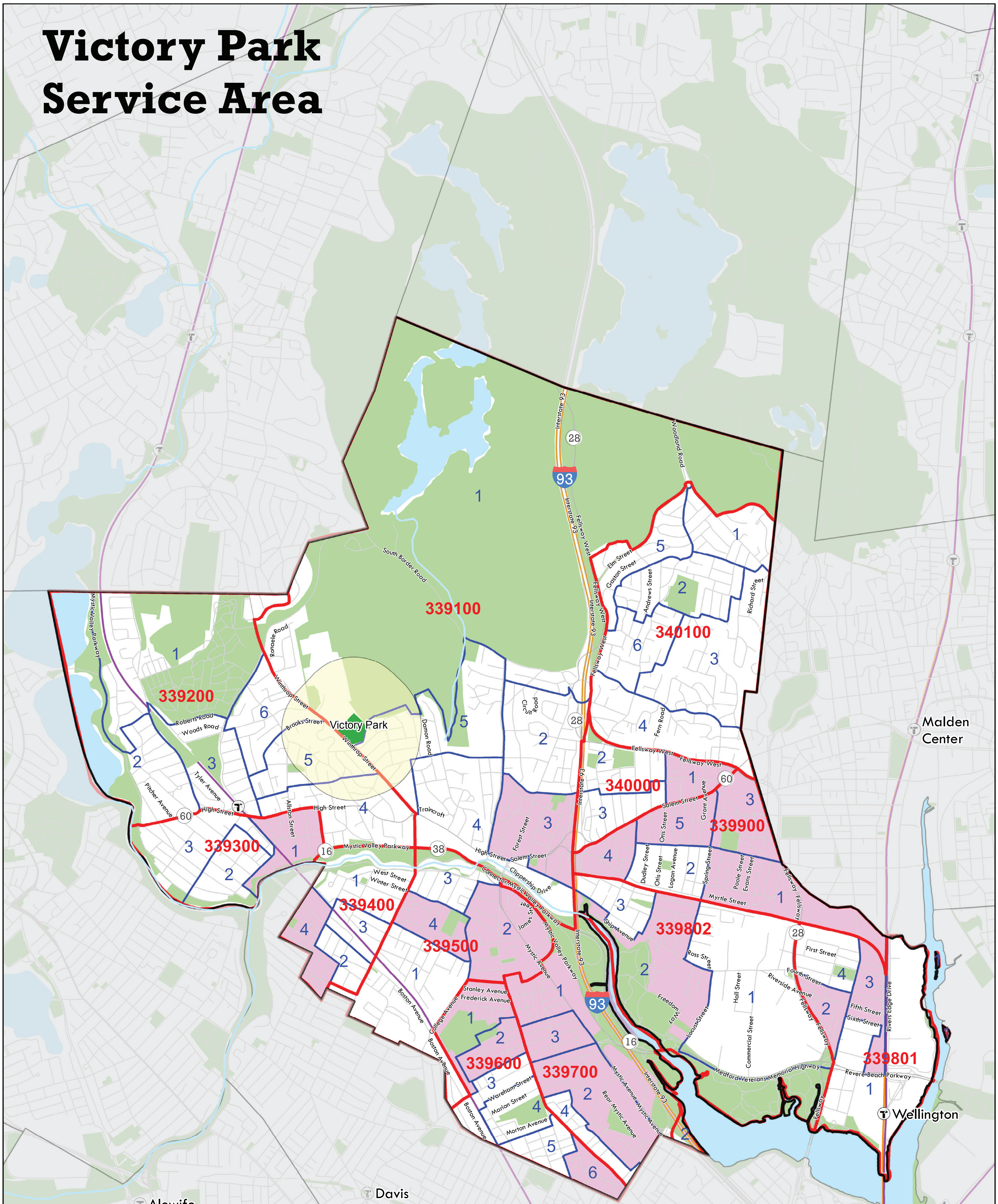

Census Tract Boundary
Block Group Boundary
Low/Moderate Income Population 51% or higher
Featured Park
1/4 Mile Buffer
Open Space
T Stations
Orange Line
Commuter Rail Line

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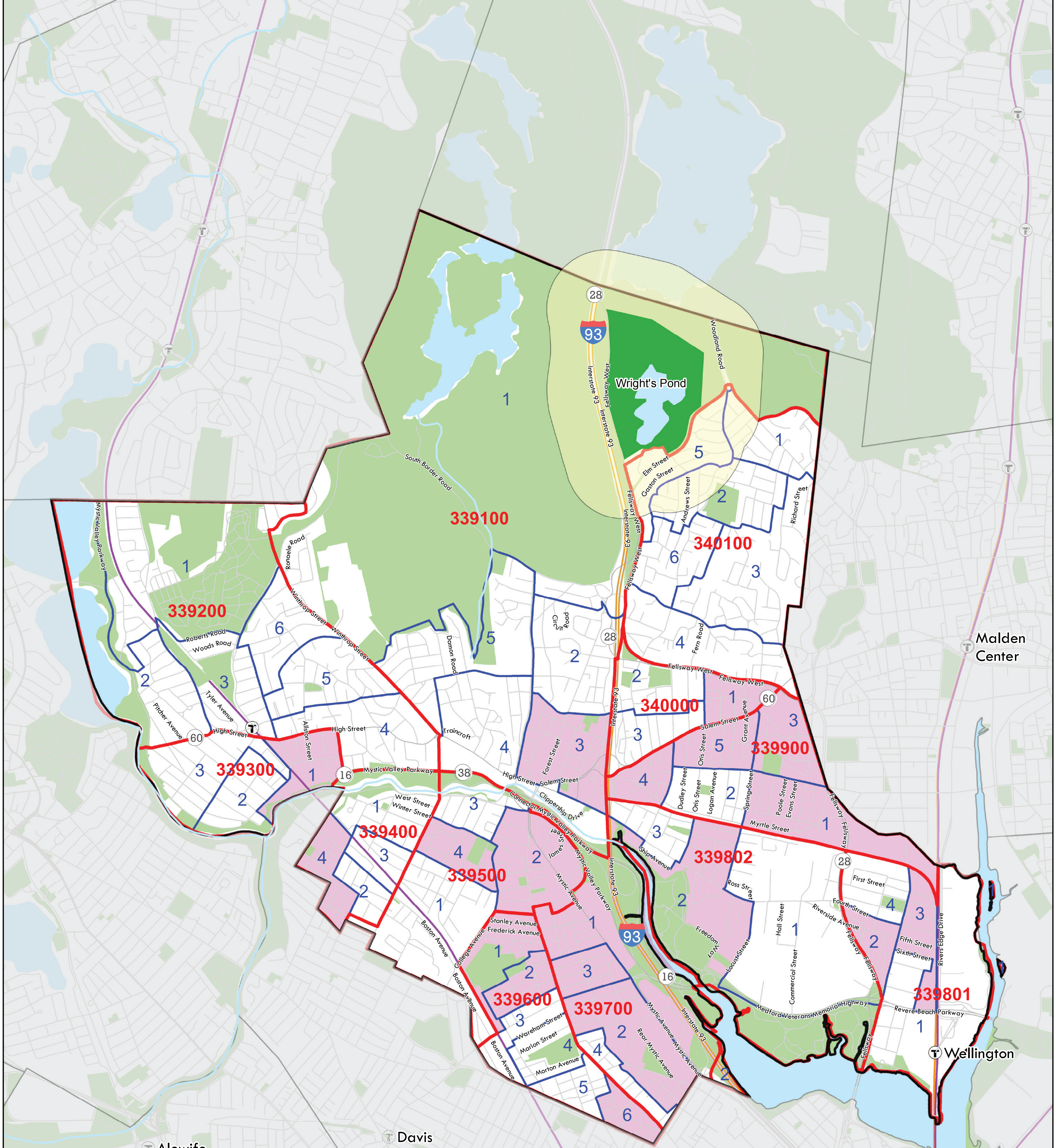

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March 2019

Appendix B: Medford Parks and Open Space for Climate Resilience Report

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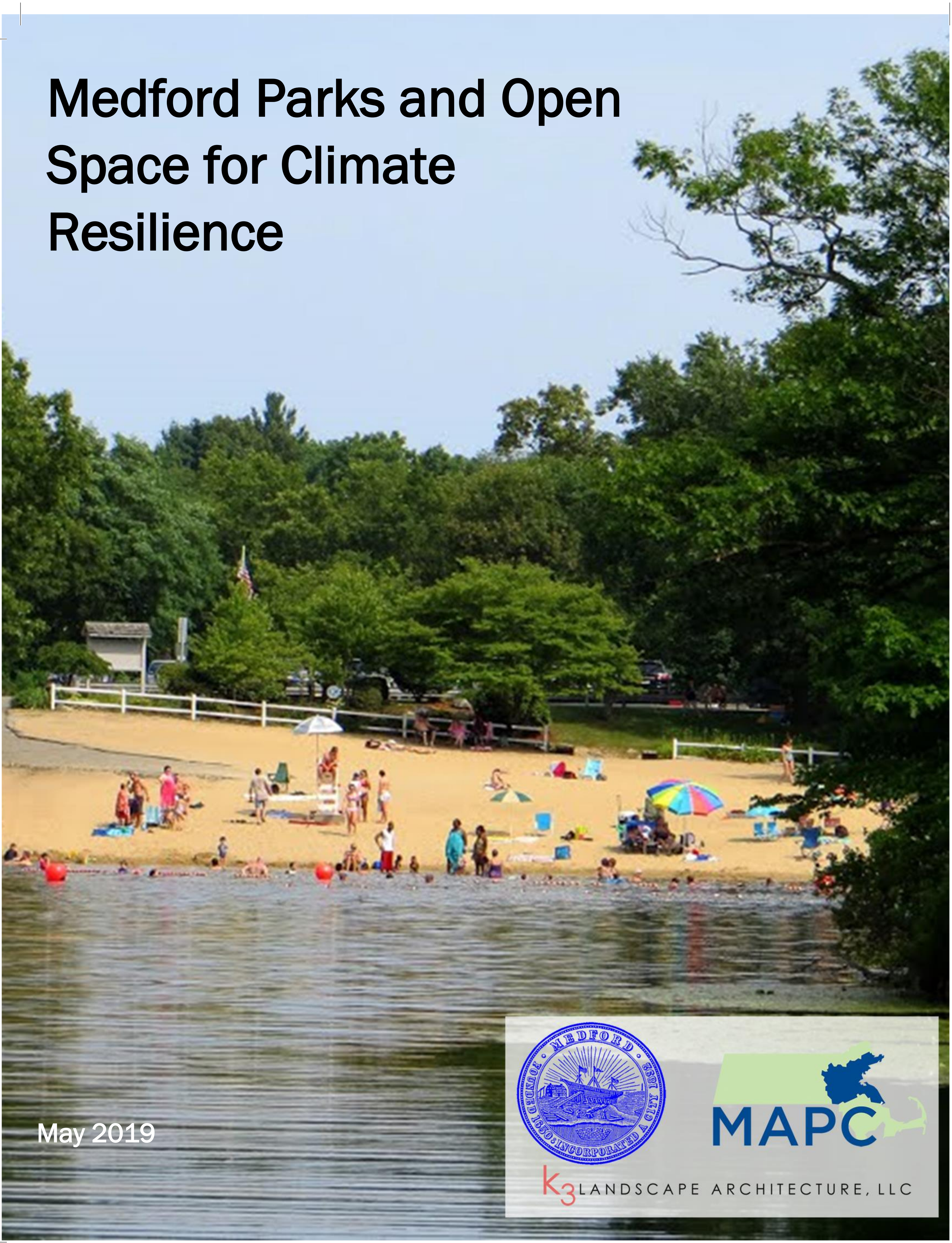
Medford Parks and Open Space for Climate Resilience



May 2019

MEDFORD
FOUNDED 1630 INCORPORATED A CITY 1892

MAPC

k3 LANDSCAPE ARCHITECTURE, LLC

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Acknowledgements

The project was conducted by the Metropolitan Area Planning Council (MAPC) with funding from the City of Medford and the Massachusetts Executive Office of Energy and Environmental Affairs Municipal Vulnerability Preparedness Action Grant.

City of Medford

- Stephanie M. Burke, Mayor
- Clodagh Stoker-Long, Economic and Community Development Planner
- Alicia Hunt, Director of Energy & Environment

Open Space and Recreation Committee

- Kevin Bailey, Recreation Department
- Reginald Graham, Park Commission
- Kenneth Krause, Citizen-at-large, Friends of the Mystic River
- Denis MacDougall, Conservation Commission and Board of Appeals
- Mike Nestor, Department of Public Works, Park Division
- Neil Osborne, Human Diversity Office
- Chenine Peloquin, Citizen-at-large, Recreation Professional at Playful Pelican
- George Scarpelli, City Council

Metropolitan Area Planning Council Officers

- Keith Bergman, President
- Erin Wortman, Vice President
- Sandra Hackman, Secretary
- Taber Keally, Treasurer
- Marc D. Draisen, Executive Director

Project Team

- Darci Schofield, Senior Environmental Planner, MAPC
- Kathleen Ogden-Fasser, Landscape Architect, K3 Landscape Architecture, LLC

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I. Introduction

In the last five years, Massachusetts has experienced increasingly more frequent and severe weather events. Record-breaking snowfall in 2015, a wide-spread and severe drought in 2016, the warmest year on record in 2017, and four Nor'easters in one month and flooding comparable to the Blizzard of 1978 in 2018 are just some examples. Climate Change is not imminent but affecting the people and cities and towns of the Commonwealth today, particularly those in coastal and riverine communities such as the City of Medford.

The City of Medford was one of the earliest English settlements in the United States, established in 1630. The landscape prior to and at colonization was comprised of the tidally influenced Mystic and Malden Rivers, tidal flats, and large forested and hilly areas. The Mystic drove trade, industry, and development patterns throughout Medford's history resulting in a dense urban environment. However parks, open space, and land protection have been complimentary to Medford's growth through time where approximately 34% of the total land area in Medford is protected land as parks and open space. This includes approximately 26% owned by the Commonwealth of Massachusetts.[1] In addition to major transportation thoroughfares including Interstate 93, Route 16 Mystic Valley Parkway, and Route 28 The Fellsway, water remains a prominent component of the City's landscape including the major urban Mystic and Malden Rivers, the Mystic Lakes, Wrights Pond, South Reservoir, and a number of important wetlands, brooks and streams. The density of development, important transportation corridors, large protected landscapes, and abundance of prominent water features are critical factors in ascertaining Medford's risk and vulnerability to climate change and how parks and open space can play a key role in protecting the City's vibrancy now and into the future.

This report, written in conjunction with the City of Medford 2018 Open Space and Recreation Plan Update and funded by the Commonwealth of Massachusetts Municipal Vulnerability Preparedness Program, will evaluate how Medford's parks and open spaces can be leveraged as part of Medford's strategy to mitigate and minimize its vulnerability to climate change by using nature-based solutions. Using the latest climate science and data and ongoing City climate vulnerability assessments, we evaluate the climatic, geomorphological, and environmental conditions of the City's park system, spatially analyze how the park system intersects with key components of the City's infrastructure, vulnerable populations, and ecological resources, and create design recommendations that enhance climate resilience across Medford's people, places, and environment. This analysis and report builds upon and aligns with the existing climate vulnerability work that has already occurred in Medford including:

- City of Medford Climate Vulnerability Assessment (2019)
- City of Medford Municipal Vulnerability Preparedness Summary of Findings (March 2018)
- Medford Natural Hazard Mitigation Plan (2017)
- Medford City Wide Drainage Model, Kleinfelder (2018)

1

Medford Climate Risks

The City of Medford is a leader in addressing climate change, being the first municipality in the Commonwealth to complete a Climate Action Plan. Medford is also a participant in the Metro Mayors Climate Preparedness Task Force, a coalition of 15 municipalities in the inner core of Metro Boston who have committed to collaborate on climate preparedness and Net Zero goals. In addition, Medford has engaged in multiple planning efforts related to mitigating and preparing for the impacts of climate change. This section will summarize key climate change risks and vulnerabilities in Medford from these efforts relevant to integrating parks, open space, and nature-based solutions for climate resilience.

Green infrastructure is a mechanism in which natural systems replicate engineered solutions to managing flooding, stormwater, extreme heat and other climate impacts. It is a cost-effective way to create climate resilience that also achieves multiple benefits of beautification, improvement of air quality and water quality, and community cohesion. Some examples include raingardens, bio-swales, pervious paving and bio-infiltration. "Nature-based Solutions" is defined by the International Union of Concerned Scientists (IUCN) as "actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."[2] Examples of nature-based solutions include green infrastructure as well as protected land/open space, restoring natural areas to improve ecosystem function (forest management, wetland restoration, stream buffers, river bank stabilization), and reducing and/or greening impervious surfaces.

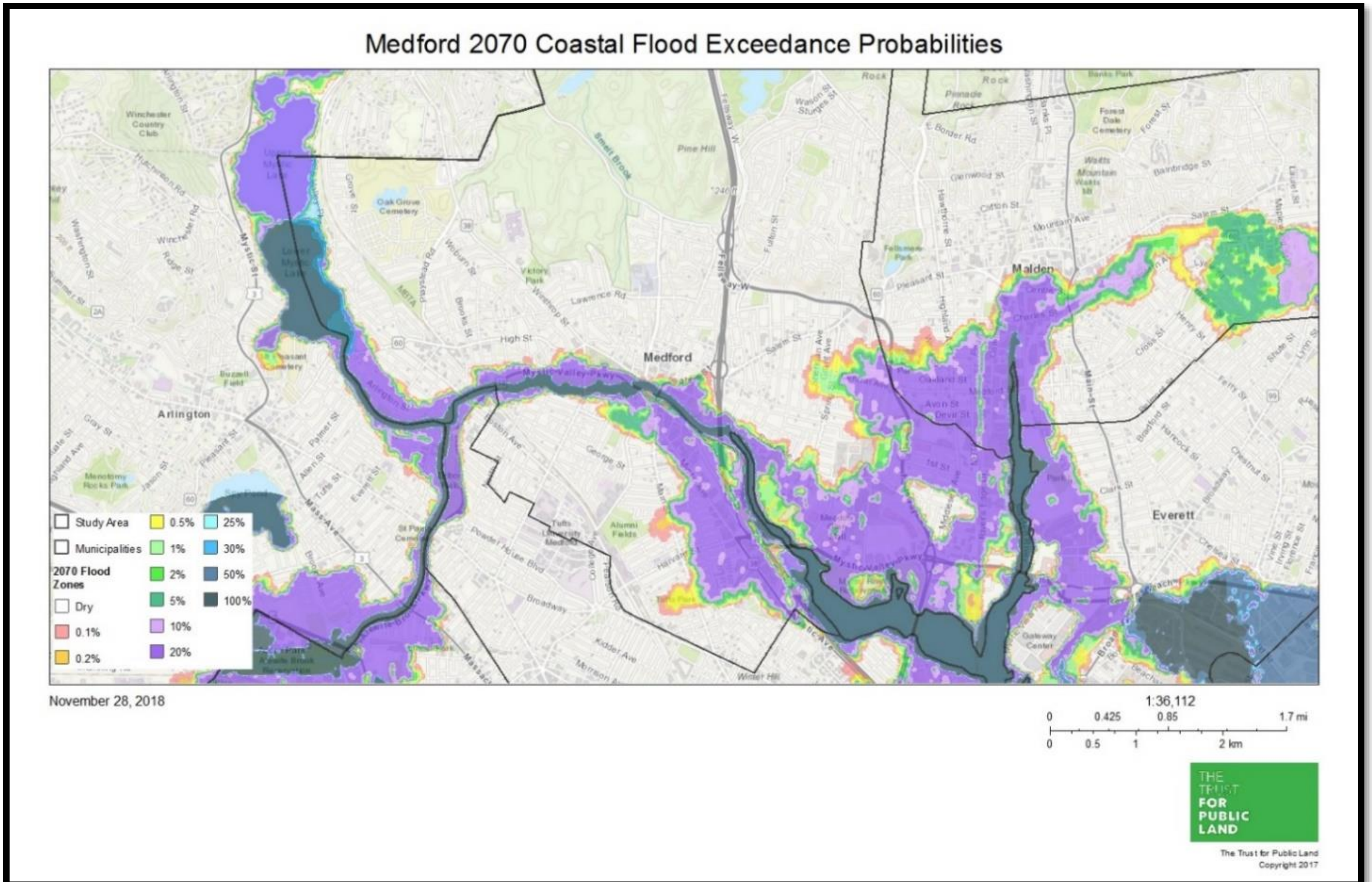
The climate risks that cause Medford the most significant vulnerability are inland flooding from extreme precipitation events, extreme heat, sea level rise with storm surge in the late century and extreme weather events such as nor'easters, hurricanes, and ice storms. The following summarizes the observed and projected climate risks for the City of Medford.

Sea Level Rise

In 2017, the Woods Hole Group completed the Boston Harbor Flood Risk Model (BH-FRM), a comprehensive hydrodynamic model that incorporates hydrology, topography, infrastructure, and other local landscape data with future sea level rise (SLR) and storm surge scenarios to ascertain the future impact on Medford. Because the tidal influence of the Mystic River is governed by the Amelia Earhart dam, the extent of future sea level rise occurs in Medford only when the dam is overtopped, projected in 2100. However, storm surge from coastal storms could cause overtopping of the dam creating a large extent of flooding along the Mystic and Malden Rivers at the 1% Annual Chance Storm starting as soon as 2040 (Figure 1). Coastal flood inundation is not significant at the 1% Annual Chance storm in 2030 because of the presence of the dam.

2

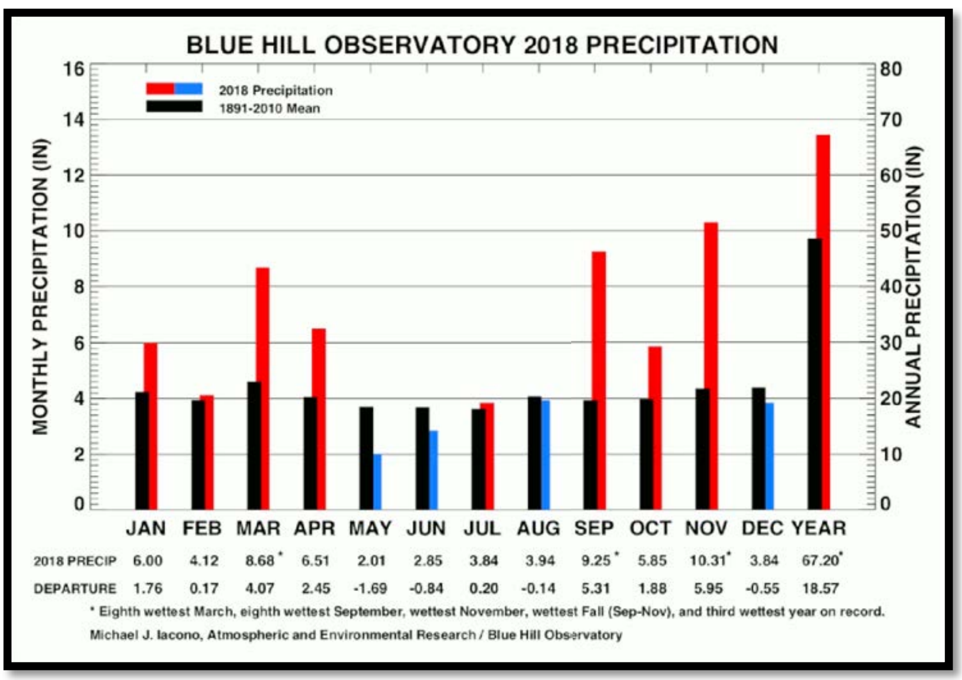
Figure 1 Coastal flood probabilities for Medford at 2070 according to the Boston Harbor Flood Risk Model.



Precipitation

For the last fifty years, precipitation in Massachusetts has increased by approximately 10%[3] and 70% in the Northeast in the amount of rain that falls in the top 1% of storm events.[4] Projections for future precipitation suggest an increase in total precipitation, changes in precipitation patterns, and increased frequency of extreme storms such as hurricanes and nor'easters. For example, a 100-year storm is defined as a storm that would have a 1% chance of occurring in any given year or consecutive years. Historically this could create 8.9 inches of rain, but that could increase to 10 inches of rain by 2044 and 11.7 inches of rain by 2084.[5] The fall of 2018 is a good example of this phenomena. November and Fall of 2018 are the wettest November and Fall on record since 1891, and the third wettest year on record.[6] Due to several stormy periods during the year, annual precipitation was very high and totaled 67.20 inches, which was more than 18 inches wetter than the long-term mean and nearly 14 inches more than the 30-year normal. The highest precipitation totals occurred in March (mostly as snow), September and November (Figure 2). This increased precipitation has the potential to exacerbate existing stormwater runoff issues and pollution of existing impaired waters.

Figure 2 Precipitation levels in 2018 which reached historic levels since 1891.



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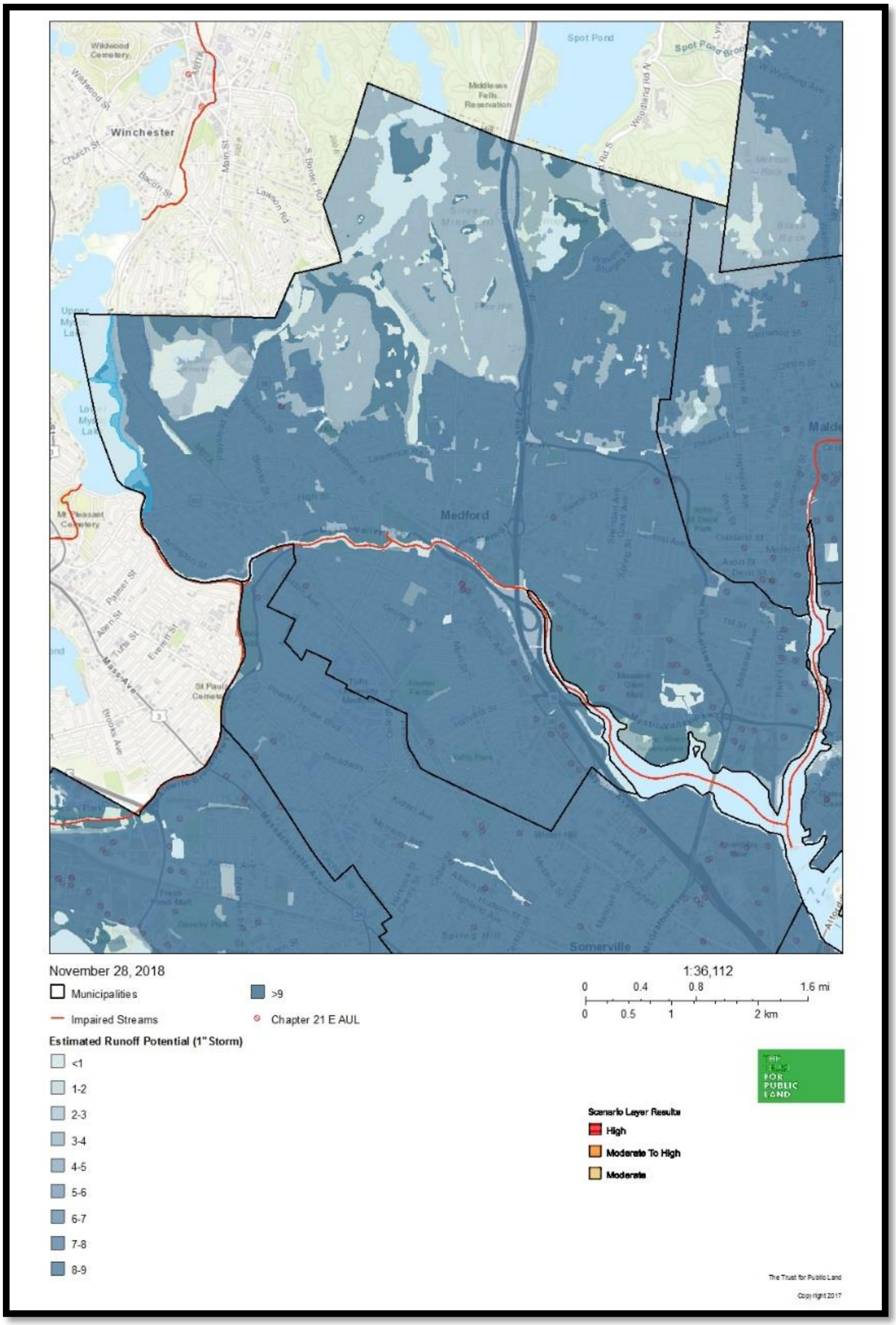
[3] Massachusetts Climate Adaptation Report. 2011. Executive Office of Energy and Environmental Affairs. pp.

[4] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.

[5] City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), Temperature and Precipitation Projections (http://www.cambridgema.gov/CDD/Projects/Climate/~/media/A9D382B8C49F4944BF64776F88B68D7A.ashx)

[6] Blue Hill Observatory & Science Center. 2019. http://bluehill.org/observatory/2018/02/2018-precipitation/

Figure 3 Estimated Runoff Potential during a 1 inch precipitation storm event.



However, the actual amount of increased precipitation or number of extreme weather events per year is difficult to ascertain, largely due to localized climate variability and greenhouse gas emissions into the future.[7,8] The Northeast Climate Center at UMass Amherst projects an increase in total annual precipitation from 45 inches today up to approximately 48 inches by 2050, 49 inches to 55 inches by the end of the century. Further, whereas Medford may have approximately 7 days with >1 inch precipitation events, that increases to 8.85 days by mid-century and 9.15 days by 2100.[9] Nonetheless, climate scientists still anticipate some periods of drought. Warming temperatures can cause greater evaporation in the summer and fall as well as earlier snowmelt, [10] and this could cause nearly 20 consecutive dry days in the Boston Harbor Basin by the end of the Century. Additionally, though scientists anticipate an overall decrease in snowfall, the Boston region will continue to experience significant snow events through 2100. [11]

Temperature

According to the US National Climate Assessment 2018, temperature in the Northeast US has increased by almost two degrees Fahrenheit between 1895 and 2016. Data from the Blue Hill Observatory in Milton located 19 miles from Medford, reflects this trend (Figure 4). Future temperature projections for the Northeastern US show a greater increase in average summer temperatures relative to winter and are projected to increase at an accelerated rate.[12] A number of local temperature projection models for Massachusetts and the Boston region also demonstrate an increasing likelihood of heat waves, as indicated by the increased number of days over 90 and 100 degrees each year.[13,14,15] Whereas Medford today averages approximately eight days above 90˚ annually, that is anticipated to increase to 22 days by mid-century and 42-50 days by the end of the century.[16] The impact of increasing temperatures is a shorter winter and longer growing season. For example, scientists expect 5-17 fewer winter days by the 2070s and 9-34 fewer winter days by the end of the century.[17]

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[7] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[8] USGCRP, 2018: *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/NCA4.2018.

[9] Northeast Climate Science Center, UMass Amherst. Massachusetts Climate Change Projections. January 2018.

[10] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[11] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[12] Climate Ready Boston, "The Boston Research Advisory Group Report: Climate Change and Sea Level Rise Projections for Boston," June 2016

[13] Under RCP 4.5 conditions. City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx cited in BRAG.

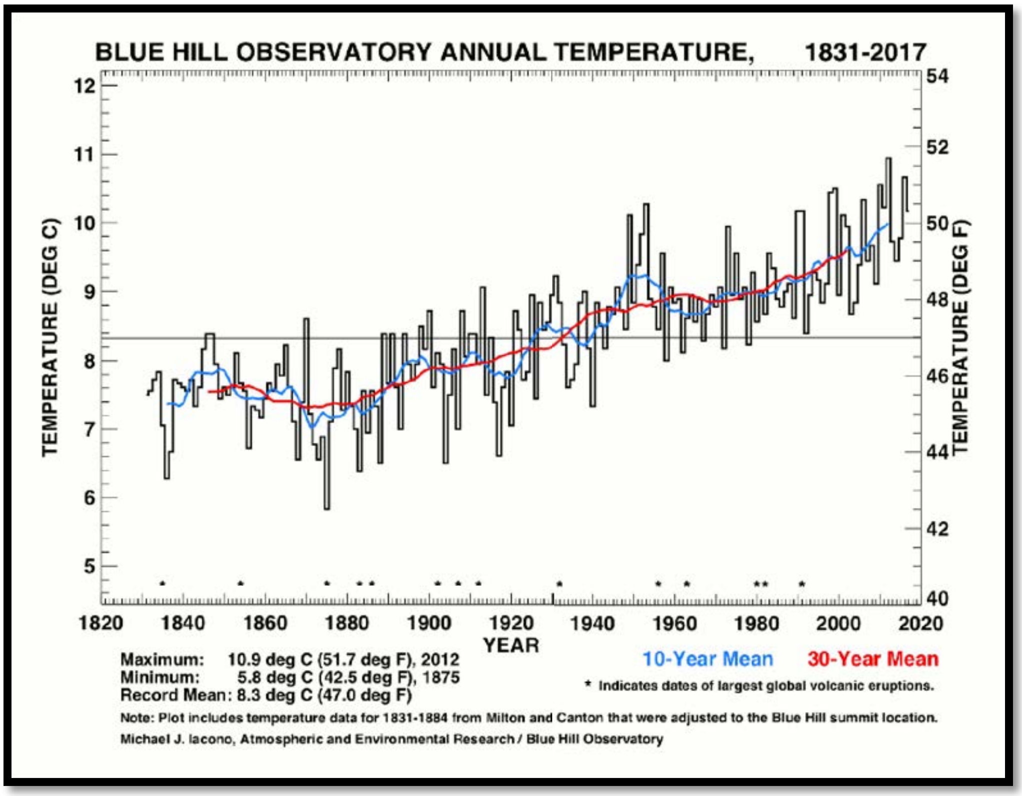
[14] Boston Indicators, "Trends in Climate Change, Metro Boston and New England," http://www.bostonindicators.org/indicators/environment-and-energy/5-4clean-energy-and-climate-stability/5-4-1trends-in-climate-change-metro-boston, accessed March 25, 2017

[15] Northeast Climate Science Center, UMass Amherst. Massachusetts Climate Change Projections. January 2018.

[16] Northeast Climate Science Center, UMass Amherst. Massachusetts Climate Change Projections. January 2018

[17] Under RCP 4.5 conditions. City of Cambridge, Climate Change Vulnerability Assessment, (City of Cambridge, 2015), http://www.cambridgema.gov/CDD/Projects/Climate/climatechangeresilianceandadaptation.aspx cited in BRAG.

Figure 4. Observed Temperature Change



Medford is experiencing significant heat during the day time and night time. Variations on the extent of heat vulnerability exists depending on the type of land surface satellite data utilized in the analysis. For example, according to the Metro Mayors Climate-Smart Cities™ DST, MODIS 30 meter land surface temperature indicates that the majority of Medford is an urban heat island during the daytime. MAPC has downscaled this data for a more specific urban heat island analysis. Using LANDSAT land surface temperature at 30m spatial resolution, MA collected land surface temperature to two very hot days with low cloud cover, July 13, 2016 and August 30, 2016. On these days, Logan Airport reported temperatures at 92°F. MAPC then identified the top 5% hottest areas across the 101 municipalities in Metro Boston to identify the region's greatest hot spots or urban heat island. The areas in Medford that are the in the top 5% hottest in the Metro Boston region are depicted in Figure 6. The MODIS satellite is the only satellite providing land surface temperatures during the night time. Medford's hottest areas during the evening are depicted in Figure 5. Night time urban heat is an important indicator of vulnerability where health deterioration occurs if individuals stressed by heat are not able to cool down, particularly those with chronic cardiovascular and respiratory medical conditions.

Figure 5 Night time urban heat island effect in Medford.

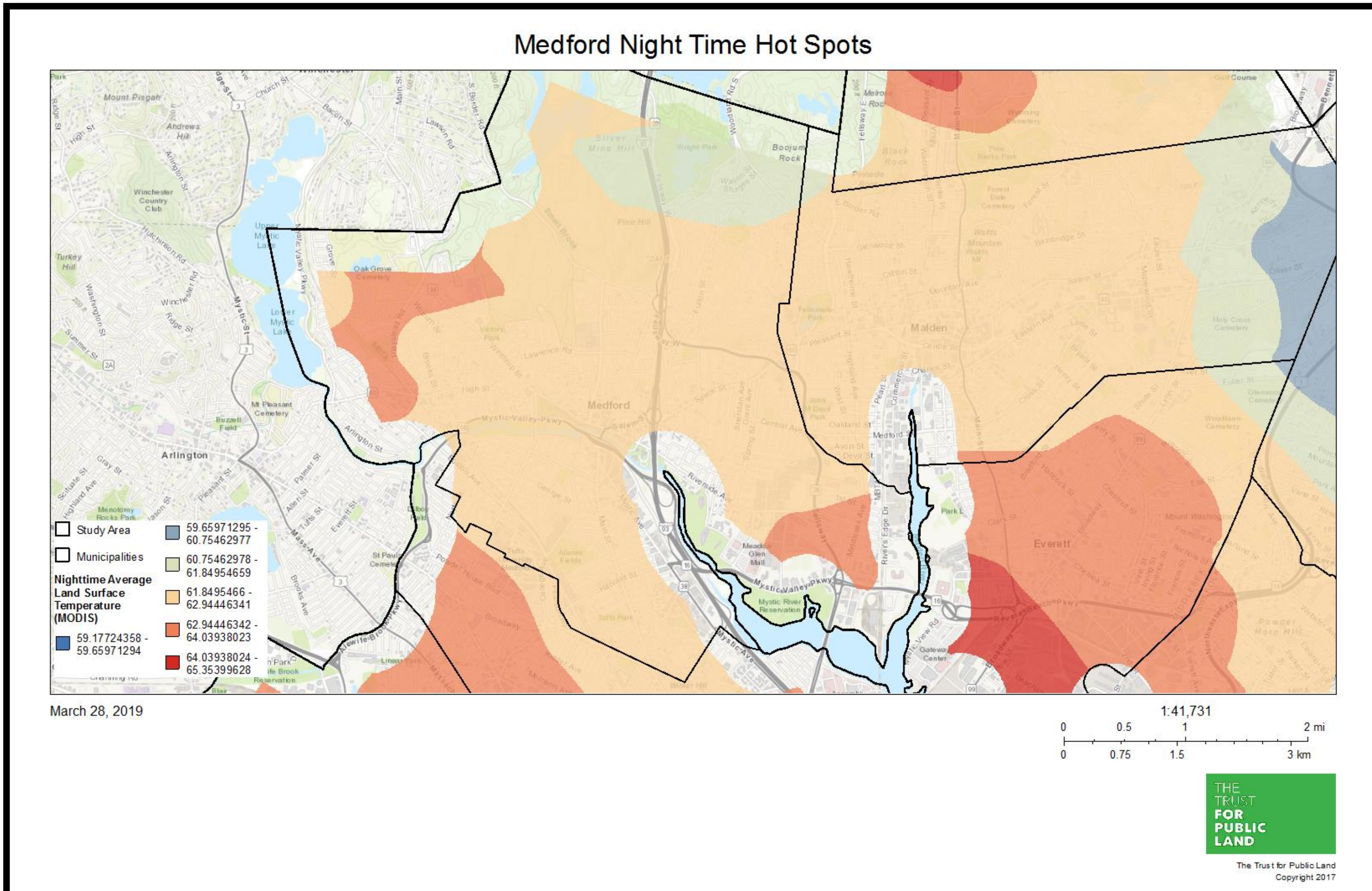


Figure 6 Medford Climate Vulnerability, Parks, and Critical Facilities map.

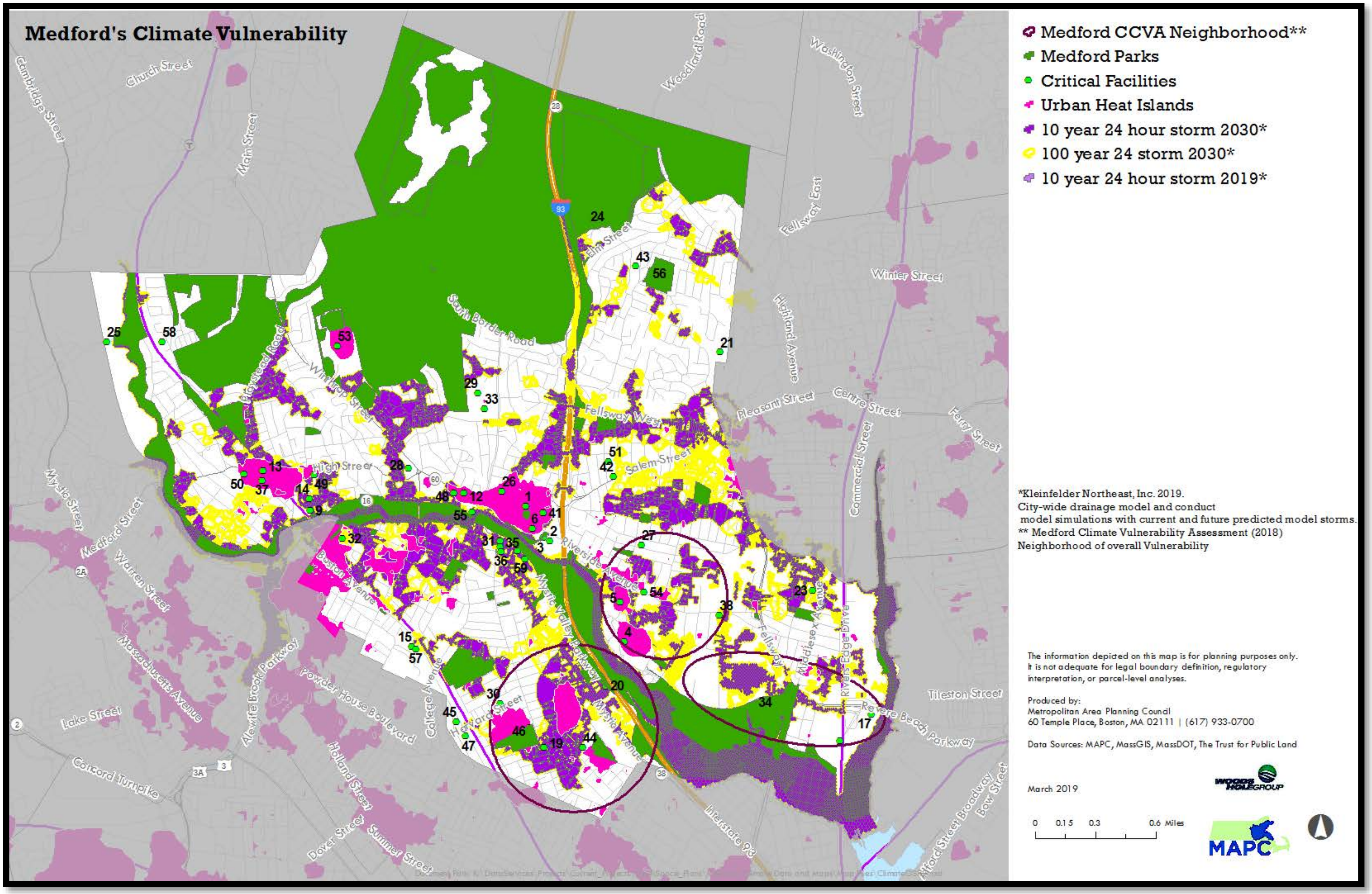


Table 1 Medford Critical Facilities and climate change vulnerability.

MAP ID	NAME	TYPE	Inland Flooding 10yr 24 h 2019	SLR 2030	SLR 2070	Medford CCVA	Inland Flooding 10yr 24h 2030	Inland Flooding 100yr 24h 2030	Top 5% Urban Heat in Region
1	Mass Electric	Power Substation							Yes
2	Saltenstall Building	Elderly Housing			Yes				
3	Senior Citizen Center	Elderly Housing			Yes				
4	McGlynn Middle School	School			Yes				Yes
5	Andrews Middle School	School			Yes				Yes
6	Winchester Hospital - Hyperbaric Chambers	Medical Facility			Yes				Yes
9	Tempone Manor	Elderly Housing			Yes	Glenwood			
12	Medford Public Library	Library							Yes
13	West Medford Train Station	Transportation Facility	Yes						Yes
14	Algonquin Gas	Gas Distribution	Yes		Yes			Yes	
15	Tufts University Campus	School							
16	Wellington Station	Transportation Facility	Yes		Yes	Wellington			
17	Kiss 108 Radio Station	Broadcast Facility			Yes	Wellington			
19	Fire Station	Fire Station			Yes	South Medford			
21	Glenridge Nursing Care	Elderly Housing							

MAP ID	NAME	TYPE	Inland Flooding 10yr 24 h 2019	SLR 2030	SLR 2070	Medford CCVA	Inland Flooding 10yr 24h 2030	Inland Flooding 100yr 24h 2030	Top 5% Urban Heat in Region
23	Mass Electric Sub Station	Power Substation	Yes		Yes				
24	Wrights Pond Dam	Dam	Yes						
25	Mystic Lakes Dam	Dam		Yes	Yes				
26	Walden Manor	Elderly Housing							Yes
27	Magoun Manor	Elderly Housing				Glenwood			
28	Winthrop House	Elderly Housing							
29	Courtyard Nursing Care Center	Elderly Housing							
30	Kennedy School	School				South Medford			
31	Office of Emergency Management	Emergency Operations Center			Yes				
32	Walkling Court	Elderly Housing							
33	Lawrence Memorial Hospital of Medford	Hospital							
34	State Police Barracks	Police Station			Yes	Wellington			
35	Police Headquarters	Police Station			Yes				
36	Fire Headquarters	Fire Station			Yes				
37	Fire Station	Fire Station							Yes
38	Fire Station	Fire Station				Glenwood			
40	Water and Sewer Plant	Public Works Facility	Yes		Yes		Yes	Yes	

MAP ID	NAME	TYPE	Inland Flooding 10yr 24 h 2019	SLR 2030	SLR 2070	Medford CCVA	Inland Flooding 10yr 24h 2030	Inland Flooding 100yr 24h 2030	Top 5% Urban Heat in Region
41	City Hall	Municipal Office			Yes				Yes
42	Fire Station	Fire Station	Yes						
43	Fire Station	Fire Station	Yes						
44	Columbus School	School			Yes	South Medford			
46	Curtis Tufts School	School				South Medford			Yes
48	St. Joseph School	School							Yes
49	Brooks School	School							Yes
50	St. Raphael School	School							Yes
51	Roberts Middle School	School							
53	Medford High School	School							Yes
54	Mass. Water Resources Authority	MWRA	Yes			Glenwood		Yes	
55	Mass. Water Resources Authority	MWRA	Yes	Yes	Yes		Yes		
56	Carr Park - Data Collection Units for gas, electric and water	Public Works Facility		Yes					
57	Tufts College Parking Garage - Data Collection Units for gas, electric and water	Public Works Facility							

MAP ID	NAME	TYPE	Inland Flooding 10yr 24 h 2019	SLR 2030	SLR 2070	Medford CCVA	Inland Flooding 10yr 24h 2030	Inland Flooding 100yr 24h 2030	Top 5% Urban Heat in Region
58	Collings Circle - Data Collection Units for gas, electric and water	Public Works Facility		Yes					
59	Department of Public Works	Public Works Facility	Yes		Yes				

Medford Climate Vulnerability

Vulnerability Sea Level Rise

Coastal flooding is important in considering future design and redevelopment of new and existing waterfront parks. Coastal parks can serve as a resilient strategy to storm surge and inundation as temporary storage of flood waters and barrier to critical infrastructure. Over the long term, sea level rise could raise the water table, reducing the depth to groundwater and subsequently the depth of infiltration space required to adequately capture stormwater and rainfall. For example, rain gardens require two -six feet of depth to bedrock or groundwater for best function.[18,19] In this case, transformation of the park toward a wetland type system along the coast with coordinating recreation amenities may be the better approach for the long term.

The greatest concerns with sea level rise are damage to City Infrastructure and loss of space. Infrastructure includes transportation corridors, utilities, stormwater infrastructure, residences, emergency services, businesses, etc. which will cause major disruption to residents lives and livelihoods or even cause displacement. There are two critical facilities in Medford located in a 2030 flood zone (exceedance probabilities). That number increases to 52 if the dam is overtopped. A summary of critical facilities at risk to climate change is summarize in Table 1.

Vulnerability Precipitation and Stormwater Flooding

Much of the infrastructure in the Northeast, including drainage and sewer systems, flood and storm protection assets, transportation systems, and the power systems, are nearing the end of their planned life expectancy. Climate-related disruptions will only exacerbate existing issues with aging infrastructure.[20]

A number of water resource areas, especially wetlands, have been filled in over time in Medford to support development or in an attempt to change drainage patterns in a specific area. These filled areas also have occurred along the Mystic River in portions of the flood plain. These areas serve as natural drainage locations and during severe rain storms, these areas still have high water levels that can contribute to localized flooding issues and potential inflow and infiltration issues with the piped drainage system. In addition, residents during public forums and comment periods through this planning effort noted that drainage in the parks systems is highly inadequate, particularly for the river front parks such as Veteran's Memorial and Condon Shell. Park users repeatedly commented that parks are prone to flooding, are saturated from precipitation events, and contain impassable paths due to mud. These conditions are likely to become more severe with more extreme precipitation events projected with climate change.

The majority of Medford's flooding problems are associated with the City's drainage system and the filling or channeling of natural water resource areas. There are a variety of issues that affect the drainage system in the City. In some cases, the system is served by older infrastructure that has been impacted by additional or increased development and does not have the necessary capacity to accommodate the resulting runoff. There are instances where waterways serve as part of the drainage system, such as along Winter Brook, but these can become restricted or blocked

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[18] Stormwater Best Management Practices: Guidance Document for Boston Water and Sewer Commission. Geosyntec Consultants. January 2013

[19] City of Lancaster Green Infrastructure Plan. PA DCNR and Lancaster County Planning Commission. February 2011. http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_004822.pdf

[20] U.S. Global Change Research Forum. *Fourth National Climate Assessment*. 2018.

due to siltation in the open channel or connecting pipes. Lastly, debris from roadways or from residents dumping (e.g., lawn clippings and other yard waste) have blocked pipes and culverts which has resulted in flooding of homes and public ways.[21]

Table 2 Water Quality Impairments for major water bodies requiring a Total Maximum Daily Load in compliance with the Clean Water Act[22]

Water Body	Category	Impairments
Lower Mystic Lake	5	Salinity, Sediment bioassay-Chronic toxicity Dissolved Oxygen, PCB in Fish Tissues, Sulfide-Hydrogen Sulfide, DDT
Upper Mystic Lake	5	Dissolved Oxygen, Non-native aquatic species, saturation, enterococcus.
Mystic River at Outlet of Lower Mystic Lake to Amelia Earhart Dam	5	Fish Passage Barrier, Non-native aquatic plants, arsenic, chlordane in fish tissue, chlorophyll-a, DDT in Fish Tissue, dissolved oxygen saturation, Escherichia coli, PCB in Fish Tissues, Phosphorus, Secchi disk transparency, Chronic toxicity freshwater in sediment bioassays

Furthermore, many of Medford's water bodies are impaired and monitored for Total Maximum Daily Loads of discharges in compliance with the Clean Water Act with the Environmental Protection Agency. The projected increase in annual precipitation and/or extreme precipitation events will only exacerbate existing water quality challenges, recreational opportunities and public health/toxicity exposure of Medford's residents. These are summarized in Table 2.

Planning and design for green infrastructure in Medford's parks need to carefully consider vegetation resilience to water stress and infiltration design that accommodates future precipitation projections. Trees and shrubs may experience long periods of pooling during and after major storms. Water storage in parks, where space is available, may be an important solution for extreme precipitation events to alleviate stress on stormwater infrastructure and aid water quality challenges. Furthermore, storage systems could provide opportunities for localized park irrigation, reducing water and energy costs, particularly in periods of drought.

Currently 11 critical facilities that are exposed to flooding during a 0.2% Annual Chance Flood (i.e., 500-year flood). These include facilities important for emergency response (Police, Fire, Office of Emergency Management, and State Police Barracks), socially vulnerable populations such as seniors, and important utilities such as the Massachusetts Water Resource Authority.,[23]

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[21] MAPC. 2017 City of Medford Natural Hazard Mitigation

[22] Massachusetts Year 2016 Integrated List of Waters Proposed Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act

[23] City of Medford Climate Vulnerability Assessment. 2018

Vulnerability Extreme Heat

Medford is a densely developed city with approximately 69% at medium to high density development and approximately 56% total land area with impervious surface. Medford also has a 30% tree canopy cover.[24] This land use creates a higher vulnerability to extreme heat and heat waves projected with climate change.

According to the MAPC heat island analysis described in Section I, the top 5% hottest areas of the region in Medford during the daytime include Medford Square, West Medford, the neighborhood adjacent to West Somerville, South Medford, and Glenwood. Medford has 14 critical facilities located in these hot spots (Table 1, Figure 6), including several schools, City Hall, emergency response facilities, and one senior housing facility, Walden Manor. Medford's parks already cool the neighborhoods throughout the City. The few parks located in an urban heat island include Salem Street Burying Ground, Tufts Park, Columbus Memorial Park, Hillside Memorial, and portions of the Mystic River Reservation by Whole Foods.

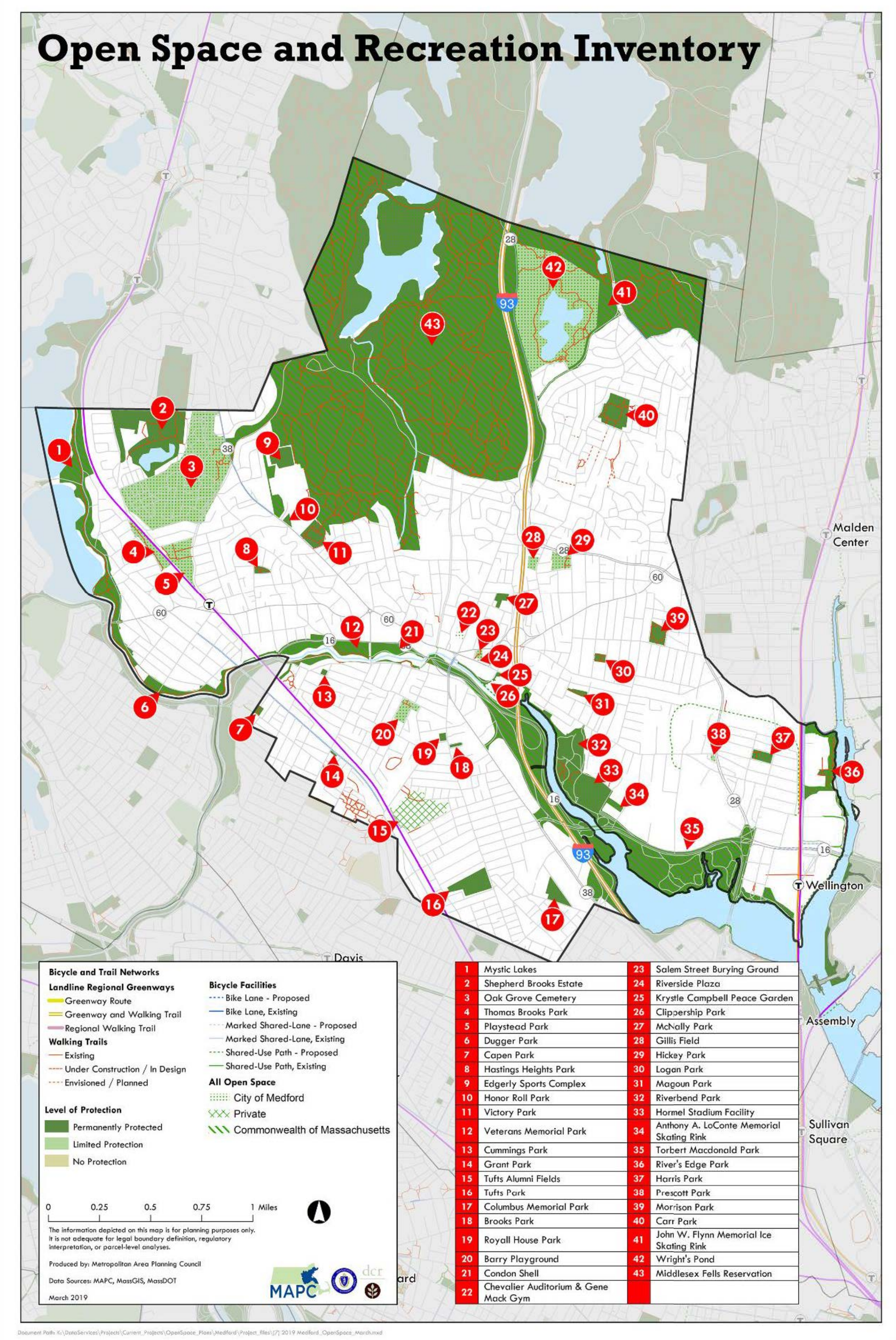
Nature-based climate resilience and/or green infrastructure are critical mechanisms to cooling cities through shading by tree canopies, evapotranspiration, and increased albedo effect (i.e., the amount of sunlight radiated from the surface of the earth). Parks present a great opportunity to increase the City's tree canopy, especially where street and sidewalk width are too constrained to incorporate street trees.

The parks and trees are already serving to cool the City in the evening, where the hottest areas are reduced along the boundaries of the Mystic River Reservation and the Middlesex Fells Reservation. In addition, Medford's water bodies are cooling the City at night. These include the Mystic and Malden Rivers and the Mystic Lakes, where the cooling effect is extending into the adjacent developed neighborhoods beyond the boundaries of the natural system (Figure 5). Furthermore, Medford's 30% tree canopy is providing additional benefits for energy cost reduction, stormwater, and health. These include sequestering 1,300 tons of carbon dioxide a year and avoiding 30.6 million gallons or stormwater runoff a year, worth $273,748 in avoided stormwater management costs.[25] The tree canopy is also capturing 115,000 pounds of air pollutants a year (i.e., CO, NO^2,O^3, $PM^{2.5}$, SO^2, PM^{10}). That is avoiding approximately 64 acute respiratory symptom incidences a year, 22 asthma exacerbation incidences a year, 8.6 school loss days and 1.8 work loss days from health issues related to air pollution.[25] Increasing Medford's tree canopy can only further enhance and geographically expand these benefits to the entire City when carefully planned and managed in its parks.

[24] National Land Cover Database 2011

[25] iTreeLandscape. Model Run on March 28, 2019

Figure 7 Medford Parks and Open Space Inventory 2019.



II. Parks and Open Space for Climate Resilience

This section provides a summary of our parks assessment on climate risk, green infrastructure suitability analysis, and prioritization methodology for implementing green infrastructure for climate resilience. It also provides site characteristics and regulatory considerations important to consider when pursuing green infrastructure. For parks that have undergone recent construction or renovation, we have included some retrofit opportunities for now or for future consideration. Figure 7 provides a map and names of Medford's parks. This report only evaluates parks and open spaces owned or managed by the City of Medford.

Leveraging Parks and Open Space for Climate Resilience

Many studies document the ancillary benefits of green infrastructure, from parks and living shorelines, to rain gardens and green roofs. These structures serve not only to capture and infiltrate stormwater, but also serve to cool cities and reduce energy demands during extreme heat events. Green infrastructure and nature-based solutions are also important mechanisms for climate resilience where natural systems work in tandem and emulate engineered systems that serve to mitigate stormwater, flooding, and extreme heat.

Several cities have taken great strides to operationalize green infrastructure solutions, particularly for stormwater management but also public health and community livability, into planning and redevelopment. Cities that have successfully implemented these across their municipalities are ones that pursue a programmatic approach that includes marketing, public engagement, policy, and dedicated funding. Particularly in dense urban environments with competing demands for constrained space, the following are identified as key strategies for successful green infrastructure in park system planning:

1. Engage communities on the benefits and designs of green infrastructure;
2. Maximize the benefits of green infrastructure solutions within a physically connected network;
3. Enable equitable access to parks and green infrastructure within system planning; and
4. Specify actions and funding sources to effectively implement at scale.[26]

Data Collection

MAPC utilized several methods to ascertain site suitability of green infrastructure design for renovations or retrofits in Medford's parks, and these are listed below. The analysis is designed to protect the people, infrastructure, and natural assets from climate change and minimize vulnerability.

1. Metro Mayors Climate Smart Region Decision Support Tool[27] Parcel Data Collection
2. Three site visits to Medford's Parks.
3. Spatially joined inland flooding present and future projections including the 10 year, 24-hour storm for 2019 and 2030 as well as the 100-year, 24-hour storm in 2030 as modeled by Kleinfelder in 2018.[28]

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[26] National Recreation and Parks Association. Resource Guide for Planning, Designing, and Implementing Green Infrastructure in Parks. 2017.
[27] https://web.tplgis.org/metromayors_csc/
[28] Kleinfelder 2018. City Wide Drainage Model for Medford,

4. Created an approximate geographic boundary and spatial located of the Medford Climate Change Vulnerability Assessment Neighborhoods of Concern as described in the 2019 report.

Figure 8 The Trust for Public Land Climate Smart Cities™ strategies applied in the Metro Mayors Climate-Smart Cities decision support tool.[29]

Trails and transit lines provide carbon-free transportation and link residents to popular destinations and each other.

Shady green spaces reduce the urban "heat island" effect, protect people from heat waves, and reduce summer energy use.

Water-smart parks, playgrounds, and green alleys absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management.

Shoreline parks and natural lands protect vulnerable infrastructure, neighborhoods, and residents from riverine flooding.

Credit: The Trust for Public Land (www.tpl.org)

In 2017, the Metropolitan Area Planning Council and The Trust for Public Land released the Metro Mayors Climate Smart Region decision support tool (the "Metro Mayors DST") for planning for climate resilience. The tool, open to the public, is a planning guide that illustrates the intersection of climate risk and opportunity for utilizing green infrastructure and nature-based solutions for climate resilience in the 15 municipalities of the Metro Mayors Climate Preparedness Task Force, including Medford. The Metro Mayors DST spatially analyzes climate risks such as urban heat island ("Cool"), inland and riverine flooding ("Absorb"), sea level rise/storm surge ("Protect"), opportunities to mitigate emissions with the opportunity to overlay active transportation corridors ("Connect") and neighborhoods and people most vulnerable to climate change ("Climate Equity"). These are described in Figure 8. There is a multitude of data and characteristics in the Metro Mayors DST, all tagged to the parcel level. MAPC researched each park and collected data for each park at the parcel level. For parks that are in multiple parcels, we utilized the one with the most risk/vulnerability. Data collected is listed in Table 3.

Finally, MAPC visited Medford's parks. For the first site visit on December 6, 2018, the conditions were partly sunny and cold. During the second site visit on December 18, 2019, the conditions were partly sunny. MAPC assessed park amenities, users, infrastructure, slope, sinks, pooling, stormwater drains, vegetation, evidence of erosion and/or runoff, and date of last renovation.

[29] https://web.tplgis.org/metromayors_csc/

Prioritization Analysis

MAPC created a prioritization analysis to guide which parks and open space can provide the greatest benefit as well as which provide the best opportunity for incorporating climate resilient design strategies into Medford's park system. The prioritization analysis, in summary, identified the sites most vulnerable to climate change and whether a park contains characteristics that make it suitable for implementing green infrastructure/nature-based solutions to help mitigate the climate change risks Medford anticipates.

Table 3 Park parcel data collection for prioritizing parks for green infrastructure for climate resilience. Note: GI is green infrastructure.

Park Climate Data and Characteristics	Qualifier	Value	Count of Parks that Qualify
Overall Green Infrastructure Priority	Yes	1	12
Walk/Bike Green Infrastructure Priority	Yes	1	13
Daytime/Night Urban Heat Island	Yes	2*	12
Daytime Urban Heat Island	Yes	1	27
Inland Flooding Green Infrastructure Priority	Yes	1	25
Runoff Potential	Yes	1	30
Soil Permeability	Yes	1	17
Slope	Yes	1	31
Sinks	Yes	1	12
Water Quality	Yes	1	31
SLR/Storm Surge GI Priority	Yes	1	4
FEMA Flood Zones	Yes	1	6
2030 Flood Zone BH_FRM	Yes	1	5
2070 Flood Zone BH_FRM	Yes	0.5††	5
Climate Equity	Yes	2*	20
Critical Infrastructure Density	Yes	1	11
% Impervious	>20%	1***	12
% Tree Canopy	<50%	1***	15
500 Ft 21E	Yes	-1**	24
Renovated <7 years	No	1	26
Green Infrastructure Installation	No	1	29
10-Year 24-Hour Flood 2019	Yes	2	36
10-Year 24-Hour Flood 2030	Yes	1	20
100-Year 24-Hour Flood 2030	Yes	1	23
Medford Climate Vulnerability Assessment Neighborhood of Concern	Yes	1.5	6
Intensity of Use	Low	0	12
	Medium	1	10
	High	2	10
Park and Amenity Condition	Good	0	13
	Fair	1	13 (+2 Medium-Fair)
	Poor	2*	4

*These characteristics were most important to the Local Steering Committee, so they are weighted higher.
**Parks within 500ft of a 21E site are less desirable for implementing GI because of potential mobility of toxins with infiltration, so they received a negative value.
***These percentage thresholds were deemed important by the Local Steering Committee for implementing GI.
†Parks located in the Medford Climate Vulnerability Assessment were valued higher since they are a compilation of a climate vulnerability data analysis and information from Medford's Municipal Vulnerability Preparedness Program.
†† Planning for flooding at 2070 was less important because it is determined by dam failure and uncertainty.

Using Metro Mayors Climate Smart Region DST, we investigated the climate risk and green infrastructure characteristics for every parcel in every park owned or managed by the City. We then assigned a value toward its benefit or lack of benefit for implementing nature/based solutions or green infrastructure for climate resilience. Certain climate risks were of greater significance to the Local Steering Committee and so those characters were weighted higher. Each park was assigned a score based on the sum of its qualifying characteristics to create an overall park climate prioritization score. Parks with the highest scores are prioritized for implementing green infrastructure and nature-based solutions first for best efficacy in using parks and open space for climate resilience, based on the priorities set by the Local Steering Committee. Table 3 indicates the climate characteristics and the value designation for each parcel. Table 4 lists the all climate/green infrastructure related data and physical characteristics of each City-owned park and their score for each characteristic.

One important consideration to note is that depth to bedrock and depth to water table data was limited and were not evaluated in this analysis for green infrastructure suitability. Most of the parks contained a value of 0 for these characteristics and communication with The Trust for Public Land indicated that these are likely areas where data does not exist rather than the depth to groundwater and bedrock is 0.

Table 4 Climate data and existing physical conditions pertaining to climate vulnerability and resilience for each park owned by the City of Medford.

Medford Park	Overall GI Priority	Walk/Bike GI	Day/Night Heat Island	Inland Flooding	Runoff Potential	Soil Permeability	Slope
Barry Park/Playground	No	No	Daytime	Yes	Yes	Yes	Yes
Brooks Estate/ Mystic River Reservation	No	Yes	No	Yes	Yes	Yes	Yes
Brooks Park	No	No	Daytime	Yes	Yes	Yes	Yes
Carr Park	No	No	Daytime	Yes	Yes	No	Yes
Clippership Park	Yes	Yes	Daytime	Yes	Yes	No	Yes
Columbus Memorial Park	Yes	No	Daytime	No	Yes	No	Yes
Condon Shell Park	Yes	Yes	Daytime	Yes	Yes	No	Yes
Cummings Park	No	No	Daytime	Yes	Yes	Yes	Yes
Edgerly Sports Complex	Yes	Yes	Yes	Yes	Yes	No	Yes
Gillis Field	No	No	Daytime	Yes	Yes	Yes	Yes
Grant Park	No	Yes	Yes	No	Yes	No	Yes
Harris Park	No	No	Daytime	Yes	Yes	Yes	Yes
Hasting Heights	No	Yes	No	No	Yes	No	Yes
Hickey Playground	No	No	Daytime	Yes	Yes	Yes	Yes
Hillside Memorial/Capen Park	Yes	No	Yes	No	Yes	Yes	Yes
Hormel Stadium/Riverbend Park	Yes	Yes	Daytime	Yes	Yes	Yes	Yes
Krystle Campbell Peace Garden	Yes	No	Daytime	Yes	Yes	No	Yes
Logan Park	Yes	No	Daytime	Yes	Yes	Yes	Yes
Magoun Park	No	No	Daytime	Yes	Yes	Yes	Yes
McNally Playground	No	Yes	Daytime	Yes	Yes	Yes	Yes
Medford Honor Roll Park	No	No	Daytime	Yes	Yes	No	Yes
Morrison Park	No	No	Daytime	Yes	Yes	Yes	Yes
Oak Grove Cemetery	No	No	Daytime	Yes	Yes	Yes	Yes
Playstead	No	No	Daytime	No	Yes	No	Yes
Prescott Park	No	No	Yes	No	Yes	No	Yes
Riverside Plaza	Yes	No	Yes	No	No	No	Yes
Royall House Park	Yes	Yes	Daytime	Yes	Yes	Yes	Yes
Salem Street Burying Ground	Yes	No	Yes	No	No	No	No
Thomas Brooks Park	No	No	Daytime	No	Yes	No	Yes
Tufts Park	Yes	Yes	Daytime	Yes	Yes	Yes	Yes
Victory Park	No	Yes	No	Yes	Yes	No	Yes
Wright's Pond	No	Yes	No	Yes	Yes	Yes	Yes

Medford Park	Density of Critical Infrastructure	Sinks	Water Quality	SLR GI Priority	FEMA Flood Zone	Flood Zone 2030 BHFRM	Flood Zone 2070 BHFRM
Barry Park/Playground	No	Yes	Yes	No	No	No	No
Brooks Estate/ Mystic River Reservation	No	Yes	Yes	No	Yes	No	No
Brooks Park	No	No	Yes	No	No	No	No
Carr Park	No	Yes	Yes	No	No	No	No
Clippership Park	Yes	No	Yes	Yes	Yes	Yes	Yes
Columbus Memorial Park	Yes	No	Yes	No	No	No	Yes
Condon Shell Park	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cummings Park	No	No	Yes	No	No	No	No
Edgerly Sports Complex	Yes	No	Yes	No	No	No	No
Gillis Field	No	No	Yes	No	No	No	No
Grant Park	No	No	Yes	No	No	No	No
Harris Park	No	Yes	Yes	No	No	No	Yes
Hasting Heights	No	No	Yes	No	No	No	No
Hickey Playground	No	Yes	Yes	No	No	No	No
Hillside Memorial/Capen Park	Yes	No	Yes	No	No	No	No
Hormel Stadium/Riverbend Park	Yes	Yes	Yes	Yes	No	Yes	Yes
Krystle Campbell Peace Garden	Yes	No	Yes	No	Yes	Yes	Yes
Logan Park	No	No	Yes	No	No	No	No
Magoun Park	No	Yes	Yes	No	No	No	No
McNally Playground	No	Yes	Yes	No	No	No	No
Medford Honor Roll Park	No	No	Yes	No	No	No	No
Morrison Park	No	No	Yes	No	No	No	No
Oak Grove Cemetery	No	Yes	Yes	No	No	No	No
Playstead	No	No	Yes	No	No	No	No
Prescott Park	No	No	Yes	No	No	No	Yes
Riverside Plaza	Yes	No	Yes	No	No	No	Yes
Royall House Park	Yes	No	Yes	No	No	No	No
Salem Street Burying Ground	Yes	No	No	Yes	Yes	Yes	Yes
Thomas Brooks Park	No	No	Yes	No	No	No	No
Tufts Park	Yes	Yes	Yes	No	No		Yes
Victory Park	No	No	Yes	No	No	No	No
Wright's Pond	No	Yes	Yes	No	Yes	No	No

Medford Park	Climate Equity	% Impervious	% Tree Canopy	500 Ft 21E	Renovated <7 years	GI Installation	Intensity of Use
Barry Park/Playground	No	18	19.4	No	No	No	1
Brooks Estate/ Mystic River Reservation	No	2.9	81.9	No	No	No	0
Brooks Park	No	4.8	37.5	No	No	No	0
Carr Park	No	12.9	53.1	No	No	No	2
Clippership Park	Yes	12.6	86.3	No	No	No	0
Columbus Memorial Park	Yes	22.3	25.2	Yes	No	No	2
Condon Shell Park	Yes	18.8	53	No	No	No	2
Cummings Park	Yes	59.5	54.6	No	No	No	1
Edgerly Sports Complex	No	50.2	18.6	Yes	No	No	2
Gillis Field	No	26.9	16.5	No	No	No	1
Grant Park	No	0.2	76.5	No	No	No	0
Harris Park	No	22.1	18.9	No	Yes	No	2
Hasting Heights	No	2.6	52.1	No	No	No	0
Hickey Playground	Yes	5.4	12.7	No	No	No	2
Hillside Memorial/Capen Park	No	51.7	40.9	Yes	No	No	1
Hormel Stadium/Riverbend Park	Yes	37.3	27.6	Yes	Yes	No	2
Krystle Campbell Peace Garden	No	49.8	6.9	No	Yes	No	1
Logan Park	Yes	0.8	56.5	No		No	0
Magoun Park	No	18.6	61.4	No	Yes	No	1
McNally Playground	No	6.1	33.5	No	Yes	Yes	1
Medford Honor Roll Park	No	25.3	30.5	No	No	No	0
Morrison Park	Yes	14.1	21.4	No	No	No	1
Oak Grove Cemetery	No	40	91.2	No	No	No	0
Playstead	No	14.8	8.6	No	No	No	2
Prescott Park	No	0.5	87.2	No	No	No	0
Riverside Plaza	Yes	28.6	62.1	No	Yes	No	1
Royall House Park	No	1.2	88.9	No	No	No	0
Salem Street Burying Ground	Yes	0.3	61.7	No	No	No	0
Thomas Brooks Park	No	0	65.8	No	No	No	0
Tufts Park	No	25.3	13.5	No	No	Yes	2
Victory Park	No	8.5	54.6	No	No	No	1
Wright's Pond	No	5.1	72.9	No	No	Yes	2

Medford Park	Park Condition	10 Yr 24H Flood 2019	10Yr 24H Flood 2030	100 Yr 24H 2030	CCVA Neighborhood
Barry Park/Playground	0	Yes	Yes	Yes	Yes
Brooks Estate/ Mystic River Reservation	2	No	Yes	Yes	No
Brooks Park	1.5	Yes	No	Yes	No
Carr Park	2	Yes	Yes	Yes	NO
Clippership Park	0	No	Yes	Yes	NO
Columbus Memorial Park	0	No	No	No	Yes
Condon Shell Park	1	Yes	Yes	Yes	No
Cummings Park	1	Yes	Yes	Yes	No
Edgerly Sports Complex	0	No	No	No	No
Gillis Field	2	No	Yes	Yes	NO
Grant Park	1	No	No	No	NO
Harris Park	0	Yes	Yes	Yes	No
Hasting Heights	1	No	No		No
Hickey Playground	1	Yes	Yes	Yes	No
Hillside Memorial/Capen Park	1	Yes	No	Yes	No
Hormel Stadium/Riverbend Park	0	Yes	Yes	Yes	No
Krystle Campbell Peace Garden	0	No	No	No	No
Logan Park	1	Yes	Yes	Yes	No
Magoun Park	0	Yes	Yes	Yes	Yes
McNally Playground	0	Yes	Yes	Yes	No
Medford Honor Roll Park	0	Yes	Yes	Yes	No
Morrison Park	1	Yes	Yes	Yes	No
Oak Grove Cemetery	1	Yes	Yes	Yes	No
Playstead	1	Yes	Yes	Yes	No
Prescott Park	0	No	No	Yes	No
Riverside Plaza	0	No	No	No	No
Royall House Park	1	No	No	No	No
Salem Street Burying Ground	1	No	No	No	No
Thomas Brooks Park	0	No	Yes	Yes	No
Tufts Park	1.5	Yes	Yes	Yes	Yes
Victory Park	1	Yes	Yes	Yes	No
Wright's Pond	2	No	No	No	No

Results

Park Prioritization

Table 5 lists the park climate prioritization score listed in order of importance where the highest scoring park is the highest priority for implementing the design strategies in Section III.

Table 5 Park prioritization results for implementing green infrastructure and nature-based solutions for climate resilience in Medford.

Medford Park	Total Score
Condon Shell Park	24.5
Tufts Park	23.5
Hormel Stadium/Riverbend Park	22.5
Hickey Playground	20
Barry Park/Playground	18.5
Clippership Park	18.5
Cummings Park	18
Morrison Park	18
Harris Park	17.5
Carr Park	17
Hillside Memorial /Capen Park	17
Logan Park	17
Brooks Estate/Mystic River Reservation	16
Gillis Field	16
Oak Grove Cemetery	16
Magoun Park	15.5
Columbus Memorial Park	15
McNally Playground	15
Playstead	15
Wright's Pond	15
Brooks Park	14.5
Krystle Campbell Peace Garden	14.5
Salem Street Burying Ground	14.5
Edgerly Sports Complex	14
Medford Honor Roll Park	14
Victory Park	14
Riverside Plaza	13.5
Royall Park	13
Grant Park	11
Prescott Park	10.5
Thomas Brooks Park	9
Hastings Heights	8

Overall, the most significant climate risks to Medford's Parks and Open Space are inland flooding and stormwater runoff, and temperature as measured by urban heat island both daytime and nighttime(Figure 5).[30] Thirty of Medford's 31 parks had runoff potential, meaning there would be stormwater flow off the site with rain events greater than 1" of precipitation. These are also parks that are located within a catchment area for an impaired water body. Six of Medford's park qualified for green infrastructure priority for the daytime and nighttime urban heat island. The urban heat island priority analysis by The Trust for Public Land considers night time urban heat island which is much less significant in Medford, however we consider daytime urban heat island an important impact to residents for those walking, biking, or recreating. In addition, the daytime urban heat island can intensify air pollution and exacerbate chronic respiratory issues such as asthma for those outside during hot days, such as children. Given the increasing frequency of both heat events and inland flooding, these are the most critical climate risks to Medford that can be addressed with nature-based solutions.

There are six parks that are located in areas that have been identified through the Medford Climate Change Vulnerability Assessment as neighborhoods of concern particularly for social vulnerability but also for flooding and urban heat island impacts. These become a higher priority for investment since they address multiple climate risks in Medford. Other notable results indicate that over half of Medford's parks have greater than 50% canopy cover and high soil permeability, creating conditions more favorable for natural infiltration infrastructure.

Finally, for the two historic cemeteries in Medford, Oak Grove Cemetery and Salem Street Burial Ground, we assume the historic nature of the site requires special considerations regarding changes to the landscape given the delicate nature of these open spaces. Therefore, recommendations were made on the preservation of both the historic asset itself from the impacts of climate change as well and preservation of the natural assets for the climate resilience services they provide the surrounding neighborhood.

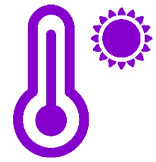
[30] This model identifies urban heat islands within the Metro Mayors planning area with elevated daytime land surface temperature (LST) averaging at least 1.25 degrees Fahrenheit above the mean daily temperature during late June/early July. The model results were derived from Landsat satellite data, which provides a 30m downscaled average land surface temperature every 16 days. Historical records show the warmest months in Boston are July and August. The model used a scene from July 7, 2015, the only cloud free LandSat scene from the year. www.tpl.org\metromayors_csc

III. Design Recommendations

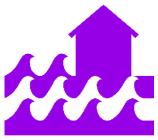
The following sections provides design recommendations to mitigate the most significant climate risks to the parks, neighborhood, or City of Medford at large. Each park contains an iconic summary of the climate risks/characteristics summarized in Table 5and bulleted design recommendations with accompanying photo examples of parks and open space utilizing these recommendations. The parks are listed in order of priority based on the park climate prioritization analysis described in Section II to address mitigation of Medford's most critical risks (inland flooding and urban heat) and protecting Medford's critical facilities. Below is the icon key to highlight characteristics important to consider for climate resilience.

Risks and Opportunities

STORMWATER MANAGEMENT



DAY/NIGHT URBAN HEAT ISLAND



CURRENT FLOOD ZONE

FUTURE FLOOD ZONE

CLIMATE EQUITY

TREE CANOPY

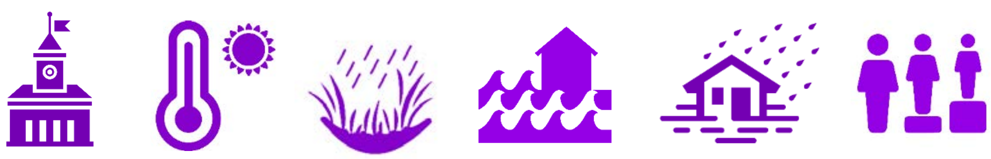
IMPERVIOUS SURFACE

CRITICAL INFRASTRUCTURE

MEDFORD CLIMATE CHANGE VULNERABILITY ASSESSMENT (CCVA)
NEIGHBORHOOD OF CONCERN

Condon Shell Park

Photo credit Patch.com



Existing Conditions

Condon Shell is a community gathering place and passive park along the Mystic River and Mystic Valley Parkway, part of the Mystic River Reservation. It contains a parking lot, a band shell, walking paths, Mystic River Reservation bike path and a community garden. Due to its location, space, and amenities, the park is perfect for festivals, the Medford Farmers Market, and other arts and cultural activities. The river bank is eroding and invasive species are compromising river bank stability and ecosystem function. The stone dust path is uneven and prone to puddling. The park is adjacent to neighborhoods with higher populations of seniors and individuals with less than a high school degree. Condon Shell is a critical park for serving climate equity. It is also located in a current and future flood zone, is adjacent to critical infrastructure, and will flood in a 10-year, 24 hour storm in 2019. Due to its riverine location, it is critical for managing stormwater and has high runoff potential. The park received a park climate priority score of 24.5.

Climate Design Recommendations

- Perform river bank restoration by removing and managing invasive species and replanting with native plant species. Use bioengineering to promote bank stabilization and enhance natural revegetation.

- Minimize runoff by replacing stone dust path with pervious pavement.
- Add bioswales and raingardens to the perimeter of the parking lot to prevent stormwater runoff from the road and Mystic Valley Parkway from entering the Mystic River (Figure 9).

Figure 9 Bio-retention area along ball fields, El Dorado Park, Salinas, CA.

Photo credit photo credit green-gardener-org

- The parking area and Codon Shell itself are susceptible to current flooding once or twice a year (100% and 50% Annual Chance Flood). The extent and depth of flooding increases significantly in 2070 compromising the Mystic Valley Parkway and the school and housing across the street from the park. Consider earthen berms along the Mystic River Parkway and Winthrop Street outside of the floodway to protect the road and building infrastructure. The earthen berm could simultaneously serve as a bike trail for safer biking along the Mystic Valley Parkway (Figure 10).

Figure 10 Raised earthen berm example for flood mitigation proposed for Battery Park, NYC.

The proposed Bridging Berm on the Lower East Side, showing landscaped berms used for recreation. Image: the BIG Team

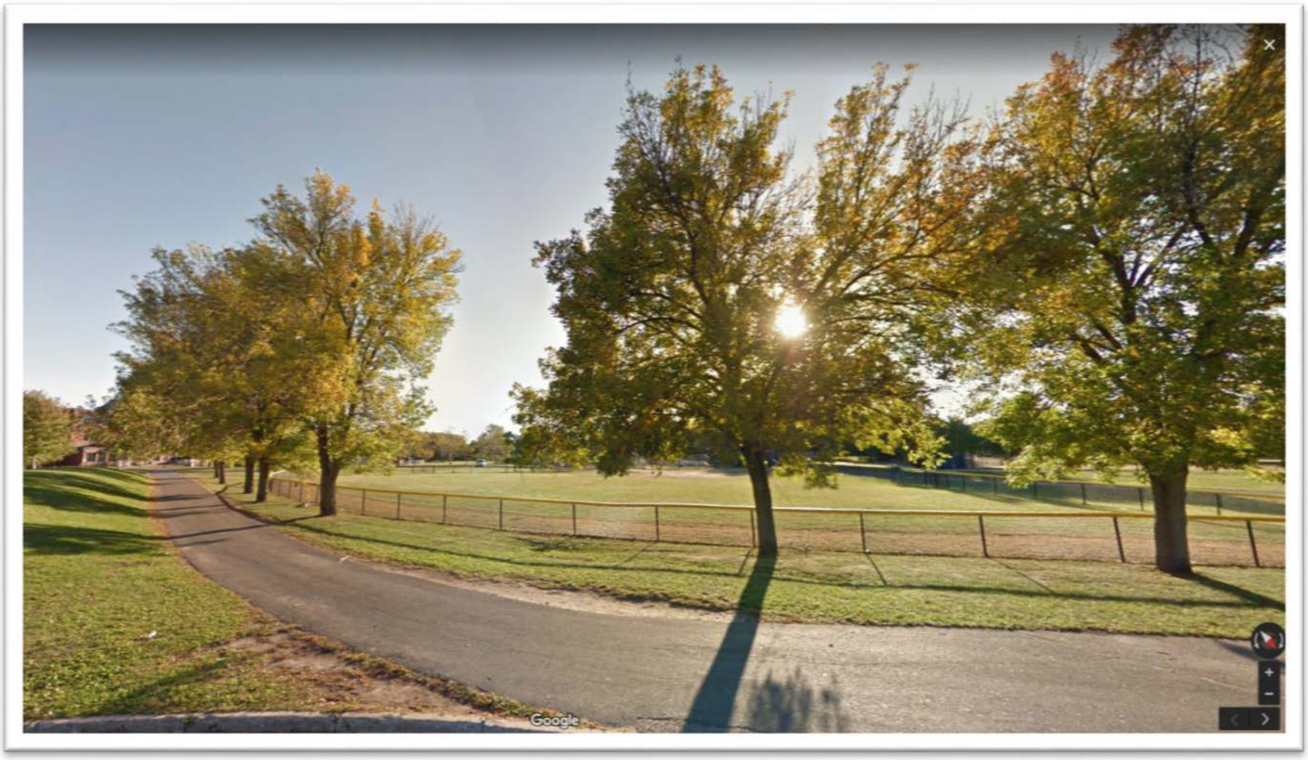
A new scenic bikeway along the Bridging Berm. Image: the BIG Team

If installed parallel to the Mystic Valley Parkway, a berm could provide both a separate bike path and protect a major roadway from current and future flooding. Photo credit: resilientdesign.org

- Another potential option is increasing the storage capacity of the park to flood waters by building wetlands and other infrastructure that can hold water and minimize flooding to adjacent infrastructure. For example, a pump track would draw more active transportation and bring new variety to youth recreation amenities. This track could also be designed to flood and hold water during flood events (Figure 11). Ensure its location enhances, not interferes with regular festival and concert activity at Condon Shell. The trees along Mystic Valley Parkway will be negatively affected by the creation of the earthen berm in the grow zone. Installation of the berm could coordinate with expected tree mortality of existing trees.

Figure 11 A pump track if designed correctly can serve as a recreation amenity and as flood storage infrastructure.

Riverbend Park/Hormel Stadium



Existing Conditions

Riverbend Park and Hormel Stadium comprise an approximately 44-acre active and passive recreation park on the Mystic River and part of the Andrews and McGlynn Elementary and Middle School complex. It contains a football field, two little league fields, one adult soccer field, a tot lot, dog park and community garden. Observations in the field indicated puddling and flooding both near and in the playground as well as near the ballfields. It is unclear whether the puddling was caused by a sudden large amount of rainfall, saturated or frozen soils or compacted subbase. However, conditions indicated surface grading did not adequately move stormwater away from amenities. The City has received a grant from the DCR, as well as permission from their Conservation Restriction owner, to improve the stone dust path along the dog park. While fall 2018 was the wettest on record, future climate projections indicate an increase in the frequency and severity of extreme precipitation events, making it a reasonable indicator of what we can expect in the future. Planning for stormwater runoff and management at the park is critical today.

This park is the most critical City-owned park for implementing nature-based solutions for resilience with a park climate priority of 22.5. The park is susceptible to future flooding in 2030 and 2070. There is greater than 20% impervious surface in the entire parcel which includes the parking lot, the schools, and the turf field which captures and radiates heat making it an urban heat island and priority for cooling during the daytime. In addition, the adjacent neighborhood is a heat island during the day and night, whose heat is likely radiating into the park. However, the park does have greater than 50% tree canopy. With its location adjacent to the river, it is a priority for stormwater management and runoff, though it is located within 500 feet of a 21E site making it less desirable for infiltration with green infrastructure. Other important characteristics include protecting critical infrastructure.

Climate Design Recommendations

Given the adjacency to the impaired Mystic River and the flooding, puddling and runoff existing challenges at the park, we suggest the following specific recommendations to manage storm water and reduce runoff:

- When upgrading the fields, re-grade the area to direct stormwater away from useable spaces to either vegetated areas or storage/infiltration areas.
- Alternatively, the lower areas that receive the stormwater can be designed to be gathering spaces for children or visitors that also allow for capture and/or infiltration (Figure 12).
- Restore the river bank to its natural ecosystem, which will enhance bank stabilization and minimize bank scouring during flood events. Restore with new native planting; additional support with bioengineering may be necessary (Figure 13).
- Manage the surface run-off from compacted soils and impervious surfaces that are contributing to the erosion and pollutant loading with bio-swales along the length of the path along the river (Figure 14).

Figure 12 "Birch Bowl" children's play area for stormwater catchment, Railroad Park, Birmingham, AL.

Photo credit LAF Online Performance Series.

Figure 13 Example of river bank stabilization with bio-engineering to restore ecosystem function, minimize scouring during flood events, and minimize pollutant runoff into the river.

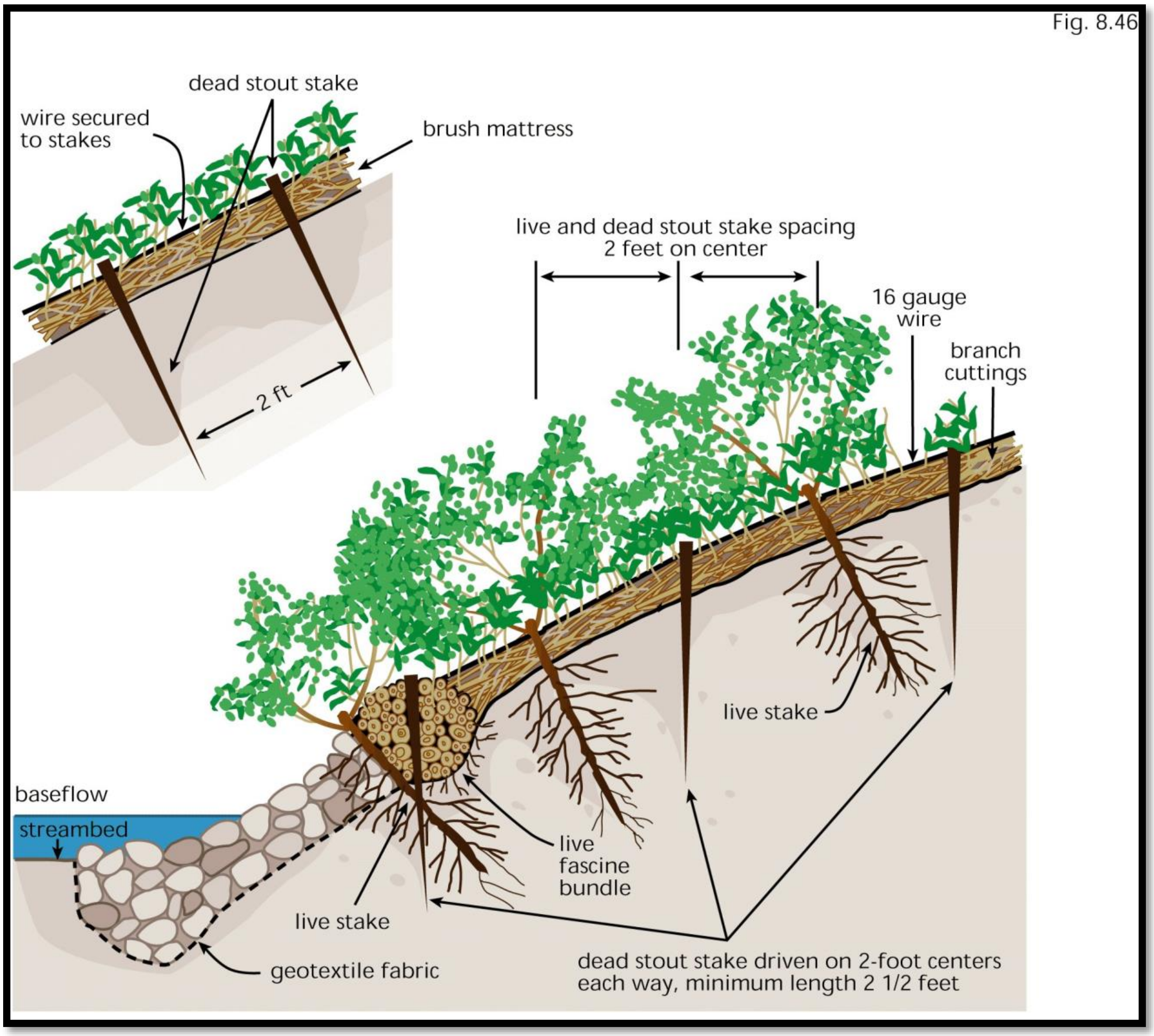


Photo credit Federal Stream Corridor Restoration Handbook Chapter 8, Page 3

Figure 14 Stone bio-swale along walkway, Buffalo Bayou Basin, Houston TX.

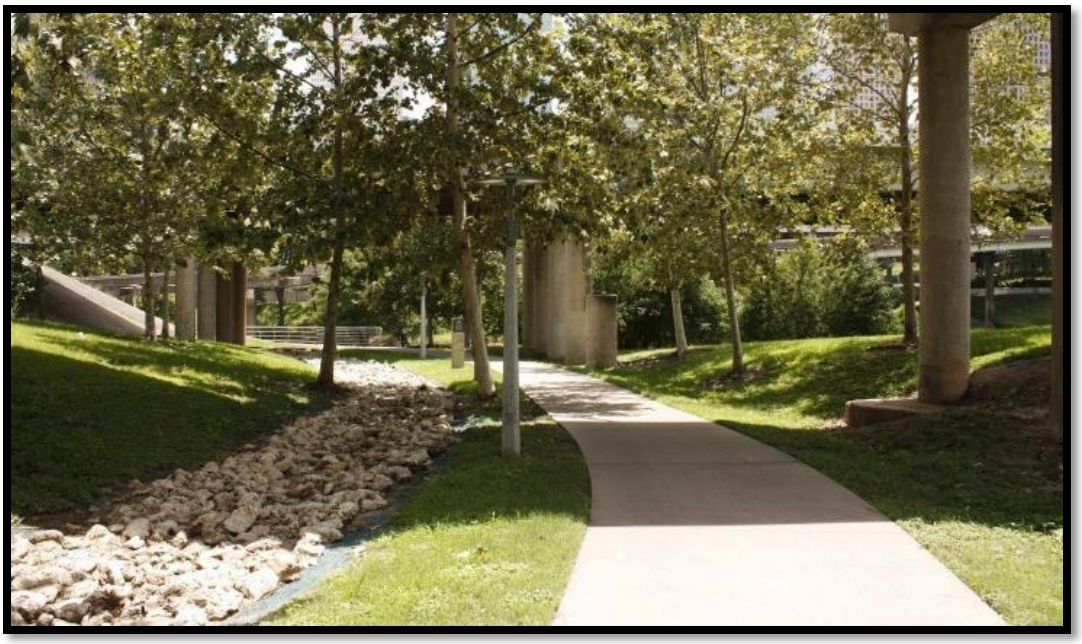


Photo credit from LAF Online Performance Series

- Replace the parking lot with porous paving (Figure 15) and direct stormwater into bio-retention areas at the lot perimeter to increase infiltration and evapotranspiration for cooling.

Figure 15 Parking lot with porous pavement, Chester Arthur Schoolyard, Philadelphia, PA.

Photo credit LAF Online Performance Series.

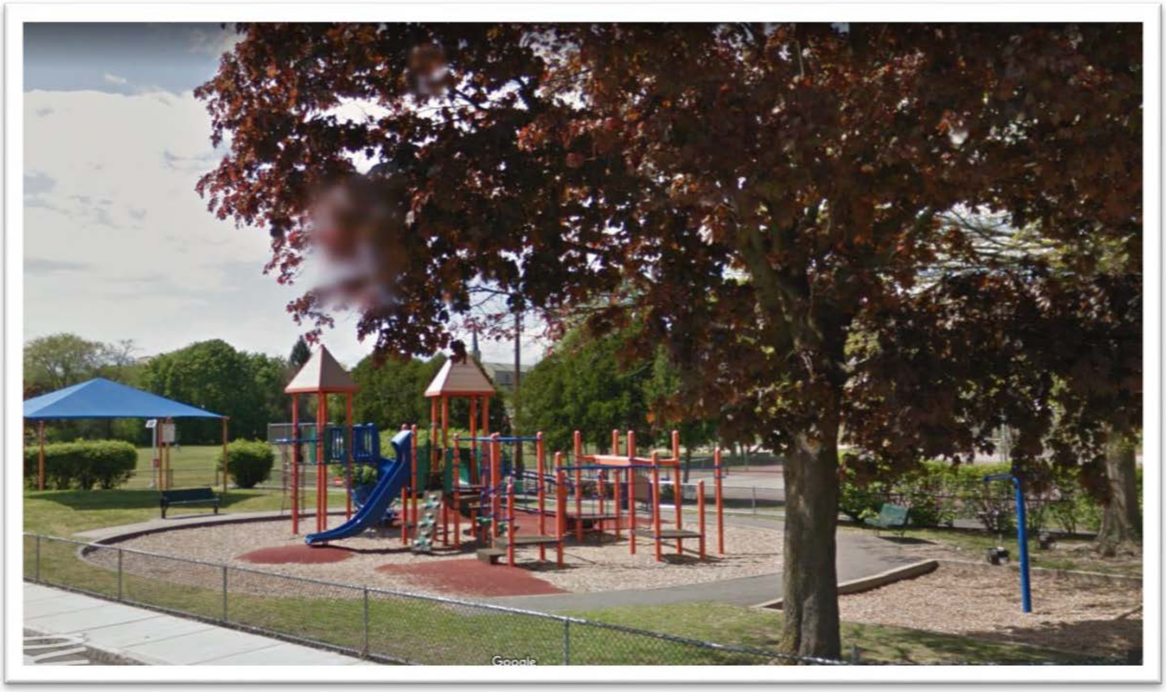
Photo credit LAF Online Performance Series

- Plant additional trees in the parking area, particularly replacing those that were recently lost. Utilize trees with deep rooted strong limbed species.
- Other considerations for cooling the site, reducing energy costs, and achieving net zero include incorporating green roofs and walls, solar panels or living roofs on buildings (Figure 16)
- Increase accessibility to students and visitors by using pervious pavement on the existing desire paths from route 16. This will further encourage walking and improve the walking experience to the park (Figure 17).

Figure 16 Green wall, Chester Arthur Schoolyard, Philadelphia, PA, photo credit LAF Online Performance Series.

Figure 17 Desire paths from Route 16 Mystic Valle Parkway to Hormel Stadium Park.

Hickey Playground



Existing Conditions

Hickey Playground/Park is 4.4-acre active recreation park containing a baseball diamond, a softball diamond, a tennis court, a basketball court, and a playground. Heavily used by local baseball and softball leagues, this an important park for the community. It is vulnerable to daytime urban heat, runoff potential, low tree canopy, and Climate Equity. The park is located in a current 10-year, 24-hour storm location and is at risk from future flooding from the 10-year and 100-year 24-hour storms. Hickey Park has a park climate priority of 20.

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Climate Design Recommendations

A perimeter walkway would provide better access from the adjacent residences.

- Consider replacing the concrete walkway along park perimeter at Park Street with pervious pavement or preplacing the walkway with raingardens or bioswales along the fence. The grade of the park lends to stormwater runoff from the basketball and tennis courts to the road leading to excess stormwater entering the road and stormwater system.
- The fields should be graded with regulation pitch towards low lying areas that have capture capacity to increase infiltration and evapotranspiration (Figure 18). In the field areas it may warrant test pits to assess the subsoil – if appropriate tilling in the fields may aid absorption.

- Additional trees could be planted to provide shade and for succession of existing trees that are in failing health. Consider planting where space is available at the perimeter of the park along Park Street, Rt. 28 and Brogan Road.
- As a Climate Equity site, crosswalks should be re-striped across Brogan Road, to increase accessibility and encourage walking and other active transportation options to the park.

Figure 18 Bio-retention area along Soccer fields, Great Park, Irvine, CA.

Photo credit from sitephocus.com.

Barry Park

Photo credit Google Maps

Park Existing Conditions

Barry Park is 3.6 acre active recreation park consisting of one baseball field, two basketball courts, two tennis courts, and one tot lot. Rain water pooling within the field areas is present with persistent rains. It is subject to current 10-year, 24-hour flooding and 10-year and 100-year 24-hour flooding in 2030. It is located in a Climate Change Vulnerability Assessment (CCVA) Neighborhood of Concern with a Park Climate Prioritization Score of 18.5.

Climate Design Recommendations

- Repave courts with porous pavement.
- Incorporate stormwater infiltration around basketball and tennis courts (Figure 19).
- Plant additional trees along Martson, Courtney and College Streets to mitigate urban heat island and mitigate vehicle emissions/air quality in active recreation areas. Street trees will also provide additional benefit of preventing stormwater runoff of compacted fields into street and stormwater system.

Figure 19 Bio-swales capturing run-off from courts, New Blair Park, Altoona, PA.

Photo credit Stiffler McGraw and Associates.

Clippership Park

Existing Conditions

Clippership Park is an approximate 1-acre passive park along the Mystic River and adjacent to Medford City Hall and the Senior Center. Due to its location and climate vulnerability, this park has tremendous opportunity to protect City Hall infrastructure while bringing people together through wayfinding, arts and cultural programming and beautification. The Park is susceptible to current and future flooding (2030 and 2070) from SLR/Storm Surge with critical infrastructure at risk due to the City's critical infrastructure adjacent to the Mystic River. As a Climate Equity site, wayfinding to/from downtown businesses could be improved to serve the largest number of people while activating Medford's downtown.

The park contains walkways that connect to the Senior Housing facility and will connect to Medford's middle schools once DCR completes the Clippership Connector, currently in design. It received a high park priority score of 18.5.

Climate Design Recommendations

- A landscaped/vegetated earthen berm could be installed along the river combined with river shoreline restoration to protect downtown Medford Critical Infrastructure from current and future flooding. The berm combined with restoration of the shoreline would create mare bank stability and prevent the river from overtopping into Clippership Drive (Figure 20). The berm would add topographic diversity to the park providing additional passive recreation amenities. Park users would have an elevated view of the river, particularly if combined with viewing and seating areas.

- Ensure trees are pruned, watered and maintained and new trees are deep rooted and strong-limbed species in order to have a greater chance of withstanding extreme weather.
- The park would benefit from artistic installations to draw more users to the area and help in create another gathering place for the community within the downtown area. The art installations could also serve to promote Medford's leadership in climate adaptation and mitigation. Sculptures could also serve to artfully capture stormwater and prevent runoff from entering storm drains and the Mystic River. (Figure 20)
- This would be a good location for Solar Trees which could provide additional renewable energy to the park and/or City as well as an attractive lighting to the area (Figure 21).

Figure 20 Rainwater harvesters and decorative stormwater planters. These cisterns contain spigots at the base to allow for re-use of the water.

Photo credit American Society of Landscape Architects.

Figure 21 Sanya Hybrid Lighting – Urban Green Energy is lighting San Francisco with its Sanya hybrid lighting street lamps, which use both wind and solar power to light up their LED.

Photo credit Solar Feeds.

Cummings Park

Existing Conditions

Cummings Park is a corner, neighborhood 0.45-acre with play equipment, tot lot, swings, pavilion, benches, a half basketball court and sand playing area. It is located near the Mystic River and Mystic River Reservation. It is located in a Climate Equity neighborhood for people with disabilities, linguistic isolation, low income, less than a high school degree, and one-person households. Parcel data suggest that the park contains nearly 60% impervious surface, but the addition of the sand play area likely has reduced that amount. It is located in a daytime and nighttime urban heat island making it a priority for green infrastructure. Cummings Park is subject to current 10 year 24 hour storm and the 10- and 100-year 24-hour storm in 2030. It scored 18 for park climate prioritization.

Climate Design Recommendations

- The park is located in a Climate Equity neighborhood which includes individuals with disabilities and over the age of 65. Some portion of that demographic could have mobility challenges and hence we suggest increasing accessibility to the park by installing crosswalks and curb ramps at the corner of Cotting Street and Lyman Avenue and mid-block at the entrance on Lyman Street.

- The walkways in the park could use replacement. We suggest porous pavement and/or ADA accessible permeable pavers to create a more decorative nature to the park (Figure 22).

Figure 22 Example of ADA Compliant permeable pavers.

Photo credit concretepaversystems.com

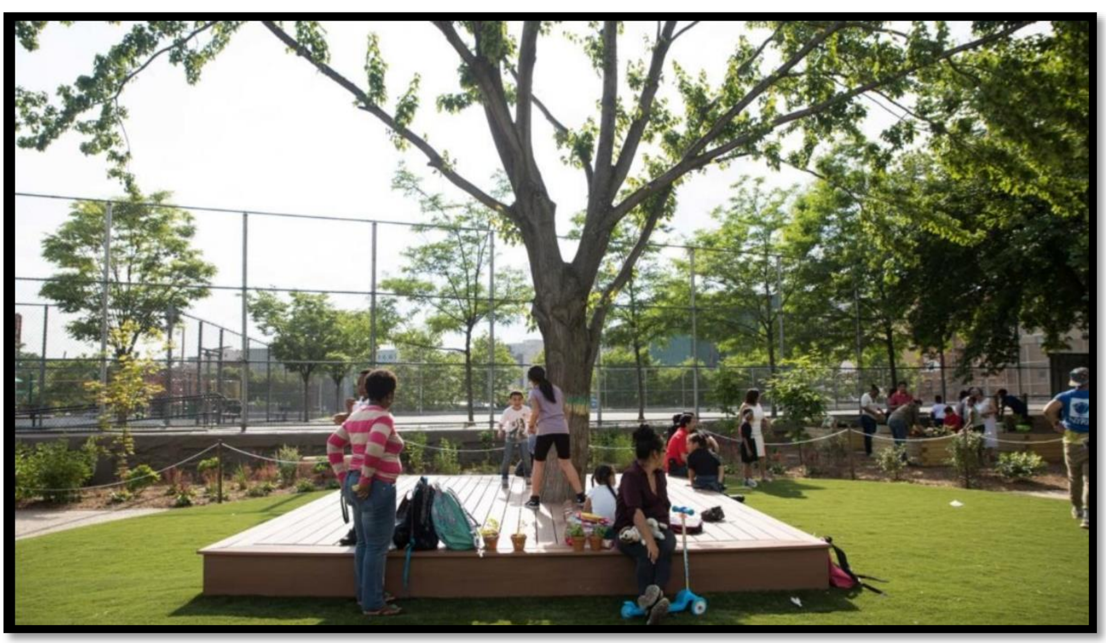
- Cummings Park is a great location to promote more sensory play and play structure accessibility with children of all ranges of disability using multi-function greenscape or natural playgrounds. This would also serve the dual purpose of cooling the park with increases evapotranspiration (Figure 23).

Figure 23 Greenspace and natural playground features (Top) Pierce Park, Baltimore, MD.

Photo credit inhabitat.com (Bottom) Urban Natural Playscapes at the University of Cincinnati.

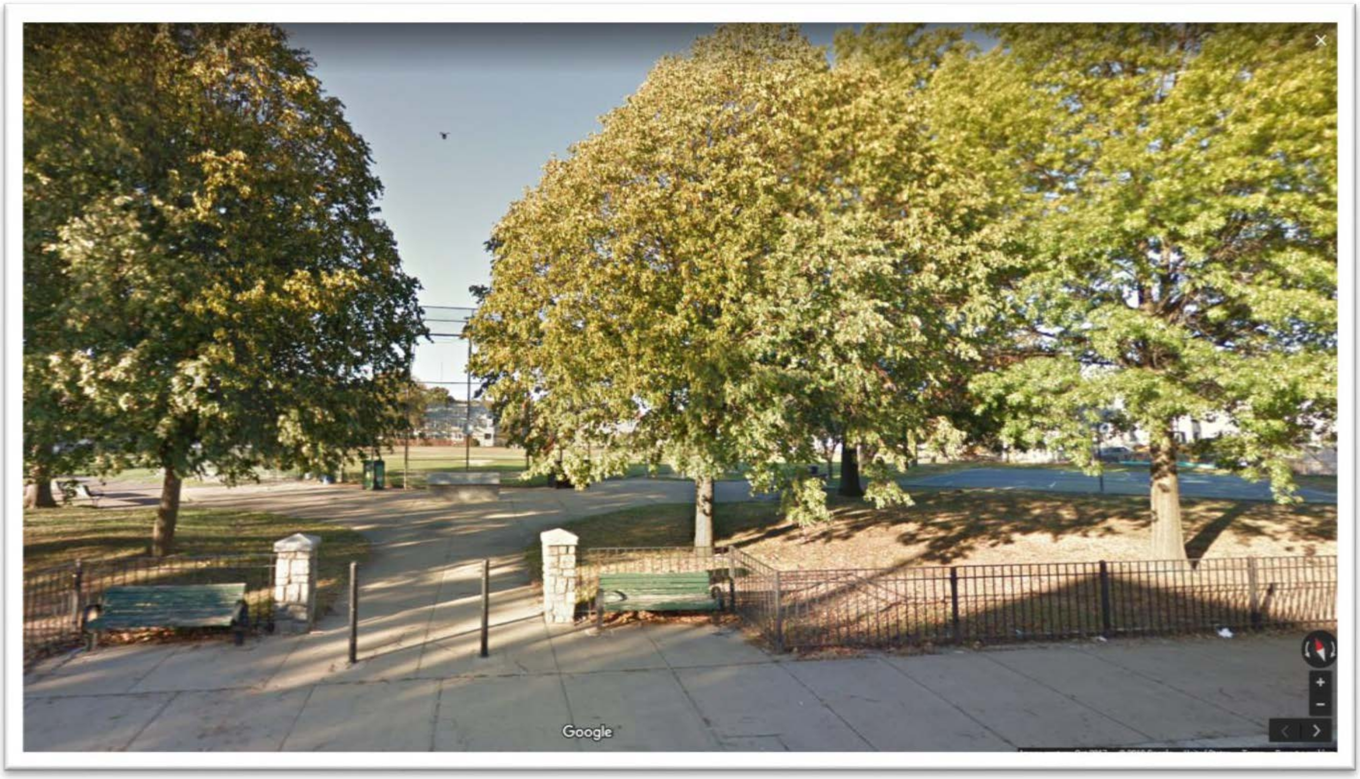
- Consider adding rain gardens at the perimeter fencing along Cotting Street and Lyman Ave *(*Figure 24*)*. This would not only capture runoff before going into the road, but also promote traffic calming further enhancing accessibility and walkability to the park.

Figure 24 Rain gardens at the park perimeter capturing stormwater runoff from the adjacent courts.



The gardens provide ecosystem services while occupying a less used space in the park. Fannie's Garden at Paradise on Earth, Bronx, NY. Photo credit Inhabit.com

Morrison Park



Existing Conditions

Morrison Park is a 4.4-acre active recreation park with a baseball diamond, two tennis courts, one basketball court and a tot lot. It is the site of a community garden to be developed in 2019 and a Climate Equity neighborhood. Some ponding was evident in the baseball field in November 2019 and the park is subject to flooding in the 10-year 24-hour storm in 2019. The park also has low tree canopy, daytime urban heat island, and priority for green infrastructure for managing stormwater. It scored an 18 on the park climate prioritization.

Climate Design Recommendations

- Improve pedestrian access with crosswalks and improved curb ramps, particularly on Linwood Street and Yeoman's Avenue to encourage walking to the park.
- Plant trees and improve tree growing conditions near tennis courts.
- When renovating the ballfield, re-grade for managing stormwater with a pervious gravel base for better infiltration.
- When restoring the basketball courts, consider using pervious pavement (Figure 25)

- On the Central Ave entrance, the grade slopes toward the road at the entrance to the baseball field. Consider adding rain gardens along the interior of the perimeter fence to minimize runoff entering the storm drain on Central Ave.

Figure 25 Basketball court with porous pavement, City Park, Lancaster, PA.

Photo credit Dave Harp.